Deutsche·Lithium

Zinnwald Lithium Project

Technical Report on the Feasibility Study for the Zinnwald Lithium Project, Germany

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1 Summary

1.1 Property Description and Ownership

Deutsche Lithium GmbH (DL, the Company) owns 100 % of the Zinnwald Lithium Project (the Project), located in the Free State of Saxony in Germany approximately 35 km south of the state capital Dresden. The Project is situated adjacent to the border with the Czech Republic and is located in a developed area with good infrastructure, services, facilities, and access roads. Power and water supply will be provided by well-established existing regional networks. Geographically, the area forms part of the Eastern Erzgebirge Mountains, a typical low mountain range with steep valleys and smooth summits with elevations of 750 to 880 m a.s.l.

DL is a 50 : 50 joint venture between Bacanora Lithium plc. (Bacanora) and SolarWorld AG i. L. (SWAG). Until the foundation of the joint venture in 2017, DL was a 100 % subsidiary of SWAG and was named Solarworld Solicium GmbH (SWS). SWS originally acquired two exploration licenses in the Zinnwald area in 2011 and 2012. In 2012, exploration drilling on the property confirmed a potential lithium resource. Subsequent drilling during 2013, 2014 and 2017 further delineated the resource. In April 2017, a mining permit was applied for, which was approved for the field ”Zinnwald“ on 12 October 2017. The mining permit covers 2,564,800 m² and is valid up to the 31 December 2047. In addition, DL holds two other exploration licenses within the area that have the potential to significantly increase the lifetime of the Project.

1.2 Geology and Mineralization

The area covered in this Feasibility Study (“FS”) is part of the Erzgebirge-Fichtelgebirge Anticlinorium, which represents one of the major allochthonous domains within the Saxo-Thuringian Zone of the Central European Variscan (Hercynian) Belt. Its geological structure is characterized by a crystalline basement and post-kinematic magmatites (plutonites and volcanites). The Zinnwald deposit belongs to the group of greisen deposits. Greisens are formed by post-magmatic metasomatic alteration of late stage, geochemically specialized granites and are developed at the upper contacts of granite intrusions with the country rock. The Zinnwald greisen is bound to an intrusive complex, which intruded rhyolitic lavas of Upper Carboniferous age along a major fault structure.

The prospective mineralization is of late Variscan age (about 280 million years old) and is geologically restricted to the cupola of the geochemically highly evolved Zinnwald granite. It was in its apical parts underground mined for veins with tin (cassiterite) and tungsten (wolframite, minor scheelite) until the end of the Second World War. Lithium is incorporated by a lithium-bearing mica, which is called “zinnwaldite”, a member of the siderophyllite-polylithionite series, which contains up to 1.9 wt.% lithium. It is enriched in 10 parallel to subparallel stretching horizons below the already mined tin mineralization. Individual lithium-bearing greisen beds show vertical thicknesses of more than 40 m. The mineral assemblage consists of quartz, Li-F-mica (zinnwaldite), topaz, fluorite and associated cassiterite, wolframite and minor scheelite and sulfides.

1.3 Exploration Status

The first underground mining for tin in the Zinnwald deposit on both sides of the current border between Germany and the Czech Republic was recorded in the second half of the 15th century. The “Tiefe-Bünau-Stollen”, which was driven from the year 1686 on, became the most important gallery of the whole Zinnwald ore field. This adit is actually part of the visitors’ mine “Vereinigt Zwitterfeld zu Zinnwald” and is located in the mining concession. Tin and minor tungsten mining on the German side ceased with the end of the Second World War, and on the Czech side in 1990. From 1890 to 1945 lithium-mica was produced as a by-product and used as raw material for lithium carbonate production. Lithium exploration on the German side started again in the 1950s.

SWS initially focused its exploration activities on the central Zinnwald area as well as underground on the accessible parts of the abandoned mine. An underground sampling campaign was conducted in the year 2012, which provided a series of 88 greisen channel samples from the sidewalls of the “Tiefer-Bünau-Stollen” (752 m a.s.l.) and the “Tiefe-Hilfe-Gottes-Stollen” galleries (722 m a.s.l.). SWS subsequently expanded the work to peripheral parts of the deposit. Exploration consisted of 10 surface drill holes (9 DDH and 1 RC DH) completed during the years 2012 to 2014 with a total length of 2,484 m. Infill and verification drilling was resumed and completed in 2017 by DL consisting of 15 surface diamond drill holes with a total length of 4,458.9 m.

1.4 Resource Estimates

The geological and geochemical results of the exploration campaigns were fully integrated in a data base, which comprises the following underlying data:

- 76 surface holes,
- 12 underground holes,
- 6,342 lithium assays of core samples covering 6,465 m of core,
- 88 lithium assays from channels,
- 1,350 lithium assays from pick samples.

SWS and DL exploration samples were analyzed by the accredited commercial ALS laboratory at Roşia Montană, Romania. Duplicates were sent to Activation Laboratories Ltd. in Ancaster, Canada, for external control. QA/QC procedures were carried out for due diligence purposes and the results confirmed the careful sampling and reasonable accuracy and precision of the assays. Twinned drill holes showed a good match. The initial geological model of several parallel to sub-parallel stretching mineral horizons ("Ore type 1 greisen beds") was verified and an authoritative resource assessed.

The general mineral inventory of lithium was estimated from the block model on the basis of a zero cut-off and without a constraint of minimum thickness of the ore bodies. It accounts for 53.8 Mt greisen tonnage ("Ore Type 1") with a rounded mean grade of 3,100 ppm.

Table 1: Mineral inventory of the Zinnwald Lithium Deposit, German part below 740 m a.s.l.

Mineral inventory "Ore Type 1"	Volume [10^6 m³]	Tonnage [10^6 tonnes]	Mean Li grade [ppm]
Total	***19.9***	***53.8***	***3,100***

Modifying factors for eventual economic extraction (vertical thickness ≥ 2 m, cut-off = 2,500 ppm Li) applied to the mineral inventory result in **a demonstrated (measured and indicated) lithium resource of 35.51 Mt of greisen ore with a mean lithium grade of 3,519 ppm** (see *Table 2*).

Table 2: Lithium resource of the Zinnwald Lithium Deposit, German part below 740 m a.s.l. – Base Case "Ore Type1" Summary

Resource classification "Ore Type 1" greisen beds	Ore volume [10^3 m³]	Ore tonnage [10^3 tonnes]	Mean Li grade [ppm]	Ore volume [10^3 m³]	Ore tonnage [10^3 tonnes]	Mean Li grade [ppm]
	Vertical thickness ≥ 2 m, cut-off Li = 2,500 ppm			**Vertical thickness ≥ 2 m, cut-off Li = 0 ppm**		
Measured	6,855	18,510	3,630	8,954	24,176	3,246
Indicated	6,296	17,000	3,399	8,046	21,725	3,114
Inferred	1,802	4,865	3,549	2,675	7,224	2,995
Demonstrated *(Measured+Indicated)*	***13,152***	***35,510***	***3,519***	***17,000***	***45,901***	***3,183***

The potential of Sn, W and K_2O have been estimated for the greisen beds as mean grades for “Ore Type 1” for the German part of the Lithium Zinnwald Deposit and below 740 m a.s.l.: At a total volume of rounded 15 million cubic meters and a tonnage of 40 million tonnes, the overall mean tin grade accounts for approximately 500 ppm, mean tungsten grade for approximately 100 ppm and mean potassium oxide grade for approximately 3.1 wt.%.

If the geological data of campaigns (5), (6), (7) and (8) as well as the lithium assay data of campaigns (5) and (8) are also taken into account, it can be summarized that the lithium resource of “Ore Type 1” has more than tripled compared to Exploration Campaign No. 4.

1.5 Reserve Estimates

CIM Definition Standards were followed for the calculation of the Mineral Reserves, which were generated using the September 30th, 2018, version of the Zinnwald deposit resource model. The Mineral Reserves are part of the Mineral Resources. They are reported at a 2,500 ppm Li cut-off grade and below 740 m a.s.l. inside the German state territory. They are inclusive of diluting material and are referenced as mined ore delivered to the plant.

The Mineral Reserve of the Zinnwald lithium deposit considers the underground preparation and development of the whole deposit as well as the technological development of an exemplarly selected mine sublevel. Volumes of material belonging to outer and inner dilution exhibit lithium grades > zero. Predominately greisenized granite accompanies the orebodies. It shows mean lithium grades of roughly 1,700 ppm. Inner dilution mostly consists of greisen and greisenized granite which shows mean lithium grades of roughly 1,900 ppm.

The portion of the geological lithium resource, which is blocked by safety pillars surrounding already existing mine workings, or which cannot be mined economically due to the isolation of ore bodies or to an insignificant ore thickness, amounts to 7 % and was excluded. Based on the reduced resource, Mineral Reserves have been estimated for mining schemes applying sublevel stoping with longitudinal stopes. The normal case suggested for the future mining procedure of the Zinnwald lithium deposit can be specifically adjusted to locally changing geological conditions. It is referred to as “Standard Mining Technology and Optimized Backfill”. It includes maximum dimensions of the rooms of 7 m x 7 m with 2 m wide safety pillars and 1 m thick horizontal roof pillars. Backfill material is characterized by a compressive strength value of at least 4 to 5 MPa.

The resulting portion of the Proven Mineral Reserve accounts for **16.5 Mt of ore** including dilution and contains **51 kt lithium metal**. This corresponds to 54 % of the total lithium metal reserve.

The Probable Mineral Reserve is **14.7 Mt** of ore including dilution with content of **43 kt lithium metal**. It comprises 46 % of the total lithium metal reserve. For further details see *Table 3* below.

Table 3: Mineral Reserve for lithium (normal case)

Category	Ore and Dilution Tonnage [kt]	Li Grade [ppm]	Li Metal Content [kt]
Mineral Reserve considering mining loss and dilution			
(1) Parameter conform ore	22,270 (71 %)	3,500	78
(2) Internal dilution	2,632 (8 %)	1,929	5
(3) External dilution	6,300 (20 %)	1,700	11
(4) Total Mineral Reserve (1+2+3)	**31,203 (100 %)**	**3,004**	**94 (100 %)**
(5) Proven Mineral Reserve	**16,504 (53 %)**	**3,075**	**51 (54 %)**
(6) Probable Mineral Reserve	**14,699 (47 %)**	**2,933**	**43 (46 %)**

1.6 Mining

The mining operation for the Project is planned as an underground mine development using a main ramp for access to the mine and for ore transportation from the mine to the surface. The mine technology will be a common load-haul-dump (LHD) room and pillar technology with subsequent backfill using self-hardening material. Based on the key figures of the overall project, the mine has been designed for an annual output of 1,800 t of Li metal. With reference to the reserve estimation this corresponds to an annually mined ore production between 500,000 to 600,000 t.

Preparation and development of the deposit by main ramp and ventilation shaft includes the following actions:

- Ramp collar at the Europark in Altenberg
- Shaft collar in the north of the deposit
- Routing towards north
- Main hauling by truck
- Ventilation with intake shaft and return air ramp

- Optional involvement of additional mine openings for ventilation purposes
- Utilization of “Tiefe-Hilfe-Gottes” gallery (THG) for water drainage

The deposit itself will be developed via short ramps and sublevels with a spacing of 8 m, initially focussing on the deeper portions of the deposit. With respect to the best possible adjustment to the deposit structure and the prevention of mining losses, a mining technology consisting of sublevel stoping with longitudinal stopes and optimized self-hardening backfill was developed. Mining consists of two extraction steps:

- 1st Extraction Step: Construction of pillar roads with a standard cross section of 5.0 by 4.0 m with permanently stable dimensioning and a horizontal roof pillar thickness of 4.0 m.

- 2nd Extraction Step: Systematic reduction of pillars and horizontal roof pillars depending on the local conditions (ore body shape, geotechnical conditions, etc.) to a dimension of up to 7.0 by 7.0 m.

1.7 Processing and Metallurgical Test Work

The FS test work program builds on the Preliminary Economic Assessment Report (PERC PEA) program completed by SolarWorld Solicium GmbH in 2014. The purpose of the FS test work program was:

- to confirm the results of the laboratory test work in a technical scale
- to define the process flowsheet to produce high quality battery-grade lithium fluoride
- to provide engineering data for basic engineering and for major equipment selection and sizing

The FS test work included flowsheet development test work using a split of a 100 t lithium-mica greisen ore sample. This ore was mined by drilling and blasting in the Zinnwald visitor underground mine from ore body B02, one of the biggest ore bodies in the deposit. During the development of the FS, the PERC PFS mineral processing flowsheet was confirmed. Some changes have been made in pyrometallurgy and hydrometallurgy, these were:

- Pyrometallurgy: Recipe has been changed with sodium sulphate being replaced by calcium carbonate (limestone)
- Hydrometallurgy: The target lithium compound was changed from lithium carbonate / lithium hydroxide to lithium fluoride

The test work was done to verify the robustness of the processes for both mineral processing and metallurgy. The mineral processing test work was carried out by UVR-FIA (Freiberg / Germany). Pyrometallurgical test work was conducted by IBU-TEC (Weimar / Germany) and the hydrometallurgical test work was done by K-UTEC (Sondershausen / Germany).

Key outcomes of the test work are summarized below.

- The mineral processing, consisting of two stage crushing, ball mill grinding, dry magnetic separation, and fine grinding of zinnwaldite concentrate, has shown to be very robust. The lithium recovery was above 90 % for both the 20 t test work of the PFS (94 %) and the 50 t test work of the FS (92 %). The lithium recovery assumed in the FS is 92 %.
- The pyrometallurgy test work has confirmed a robust roasting recipe consistently achieving > 85 % lithium extraction in the leach.
- The hydrometallurgical test work confirmed that impurity removal successfully reduced calcium and magnesium contaminants in the pregnant leach solution (PLS). The precipitation by adding potassium fluoride resulted in a battery-grade lithium fluoride with 99.5 % purity with a recovery rate of 95 %.
- The overall recovery rate from ROM to end product (LiF) is 76 %.

The design criteria which have been used to develop mass balances and process design are based on these test work results.

In addition, a test work program was undertaken in the PERC-PFS to demonstrate the direct synthesis of lithium carbonate products out of the zinnwaldite concentrate. This can also be adapted to the LiF flowsheet with minimum optimization.

1.8 Recovery Methods

The process engineering and design for the process plants and infrastructure was completed by the following:

- Mineral processing: UVR-FIA GmbH (Freiberg / Germany), KÖPPERN (Freiberg / Germany)
- Chemical processing: IBU-TEC (Weimar / Germany), K-UTEC (Sondershausen / Germany), CEMTEC (Enns / Austria), ERCOSPLAN (Erfurt / Germany), AMPROMA (Herrschingen / Germany)

The extraction of lithium from the greisen ore is structured in two main operation units:

- Mineral processing unit in Freiberg

- Metallurgical / chemical processing plant in Freiberg

The FS is based on an operating life of 30 years with an average annual mine production of approximately 573,000 t greisen ore containing an average of 0,31 wt.% Li. In the mineral processing unit, the ore is beneficiated to produce approximately 124,420 t/a of a zinnwaldite concentrate containing around 1.33 wt.% Li, using a dry magnetic separation process.

The subsequent metallurgical / chemical processing starts with a roasting process in a rotary kiln on the chemical site by blending the concentrate with limestone and anhydrite / gypsum prior roasting. The roasted zinnwaldite-limestone-anhydrite mixture is than leached with hot water. In this process lithium and potassium are converted into water soluble lithium and potassium sulfates, which can be separated by several crystallization cycles. This is followed by various purification steps.

Finally, an average of 5,112 t/a of high purity lithium fluoride can be produced from the solution, which corresponds to 7,285 t/a lithium carbonate equivalent (LCE) or 8,274 t/a lithium hydroxide monohydrate ($LiOH \cdot H_2O$). As a by-product of this production process, approximately 32,000 t/a of potassium sulfate (SOP) is expected to be produced. This co-product will be sold to chemical companies in Germany to produce fertilizer.

The forecast operating schedule for the mine in Zinnwald and the mineral processing unit in Freiberg is 24 hours from Monday to Friday and 6,000 hours per annum. The weekends will be used for maintenance. The chemical plant will run 24/7 and 8,000 h/a. The overall designed plant availability is 83 % for the mineral processing unit and pyrometallurgical plant. *Figure 1* presents a summary of the overall process flowsheet.

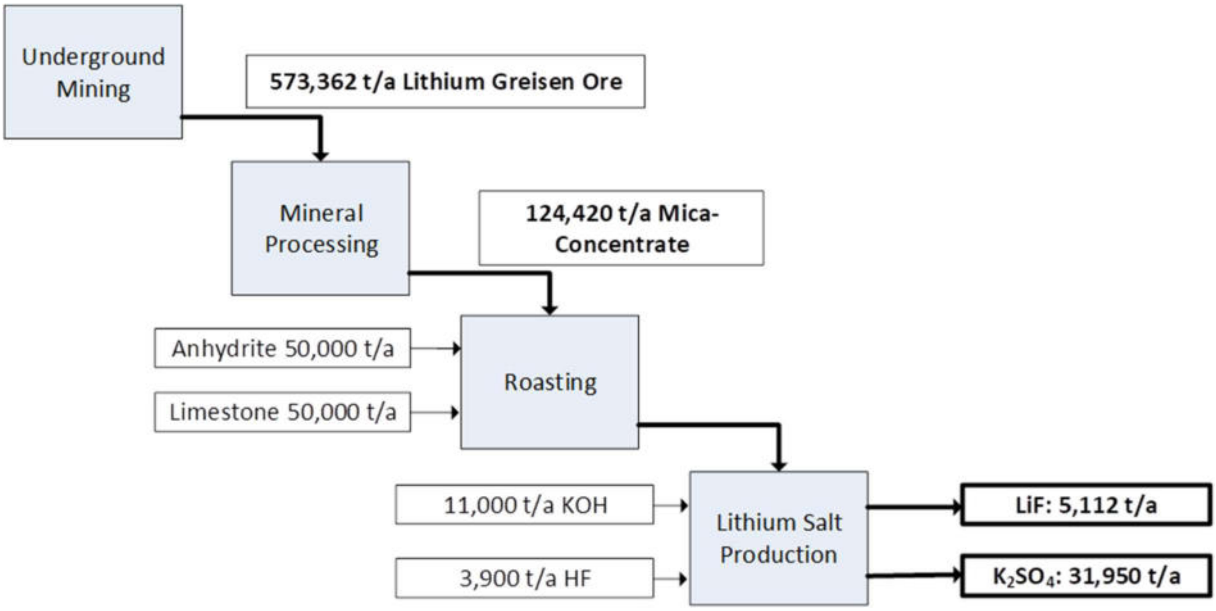


Figure 1: Summary flowsheet (5,112 t LiF are equivalent to 7,285 t LCE or 8,274 t/a Li-OH·H_2O)

1.9 Project Infrastructure

The Project is located in a region with developed infrastructure, services, facilities, and access roads. Power and water are provided by existing regional supply networks. The mining site is in Altenberg situated on the former mining site of “Zinnerz Altenberg”.

The processing plant will be located in Freiberg, 49 km far from Altenberg, in the industrial area “Saxonia”. Saxonia is an industrial zone with an existing pyrometallurgical industry for zinc oxide production from zinc-containing residues (mainly steel plant dusts) and a well-developed general infrastructure. This plant will cover the entire process from beneficiation of the mined ore to pyrometallurgical and then hydrometallurgical processing. All services (power, gas, water) and railway connections are available. Steam will be supplied by the local power supply company.

1.10 Market Review and Lithium Pricing

The Zinnwald deposit provides an opportunity to focus on the direct production of high value downstream lithium products, rather than only concentrates (e.g. spodumene) or lower-value lithium carbonate products. With an abundant supply of fluorspar / hydrofluoric acid available in the Dresden / Zinnwald region of Germany, DL has chosen to focus on lithium fluoride production. Lithium fluoride (LiF) is an important component in the manufacturing process of $LiPF_6$, which is the most important conducting salt in lithium-ion batteries.

Due to the growing utilization of electro-vehicles (EV), the lithium fluoride market is expected to grow markedly over the next 30 years. The FS has been developed on a planned average annual production capacity of 5,112 t/a lithium fluoride (7,285 t LCE / 8,274 t $LiOH \cdot H_2O$). Whilst the FS is based solely on the production of lithium fluoride, DL has established the possibility to produce battery-grade lithium carbonate directly from the lithium mica concentrate with only minimal modifications to the chemical plant circuits. The same applies to a possible $LiOH \cdot H_2O$ production.

SignumBox Chile (www.signumbox.com) has provided the Company with its detailed 20 years analysis of the wider global lithium market. The Fraunhofer Institute in Germany (www.fraunhofer.de) has provided a detailed analysis of the electrolyte / LiF market. These reports can be summarized as follows:

- By 2037, SignumBox anticipates a global annual demand for lithium chemicals to reach about 1,700,000 t of LCE in its base scenario, compared to the current 360,000 t in 2019, equating to an average annual growth rate of about 11.5 % over the next 20 years.
- Contract prices for battery grade lithium carbonate products have increased significantly since Q3 2015 from a global average price of lithium carbonate of approx. 6,000 USD/t to over 12,000 USD/t (Q2 2019).
- SignumBox' estimates of the total demand for electrolyte materials reached 142,000 t in 2018 with a value of 4 billion USD, which represents a 11.4 % growth compared with 2017. SignumBox expects the annual demand to grow to over 230,000 t by 2030.
- Fraunhofer estimates, that mid-case consumption of LiF in electrolyte production will be in the range of 20,000 t/a to 40,000 t/a by 2030, depending on LiF density remaining in the electrolyte in the range of 5 % to 10 %.

For the FS cashflow analysis, the Company reached a consensus forecast for LiF pricing and uses a price of EUR 22,000 t for battery grade lithium fluoride over 25 years of production. It is based on an average pricing from a number of sources:

Zion Market Research:	26,000 – 26,500 USD/t
SignumBox Calculation:	22,725 – 27,269 USD/t (Average global production cost)
Spot market price (Q1 2019 China):	30,000 – 32,000 USD/t

For the potassium sulphate co-product, the FS assumes a sale price of 500 EUR/t based on existing spot market prices in the local German economy.

The cashflow analysis was prepared by the Company's financial consultants eXnet audit GmbH.

1.11 Environmental Studies

An environmental impact analysis (EIA) pre-study for the mining activities was prepared and applied for, which is based on the German Mining Act standards as follows:

- Land use of the Project below 10 ha
- Forest use of the Project below 1 ha
- Water handling in the mine below 100,000 m³/a

The Mining Authority of Saxony decided in March 2018 that a full EIA was not required. The permit process follows a simplified model called Facultative Frame Operation Plan ("fakultativer Rahmenbetriebsplan"). In November 2018, DL started this permit process. The application was submitted to the Mining Authority in June 2019 and the process is still ongoing.

The permit process for the chemical site in Freiberg will follow the standard BImSchG – Permission Process according to the German BImSchG rules.

1.12 Capital Cost Estimates

The capital cost estimates cover the design and construction of the mine and the process plants, together with on-site and off-site infrastructure to support the operation including water and power distribution and support services. The capital costs associated with the gas supply pipeline and power / steam stations are also included. *Table 4* is a summary of the capital cost estimates included in the FS with an expected accuracy of ±10 % and a base date of Q1 2019. All amounts expressed are in Euro unless otherwise indicated. An exchange rate of 1.12 from USD to EUR was considered during the FS.

Table 4: Estimated Capital Cost for the execution of the Project

Area	M EUR
Mining equipment, infrastructure and site	27.4
Beneficiation / mineral processing plant	23.3
Chemical plant	82.0
Property and general on-site infrastructure	10.6
EPCM / Project management	14.9
Contingency	15.8
Subsidies / grants*	(15.0)
Total:	158.9

(* The subsidies are based on present EU and German laws and are granted for investments in the industrial sector of the former German Democratic Republic.)

1.13 Operating Cost Estimates

The mining and processing operating costs were calculated for an operation achieving an average annual production of approx. 5,112 t/a of battery grade (99.5 %) lithium fluoride and are based on the operating cost estimations of the engineering companies G.E.O.S. (mining), KÖPPERN (processing), CEMTEC (roasting) and K-UTEC / AMPROMA (LiF production).

The operating cost estimate covers the mine, the beneficiation plant and the process plants and general and administration facilities. Operating costs have been estimated with an accuracy of ±10 % and are summarized in *Table 5*.

The financial model includes a production ramp-up for the mine and processing plants. This results in lower recoveries and thus in slightly lower LiF production for the first two years of operation.

Table 5: Average Annual Operating costs per tonne of LiF

Category	**EUR/t LiF**
Mining	2,525
Mechanical Processing	2,699
Chemical Processing	7,448
Environmental and Central	386
Total - Direct Operating Costs	13,058
G&A	607
Total - All costs per LiF	13,665

1.14 Economic Analysis

As shown in Table 6, the FS demonstrates the financial viability of the Zinnwald Lithium Project at an initial minimum design production rate of 5,112 t/a LiF (battery grade 99.5 %).

The Project is currently estimated to have a payback period of 6.1 years. Cash flows are based on 100 % equity funding. The average gross annual revenue is 129 M EUR over 30 years of operation. The economic analysis indicates a pre-tax NPV, discounted at 8 %, of approximately 428 M EUR and an Internal Rate of Return (IRR) of approximately 27.4 %. Post-tax NPV is approx. 270 M EUR and IRR 21.5 %.

A sensitivity analysis has shown that the Project is more sensitive to the lithium price than it is to either CAPEX or OPEX. An increase of 30 % in the average lithium fluoride price from 22,000 EUR/t to 28,600 EUR/t increases the Post-Tax NPV from 270 M EUR to 511 M EUR and the Post-Tax IRR to 31 %. A decrease of 30 % in the average lithium fluoride price from 22,000 EUR/t to 15,400 EUR/t decreases the Post-Tax NPV from 270 M EUR to 30 M EUR and the Post-Tax IRR to 10 %.

Table 6: Overview Financial Analysis

Feasibility Study Key Indicators	Value
Pre-tax NPV (at 8 % discount) (M EUR)	428
Pre-tax IRR (%)	27.4 %
Simple Payback (years)	6.1
Initial Construction Capital Cost (M EUR)	159
Average LOM Unit Operating Costs (EUR/t LiF)	13,058
Average LOM Revenue (M EUR/a)	112
Post-tax NPV (at 8 % discount) (M EUR)	270
Post-tax IRR (%)	21.5 %
Average Annual EBITDA with co-products (M EUR)	58.5
Annual Average LiF Production	5,112
Annual K_2SO_4 Production Capacity	32,000

1.15 Conclusions and Recommendations

Diamond core confirmation and infill drilling and underground sampling was conducted by DL between the years 2011 and 2017. Drilling, sampling, sample preparation and sample assaying by ALS and Actlabs fulfilled high industrial standards. Internal and external QA/QC procedures were performed with reasonable care. A comprehensive geostatistical evaluation of the geological and geochemical data was conducted and proved its reliability. The geological model was verified and an authoritative resource assessed.

The majority of the Measured and Indicated Mineral Resources was converted to Mineral Reserves. There is appreciable potential to upgrade the current Inferred Mineral Resources to Measured and Indicated Mineral Resources by infill drilling and underground exploration. The lithium deposit is open to the west and at least one additional drill hole west of the hole ZGLi 11/2017 is recommended. Additionally, it is recommended to explore the claims “Falkenhain” and “Altenberg DL” in order to assess future resources.

The mine technology will be a common load-haul-dump (LHD) room and pillar technology with subsequent backfill using self-hardening material. Technical risks due to historic mine workings and water drainage pathways should be avoided by detailed technical planning. At the present time no significant risks have been identified that would inhibit the development of the property. Public acceptance of the planned mine seems to be sufficient and major environmental restrictions do not appear to exist.

Further process and test work investigations are recommended to reduce technical risks of the Project and to optimize operating parameters. Additional development is required at the start of the next phase (detailed engineering and design) regarding an optimization of the site layout of the chemical plant. The key technical aspects involve engagement with vendors of the rotary kiln and crystallizer and evaporator packages. Further test work should be done to improve the quality of the LiF from 99.5 % to 99.9 % and the particle size from 20 µm to approximately 100 µm. Additionally it is recommended to investigate a more profitable option for the further application of the leached roasted product tailings.

Financial modelling carried out for the FS demonstrates that the Zinnwald Lithium Project is financially viable. The proposed execution schedule, whilst achievable, is considered 'fast track' and is reliant upon rapid decision making, unencumbered design process, collaborative engagement, and no adverse outcomes from the recommended work.

1.16 Forward Work Program

1.16.1 Geology

The Project is ready for execution based on the mineral reserves. Some potential exists to improve it by:

- infill drilling on the western side of the mining license "Zinnwald"
- a new evaluation of the tin and tungsten resources in case of increasing prices

1.16.2 Mining

The following activities have to be addressed in order to start the Project:

- Purchase of real estate in Altenberg for surface mine infrastructure
- Signing of supply contracts with customers for site materials during the construction of the ramp

- Finalization of the permission process with mining authorities and county authorities regarding operation and construction permits
- Bidding process for construction of ramp and ventilation shaft by service companies
- Subsoil investigations at the planned location of the mine portal
- Establishing the project management team at Deutsche Lithium
- Border security post to be defined during the permission process

The following tasks should be addressed in order to conduct an efficient and optimized mining operation:

- Modelling the mine ventilation to optimize energy demand
- Developing standard operating procedures for intermediate storage of leached roasted tailings
- Hiring underground mining engineer
- Application for construction permits for ramp, ventilation shaft and buildings
- Hiring mine operators for training after 6 months past the start of the ramp construction
- Start of bidding process for leasing of mine equipment 12 months after start of the ramp construction

1.16.3 Processing

The following process-related activities are recommended before starting the execution of the Project:

- Purchase of real estate in Freiberg for processing site
- Establishing of project management team at DL
- Signing supply contracts with suppliers for HF, anhydrite / gypsum, limestone, KOH
- Signing of supply contracts with customers / off-takers for SOP and LiF
- Finalization of the permission process with county authorities regarding operation permit (BImSchG) and construction permits
- EPC/EPCM - Bidding process for mechanical and chemical processing plant
- Application of lithium fluoride at Reach-Organisation

The following process related activities are recommended to improve or to optimize the processing technology and operation:

- Additional test work to enhance the application of tailings by sieving to increase the potential of selling these materials in several applications

- Test work to increase the purity of lithium fluoride from 99.5 % to 99.9 %
- Test work to increase the lithium yield of the roasting-leaching step from > 85 % to > 90 %
- Test work to check tunnel kiln application with respect to a better process stability
- Evaluation of grinding of limestone by DL
- Test work to increase the yield of potassium in roasting and leaching

1.16.4 Infrastructure

Infrastructure work is recommended in the following areas:

- Signing of service contract with power & gas supplier for the sites Altenberg and Freiberg and steam supplier in Freiberg
- Signing service contract with railway company "Deutsche Bahn"
- Increase activities to purchase landfill IAA Bielatal in Altenberg
- Signing supply contracts with companies for takeover of tailing sands
- Signing of supply contracts for lignite filter ash for backfilling of the mine

1.16.5 Environment

Environmental work is recommended in the following areas:

- A social engagement plan has to be developed to ensure risks are mitigated as the Project continues through construction and operation
- A site-wide project has to monitor animal activities within the mine site in Altenberg as part of the construction permit of the ramp
- Application for a temporary water discharge permit during the construction of the ramp
- Preparation and negotiation of environmental countervailing measures ("Ausgleichsmaßnahmen") according to the landscape conversation measures concept

2 Introduction

2.1 Background

The Company holds the mining permit according to the Federal Mining Act (BBergG § 8) for the lithium deposit in Zinnwald / Germany. The "Zinnwald Lithium Project" consists of exploration, mining, mineral processing / beneficiation and chemical processing with pyro- and hydrometallurgy.

This Technical Report has been prepared for the Company and summarizes the FS completed in May 2019 and was updated in April 2020 and September 2020. It was prepared according to the rules of the National Instrument 43-101 "Standards of Disclosure for Mineral Projects" developed by the Canadian Securities Administrators effective as per June 30, 2011. The NI 43-101 follows the recommendations of the Canadian Institute of Mining (CIM) Standing Committee on Reserve Definitions.

2.2 Project Scope and Terms of Reference

The project consists of an underground mine and a processing facility 50 km away from the mine in a developed industrial area. The expected mine life is more than 30 years. The nominal annual output for the Project is 5,112 t battery-grade LiF which corresponds to 7,280 t/a LCE or 8,274 t/a $LiOH \cdot H_2O$. In addition, the project has been designed to produce up to 32,000 t/a of potassium sulfate (SOP) for sale to the fertilizer industry. The average mined tonnage over the project live time of 30 years is 573,362 t at a grade of 3,140 ppm Li. However, in order to make the project more viable and to reduce the payback time for the investment, the average mined tonnage of the first 5 years of production is 522,000 t at a grade of 3,400 ppm Li. This is achieved by mining of higher grade ores during the development of the mine.

A feasibility study (FS) was completed by the Company in May 2019 to provide the information on the economic feasibility of the Project. This Technical Report provides an update to the outcomes of the FS. The report is partly based on internal technical reports and maps, letters and memoranda as well as public information as listed in the "References" (see item 27). Several parts were prepared by external contractors and have been implemented directly into the report. To some extent it refers on the PERC-Report "Zinnwald Lithium Project" of the year 2014, which was prepared on behalf of SolarWorld Solicium GmbH (SWS). The preparation of that report was supervised by the Competent Person EuroGeol. Dr. Michael Neumann. Dr. Neumann is the vice-president of the Federation of European Geologists (EFG) and deputy chairman of the European Commission of Resource Classification (ECRC).

The actual report is prepared under the direction of the Qualified Persons EurGeol Dr. Wolf-Dietrich Bock (independent consultant, Denzlingen / Germany), EurGeol Kersten Kühn (G.E.O.S. Ingenieurgesellschaft mbH, Halsbrücke / Germany) and Dr. Richard Gowans President of Micon International Ltd., Toronto / Canada).

2.3 Study Participants

G.E.O.S. was commissioned by the Company in November 2017 to prepare the FS and the NI 43-101 compliant technical report on the project. G.E.O.S. was also engaged to prepare the Mineral Resource estimate, the Mineral Reserve estimate and the mine design including mine capital and operating costs and economic modelling. G.E.O.S. and external experts have been engaged to conduct environmental and social studies. eXnet audit GmbH produced the economic model. An overview of the other key participants and their area of responsibility are provided in *Table 7*.

Table 7: Project key participants and their area of responsibility

Company	Area of Responsibility
Actlabs Activation Laboratories Ltd. (Ancaster / Canada)	Chemical analytics
ALS Global (Rosia Montana / Romania)	Chemical analytics
AMPROMA GmbH (Herrsching am Ammersee / Germany)	Basic engineering of hydrometallurgy and Capex and Opex estimation
Bacanora Lithium (London / England)	Marketing, market study
BBF Baubüro Freiberg GmbH (Freiberg / Germany)	Civil engineering and infrastructure
Beratende Ingenieure Akustik-Gutachten-Planung SHN GmbH (Erlau / Germany)	Report acoustic study
Beratende Ingenieure Bau-Anlagen-Umwelttechnik SHN GmbH (Chemnitz / Germany)	Immission report dust
Bergsicherung Freital GmbH (Freital / Germany)	Underground mining 100 t
BOG Bohr- und Umwelttechnik GmbH (Caaschwitz / Germany)	Infill drilling
CEMTEC Cement & Mining Technology GmbH (Enns / Austria)	Process design, flowsheet and basic engineering of pyrometallurgy incl. Capex and Opex estimation
Dr. Ing. Michael Penzel, Geotechnik Projekt (Markranstädt / Germany)	Expert report settlement

Company	Area of Responsibility
ERCOSPLAN Ingenieurbüro Anlagentechnik GmbH (Erfurt / Germany)	Process design of SOP crystallization, flowsheet
Eurofins Umwelt Ost GmbH Niederlassung Freiberg (Bobritzsch-Hilbersdorf / Germany)	Chemical analytics
eXnet audit GmbH Wirtschaftsprüfungsgesell-schaft (Dresden / Germany)	Financial model, economic analysis
G.E.O.S. Ingenieurgesellschaft mbH (Hals-brücke / Germany)	Exploration, geological modelling, mineral resource and reserve estimation
	Mine design detailed engineering, incl. Capex and Opex estimation and economic modelling
	Hydrogeological and environmental studies
	Facultative framework operational plan
	Laboratory test work pyrometallurgy
	Laboratory test work hydrometallurgy
GEOPS Bolkan Drilling Services Ltd. (Plovdiv / Bulgaria)	Infill drilling
Geotechnisches Sachverständigenbüro Dr. Ing. habil. Bernd Müller (Schkeuditz / Germany)	Expert report blasting
Hans Lingl Anlagenbau und Verfahrenstechnik GmbH & Co. KG (Krumbach / Germany)	Laboratory test work on pyrometallurgy (tunnel kiln)
IBU-tec advanced materials AG (Weimar / Germany)	Test work on pyrometallurgy and preliminary process design
IBZ Salzchemie GmbH & Co. KG (Freiberg / Germany)	LiF preparation, laboratory test work
iKD Ingenieur-Consult GmbH (Dresden / Ger-many)	Report water framework directive
KÖPPERN Aufbereitungstechnik GmbH & Co. KG (Freiberg / Germany)	Basic engineering of mineral processing and Capex and Opex estimation
K-UTEC AG Salt Technologies (Sondershau-sen / Germany)	Test work on hydrometallurgy and process design, flowsheet
Schulz Umweltplanung (Pirna / Germany)	Environmental investigation
SignumBox (Santiago / Chile)	Marketing, market study
Uhlig & Wehling Beratende Ingenieure GbR (Mittweida / Germany)	Expert report traffic connection
UVR-FIA GmbH (Freiberg / Germany)	Test work on mineral processing and process design, flowsheet
Wolfener Analytik GmbH (Bitterfeld-Wolfen / Germany)	Chemical analytics
Zion Market Research (India / USA)	Marketing, market study

Details about qualifications and experience of the expert team of the Project the Qualified Persons have relied on are reported in *chapter 3.*

2.4 Site Visits

Site visits and inspections were undertaken by the responsible QP's on a regular basis and according to the progress of the FS. Dr. Bock has inspected the property twice underground and on surface. Mr. Kühn has organized and supervised underground sampling and surface drilling for the project and knows therefore the property very well. Mr. Gowans has inspected the site once underground and paid visits to the companies performing the processing test work. In addition to the site visits, the QP's were regularly updated via conference calls and emails.

For the independence statement and details with respect to the Qualified Persons see *attachment 1*.

2.5 Frequently used Abbreviations, Acronyms and Units of Measure

Lists of terminology are presented in *attachment 2* and *3* of this report. All reported investigations, measurements and calculations are based on the metric system.

All investigations and conclusions of this report are concentrated on and limited within the borderlines of the exploration fields "Zinnwald" and "Zinnwald-North" of the SWS Zinnwald concession and the mining license field "Zinnwald" of the DL.

3 Reliance on Other Experts

The Qualified Persons to some extent rely on the PERC-Report “Zinnwald Lithium Project” of the year 2014 [92], which was prepared on behalf of SolarWorld Solicium GmbH. The preparation of that report was supervised by the Competent Person Dr. Michael Neumann. Dr. Neumann is graduated geologist and European Geologist. At present, he is the vice-president of the European Federation of Geologists and deputy chairman of the European Commission of Resource Classification. Dr. Neumann was until 2018 operating manager and chief geologist of Sachtleben Bergbau Verwaltungs-GmbH in Lennestadt / Germany. The sections of the items 9, 10, 11, and 12 of the actual report, which deal with the historic drilling campaigns and the exploration campaign of the years 2012 - 2014 rely on the respective chapters of the PERC report.

Project leader of the 2017 exploration campaign was Dipl. Geol. Dr. Thomas Dittrich. graduated from Technical University Bergakademie Freiberg in geology / palaeontology in 2009. Between 2009 and 2017, he was a Scientific Research Assistant at Technical University of Freiberg, where he worked in the fields of assessment of rare metal deposits (e.g, gallium) and development of exploration strategies for pollucite bearing rare metal pegmatites (caesium, lithium, tantalum, niobium, tin). He has more than 10 years of experience in science and industry and also spent several months doing fieldwork in Brazil, Australia, and Zimbabwe. In 2017 he joined Deutsche Lithium GmbH where he is in charge of mineral exploration and mining.. Data base management and maintenance, modelling, mineral resource estimation and mineral reserve estimation was performed by Mr. Matthias Helbig, Senior Expert of the G.E.O.S. Ingenieurgesellschaft mbH in Halsbrücke / Germany. Mr. Helbig is Dipl. Geoecologist (Graduate of Technical University Bergakademie Freiberg / Germany). He has 10 years of experience in geologic modelling and 6 years of experience in resource estimation. The work and results of Mr. Helbig are essentially contained in items 12, 14 and 15.

Prof. Dr. Wolfgang Schilka is graduated geologist with Diploma and PhD in Geology of Bergakademie Freiberg. In more than 40 professional years he worked as mining geologist, mining director and managing director in underground tin and fluorspar mining as well as underground industrial marble mining. After retirement he continued to work as self-employed consultant for mining and mining geology. He is based near the Zinnwald property and gave important project inputs for the sections geology and mine planning.

Mr. André Baumann and Mr. Thomas Graner are responsible for the section “Mine Planning” in the project. Mr. Baumann is Dipl.-Ing. of Mining with a Diploma of Bergakademie Freiberg and has more than 28 years professional experience in the field of mining. He is the Head of the Division Mining in the G.E.O.S. Ingenieurgesellschaft mbH, Halsbrücke / Germany and an authorized signatory of this company. Mr. Graner is graduated mining engineer with a Diploma of the TU Bergakademie Freiberg. He works as project engineer with more than 4 years professional experience in the mining division of G.E.O.S. Ingenieurgesellschaft mbH, Halsbrücke.

Prof. Dr. Egon Fahning holds a doctorate in Mining Engineering and is a graduate of the TU Bergakademie Freiberg. In almost 50 years he has worked as a miner, research engineer and head of specialist departments of the mining industry, owner and managing director of engineering offices in the field of mining and related fields. From 2009 to 2010 he was the Head of the Department of Underground Mining Methods at the TU Bergakademie Freiberg. He has been in retirement for 6 years, but continues to lecture at the university, supervises students and works as an independent consultant for the mining industry. He is a member of the worldwide association of mining professors. Prof. Dr. Fahning acted as consultant for the mine planning.

Mr. Holger Kunz is responsible consultant for the finance model of the project. He is a graduate of TU Dresden (Diplomkaufmann, diploma in business administration, 1997) and a publicly appointed auditor (2004). Over a period of 12 years he was employed as a consultant (senior manager) at a Big 4 company (EY). Since 2012, Mr. Kunz has been working as an independent management consultant (eXnet audit gmbh). His work focuses - for example - on advising start-up companies on the preparation of business plans and the development of financing models.

Development and design of ore processing and beneficiation technologies of the lithium ores were covered by Dipl.-Ing. Jan Henker, Dipl.-Ing. Dr. Torsten Bachmann and Dipl.-Ing. Dr. Matthias Reinecke.

Mr. Henker is Dipl.-Ing. of Process Engineering (Graduate of Technical University Bergakademie Freiberg / Germany). He has over 15 years industry experience in the sectors mechanical processing, photovoltaics and inorganic chemistry and over five years of experience in managing plant engineering and construction. He is project leader of the working package “Beneficiation” in the “Lithium Zinnwald Project” from 2012 to 2015 and since 2017.

Dr. Torsten Bachmann is Dipl.-Ing. of Environmental Technology (Graduate of University Mittweida / Germany) and has a PhD in Chemistry (Technical University of Dresden / Germany). Dr. Bachmann has over 20 years of experience in science and industry in the area of photovoltaics and inorganic chemistry and long-term experience in managing of national research projects as well as department manager in technology companies. He was team leader in the “Lithium

Zinnwald Project” from 2011 to 2015 and is the project leader of the working package “Chemical Processing” since 2017.

Dr. Matthias Reinecke is Dipl.-Ing. for Materials Science (Graduate of University Mittweida / Germany) and holds a PhD in Chemistry (Technical University Freiberg / Germany). Dr. Reinecke has over 20 years of experience in industry in the area of process development in silicon crystallization and chemistry and of application of Li-ion battery systems for stationary storage. He is project leader of the working package “Hydrometallurgical Processing”.

Dr.-Ing. Henning Morgenroth is Dipl.-Ing. of Mineral Processing and has a PhD in Engineering (Technical University Bergakademie Freiberg / Germany). He has 35 years professional experience in the field of processing of raw materials. Dr. Morgenroth is managing director of UVR-FIA GmbH Freiberg / Germany. The UVR-FIA GmbH is a well-established comprehensive provider of research and development services in the field of processing raw materials.

Director of the Zinnwald Lithium Project is Prof. Dr. Armin Müller. He is graduated Chemist (Diploma) and has a PhD in Chemistry (Technical University Bergakademie Freiberg / Germany). He is honorary professor for industrial inorganic technologies at the Technical University Bergakademie Freiberg. Prof. Müller has more than 28 years of experience in the chemical industry in positions of managing director as well as board member of several enterprises of the photovoltaics and chemistry branch. He is managing director of Deutsche Lithium GmbH.

4 Property Description and Location

4.1 Mine Site

4.1.1 Location

The Zinnwald property is located in the eastern range of the Erzgebirge Mountains in Germany, approximately 35 km south of the capital of the Free State of Saxony, Dresden, approximately 220 km south of Berlin and 50 km southeast of Freiberg, the site for the mechanical and metallurgical processing plant. The center of the property is situated at about 50°44’11’’N and 13°45’55’’E. The ore deposit stretches along the German-Czech border and continues into the territory of the Czech Republic.

The licence essentially covers parts of the residential area of Zinnwald village, which is a subdistrict of the town of Altenberg. Border crossing at Zinnwald is possible by car and truck. The motorway A 17 (E 55), which connects Dresden with Prague in the Czech Republic (CZ) bypasses the property 17 km to the east. The airports of Dresden, Berlin and Prague are 70, 230 and 100 km away, respectively. The Altenberg railway station is located on the north side of the city Altenberg. The Heidenau-Altenberg railway (38 km) connects in Heidenau (near Dresden) with the Elbe valley railway. This railway represents line 22 of the Trans-European Transport Network (TEN-T). The nearest seaport is located in Szczecin (PL) and is 410 km north of Altenberg.

Figure 2 shows the properties in the center of Europe and the position in Germany.

Figure 2: General location of the Zinnwald and Freiberg properties in Europe

The area of the Zinnwald deposit belongs to the town of Altenberg and has the following administrative categorisation:

Federal country:	Free State of Saxony
Directory region:	Dresden
District:	Sächsische Schweiz – Osterzgebirge
Town:	Altenberg
Sub-district:	Zinnwald
Mining authority:	Sächsisches Oberbergamt, Freiberg (SächsOBA)

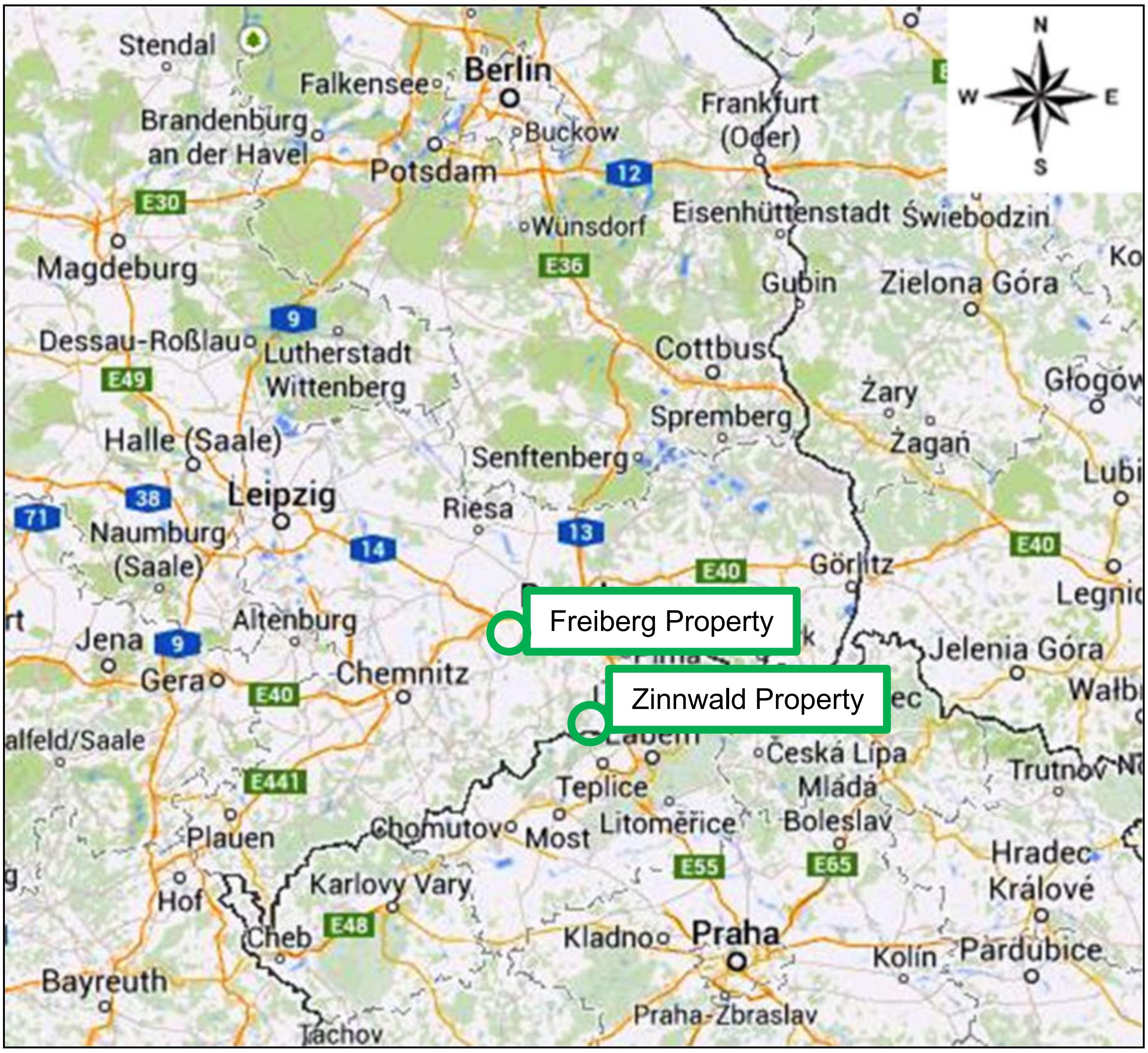


Figure 3: Position of the Zinnwald property on the German/Czech border and the Freiberg property 50 km towards northwest

4.1.2 Legal Aspects and Tenure

In 2011 and 2012 the two exploration permits for the license areas ”Zinnwald“ and ”Zinnwald-North“ were granted by the Saxon Mining Authority (SOBA) to SolarWorld Solicium GmbH (“SWS“) based in Freiberg / Germany, respectively (*Table 8*). These permits cover the commodities lithium, rubidium, caesium, tin, tungsten, molybdenum, scandium, yttrium, lanthanum and lanthanides, bismuth, indium, germanium, gallium, zinc, silver and gold. The permits were valid up to the 31st of December 2015 and were extended upon request in November 2015. New expiry date was the 31st of December 2017. Exploration work consisted of underground sampling in the abandoned mine and of a surface diamond drilling programme. The results were integrated in a geological model of the ore deposit with respect to lithium mineralization and a mineral resource according to the PERC standard was estimated.

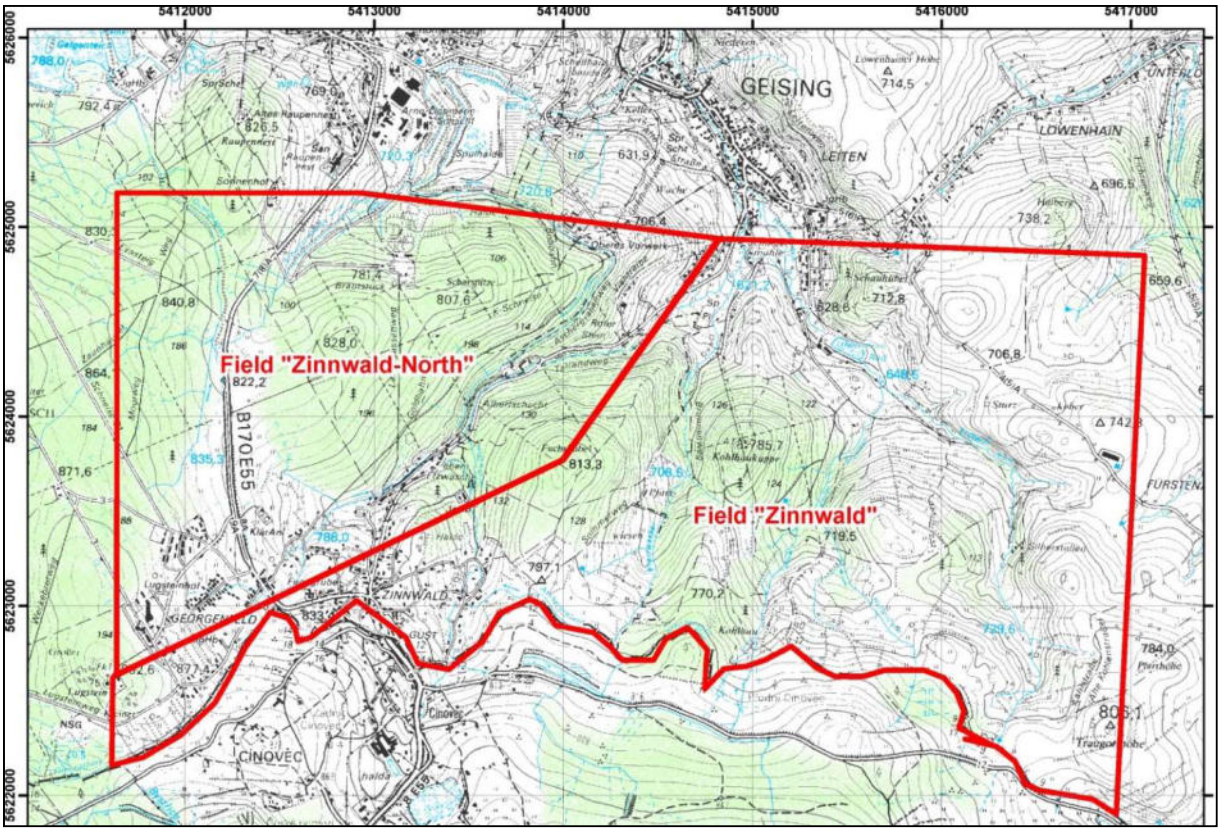


Figure 4: Location plan of the exploration licenses “Zinnwald-North” and “Zinnwald”

Following the establishment of the joint venture “Deutsche Lithium GmbH” by SWS and Bacanora Minerals Ltd. in February 2017, a mining permit was applied, which was approved for the field “Zinnwald“ as of the 12th of October 2017. The mining permit covers 2,564,800 m² and is valid up to the 31st of December 2047 (*Figure 5*, [35]).

Table 8: Coordinates of the edge points of the Zinnwald exploration licenses

Edge points of the exploration licenses		East (Gauss-Krueger)	North (Gauss-Krueger)
Field ”Zinnwald“	Field ”Zinnwald-North“		
1	5	54 11 639.637	56 22 634.635
2	4	54 14 000.005	56 23 770.004
3	3	54 14 827.197	56 24 938.593
4	---	54 17 080.000	56 24 850.000
5	---	54 16 930.000	56 21 900.000
6	---	54 11 620.000	56 22 160.000
---	1	54 11 639.956	56 25 180.000
---	2	54 12 930.000	56 25 180.000

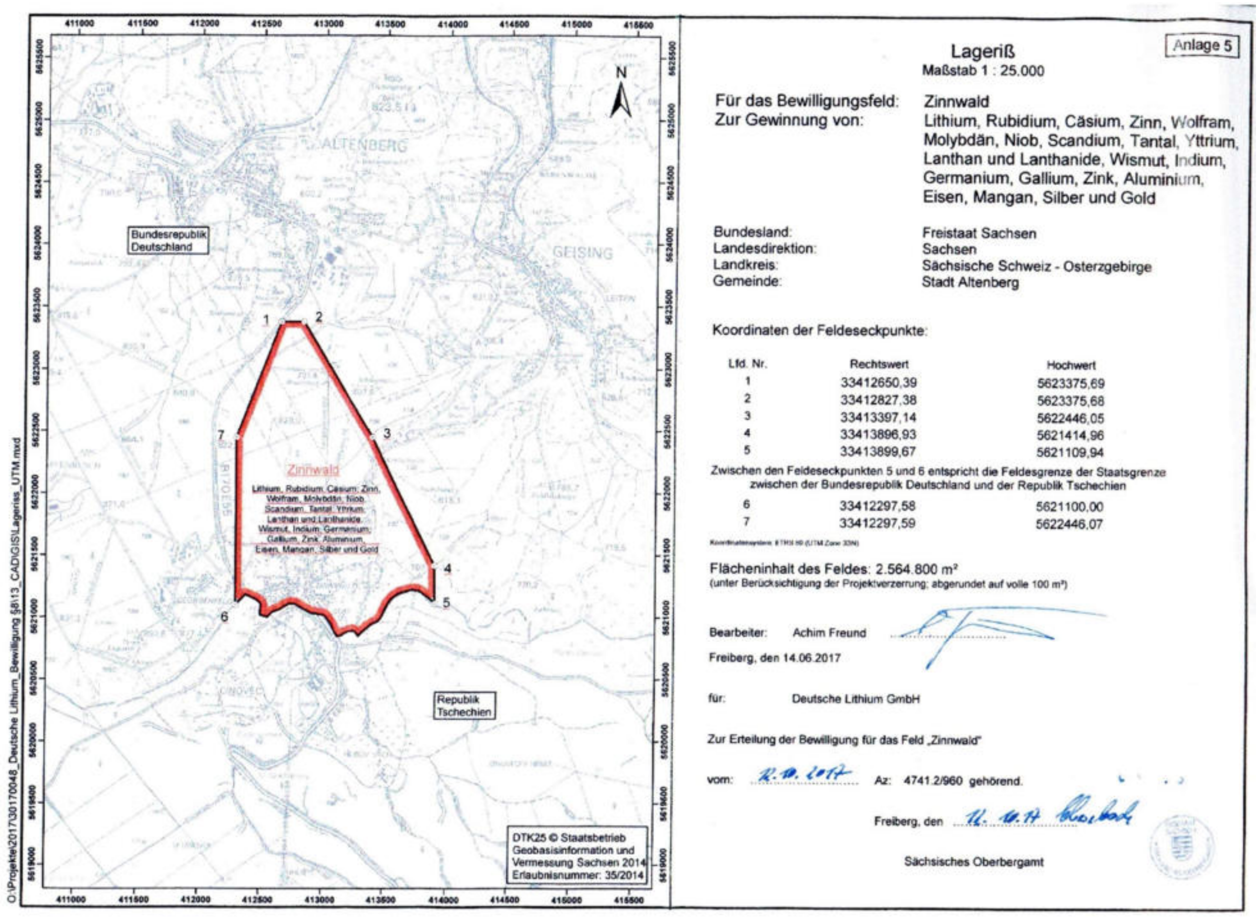


Figure 5: Location plan of “Zinnwald“ Mining License (coordinates ETRS 89_UTM33)

Figure 6: Location plan of the exploration and mining licenses of DL

The coordinates of the surrounding exploration areas (Figure 6), granted to DL, are described in the following table:

Table 9: Edge point coordinates of the surrounding DL exploration licenses

Field "Falkenhain"		
Edge point No.	**East ETRS89_UTM33**	**North ETRS89_UTM33**
1	33411074.66	5630113.43
2	33412187.87	5629789.73
3	33 412473.89	5629380.20
4	33413347.18	5629252,92
5	33413648.06	5628518.44
6	33412461.66	5628128.25
7	33411584.41	5628163.11
8	44411502.60	5628557.24
9	44411161.03	5629613.02
10	33411188.99	5629782.83
Field "Altenberg DL"		
1	410000.00	5627000.00
2	411000.00	5626000.00
3	413472.45	5626000.00
4	415100.00	5624620.00
5	416000.00	5623000.00
6	417167.51	5619809.01
7	413899.67	5621109.94
8	413896.93	5621414.96
9	413397.14	5622446.05
10	412827.38	5623375.68
11	412650.39	5623375.69
12	412297.59	5622446.07
13	412297.58	5621100.00
14	408826.80	5620086.28
15	408000.00	5621000.00
16	407000.00	5623000.00
17	407000.00	5625000.00
18	412332.60	5624759.13
19	412595.50	5624886.07
20	412773.42	5624889.07
21	413003.33	5624551.20
22	413045.31	5624375.27

Field "Falkenhain"		
Edge point No.	East ETRS89_UTM33	North ETRS89_UTM33
23	412912.36	5624221.34
24	412806.40	5624243.33
25	412618.48	5624403.27
26	412640.47	5624539.21
27	412369.59	5624620.18

The edge points no. 1 – 7 of "Altenberg DL" represent the external field border. Its internal border points no. 18 – 27 are identical to the edge points of the former mining field "Zwitterstock and Zinnkluft Altenberg", held by the state-owned company "Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH" (LMBV). Between point 6 and 7 as well as between point 13 and 14 the field border is in accordance with the state border to the Czech Republic.

The two additional exploration licenses are located in immediate vicinity to the "Zinnwald" mining license (*Figure 6*). The currently ongoing exploration work aims at identifying additional lithium resources which will extend the lifetime of the project and its economic viability

Table 10: Summary table of granted licenses

Asset	Holder	Interest	(%) Status	License expiry date	License area m²	Comments
Zinnwald Germany	SolarWorld Solicium GmbH	100 %	Exploration	31.12.2017	7,794,278	Sampling and drilling completed
Zinnwald North Germany	SolarWorld Solicium GmbH	100 %	Exploration	31.12.2017	5,121,664	Sampling and drilling completed
Zinnwald Germany	Deutsche Lithium GmbH	100 %	Development	31.12.2047	2,564,800	
Falkenhain Germany	Deutsche Lithium GmbH	100 %	Exploration	31.12.2022	2,957,000	Exploration in progress
Altenberg DL Germany	Deutsche Lithium GmbH	100 %	Exploration	15.02.2024	42,252,700	Exploration in planning

4.1.3 Environmental Liabilities

Nature conservation areas exist in the surroundings of the deposit. This relates in particular to the "Oberes Osterzgebirge Country Conservation Area" (LSG) which extends from the state border to a line across the villages Rechenberg-Bienenmühle-Schmiedeberg-Fürstenwalde. Furthermore, the eastern portions of the exploration license "Zinnwald" are declared as a "nature protection area".

The two important drinking water protection areas T-5370020 at Altenberg and T-5370019 at Klingenberg-Lehnmühle are not affected by the Project.

On 17th of August 2006 by a decree of the Regierungspräsidium Dresden Authority (Regional Council), the area of Geising-Altenberg was legally confirmed as flood formation area. This means that all new actions in the area are requested by law to include necessary measures for reducing the surficial drainage even in the case of heavy rain. Both exploration fields "Zinnwald" and "Zinnwald North" and the mining license areas "Zinnwald" are located completely within this area.

Official requirements to the exploration permits (see [1], [16]) included the renaturation of all sites used for the exploration works (i.e. for drilling). By end of May 2018 contouring and seeding was completed on all drilling sites used for the infill drillings by DL in 2017.

4.1.4 Minerals Fee (royalty)

Royalties are regulated by national law (§§ 31, 32 BBergG) and by edict transposed into the federal law of the State of Saxony. Currently the Federal State of Saxony does not impose a royalty on lithium.

4.1.5 Taxes

An overall taxation of approx. 30 % on the profit is calculated in the project economic analysis and considered in IRR and NPV (will be done separately in *item 21 and item 22*). All applicable taxes were taken into account by the independent auditor in the FM.

4.2 Mechanical and Metallurgical Processing Site

The preferred property for the mechanical and metallurgical processing plant is located in the southern outskirts of Freiberg within a well-developed industrial area. The property is connected to existing roads and the railway network. The distance between Freiberg and the Zinnwald lithium deposit is 49 km. The property was formerly used as chemical plant site for production of synthetic diesel. This chemical plant is still on the property and parts of it must be demolished prior to a further use by DL.

Freiberg, a district town about 42 km southwest of Dresden and approx. 235 km south of Berlin, is located on the northern slope of the Erzgebirge at a maximum elevation of 491 m a.s.l. (*Figure 3*). It lies within an old landscape embossed by grubbing and mining and is surrounded by forests, fields and meadows. The climate is mild and generally warm and temperate. The average temperature is 7.3 °C and the average annual precipitation is about 661 mm.

Freiberg is a university and old mining town. Until 1969, the city was shaped and dominated by mining and metallurgy for some 800 years. In the last decades, a structural change to a high-tech location comprising semi-conductor production and solar technology took place. At present Freiberg is the host for about 42.000 inhabitants.

Freiberg can be reached via the A 4 motorway, exit Siebenlehn, and the federal highway 101, from Dresden or Chemnitz via the federal highway 173. From Prague, the connection is via the A 17 motorway, exit Dresden-Gorbitz. Freiberg represents the crossing and starting point of several federal highway and state roads towards the eastern (Altenberg) and central-western (Annaberg-Bucholz) Erzgebirge region. Freiberg can also be reached by train along the Sachsen-Franken-Magistrale, which connects Freiberg with the major north-south connections between Hamburg-Berlin-Prague and Hamburg-Leipzig-Munich. This railway line is used by both public and freight transport. The nearest international airports are Dresden-Klotzsche (45 km) and Leipzig / Halle (110 km).

The Technical University Bergakademie Freiberg (TU BAF) is the oldest existing educational institution for mining science in the world. It was founded in 1765 as a training center for miners. As a resource university, it focuses on exploring, extracting, processing, refining and recycling of raw materials. The Helmholtz Institute Freiberg (HIF) for resource technology is also located in Freiberg. The institute, founded in 2011, aims to develop new technologies to secure the supply of mineral- and metal-containing raw materials, to use raw materials more efficiently and to recycle in an environmentally friendly manner. In addition, the HIF strives to network exploration companies, mining companies and research institutions more closely at national and international levels. Furthermore, the Technical College of Technology “BSZ Julius Weisbach” offers training courses for state-certified geological technicians, drilling technicians and miners.

5 Accessibility, Climate, Local Resources, Infrastructure and Physiography

5.1 Accessibility

The deposit is located within an infrastructurally well-developed region:

- Motorway No. A 17 (E 55) Dresden – Prague, with the nearest motorway access at Bad Gottleuba about 17 km to the east
- State road No. B 170 leads from Dresden via Zinnwald / Cínovec to Teplice and crosses the license area at its south west end
- The national road No. S 174 leads from Pirna and the Gottleuba Valley via Breitenau, Liebenau, Geising and the Geisinggrund Valley to Zinnwald. This national road is the main connection between the state road B 172 at Pirna in the north (distance about 25 km) and the B 170 at Altenberg / Zinnwald in the west
- Railway stations exist in distances of about 4 km at Geising and of 6 km at Altenberg (both situated on the Altenberg – Heidenau railway line)
- The immediate area of the deposit is accessible through local normal, agricultural or forestry roads
- Zinnwald / Cínovec is a border crossing point for international transit of vehicles and pedestrians. Next possible border crossing at the motorway A 17 (E 55) Dresden – Prague is 17 km to the east at Bahratal / Petrovice
- The closest international airports are Dresden-Klotzsche / Germany (50 km to the east) and Prague-Ružyne International Airport / Czech Republic (100 km to the south)

5.2 Climate

The climate at Zinnwald is cool and humid which is typical for the upper levels of a low mountain range like the Erzgebirge. A third of the average precipitation is due to snow, with the first snowfall normally occurring in October that usually does not change to rain until May. Therefore, snow cover exists for approximately 130 days in the year. Furthermore, the climate is characterized by numerous foggy days together with frost periods resulting in pronounced hoarfrost formation.

Meteorological data since 1971 show extreme values as follows:

- Highest temperature	31.0 °C (2003-01-13)
- Lowest temperature	-25.4 °C (1987-12-01)
- Longest sunshine per annum	1,895.8 hours (2003)
- Greatest thickness of snow	163 cm (2005-03-14)
- Highest precipitation	312 mm/24 h (2002-08-13)
- Strongest wind peak	191 km/h (2005-07-29)

<u>Precipitation and Temperatures</u>

The average yearly precipitation in Zinnwald is about 1,000 mm. The annual precipitation does not show long-term tendencies. Over many years precipitation maxima occur in summer and around the turn of the year. However, repeated episodes of heavy precipitation caused flooding with essential damages in the past. Since the so called “flood of the century” in August 2002 the region between Zinnwald / Cínovec, Geising and Altenberg is regarded as a flood formation area. For the 13th of August 2002, the weather station Zinnwald-Georgenfeld of the German Meteorological Institute (Deutscher Wetterdienst) recorded 312 mm of rain per square meters, which represents the highest precipitation rate within 24 hours that was ever measured in Germany.

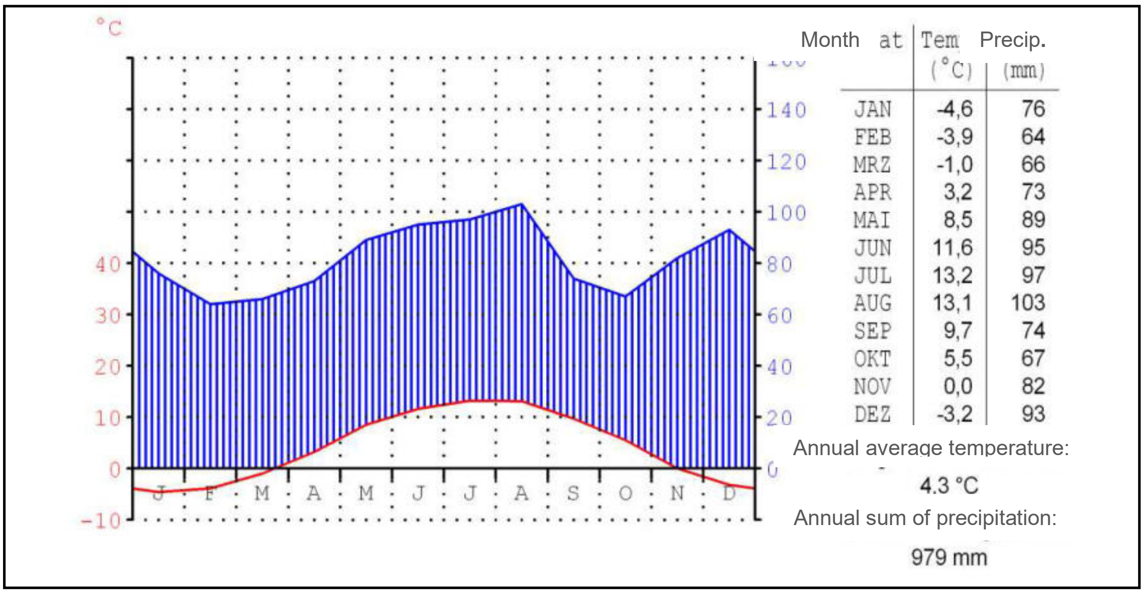


Figure 7: Average climate diagramme 1961 - 1990 for Geisingberg / Zinnwald-Georgenfeld (Deutscher Wetterdienst [319])

Table 11: Monthly average precipitation and air temperatures of the years 1971 - 2006 at the Zinnwald-Georgenfeld weather station (Deutscher Wetterdienst [319])

Station	Altitude	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Zinnwald-Georgenfeld	877 m a.s.l.	Precipitation in mm	75	59	70	64	83	93	107	115	75	68	85	85	980
		T in °C	-3.9	-3.4	-0.4	3.7	9.1	11.7	13.9	13.9	9.8	5.3	0.0	-2.7	4.8

Wind

Westerly winds predominate in Zinnwald. In addition, south breezes, which rise from the Bohemian Basin in the South is characteristic. Wind velocities are much higher during winter than in summer and are caused due to the seasonal temperature differences.

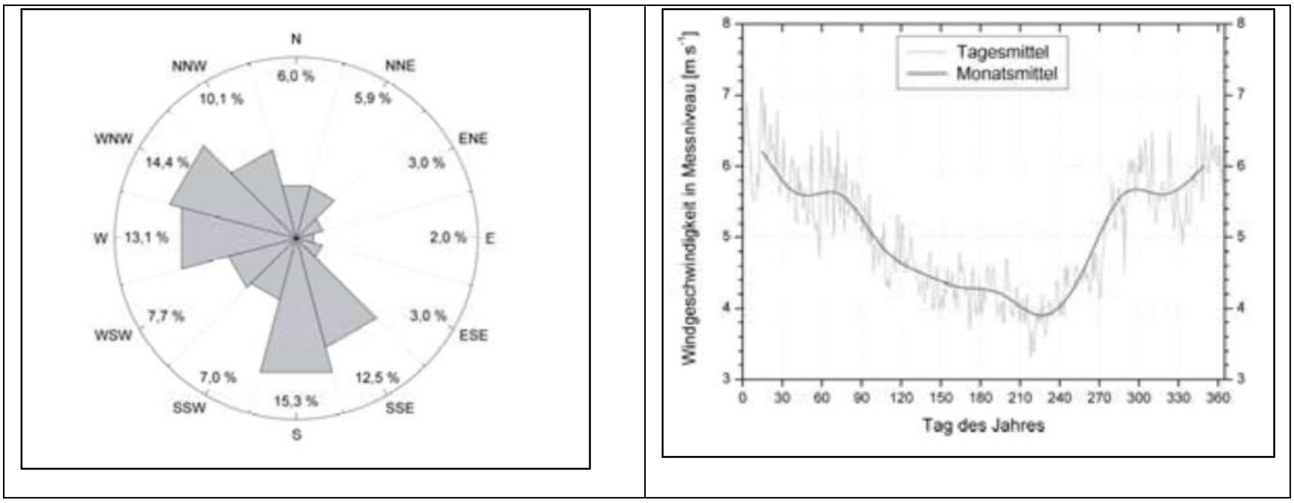


Figure 8: Wind directions of the years 1992 - 2005 and wind velocities of 1971-2005 at the Zinnwald-Georgenfeld station (Deutscher Wetterdienst [319])

5.3 Local Resources

With an average of 65 inhabitants per km^2 the region is sparsely populated. Small villages and settlements are typical. Former mining towns like Altenberg or Schmiedeberg have about 2,000 to 3,000 inhabitants. As of 31.12.2018 the city of Altenberg, including all sub-districts like Zinnwald, has a population of 7,920 inhabitants. Zinnwald counts 423 inhabitants for the same reference date [382].

Several industrial branches exist in the region. Following the the closure of the Altenberg mines in 1991 the region has experienced a radical structural change. As a consequence, a considerable portion of the qualified labour force had left the region. However, essential efforts of the local administration and due to federal, governmental and European funding, the city of Altenberg is now one of the most important recreational centres of Saxony. The local tourism counts up to 10,000 guests per day during the summer season, winter holidays, in Christmas time, or at weekends. Main objects of the tourism are recreation (public bath and sanatorium “Raupennest” in Altenberg) and sports (biathlon “Sparkassenarena Zinnwald”, luge, skeleton and bobsleigh at the “Rennschlitten- und Bobbahn Altenberg”). Every year important national and international sport events take place in the region (luge, bobsleigh, skeleton, cross country skiing, biathlon, mountain biking). Additional main tourist attractions are the mining museums and visitor mines in Altenberg and Zinnwald as well as the German watch museum in Glashütte. It is the long mining tradition of the region that causes a wide acceptance of the population for new mining plans.

In addition to tourism, the region is home to numerous small- and medium-sized enterprises that are based within in the mechanical, electrotechnical and automotive industry sectors. The town Glashütte 25 km from Zinnwald is world-famous for its luxury watch manufacturing.

The education level of the work force in the region based on the German school and work education system is high. Local resources necessary for the exploration, development and operation of the property are available from the industries of the Erzgebirge region and adjacent areas of Saxony.

5.4 Infrastructure

The traffic infrastructure is well established. Side streets and forest roads provide a good access to all areas of the mining licence. For further infrastructure details (motorways, railways, airports) see *Item 5.1*.

The overall area is well developed with respect to regional electricity, water and gas networks. A steadily supply with electric power, gas and drinking water in best qualities is guaranteed in the region. The collection and treatment of the waste water from Zinnwald and Georgenfeld is performed by the sewage plants of “Oberes Müglitztal Waste Water Association”.

Area-wide broadband internet access is in preparation. In addition, the area is almost completely covered by mobile telephone networks of German and close to the border even of Czech operators.

5.5 Physiography

The deposit is located in the upper levels of the Eastern Erzgebirge at elevations of 780-880 m. The highest peak is represented by the Kahleberg (3 km north of Zinnwald) with 905 m a.s.l.. The topography is typical for a low mountain range with steep valleys and smooth summits, the latter gently dipping towards north. It comprises wide grasslands surrounded by forests and is structured by the local river network with pronounced V-shaped valleys belonging to the Elbe River Basin.

At present, the common land use in the area is agriculture and forestry. Most surface rights are privately owned. The surficial water bodies are reserved for public water supply, farming or recreation.

6 History

6.1 Historical Mining

Mining in the Erzgebirge has a long tradition and tracks back to the Bronze Age (TOLKSDORF et al. 2019 [439]). The region hosts to numerous ore deposits that were important raw material sources for Fe, Sn, W and later also Ag, Zn, Cu, Pb, Co and U in Saxony and the entire Central German region for several centuries (BAUMANN et al. 2000 [316]).

The exploitation of tin and later of tungsten in the Zinnwald area started with panning of cassiterite from placers in the valleys south of the present German-Czech border. The first mining activities on the primary deposit are recorded from the second half of the 15th Century. A short time later the mining activities expanded to the German parts of the deposit.

The exact date and circumstances of the discovery of the cross-border deposit Zinnwald / Cínovec are not known. The main mining period lasted from 1550 to 1600, during which the mining towns of Zinnwald and Cínovec developed. In the early years only tin ores with cassiterite were mined. Mid of the 19th century the mining of tungsten ores became more important.
According to EISENTRAUT, 1944 [225] the production figures are:

1880 - 1890: 4.5 t of tin ore concentrate, 390 t of wolframite concentrate
1891 - 1899: 9 t of tin ore concentrate, 370 t of wolframite concentrate
1900 - 1924: 1,400 t of tin ore concentrate, 1,200 t of wolframite concentrate

Between 1890 until the end of the Second World War lithium-mica (zinnwaldite) was produced as a by-product. Production is reported as follows (EISENTRAUT, 1944 [225]):

1900 - 1924: 600 t of mica concentrate
1925 - 1933: 4,200 t of mica concentrate

The last mining efforts commenced in 1934, when the state of Saxony and the mining company Metallgesellschaft signed a contract on the takeover of the mining rights and mine facilities of Sachsen Aktiengesellschaft. Metallgesellschaft held some optional rights for production of lithium mica from the old tailings and the pre-emption right for half of the mica concentrate production by the new mine operator. The main production of lithium mica was achieved by reprocessing of the tin and tungsten tailings.

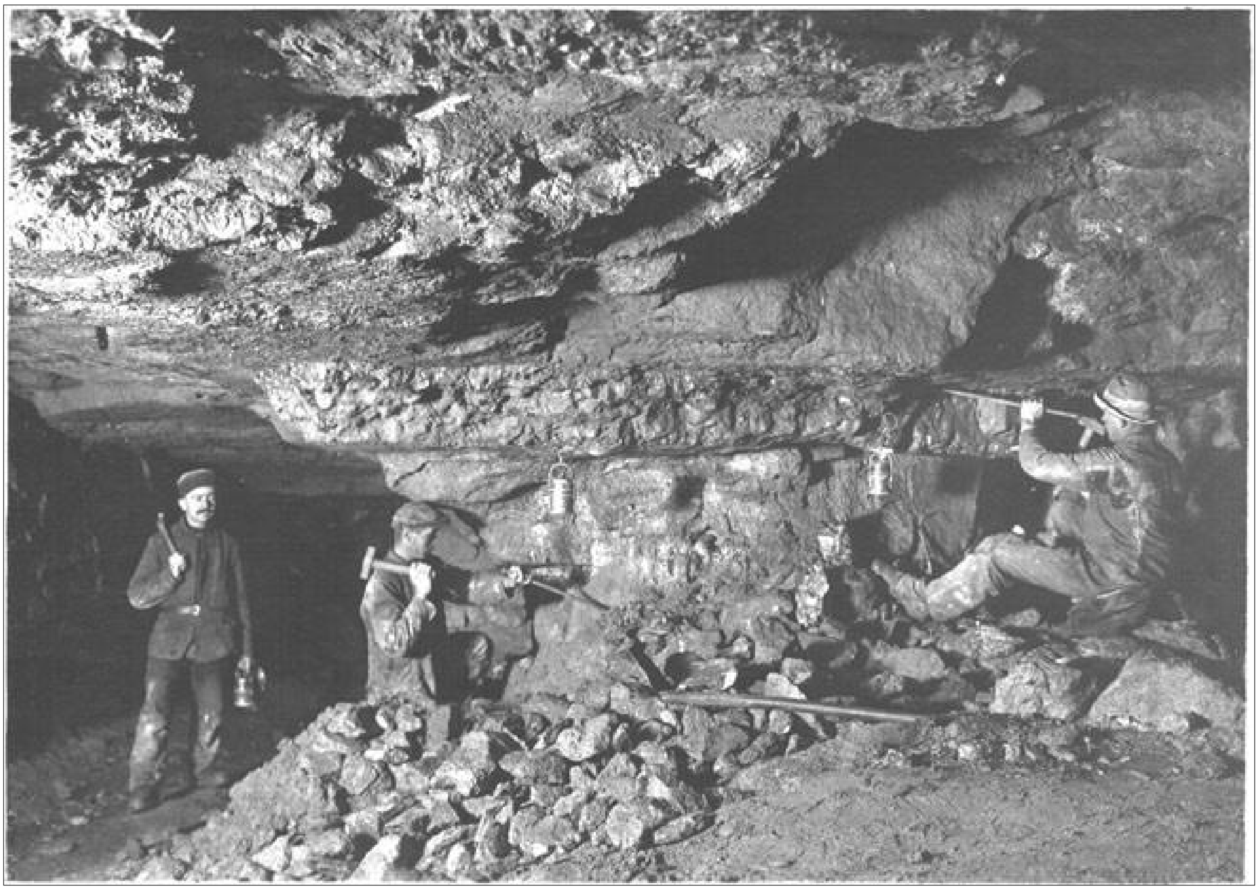


Figure 9: Mining of the “Flöz 9” Sn-W ore horizon (Source: archive Stahlwerk Becker AG, 1921)

From 1936 to 1937 a joint venture of Metallgesellschaft and the mining company Zwitterstock Aktiengesellschaft Altenberg build the Schwarzwasser ore processing plant. In addition, the shaft complex of the Albert-Schacht and the cable railway connection to the central ore processing plant were developed. Thus, a regular mine production in Zinnwald could restart in 1937. Between January 1943 and April 1945 approximately 7,700 t of mica greisen were mined for lithium. Due to decreasing reserves the production shifted more and more to the Czech part of the deposit. Therefore, the Militärschacht was developed as central shaft and a modern hydrometallurgical processing plant was put into operation at Cínovec in 1940/41.

In the German part of the deposit the mining activities ceased after the Second World War owing to the depletion of the tin and tungsten ore resources. Until 1967 the mine was owned by the Zinnerz Altenberg mining company, but only was kept open for maintenance measures.
The operations on the Czech side were taken over by the state-owned mining company Rude Doly Přibram, which continued the production of tin and tungsten ore by its subsidiary Rudne Doly Cínovec in the block Cínovec 1 (Žily) until 1978 and in the block Cínovec 2 (Jih) until 1990. The last ore was hauled in Cínovec on November 22, 1990. In 1991 the mining activities ceased for economic reasons.

6.2 Recent Safety and Remediation Measures

A substantial part of the mining activities took place in depths near to the surface and therefore affected the rock stability. Collapses of underground mine workings and associated rockfall resulted in the subsidence of the surface and the development of sinkholes at many places, in particular in the settlement areas directly above the deposit. Backfill measures were conducted already since 1920 using tailings disposed on the surface. For this purpose, sealed shafts were reopened and used for hydraulic transportation of the backfilling masses. The tailings were then backfilled by hand in the endangered open stopes.

In 1968 the company Bergsicherung Dresden started a detailed technical investigation to prepare an extensive remediation programme. Based on this study and on a stability risk assessment by VEB Steinkohle Zwickau extensive remediation, stability and backfill measures began in 1969. Within the old mining workings, the adits to the discarded mining blocks were encapsulated using dams and were backfilled with a mixture, which consisted of approximately 175 g of tailing sand on 1 l of water. In addition, numerous old shafts were re-opened and additional new shafts were built in order to gain access to further artisanal mines. This old mining workings were backfilled the same way. All shafts were then sealed near surface by a concrete plug. Hence, the stability conditions in the near surface portions of the old mining area on the German territory was considerably improved and further collapses and rockfalls could thus be prevented.

Between 1990 and 1992 technical rehabilitation and safety measures were carried out on the level of the Tiefen-Bünau-Stollen gallery (German side of the deposit) to secure the installation of an underground visitor mine and museum. This is operated today by the Tourismus- und Veranstaltungs-GmbH, owned by the municipality of Altenberg.

Between 2007 and 2011 comprehensive underground operations took place on the German side of the Zinnwald / Cínovec deposit. The specialized company Bergsicherung Freital was contracted by the Saxon Mine Authority for safekeeping of selected mine stopes and drifts and for long-term stable restoration of the water drainage in the old mine. The latter work focussed on the system of the Tiefer-Bünau-Stollen gallery, which additionally drains the Czech part of the deposit.

In the years between 2011 and 2020 on behalf of the Mining Authority a detailed status investigation and risk analysis of all old mining underground workings, shafts and galleries in Zinnwald region has been done [441].

The underground and surface water qualities and qualities were monitored in the border crossing German - Czech public financed VODAMIN project 2011 – 2014 [286]. In result the water quanties and hydrochemical variations, concerning the influence of the old mining workings, were defined for typical local weather szenarios.

6.3 Exploration History

6.3.1 Preface

The Li-Sn-W greisen deposit Zinnwald / Cínovec deposit was target of nine exploration campaigns since 1917. However, main focus of most of these investigations was the tin and tungsten mineralization. Various methods of sampling, geological interpretation and modelling were applied since the first systematic exploration efforts in the year 1917. During the years 1940 and 1941 extensive exploration activities took place in the Czech part of the Zinnwald / Cínovec deposit.

In the case lithium, a first systematic exploration on the German portion of the deposit began in 1954 and was completed in 1960. This investigation was done by the Freiberg branch of the “Zentraler Geologischer Dienst der DDR” (Central Geological Survey of the G.D.R.). During that time the Central Geological Institute of the G.D.R. performed a regional re-assessment of the mineral potential of the Erzgebirge Mountains, including the lithium mineralization at Zinnwald.

In 1977 and 1987 additional exploration campaigns on tin, tungsten and lithium were carried out by the Central Geological Institute of the G.D.R., with the latter terminated due to the political changes in 1990.

In 2007 the Canadian company TINCO Exploration Inc. in Vancouver (TINCO) received an exploration license that covered almost all known tin-tungsten-molybdenum occurences on the German territory, including substantial portions of the Zinnwald area. TINCO quit the license in September 2011.

In 2010 Solar World AG in Bonn, Germany, applied for exploration rights in all the remaining areas on the German side, which were not blocked by the rights of third companies (Field “Zinnwald"). In November 2011 Solar World further claimed the Field "Zinnwald-North", located north of Field "Zinnwald", which prior to that was covered by the exploration license of TINCO. In 2012 drilling of SolarWorld Solicium GmbH (SWS) commenced in its Zinnwald properties, which continued in the years 2013 and 2014. The successor Deutsche Lithium GmbH (DL) completed a drilling program in 2017.

6.3.2 Geological Mapping

In the 1880ies the German Geological Survey started with systematic geological mapping. A first map of the scale 1:25,000 was published 1890. A revised version of the map followed in 1908 (DALMER, revisioned by GÄBERT [324]), completed by an explanatory brochure on the geological findings (DALMER, 1890, revisioned by GÄBERT, 1908 [294]).

6.3.3 Drilling and Sampling

6.3.3.1 Introduction

Drilling and sampling within the the German part of the Zinnwald / Cínovec deposit took place during the following campaigns:

- The first drill holes were drilled in the beginning of the 20th century. The quality of the geological logging was not sufficient compared to present day standards.
- First systematic exploration drilling (10 drill holes) for lithium took place in Zinnwald from 1954 to 1956 (BOLDUAN, 1956 [239]). Most of the drill holes were collared underground on existing mine drifts.
- In the period from 1958 to 1960 further drilling of 17 holes and sampling with respect to lithium followed in Zinnwald (LÄCHELT, 1960 [242]).
- From 1977 to 1978 two additional drill holes were drilled for the re-assessment of the tin, tungsten and lithium potential (GRUNEWALD, 1978a [259], GRUNEWALD, 1978b [260]).
- Between 1987 and 1990 intensive exploration including 8 drill holes and rock chip sampling followed. The work focussed on tin (BESSER & KÜHNE, 1989 [265], BESSER, 1990 [267]).
- SolarWorld Solicium GmbH (SWS) and its successor Deutsche Lithium GmbH (DL) have performed two exploration drilling campaigns on the Zinnwald lithium property, respectively 10 drill holes in 2012 and 2013 to 2014 and 15 drill holes in 2017.

The individual drilling campaigns are presented in the following chapters.

6.3.3.2 Exploration Campaign No. (1) 1917 - 1918, Germany

The data collective of exploration campaign No. (1) comprises 2 drill holes – one surface drill hole and one underground drill holl sunken from the adit "Tiefer-Bünau-Stolln" (752 m a.s.l.). Tin and tungsten mineralizations were tested.

A total of 27 geological records were integrated into the "geology" table of the project database. The total length of the drilled holes accounts for 345 m. Neither sample assays and core recovery reports nor survey data are available. The drill hole paths were assumed to be vertical. No information on data quality and quality control procedures is available.

6.3.3.3 Exploration Campaign No. (2) 1930 - 1945, Germany

This exploration campaign focussed on the investigation of the ore bearing geological structures. Three drill holes that reached the endocontact of the granite were integrated into the database. Two holes were drilled from surface and one from underground. This dataset comprises 39 geological records that cover a total drilled length of 515 m. Neither sample assays and core recovery reports nor survey data were available. With the exception of drill hole "BoFo 7" for which a dip angle of 45° and an azimuth of 244° was reported, all other drillhole paths were assumed to be vertical.
No information on data quality and quality control procedures is available.

6.3.3.4 Exploration Campaign No. (3) 1955, Czech Republic

This exploration campaign was carried out by the Czech Republic and was focussed on investigation of greisen structures containing lithium, tin and tungsten at Cínovec. Data from three surface drill holes of the Czech exploration campaign of 1955 were integrated into the database. The data comprise 74 geological records representing a total drilling length of 601 m. Neither sample assays and core recovery reports nor survey data were available. The drill holes Pc 1/55 and Pc 2/55 were not used for the design of the geological model owing to the lack of a reliable designation and distinction of greisen intervals.

Information on data quality and quality control procedures was not available.

6.3.3.5 Exploration Campaign No. (4) 1951 - 1960, Germany

Exploration campaign No. (4) represents the first comprehensive investigation programme that was focused on the search for the principle component lithium. In addition, tin and tungsten grades were reported.

This program comprises a total of 17 surface drill holes and 10 underground drill holes. A total of 5,973 m was drilled resulting in 806 geological records. The geochemical records are as follows:

Table 12: Summary of geochemical data of exploration campaign No. (4)

Component	Number of records	Total sample length [m]	Sampling method	Method of geochemical analysis
Lithium	581	502	core sample	flame photometry
Tin	514	495	core sample	spectral analysis
Tungsten	519	496	core sample	spectral analysis

As the data from the tin assays systematically tended to higher values compared to those of campaigns (7) or (8), BESSER & KÜHNE [265] suggested a correction by a factor of 0.7. Tungsten assays are in general above 250 ppm and therefore appear questionable when compared to results of other exploration campaigns, especially the campaign No. (8) of SWS (2012-2014). Consequently, this data cannot be used for resource estimation.

As no drill hole survey data are available, the drill holes were assumed to be vertical. Core recoveries were reported only fragmentarily. It is assumed that the assayed sample intervals represent recoveries of more than 80 %.

6.3.3.6 Exploration Campaign No. (5) 1961- 1962, Czech Republic

The campaign focussed on tin, tungsten and lithium mineralization and comprises 14 surface drill holes predominantly situated close to the German-Czech border. A total of 929 geological records representing a total sample length of 3,961 m were integrated into the project database.

Geochemical records are as listed in *Table 13*:

Table 13: Summary of geochemical data of exploration campaign No. (5)

Component	Number of records	Total sample length [m]	Sampling method	Method of geochemical analysis
Lithium	945	1,289	core sample	not specified
Tin	447	447	core sample	not specified
Tungsten	331	328	core sample	not specified

As no drill hole survey data were available, the drill holes were assumed to be vertical. Major core losses were reported as separate intervals in the drill log. No further data were at hand.

No information on data quality and quality control procedures was available.

6.3.3.7 Exploration Campaign No. (6) 1977 - 1978, Germany

The data set of exploration campaign No. (6) contains information on two surface drill holes with 230 geological recordings representing a total length of 1,216 m. Additionally 1,350 pick samples were collected underground from the "Tiefer-Bünau-Stollen" level (752 m a.s.l.).

This exploration campaign was focused on scientific aspects and was carried out by GRUNEWALD, 1978a [259]. Therefore, rock chip samples were taken from the cores at intervals of 20 cm and compiled to composite samples which represent core intervals of 2 m to 6 m length.

These were assayed by spectral analysis for tin, tungsten and lithium. Intervals that showed elevated tin and tungsten grades during this first screening were reanalyzed by X-Ray fluorescence (XRF) using drill core samples of interval lengths of approximately 1 m.

The pick samples were randomly collected at spacings of 2 to 5 m from the sidewalls of the drifts on the "Tiefer-Bünau-Stollen" level.

Table 14: Summary of geochemical data of exploration campaign No. (6)

Component	Number of records	Total sample length [m]	Sampling method	Method of geochemical analysis
Lithium	373	1,216	rock chip sample	spectral analysis
Tin	373	1,216	rock chip sample	spectral analysis
Tungsten	373	1,216	rock chip sample	spectral analysis
Tin	106	104	core sample	X-Ray fluorescence analysis
Tungsten	106	104	core sample	X-Ray fluorescence analysis

Component	Number of records	Total sample length [m]	Sampling method	Method of geochemical analysis
Lithium	1,341	-	pick sample	spectral analysis
Tin	1,341	-	pick sample	spectral analysis
Tungsten	1,326	-	pick sample	spectral analysis

Survey data of the drill holes are available and were integrated in the database. The average core recoveries are reported as follows:

Drill hole 19/77: 97.8 %

Drill hole 20/77: 92.7 %

6.3.3.8 Exploration Campaign No. (7) 1988 - 1989, Germany

During exploration campaign No. (7), eight holes were drilled from surface providing 684 geological records representing a total length of 3,148 m. The sampling and geochemical analysis programme was comparable to that of exploration campaign No. (6). However, this exploration campaign was preliminarily focussed on the tin and tungsten mineralization. Lithium was only tested on rock chip samples.

Table 15: Summary of geochemical data of exploration campaign No. (7)

Component	Number of records	Total sample length [m]	Sampling method	Method of geochemical analysis
Lithium	1,188	3,149	rock chip sample	spectral analysis
Tin	1,188	3,149	rock chip sample	spectral analysis
Tungsten	1,188	3,149	rock chip sample	spectral analysis
Tin	397	403	core sample	X-Ray fluorescence analysis
Tungsten	397	403	core sample	X-Ray fluorescence analysis

Survey data of the drill holes are available and were integrated in the database. The average core recoveries are reported as follows:

Drill hole 21/88:	86.8 %,	Drill hole 22/88:	95.9 %
Drill hole 23/88:	95.6 %,	Drill hole 24/88:	95.4 %
Drill hole 25/88:	96.5 %,	Drill hole 26/88:	91.7 %
Drill hole 27/88:	89.3 %,	Drill hole 28/88:	96.7 %

6.3.3.9 Exploration Campaign (8a / 8b) 2012 - 2013, Germany

The exploration campaign of SWS comprises 10 surface drill holes. Nine of them were drilled as diamond drill holes (DDH) with various diameters (at least type NQ with hole diameter 75.7 mm and core diameter 47.6 mm). In addition, one reverse circulation drill hole (RC DH, ZGLi 05/2013) was performed. The drill holes were selectively designed as infill holes and twin holes (ZGLi 05/2013 and 05A/2013, ZGLi 06/2013 and 06A/2013).

In addition, 88 channel samples of 1.5 m length and 2 m spacing were taken from the sidewalls of the "Tiefer-Bünau-Stollen" (752 m a.s.l.) and "Tiefer-Hilfe-Gottes-Stollen" galleries (722 m a.s.l.). A total of 419 geological records representing a total length of 2,563 m are documented. Multi-element assays by ICP-MS were performed on one half of the DDH core and on the channel samples. Supplementary X-Ray fluorescence assays of tin and tungsten grades have been carried out for the drill hole samples from ZGLi 01/2012 and ZGLi 02/2012. The results are fully comparable to ICP-MS assays and were used for the resource estimation.

Table 16: Summary of geochemical data of exploration campaign No. (8)

Component	Number of records	Total sample length [m]	Sampling method	Method of geochemical analysis
Lithium	1,247	1,237	core sample	acid fusion + ICP-MS
Tin	1,244	1,235	core sample	Li metaborate fusion + ICP-MS
Tungsten	1,247	1,237	core sample	Li metaborate fusion + ICP-MS
Tin	407	393	core sample	X-Ray fluorescence analysis
Tungsten	406	392	core sample	X-Ray fluorescence analysis
K_2O	1,247	1,237	core sample	Li metaborate fusion + ICP-AES
Na_2O	1,247	1,237	core sample	Li metaborate fusion + ICP-AES

Drill hole surveys were performed on all drill holes and the data was integrated in the database.

6.3.3.10 Exploration Campaign (8c) 2017, Germany

DL drilled 15 holes in 2017 with a total length of 4,458.9 m. Depending on the near-surface conditions in the overburden the first 10 m or so were drilled with PQ 85.0/122.6 mm diameter. Owing to technical reasons, HQ 63.5/96.0 mm diameter was used below down to a maximum of 60 m depth. NQ diameter holes with 75.7/47.6 mm were drilled at greater depth in the granite and the ore zones.

6.3.4 Geochemical Surveys

Stream sediment sampling results were reported by OSSENKOPF [305] in 1982.

A pedogeochemical survey in the regional to detailed local scale followed in the Eastern Erzgebirge including the area of Zinnwald (PÄLCHEN et al., 1989 [310] and PÄLCHEN et al., 1989 [311]). In order to eliminate anthropogenic influences two samples were taken at each sampling point, the first from surface to 0.1 m depth and the second from 0.1 to 0.3 m depth.

A wide range of elements were analysed, including the elements relevant to greisen and granite-related mineralizations, such as Li, Sn, W, Mo, Bi, Nb, As and F. The geochemical results indicated significant Sn, W and As anomalies. By implementing further trace elements the mineral potential of the region was re-assessed and recommendations given for further exploration work.

In recent years, the German Government founded comprehensive reviews of the available historic exploration and research data as well as a new geochemical survey of the Erzgebirge / Vogtland area (BARTH et al., 2019a [436], HELBIG et. al., 2018 [[438]). This work resulted in the revision and construction of the metallogenetic development of the Erzgebirge and Vogtland area (BARTH et al., 2019a [436], HELBIG et al., 2018 [438]), as well as the identification of raw material potential areas, including for Li (BARTH et al., 2019b [437]).

6.3.5 Geophysical Surveys

Systematic geophysical surveys started in the 1950ies with gravity measurements (OELSNER, 1961 [298]). A summary report was published in 1964 (LINDNER, 1964 [301]). Geomagnetic data was published in 1966 (SCHEIBE, 1966 [302]). Further detailed geophysical surveys took place in the 1980ies in the scope of tin, tungsten and barite exploration (STEINER et al., 1987 [309]; PÄLCHEN et al., 1989 [311]) including a special airborne survey (RUHL, 1985 [307]).

The outcomes of the geophysical surveys indicated relevant gravity anomalies, which were used for the design of detailed geochemical mapping campaigns and for the determination of drilling targets.

7 Geological Setting and Mineralization

7.1 Regional Geology

The Erzgebirge-Fichtelgebirge Anticlinorium represents one of the major allochthonous domains within the Saxo-Thuringian Zone of the Central European Variscan Belt, which was formed by the collision of Gondwana and Laurentia in the Late Paleozoic (PÄLCHEN & WALTHER, 2008 [318]). It spreads over an area of about 150 x 40 km within the eastern part of Germany and the northwestern part of Czech Republic, where the Erzgebirge Mountains are called Krušné Hory. Metamorphic rocks of Proterozoic and Late Paleozoic age and intercalating magmatic and volcanic units shape the geological structure of the Erzgebirge area. Confined by deep reaching tectonic lineament zones the Erzgebirge forms a fault-block of slightly ascending topography from NW to SE (from 300 to 800-1,000 m a.s.l.) and a steep escarpment towards the Eger-Rift in the SE (*Figure 10*).

The internal geological structure of the Erzgebirge Mountains is represented by a major NE-SW-striking anticline that is dipping towards SW. The pre-Variscan rock series of the Erzgebirge Mountains have received a marked overprint by deformation, metamorphism, magmatism and metasomatism associated with the Variscan orogeny (BAUMANN et al, 2000 [316]). Felsic intrusions intersected the metamorphic basement during the extensional stage of the Variscan Orogeny with two peaks of magmatic activity, allowing a subdivision of late collisional magmatism (Older Intrusive Complex [OIC]; 330 - 320 Ma) and post collisional magmatism (Younger Intrusive Complex [YIC]; 310 - 290 Ma) (SEIFERT & KEMPE, 1994 [366]; summarized by ROMER et al., 2010 [363]). In terms of size and volume, the granites of the late collisional stage significantly exceed the post collisional granites.

The granites of the Erzgebirge Mountains are exposed along two zones in the eastern and western distributional areas with additionally outcropping in- / extrusions of rhyolites and dykes of porphyritic granites in the eastern part (*Figure 11*). The latter are formed in close spatial and temporal association with the younger post collisional granites and can be linked to fault tectonics that occurred dominantly in this particular area. This Carboniferous magmatism and the associated intrusions of granitic magmas is therefore interpreted as the most essential event for the formation of mineral deposits in the Erzgebirge ore province (NEßLER et al., 2018 [290]).

From the Upper Carboniferous throughout the Mesozoic and Cainozoic the Erzgebirge was with short interruptions object of erosional processes that modified this area and defined today's near surface position of the Proterozoic and Palaeozoic units (BAUMANN et al., 2000 [316]; HENNIGSEN & KATZUNG, 2006 [350]).

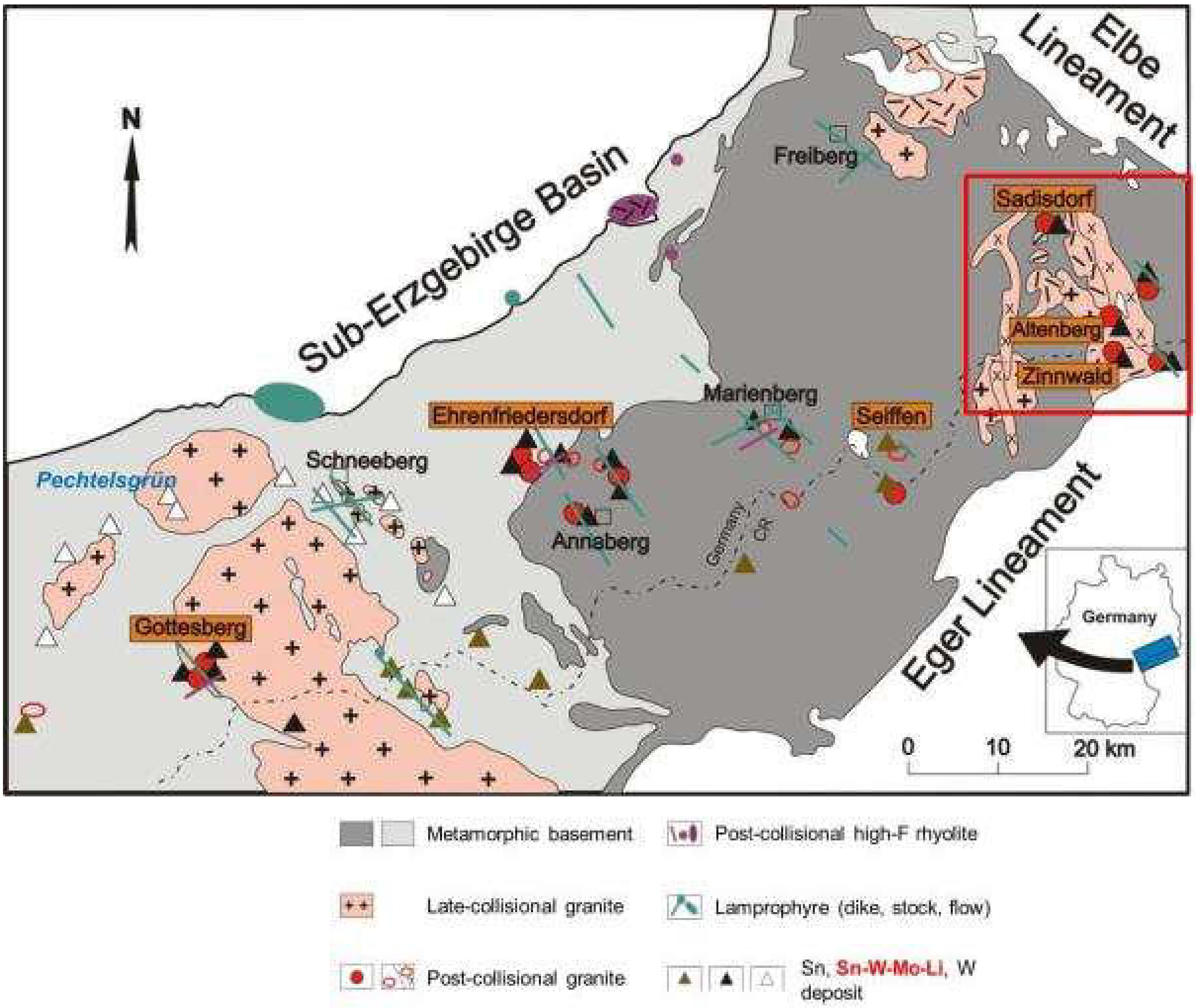


Figure 10: Simplified geological map with major metamorphic and magmatic units of the Erzgebirge Mountains and their accompanied mineral deposits (modified from SEIFERT, 2008 [367].

An enlarged view of the area marked with the red box in *Figure 10* is given in *Figure 11* (modified from SEIFERT, 2008 [367]).

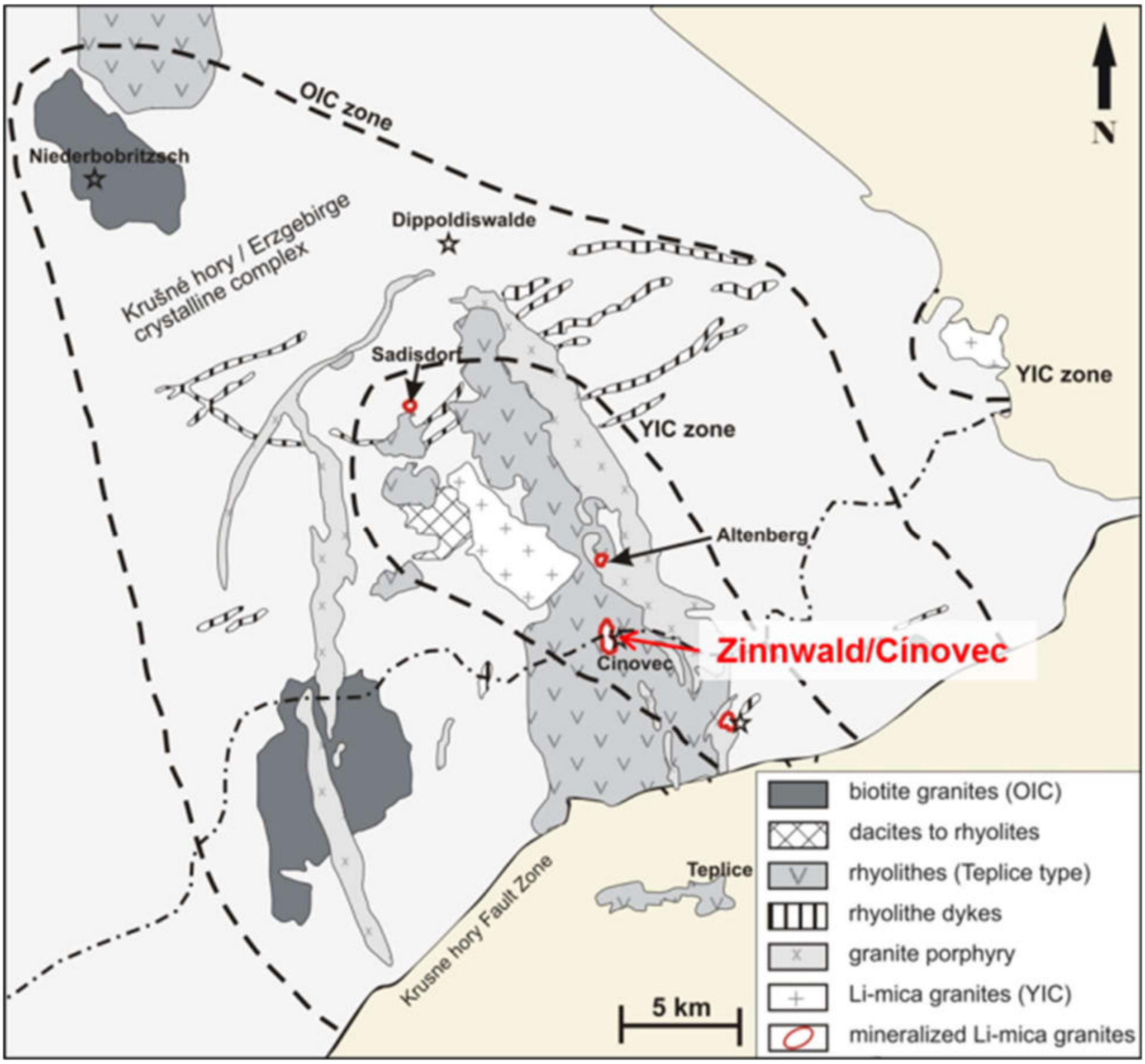


Figure 11: Geological map of the eastern Erzgebirge (modified after CZECH GEOLOGICAL SURVEY, 1992 [345], Geological map 1 : 50 000 and ŠTEMPROK et al., 2003 [378])

7.2 Project Geology

7.2.1 Lithology

The geological setting of the Zinnwald deposit is characterized by the appearance of two main lithologies, the Teplice Rhyolite (TR) and the Zinnwald Albite Granite (ZG) which are presented in *Figure 12.*

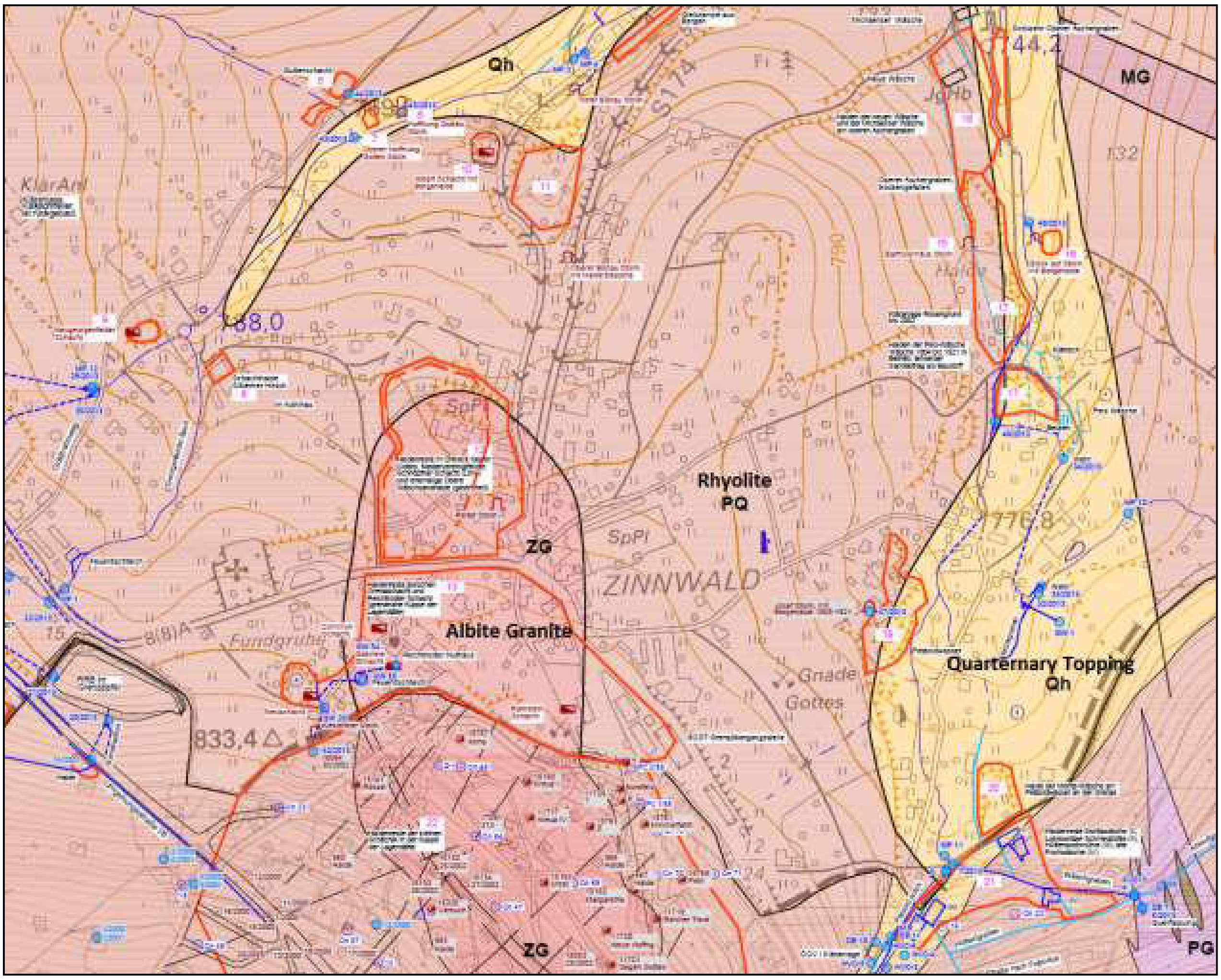


Figure 12: Geological map of the Zinnwald / Cínovec deposit (section approx. 1.25 x 1.25 km), section from KÜHN & MÜLLER [93]

The ZG is regarded as highly altered albite granite which intruded the volcanic pile of the Teplice rhyolite. The ZG intrusive body covers an ellipsoid N-S-striking outcrop area of 1.4 km x 0.4 km and straddles the border between Germany and Czech Republic.

The volcanic rocks of the Teplice rhyolite, covering a large area at the eastern margin of the Altenberg Block (Altenberger Scholle), extend for about 22 km in NNW-SSE direction (PÄLCHEN, 1968 [254]). Within the property the TR represent the most dominant country rock and exhibit a wide textural variability. They are generally reddish grey to dark red in colour. Based on their textural appearance three subdomains / varieties can be distinguished:

(I) A dominant phenocryst rich rhyolite (*Figure 13C*).

(II) A subordinate phenocryst poor, ignimbritic rhyolite.

(III) A vein-like, coarse-grained, porphyroidic granite resembling a subordinate type of the TR that is exposed only in borehole ZG 19/77 and ZGLi 01/2012 (Figure 13*D*).

The general modal composition of rhyolite in the property is about 43.8 - 48.0 % quartz, 24.1 - 32.1 % orthoclase, 5.6 - 14.8 % plagioclase (~10 % anorthite), 10.4 - 18.0 % mica with minor haematite, kaolinite, zircon, and apatite. All three varieties can display different types of xenoliths (0.5 - 10 cm) of either rhyolitic material or altered gneiss fragments from the underlying metamorphic basement.

The Zinnwald Granite is a typical example of a pipe-like felsic intrusive body in a subvolcanic environment. It is ovoid in shape with generally gently inclined (10° - 30°) flanks to the N, E and S of the ZG and a steeply inclined (40° - 70°) W-flank (*Figure 14*). Commonly, the contact of the ZG to the TR presents a marginal pegmatite (or so-called stockscheider) with a thickness between 0.3 - 2 m (GRUNEWALD, 1978b [260]*, Figure 13B*).

Detailed petrologic descriptions of the Zinnwald Granite are given amongst others by BOLDUAN & LÄCHELT, 1960 [249], GRUNEWALD, 1978b [260], BESSER & KÜHNE, 1989 [265], NEßLER, 2017 [289] and NEßLER et al., 2018 [290] for the German part and by ŠTEMPROK & ŠULCEK, 1969 [370], SELTMANN & ŠTEMPROK, 1995 [368] and RUB et al., 1998 [377] for the Czech part. The respective data are based on exploration drilling and on surface as well as underground mapping.

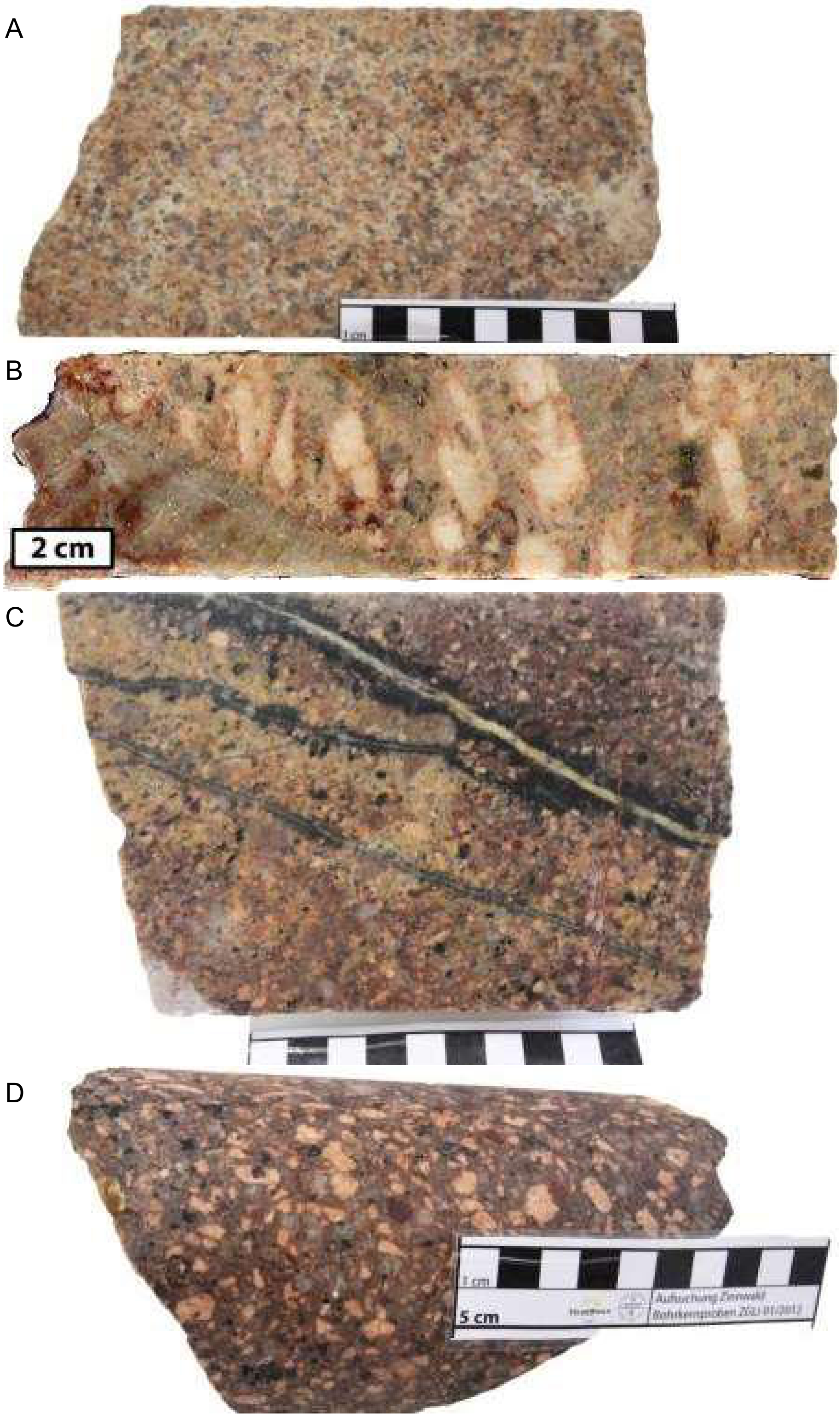


Figure 13: Representative drill core images of the major lithologies from the Zinnwald endo-contact:
(A) Zinnwald albite granite (ZAG)
(B) Stockscheider between ZAG and TR (ZGLi 03-2013 – 235.5-235.7 m)
(C) Teplice Rhyolite (TR) cross cut by greisen veins (ZGLi 01-2012 – 71.6 to 71.75 m)
(D) Granite porphyry (ZGLi 01/2012 – 34.35 to 34.6 m)

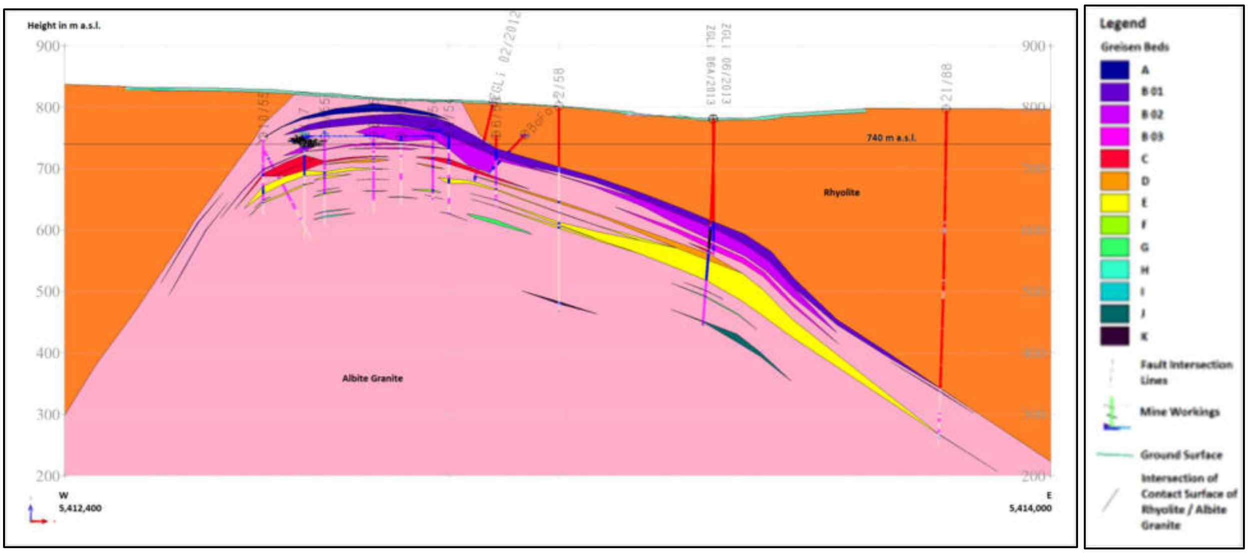


Figure 14: Geological E-W cross section (5,623,000 N) showing the Zinnwald granite with greisen ore bodies trending parallel to sub-parallel towards the granite contact with the Teplice Rhyolite

Vertical compositional and textural zoning is known from the deep borehole CS-1 (1,596 m) drilled in the intrusive body of Zinnwald / Cínovec (ŠTEMPROK & ŠULCEK, 1969 [370] as well as RUB et al., 1998 [377]).

To avoid inconsistent terminology, the Zinnwald Granite (ZG) is referred to the complete intrusion independent from any mineralogical, textural or geochemical characteristics. *Figure 15* gives a concise summary of different granitic lithologies intersected in the deep drillhole CS-1, starting with a succession of medium-grained equigranular zinnwaldite-albite-granite (ZAG) to a depth of about 730 m, which resembles the dominant rock type within the upper part of the granite cupola and hosts the entire ore mineralization.

The ZAG is generally bright grey to yellowish grey in colour (*Figure 13A*). On average it is composed of plagioclase (albite 34.8 %), quartz (32.8 %), orthoclase (23.4 %), Li-mica (zinnwaldite 5.9 %), sericite (2.1 %) and accessory topaz, fluorite, zircon, cassiterite and clay minerals. The texture of the rock is granitic, weak porphyritic and poikilitic. Sericite, albite and fine-grained quartz constitute a coherent groundmass with embedded bigger grains of quartz, orthoclase and minor zinnwaldite. Individual sections/portions of the ZAG can be strikingly variable in texture.

Plagioclase of 5 % anorthite (≤ 1.4 mm, Ø = 0.6 mm) is mostly present as small, lath-like, euhedral grains forming the groundmass and showing distinct or faint twinning lamellae. Additionally, it can represent inclusions within bigger grains of quartz or zinnwaldite.

A population of big xenomorphic, phenocryst-like grains of quartz I (≤ 6 mm, Ø = 3 mm) with uneven and crenated grain boundaries towards groundmass-albite can be distinguished from fine grained quartz II (0.3 - 0.5 mm), which forms a portion of the groundmass.

Orthoclase I (≤ 2.5 mm, Ø = 2 mm) is represented by big subhedral grains with evenly shaped grain boundaries and numerous inclusions of plagioclase. The transformation to sericite is very common and can be found in a broad range of intensity. Interstitial orthoclase II (0.15 - 0.6 mm) of various grain sizes is also common.

Zinnwaldite (≤ 2.5 mm, Ø = 1 mm) was identified as the prevailing mica species in the ZAG. Tabular crystals are corroded by minerals of the groundmass very intensely, in part leaving only relicts of zinnwaldite. Pleochroic haloes are abundant as are inclusions of fluorite and other accessories. Zinnwaldite is transformed to sericite mainly along cleavage planes and can show orientated muscovite overgrowth.

As one of the dominant groundmass minerals sericite is abundant and forms flaky and rosette-like aggregates. The amount of sericite within the rock varies exceptionally (up to 37 %, on average about 2 - 3 %).

Euhedral to xenomorphic cassiterite (≤ 1.2 mm, Ø = 0.15 mm) of various grain shapes and irregular pleochroism and colourless to patchy purple coloured fluorite (≤ 0.3 mm, Ø = 0.2 mm) are among the most common accessory mineral phases.

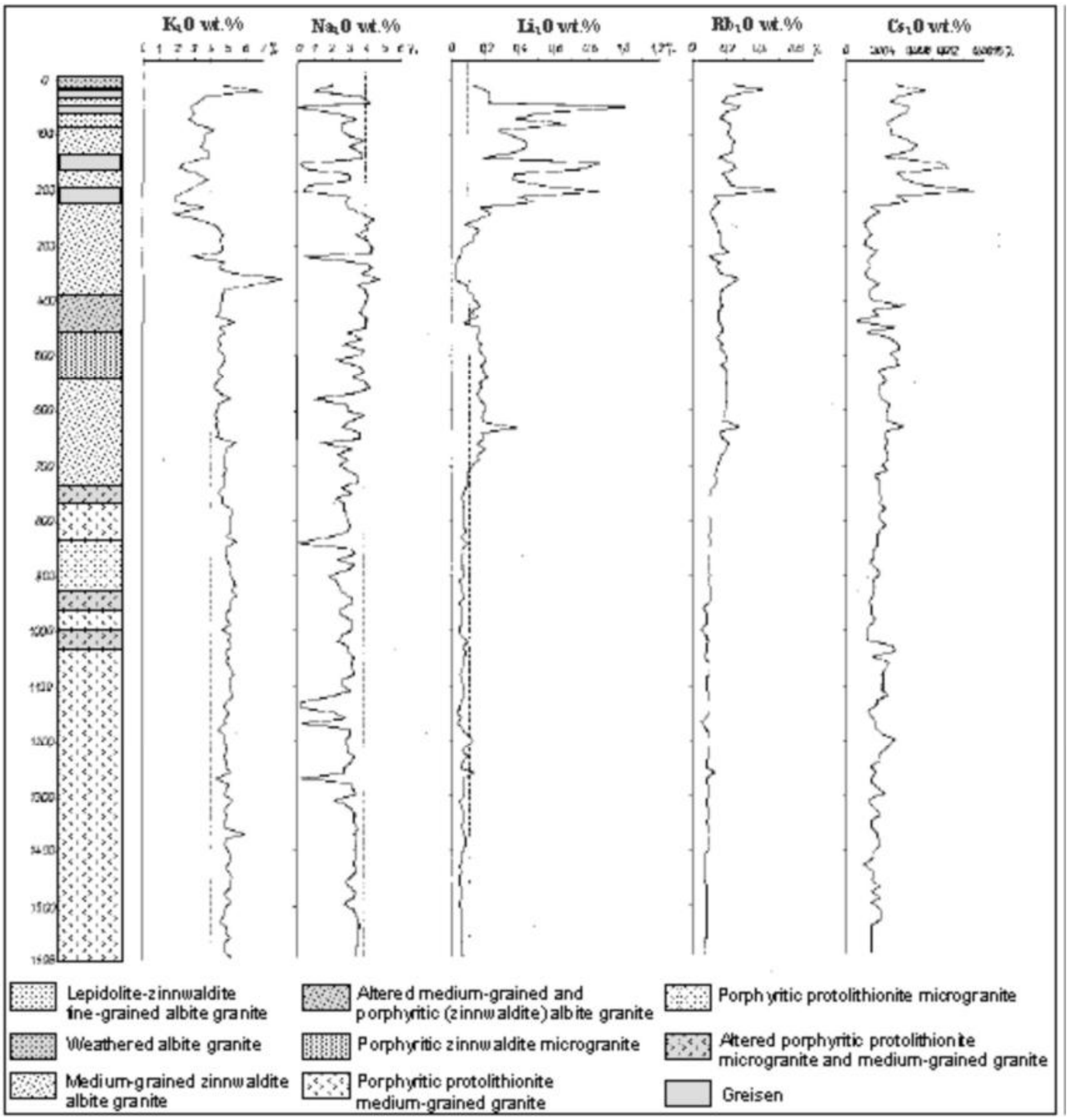


Figure 15: Drill log and distribution curve of alkali elements (K_2O, Ba_2O, Li_2O, Rb_2O and Cs_2O) of the deep drill core CS-1, drilled in the centre of the Zinnwald / Cínovec granite cupola after ŠTEMPROK & ŠULCEK, 1969 [370] and RUB et al., 1998 [377]

In drill hole CS-1 the ZAG was found up to a depth of 730 m. From 390 to 540 m major zones of alternating ZAG and porphyritic zinnwaldite-microgranite (PZM) occurred. Equivalents of this rock type were also found at more shallow depths within different drillholes on the German side. Relatively similar in composition to the ZAG, the PZM shows a prominent porphyritic texture with euhedral grains of quartz (≤ 1.5 cm) and plagioclase (≤ 2 cm) in a groundmass of quartz, plagioclase and sericite. The thickness of equally textured zones is in the range of centimeters to a few meters.

The Zinnwald pluton shows partial depletion in Li, Rb and Cs with depth (ŠTEMPROK & ŠULCEK, 1969 [370] as presented in *Figure 15.* In the centre of the cupola a gradual transition into Li-poor, medium-grained, porphyritic protolithionite granite (PPG) is taking place at a depth of 730 m. Differing in texture and mica composition from the upper ZAG this Li-poor PPG is characterized by phenocrysts of orthoclase (2 - 3 cm), rounded quartz, tabular albite crystals and dark green protolithionite. The continuous succession of PPG was intersected by CS-1 to a final depth of 1,596 m.

To the south west of the Zinnwald property a granite porphyry dike and a small eroded chimney of tertiary basalt are exposed.

7.2.2 Structure

The development of genetically important late to post Variscan tectonic structures in the eastern part of the Erzgebirge are already predefined by deep reaching fault zones of Proterozoic to pre-Ordovician age. Additional to major tectonic lineaments confining the rocks of the Erzgebirge Mountains there are several deep-seated fault zones with a high significance for the tectonic and magmatic development of the region:

- fault system of Niederbobritzsch – Schellerhau – Krupka (NW – SE)
- fault system of Meißen – Teplice (NNW – SSE)
- fault system of Frauenstein – Seiffen (NNE-SSW)
- fault system of the central Erzgebirge (NE-SW)
- fault system of the southern Erzgebirge (NE-SW)

The most important regional tectonic element is represented by the fault “Seegrundstörung” which forms a part of the deep fault system of Niederbobritzsch – Schellerhau – Krupka and runs in the immediate southwest of the Zinnwald granitic intrusion. This fault zone is thought to have a major relevance for the arrangement and postmagmatic development of the deposit.

The tectonic framework of the deposit itself is dominated by the NE-SW directed hydrothermal veins, the so called “Morgengänge” veins, and perpendicular trending cross joints. The former are characterized by a high-angle dip, large continuity in strike direction, and a mean thickness of 10 cm to 20 cm (max. 50 cm). According to numerous authors, including BERGSICHERUNG DRESDEN, 1991 [332] and SENNEWALD, 2007 – 2011 [283], they are formed synchronous with the flat dipping mineralized veins (so called “Flöze” of the previous miners) cross cutting them in vertical to sub vertical direction. The direction of displacement is subhorizontal. Mostly developed along the western flank of the deposit the “Morgengänge” veins are related to younger tectonic

movements with displacement in the range of meters. Especially in this area, the contact of the Zinnwald granite to the surrounding Teplice rhyolite is tectonically dominated and a set of progressive step faults shape a steeply dipping western flank.
Additionally, minor tectonic movements appeared along the gently inclined and flat dipping surfaces of quartz veins, displayed by numerous slickensides.

At many locations the “Morgengänge” veins and the adjacent granite are mineralized with quartz, fluorite, cassiterite, and minor wolframite and were frequently exploited during historic mining. Morgengänge veins that developed in the country rocks (Teplice rhyolite) can also show greisenization features and minor impregnation with tin oxides.

Several types of variably angled joints documented during the 1950’s reveal a general system that can be applied to the granite and greisen lithologies (*Table 17*).

Table 17: Systematic scheme of joints in the German part of the Zinnwald deposit (after BOLDUAN & LÄCHELT, 1960 [249])

System	Index	Azimuth	Dip	Characteristics
Erzgebirgian (morningvein-like)	a	40°	60-80°	well developed, not mineralized, rare joint layer clay
Hercynian (strikingjoint-like)	h	120-160°	48-80°	well developed, not mineralized
L-joints (flöz-like)	L	turning around	following granite contact	poorly developed, mineralized
S-joints	S	100°	80-90°	very poorly developed
Diagonal joints	dk‘	80°	15-65°	very poorly developed, not mineralized
Diagonal joints	dk“	350°	50°	very poorly developed, not mineralized
Q ? - joints	Q	180°	90°	well developed, not mineralized

7.2.3 Alteration

The ZG has experienced a series of post-intrusive metasomatic and hydrothermal alteration events. Microclinization followed by albitization, greisenization, argillic alteration and haematitization took place after solidification (ŠTEMPROK & ŠULCEK, 1969 [370]). Distinct zones of alteration intensity are common for all types of alteration while boundaries of these zones can be either sharp or blurred.

The most prominent alteration feature comprises the transformation of rock forming minerals (e.g. Ca-plagioclase, orthoclase) to albite during Na-metasomatism, the so-called albitization. This type of auto-metasomatic alteration incorporates the entire volume of the upper ZAG and PZM to a depth of 730 m, whereas it is less pronounced or absent in the deeper parts of PPG. The intensity of albitization is highly variable. While most of the ZAG has undergone an intermediated albitization with the transformation of the majority of Ca- / K-feldspar to albite, ongoing Na-metasomatism in combination with removal of SiO_2 produced rocks of up to 70 % albite, so called albitites. Irregular bodies of albitites of up to 1 m thickness are found in drill core and underground.
Similar to albitization, but of much less abundance is the process of K-metasomatism, producing rocks of up to 50 % orthoclase. Together with albitites, these so-called feldspatites are of particular interest for mechanical rock behaviour as they are representing zones of unusual crumbly and unstable rock.

Greisenization is the most important feature of high-temperature alteration in the deposit of Zinnwald / Cínovec. Since it is related to the formation of lithium ore mineralization, it will be discussed in *chapter 7.3.1.*

Sericitic alteration of the ZAG is common, where a fine-grained variety of muscovite (sericite) is replacing plagioclase, orthoclase and zinnwaldite to a variable degree. It can be accompanied by the formation of illite (a K-deficient muscovite) and clinochlore (member of the chlorite group) and can be recognized as fine-grained, light greyish to greenish aggregates between the other minerals. Likewise, the TR and greisen mineralization can be affected by sericitic and chloritic alteration. The latter shows a pronounced alteration and transformation along the mica's grain boundaries as can be seen in the BSE-image *(Figure 16)*.

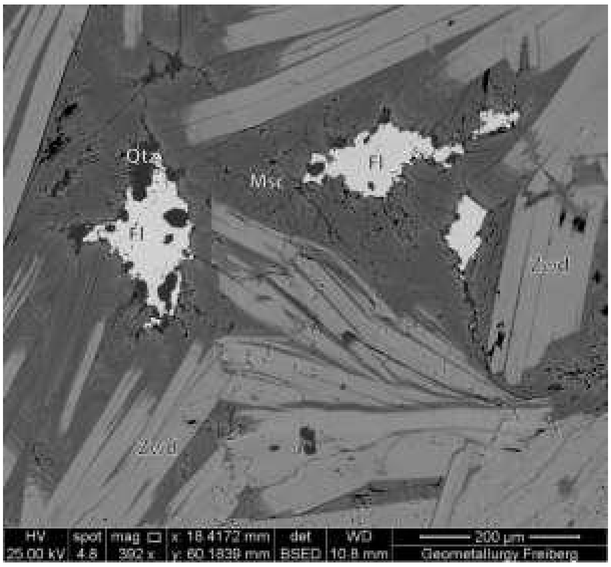


Figure 16: Back scatter electron (BSE) image of a zinnwaldite rich greisen sample (ZGLi 01/2012 – 107.5 m) showing pronounced sericitic alteration along grain boundaries and cleavage planes of zinnwaldite as well as fluorite and euhedral quartz in the interstitials

Argillic alteration of ZAG (and subordinately of all other lithologies within the Zinnwald property) is a common feature as well. Superseding micas and the group of sodic and potassic feldspars, fine grained aggregates of well intergrown kaolinite crystals create a whitish to greyish rock according to the variable intensity of alteration. Argillic alteration can cause a distinct decrease in rock strength as it lowers the cohesive strength of the mineral grains in the rock's fabric.

The impregnation of the matrix of ZAG and TR by fine grained hematite and / or other iron oxides / hydroxides is another common alteration feature and can be found in various intensities. The character of haematitization can be either disseminated and blurry or discrete with local haematite spots and / or stringers.

A type of alteration that is constrained to the lithology of TR is silicification which is most pronounced along the northern and eastern portion of the deposit.

7.3 Styles of Mineralization

Mineralogical and petrological characterization of the different rock types was conducted by macroscopic observation of outcrops (above and below ground), drill core (historic and recent) as well as microscopic investigation of thin sections made from selected drill core samples. Information on modal composition of the rocks was supported by data from literature, basically BOLDUAN & LÄCHELT, 1960 [249], PÄLCHEN, 1968 [254], ŠTEMPROK & ŠULCEK, 1969 [370] and GRUNEWALD, 1978a [259], based on point-counting methods and X-Ray diffraction analysis. Furthermore, recent results on modal composition of greisen ore material from an automated mineral liberation analysing system (MLA) was added here in the report.

Greisen type mineralization at the Zinnwald / Cínovec deposit is related to flat dipping, sheet-like greisen ore bodies and veins in the apical part of a geochemically highly evolved granitic intrusion. Lithium, tin, and tungsten mineralization is potentially economic and occurs mainly as quartz-mica greisen.

Exploration at Zinnwald has defined a Li-Sn-W greisen deposit in several stacked continuous bodies with a dimension of 1.6 x 1.5 km on the German territory (corner points according to Gauss-Krueger coordinate system: 5,412,400; 5,622,650 – 5,414,000; 5,624,150). The deposit reaches from 200 m a.s.l. up to 850 m a.s.l..

Individual greisen beds show a vertical thickness between less than 1 m and more than 40 m.

No other areas of significant mineralization are known at present at the Zinnwald property, but surface exposures and drillings indicate various preliminary investigated or untested anomalies in the vicinity. Li-Sn-W-(Mo) mineralization is also known to exist to the north at the Altenberg "Zwitterstock" deposit. Furthermore, a Sn-W-Nb-Ta mineralization was intersected by drilling in the southeastern portion of the deposit (NEßLER, 2017 [289], NEßLER et al., 2018 [290]).

The Zinnwald / Cínovec greisen deposit and subordinately the Teplice Rhyolite can be characterized by a number of different mineralization styles. The most important include:

I. Independent or vein adjoining greisen bodies
II. Flat dipping veins (so called "Flöze")
III. Subvertical dipping veins (so called "Morgengänge")
IV. Metaalbite granite Sn-W-(Nb-Ta) mineralization

The vast majority of lithium and portions of the tin and tungsten mineralization within the Zinnwald / Cínovec granite stock can be found in the metasomatic greisen ore bodies (style I). The position of greisen mineralization is a result of late- to post-magmatic fluids, infiltrating the uppermost part of the granite stock. They were distributed in dependence on the granite's joint system along cracks and intergranular pathways. Consequently, faults and joints played an important role in the dispersal of mineralizing fluids throughout the cupola. According to investigations of BOLDUAN & LÄCHELT, 1960 [249] and BESSER & KÜHNE, 1989 [265] greisenization as well as the development of the "Flöze" is closely linked to the flat dipping L-joints, representing cracks and joints resulting from the volume loss of the granite during cooling and crystallization. Areas of cross-cutting L-joints and sub-vertical faults / joints are considered to be favourable for the development of particular thick bodies of greisen mineralization.

Mineralization styles II and III are of subordinate importance for lithium but are well mineralized with cassiterite, wolframite and minor scheelite and played therefore an important role during historic mining. The predominant part of this resource was exploited in the past. Subordinate amounts of zinnwaldite can be found in the flat dipping veins (style II) along the endo- and exo-contact of the deposit, where it forms selvages of very coarse grained zinnwaldite (up to 50 mm). Detailed information on veining in the deposit will be presented in *Item 7.3.3.*
Mineralization style IV represents an unusual type of ore mineralization in the Zinnwald deposit and will be discussed in the following chapter based on geological, mineralogical and geochemical findings.

7.3.1 Description of Mineralized Zones

Independent or vein adjoining greisen bodies

The lithium ore mineralization of the Zinnwald property is closely linked to the existence of metasomatic greisen ore bodies that are located at the endo-contact of the uppermost parts of the ZG stock (style I). They form curved, stacked and lensoidal compact greisen bodies that can be highly irregular in shape but commonly exhibit a larger horizontal and limited vertical extend. The presence of stock-like greisen, reported in literature (e.g. BOLDUAN & LÄCHELT, 1960 [249]), remains disputable owing to the lack of prove by drilling intersections. However, maximum intersected greisen thickness was about 44 m (ZGLi 06A/2013). This style of greisen mineralization occurs in the central uppermost part and along the flanks of the ZG and follows with subparallel dip the morphology of the granite's surface. Frequency and thickness generally decrease with depth. True thickness of greisen bodies is consequently consistent with the vertical depth for the central parts where the dip angle is less than 10°. Towards the gently inclined (10° - 30°) flanks of the N, E and S and a steeply inclined (40° - 70°) W-flank the true vertical thickness needs to be recalculated, respectively. On average, thickness of potentially mineable greisen bodies in the property area is between 2 m and 15 m.

In addition to the predominant type of independent greisen ore bodies which are described above, there are greisen masses confined to flat dipping veins and sub-vertical dipping faults / veins, the so-called adjoining greisens. They represent intensely greisenized wall rocks of the veins / faults, are highly irregular in shape and follow the veins / faults in strike direction throughout the upper part of the deposit. They are of limited dimension. Thicknesses vary from a few centimeters to several meters. Although veins and faults obviously represent the controlling structures, general principles regarding the position and thickness of these elements cannot be deduced from underground exposures. More precisely, they can be formed either in the hanging and / or in the footwall of the vein / fault or they can be completely absent. The thickness of adjoining greisens can be very variable in strike direction. The independent greisen bodies volumetrically exceed the adjoining greisens by far.

The contacts between greisen and albite granite (ZAG) host lithologies can be either sharp or diffuse with a thickness between a few centimeters to some decimeters (*Figure 19D*). However, there are numerous records of transitions from altered ZAG to greisen with relicts of feldspar and typical greisen. Additionally, lenses of irregular shaped pockets of greisenized ZAG can be present.

The Zinnwald greisen contains variable amounts of quartz, Li-Rb-Cs-bearing mica named zinnwaldite, topaz and accessory minerals. Under consideration of the protolith and the modal mineralogical composition several subtypes of greisens can be distinguished. A frequently used and easily applicable classification scheme involves the amount of quartz, mica and topaz plotted in a ternary diagram (see KÜHNE et al., 1967 [253]). Among the greisens of a granitic protolith three ideal end members can be inferred:

I.	Quartz greisens	(quartz 85 to 100 %)
II.	Mica greisens	(zinnwaldite 85 to 100 %)
III.	Topaz greisens	(topaz 85 to 100 %)

Whereas monomineralic greisen mineralization is of subordinate significance further subtypes with different proportions of quartz-mica-topaz are described for the deposit. The most abundant types and its average composition are the following:

IV.	Quartz-mica greisens	(quartz 65 %, zinnwaldite 25 %, topaz 5 %)
V.	Mica greisens	(quartz 50 %, zinnwaldite 40 %, topaz 5 %)
VI.	Quartz-poor mica greisens	(quartz 15 %, zinnwaldite 75 %, topaz 5 %)
VII.	Quartz-topaz greisens	(quartz 80 %, zinnwaldite 5 %, topaz 10 %)
VIII.	Topaz-mica greisens	(quartz 65 %, zinnwaldite 20 %, topaz 10 %)

(each case including 5 % accessories).

The macroscopic appearance of greisen is homogeneous (*Figure 13A*). Predominantly light to dark grey in colour the greisen is occasionally stained brick red due to intermediate to intense haematization. The texture can be characterized by coarse-grained, metablastic quartz and zinnwaldite forming a closely interlocked and sutural fabric. Topaz is visible as pale yellow and saccharoidal grains within the interstices of quartz and zinnwaldite. The recognition of the rock’s initial (pre-greisenization) texture is not possible due to the overall replacement and recrystallization of the major components. Intermediate-grained varieties of greisens are less common. Greisen textures can be diversified due to the presence of local mica nests or pockets ranging from about 2 cm to 1 m in diameter representing local zones of quartz-poor mica greisens. According to investigations by GRUNEWALD, 1978a [259] the grain size of quartz in greisen mineralizations ranges from 1 to 10 mm (Ø = 5 mm). Quartz forms irregular shaped, allotriomorphic grains with straight, rounded or serrated boundaries and exhibits euhedral shapes only in small vugs (*Figure 17).* It can be further characterized by a straight extinction and the existence of numerous fluid and / or gas inclusions (*Figure 17*), mineral inclusions of small euhedral plates of albite, flakes of zinnwaldite and of small grains of cassiterite, fluorite and apatite.

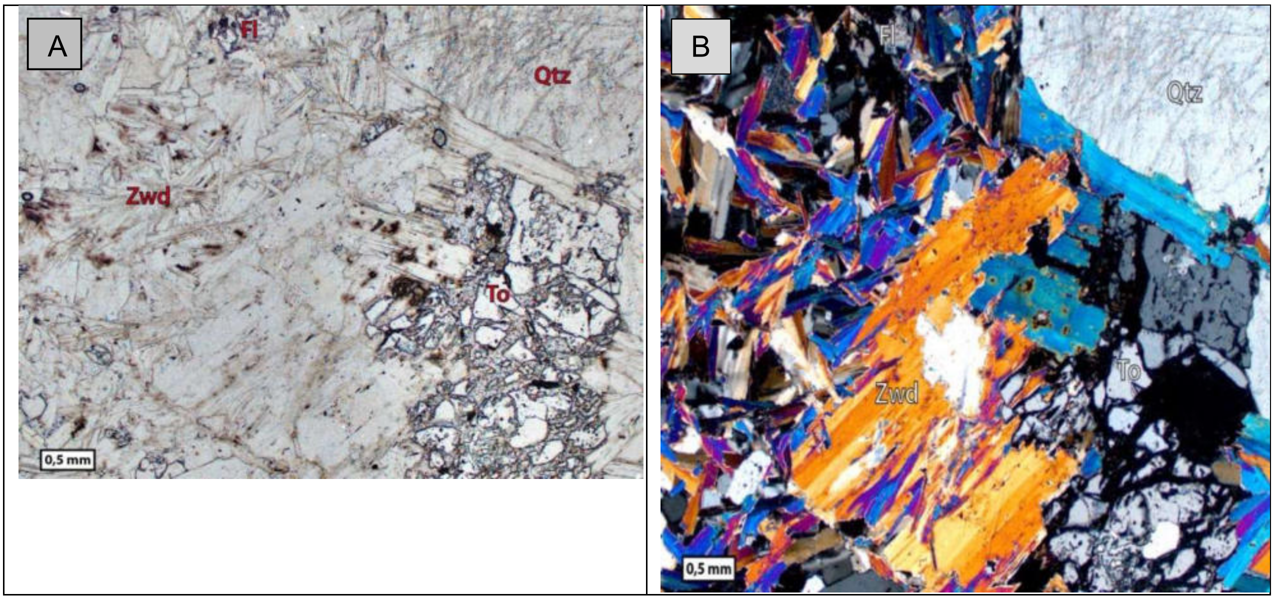


Figure 17: Microphotographs of a representative greisen sample (ZGLi 02/2012 – 81.45 m) showing large, altered grains of zinnwaldite with abundant pleochroic haloes and inclusion-rich quartz intergrown with randomly oriented laths of zinnwaldite and highly fractured aggregates of topaz (high relief). Fluorite is apparent as small independent aggregates and within the fractures of topaz aggregates
(A) Transmitted light, linear polarization;
(B) Transmitted light, crossed polarization

Zinnwaldite, the host mineral of the vast majority of lithium metal in the deposit is namend after its type locality Zinnwald. It forms euhedral to subhedral tablets of mostly thick habitus (0.3 mm to 30 mm, Ø = 1.2 mm) or aggregates of individual grains that have an irregular orientation towards each other (*Figure 17*). In rare cases these aggregates can form fans or rosettes.

Mineral inclusions of fluorite, cassiterite, topaz, haematite, zircon, monazite, and opaque phases are common, and some are surrounded by distinct pleochroic haloes. Exhibiting a zonal structure, abundant alteration of zinnwaldite to muscovite (sericite) took place at the grain boundaries but also along the cleavage plains within the zinnwaldite. Moreover, it can be replaced by quartz in a way that the relicts of zinnwaldite exhibit a skeletal grain shape.

Zinnwaldite is considered as a series of trioctahedral micas on the siderophyllite join (RIEDER et al. 1998, [361]). It represents one of the most common mica species along this join and is reported from various types of granitic rocks all around the world (CUNDY et al., 1960 [344]; UHLIG, 1992 [313]; HAYNES et al., 1993 [349]; NOVÁK et al., 1999 [374]; LOWELL et al. 2000, [353]; RODA ROBLES et al., 2012 [362]). Lithium content of the zinnwaldite mica is in the range of 0.8 to 1.9 wt.%. It contains a high enrichment of iron (8.1 to 11.0 wt.%) and fluorine (3.5 to 7.2 wt.%) (e.g. GOTTESMANN, 1962 [245]; UHLIG, 1992 [313]; GONVINDARAJU et al., 1994, [347]; JOHAN et al., 2012 [351]).

The characteristic physical properties of zinnwaldite are listed in *Table 19*. Zinnwaldite belongs to the group of paramagnetic minerals, which make this mineral favourable for processing by magnetic separation.

Topaz is characterized by grains of columnar to isometric habitus and grain sizes of up to 2.8 mm for single grains and more frequently of up to 5.6 mm for irregular aggregates. Commonly, they are intensely fractured by cleavage cracks and irregular oriented fissures (*Figure 17),* which are usually filled by fluorite, sericite, and minerals of the kaolinite group. Topaz is frequently replaced by clay minerals.

Colourless to irregularly purple-coloured grains or aggregates of fluorite are present at sizes up to 1 mm. Normally fluorite tends to fill small vugs, cleavage cracks or rock fissures and forms therefore anhedral grains (*Figure 17).* Subordinately, it can form small cubic inclusions in quartz and zinnwaldite.

Cassiterite is among the accessory phases of the greisen and is characterized by euhedral to subhedral grains of 0.02 mm size that can agglomerate to aggregates of up to 2 mm. Disregarding traces of tin in the crystal lattice of zinnwaldite, cassiterite represents the sole tin bearing mineral phase in the greisen lithology. Typical brownish to pinkish colours are common as well as a zonal structure. The crystals are generally twinned and show distinct pleochroism. Cassiterite also forms blastic to fine-grained mineral inclusions in zinnwaldite and within the mineral interstices.

Rare wolframite, scheelite and columbite were identified among the accessory minerals. Whereas columbite occurs as euhedral inclusions in zinnwaldite or in aggregates with cassiterite, the tungsten-bearing mineral phases are anhedral, randomly distributed within the rocks fabric and show no preferred paragenesis. Grain sizes are in the range of 0.02 to 0.5 mm and 0.01 to 0.1 mm for columbite and wolframite / scheelite, respectively. Columbite of Zinnwald can incorporate variable amounts of Ta, Fe, Mn, Ti and U. Growth zoning or irregular “patchy” zones of different composition represent therefore characteristic features. Scheelite was found to originate from alteration of wolframite in flat dipping veins. However, no similar observations were made for greisen lithology so far.

For chemical formulas and grades of commodities see *Table 18.*

Among all other greisen types only quartz-poor mica greisen and quartz greisen are of certain importance. Each type is about less than 5 % of the total greisen volume in the deposit. Quartz-poor mica greisen are characterized by the dominant abundance of zinnwaldite (>70 %). Laths and tablets of metablastic zinnwaldite form an intensely interlocked fabric (*Figure 18B*) with sub-hedral quartz and abundant fluorite. The texture of this greisen type can differ significantly by zinnwaldite grain sizes ranging from 0.3 mm to 20 mm and by variable amounts of quartz, fluorite and alteration minerals (sericite, green clinochlore). Quartz-poor mica greisen are commonly en-closed in the prevailing quartz-mica greisen forming sheet like intercalations of limited thickness (max 1.0 m) and uncertain lateral extension. Additionally, local nests and pockets of this mica-rich greisen can be formed in quartz-mica greisen as well as in the greisenized ZAG (*Figure 18C*).

Quartz greisens are almost monomineralic rocks composed of > 85 % quartz, minor zinnwaldite, fluorite, kaolinite, haematite, and cassiterite. They exhibit a greyish colour and feathery / streaky textures due to numerous cracks and inclusions within the quartz (*Figure 18C).* Similar to the quartz-poor mica greisens they form intercalations within the quartz-mica-greisens and can reach a maximum thickness of about 5.5 m.

Table 18: Zinnwald ore minerals and average commodity grades

Mineral name	Chemical formula	Element	Average grade (wt.%)
Zinnwaldite	$KLiFe^{2+}Al(AlSi_3O_{10})(F,OH)_2$	Li	1.6
Zinnwaldite	$KLiFe^{2+}Al(AlSi_3O_{10})(F,OH)_2$	K	8.9
Cassiterite	SnO_2	Sn	78.8
Wolframite	$(Fe^{2+}, Mn^{2+})WO_4$	W	60.6
Scheelite	$CaWO_4$	W	63.0
Columbite	$Fe^{2+}Nb_2O_6$	Nb	55.0

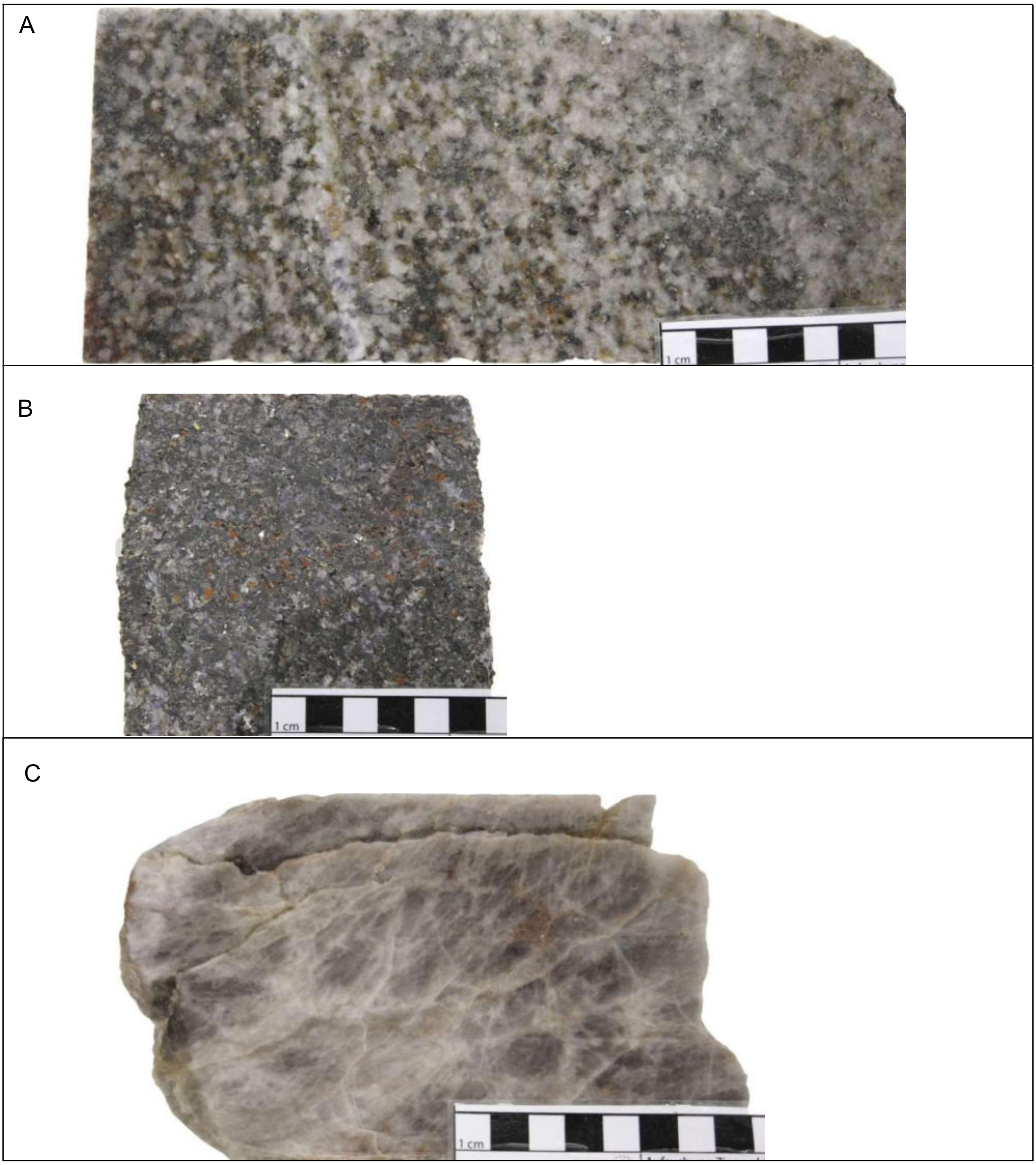


Figure 18: Representative drill core images of the prevailing three greisen types occurring in the Zinnwald deposit

(A) Predominant quartz-mica greisen (ZGLi 01/2012 – 108.0 to 108.25 m),
(B) Quartz-poor mica greisen rich in purple fluorite (ZGLi 02-2012 - 97.9 to 98.0 m),
(C) Quartz greisen (ZGLi 02/2012 – 189.85 to 191.0 m)

Other greisenized lithologies

Zinnwaldite is not restricted solely to greisen ore bodies. Subsequent greisenization affected various rock types of the ZG cupola and adjacent wall rocks to a different degree. Therefore, the term “greisenized” is used for rocks that are not completely transformed into a greisen, meaning that they exhibit remnants of feldspar. In terms of volume the ZAG is by far the most influenced lithology. Progressive greisenization produced an enormous amount of greisenized ZAG that exhibits typical features, e.g. beginning replacement of feldspar by the growth of metablastic quartz and zinnwaldite as well as advanced argillic, sericitic and haematitic alteration.

A continuous succession of rocks that underwent a progressive metasomatic overprint can be described as follows:

Unmodified ZAG → slightly greisenized ZAG → intensely greisenized ZAG → greisen

Table 19: Selected physical and optical properties of zinnwaldite mica

Chemical formula	$KLiFe^{2+}Al(AlSi_3O_{10})(F,OH)_2$
System	Monoclinic
Colour	Greyish-brown, yellowish-brown, silver-grey, green-grey, nearly black
Mohs' Hardness	2.5 to 4
Lustre	Vitreous, pearly
Transparency	Transparent, translucent
Density (measured)	2.9 to 3.02 g/cm³

For mineralogical processes occurring during the metasomatic transformation see *chapter 8.1*. Depending on time, the amount and the chemistry of fluids leading to the transformation, the ZAG can show numerous stages of greisenization intensity, commonly accompanied by different types of alteration (*Figure 18A and B*). They display a high degree of variability regarding dimension, greisenization intensity, lithium content, and position towards the greisen bodies.

The greisenization of the other granitic lithologies like porphyritic zinnwaldite microgranite is only weakly developed. The aplite and the stockscheider show only minor metasomatic changes.

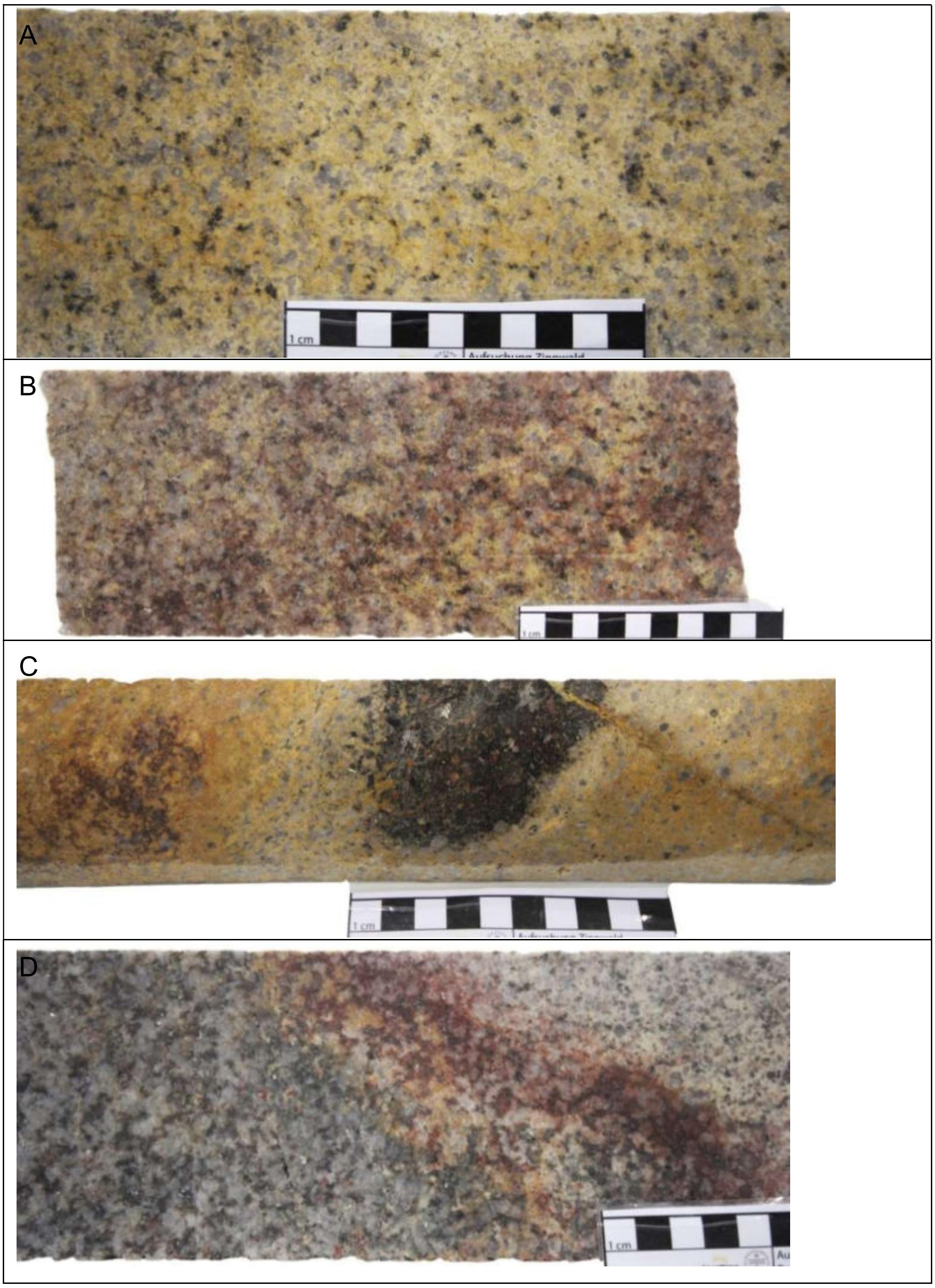


Figure 19: Representative drill core images of the rocks adjacent to ore mineralization
(A) Intermediate greisenized Zinnwald albite granite (ZAG) (ZGLi 01/2012 – 116.2 to 116.4 m)
(B) Strong greisenized and haematized ZAG (ZGLi 01/2012 – 121.75 to 122.0 m),
(C) Nest of quartz-poor mica greisen in greisenized ZAG (ZGLi 01/2012 – 245.65-245.9 m
(D) Contact of ZAG and greisen separated by a narrow zone of intense haematization (ZGLi 01/2012 - 142.4 to 142.65 m)

Greisenization can also affect the wall rock (TR). Unlike the medium-grained zinnwaldite albite granite, which shows strong greisenization in the upper part, the TR is only affected along flat or steep zones / cracks and along the contact between TR and ZAG, which were potential paths for the hot and pressurised fluids. Greisenized TR can be characterized by a prominent dark colour-ing due to the presence of fine-grained micas (muscovite and zinnwaldite) dispersed in the matrix of the TR. The original texture of the protolith is still recognisable. Thickness of greisenized TR can reach up to 5 m in direct vicinity of the contact towards the ZAG but tends to be less than 10 cm. Greisenized joints are commonly mineralized in the centre by quartz, zinnwaldite and / or topaz.

Metaalbite granite Sn-W(-Nb-Ta) mineralization

Moderate to intermediate greisenization of albite granite associated with significant mineralization of Sn-, W- and Nb-Ta-oxides (style IV) represents an unusual mineralization style of the Zinnwald deposit. Spatially independent from major greisen ore bodies this style is characterised by greisenized albite granite of common appearance but with a disseminated ore mineralization.

A continuous body of metaalbite granite Sn-W(-Nb-Ta) mineralization with 20 m of apparent thickness was intersected at drill hole ZGLi 06A/2013 (depth from 299 to 319 m). The mean ore grades are 0.26 wt.% Sn, 520 ppm W, 130 ppm Nb and 40 ppm Ta. Maximum grades amount to 0.39 wt.% Sn, 1200 ppm W, 160 ppm Nb and 50 ppm Ta. Located below a stacked quartz-mica greisen ore body of exceptional thickness and grade (50 m at 0.47 wt.% Li), the presence of this mineralization was indicated by geochemistry rather than by macroscopically significant features on the drill core. The identical style of mineralization was observed in the adjacent drill hole (ZGLi 07/2013) with less thickness and grade. Examination of thin sections from this zone revealed the presence of cassiterite as the sole tin bearing mineral phase. Moreover, scheelite, columbite and rare wolframite were documented. The ore minerals are associated randomly with the main mineral phases quartz, zinnwaldite, albite and sericite. First measurements on the grain size distribution resulted in a cumulative passing of 85 wt.% below 300 to 120 µm for cassiterite, 150 to 45 µm for scheelite and 100 to 30 µm for columbite. No figures can be given for wolframite due to an insufficient amount of mineral grains.

Intersections of minor thickness and distinct lower grades have already been reported by GRUNEWALD, 1978a [259]. Exploring the resource data base for the metaalbite granite Sn-W (-Nb-Ta) mineralization at the criteria of > 0.1 wt.% Sn, several more or less continuous intersections were manifested throughout the deposit (see *Table 20).* The finding of ZGLi 06A/2013 represents the most extensive and constant mineralization with the highest average grade documented for the Zinnwald property. Assuming a flat lensoidal shape of this mineralized zones and a low dip angle, a preliminary correlation between drill holes of the eastern flank is possible due to this new outcrop. Incorporating drill holes 19/77, ZGLi 06A/2013, 26/88, ZGLi 07/2013 and Cn22, a continuous mineralized zone of about 20 m thickness can be followed for about 700 m along strike in N-S direction dipping about 10 to 20° towards north (see *Figure 20* and *Figure 21*).

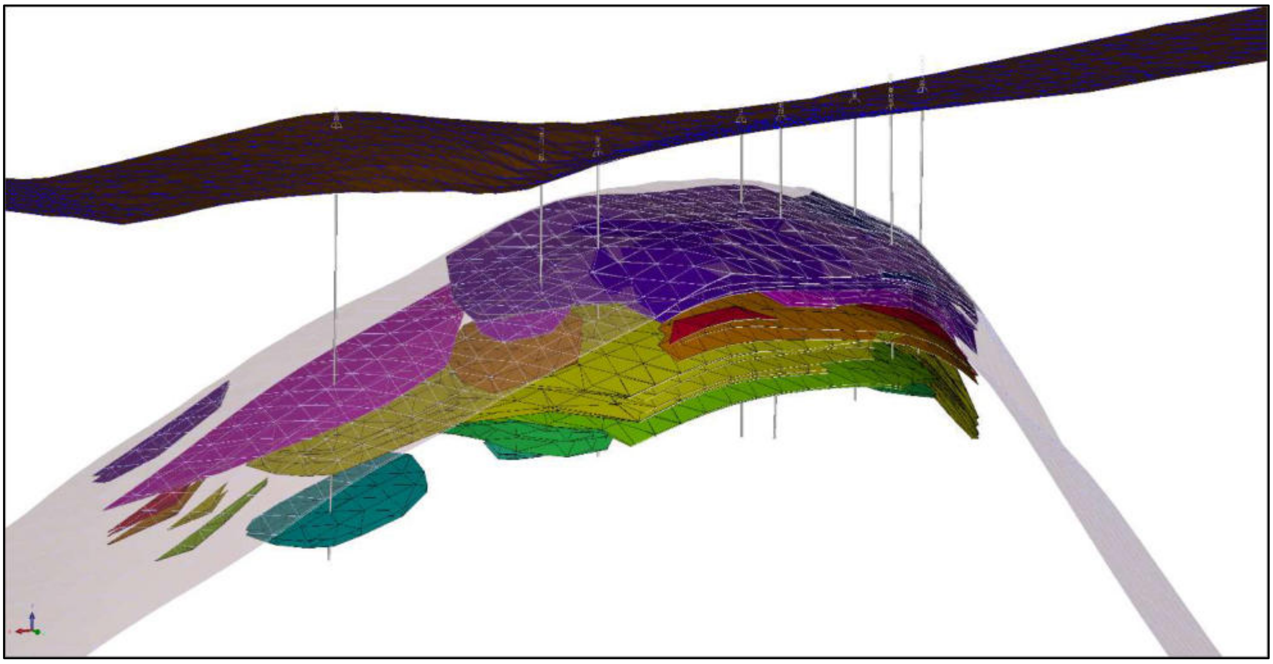


Figure 20: East – West cross section of the Zinnwald Lithium orebodies

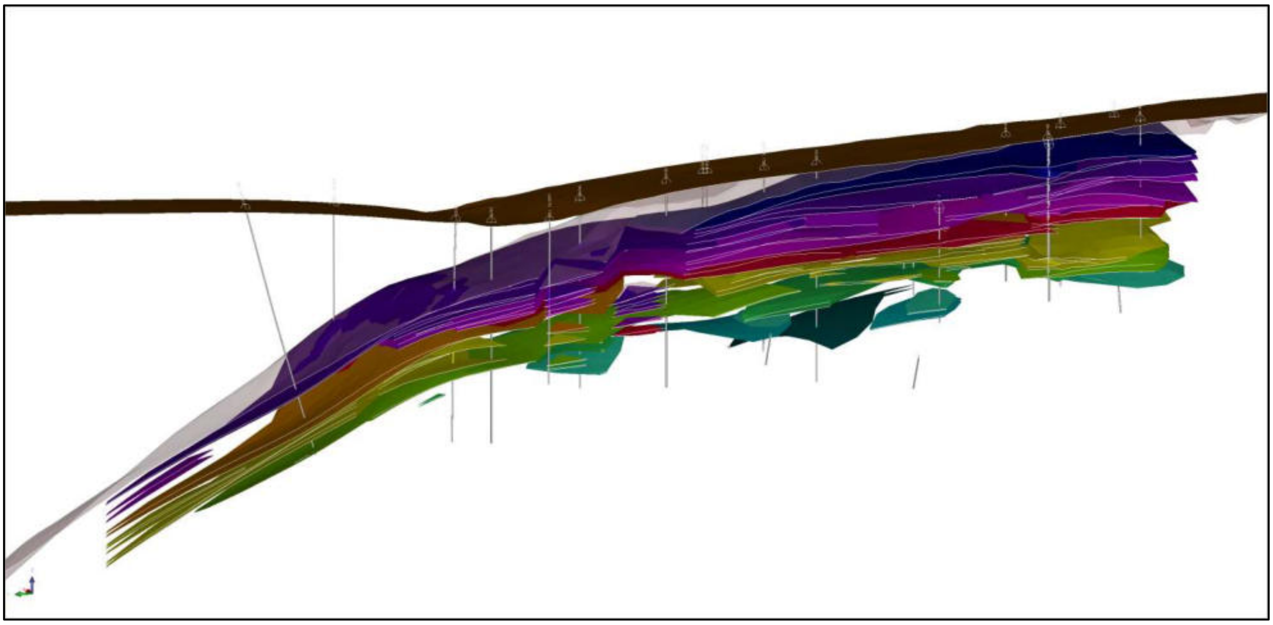


Figure 21: North – South cross section of the Zinnwald Lithium orebodies

Table 20: Summary of continuous and discontinuous drilling intersections of albite granite with Sn > 0.1 wt.% (n.a. = not analyzed)

Hole ID	Part of the deposit	Depth from [m]	Depth to [m]	Drilled thickness [m]	Sn [ppm]	W [ppm]
19/77	Eastern flank	346.00	371.00	25.00	1,132	94
24/88	Eastern flank	259.00	265.00	6.00	1,150	130
25/88	Eastern flank	194.00	196.00	2.00	1,115	120
26/88	Eastern flank	269.00	289.00	20.00	1,313	120
Cn 22	Eastern flank	220.00	238.00	18.00	1,076	n.a.
ZGLi 06A/2013	Eastern flank	299.00	318.95	19.95	2,663	522
ZGLi 07/2013	Eastern flank	259.00	269.00	10.00	2,285	346
ZGLi 07/2013	Eastern flank	290.70	303.60	12.90	1,496	95
22/88	Northern flank	231.00	237.00	6.00	1,655	505
23/88	Northern flank	274.00	276.00	2.00	1,130	10
23/88	Northern flank	298.00	301.00	3.00	4,387	163
Cn 65	Central zone	43.90	47.60	3.70	4,287	n.a.
ZGLi 01/2012	Central zone	113.00	124.00	11.00	1,690	153

7.3.2 Ore Grades

For a geological cut-off exclusively petrographic attributes were used for defining the orebodies. The differentiation of potential economically interesting ore types was based on mean lithium grades and aspects of ore processing. According to these criteria two ore types can be distinguished:

“Ore Type 1”: greisen

“Ore Type 2”: greisenized albite granite und greizenized microgranite

The “Ore Type 1” consists of the petrographic sub-types quartz-greisen (TGQ), quartz-mica-greisen (TGQ+GM) and mica-greisen (TGGM). Despite the opportunity to distinguish up to three levels of increasing greisenization intensity, all greisenized intervals of albite granite and microgranite were merged into “Ore Type 2”.

With respect to the generally low lithium grades in greisenized rhyolite the corresponding intervals were not included into “Ore Type 2”. The table below gives an overview of petrographic sub-types bound to the two ore types and the barren host rock (*Table 21*). The weighted mean lithium grades and other statistical parameters for the core samples of exploration campaigns No.s (4), (5) and (8) are shown as well.

The weighted lithium grades for “Ore Type 1” vary from about 1,000 ppm to 8,100 ppm (0.10 % – 0.81 %). The quartz-mica-greisen with a mean of about 3,400 ppm Li (0.34 %) represents the most prevalent petrographic sub-type within this group. It is assumed that this sub-type mainly determines the overall mean Li grade of the ore deposit. The predominant portion of the greisen structures is characterized by extensive beds that can be found in the endocontact of the albite granite cupola of Zinnwald / Cínovec. The inclination of the beds follows predominantely the granite surface.

Table 21: Classification of ore types by evaluation of Li core sample assays of campaigns No.s (4), (5) and (8)

Ore Type	Petrographic key sign	Petrographic description	Apparent thickness weighted mean Li grade [ppm]	Arithmetic mean Li grade [ppm]	Median Li grade [ppm]	Min Li grade [ppm]	Max Li grade [ppm]	Number of core samples
1	TGGM	mica-greisen	8,133	8,121	7,785	4,160	13,500	8
	TGQ+GM	quartz-mica-greisen	3,438	3,494	3,370	100	14,817	853
	TGQ	quartz-greisen	1,064	1,187	750	10	4,100	56
2	PG_GGM_3 UG_GGM_3 PG_PR_GGM_3	strongly altered to mica-greisen: albite granite, microgranite and porphyritic granite	1,980	2,019	1,858	300	4,830	141
	PG_GGM_2 UG_GGM_2 PG_PR_GGM_2	medium-altered to mica-greisen: albite granite, microgranite and porphyritic granite	1,837	1,859	1,875	140	11,194	398
	PG_GGM_1 UG_GGM_1 PG_PR_GGM_1	weakly-altered to mica-greisen: albite granite, microgranite and porphyritic granite	1,538	1,561	1,620	180	6,642	403
3	PG UG	albite granite and microgranite	1,378	1,413	1,400	50	7,339	543
	YI	rhyolite	656	581	420	50	1,900	47

Quartz-greisen contains less mica and therefore less lithium (1,000 ppm, 0.10 %), whereas quartz-poor mica greisen represents a mica-rich variety (8,100 ppm = 0.81 %) Commonly, thin layers of quartz-greisen can be found as intercalation in massive structures of quartz-mica-greisen.

The lithium grade of greisenized albite granite – and of subordinate greisenized microgranite – ("Ore Type 2") ranges from 1,500 ppm to 2,000 ppm (0.15 % - 0.20 %). This clearly reflects the lower degree of greisenization intensity.

The "greisenized zones" are thought to envelop the greisen beds and reaching 810 m a.s.l. in the southern part and 350 m a.s.l. in the northern part of the modelled deposit.

The surrounding albite granite and microgranite show considerable high Li grades with 1,400 ppm (0.14 %) on average. This refers to the prominent geochemical specialization of the small granite intrusions of the post-Variscian stage with a remarkable enrichment of incompatible elements like Li, F, Rb, Cs etc. Similar observations can be reported for the overlying rhyolite as far as it is located near the endocontact. Here the core samples showed mean lithium grades of about 600 ppm (0.06 %).

During the exploration campaigns No.s (1) to (7) the greisenized structures were not always identified and completely and correctly distinguished. During these periods it could happen that a rock with lithium grades of 2,000 ppm was determined as an albite granite, which represented rather a *greisenized* albite granite. The results of campaign No. (8) substantiated extensive greisenized zones throughout the entire upper part of the granitic cupola.

The review of the data sets showed that sampling during the campaign No. (4) by LÄCHELT, 1960 [242], in many cases ignored lithological boundaries. Therefore, it is possible that granite samples partly include greisen or altered intervals and the other way around. The following mean grades of tin, tungsten, potassium oxide and sodium oxide have been calculated from drill core assays of exploration campaigns No.s (4), (5) and (8). They are representative for the common mineralization of the greisen beds and greisenized granite.
Locally embedded veins, seams and tin greisen stockworks might show significant higher mean values of tin and tungsten.

Table 22: Approximated mean grades of Sn, W, K_2O and Na_2O in greisen and greisenized granite

Potential shown as a mineral inventory	Mean Sn grade [ppm]	Mean W grade [ppm]	Mean K_2O grade [wt.%]	Mean Na_2O grade [wt.%]
„Ore Type 1" greisens	approx. 400	approx. 80	approx. 2.50	approx. 0.2
„Ore Type 2" greisenized granite	approx. 240	approx. 40	approx. 3.40	approx. 1.9

7.3.3 Veining

Mineral veins of the ZAG and the surrounding TR can be subdivided into flat dipping so-called "Flöze" (style II) and "Morgengänge" displaying a sub-vertical dip (style III). The "Flöze" are characterized as flat, curved and onion-like shaped ore mineralizations. According to its flat dip and high lateral continuity they were historically designated by the term "Flöz", corresponding to a coal seam in German mining terminology. The veins of the uppermost part of the Zinnwald intrusion cupola are the main host of the historically exploited tin and tungsten mineralization. They are generally not considered to be hydrothermal veins sensu stricto, since they are composed solely of greisen minerals, namely quartz, zinnwaldite, topaz, and fluorite. Furthermore, the mineral assemblage of the veins depends on the adjacent host rock, meaning that "Flöze" exhibit quartz, zinnwaldite and topaz in areas of major greisen mineralization whereas they tend to comprise higher, almost monomineralic quartz contents when the adjacent lithology is represented by feldspathic ZAG or TR.

Dip angles are in the range of 15° to 30° and only in the central Czech part of the deposit they exhibit horizontal bedding. They strike almost parallel to each other but none of them continues over the complete extension of the granite. The lateral continuity correlates positively with the mean thickness of the veins. They tend to disintegrate and re-join erratically, which significantly affects the vein thickness. Moreover, lateral continuity is reduced by fault tectonics. "Flöz"-mineralization is considerably frequent along the steep western flank of the granite, probably due to the presence of intense fracture and L-joint systems. Towards the central part the abundance of the "Flöze" diminishes. The vertical spacing of the "Flöze" is variable and varies between 1 to 40 m. The thickness is in the range of 1 cm to 1 m with an average of around 0.2 to 0.5 m (*Figure 22*). Displaying a variety of textures, the "Flöze" are commonly symmetrically mineralized showing a selvage of very coarse-grained zinnwaldite followed by pegmatitic and drusy quartz towards the center. Topaz and euhedral fluorite are present in the interstices.

The predominant ore minerals cassiterite and wolframite occur as nests and nodules either at the interstices of coarse-grained quartz or along the selvages. Further ore minerals include scheelite and sulfide minerals (galena, sphalerite, stannite, arsenopyrite, bismuthinite, and seldom acanthite) in the western part of the deposit. The strong heterogenic character of "Flöz"-mineralization is displayed by very ore-rich portions located close to barren zones consisting of almost pure quartz along strike. Within the property the grade of ore mineralization and thickness of the "Flöze" is considered to diminish below the level of Tiefer-Bünau-Stollen (752 ma.s.l.) and to subsequently wedge out with depth. "Flöz"-mineralisations are also developed in the wall rock (TR) where they are less frequent and display lower thicknesses. Relatively abundant quartz and wolframite compared to minor zinnwaldite and cassiterite and the absence of topaz are the most characteristic features (*Figure 22A*). In close relationship to the "Flöze" subvertically to vertically dipping and NE-SW trending veins, the so-called "Morgengänge" veins, are developed in the Zinnwald deposit. They represent mineralized faults (described in Section 7.3) and are formed synchronous with the "Flöze". These veins are considered to have served as feeding channels for metal-bearing fluids indicated by accompanying symmetrical greisenization of the adjacent wall rock. They display a broad range of textures. The thickness is about 10 to 20 cm and the mineral assemblage equals the "Flöz"-mineralization. The "Morgengänge" veins underwent normal faulting with displacements in the range of a few meters. In some parts of the deposit with post-Variscan reactivation they are accompanied by pink to deep red barite.

Figure 22: Representative drill core images of intersected vein mineralization
(A) One major and several sub-veins of quartz and wolframite in the wall rock of the Teplice rhyolite (TR) (ZGLi 01/2012 – 71.0 to 71.75 m),
(B) Typical "Flöz" vein hosted in Zinnwald albite granite (ZAG) showing narrow seams of adjoining greisenization (ZGLi 01/2012 – 88.0 to 88.45 m)

8 Deposit Type

8.1 Characterization of Greisen Deposits

Greisen formation is associated with the cooling of a highly fractionated H_2O-rich granitic intrusion and the enrichment of incompatible volatile elements in the upper part of the intrusion such as F, Cl, B and Li during fractional crystallization. The main evolution stages of greisenized granitoids are as follows: (1) solidification and fissuring, followed by (2) formation of pegmatites (stockscheider) and K-feldspathization (microclinization), (3) Na-feldspathization (albitization), (4) greisenization and hydrothermal alteration (sericitic alteration and / or kaolinization) and final (5) formation of veins (SHCHERBA, 1970 [369]; POLLARD, 1983 [360]).

The metasomatic greisen formation, called greisenization, is defined as a granite-related, post-magmatic process in the course of which biotite and K- / Na-feldspars became unstable (ŠTEMPROK, 1987 [371]). Subsequently to Na-feldspathization it is commonly controlled by the further decrease of the alkali / H^+ ratios (PIRAJNO, 2009 [359]). Granite minerals and textures are replaced by complex aggregates of micas, quartz, topaz, and fluorite with a considerable addition of some elements such as Sn, W, Li, Mo, Be, and others. Highly aggressive, F-bearing solutions induce the formation of fluoride minerals, which are compared to other metasomatic rocks very common in greisen (ROMER et al., 2010 [364]). Greisenization can affect different wall rocks. Its intensity depends basically on the texture of the protolith.

A broad range of formation temperatures between 250° – 500 °C at pressures of 0.3 – 0.8 kbar is suggested by POLLARD, 1983 [360] for the formation of greisen minerals. Latest fluid inclusion studies indicate that all elements required for the formation of the mineralization at Zinnwald were contained in a single magmatic hydrothermal fluid that underwent two main processes, fluid rock interaction and depressuration (KORGES et al, 2017 [352]). The authors recorded homogenization temperatures of various generations of fluid inclusions ranging from 490 to about 300 °C. These numbers are in good agreement with older data that have indicated an average homogenization temperature of 389 ± 28 °C gained from two-phase fluid inclusions in quartz, Li-mica, cassiterite and fluorite of albite granite, stockscheider and veins from Zinnwald (UHLIG, 1992 [313]).

8.2 Application to the Zinnwald / Cínovec deposit

The Zinnwald property covers the German portion of the Zinnwald / Cínovec deposit. The Zinnwald/Cínovec deposit is located in a magmatic-volcanic complex in the eastern part of the Erzgebirge Mountains (*Figure 11*), a world-famous metallogenic province with a mining history going back to the 12th century. Among a multitude of ore deposit types numerous greisen deposits of economic significance were recognized.

The Zinnwald / Cínovec deposit is a typical example of a granite hosted greisen deposit. Among a number of general characteristic features fulfilled by the ore deposit, most relevant for the classification as a greisen is the existence of subsequent post-magmatic alteration stages including greisenization in the endo-contact. The mineral assemblage of quartz, Li-F-mica (zinnwaldite), topaz, fluorite and the associated ore minerals cassiterite and wolframite prove the affiliation to this deposit type. The flat dipping greisen ore bodies are marked by the absence of feldspar indicating a complete succession of greisenization of the host rocks.

8.3 Regional Deposits

The Zinnwald / Cínovec deposit is located in the Eastern Erzgebirge which is characterized by rhyolitic volcanic and subvolcanic rocks as result of a period with intensive volcano-magmatic activity especially in the Upper Carboniferous. At the end of this period numerous granitic melts were emplaced along major faults resulting in the formation of granitic bodies and multiple mineralized structures (e.g. veins, stockworks, breccias). The reactivation of the tectonic structures was accompanied by an intensive postmagmatic metasomatism, which led to greisenization and the formation of the quartz-mica mineralization. This style of mineralization is typical for the Eastern Erzgebirge and is in association with the enrichment of tin, tungsten, lithium and other typical granitic elements (see also *Figure 10* and *Figure 11*).

Many deposits within a radius of 20 km to the Zinnwald / Cínovec deposit have been already mined for typical greisen minerals since the middle of the 14th century. These include:

- Altenberg directly north of the Zinnwald property with mines like “Zwitterstock“, “Neufang / Rote Zeche”, „Zinnkluft“ and other small scale mines
- Hegelshöhe and Schenkenshöhe near Falkenhain
- Sachsenhöhe near Bärenstein
- Schmiedeberg / Sadisdorf
- Greisenzone Löwenhain
- Horni Krupka / Graupen (CZ)

Figure 23 presents block pictures of the most important and best known tin-tungsten deposits in the region of the Eastern Erzgebirge (SEBASTIAN, 2013 [365]).

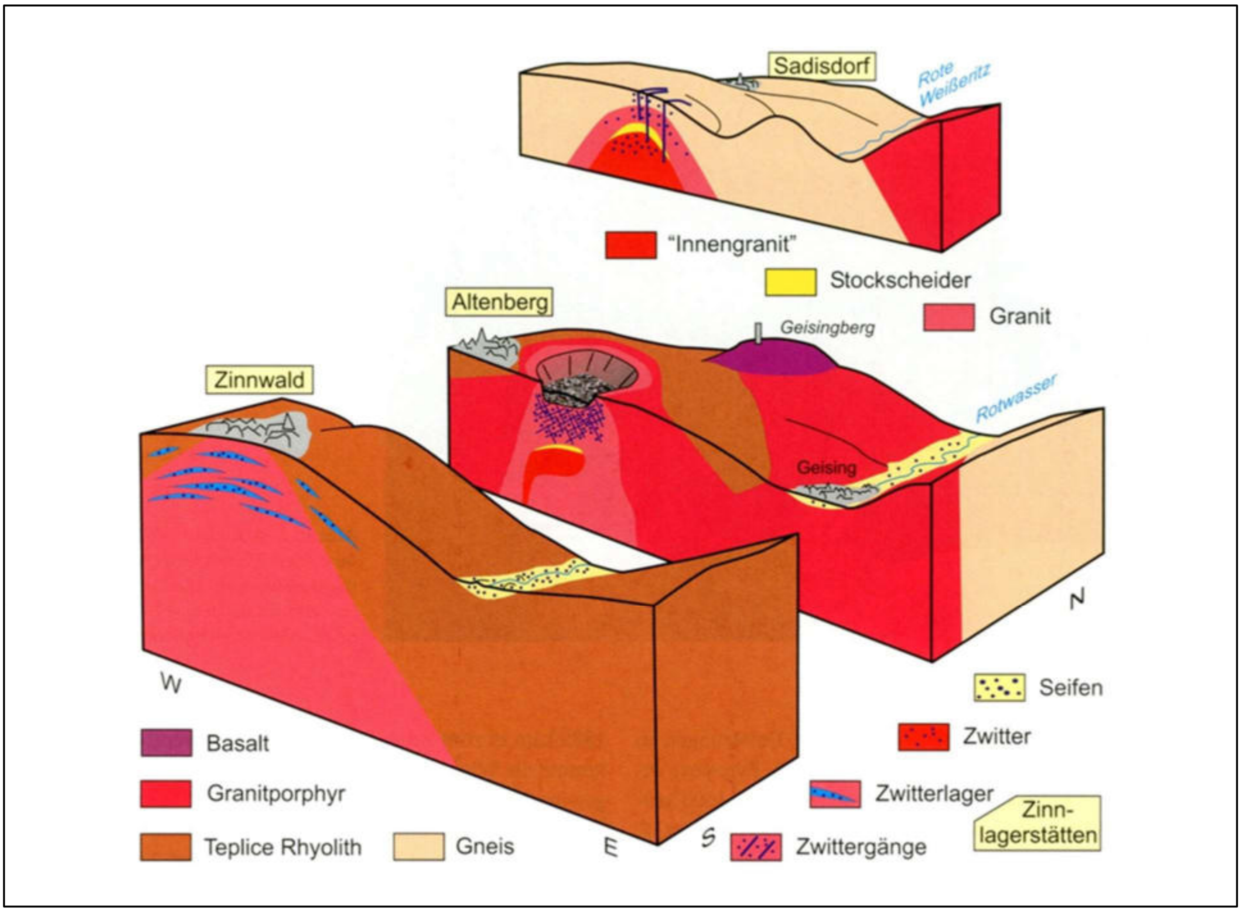


Figure 23: Tin-tungsten deposits of the Eastern Erzgebirge (SEBASTIAN, 2013 [365])

Further prospective exploration licenses in the vicinity of the Zinnwald property were already acquired by DL (see *Item 23*).

9 Exploration

9.1 Introduction

In the abandoned Zinnwald mine a significant part of the historic galleries and workings is still accessible. A visitor mine and mining museum was established in 1992 on the most developed level, named "Tiefer-Bünau-Stollen". Although the ore resource of "Tiefer Bünau Stollen" is almost completely mined out, it provides an excellent possibility for studying the variability of the greisen ore bodies in terms of mineralogy and geochemistry.

9.2 Underground Trench Sampling

An underground sampling campaign was conducted in the year 2012 [44], which provided a series of 88 greisen trench samples from the sidewalls of the “Tiefer-Bünau-Stollen” (752 m a.s.l.) and the “Tiefer-Hilfe-Gottes Stollen” (THG) galleries (722 m a.s.l.).

The lithium grades of these trenches were comparable to the results from drill cores with respect to range and variability. The horizontal distribution of lithium grades was found to be relatively homogenous with the exception of high and low outliers due to mica-rich nests or barren quartz greisen, respectively. Lithium distribution is closely linked to the amount of zinnwaldite in the rock. Known from numerous publications, tin and tungsten show a more heterogenic distribution in the greisen mineralization, which was adequately reproduced by the trench sampling method.

The comparison of results from the two different levels of about 40 m vertical distance allowed the discrimination of two geochemically different greisen zones. The upper level showed greisen mineralizations which are more Li-rich and poor in Sn and W, whereas the lower level revealed element concentrations vice versa. Since the mine workings give only an insight into the upper parts of the greisen mineralization, predictions of deeper positioned ore bodies must be made with care.

Trench sampling was conducted discontinuously from March to April 2012 [66]. First step was to mark the starting point at each sampling locality and to label 2 m intervals on the walls of the gallery by using chalk and ribbons.

The trenches were cut with a handheld electric Dollmar diamond stone saw (type EC 2412). Therefore, the electric power supply of a junction box next to the Albert shaft was used. Dust formation was reduced by using a water sprayer. For each trench two parallel slits were cut at distance of 4 to 5 cm to contour the trench over the complete height of the gallery. The depths of the slits varied slightly between about 2 cm and 3 cm.

After cleaning the dusty faces with brushes and fresh water the rock material between the slits was diggeded out with hammer and chisel. Particular attention was paid to sample a series of rock bars and not to pulverise the slivering rock as this may result in the separation and therefore loss of minerals of different density and rigidity. The broken material was collected in a big plastic trough held directly beneath the particular sampling section.

After completion of a trench the material was packed into labelled plastic bags and transported to the surface. In analogy to samples from drill cores a sample ticket with a distinct sample number and other information was inserted. The tools and plastic troughs were cleaned with water to avoid contamination of the next sample.

Health and safety measures included use of helmets, safety boots, safety glasses, ear protection and dust respirator. To discharge continuously dusty mine air the ventilation within the mine was controlled by the help of an aerometer. Additionally, different mine doors have been regulated to ensure a fast and effective aeration.

9.3 Bulk Underground Sampling

About 20 t of bulk ore material was recovered from the underground mine workings of Zinnwald for mechanical processing and metallurgical test work during August 2011 [8]. For further beneficiation studies a 100 t greisen ore sample from two selected parts of the Zinnwald public pisitors mine was collected in August 2017 ([28], [31], [100]).

9.4 Mapping

There are only a few detailed geological maps combining the information from the German and the Czech sides of the deposit. A first comprehensive geological map of the area was presented by DALMER (1890), revised version by GÄBERT in 1908 (scale 1:25,000, see [324]). Later detailed geological maps with cross sections of the German part were produced during the three major exploration campaigns and compiled by BOLDUAN & LÄCHELT, 1960 [249], GRUNEWALD, 1978a [259], and BESSER & KÜHNE, 1989 [265]. The Czech part of the deposit was mapped and studied in detail by ČABLA & TICHY, 1985 [262]. Information from underground mining is presented in several upright projections compiled by TICHY et al., 1961 [244].

The underground trench sampling of 2012 was accompanied by detailed mapping of the sampling localities and their immediate surroundings as far as they were accessible. These works were done at a mapping scale of 1:50 by B.Sc. Matthias Bauer from the Technical University Bergakademie Freiberg (NEßLER, 2012a [65], 2012b [66]). For visualization of the recordings a method was chosen, that allowed the detailed documentation of the roof and both drift faces considering lithology, mineralogy, faults and cleavages as well as the trench location (see report NEßLER, 2012b [66]).

10 Drilling

10.1 Overview

SolarWorld Solicium GmbH (SWS) and its successor Deutsche Lithium GmbH (DL) have performed two exploration drilling campaigns on the Zinnwald lithium property, respectively:

- 10 drill holes in 2012 and 2013 to 2014
- 15 drill holes in 2017

For the exploration drilling program of the years 2012 to 2014 SWS contracted various German drilling companies including Geomechanik Bohrungen und Umwelttechnik GmbH Sachsen (Geomechanik) from Penig, BOG Bohr- und Umwelttechnik GmbH from Caaschwitz (BOG, as subcontractor of Geomechanik) and Pruy KG from Schönheide. Drill rig positioning was restricted in some cases by the existing land-use dominated by scattered dwellings within pasture areas. The drilling program used both wire line diamond core and percussion drilling (PD) equipment. Reverse circulation (RC) equipment was applied only in a single twin hole for test purposes.

For the second drilling program GEOPS Bolkan Drilling Services Ltd. of Asenovgrad / Bulgaria was commissioned by DL. Drilling started on 27 September 2017 with two Atlas Copco Christensen wire line diamond core rigs operated parallel by two teams of the company. At the end of the campaign three rigs were used in parallel. Five of the planned holes had to be relocated to alternative places, because several landowners refused access to their land. Drilling was successfully completed at the end of December 2017.

10.2 Drilling Program 2012 – 2014

SWS completed 10 drill holes with a total length of 2,484 m. While drilling in 2012 focused on the verification of historic data by two twin holes, drilling locations of 2013-2014 were chosen on the basis of the first geostatistical results (see also NEßLER & KÜHN, 2012 [69] and HARTSCH et al., 2013 [80]). A maximum drill hole spacing of about 120 m was considered to be adequate for the infill holes. Particular attention was paid on greisen ore bodies on the southeastern part of the property where historic drilling was limited. Including the drill holes of all historic campaigns a new drill grid was designed with a drill hole spacing ranging from 150 m to 250 m along north-south and east-west profiles. The holes were drilled down to depths between 79 m and 376 m. 8 of 10 holes achieved or exceeded their planned target depth. For the first two holes diamond core drilling technology was used. During the second campaign the approach was changed. To avoid problems by old mine stopes a pre-collaring by percussion drilling was used to provide fast and cost-effective access to the level below the known historic mine workings (740 m a.s.l.).

The depth of 740 m a.s.l. represents the top of the resource model. Below this level diamond core drilling took place. Additionally, one reverse circulation hole was drilled to duplicate a previous diamond drill hole. For all drill holes inclination logging was conducted every 1 m in 2012 and every 0.05 m in 2013/14.

Figure 24 shows the location and distribution of recent and historic drill holes at Zinnwald.

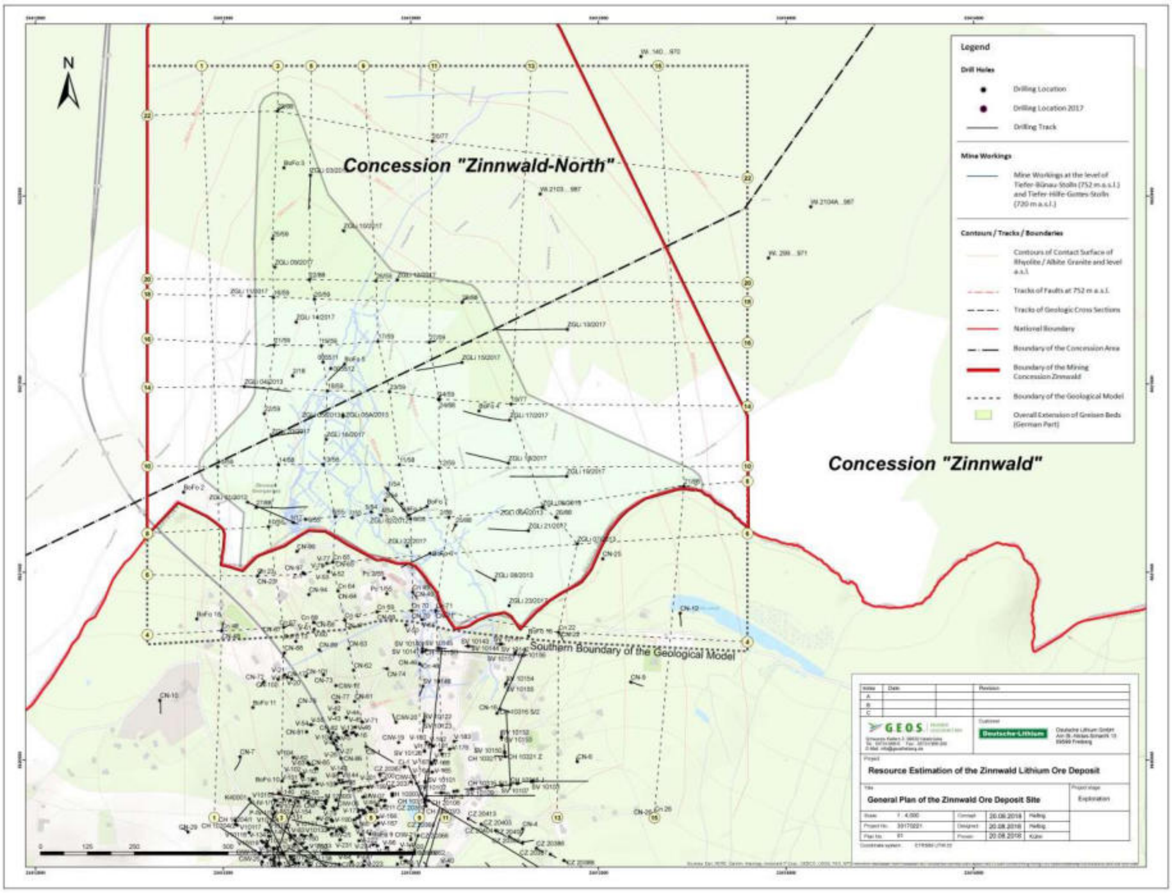


Figure 24: Overview map of drill holes in the concession area

10.2.1 Drill Hole Summaries

A summary of the drilling performance and of significant lithium results is presented in the following *Table 23* to *Table 26* respectively.

Drilling within the Zinnwald property has confirmed the presence of several lithium bearing greisen ore bodies with dimensions of around 1 km from north to south and of around 1 km in east-west direction at a depth below 820 m a.s.l. Convex and flat to moderately dipping ore bodies follow the endo-contact of the granitic intrusion of Zinnwald / Cínovec. Generally, the orebodies decrease in frequency and thickness with depth.

Greisen mineralization was intersected in every of the holes drilled by SWS. Intersected thicknesses range between a minimum of 0.1 m and a maximum of 43.7 m from drill holes ZGLi 6/2013 and ZGLi 6A/2013, respectively. The deepest exposure of greisen ore was encountered in drill hole ZGLi 07/2013 at a depth of 376 m (416 m a.s.l.).

The contact zone of greisen and the host rock albite granite (ZG) is either sharp or diffuse and is a few centimeters to some decimeters thick. There are numerous intersections of strongly argillic-altered and hematized ZG adjacent to greisen with and without feldspar relicts, which exhibit a total thickness in the order of several meters. Sharp contacts of greisen and poorly greisenized ZG occur independently of depth, position against the greisen bodies (hanging or footwall), and thickness of the greisen bodies.

True vertical thickness of the greisen ore bodies corresponds to the position along the granite contact and is therefore consistent with the vertical depth for the central parts where the dip angle is less than 10°. Towards the gently inclined (10-30°) flanks of the N, E and S and the steeply inclined (40-70°) western flank, the true vertical thickness needed to be calculated adequately.

Ideas on the spatial orientation of the ore bodies were up to now based on exploration and research of the last 65 years. The model of elongated, N-S trending greisen bodies must be revised to some extent by the results of the SWS drill campaign. A set of shallower greisen bodies occurs in the center of the deposit (southern part of the property), whereas greisen bodies were found towards the northern and the eastern flank at deeper levels. More detailed information is presented in *chapter 7.3.*

The tectonic situation was in particular complicated along the western flank of the intrusion. Therefore, drilling results needed to be carefully compared and adjusted with historic mining documents of the German and Czech part to design a coherent lithological-tectonic model.

Log sheets visualizing and summarizing all drilling results were prepared with Golden Software's Strater® 4 which combines information on lithology, alteration, structure, geochemical and geotechnical parameters. Depths are presented as drilled length (m), true vertical depth (m) and depth above sea level (m a.s.l.).

Table 23: Summary of drilling performance by SWS during 2012 and 2014

Drillhole number	Start of drilling	End of drilling	Drilling performance		Total drilling & inclination survey (m)			Percussion drilling (m)		Diamond drilling (m)	
	Date	Date	Drilling Days	Meters per Day	Plan	Actual	Survey	Plan	Actual	Plan	Actual
ZGLi 01/2012	09.04.12	21.05.12	26	10.8	280	280.0	276.30	-	-	280.0	280.0
ZGLi 02/2012	02.04.12	29.05.12	35	7.5	260	262.5	262.50	-	-	260.0	262.5
ZGLi 3/2013	17.09.13	21.11.13	45	7.3	325	330.2	330.51	65	65	260.0	265.3
ZGLi 4/2013	20.08.13	01.10.13	31	8.4	260	260.0	154.35	68	68	192.0	192.0
ZGLi 5/2013	13.08.13	28.08.13	12	13.0	155	156.3	156.00	55	55	100.0	101.3
ZGLi 6/2013	29.08.13	04.10.13	27	8.5	334	221.3	100.25	40	40	294.0	181.3
ZGLi 6A/2013	07.10.13	14.11.13	24	14.0		336.4	334.73		200		136.4
ZGLi 7/2013	10.10.13	10.01.14	62	6.1	363	376.2	375.55	50	50	313.0	326.2
ZGLi 8/2013	04.11.13	17.01.14	50	5.2	259	260.8	259.95	64	64	195.0	196.8
Sum				**Ø 8.0**	**2,236**	**2,483.7**	**2,250.14**	**342**	**542**	**1,894**	**1,941.8**
ZGLi 5A/2013 (RC-Drilling)	24.01.14	29.01.14	4	19.8	150	79	41.49	150	79	---	---

Table 24: Summary of significant Li grades obtained in the SWS drill holes

Drill hole number	Depth from [m]	Depth to [m]	Drilled thickness [m]	Mean Li [ppm]
ZGLi 02/2012	71.3	82.6	11.3	3,908
ZGLi 02/2012	85.5	114.5	29.0	4,014
ZGLi 04/2013	173.4	179.4	5.9	3,903
ZGLi 04/2013	200.5	207.0	6.5	2,722
ZGLi 05/2013	57.3	66.3	9.0	4,137
ZGLi 05/2013	115.2	127.3	12.2	3,554
ZGLi 06A/2013	214.0	264.0	50.0	4,711
ZGLi 07/2013	238.3	254.7	16.4	2,646
ZGLi 07/2013	349.9	355.6	5.8	2,991
ZGLi 08/2013	121.4	146.6	25.2	3,121

10.2.2 Core Recovery and RQD

Drill core recovery was recorded at the drilling site and ranged on average between 97.4 % for the ore zones and 98.9 % for the total drilled length.

In drill hole ZGLi 06/2013 a zone of intense alteration was intersected from 167 to 171.5 m and from 175 to 182 m which corresponds to the lithological contact of TR and quartz-poor mica greisen. Due to greisenization accompanied by a strong hydrothermal overprint both lithologies were transformed to loose clay material and rock fragments. Possible tectonic movements within this zone are indicated by brecciation features. Core recovery within this zone dropped below 90 % and partly to 33 %. Further drilling of this zone caused a deadlock of the drill string at a depth of 220 m. For this reason and since the planned final depth was not achieved drilling was halted and the compensatory drill hole ZGLi 06A/2013 was collared about 1.5 m further east. Percussion drilling was then performed to a depth of 161.5 m and again from 180 to 211.5 m. No complications occurred during further diamond drilling and ZGLi 06A/2013 reached the envisaged final depth (334.7 m) with the required core recovery of at least 95 %.

Analogously, the rock quality designation index (RQD) was recorded at the drill site. One value was documented for every drill run (usually 3 m long; in rare cases 1.5 m). It ranged from 0 to 100 %. Average RQD value for the total drilled length was about 88.0 %.

10.2.3 Drill Core Logging

Detailed drill core logging was carried out in the project camp by the geologist of the Technical University Bergakademie Freiberg. It is important to note, that all drill core was logged by the same geologist throughout both SWS exploration campaigns.

Log sheets were coded and details recorded downhole for lithology (including types of greisen and intensity of greisenisation), modal composition, rock color, texture, alteration type, alteration intensity, degree of decomposition and other observations. Special emphasis was given to the distribution of different types of greisen mineralization, related alteration mineral associations, and the presence of various types of veins / veinlets and structures.

Geotechnical parameters were recorded including the percentage of core recovery, index of rock quality designation (RQD), cleavage density and features of tectonic stress, as well as fracture fill material. Additionally, all drill cores were photographed either on drill site or in the project camp. All data was then transferred to a digital database.

10.2.4 Drill Core Sampling

In 2012 the core diameter was 101 mm (NSK 146/102). Labelling and photographing took place at the drilling site (five consecutive core boxes per photograph). After the transport of the core boxes to the permanent core shed next to the main facilities of SWS the cores were cut by a local mason using an automatic diamond stone bridge saw.

The main difference in sample preparation of the 2013 – 2014 campaign compared with 2012 campaign was set up by the reduction of the core diameter to NQ (47 mm). In addition, core cutting was performed directly in the temporary project camp in the immediate vicinity of the drilling field. Cutting was carried out by a transportable diamond bladed core saw. The detailed logging procedure and photography was performed when ten consecutive core boxes were arranged.

A diamond rock saw was used, because it is the most accurate cutting tool, when no sooty or water-soluble minerals are present, which could be lost by wet cutting. Broken or significantly disintegrated core was divided with a trowel in equal parts in order to obtain a representative sample. This work was assisted permanently by at least one person of the responsible and qualified SWS staff.

Core runs were 3 and 1.5 m long. The cores were placed in core boxes of 1 m length by the drilling crew after cutting with a diamond saw and were systematically logged by the geological staff either at the drilling site or in the project camp immediately after delivery. RQD and core recovery were measured prior to the core cutting. After transportation to the permanent core shed (in 2012) or to the temporary project camp at Zinnwald (in 2013-2014) the sample segments were marked for splitting.

Sample length should not deviate from 1.0 ± 0.2 m while considering lithological boundaries and different greisenization intensities. Extreme deviations were an exemption represented by a minimum length of 0.30 m and a maximum of 1.55 m. The median sample length was 1.0 m as shown in the histogram of *Figure 25.* After cutting, one core quarter (in the campaign of 2012) or one core half (in the campaign of 2013 – 2014) was placed in plastic sample bags and tagged accordingly. Core splitting and sampling took place according to the routine that a minimum sample mass of 2 kg was required for preparing the pulp for the chemical analyses.

The sample tickets provided information on project name, drill hole number, sample number, depth interval, lithology code, date of sampling as well as the name of the sampling staff and were put in a robust plastic bag. Additionally, the sample bag was labelled with the number of drill hole and the depth interval. Both the sample bag and tag were marked with a distinct sample number decoding the type and year of the sample, the corresponding drill hole number and a consecutive sample number.

Pre-printed tags were used to avoid double numbers or transposed digits. A strap of seven more sample number tags was put in each sample bag for later usage. Finally, cable ties were used to seal the bags and batches of 20 samples, which were prepared for transportation. In order to allow a quick reference of the assays back to the core, the sample intervals and numbers were marked on the long side of the wooden trays placed in the core boxes.

For exploration projects it is commonly required, that some core must be retained for future examination and verification. Accordingly, all drilled cores from the project were transported to Freiberg and stored in a secured and well-organized manner in a high bay warehouse on the facilities of SWS.

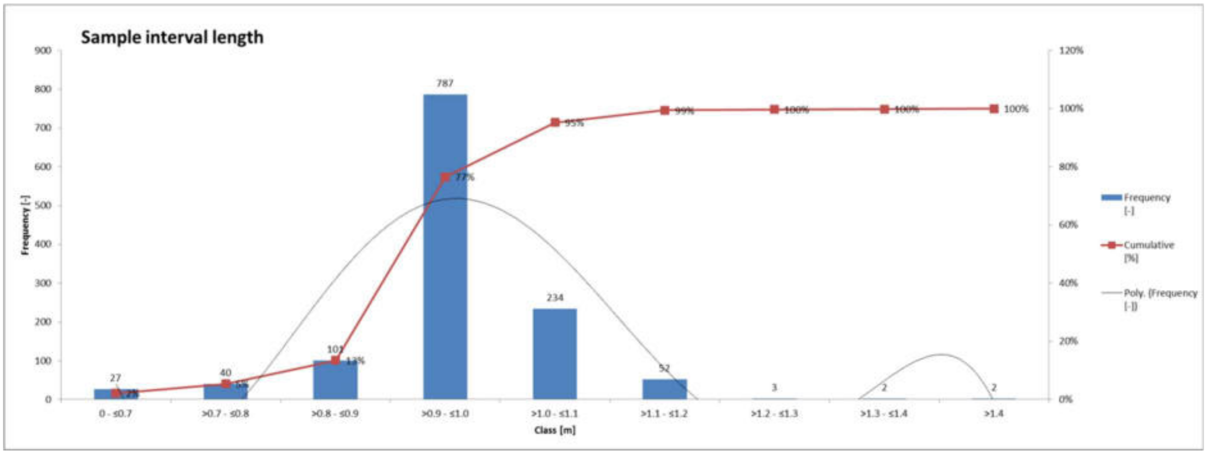


Figure 25: Histogram of sample length from drill core samples of the period 2012 – 2014 (N = 1,258)

10.3 Drilling Program 2017

The 2017 exploration program by DL consisted of 15 surface diamond drill holes with a total length of 4,458.9 m. Depending on the near-surface conditions in the overburden the first 10 m or so were drilled with PQ 85.0/122.6 mm diameter. Owing to technical reasons, HQ 63.5/96.0 mm diameter was used below down to a maximum of 60 m depth. NQ diameter holes with 75.7/47.6 mm were drilled at greater depth in the granite and the ore zones. The holes were planned on the one hand as infill holes to improve the density of the drill grid and on the other hand to verify the continuity of ore bodies towards the external borders of the deposit. Drill hole surveys and refilling (cementation) were conducted on the last drilling day or on the following day. Naturally, the geological and sampling team had changed between the two drilling campaigns. Procedures, however, were kept more or less identical. However, in order to assure a transparent documentation and high-quality results of this exploration campaign a new **Q**uality **A**ssurance/**Q**uality **C**ontrol (QA/QC) instruction [99] was worked out by the DL project leader, which is authoritative for the technical implementation during drilling, sampling, sample preparation and sample processing. A summary flowsheet of the work instructions is shown in the next chapter. The whole process of the QA/QC program was supervised and controlled by the responsible project leader of DL. In addition, the consistent adherence of this QA/QC program with respect to the requirements of the NI 43-101 standard was monitored by the independent qualified persons.

The following principles were adhered for the initial drill core documentation and processing:

- Each cored interval and each core box must be numbered in clear ascending order
- The core must be placed in sections of 1m within core boxes which have a minimum length of 1.05 m.
- The core boxes are labelled on the upper side and on the front side
- Core losses are logged for each cored interval
- The cores are photographed within the core boxes (3 m intervals)
- One half of the drill core is archived. The other half is used for geochemical and if necessary mineralogical and other investigations
- Sawing of the cores is exclusively done by the responsible specialized company (GEOMONTAN GmbH & Co.KG, Großschirma)
- The cores are sawed along the long axis of the core and the two halves are positioned correctly back into the core box
- The professional execution of the sawing is monitored by the responsible geologist
- Prior to sampling adherent sawing mud is removed from the core pieces

10.3.1 Drill Hole Summaries

Table 25: Summary of drilling performance by DL in 2017

Drillhole ID	Start of drilling	End of drilling	Drilling performance		Total drilling & inclination survey (m)		
	Date	Date	Drilling Days	Meters per Day	Plan	Actual	Survey
ZGLi 09/2017	02.10.17	10.10.17	9	27.6	249	249	249.1
ZGLi 10/2017	26.09.17	04.10.17	10	26.5	265	265	265.1
ZGLi 11/2017	11.10.17	21.10.17	10	27.1	271	271	271.1
ZGLi 12/2073	14.11.17	22.11.17	11	23.6	260	260.0	260.2
ZGLi 13/2017	02.12.17	15.12.17	15	28.7	430	430	430.2

Drillhole ID	Start of drilling	End of drilling	Drilling performance		Total drilling & inclination survey (m)		
	Date	Date	Drilling Days	Meters per Day	Plan	Actual	Survey
ZGLi 14/2017	07.12.17	15.12.17	9	23.0	207	207	207.2
ZGLi 15/2017	16.11.17	30.11.17	15	22.1	331	331	331.1
ZGLi 16/2017	06.11.17	14.11.17	9	25.7	231	231	231.3
ZGLi 17/2017	16.10.17	28.10.17	13	26.0	335	338	338.3
ZGLi 18/2017	14.12.17	27.12.17	14	23.0	322	322	322.2
ZGLi 19/2017	27.11.17	12.12.17	15	24.9	374	373.8	373.8
ZGLi 20/2017	07.10.17	03.11.17	30	17.4/ 27.4	259	259	259.0
ZGLi 21/2017	14.11.17	24.11.17	12	27.0	324	324	324.1
ZGLi 22/2017	24.11.17	04.12.17	11	23.1	262	254	254.2
ZGLi 23/2017	26.10.17	10.11.17	17	20.1	342	342	342.0
Sum				**Ø 25.05**	**4,462**	**4,456.8**	**4,458.9**

The drilling results of the 2017 campaign fulfilled the predictions and verified the preliminary geological model of the previous campaign. Drill hole ZGLi 11/2017 with an ore intercept of 26 m even confirmed the continuation of greisen beds beyond the expected limits of the deposit in the west.

Drilling progressed without major problems, with the exception of drill hole ZGLi 20/2017, where three caverns were met, and rods lost. ZGLi 22/2017 was deadlocked and aborted 8 m before the planned depth was reached.

Table 26: Summary of significant Li grades obtained in the DL drill holes

Drill hole ID	Depth from [m]	Depth to [m]	Drilled thickness [m]	Mean Li [ppm]
ZGLi 09/2017	120.45	133.93	13.48	2,957
ZGLi 10/2017	147.30	157.35	10.05	3,986
ZGLi 10/2017	226,23	236.80	10.57	2,396
ZGLi 11/2017	136.15	166.7	30.55	3,627
ZGLi 11/2017	175.20	181.90	6.70	2,526
ZGLi 12/2017	141.8	148.3	6.50	3,835
ZGLi 13/2017	260.50	263.65	3.15	3,029
ZGLi 14/2017	81.30	97.7	16.40	3,724
ZGLi 14/2017	97.7	107.95	10.25	4,388
ZGLi 14/2017	107.95	112.95	5.00	4,046
ZGLi 15/2017	275.50	297.20	21.70	5,894
ZGLi 16/2017	34.60	42.35	7.75	2,162
ZGLi 16/2017	52.40	67.15	14.75	3,017
ZGLi 16/2017	118.75	122.50	3.75	6,240
ZGLi 18/2017	310.60	314.95	4.35	2,787
ZGLi 19/2017	297.20	301.50	3.50	3,195
ZGLi 20/2017	91.75	102.85	11.10	4,693
ZGLi 20/2017	107.30	123.60	16.30	3,392
ZGLi 20/2017	123,60	137.75	14.15	5,926
ZGLi 20/2017	145.75	154.35	8.60	2,805
ZGLi 20/2017	190.30	193.9	3.60	3,256
ZGLi 21/2017	151.10	165,90	14.8	2,196
ZGLi 21/2017	165.90	177.10	11.20	3,012
ZGLi 21/2017	177.10	189.20	12.10	2,994
ZGLi 22/2017	37.20	53.70	16.50	3,664
ZGLi 22/2017	140.80	163.15	22.35	2,555
ZGLi 23/2017	201.80	205.25	3.45	6,299

10.3.2 Core Recovery, RQD and Drill Core Logging

Rock Quality Designation Index (RQD) determinations, ambient gamma radiation dose rate measurements and a general lithological logging were conducted by personnel of Dr. Sprang Ingenieurgesellschaft für Bauwesen, Geologie und Umwelttechnik mbH, Freiberg office and BOG Bohr- und Umwelttechnik GmbH in Caaschwitz.

Drill core recovery and detailed drill core logging as well as core sampling was performed by DL staff in a warehouse on the former German / Czech border station near Zinnwald. Core recovery ranged between 97.9 and 99.5 %

10.3.3 Drill Core Sampling

The core sample intervals were defined following the geological and mineralogical description and interpretation by the responsible geologist. Standard length of the sample interval is 1 m, with a special focus, however, on lithological boundaries. Thus, core splitting was done at sharp lithological boundaries. Fuzzy or gradual boundaries exceeding a total thickness of 0.5 m were sampled individually. If the transitional zones amounted to less than 0.5 m, they were split onto both adjacent lithologies. If alternating lithologies with a thickness of < 1 m were met, these intervals were sampled as coherent sample.

Splitting of the sample intervals was done by a saw or angle grinder. Sample sections were packed in adequately labelled sample bags containing a sample ticket inside. In the case of a poor condition of the core (e.g. fine-grained material, clayey material, fault zones etc.) sampling was done along the long axis of the core using appropriate tools (e.g. palette knives, spoons).

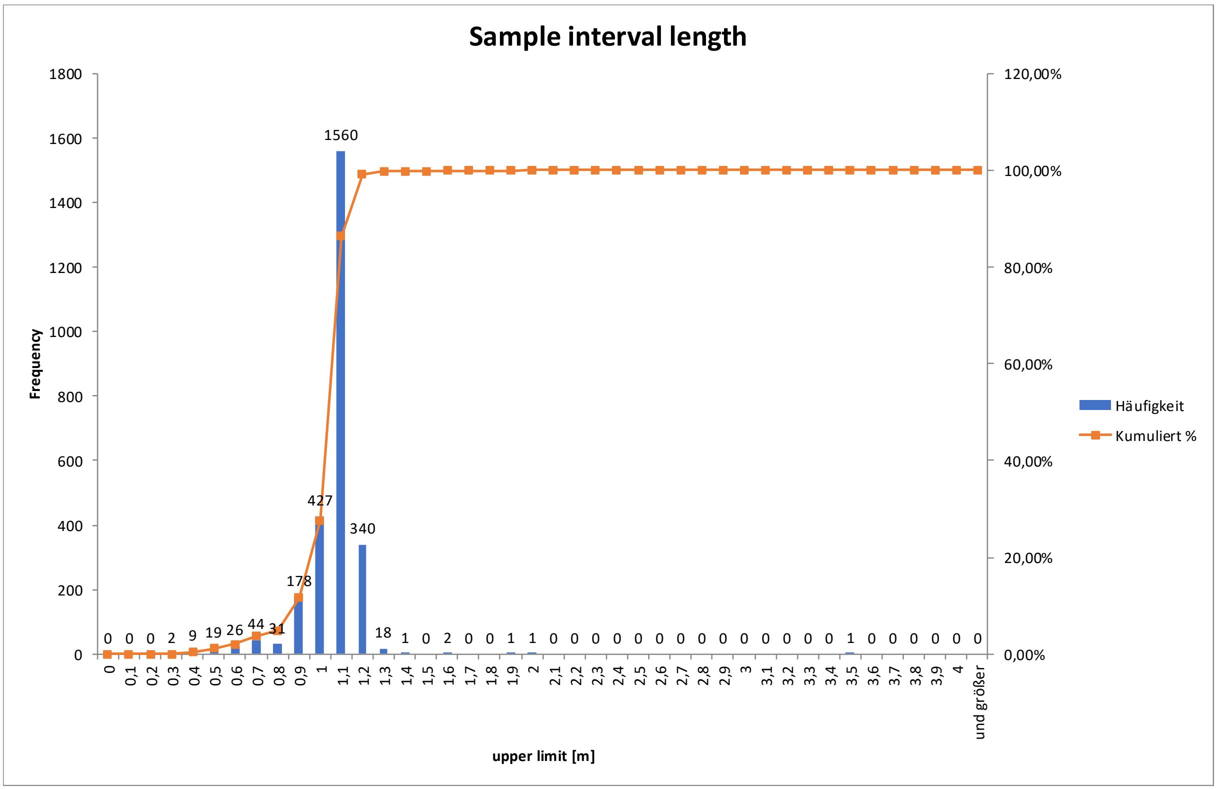


Figure 26: Histogram of sample length from drill core samples of the campaign 2017 (N = 2,660)

Sample length ranged generally between 0.3 and 1.4 m. Only four samples were more than 1.6 m long due to core loss. Sample length from 2,660 samples averages to 0.98 m.

11 Sample Preparation, Analysis and Security

11.1 2012 – 2014 Drilling Campaign

11.1.1 Method of Sample Preparation

Following the geological documentation and sampling procedure at the project camp site all subsequent sample preparation was executed in the processing laboratory of G.E.O.S.. The samples were transported at least once every two weeks to the laboratory by project personnel. The accompanying documents containing a list with the sample numbers were signed by the responsible personnel handing over and receiving the material to assure a chain of custody. Within the laboratory of G.E.O.S the samples were partitioned to batches consisting of not more than 20 samples were handled at the same time. If required, samples first were dried overnight within a drying kiln. Following weighing the entire sample was crushed using a jaw crusher (RETSCH BB 200) to 80 % passing 10 mesh (2 mm) sieves. About 500 g of crushed material was split and further grinded to 95 % passing 150 mesh (63 µm) sieves within a ring-and-puck pulverizer (MSL

2 of former VEB Bergbau- und Hüttenkombinat „Albert Funk“ in Freiberg). The particle size of the samples was checked by simple finger test and again by screening random samples in the executing geochemical laboratories.

For each sample a 50 g split of the pulp was placed in an envelope and labeled with pre-printed tags. The remainder of the 500 g pulp sample was saved. For samples that were envisaged for QA/QC procedures like duplicates three more subsamples of 50 g each were split off from the pulp reject. All splitting procedures were performed using a riffle splitter made of stainless steel. Remaining material of different grain sizes was packed and labeled accordingly and sent back to the permanent core shed. To avoid contamination, jaw crusher, disk mill and all tools were cleaned neatly after every sample by the help of a stiff brush and high-pressure air. In addition, the ring-and-puck pulverizer was cleaned by grinding with pure quartz sand on a daily basis. Envelopes for the pulps were laid out on the sample preparation pad to allow the insertion of standards to the batches before shipment.

Once QA/QC samples had been inserted the samples were placed in batches of approximately 150 to 350 samples into robust cardboard boxes which were sealed and marked up with the containing sample numbers and shipping details.

All procedures were carefully attended and met industry standards for collection, handling and transport of drill core samples.

11.1.2 Methods of Analysis

All drill core samples of the SWS exploration activities during 2012 and 2014 were analyzed by the accredited commercial ALS laboratory at Roşia Montană, Romania. The analytical package comprises the determination of 53 elements. For this purpose, several different digestion and analytical methods were applied.

Lithium which is incorporated in semi-resistant micas was analyzed together with the group of base metals and scandium by ICP-MS after a four-acid digestion (Code ME-4ACD81). One sample that exceeded the maximum detection level for lithium of 10,000 ppm was additionally analyzed using four acid digestion and AAS finish (Code: Li-OG63).

Tin and tungsten together with a broad range of other trace elements including rare earth elements were fused with lithium metaborate followed by an acid digestion and ICP-MS measurement (Code ME-MS81d). This technique solubilizes most mineral species including those, which are highly refractory.

An identical procedure was applied for the group of major elements (Code: ME-ICP06). During the first campaign (2012) tin and tungsten were additionally analyzed by wavelength dispersive XRF analysis (Code XRF05) on pressed pellets for cross checking with the results of ICP-MS analysis of fused pellets.

Samples of the second campaign (2013 – 2014) that exceeded the maximum detection level for tin of 10,000 ppm were additionally analyzed by the ion selective electrode method (ISE) following Na_2O_2 fusion and citric acid leach. Ion chromatography after KOH fusion was used to analyze fluorine (Code F-ELE82 and F-IC881).

Duplicates were sent to Activation Laboratories Ltd. in Ancaster, Canada for analysis. Analogous to the digestion procedure at ALS the sample material was treated with a four-acid leach and measured for lithium with ICP-OES (Code 8 Lithium ore). The group of elements including tin, tungsten, base metals and rare earth elements was analyzed together with the major elements by ICP-MS and ICP-OES after fusion with lithium metaborate / tetraborate and an acid leach. Sodium peroxide fusion and ICP-MS finish was utilized for samples exceeding the upper limit of detection of tin (Sn >10,000 ppm). Fluorine was measured using ISE.

The list of elements analyzed by ALS including the analytical code, the lower and upper detection limits is shown in *Table 27*.

Table 27: List of elements analyzed at the ALS laboratory, codes of analytical procedure and limits of detection

Element	Code	Unit	lower LOD	upper LOD	Element	Code	Unit	lower LOD	upper LOD
Ba	ME-MS81d	ppm	0.5	10,000	SiO_2	ME-ICP06	%	0.01	100
Ce		ppm	0.5	10,000	Al_2O_3		%	0.01	100
Cr		ppm	10	10,000	Fe_2O_3		%	0.01	100
Cs		ppm	0.01	10,000	CaO		%	0.01	100
Dy		ppm	0.05	1,000	MgO		%	0.01	100
Er		ppm	0.03	1,000	Na_2O		%	0.01	100
Eu		ppm	0.03	1,000	K_2O		%	0.01	100
Ga		ppm	0.1	1,000	Cr_2O_3		%	0.01	100
Gd		ppm	0.05	1,000	TiO_2		%	0.01	100
Hf		ppm	0.2	10,000	MnO		%	0.01	100
Ho		ppm	0.01	1,000	P_2O_5		%	0.01	100
La		ppm	0.5	10,000	SrO		%	0.01	100
Lu		ppm	0.01	1,000	BaO		%	0.01	100
Nb		ppm	0.2	2,500	LOI		%	0.01	100
Nd		ppm	0.1	10,000	Total		%	-	-
Pr		ppm	0.03	1,000	Ag	- 4A CD	ppm	0.5	100

Element	Code	Unit	lower LOD	upper LOD	Element	Code	Unit	lower LOD	upper LOD
Rb		ppm	0.2	10,000	As		ppm	5	10,000
Sm		ppm	0.03	1,000	Cd		ppm	0.5	1,000
Sn		ppm	1	10,000	Co		ppm	1	10,000
Sr		ppm	0.1	10,000	Cu		ppm	1	10,000
Ta		ppm	0.1	2,500	Mo		ppm	1	10,000
Tb		ppm	0.01	1,000	Ni		ppm	1	10,000
Th		ppm	0.05	1,000	Pb		ppm	2	10,000
Tl		ppm	10	10,000	Sc		ppm	1	10,000
Tm		ppm	0.01	1,000	Zn		ppm	2	10,000
U		ppm	0.05	1,000	Li		ppm	10	10,000
V		ppm	5	10,000	Li	Li-OG63	%	0.005	10
W		ppm	1	10,000	Sn	XRF05	ppm	5	10,000
Y		ppm	0.5	10,000	W		ppm	10	10,000
Yb		ppm	0.03	1,000	F	F-IC881	ppm	20	20,000
Zr		ppm	2	10,000	F	F-ELE82	%	0.01	100

11.1.3 Quality Assurance and Control Measures

Quality assurance and control procedures are required to review the reliability of the assay results. For this reason, control samples had to be included into the analytical program. Control samples may consist of blanks, duplicates and reference standard samples in addition to an appropriate number of duplicate samples analyzed by an external laboratory. Blank samples test for contamination, internal duplicates for contamination, precision as well as intrasample variance grade and reference standards test for assay precision and accuracy. Core quarter duplicates, pulp duplicates, and internal standard material were analyzed in the project.

ALS and Actlabs are certified by the International Organization for Standardization to ISO 9001:2008 and / or are accredited after ISO 17025. The laboratories used internal quality control systems. Each assay certificate lists the sample results plus the lab's internal sample control results based on own duplicates, blanks and certified reference standard pulps. They were inserted for each batch.

Reporting of assay results from the laboratory was transferred to SWS in electronic format using both Excel files and PDF format. Complete and final assays were prepared by the labs in PDF format with the lab certification results for each batch.

11.1.3.1 Internal Standard Material

The accuracy of laboratory results during the drilling / sampling program was monitored by two non-referenced internal standards prepared by SWS. Material from preliminary processing test work was used to create the internal lithium standard IS1, a high-grade material made from magnetic separates, and IS2, a low-grade material made from tailings of magnetic separation. About 10 kg of each material was crushed and milled to 95 percent passing 150 mesh (63 µm) sieves, homogenized and bagged in envelopes at the facilities of a local research institute for mechanical processing (UVR FIA in Freiberg). Some 50 g were provided for each standard which was designated for the sample batch.

During the first campaign in 2012 each standard was placed in a frequency of 1 in 40 (2.5 %) while it was reduced to 1 in 80 (1.25 %) in 2013 – 2014.

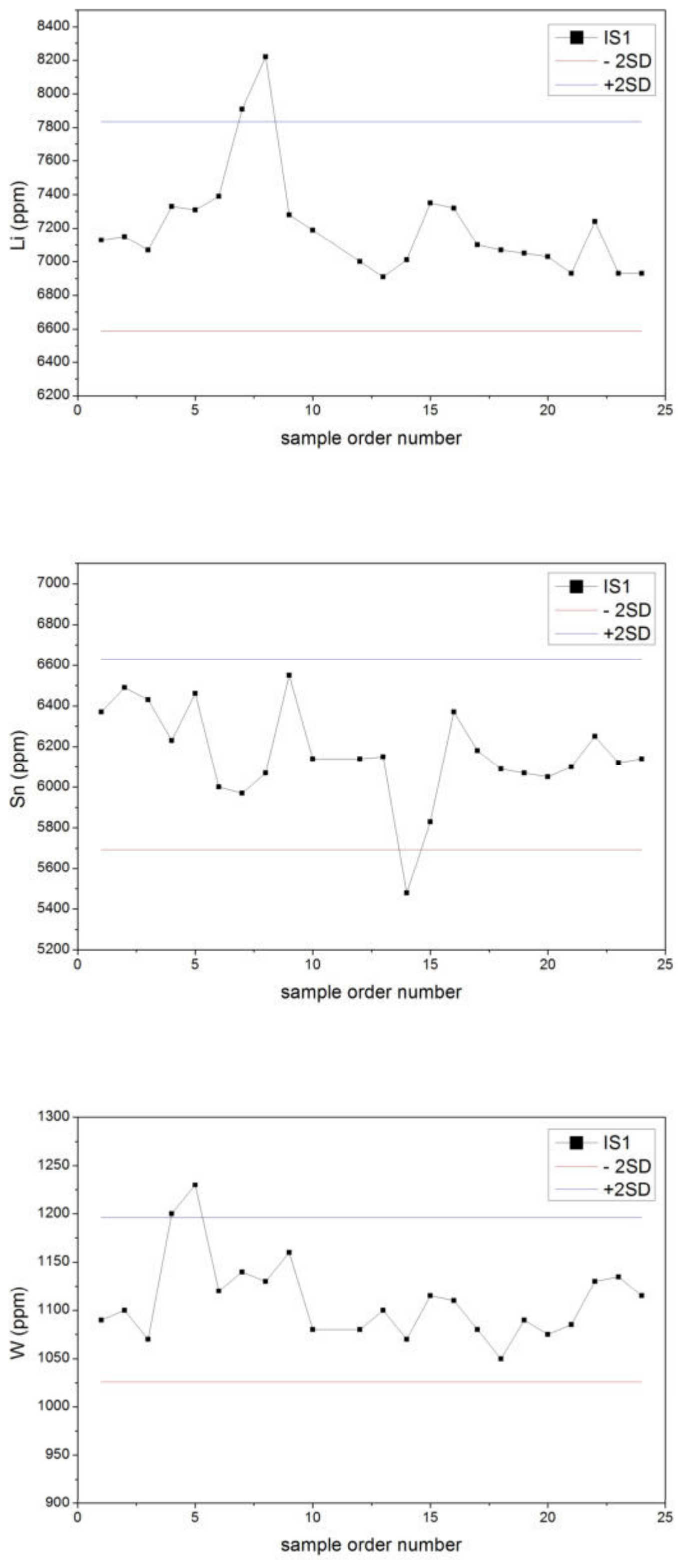


Figure 27: Li, Sn and W control assays for internal standard IS1 (high grade)

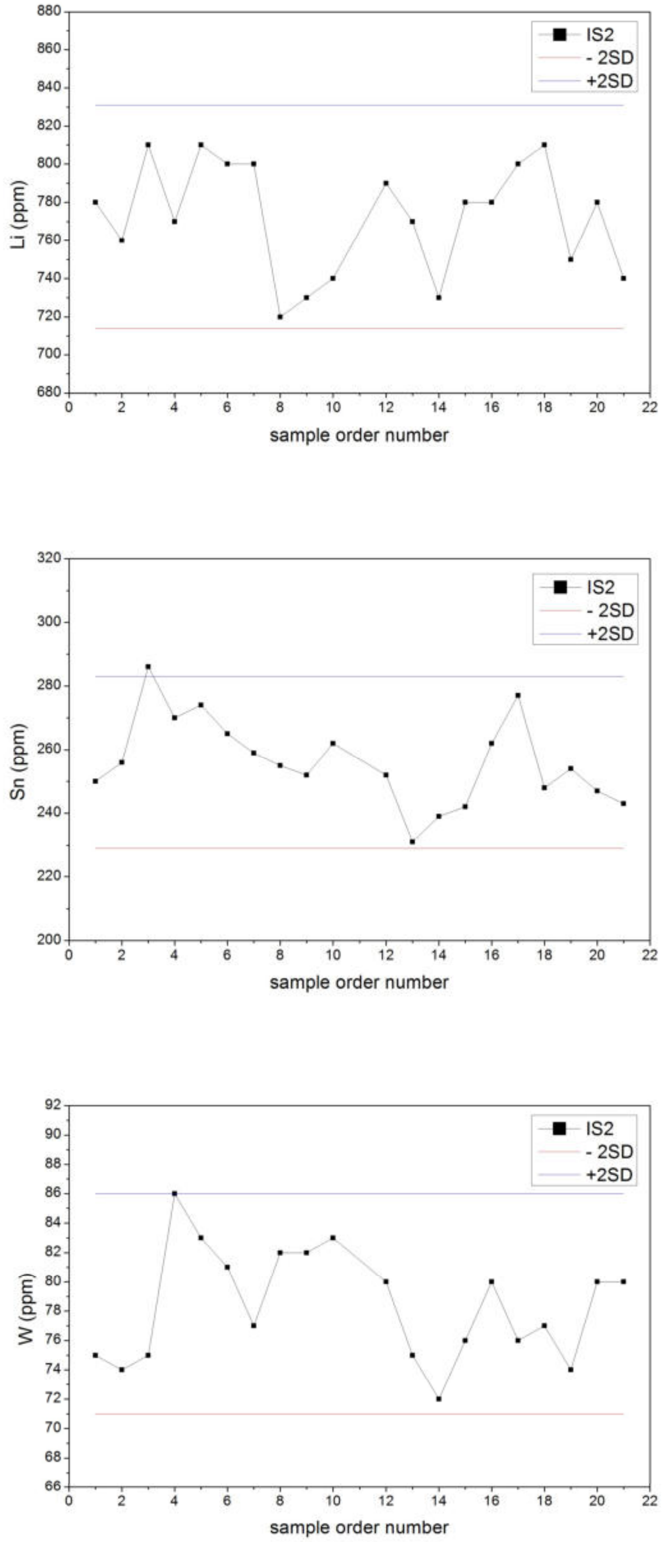


Figure 28: Li, Sn and W control assays for internal standard IS2 (low grade)

Table 28: Summary of base statistics for selected elements assayed in the internal standards IS1 and IS2

Internal standard	Element	N total	Mean [ppm]	Standard deviation [ppm]	Coefficient of variation	Minimum (ppm)	Median [ppm]	Maximum [ppm]	Range (Max – Min) [ppm]
IS1 (high grade)	Li	23	7,211	311	0.043	6,910	7,130	8,220	1,310
	Sn	23	6,160	233	0.038	5,480	6,140	6,550	1,070
	W	23	1,111	43	0.038	1,050	1,100	1,230	180
IS2 (low grade)	Li	20	773	29	0.038	720	780	810	90
	Sn	20	256	14	0.053	231	255	286	55
	W	20	78	4	0.048	72	79	86	14

11.1.3.2 Certified Reference Standard Material

ALS used certified reference standard material for internal control. Different standard materials were employed with respect to the analytical procedure (*Table 29*). Depending on the assay type these standard samples were implemented at a frequency of about 1 in 100 to 1 in 20 (1 to 5 %).

Table 29: List of certified reference standard material used at the ALS laboratory

Analytical Code	Objectives	Standard identification
4ACD81	Li, Sc, base metals	LS-1; LS-3; OGGeo08
ME-ICP06	Major elements	SY-4; AMIS0085; AMIS0167
ME-MS81d	Trace elements (including Sn, W)	SY-4; TRHB; OREAS 146; AMIS0085
XRF	Sn, W	KC-1a; TLG-1

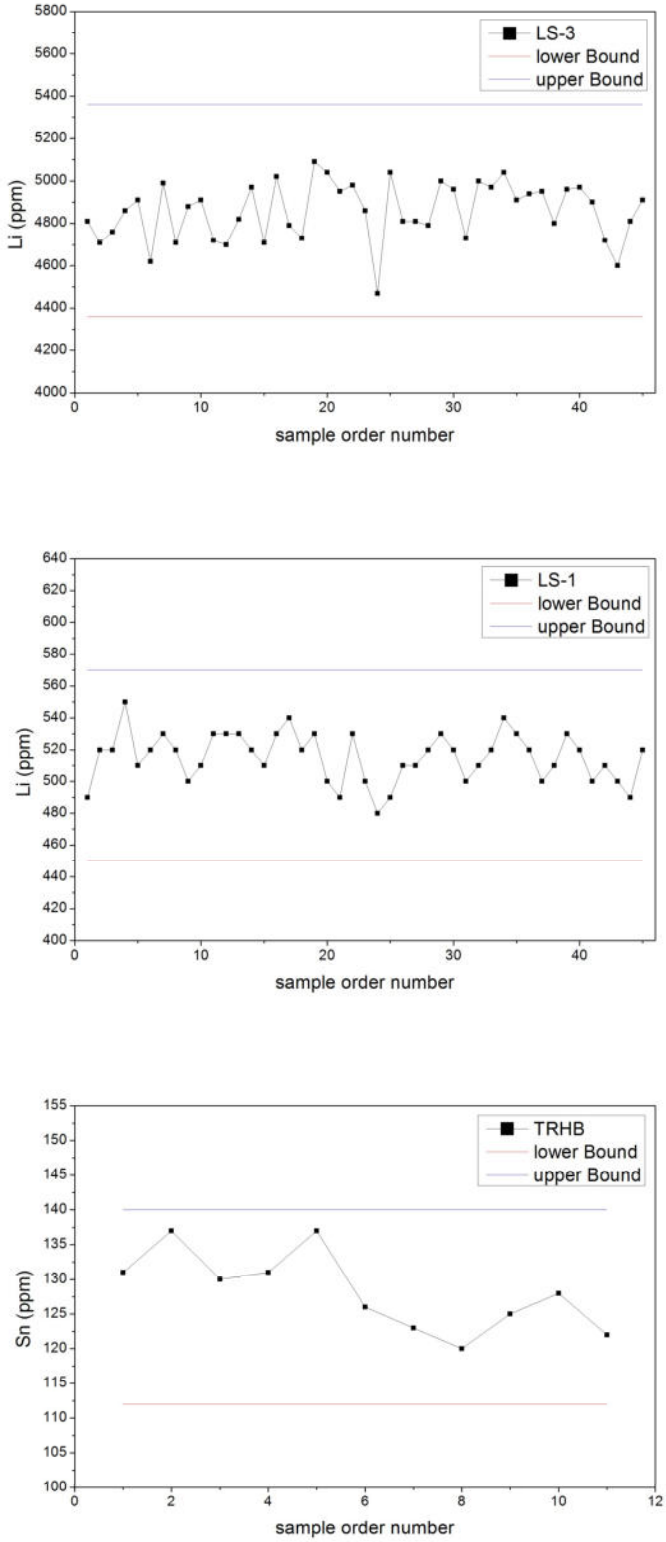


Figure 29: Li and Sn internal control assays (certified standards LS-1, LS-3, TRHB)

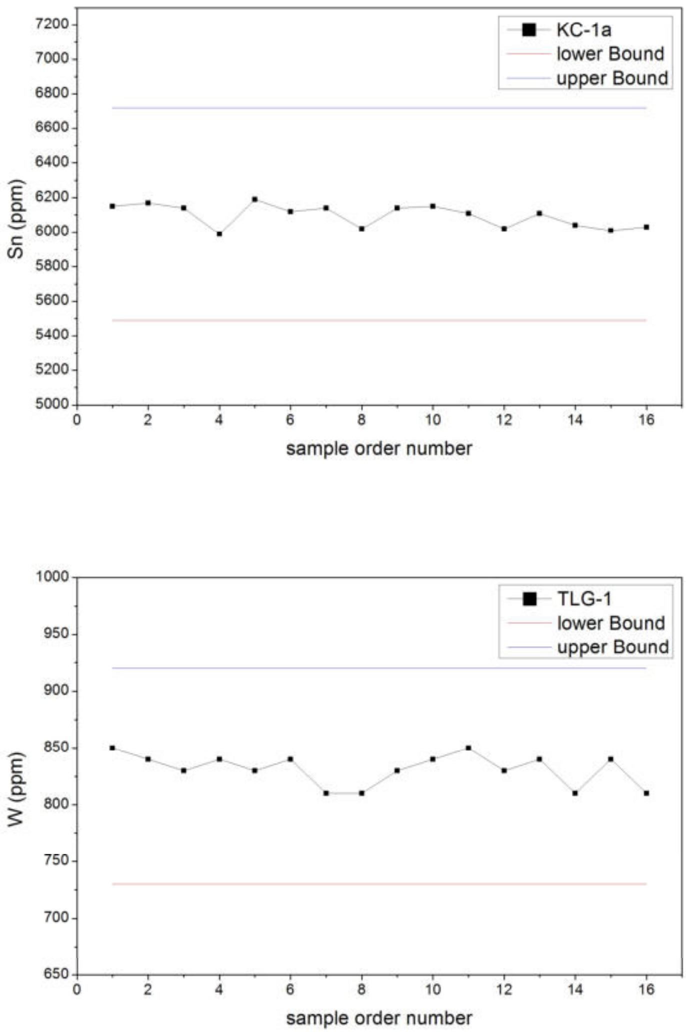


Figure 30: Sn and W internal control assays (certified standards KC-1a, TLG-1)

11.1.3.3 Core Quarter Duplicates

During the first exploration campaign of SWS (2012) sample preparation protocol, adequacy of sample mass and uniform distribution of mineralization was tested by inserting duplicate samples of another drill core quarter from the same depth interval. Both samples were analyzed by ALS. This type of control analysis was carried out at a frequency of 1 sample in 10 (10 %).

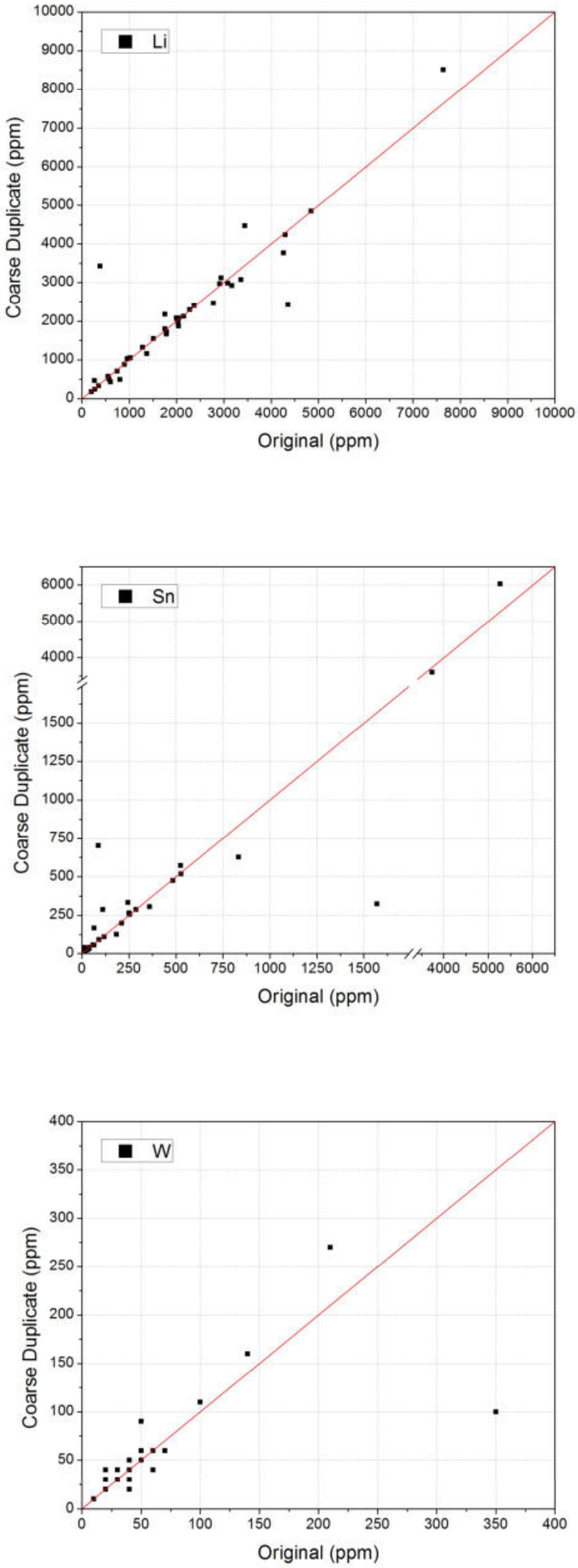


Figure 31: Scatter plots of Li, Sn and W for core quarter duplicates

11.1.3.4 Pulp Duplicates

Pulp or lab duplicates were manufactured during ongoing sample preparation at the laboratories of G.E.O.S. and were inserted at a frequency of 1 in 10 (10 %) in 2012. In 2013 – 2014 after an evaluation of the results of the first exploration campaign the frequency could be reduced to a ratio of 1 in 20 (5 %).

The pulps were submitted to an independent laboratory (Actlabs) for an external accuracy check.

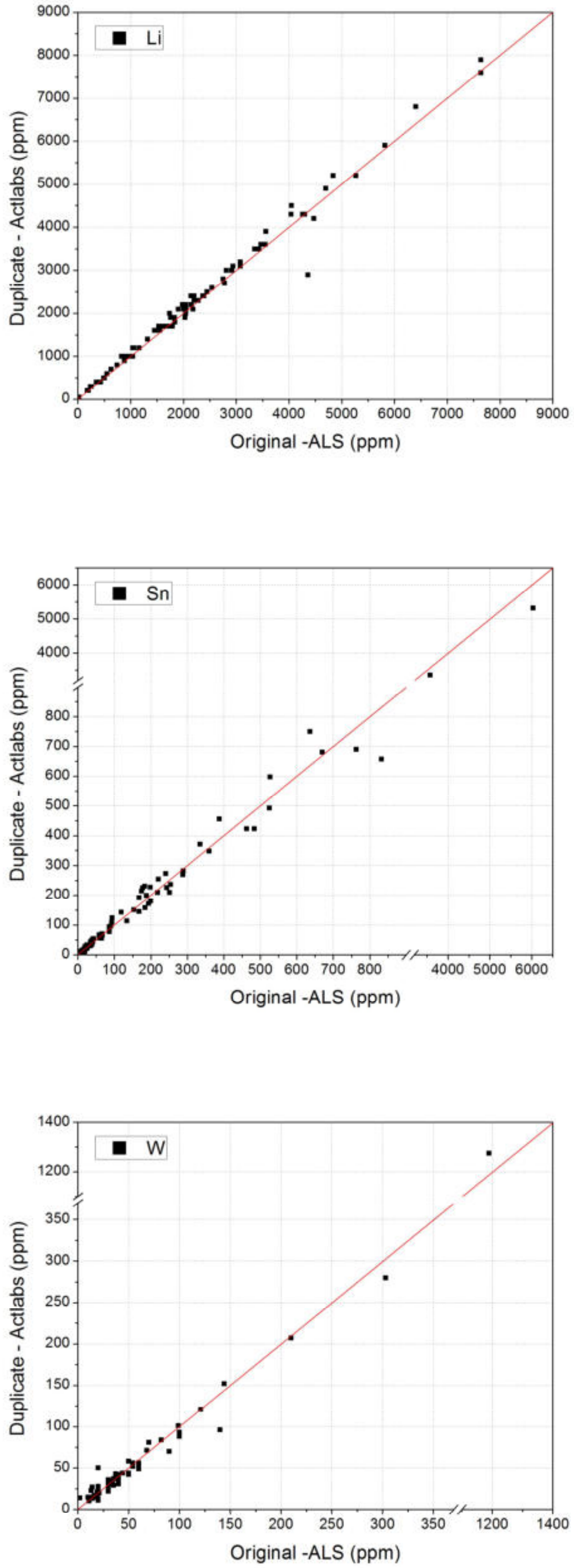


Figure 32: Li, Sn and W assays for pulp duplicates of ALS and Actlabs

11.1.3.5 Blanks

Explicit blank material was not inserted into the analytical program by SWS. Intersections of very quartz-rich greisen, however, which were sampled throughout the campaigns, provided information on the geochemical spectra at lower limits of detection.

Assays of blank material implemented by the primary laboratory (ALS) were used to detect any contamination. The following charts present the results of this lab-internal blank analysis compiled for the different analytical procedures.

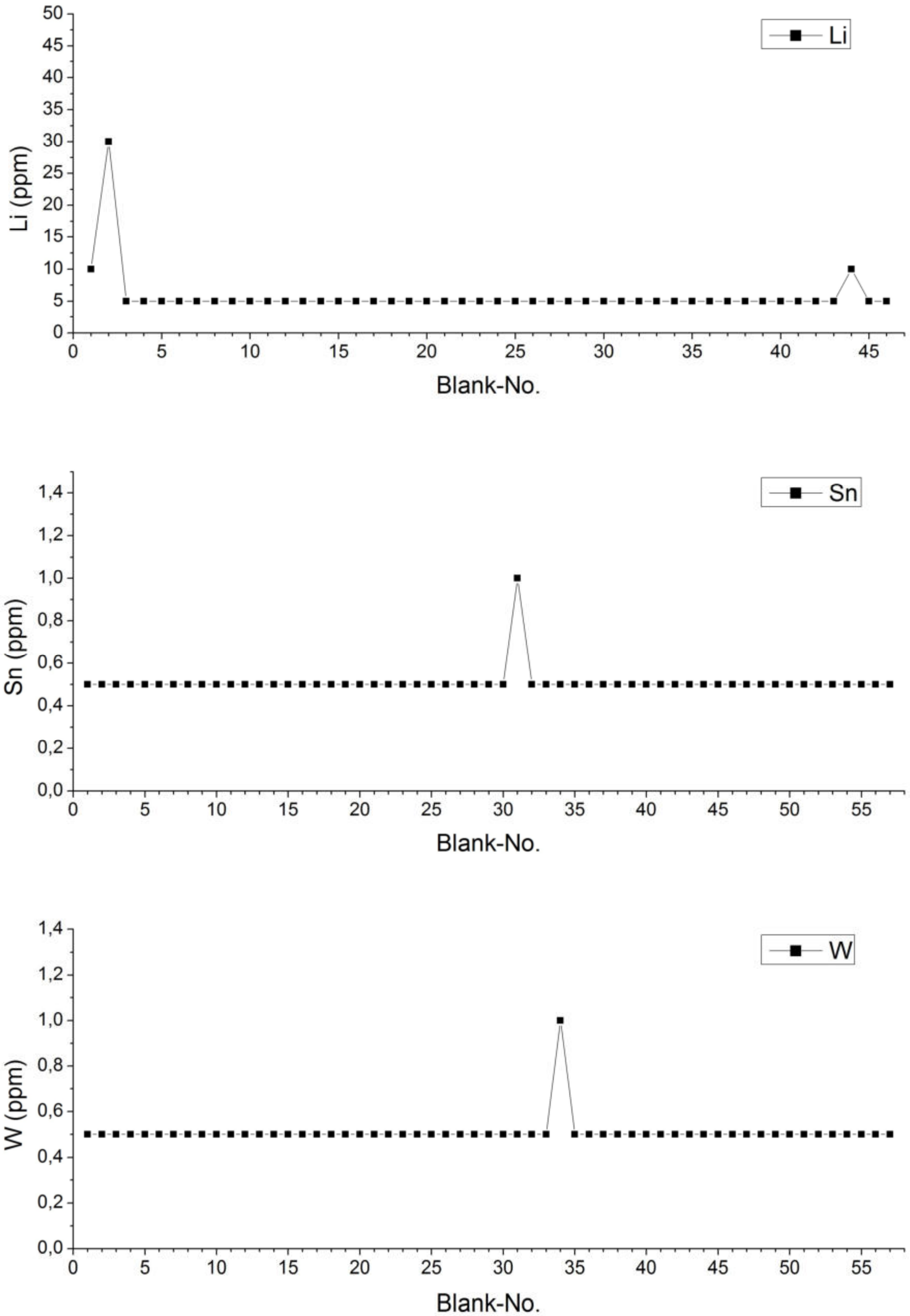


Figure 33: Results of lab-internal blank analysis of Li, Sn and W.

11.1.3.6 Internal Standard Performance

The performance of internal (non-certified) standard material was evaluated using the criterion that ninety percent of the results must fall within ± 2 times the standard deviation (±2SD) of the mean value. Assuming Gaussian distribution, this measure implies that each assayed value is in the range of about 95.4 % of all assays of the standard. Results are presented using statistical process control charts. Within the charts the assay values for the standard are presented as black squares and the mean value of the standard is listed on the right side of the chart. Control limits at ±2SD of the mean value are marked with red and blue lines.

Both internal standards (IS1 and IS2) showed no overall bias and no bias with time. For the case of lithium, 21 out of 23 (91 %) assays of IS1 and 20 out of 20 (100 %) assays of IS2 fell within the permitted limits. Similar results are obtained for tin and tungsten where 96 % (IS1) and 95 % (IS2) and 91 % (IS1) and 100 % (IS2) fell within the limits, respectively. The analyses are therefore considered to be within precision and accuracy requirements (*Figure 27, Figure 28, Table 28).*

11.1.3.7 Laboratory Internal Reference Standard Performance

The evaluation of reference standard material implemented by the lab uses the criterion that ninety percent of the results must fall within the limits (in general ±2SD) of the certified value. The results are presented analogously to the section above, displaying the name of the standard material and the lower / upper limits. Regarding lithium, tin and tungsten all of the samples met the criteria mentioned above and the assays were therefore considered as accurate and precise (*Figure 29* and *Figure 30*).

11.1.3.8 Core Quarter Duplicate Sample Performance

Duplicate samples of a second quarter of drill core were assayed to check the sample preparation protocol, adequacy of sample mass and uniform distribution of mineralization during the 2012 campaign. If the protocol was adequate, ninety percent of the duplicate pairs of assays should fall within ±30 %. Lithium assays of core quarter duplicates fell within these control limits. Tin and tungsten duplicates, however, showed only about 75 % assay pairs within the control limits suggesting a more heterogeneous distribution of cassiterite and wolframite (*Figure 31*).

Since the results demonstrated the appropriateness of sampling procedures chosen in 2012 core quarter duplicates were not implemented during the next campaign.

11.1.3.9 Pulp Duplicate Sample Performance

Duplicate samples of pulp material were assayed for another test on assay accuracy and precision. For the 2012 – 2013 season, lithium duplicate pairs from pulp material fell within control limits above the rate of 90 percent ±15 %.

Pearson correlation coefficient was about 0.992 while rank correlation coefficient after Spearman was about 0.993. Tin and tungsten did not meet these criteria, basically because abundant duplicate samples with low grades led to a higher percentage of deviation. However, the coefficient of Pearson correlation of about 0.992 (Sn) and 0.997 (W) demonstrated the strong assay interrelation from duplicate pairs (*Figure 32*).

11.1.3.10 Blank Sample Performance

Blank samples of the lab were measured to detect possible contamination during sample preparation. A large number of the blanks demonstrated low-level lithium grades (< 5 ppm), only 3 samples were characterized by values above this limit (max. 30 ppm). Similar results were obtained for other elements in blanks including tin and tungsten, where all samples except of one showed grades below 0.5 ppm (max. 1 ppm, see *Figure 33*). Furthermore, analysis of barren quartz greisen consisting of almost pure quartz revealed low concentrations of lithium below 150 ppm.

11.1.3.11 Overall Interpretation of the QA/QC Program

Results from standard material analysis (internal, non-certified standard material and certified reference material implemented by the lab) indicated that the lithium, tin and tungsten assay processes were under sufficient control over a broad range of concentration. A high correspondence of lithium assays from core quarter duplicates and pulp duplicates was obtained and demonstrated. Core quarter duplicate assays of tin and tungsten indicated, however, a more heterogeneous distribution of the respective mineralization.

Sample preparation did not induce any relevant contamination. The analysis of blank material by the lab confirmed that contamination was not introduced during the analytical procedures.

The Zinnwald sampling and assaying program meets the industry standards for the accuracy and reliability of lithium, tin and tungsten grades. The assay results were sufficiently accurate and precise for the use in resource estimation.

11.2 2017 Drilling Campaign

In order to assure a transparent documentation and high-quality results of this exploration campaign a **Q**uality **A**ssurance/**Q**uality **C**ontrol (QA/QC) instruction was worked out by DL [99], which is also authoritative for the technical implementation during sample preparation and sample processing (*Figure 34*).

The whole process of the QA/QC program was supervised and controlled by the responsible project leader of DL. In addition, the consistent adherence of this QA/QC program with respect to the requirements of the NI 43-101 standard was monitored by the independent qualified persons.

Generally, in the 2017 campaign sampling and sample preparation procedures were similar compared to 2012 – 2014 with some minor modifications. DL delivered the core halves (about 2,250 g/sample) to G.E.O.S. in Freiberg.

The core material was dried, milled ≤ 2 mm with a jaw breaker, homogenized and successively quartered with a riffle splitter to 250 g. Samples were carefully ticketed und packed for shipment.

Duplicates and retention samples were prepared as well. Duplicates and the internal standards IS1 and IS2 were introduced in the sample series according to the QA/QC program of DL.

A newly produced lithium high-grade standard IS1 with a grade of about 4,600 ppm Li was used. Within 2,643 samples 280 duplicates and 83 standards were inserted in the sample batches by DL corresponding to about 11 and 3 % on rounded average, respectively.

Shipping of the samples to ALS in Romania and Actlabs in Canada was organized by DL as well as the pick-up and storage of the retention pulps and the remaining core halves in the core store in Freiberg / Brand Erbisdorf.

Pulverizing of the sample pulps was conducted by the labs abroad. Assay techniques were the same as in the earlier campaign.

Table 30: Internal and external assay control of the 2017 drill campaign

Drill hole No.	Drill core samples	Duplicates	Duplicates (%)	Standards	Standards (%)
ZGLi 09/2017	133	14	10.53	4	3.01
ZGLi 10/2017	128	14	10.94	4	3.13
ZGLi 11/2017	128	14	10.94	4	3.13
ZGLi 12/2017	166	18	10.84	4	2.41
ZGLi 13/2017	181	20	11.05	7	3.87
ZGLi 14/2017	132	14	10.61	4	3.03
ZGLi 15/2017	170	20	11.76	8	4.71
ZGLi 16/2017	231	24	10.93	6	2.60
ZGLi 17/2017	179	18	10.06	4	2.23
ZGLi 18/2017	196	22	11.22	6	3.06
ZGLi 19/2017	186	20	10.75	6	3.23
ZGLi 20/2017	198	20	10.10	6	3.03
ZGLi 21/2017	178	18	10.11	6	3.37
ZGLi 22/2017	221	22	9.95	6	2.71
ZGLi 23/2017	216	22	10.19	8	3.70
Total	**2,643**	**280**	**10.59**	**83**	**3.14**

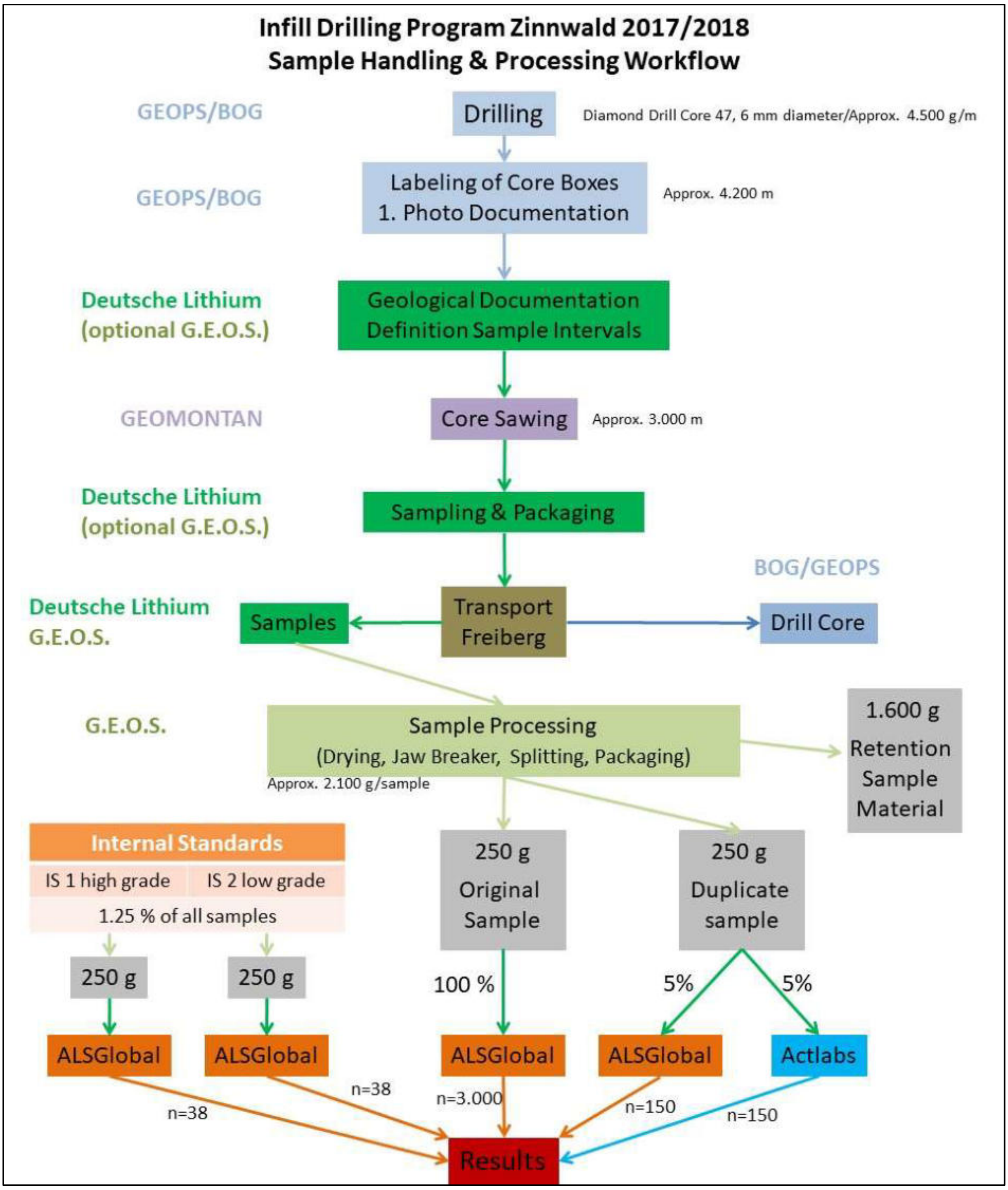


Figure 34: Sample handling and processing of the 2017 drilling campaign [99]

11.2.1 Internal Standard Performance

Assay results of the issuer's lithium standards IS1 and IS2 show a satisfying consistency.

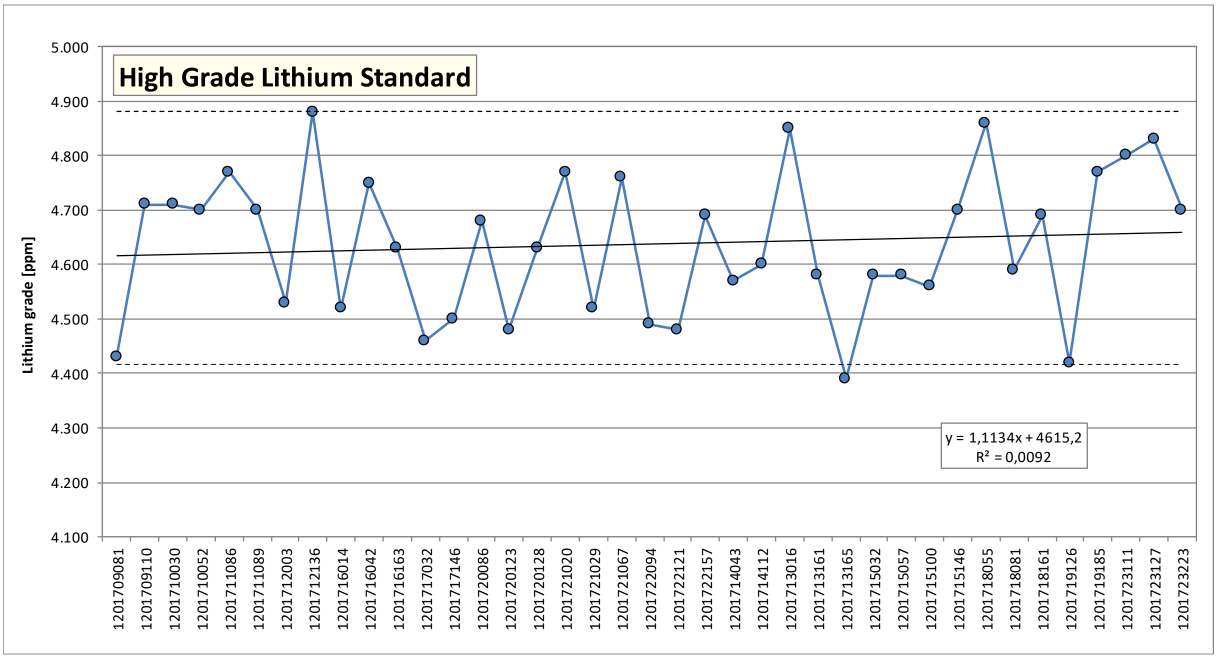


Figure 35: Li control assays for internal standard IS1 (high grade)

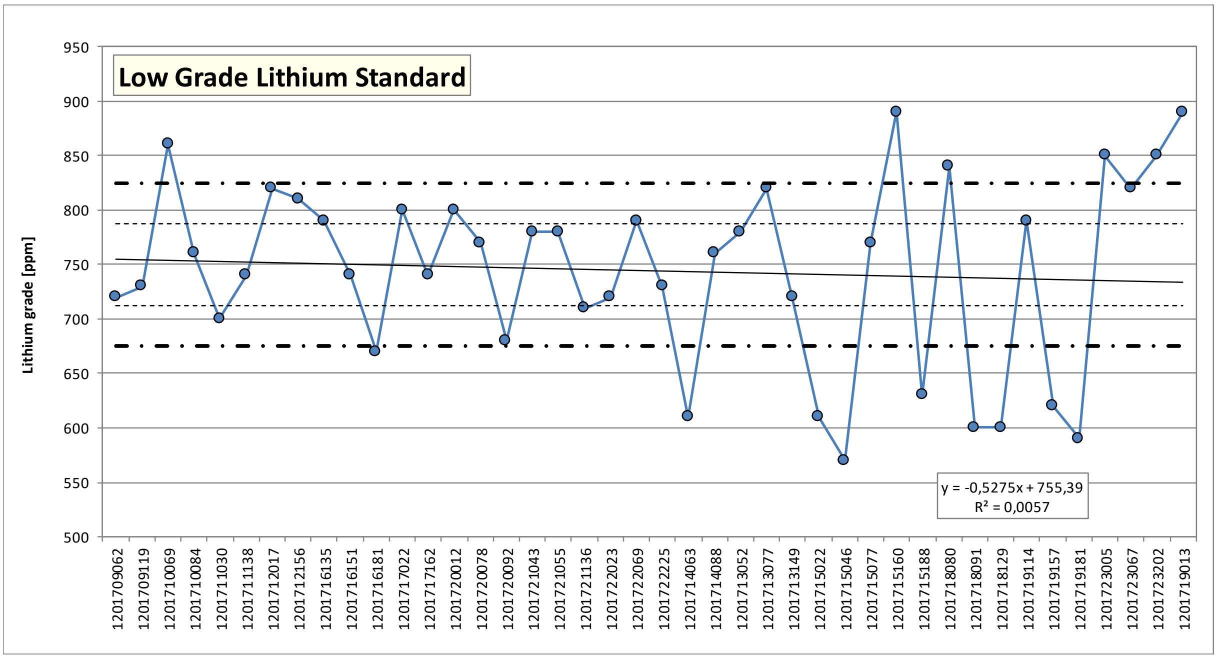


Figure 36: Li control assays for internal standard IS2 (low grade)

11.2.2 Internal Duplicate Sample Performance

Excellent results were received from the internal control assays of ALS on lithium, tin, tungsten and potassium oxide with respect to pulp duplicate samples.

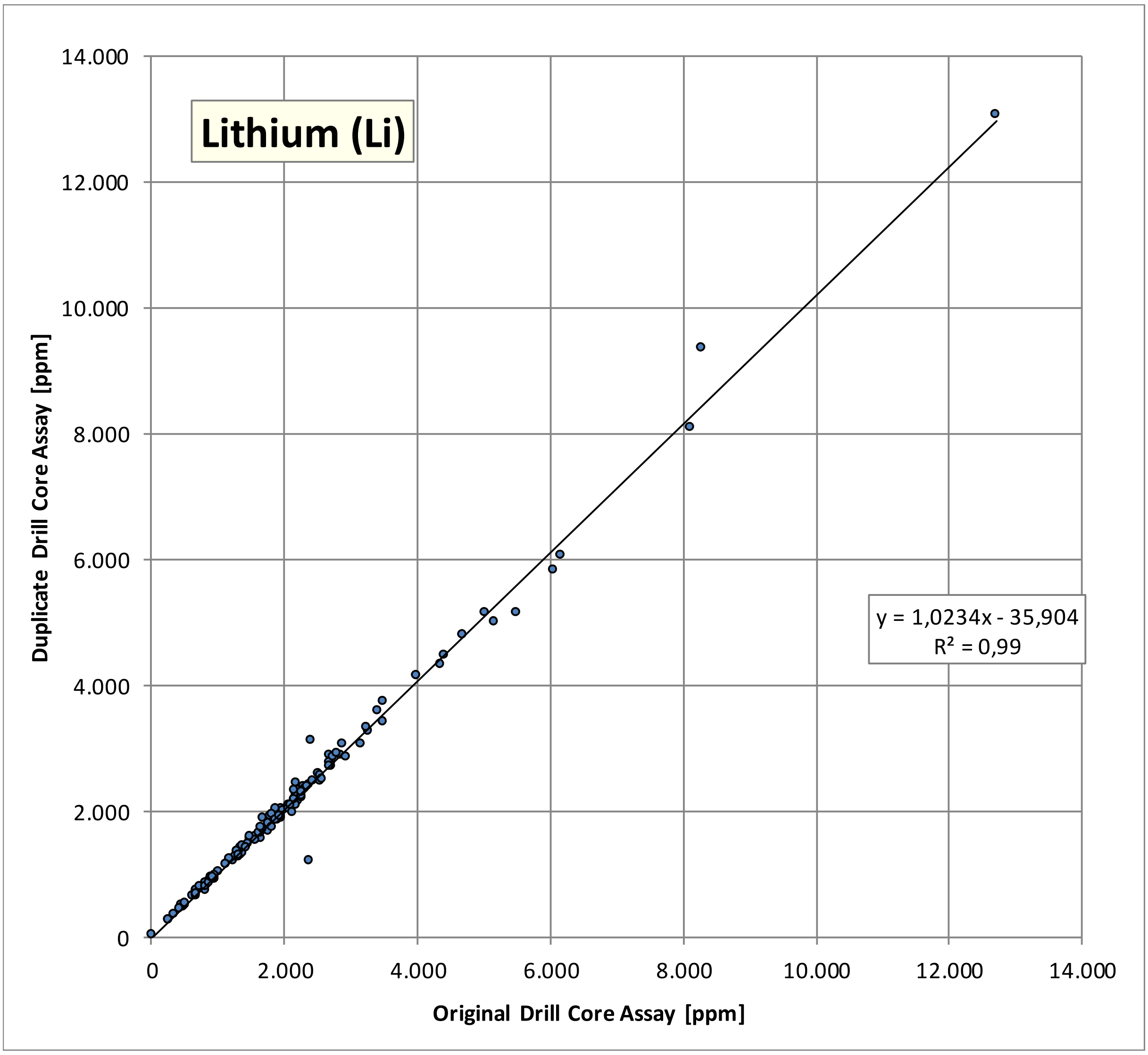


Figure 37: Comparison of lithium assays of original versus duplicate core samples (internal control by ALS)

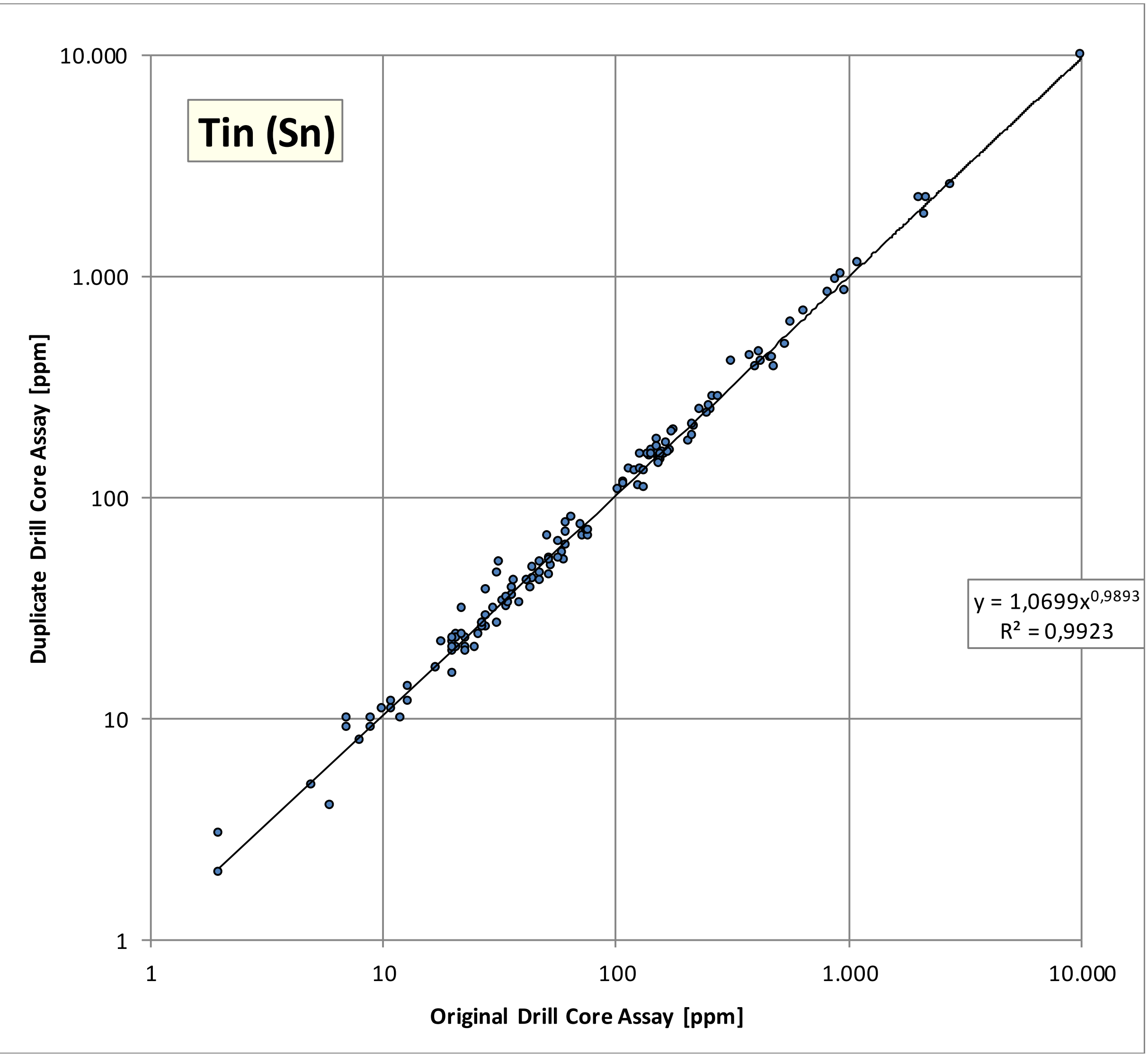


Figure 38: Comparison of tin assays of original versus duplicate core samples (internal control by ALS)

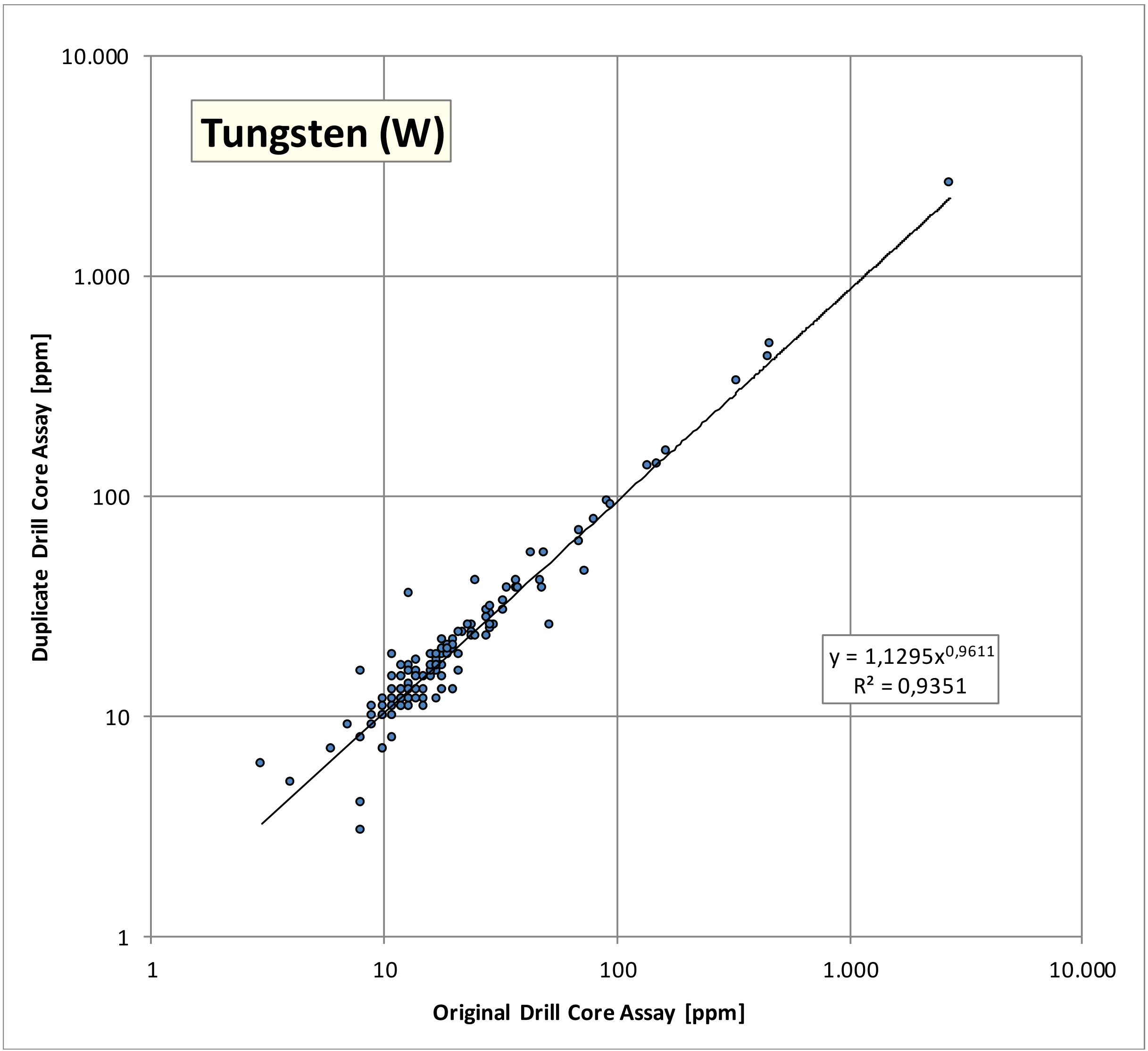


Figure 39: Comparison of tungsten assays of original versus duplicate core samples (internal control by ALS)

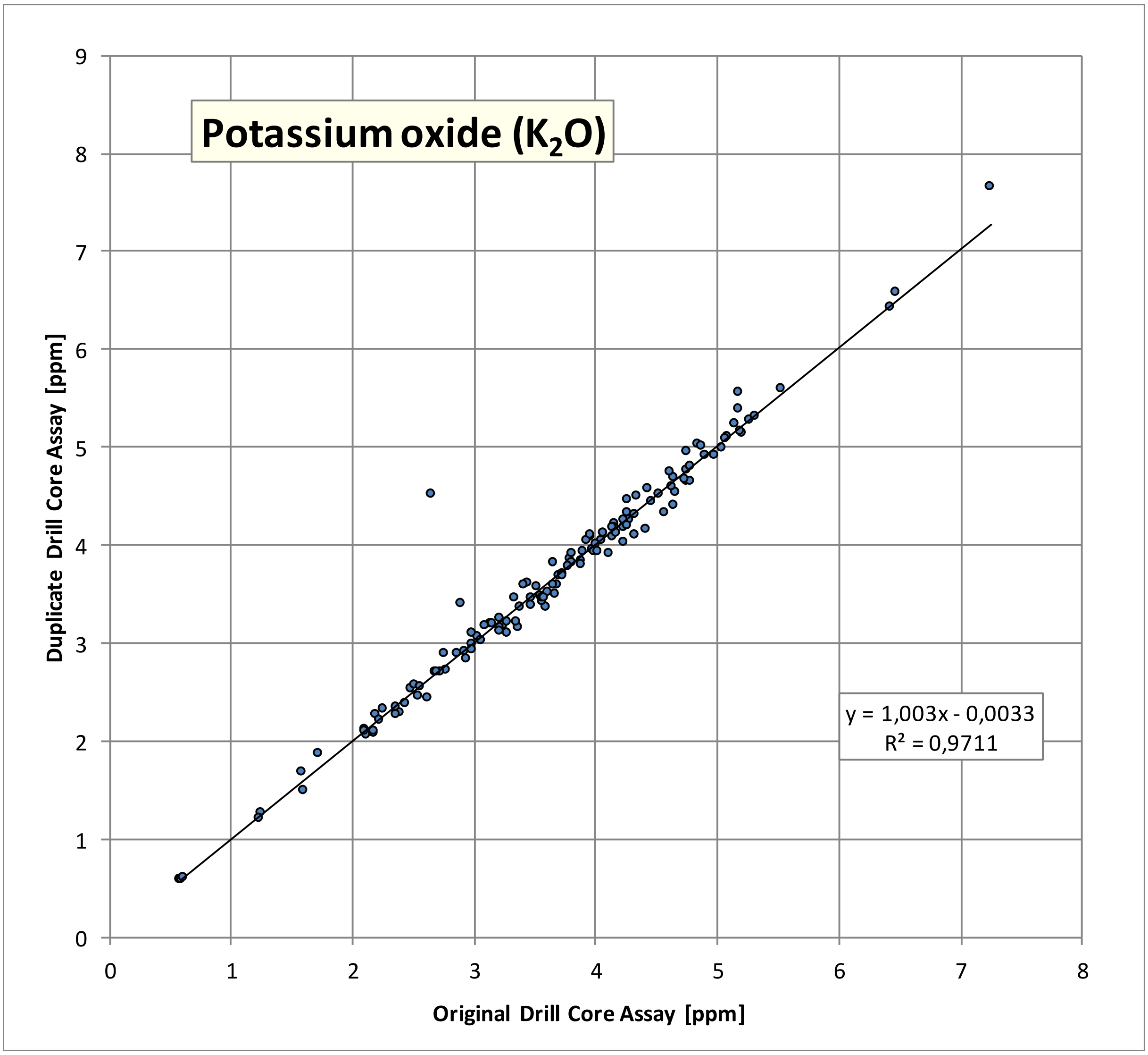


Figure 40: Comparison of K_2O assays of original versus duplicate core samples (internal control by ALS)

11.2.3 External Duplicate Sample Performance

Consistent results were also received from the external control assays of Actlabs on lithium, tin and potassium oxide with respect to pulp duplicate samples. Some outliers, however, were observed for tungsten.

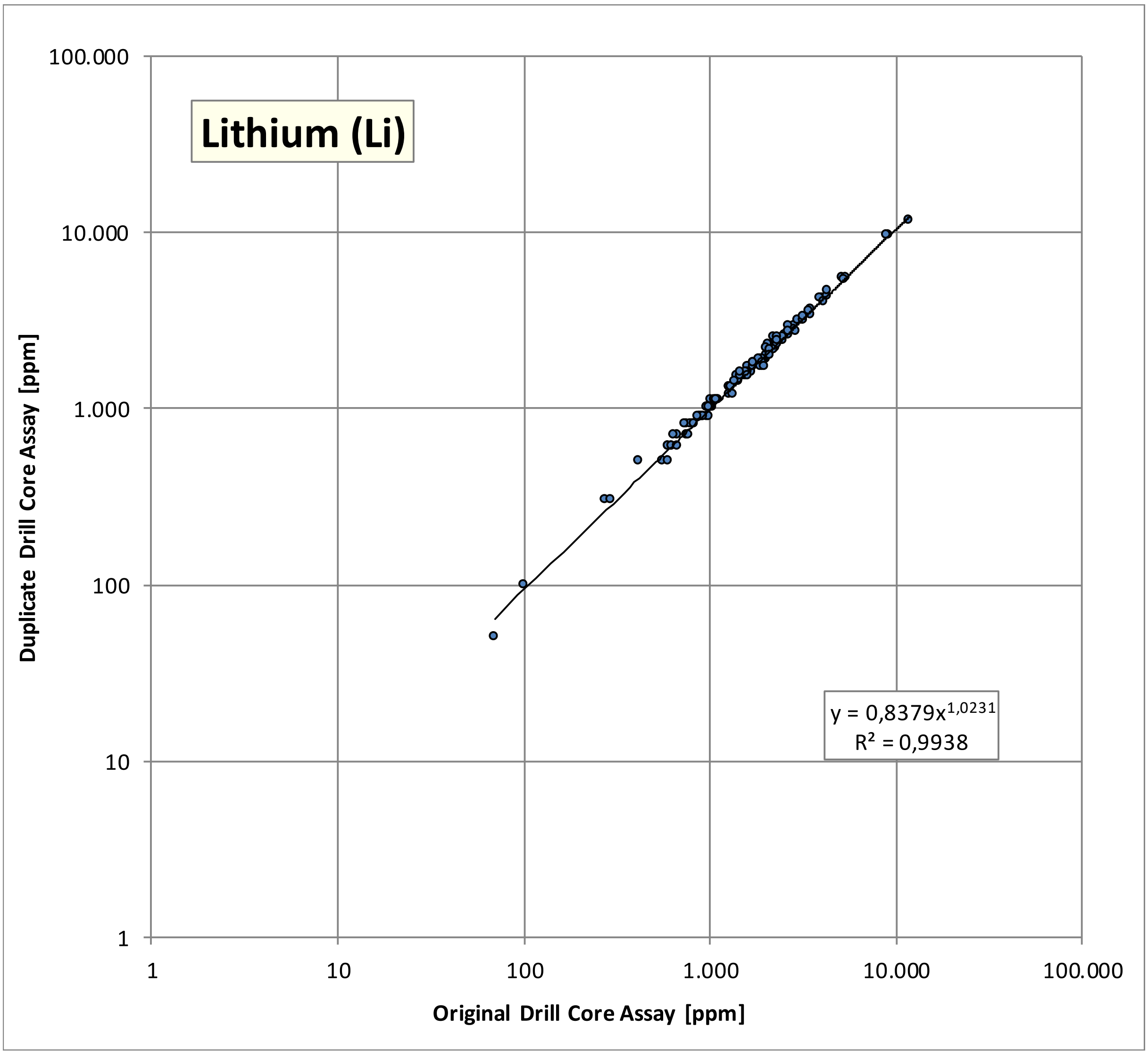


Figure 41: Comparison of lithium assays of original versus duplicate core samples (external control by Actlabs)

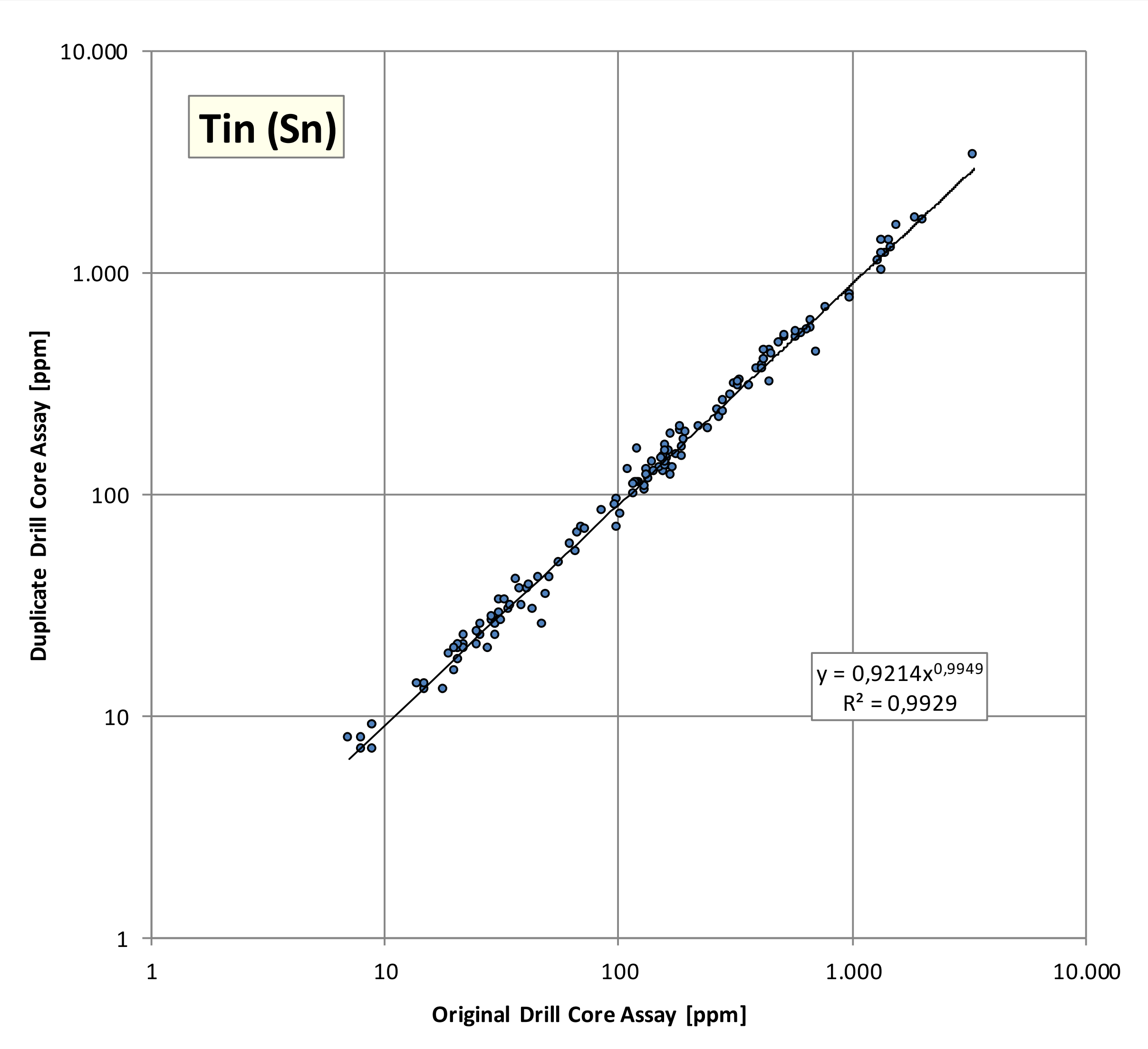


Figure 42: Comparison of tin assays of original versus duplicate core samples (external control by Actlabs)

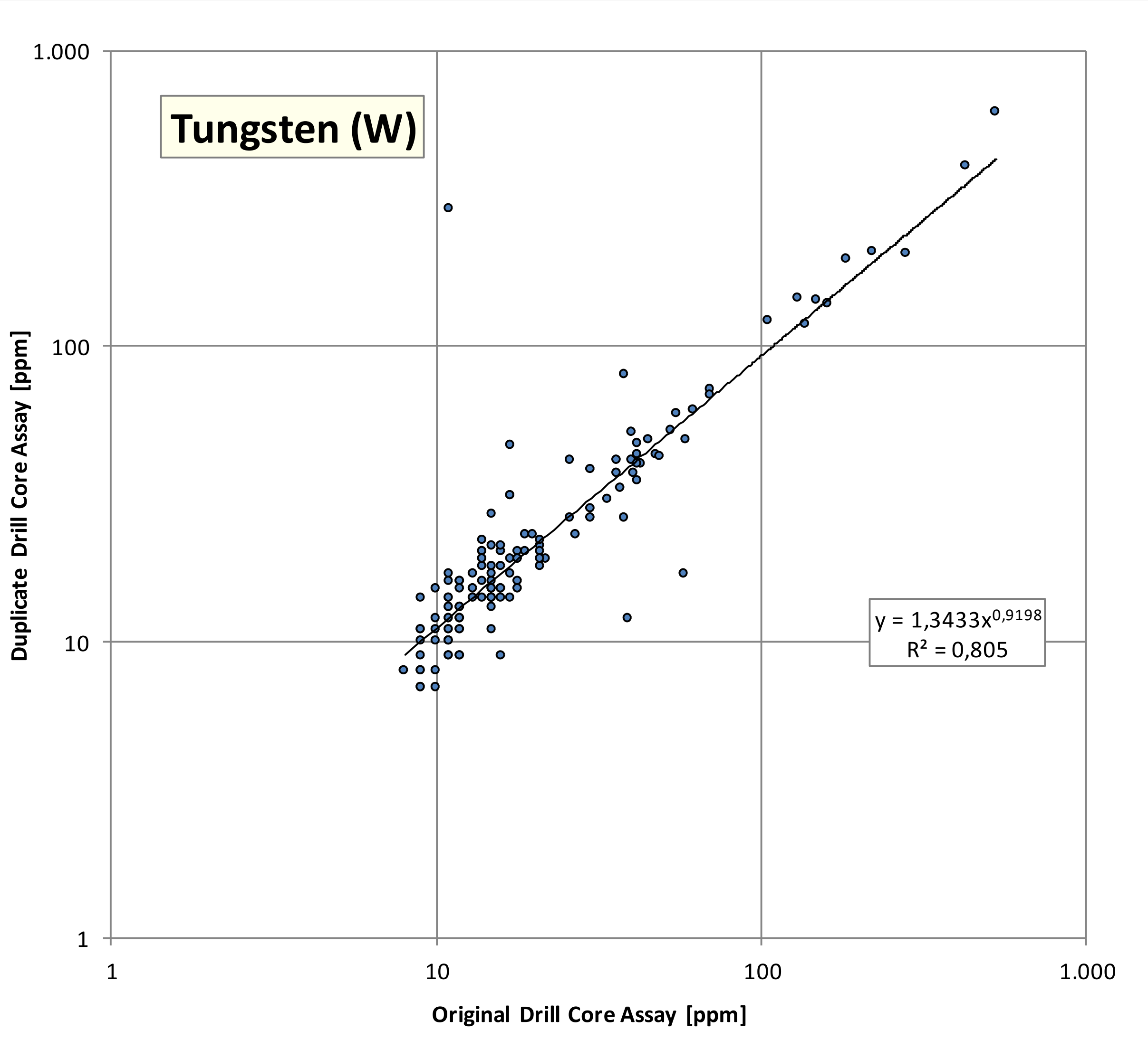


Figure 43: Comparison of tungsten assays of original versus duplicate core samples (external control by Actlabs)

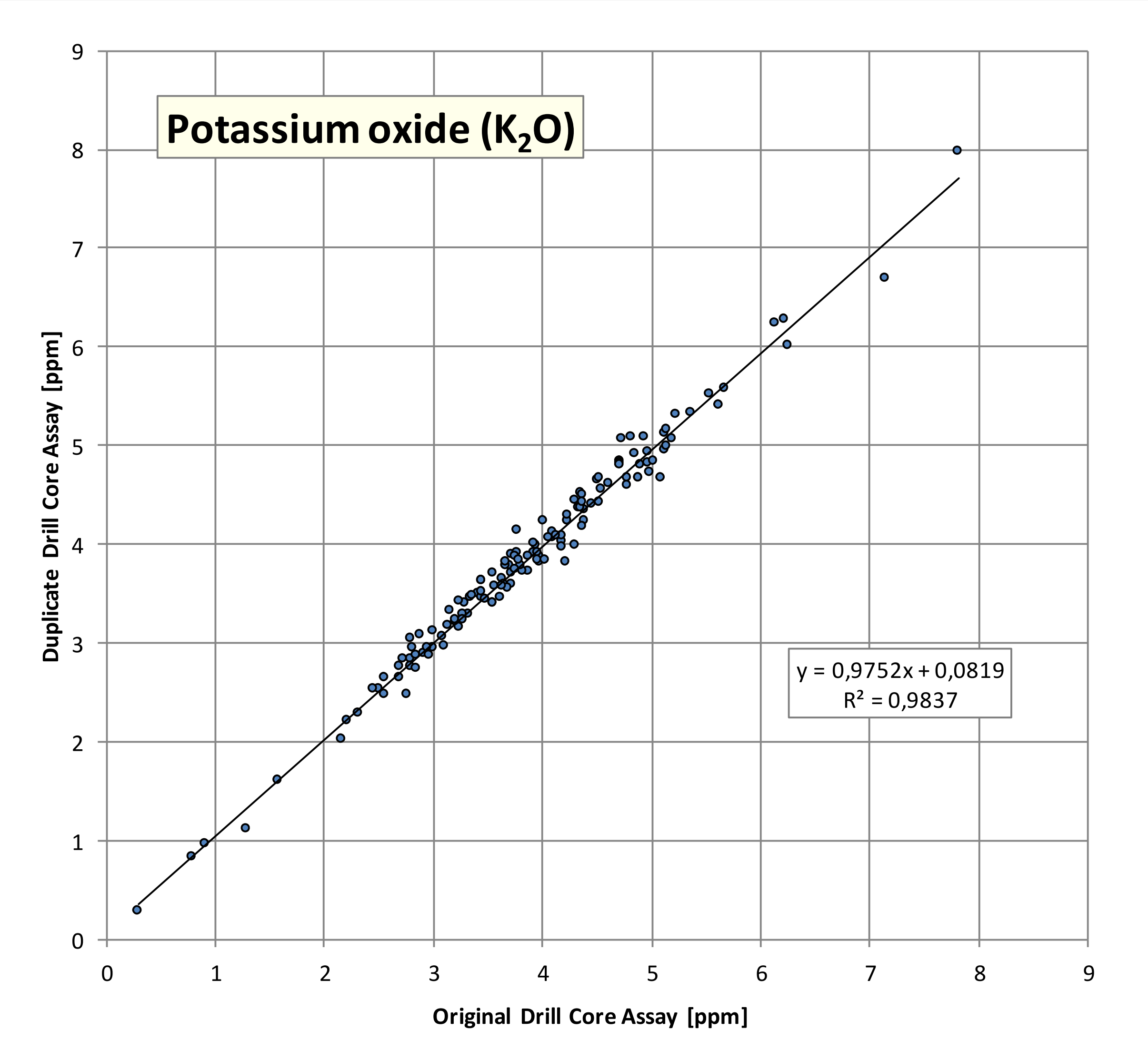


Figure 44: Comparison of K_2O assays of original versus duplicate core samples (external control by Actlabs)

11.2.4 Overall Interpretation of the QA/QC Programm

Approximately 10 % of the 2,660 core samples of the 2017 drilling campaign were additionally analysed as duplicates. 140 samples stand for internal control (ALS) and 140 for external control (Actlabs). 40 low-grade standards and 40 high-grade standards were assayed. Blanks were not manufactured by the client. Summing up, accuracy and precision of the core assays concerning lithium, tin, tungsten and potassium oxide fulfill again high industrial standards (see *Table 31*).

Furthermore, the geological model and the geochemical characteristics of the lithium deposit were confirmed by the new results. Expectations of ore intercepts and lithium grades were even outperformed. Together with the results of the other exploration campaigns a significant mineral resource estimate is possible.

Table 31: Summary of assay deviations between original and duplicate samples

Commodity	Statistic Parameter	Internal Control	External Control
Lithium	Average Deviation	13 ppm	6 ppm
	Standard Deviation of Average Deviation	170 ppm	110 ppm
	Mean Percent Deviation	1 %	0 %
Tin	Average Deviation	1 ppm	-29 ppm
	Standard Deviation of Average Deviation	40 ppm	60 ppm
	Mean Percent Deviation	3 %	-9 %
Tungsten	Average Deviation	-1 ppm	2 ppm
	Standard Deviation of Average Deviation	11 ppm	27 ppm
	Mean Percent Deviation	3 %	25 %
Potassium Oxide	Average Deviation	0.01 wt.%	-0.01 wt.%
	Standard Deviation of Average Deviation	0.2 wt.%	0.14 wt.%
	Mean Percent Deviation	0 %	0 %

12 Data Verification

12.1 Database

For the geological modelling and the calculation of the resource estimate 76 surface holes and 12 underground drill holes have been used. Among these, 25 of the surface holes have been drilled during the past five years as part of the exploration campaign done by SWS and DL. The samples from the last drilling campaigns (2012 - 2017) have been assayed by ALS. In total, 6,342 lithium core sample assays are taken for the evaluation, covering 6,465 m of core.

Further 88 assays were available from underground channel sampling, performed by SWS in the year 2012 and another 1,350 assays from underground pick samples, reported by GRUNEWALD, 1978a [259].

General information on the drill holes is presented in the data table “collar”. The data table “geology” contains the geologic drill logs whereas the data table “sample” contains information on sample assays. Discrete point sample data for underground pick samples and channel samples is given in data table “sample_disc”. In data table “sample” information of the tables “sample” and “geology” was merged. Geological model and resource estimation are based on this table.

12.2 Procedures

12.2.1 Database Verification

For the Zinnwald / Cínovec deposit datasets of various kinds and ages are available. They go back to the 16th century and comprise geological, mineralogical, geotechnical, geochemical data. Since the beginning of the 20th century the Zinnwald deposit has been investigated by three major exploration campaigns, which built up the fundamental base of the historic datasets used within the recent exploration campaign (LÄCHELT, 1960 [242], GRUNEWALD, 1978a [259], BESSER & KÜHNE, 1989 [265], and BESSER, 1990 [267]). The extent and the results of these programs are described in the report “Lithiumgewinnung in der Lagerstätte Zinnwald - Ressourceneinschätzung” which was compiled by KÜHN et al., 2012 [67]. From these exploration and research reports the main information used for the evaluation of the Li-Sn-W-deposit Zinnwald consists of information from drill core, mine maps and results of geochemical assays.

All original historic data found in geological and mining archives are available as printed text, tables or figures implemented in final exploration and / or research reports. For the utilization within a multi-source resource model dataset have been converted into digital format by simply typewriting. Naturally, errors arise during this process and a control of digitized data is necessary. Additionally, recent data obtained during the ongoing exploration campaign need to be tested for incorrect values introduced during digitization. *Table 32* gives an overview of datasets included in the data control.

Prior to the actual controlling process general instructions need to be defined concerning the amount and accuracy of controlled data. As a general rule, the data control is applied to at least 10 % of the entities of each dataset. One entity corresponds to a complete column or row of the dataset (e.g. one depth interval with lithological and tectonic information or one depth interval with numerous analyzed elements). Hence, an amount of 10 % of the data entities is randomly selected from the original documents. All values of this subgroup are now transferred to an independent spread sheet similar to the first data transmission / digitization.

In doing so, the documentation of the digital data and the input template are structured identically. It is important to note, that the input of raw and controlled data is performed by at least two different persons.

The analysis of deviating pairs of values is conducted by either ordinary subtracting of one by the other for numeric values or detecting of identical entities for non-numeric values using Excel-routines. Results are then expressed in additional “deviation”-columns. Identical and therefore correct values are designated by a deviation of 0 (zero), independent from the fact whether they are numeric or non-numeric values. As a result, the quantity of incorrect values is calculated as percentage expression of the total number of controlled values within this dataset. A dataset is designated as accurate if this portion of faulty values is below 10 % of the controlled values. If the portion is higher than 10 %, the complete dataset must be digitized again from the original documents. After errors have been detected, which did not exceed the 10 % level, corresponding values are corrected, and the datasets are implemented back into the fundamental database. Within the database, controlled entities are marked separately with an indication of amendment, the name of the conducting person and date of data control.

Table 32: List of datasets used in the reevaluation of the Li-Sn-W deposit Zinnwald / Cínovec and subjected to data control procedures

Li-Exploration: 1954 – 1960 (BOLDUAN & LÄCHELT,1960) (Exploration campaigns No.s (4a) & (4b))	
Drill hole data (number of drill holes = 27)	
	Basic drill hole data
	Lithological drill hole record
	Sample list including the results of chemical analysis from core samples
Research program: 1977 – 1978 (GRUNEWALD) (Exploration campaign No. (6))	
Drill hole data (number of drill holes = 2)	
	Basic drill hole data
	Deviation measurement record
	Lithological bore hole record
	Sample list and results of chemical analysis from soil samples
	Sample list and results of chemical analysis from core samples
Data from underground pick samples (number of samples = 1,350) (Exploration campaign No. (6))	
	Basic location data
	Sample list including the results of chemical analysis
Sn-W-Exploration 1988 – 1989 (KÜHNE & BESSER) (Exploration campaign No. (7))	
Drill hole data (number of drill holes = 8)	
	Basic drill hole data
	Deviation measurement record
	Lithological drill hole record
	Sample list and results of chemical analysis from moil samples
	Sample list and results of chemical analysis from core samples

Li-Exploration 2011 - 2018 (SolarWorld Solicium GmbH and Deutsche Lithium GmbH) (Exploration Campaigns No.s (8a) – (8c))	
Drill hole data (number of drill holes = 25)	
	Basic drill hole data
	Lithological drill hole record
	Sample list and results of chemical analysis from core samples
	Rock quality designation index (RQD)

The overall outcome of data control shows that all checked data sets comply with the determined limits in terms of correctness and accuracy. None of the datasets controlled within this project exceeded the limit of 10 % of incorrect values. The most elevated percentage of faulty values is about 1.7 % for the basic drill hole data (collar). A summary of the results from data control of all data sets that have been utilized within the current resource estimation is shown in *Table 33*.

Furthermore, results of data control show that the majority of faulty values are due to transposed digits crept in during digitization. All errors or faulty values are of minor impact, i.e. none would induce major systematic changes or generate deviating interpretations. Nevertheless, even numerical small errors need to be detected and corrected.

Table 33: Results of data control performed on historic and recent exploration data

Data type	Data source	Total number of columns in the original dataset	Total number of controlled columns	Percentage of controlled columns [%]	Total number of controlled entries (rows x columns)	Total number of faulty entries	Percentage of faulty entries [%]
Basic drill hole data	BOLDUAN & LÄCHELT, 1960; GRUNEWALD 1978a; KÜHNE & BESSER 1989; SolarWorld Solicium GmbH 2011-2014	47	47	100.00	235	4	**1.70**
Lithological drill hole record	BOLDUAN & LÄCHELT, 1960	806	91	11.3	1,547	10	**0.64**
Results of chemical analysis of samples from drill core	BOLDUAN & LÄCHELT, 1960	581	60	10.3	300	4	**1.33**

Data type	Data source	Total number of columns in the original dataset	Total number of controlled columns	Percentage of controlled columns [%]	Total number of controlled entries (rows x columns)	Total number of faulty entries	Percentage of faulty entries [%]
Results of chemical analysis of mine samples	GRUNEWALD 1978a	1,335	142	10.6	994	1	**0.10**
Results of chemical analysis of samples from drill core	KÜHNE & BESSER 1989	1,252	294	23.48	6,468	7	**0.11**
Drill hole deviation record	Objektakte Sn Altenberg, Suche 2 - TG ZW; VEB BLM Gotha	638	84	13.17	336	1	**0.30**
Lithological drill hole record	SolarWorld Solicium GmbH and Deutsche Lithium GmbH 2011-2018	1,370	35	11.1	1,365	6	**0.44**
Results of chemical analysis of samples from drill core	SolarWorld Solicium GmbH and Deutsche Lithium GmbH 2011-2018	4,579	461	10.0	4,610	0	**0.00**
Rock quality designation index (RQD)	SolarWorld Solicium GmbH and Deutsche Lithium GmbH 2011-2018	572	60	10.5	360	0	**0.00**

12.2.2 Reanalysis of Historic Samples

12.2.2.1 Overview

In addition to the recent exploration results of SWS and DL during the period 2011 to 2017, the geological model, assay data and consequently the resource estimation of the Zinnwald property are based on data from historic exploration campaigns reviewed in *Item 12.2.1.*

In order to validate the results from chemical analysis of these former campaigns a reassessment of the assayed values was conducted during the first year of SWS exploration campaign (2011 - 2012). This work included the geochemical analysis and comparison of about 53 historic samples from drill core at certified analytical labs (ALS and Actlabs).

Since the sample types and the grade of availability are different for the historic exploration campaigns, the results of the reassessment are presented for the campaign of Li-exploration (BOLDUAN & LÄCHELT, 1960 [249] and Sn-W-exploration (GRUNEWALD 1978a [259] and 1978b [260]; BESSER & KÜHNE, 1989 [265] separately.

The original sample material of historic campaigns was stored in the permanent core shed of the Federal State Office for Agriculture, Environment and Geology of Saxony (LfULG) in Rothenfurth, close to Freiberg. Unfortunately, only a fractional amount of original drill core material is preserved there. Halves of drill core are stored in wooden core boxes in a high-bay racking in the order of the exploration campaign, drill hole number and depth.

Beside the fact that only sporadic parts of the drilled succession are preserved, the cores are stored in a well-organized manner. Furthermore, rejects of pulp drill core samples were found as well. They are stored in small paper bags to about 50 g each and are ordered by drill hole number and depth. A fraction of this material was destroyed by water damage due to roof leakage.

With respect to the different objectives, different sample types and different analytical procedures during Li- and Sn-W-exploration campaigns it is absolutely necessary to evaluate the reanalysis for each campaign separately.

Table 34 and *Table* 35 give a comprehensive overview of type, amount and quality of sample material for the main historic exploration campaigns.

Table 34: Overview of sample material of historic Li-exploration campaign No. (4)

Li-Exploration (BOLDUAN & LÄCHELT, 1960) (Exploration campaign No. (4))	
Sample type	Drill core (Ø=100 mm)
Sampled lithologies	Greisen
Mean length of sample intervals	1.00 m
Total sample number	562
Analyzed elements	Li, Sn, W
Analytical methods	
Li	Flame photometry
Sn, W	Spectral analysis
Preserved sample material	Half drill core
Estimated portion of preserved sample material	About 1 %

Table 35: Overview of sample material of historic Sn-W-exploration campaigns No. (6) and (7)

Sn-W-exploration (GRUNEWALD, 1978; KÜHNE & BESSER, 1989) (Exploration campaigns No. (6) and (7))	
Sample type I	Soil samples
Sampled lithologies	Complete drill core
Mean length of sample intervals	4.00 m
Total sample number	1,332
Analyzed elements	Ag, As, B, Ba, Be, Bi, Co, Cu, Li, Mn, Mo, Nb, Ni, Pb, Sn, W, Zn, Zr, Y
Analytical method	Spectral analysis
Sample type II	Drill core (Ø=47 mm)
Sampled lithologies	All intersections with moil samples of > 800 ppm Sn
Mean length of sample intervals	1.00 m
Total sample number	498
Analyzed elements	Sn, W (less frequently As)
Analytical method	X-ray fluorescence analysis (XRF)
Preserved sample material	Retained pulp sample, about 50 g each
Estimated portion of preserved sample material	100 % (but partly damaged)

Samples for reanalysis were selected based on the availability of corresponding historic assays and the most extensive spatial distribution throughout the deposit area. In case of Li-exploration about 28 samples (1 m length) of quarter drill core from 4 different drill holes were sampled using a diamond saw.

A representative set comprising 25 retained pulp samples of Sn-W-exploration were selected from 6 different drill holes. All material was crushed and grinded in concordance with project sample preparation instructions at the facilities of Technical University Bergakademie Freiberg and G.E.O.S. Ingenieurgesellschaft mbH prior to shipment to accredited analytical labs.

All chemical analysis was performed by identical methods used during the SWS exploration, which is described in *Item 11.1.3.*

The following chapter gives a summary of the results obtained by reanalysis of samples from historic exploration campaigns for the elements lithium and tin. The comprehensive final report with detailed results, significant tables and figures and discussion is presented in appendix 5.1 of the PERC Report 2014 [92].

12.2.2.2 Results of reanalysis of drill core samples from Li-exploration (campaign No. (4))

Lithium

About 28 core samples of 4 different historic drill holes were assayed and compared with the original results. As a result, a considerable correspondence of historic and recent Li-concentrations is recognizable (*Figure 45*). Correlation coefficient of Pearson (r_P) is about 0.8, while rank correlation coefficient of Spearman (r_S) is about 0.78.

The present deviations are in a way systematic that recent Li-grades exceed results from historic analysis in about 24 of 28 samples. The absolute value of deviation is most elevated in the sample 24/59-16 with about 2,340 ppm and averages about 590 ppm for all 28 samples. The calculation of a mean percentaged deviation shows that the recent Li-grades are about 132 % of the historic values (median = 118 %). Furthermore, there is no indication of a systematic change of deviation corresponding to the concentration range, which is also shown by Gaussian distribution of the deviations (tested with Shapirov-Wilk-test and Kolmogorov-Smirnov-test at 0.05 significance-level).

As a result, the Li-concentrations are almost consistently undervalued. This provides proof that Li-concentrations stand at least on the documented level. Considering a conservative approach, the Li-concentrations are not amended.

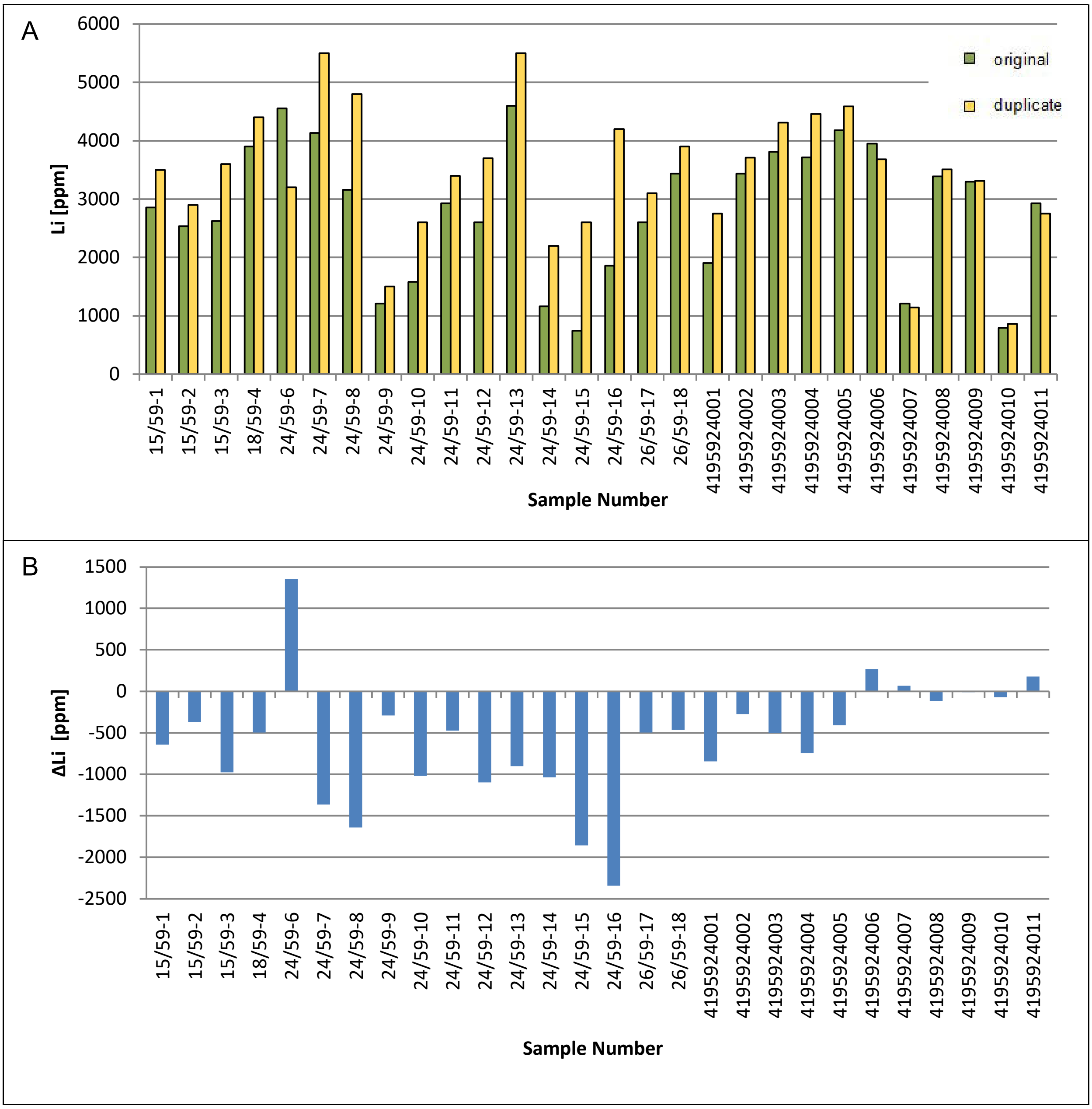


Figure 45: Results of sample pairs from historic and recent analysis of Li-exploration data (campaign No (4))
(A) Absolute lithium-concentration of original and duplicate assays
(B) Absolute deviation of lithium-concentration (original minus duplicate)

Tin

The assayed Sn-concentrations from Li-exploration data are available over a broad range of concentrations. Generally, they show a slight excess in the historic values compared to recent assays but also indicate several strong deviating sample pairs in both directions (*Figure 46*). Therefore, the mean absolute deviations are misleadingly small with a mean of about 16 ppm (median = 42 ppm). The low correspondence of the sample pairs is displayed by low values of correlation coefficients (r_P = 0.45 and r_S = 0.04). Within the rocks of the Zinnwald deposit the element tin is mainly represented by the mineral cassiterite, which is more heterogeneously distributed with local nests and adjacent barren zones. Therefore, interpretation of Sn grades is hampered by the character of distribution in the rocks of the Zinnwald deposit. Results from reanalysis are characterized by a very weak consistency and reproducibility and do not indicate any systematic shift. An overlap of errors induced by analytics and sampling is most likely and impede the usage of historic values for any type of resource classification. However, the confined utilization of tin concentrations for qualitative markers (barren - weakly mineralized - strong mineralized) is possible.

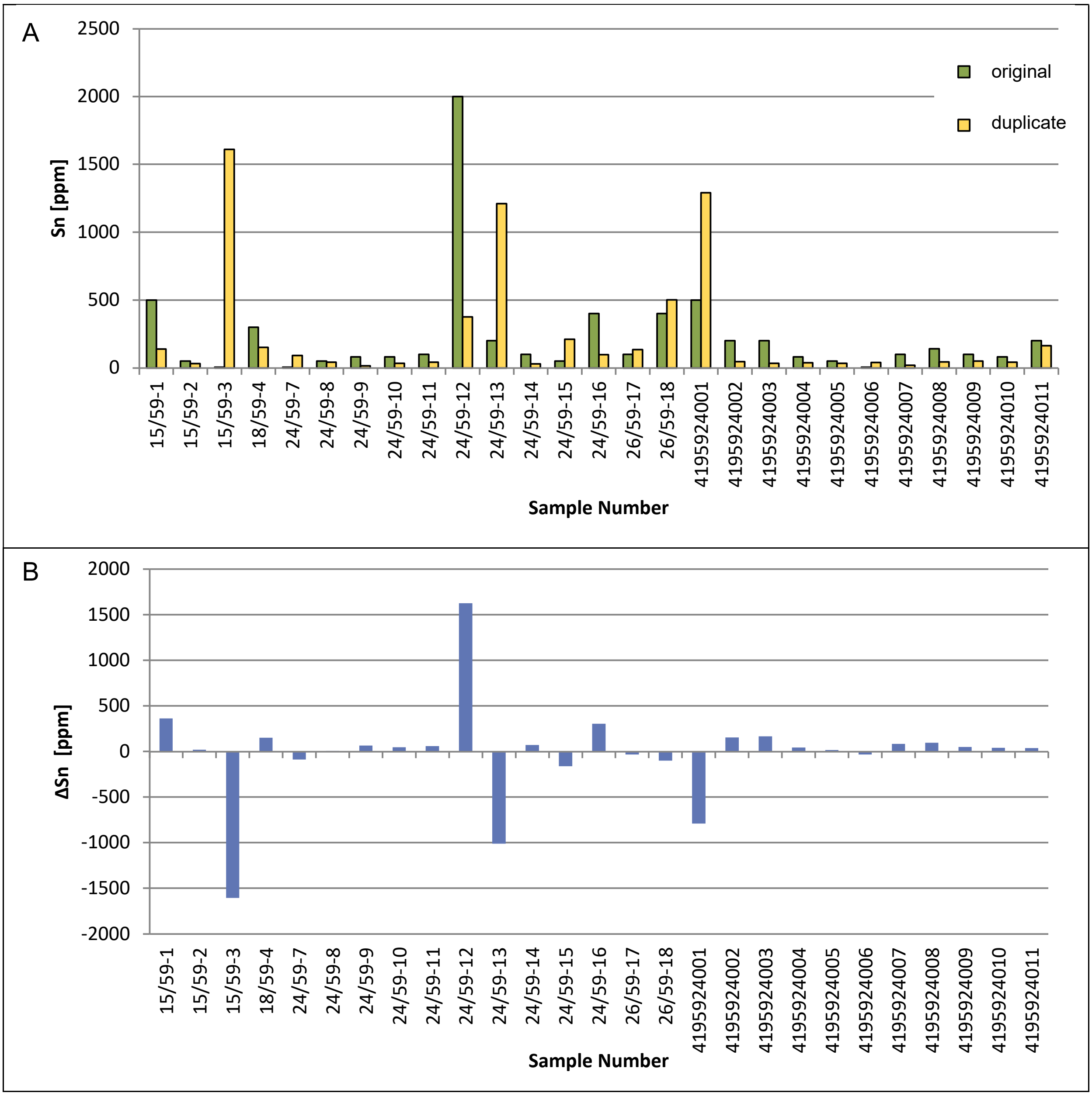


Figure 46: Results of sample pairs from historic and recent analysis of Li-exploration data (campaign No. (4))
(A) Absolute tin-concentration of original and duplicate assays
(B) Absolute deviation of tin-concentration (original minus duplicate)

12.2.2.3 Results of Reanalysis of Drill Core Samples from Sn-W-Exploration (Campaigns No. (6) and (7))

Samples from Sn-W-exploration campaigns are available as retained pulp samples grinded to less than 100 µm and packed in small labelled paper bags of about 50 g. The sample material that has been chosen for reanalysis represents drill core material from either chip samples or samples from half drill core (see *Table 35*).

In total, about 25 samples from 6 different drill holes were examined. Since the reanalysis of Sn-W-exploration samples is done on retained pulp material, which represents the identical sample material of the historic analyses, it provides a possibility to determine precision of analytical procedures from that time. No sampling bias is introduced.

Lithium

Results of duplicate analysis indicate a two-sided distribution of deviations for Li-concentrations. Whereas the majority of historic results of campaign No. (6) shows an excess of Li in comparison to the duplicates (mean / median of deviation = 430 / 310 ppm), results from campaign No. (7) indicates higher Li-concentration in the duplicates (mean / median of deviation = 115 / 40 ppm, see *Figure 47*).

The maximum absolute deviation of campaign No. (6) and (7) is about 1,220 and 920 ppm, respectively. However, since strong correspondence of original and duplicate analysis is displayed by high correlation coefficients of 0.92 (r_P) and 0.87 (r_S) for campaign No. (6) and 0.96 (r_P) and 0.97 (r_S) for campaign No. (7) as well as a mean deviation of sample pairs of both campaigns fell into the range of variations of natural greisen samples, Li-assays can be considered as reliable and therefore utilized in the resource calculation procedure.

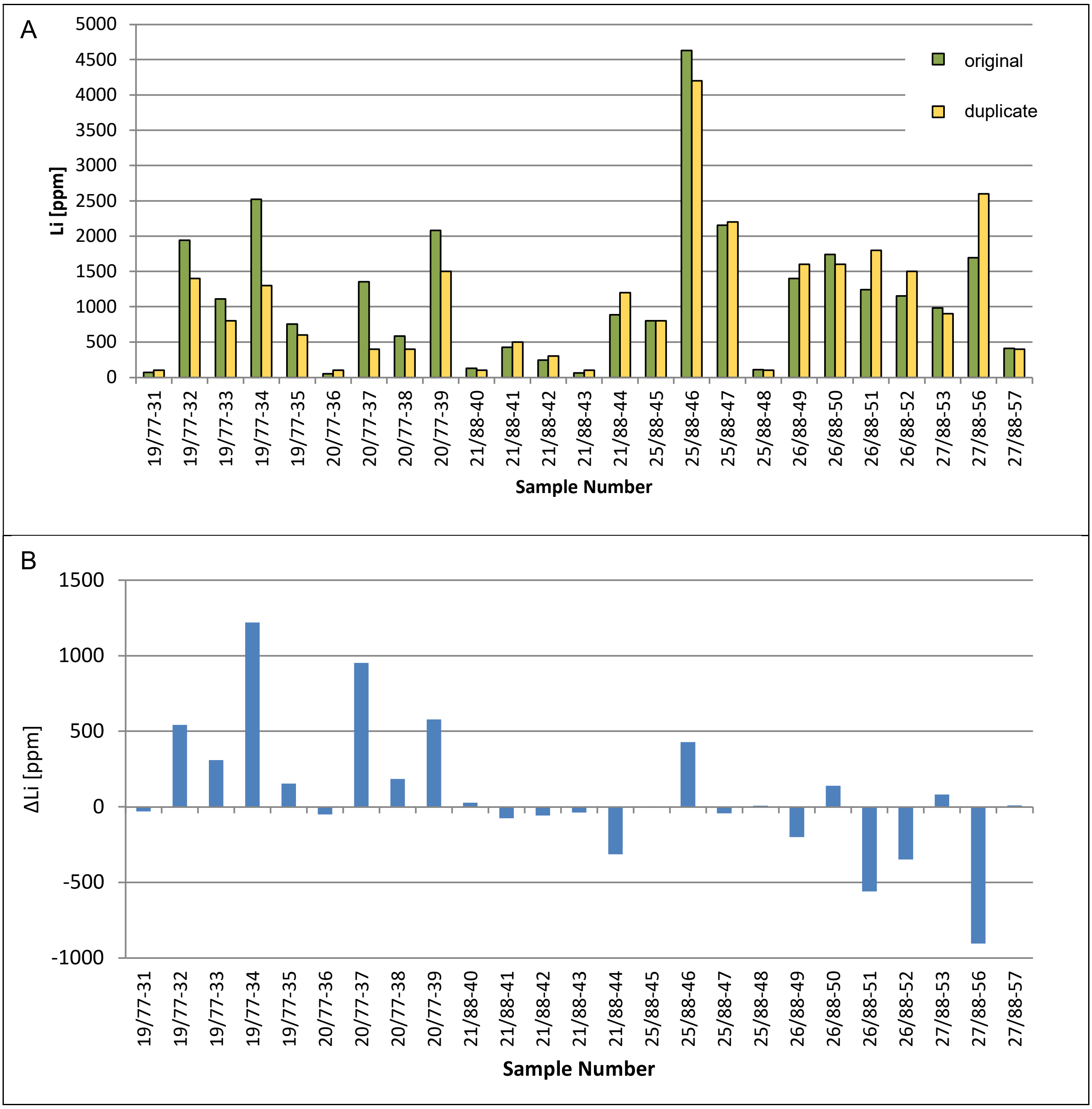


Figure 47: Results of sample pairs from historic and recent analysis of Sn-W-exploration data (campaigns No. (6) and (7))
(A) Absolute lithium-concentration of original and duplicate assays
(B) Absolute deviation of lithium-concentration (original minus duplicate)

Tin

Recent results of duplicate Sn-assays correspond well with the historic values for both campaigns. The trend of deviation indicates a constant but very slight excess of duplicate values in comparison to the historic ones. The maximum absolute deviation of about 65 ppm is close to the overall mean absolute deviation of about 18 ppm (median = 15 ppm) which is supported by correlation coefficients close to 1 (r_P=0.996 and r_S=0.984). However, one constraint refers to the limited grade range with a maximum of 940 ppm Sn.

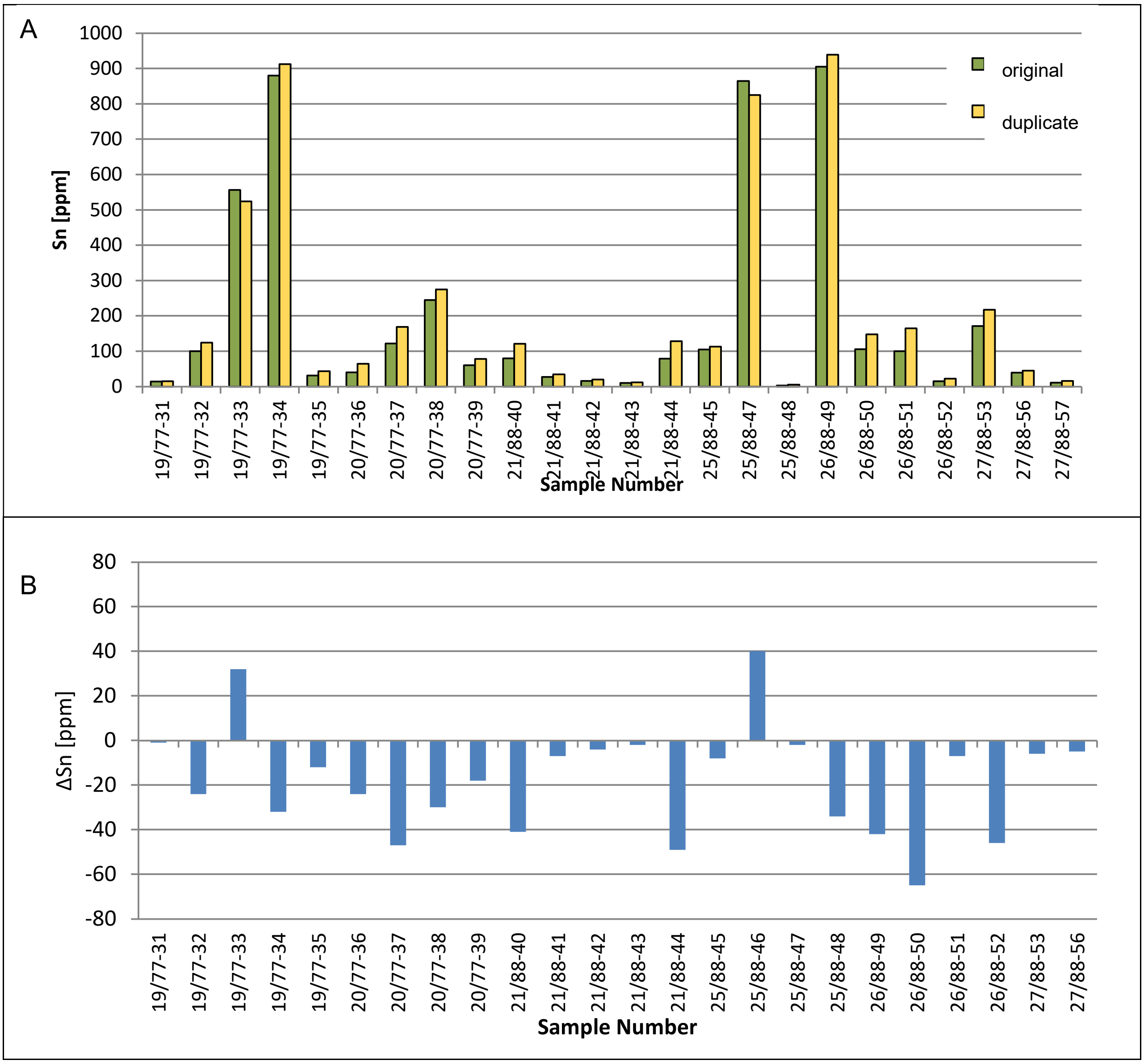


Figure 48: Results of sample pairs from historic and recent analysis of Sn-W-exploration data (campaigns No. (6) and (7))
(A) Absolute tin-concentration of original and duplicate assays
(B) Absolute deviation of tin-concentration (original minus duplicate)

Sn-concentrations of Sn-W-exploration data result from analytical procedures that can be considered as highly reliably reproducible and can be therefore utilized in the resource calculation without correction. However, since pairs of assays are available at limited concentration ranges, attempts should be made to gain material from stronger mineralized sample portions.

12.2.3 Quality Control Procedures

During exploration campaign No. (4) sample duplicates have been analyzed by ZGD (Central Geological Service of the GDR) in Berlin and Dresden. Assays of the laboratory of Dresden seem to be correct as confirmed by an arbitrary analysis of the laboratory of the Department of Non-Ferrous Metals of the Technical University Bergakademie Freiberg. Systematic differences stem from the usage of different sample digestion methods. 10 % of the samples have been internally controlled in Dresden. Further 10 % were analyzed as external control in Berlin and Freiberg using the same digestion procedure.

For exploration campaigns No.s (5), (6) and (7) no information on quality control of geochemical analysis was available so far.

Core quarter and core half duplicates, pulp and coarse (lab) duplicates, and internal standard material as well as certified standard material were applied during the recent exploration campaign No. (8) for the determination of the adequacy of chemical analysis. Furthermore, internal QA/QC measurements were conducted by the involved labs. Assaying was performed by the geochemical laboratory of ALS in Romania. External control based on pulp and coarse duplicates was carried out by the chemical laboratory of SolarWorld Innovations GmbH in Freiberg and by Actlabs, which are all certified through the International Organization for Standardization to ISO 9001:2008 and / or are accredited after ISO 17025.

For the drill holes ZGLi 01/2012 and ZGLi 02/2012 10 % of the samples had been checked by the external laboratory. For further drill holes of campaign No. (8) the ratio was reduced to 5 %.

12.2.4 Drill Hole Database

All data integrated in the database was checked by testing 10 % of the entries of the collar, survey, geology and samples tables. Less than 1 % of the checked data had to be corrected.
A second check for data plausibility has been executed as well. All data manipulation of the testing cycles is documented in the database.

12.2.5 Drilling Location and Survey Control

Drilling locations were controlled by checking the coordinates against the digital elevation model or by localizing the drill holes underground at the “Tiefer-Bünau-Stollen” level.

All collar positions were transformed to or surveyed in UTM 33N coordinates.

For most of the drill holes no downhole survey data was available and so they are assumed to be vertical. For drill holes with survey data, the paths have been controlled visually. The protocols of coordinate deviation of the drilling location towards the endpoint of the survey measurement were checked against the deviation in the SURPAC^{TM} model.

13 Mineral Processing and Metallurgical Testing

13.1 Introduction

The objectives of the feasibility study (FS) test work program were:

- To develop the process flowsheet to produce battery-grade lithium fluoride.
- To confirm that battery grade lithium can be produced at a pilot plant scale.
- Provide the design criteria and engineering data for major equipment selection and sizing.

The flowsheet developed during the prefeasibility study (PFS, [91]) consisted of mineral processing / beneficiation and lithium extraction stages.

The Mineral Processing / Beneficiation steps to produce a lithium mica concentrate and a quartz-rich tailing is based on:

1. Primary crushing using a jaw chusher
2. Secondary crushing using a cone crusher
3. Drying of the crushed material
4. Liberation dry grinding
5. Magnetic separation

The FS lithium extraction process is based on a gypsum / anhydrite and limestone roast followed by water leach, solution purification and evaporation and crystallization to produce lithium fluoride and potassium sulfate.

There were modifications to the PFS flowsheet resulting from the FS test work results.

These resulted in improved project economics and better expected process plant perfromance. The modifications include:

- Reduction of two magnetic separation circuits to one magnetic separation circuit to reduce capex
- Increase of the plant feed dryer capacity, up to 6 wt.% water in the ore
- The roasting recipe was changed to a calcium sulfate / carbonate roast, from the PFS sodium sulfate / anhydrite roast, to increase the recoveries of of lithium and potassium
- The final product was changed from Li_2CO_3 / $LiOH{\cdot}H_2O$ to LiF, to improve project economics
- A fluoride removal step was included where activated limestone removes trace fluoride

Based on the results on “20 t PERC 2011 sample” used in the PFS [91] the final feasibility flowsheet was established by design work on 50 t from a 100 t 2017 lithium mica greisen bulk ore sample and the mineral processing stage was confirmed by additional test work on 25 drilling core samples from several ore bodies of different parts of the deposit.

Key test work results are summarized below:

- Initial beneficiation circuit definition tests identified the specifications for the crushing, grinding and magnetic separation circuits.
- Beneficiation test work on both the 20 t and 50 t samples using the selected flowsheet gave similar high yields, > 90 % Li recoveries with a difference of only 2 %.
- Overall lithium recovery of the 25 drilling core samples ranged from 86,2 wt.% to 96,4 wt.%.
- Roasting recipe (concentrate : anhydrite : limestone) has been verified at a bench scale and pilot plant scale. The best performance used a 14 : 5.6 : 5.6 mass ratio.
- Extraction test work confirmed a robust roasting recipe, consistently achieving > 85 wt.% lithium extraction. Impurity removal successfully reduced levels of calcium and magnesium.
- Extraction test work on four production composites successfully followed the process flowsheet. Impurities were removed and battery grade lithium fluoride (comparable to Albemarle and FMC) was produced for each of the four composites. The purity of the four refined lithium fluoride samples, expressed as percent lithium fluoride, were 99,5 wt.% [160], 99,4 wt.% [175], 99,4 wt.% [186] and 99,5 wt.% [127].

The test work results served as inputs to the process design criteria, which were used to develop the mass balance.

13.2 Test Work Sample Selection and Feed Grades

The following test work samples were selected and prepared and used for the PFS and FS metallurgical test work programs:

- 2011, 20 t PFS bulk ore sample [91]: Approximately 20 t of lithium mica greisen ore was mined from the visitor mine in Zinnwald. The sample originates from ore body B and had a mean Li grade of 3,900 ppm.
- 2017, 100 t FS bulk ore sample [157]: About 100 t of lithium mica greisen ore was mined from the visitor mine in Zinnwald. The sample originates from ore body B and had a mean Li grade of 4,009 ppm. From the 100 t sample, approximately 50 t was used for beneficiation test work. About 10 t of mica concentrate was produced that was used for downstream pyrometallurgical and hydrometallurgical test work.
- DDH core samples: In order to test the process using samples from different areas with the deposit, 25 variability samples were selected from drill core available from the drilling campaigns of 2012- 2013 and 2017. The selected samples represent all major ore bodies, as well as their spatial distribution across the deposit.

Figure 49 presents the location of the variability samples from the 2012 – 2013 and 2017 exploration drilling campaigns as well as the location of the 20 t and the 100 t bulk ore samples extracted in 2011 and 2017, respectively. The results of the test work completed on these samples are presented in the following sections.

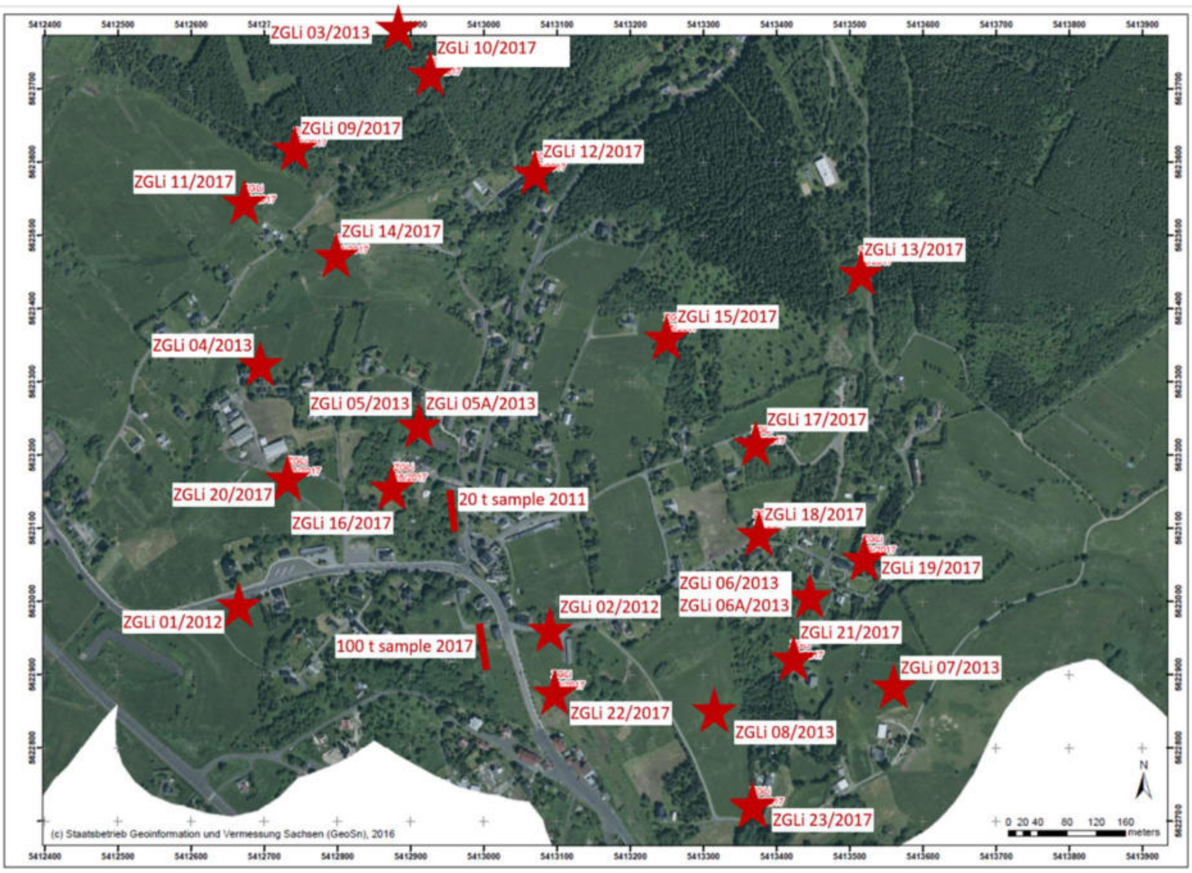


Figure 49: Locations of the variability of drill core samples from the exploration campaigns 2012-2013, 2017, and the underground bulk ore samples of 2011 and 2017

13.3 Mineralogical Test Work

13.3.1 Sample Selection and Methodology

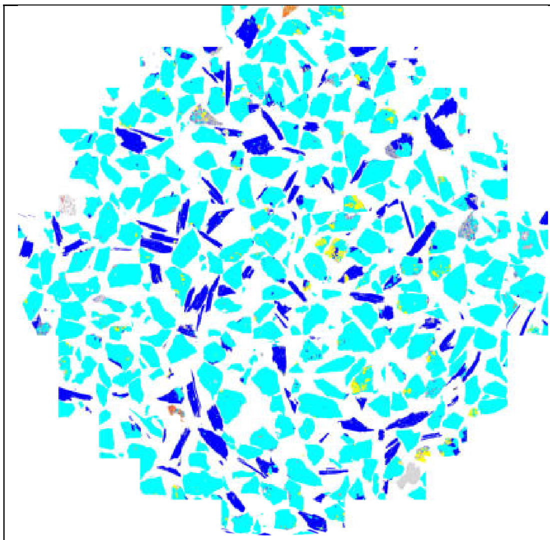
The mineralogical test work was carried out by the Department Mineralogy, Division of Economic Geology and Petrology of the Technical University of Freiberg [54]. The sample material used for this work originated from the 20 t ROM sample taken 2011. The material was crushed, ground and divided into 6 particle size fractions by UVR-FIA GmbH (*Table 36).*

Table 36: Particle size fractions for MLA measurements

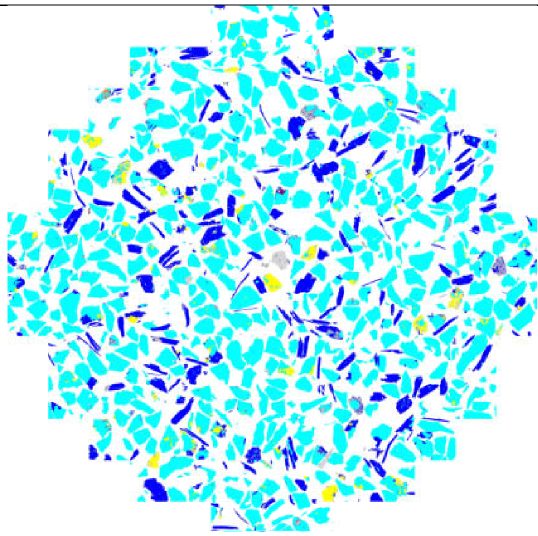
Fraction 1	Li 1	1.250 - 0.800 mm	Fraction 4	Li 4	0.315 - 0.160 mm
Fraction 2	Li 2	0.800 - 0.630 mm	Fraction 5	Li 5	0.160 - 0.090 mm
Fraction 3	Li 3	0.630 - 0.315 mm	Fraction 6	Li 6	< 0.09 mm

The 6 sub samples were examined using scanning electron microscopy (SEM) with semiquantitative energy dispersive X-ray spectroscopy (EDX). The data obtained were analysed with the mineral liberation analyzer (MLA) software package. The results provided an assement of the mineralogical composition, mineral intergrowth, degree of liberation as well as grain size and grain shape. It also presented the liberation characteristics for optimum physical separation of the ore minerals (i.e. zinnwaldite) from the gangue (i.e. quartz).

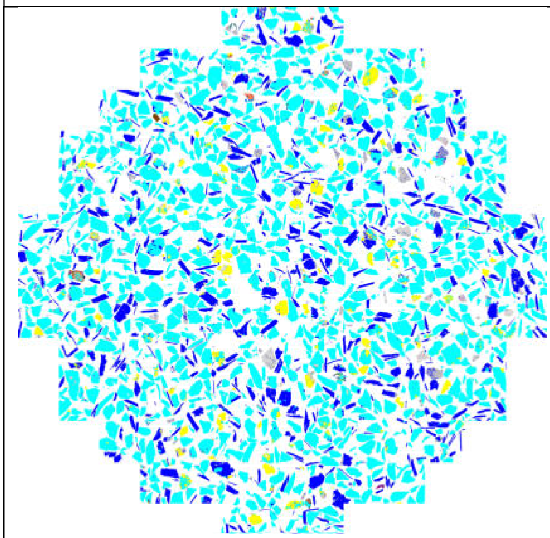
Figure 50 provides an overview of the image data of the measured samples along with an indication of the fraction size and number of measured particles.



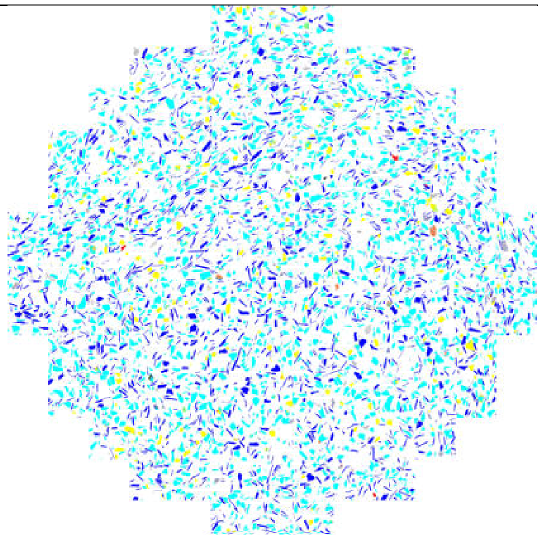
Sample Li 1 (1.250 – 0.800 mm): 558 particles



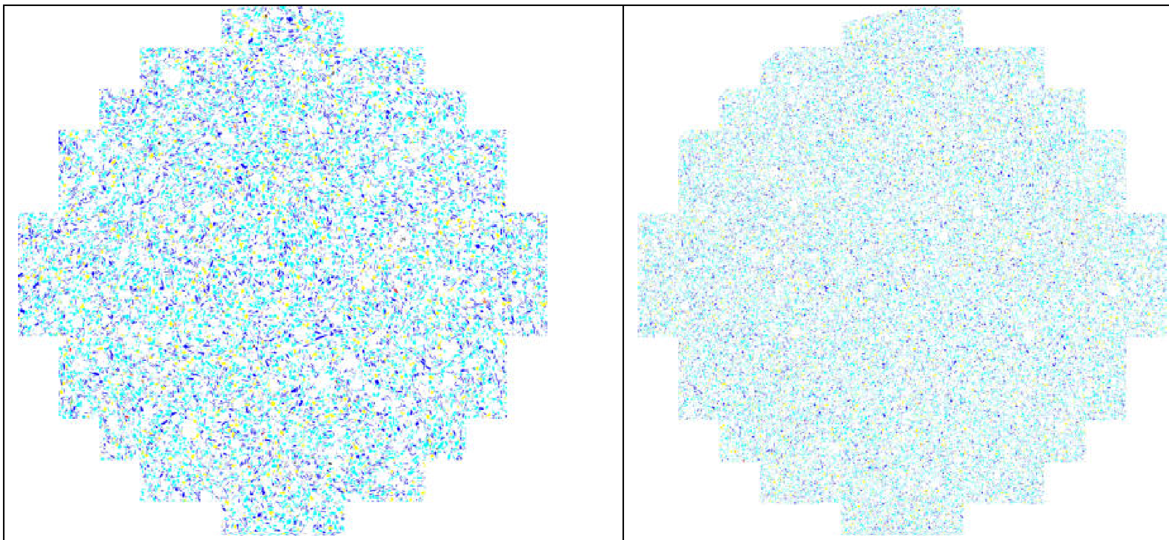
Sample Li 2 (0.800 - 0.630 mm): 1,013 particles



Sample Li 3 (0.630 – 0.315 mm): 2,157 particles



Sample Li 4 (0.315 – 0.160 mm): 5,274 particles



Sample Li 5 (0.160 – 0.09 mm): 17,116 particles | Sample Li 6 (< 0.09 mm): 63,839 particles

Figure 50: Overview of the processed image data of samples Li 1 to Li 6 (Note – Dark blue – Zinnwaldite, light blue – quartz and yellow – topaz)

13.3.2 Modal Mineralogical Composition

The modal mineralogical composition is derived from the relative percentage area of a mineral on the total area of all investigated mineral grains. The main minerals quartz, zinnwaldite and topaz dominate the composition of the samples and exhibit a combined proportion that range from 96 wt.% in the coarsest fraction (Li 1) up to 88 wt.%t in the finest fraction (Li 6).

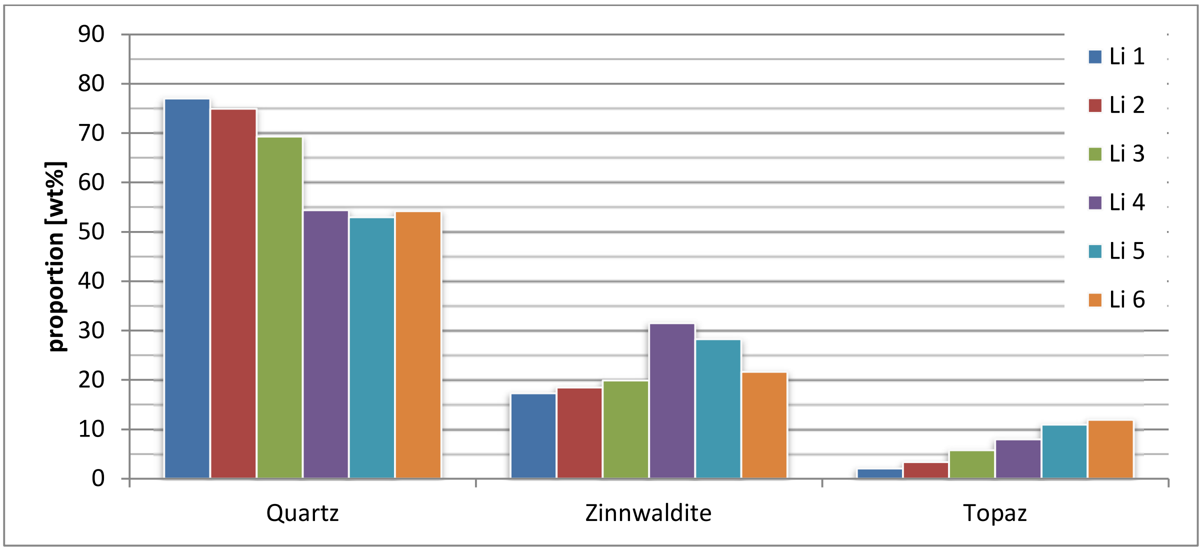


Figure 51: Distribution of the main minerals quartz, zinnwaldite and topaz

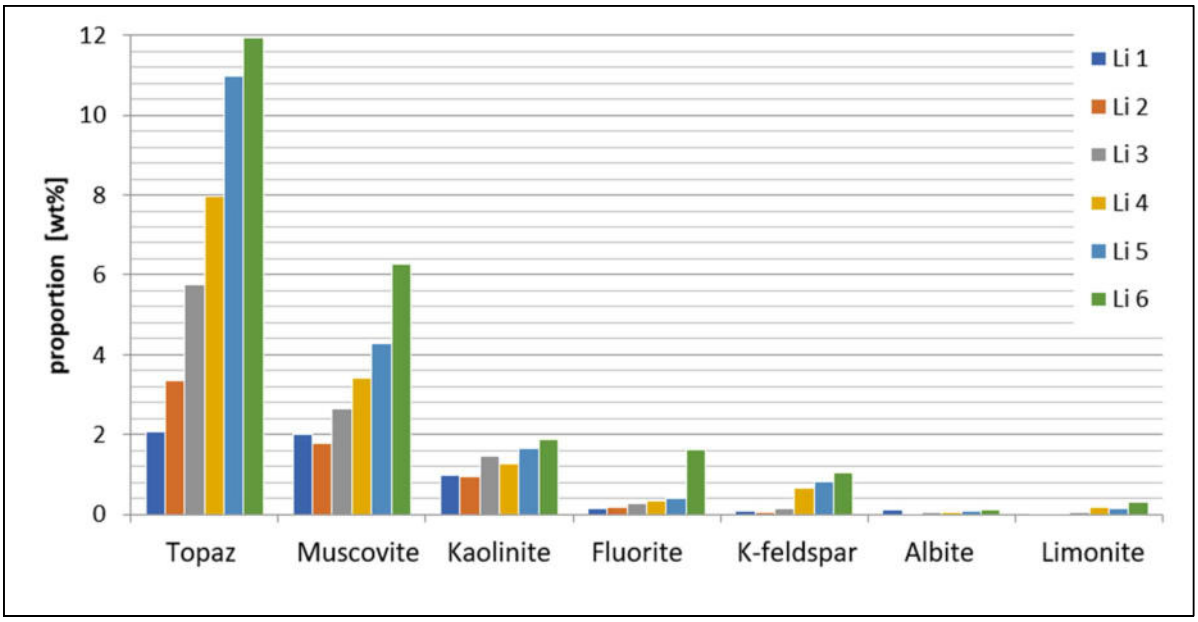


Figure 52: Distribution of subordinate and minor minerals. Topaz is shown for comparison with main minerals

.

Table 37: Modal mineralogical composition

Mineral [wt.%]	Li 1	Li 2	Li 3	Li 4	Li 5	Li 6
Quartz	77.03	74.95	69.30	54.37	52.97	54.18
Zinnwaldite	17.30	18.44	19.91	31.49	28.26	21.63
Topaz	2.09	3.35	5.75	7.97	10.97	11.95
Muscovite	2,02	1.80	2.64	3.42	4.28	6.26
Kaolinite	1.00	0.94	1.47	1.26	1.67	1.87
Fluorite	0.17	0,20	0.27	0.36	0.42	1.62
K-feldspar	0.08	0.07	0.17	0.68	0.82	1.04
Albite	0.12	0.04	0.06	0.06	0.09	0.12
Limonite	0.04	0.03	0.07	0.19	0.14	0.31
Cassiterite	0.01	0.01	0.10	0.02	0.08	0.11
Wolframite	0.01	0.00	0.00	0.00	0.00	0.00
Scheelite	0.01	0.07	0.05	0.03	0.00	0.12
Total	99.88	99.90	99.79	99.85	99.70	99.21

The relative modal mineralogical composition presented in [54], is summarized in *Table 37* and shows that the proportion of quartz in the individual fractions decreases with decreasing grain size from 77 to 53 wt.%. In contrast, the minerals topaz (2 to 12 wt.%), muscovite (2 to 6 wt.%), kaolinite (1.0 to 1.9 wt.%), fluorite (0.2 to 1.6 wt.%) and potassium feldspar (0.1 to 1.0 wt.%) show an opposite behavior. The main ore mineral zinnwaldite exhibits a bell-shaped distribution with a maximum content of 31 wt.% in the fraction Li 4 (0.315-0.160 mm). *Figure 53* displays the accumulated proportions of the main minerals for the different size fractions. This shows which mineral in the corresponding particle size fraction is enriched or suppressed relative to the others and demonstrates that the proportion of quartz, which decreases towards the finer fractions, is essentially replaced by the growing proportions of zinnwaldite, topaz, muscovite and fluorite. Identified accessory minerals comprise cassiterite, wolframite, scheelite, baryte, chamosite and zircon.

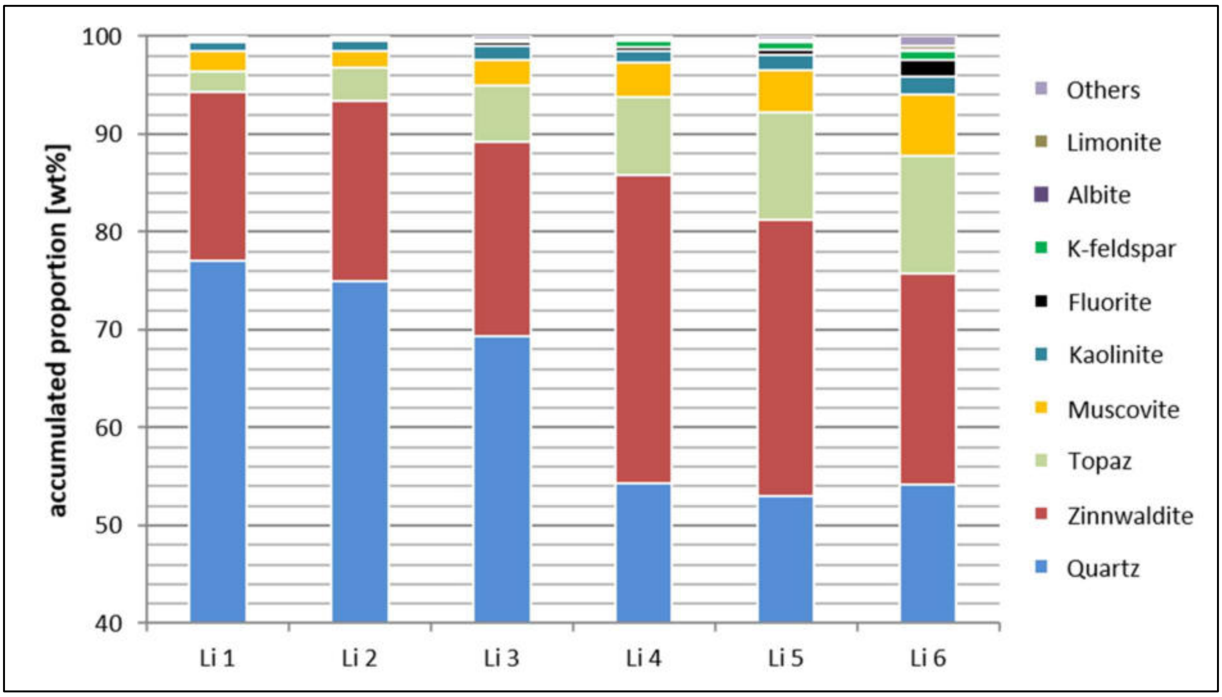


Figure 53: Accumulated proportion of the main minerals per size fraction.

13.3.3 Mineral Intergrowth and Liberation

In addition to the results on particle size and mineralogical composition, the MLA software package provides information about intergrowths, liberation and potential recovery of the main ore mineral zinnwaldite.

Figure 54 display the two types of zinnwaldite intergrowths observed within the samples. In *Figure 54a*, the intergrowth consists of two or more minerals and all minerals have a share of the grain boundary. The second type of intergrowth represents mineral inclusions were a mineral is completely enclosed by one or more minerals (*Figure 54b*).

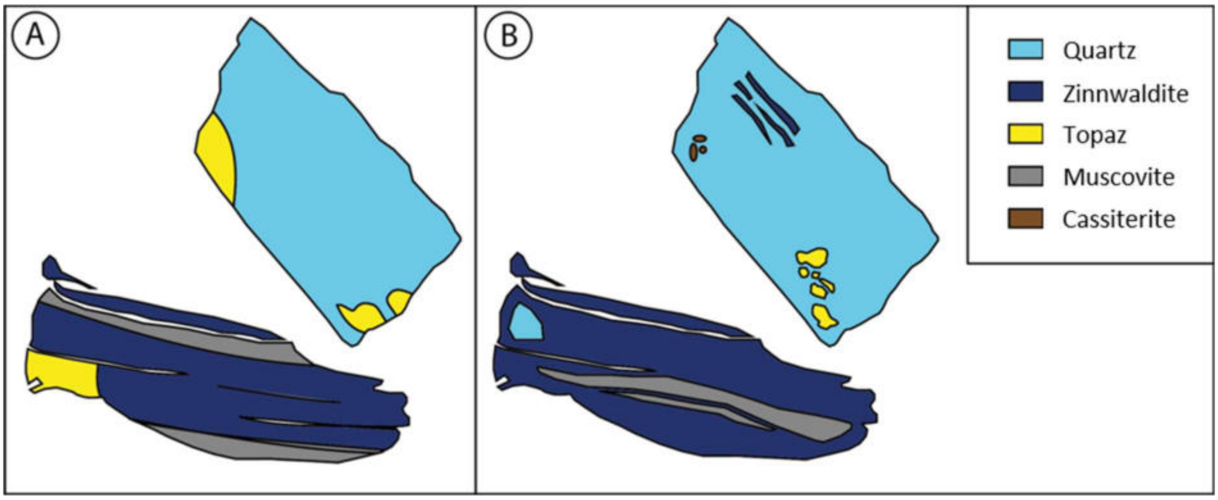


Figure 54: Schematic illustration of the two types of intergrowth conditions. (A) Two- and three-phase intergrowth, where all minerals share a part of the particle boundary. (B) Three- and multiphase intergrowth in the form of inclusions

The type and extent of mineral inclusions of zinnwaldite within other minerals is illustrated in *Figure 55* and *Figure 56*. For each grain fraction, the percentage of minerals is shown that completely enclose the zinnwaldite. *Figure 55* only considers binary intergrowths, i.e. inclusions of zinnwaldite in another phase. This illustrates the dominance of quartz and muscovite in coaser fractions (Li 1 to Li 3) and that these fractions contain the highest proportion of trapped zinnwaldite (up to 53 wt.%). Towards the finer fractions (Li 4 to Li 6) the total proportion of zinnwaldite inclusion decreases to 21 wt.% while the total amount of zinnwaldite inclusions in potassium feldspar increases, the inclusions in muscovite tend to decrease and inclusions in quartz are at a relatively low level.

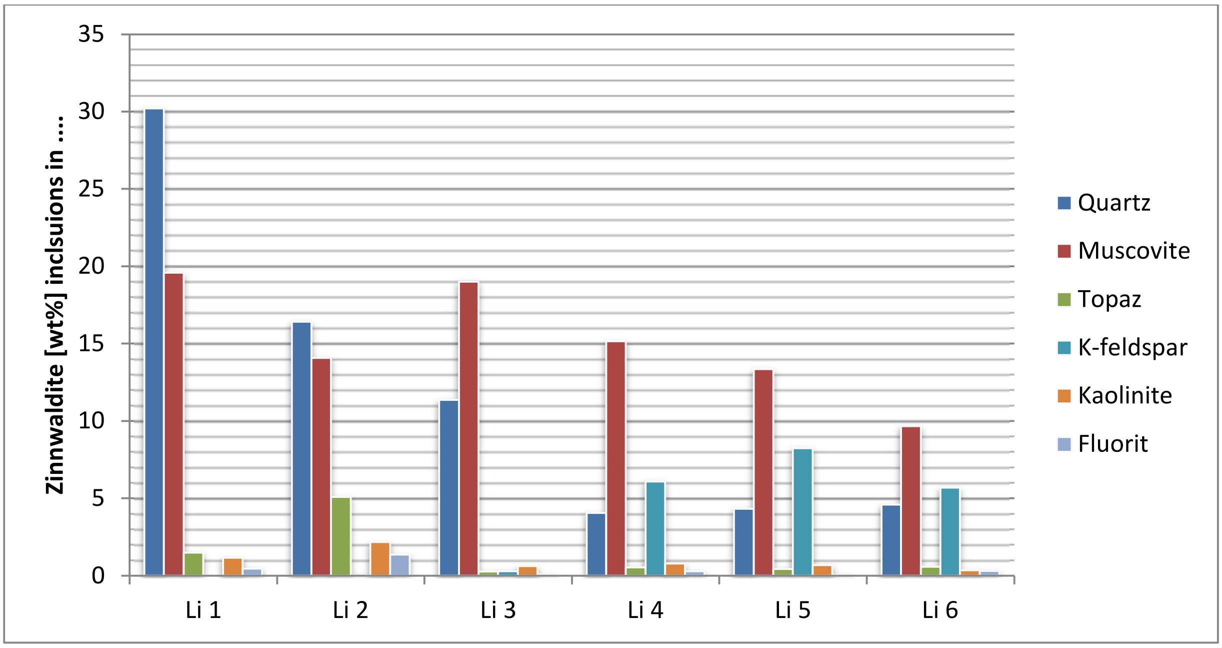


Figure 55: Type and proportion of binary zinnwaldite inclusions

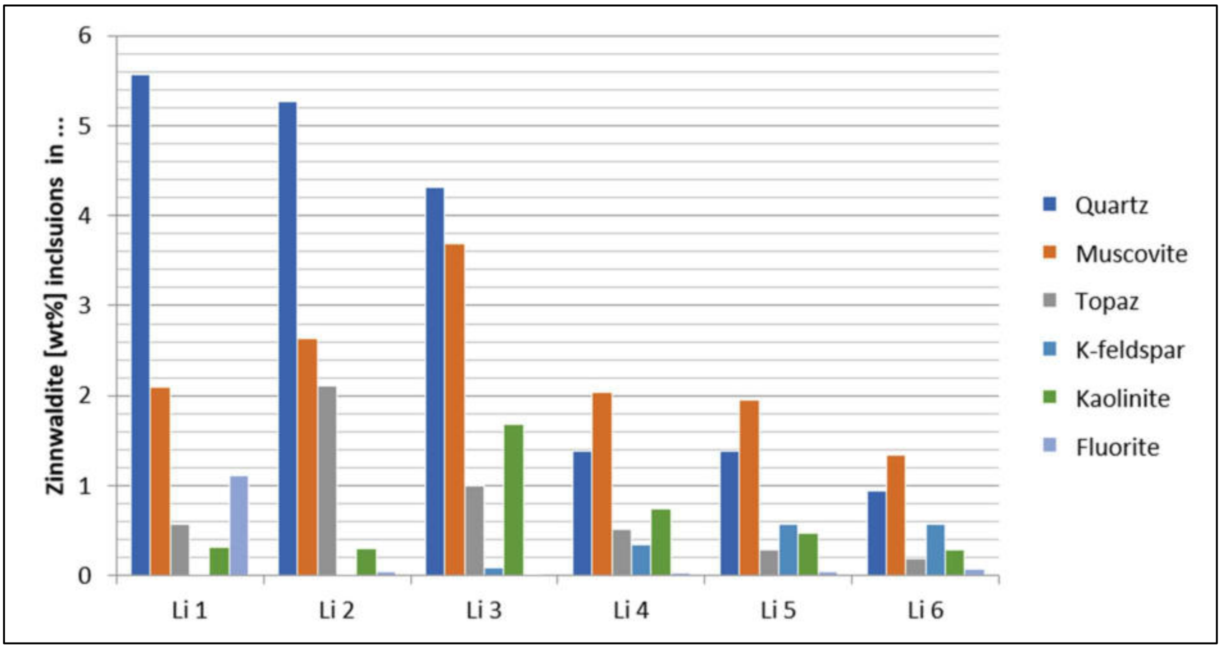


Figure 56: Type and proportion of zinnwaldite inclusions in multiple phases

Figure 56 suggests a much lower proportion of included zinnwaldite as tri- and multiphasic inclusions (total 11 to 3 wt.%).

13.3.4 Liberation and Recovery

Figure 57 displays the accumulated (cumulative) liberation and potential recovery of liberated zinnwaldite within each size fraction. Thus, the degree of zinnwaldite liberation and recovery is the lowest in the coarsest fraction (Li 1) due to the high degree of intergrowth. This effect decreases towards sample Li 2 and Li 3. Due to the increasing proportion of accompanying minerals such as muscovite, kaolinite, fluorite and others, the zinnwaldite liberation cannot be increased further. Consequently, the optimum ratio of maximum liberation and recovery to maximum zinnwaldite content is considred to be in fraction Li 4 (0.315-0.160 mm).

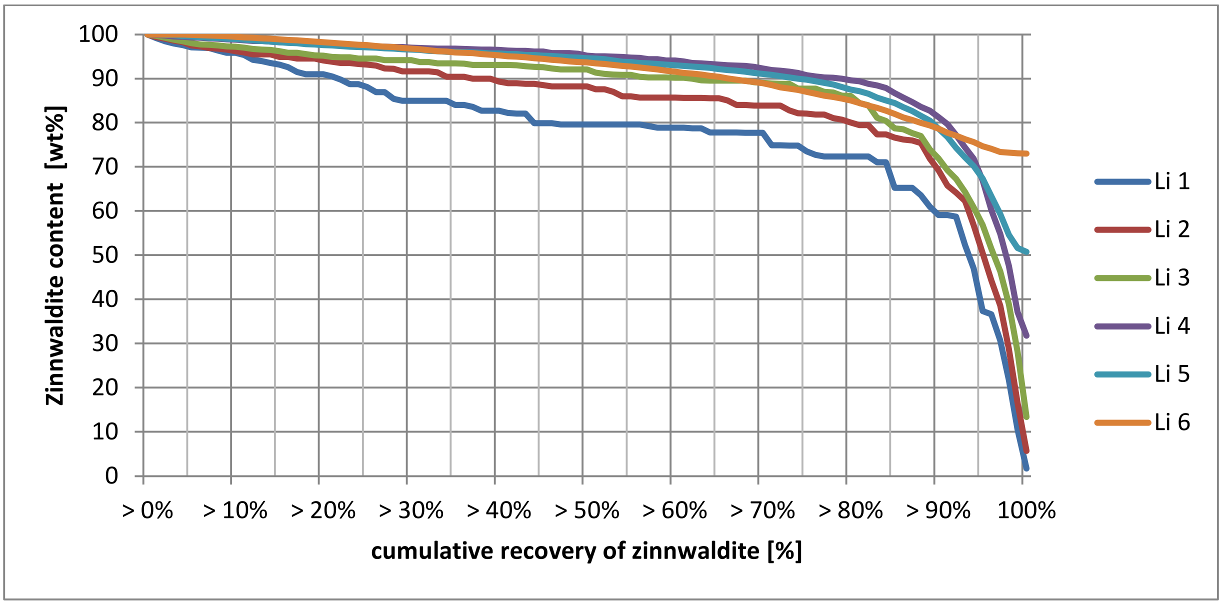


Figure 57: Comparison of cumulative zinnwaldite recovery for the grain size fractions Li 1 to Li 6

13.4 Benefication Test Work

The beneficiation steps of the zinnwaldite recovery process comprises crushing, grinding, multi-stage magnetic separation and fine grinding of the concentrate to minus 315 µm (*Figure 58*). Several bench scale tests were performed to determine the optimal grain size for an effective magnetic separation process and to optimize the parameters for the whole process. The results from these tests were used as a basis for a pilot test using approximately 10 t of lithium mica greisen mineralization.

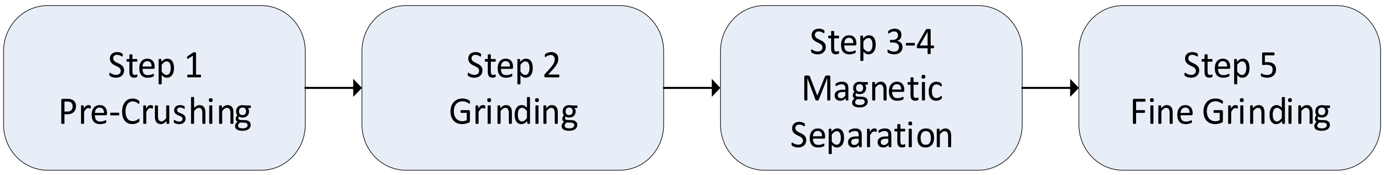


Figure 58: Block flow chart for mineral processing

13.4.1 Historical Test Work Programs

The experimental studies were performed by the UVR-FIA GmbH ([60], [61], [62], [64], [72], [76], [85]). The scope of these tests and their main findings are summarized below:

- Preliminary-study on a theoretical process design of wet and dry magnetic separation process for zinnwaldite concentrate production based on theoretical data and experiences of other mineral processing plants [60]:
    - High water consumption of wet processing
    - Estimated costs for a wet magnetic separation plant are less than for a dry magnetic plant.
    - Recommended further test work on both the wet and dry process
- Laboratory wet high intensity magnetic separation (HIMS) tests and plant feed grind size optimization [62]:
    - A two-step wet magnetic separation demonstrated a lithium recovery of 72 wt.%.
- Laboratory single step dry magnetic separation tests [61]:
    - Demonstrated a lithium recovery of between 60 to 80 wt.%. Additional magnetic separation steps could improve the recovery to around 94 wt.% Li.
- Laboratory test work to maximize the lithium mica recovery by means of multi-stage comminution, classification and magnetic separation [72]:
    - The two-step magnetic separation achieved a lithium recovery rate of >90 wt.%.
    - The resulting mica concentrate contained 1.2 wt.% Li.
    - Recommended further development of the dry magnetic separation process.
- Test work program for fine grinding of lithium mica concentrate with an impact mill [64]:
    - It was demonstrated that an impact mill is suitable for the fine grinding of lithium mica.
    - High wear of the impact mill was noted.
- Comparative test work program for fine grinding of zinnwaldite concentrate with a vertical roller mill, an eccentric vibrating mill and an impact mill [85]:
    - All types of the mills tested can successfully grind the mica concentrate to below 315 µm.
    - Main differences were detected in the wear resistance.

  - The vertical roller mill turned out to be most practicable and suggested further processing test work (established milling technology for mica milling).

- Development of a preliminary process flowsheet based on the above mentioned laboratory test work results [76].

- Pilot test work using a 10 t split of the 20 t ROM sample from 2011, including locked cycle tests with high pressure grinding rolls and optimization of the magnetic separation process [85]:

  - Lithium recovery of > 94 wt.% was achieved.
  - The resulting mica concentrate contained 1.2 wt.% Li.
  - Based on these results, the beneficiation process flowsheet was defined and optimized (*Figure 59).*

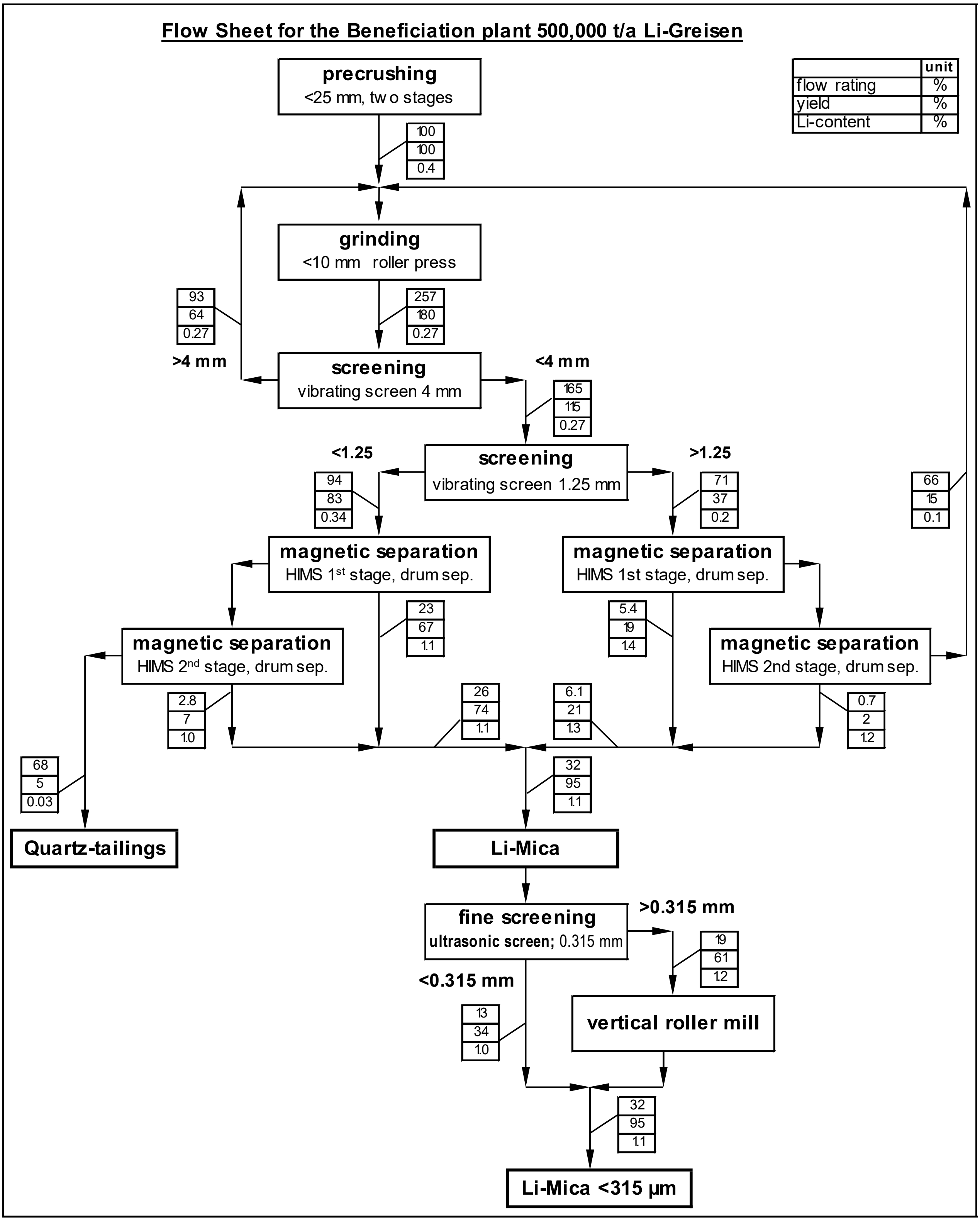


Figure 59: Process flowsheet based on the 2011 – 2014 test results.

13.4.2 Feasibility Study Pilot Plant Test Work

In 2017, a bulk sample of 100 t was mined of which 50 t was used for the validation of the mineral processing flowsheet [157] presented in *Figure 59*. This pilot plant scale testing was mainly undertaken at the UVR-FIA GmbH technical center in Freiberg; however, as the number and scale of the technical equipment at this facility was limited, it was necessary to make some adjustments of the test work flowsheet:

- Due to logistical requirements the flowsheet from 2013 was subdivided into 6 steps.

    1. Comminution to ≤ 4 mm (including drying of the ROM ore)
    2. Magnetic Separation and further grinding of the coarse fraction (1.25 - 4 mm)
    3. Magnetic Separation of the fine fraction (≤ 1.25 mm)
    4. Blending of the concentrate products
    5. Grinding of the concentrate to ≤ 0.3 mm
    6. Final blending of mica concentrate

- The process steps were carried out successively. Between the steps, the semi-finished products were stored in flexible intermediate bulk containers (FIBCs).
- The grinding circuit of the roller press mill, which also includes screening and magnetic separation steps, was replaced by several grinding steps with roller crushers.
- The magnetic separation was subdivided into several campaigns as only one suitable HIMS was available.
- The milling of the mica concentrate was carried out with a vertical roller mill at CEMTEC (Enns / Austria).
- Finally, the mica concentrates from the individual separation steps were blended to produce the final Li-mica concentrate.

The mica concentrate product from the pilot scale test had an average lithium content of 1.33 wt.% Li and a recovery of 92.1 wt.% Li was achieved. A lithium recovery of 92 wt.% was used for further technological and economic evaluations.

Based on the results of the test work, the FS process flowsheet, design criteria and the mass balance was adjusted [158]. To reduce capital cost, one of the two magnetic separation lines was omitted. *Figure 60* displays the FS flowsheet and mass balance. These results were used as a basis for the basic engineering.

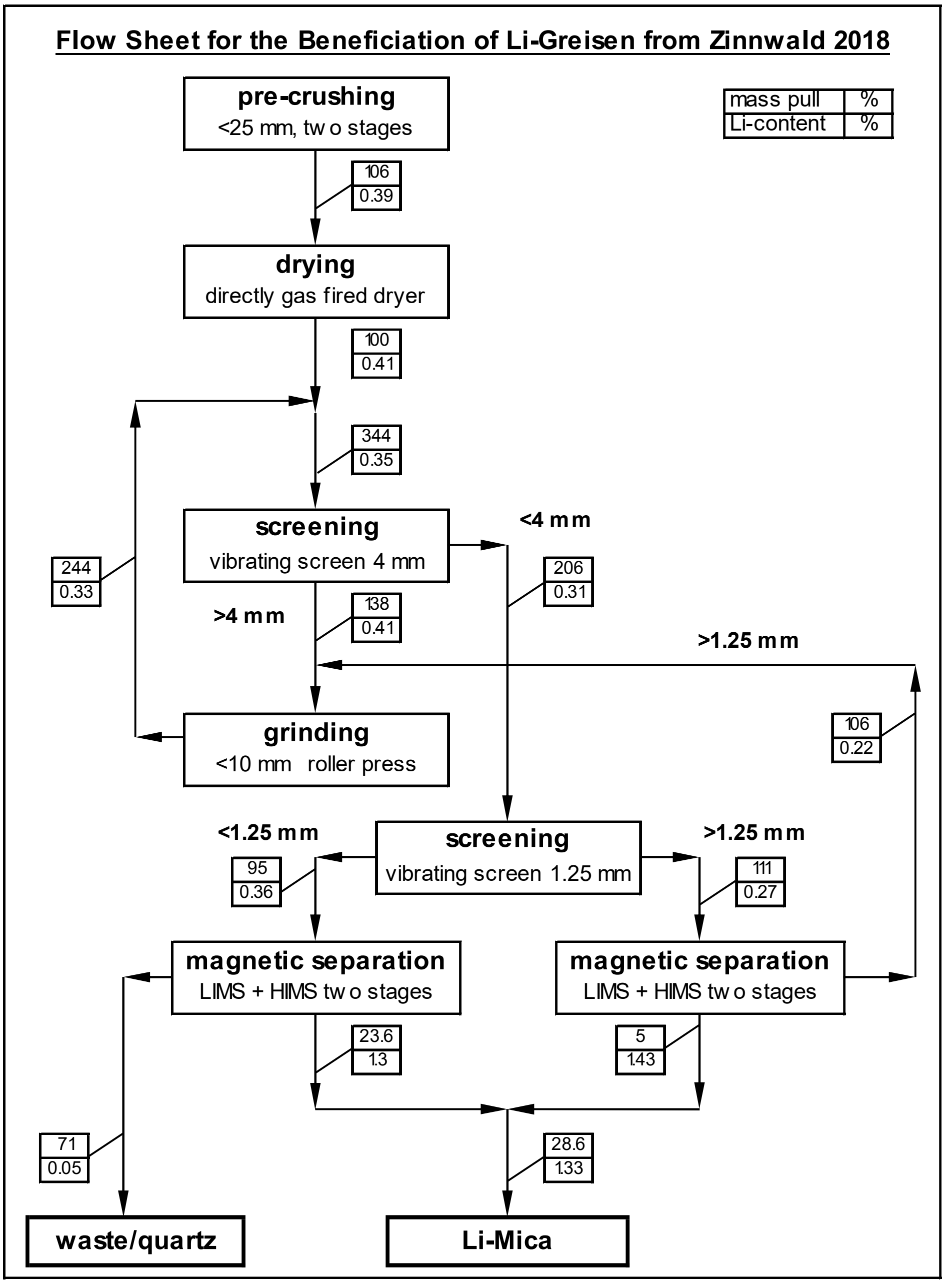


Figure 60: Flowsheet and mass balance for the basic engineering 2018.

13.4.3 Variability Test Work

To test the variability of the ore throughout the deposit, 25 samples from the DDH cores were tested using the FS flowsheet [159]. This program included 25 variability samples comprising about 3 to 50 kg of drill core and one reference sample from the 50 t bulk ore test work. Because the drill core samples contained some residual water, they were first dried at 110 °C.

The overall lithium recovery for the 25 drilling core samples ranged from 86.2 wt.% to 96.4 wt.% and averaged 89.7 wt.% for 18 of the 25 samples, which is a bit lower than that achieved in the 50 t bulk ore sample pilot plant. This is due to different mineralogical composition and alteration of the greisen ore. Samples with higher clay contents typicaly exhibited lower lithium recoveries. The average Li recovery of samples from the main ore lithologies (TGQ+GM and TGGM) was 94.2 wt.% Li.

The variability testwork underlines the importance of checking ore quality in the mine to ensure a supply to the mineral processing plant of material with consistent quality.

13.5 Lithium Extraction Metallurgical Test Work

The lithium extraction metallurgical process consists of two main steps; the pyrometallurgical process and the hydrometallurgical process.

The pyrometallurgical process consists of:

- Fine grinding of mica concentrate to below 315 µm
- Mixing of milled concentrate with suitable additives such as anhydrite/gypsum and lime-stone
- Roasting in kilns e.g. rotary or tunnel kilns

The hydrometallurgical processing consists of:

- Deagglomeration of roasted material
- Leaching of roasted material with hot water
- Purification of the mother leach liquor
- Precipitation, washing and drying of lithium fluoride

- Sulfate of potassium (SOP)-crystallization

13.5.1 Pyrometallurgical Processing

The FS roaster feed preparation process includes the blending and pelletizing of ground zinnwaldite concentrate and reagents (anhydrite, limestone and water) to produce green pellets measuring 2 to 10 mm in diameter and containing 12 to 15 wt.% moisture. During the PFS in 2012 to 2013, alternative possibilities were considered and tested.

In 2012, lithium extraction with sulfuric acid and subsequent roasting with anhydrite and sodium sulfate at 900 °C was evaluated. Although, this process achieved promising lithium recoveries (> 90 wt.%), the cost for sulfuric acid and disposal of the leached roasted tailings were deemed too expensive. Similarly, the addition of anhydrite and sodium sulfate at a roasting temperature of 900 °C was evaluated. This resulted in comparable high recovery rates of lithium (> 90 wt.%), but the potassium recovery rate dropped to below 20 wt.% [48].

Additional, laboratory scale roasting test work was performed by G.E.O.S. in 2014 [58] in order to define the optimum feed blend and basic process parameters (roasting temperature, roasting duration, additives etc.). The results showed a recovery rate of > 95 wt.% for lithium and > 50 wt.% for potassium. The highest lithium recovery was achieved with a zinnwaldite : anhydrite : limestone mass ratio blend of 14 : 5.6 : 5.6. This mass ratio of anhydrite and limestone corresponds to the effective calcium sulfate and calcium carbonate in the zinnwaldite concentrate.

For confirmation of these parameters, roasting test work was performed in a small pilot plant at IBU-Tec in Weimar (Germany) in August 2017 [96]). A 7 m long by 0.3 m inner diameter rotary kiln (KDO) was used for this work and during the continuous one-week test period about 700 kg of roasted product was generated.

In March 2018, the FS roasting test work comprised two campaigns at a pilot plant located at IBU-Tec in Weimar / Germany [124]. This pilot plant (*Figure 61*) consisted of a natural gas fired 12 m long by 1 m inner diameter rotary kiln (GDO) and a downstream rotary cooler. A mixture of lithium mica concentrate, anhydrite and limestone was fed to an intensive mixer (Eirich R 11, 250 L live volume, *Figure 62*) at a controlled rate. The resulting wet granules were dried and roasted for 30 minutes at 1,000 °C in a rotary kiln under an oxidizing atmosphere (*Figure 63, Figure 64*) and then cooled down to around 30 °C in a rotary cooling system before filling the product big bag using a pneumatic conveying pipe. The feed rate during the testwork campaign (wet mixture) varied between 240 and 300 kg/h.

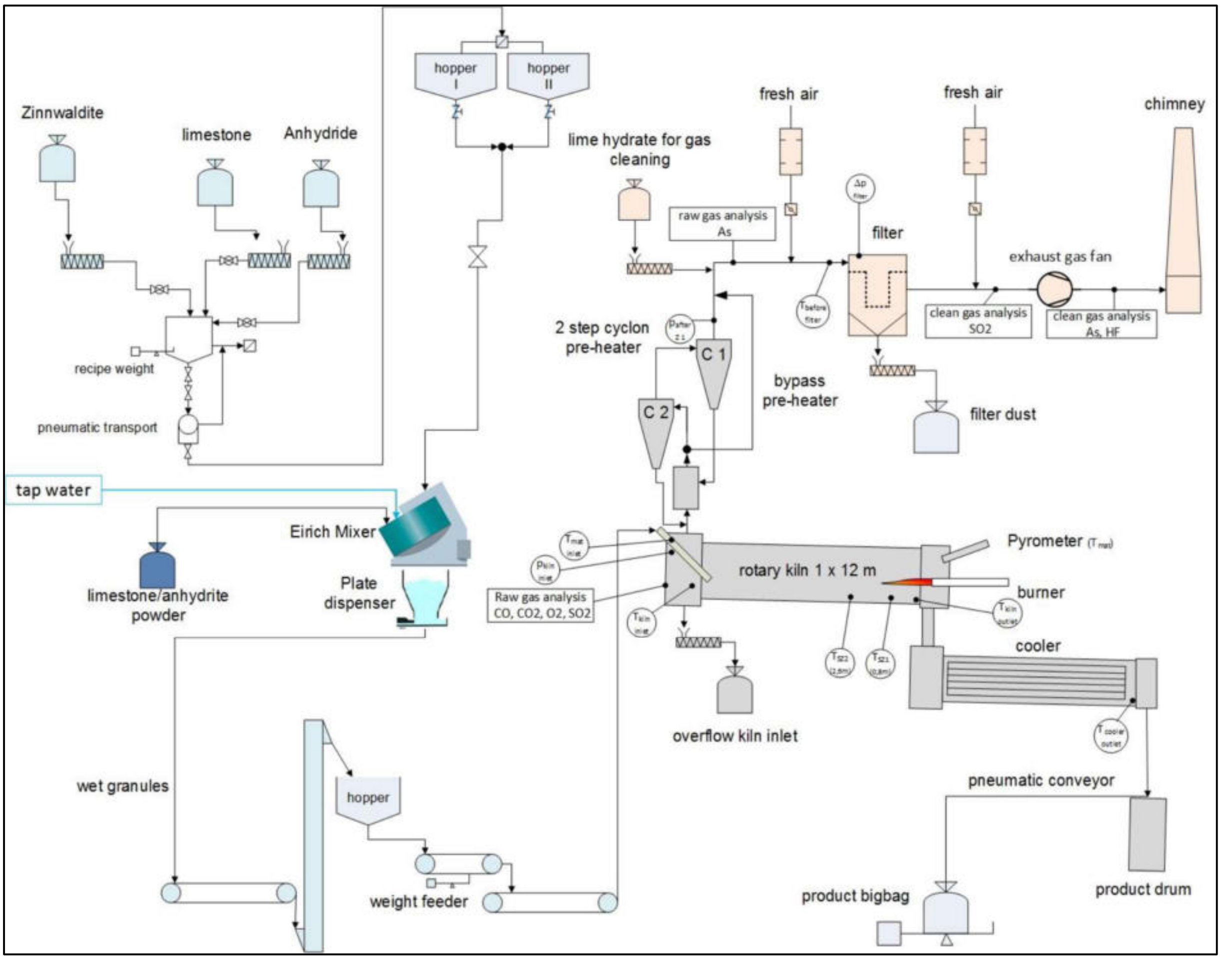


Figure 61: Flowsheet of the roasting pilot plant used in the FS

Figure 62: Eirich mixer R 11 used for the granulation batches

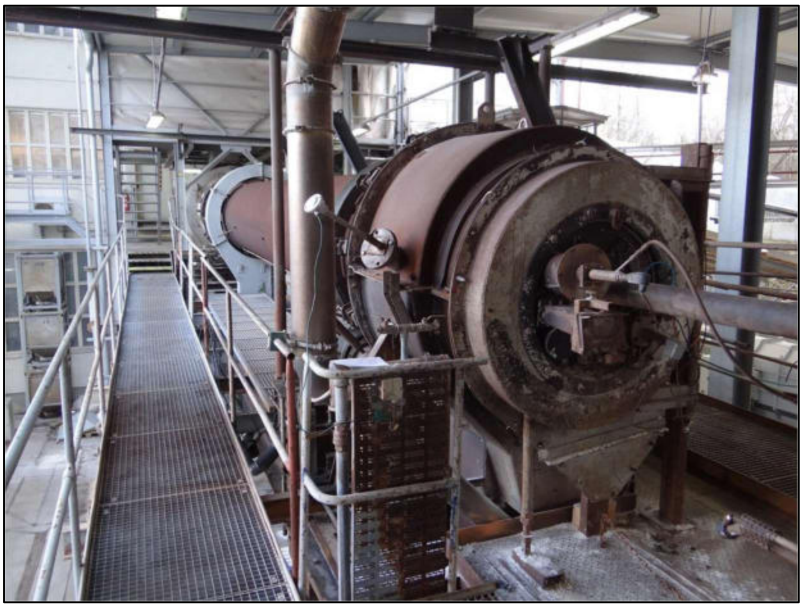


Figure 63: Rotary kiln with burner on the kiln outlet

Figure 64: View inside the rotary kiln during the test campaign

Roasting and cooling are a continuous process. The lithium and potassium in the zinnwaldite concentrate are converted to water-soluble lithium-potassium sulfate (roasted product; *Figure* 65), while the iron and aluminum contained in the zinnwaldite are converted to water-insoluble oxides.

The emissions from the calcination process contain hydrogen fluoride and sulfur dioxide, which must be absorbed with calcium hydroxide powder in order to ensure legal environmental regulations. Therefore, the concentration of CO, CO_2, O_2, HF and SO_2 as well as As were monitored in the exhaust gas during the tests.

Figure 65: Roasted product

The two test work campaigns used varying proportions of limestone. In total, about 14.8 t of roasted product was produced in both campaigns. A portion of this roasted product material was used as feed to the hydrometallurgical test work.

In summary, all bench and pilot scale test work on the 20 t and 100 t ore samples, including all variations of the roast feed recipe, yielded a lithium recovery of > 85 wt.%. This demonstrated that the gypsum – limestone roasting approach is robust with respect to the extraction of lithium. It was noted that good mixing and granulation are important factors and the selection of the mixer and pelletizer for the full-scale facility will be cruicial.

Roasting using a tunnel kiln rather than a rotary kiln is considered a valid alternative. This technology has the advantage that the firing temperatures can be set exactly according to the requirements of the material. Preliminary laboratory scale tests were carried out by Lingl in a gas heated test kiln [149]. Although these tests were reasonably successful, however more test work is required to confirm the potential of this technology for the Zinnwald Lithium Project.

13.5.2 Hydrometallurgical Processing

Bench scale hydrometallurgical test work has been carried out at G.E.O.S. and IBZ Salzchemie (kg scale) and at pilot plant scale at K-UTEC (approximately 1.5 t roasted product). The roasted product used as feed for these tests was prepared in the calcination campaigns at IBU-TEC in 2014, 2017 and 2018.

The detailed results of the hydrometallurgical test work are presented in references [48], [124], [127], [160], [171].

Figure 66 shows the main process steps included in the pilot scale test work for LiF and K_2SO_4 production.

Samples of the lithium fluoride produced have been characterized and sent to potential customers for evaluation.

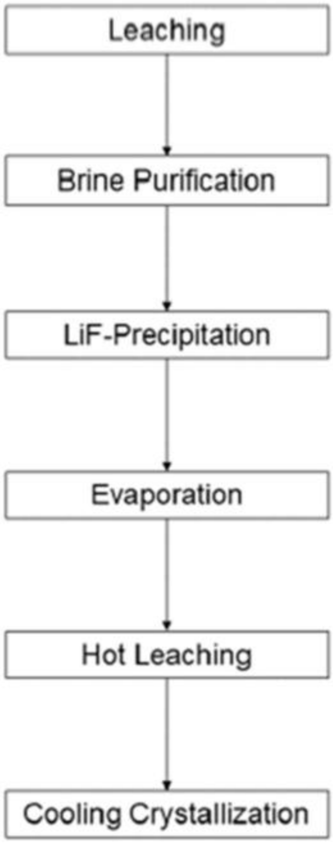


Figure 66: Principle process steps tested at the hydrometallurgical pilot plant for LiF and K_2SO_4 production [160]

13.5.2.1 Leaching of the Roasted Product

Bench scale laboratory leaching tests were carried out by G.E.O.S. and pilot scale at by K-UTEC.

The following leaching parameters have been investigated in detail:

- Leaching time
- Particle size of the roasted product 0.1 – 10 mm
- Leaching temperature 20 °C – 100 °C
- Ratio of water: roasted product. 0,5 : 1 up to 2 : 1 (*Table 38*)

The influences of the above mentioned parameters on the yield of lithium and potassium were shown to be small.

Table 38: Ratio water to roasted product (calcine) [160]

Parameter		Unit	Cycle 1	Cycle 2	Cycle 3	Cycle 4
Ratio Water to Calcine			12:6	6:6	4:6	3:6
	Lithium	g/kg	1.44	1.44	1.45	1.55
	Potassium	g/kg	23.3	22.7	21.9	24.3
	Sodium	g/kg	0.283	0.317	0.281	0.276

The optimal recipe for the leaching step is:

- Particle size: approx. 1 mm
- Leaching temperature: 65 °C
- Leaching time: 20 min
- Ratio water : roasted product: 1 : 1 to 1,5 : 1

The yield of lithium was consistently > 85 wt.%, typically in a range of 87 – 90 wt.%. The yield of potassium was in a range of 40 – 50 wt.%.([127], [160]).

Figure 67 illustrates the process scheme used for the pilot scale semi-continuous calcine leaching tests. The products from this test work included a roasted product and a mother leach liquor.

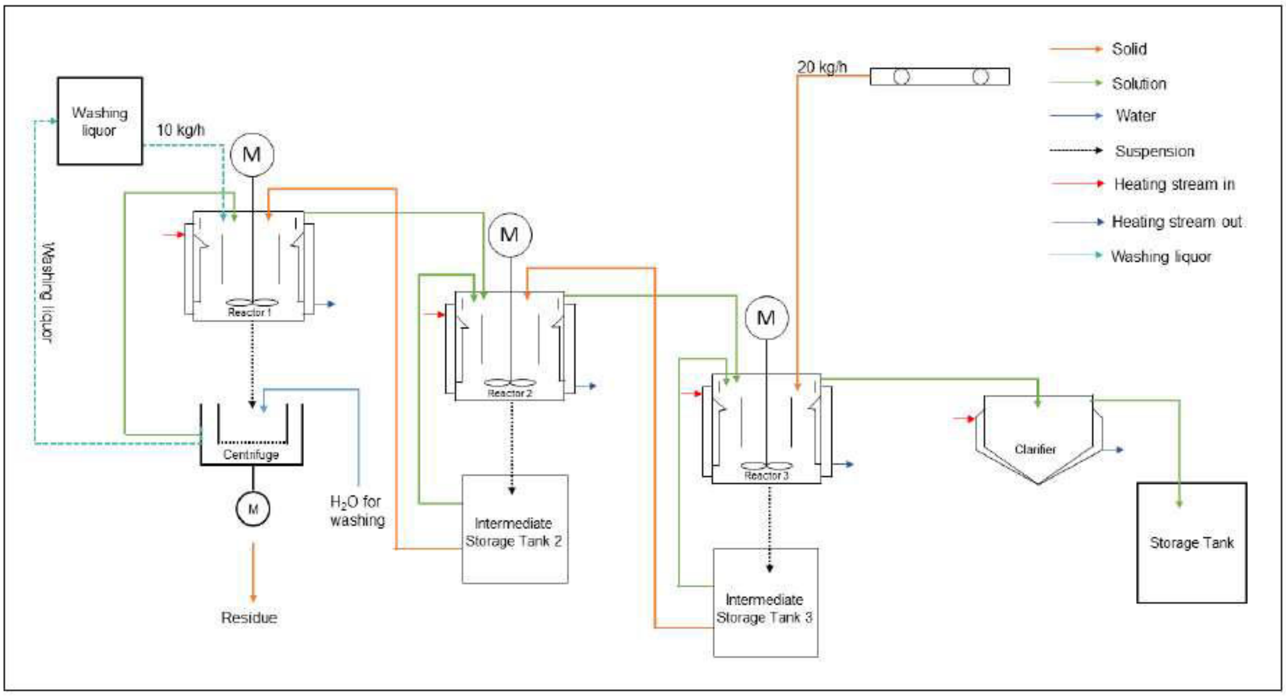


Figure 67: Process scheme for the semi-continuous phase of the pilot plant calcine leaching test [160]

13.5.2.2 Impurity Removal

The mother liquor from the leaching step consists predominately of lithium and potassium sulfate but contains impurities of calcium, magnesium, rubidium and cesium.

The purification was tested at G.E.O.S. [127], K-UTEC [160], [175] and IBZ Salzchemie [186].

Calcium removal was tested by precipitation of calcium carbonate with potassium carbonate ([175], [186]).

Magnesium removal was tested by precipitation as magnesium hydroxide with potassium hydroxide.

The remaining impurities after Mg and Ca removal, comprising rubidium sulfate and cesium sulfate, were to be separated during the crystallization of SOP.

An ion-exchange column was tested for further purification of the mother liquor by removing traces of calcium and magnesium ([127], [160], [186]).

13.5.2.3 Precipitation of Lithium Fluoride

After purification of the mother liquor, lithium fluoride was precipitated with the addition of 37 wt.% potassium fluoride solution ([175]). While commercial potassium fluoride was used for the tests it is likely that potassium fluoride for the full scale operation will be prepared from commercial anhydrous hydrofluoric acid and potassium hydroxide.

The precipitated lithium fluoride was filtered, washed and dried. In total, approximately 20 kg of lithium fluoride was produced from a number of tests. The quality of lithium fluoride produced was > 99 wt.% (typically 99.4 to 99.5 wt.%), which is consídred to be battery grade. The main impurity in the product was calcium sulfate.

13.5.2.4 K_2SO_4 (SOP) – Crystallization

The crystallization of potassium sulfate (SOP) has been carried out at K-UTEC [175].

The main process steps are:

1. Evaporation of the remaining mother liquor by appr. 80 wt.%
2. Filtration of the crystallized salt, mainly SOP and LiF
3. Desolving the SOP in hot water (95 °C)
4. Cooling crystallization at about 0°C and crystallization of pure SOP

The quality of the SOP produced during the testwork has been > 99.5 wt.% K_2SO_4, which is considred a very good fertilizer quality and maybe chemical quality.

The remaining salt after step 3 “hot desolving” consists of approximately SOP (59.27 wt.%) and LiF (30.60 wt.%) and is recycled.

The remaining aqueous solution consists predominately of potassium sulfate with minor rubidium and cesium sulfate. A portion of this solution is returned to the process and used for pelleting before the roasting process. Since the remaining solution consists to > 90 wt.% of SOP, it can also be used for fertilizer production.

14 Mineral Resource Estimates

14.1 Introduction

The Mineral Resource model presented here represents a resource estimate for the Zinnwald Lithium Project license area in the German part of the Zinnwald / Cínovec greisen deposit. The resource estimate was completed by Matthias Helbig, a Senior Consultant (resource geologist at G.E.O.S.). The effective date of this resource estimate is September 30th, 2018. This section describes the work undertaken by G.E.O.S. and summarizes the key assumptions and parameters used to prepare the revised mineral resource models.

The Mineral Resources presented here are reported in accordance with Canadian Securities Administrators' National Instrument 43-101 and have been estimated in conformity with generally accepted CIM "Estimation of Mineral Resource and Mineral Reserves Best Practices" guidelines.

14.2 Database Construction and Validation

The database was generated with software MS Access. It contains the following data tables:

- "collar" – general information and locations of drill holes and sampling points
- "survey" – drill path data
- "geology" – lithologic logs of the drill holes
- "sample" – data composition of drill core assays used for resource estimation
- "sample_disc" – assays of discrete sample points or channel samples
- data tables with laboratory assay results (originals, duplicates and standards)
- data tables with compiled information (e.g. summary of ore intervals) that is based on data of the 5 main data tables mentioned before

Every data collective has been cross-checked against original source documents by a minimum of 10 % randomly chosen data sets.

14.3 Geological Interpretation and Domaining

For the central part of the Zinnwald lithium deposit the spacing between the drill holes ranges approximately from 100 m in east-west direction to 150 m in north-south direction. The spacing between the marginal drill holes 26/59, 19/77, 20/77, 21/88, 23/88, 26/88, 28/88, Cn 22, Cn 26 and Cn 46 is in the range of 300 - 350 m. Positionning of the last 25 drill holes of exploration campaign No. (8), completed in the period 2012 – 2017 did not change this pattern in general. This is because some of the drill holes had to be placed into the peripheral parts of the deposit.

Like the geological cut-off, exclusively lithologic attributes were used for defining the orebodies. The differentiation of potential economically interesting ore types was based on mean lithium grades and aspects of ore processing. According to these criteria two ore types can be distinguished:

"Ore Type 1": greisen beds and interburden intervals up to 2 m and

"Ore Type 2": greisenized albite granite und greisenized porphyritic microgranite.

The "Ore Type 1" - greisen consists of the lithologic sub-types quartz-greisen (TGQ), quartz-mica-greisen (TGQ+GM) and mica-greisen (TGGM).

Despite the opportunity to distinguish up to three levels of postmagmatic alteration intensities, all greisenized intervals of albite granite and porphyritic microgranite were merged into "Ore Type 2".

According to the base case cut-off grade of lithium of 2,500 ppm, the greisen bed unit ("Ore Type 1") can be seen as the lithologic domain containing most of the ore. This is caused by the statistical character of the lithium grade frequency distribution that reaches roughly from 2,000 to 4,000 ppm for the majority of the greisen assays.

The geological sections and plans of the "Tiefer Bünau Stolln" level of LÄCHELT, 1960 [242] were used as a first idea for analyzing the core region of the Zinnwald lithium deposit on the German territory. The sections and plans were digitized and geo-referenced.

After this procedure the already interpreted greisen beds were used for digital construction of CAD sections of the conceptual geological model with SURPAC™ (version 6.6).

During the next step, top and bottom of the sections were tied up to the suitable intervals of the diamond drill holes. Based on this stage, the greisen beds were extended to the drill holes of the exploration campaigns performed in the 1970s and 1980s and to the drill holes located on the Czech side, as far as possible.

Based on the conceptual geological model, the 3D greisen bed wire frame models have been constructed by a semi-automated interpolation process. Therefore, point data of the conceptual geological model was complemented by information of strike and dip from a wire frame model of the contact surface of the albite granite and the rhyolite. The contact surface has been identified as the main structural control of the greisen beds.

Outer and inner borders of the horizontal extensions of the greisen layers were defined. For the case that no marginal drill holes existed, the greisen layers were extended further 50 m into the space (half the theoretical drill hole spacing, half the semi-major range). Greisen layers were interrupted half the way between drill holes, if an adjacent drill hole did not show an assignable greisen interval.

According to *Table 39* the following greisen beds with subordinate layers have been modelled:

Table 39: Greisen beds and modelled subordinate layers

Greisen bed	Subordinated layers
A	A_01, no further subordinate layers modelled
B	B_01a, B0_1b, B_01c, B_02a, B_02b, B_03a, B_03b
C	C_01, C_02
D	D_01, no further subordinate layers modelled
E	E_01, E_02, E_03, E_04, E_05
F	F_01, no further subordinate layers modelled
G	G_01, no further subordinate layers modelled
H	H_01, no further subordinate layers modelled
I	I_01, no further subordinate layers modelled
J	J_01, no further subordinate layers modelled
K	K_01, no further subordinate layers modelled

Intersection lines of tectonic structures were digitized from the plans of the “Tiefer Bünau Stolln” level. In the structural model it is assumed that they dip with 85 degrees towards the north-east. They appear as 3D planes in the SURPAC^{TM} model. Tectonic displacements of the greisen beds have been implemented if they could be detected from input data. Displacements of discrete blocks at the western flank of the Zinnwald lithium deposit account for up to 50 m.

The geological model has been continuously updated to reflect the new drill results from exploration campaign No. (8) (2012-2017). It has also been used successfully for drill hole planning. Ore intervals could be predicted sufficiently, and, in most cases, cumulated ore interval thickness exceeded the expectations.

The validation of the geological and structural model was done continuously by Dr. Jörg Neßler (Geologist, Technical University Bergakademie Freiberg / Germany). German and Czech geologic plans of the “Tiefer Bünau Stolln” level were geo-referenced and plotted against the models.

Several inspections of the geology at the “Tiefer-Bünau-Stollen” level were undertaken to verify the models. In this regard even for tectonic structures good congruence could be demonstrated. However, some uncertainties remain for the detailed geological structure of the eastern part of the Zinnwald lithium deposit.

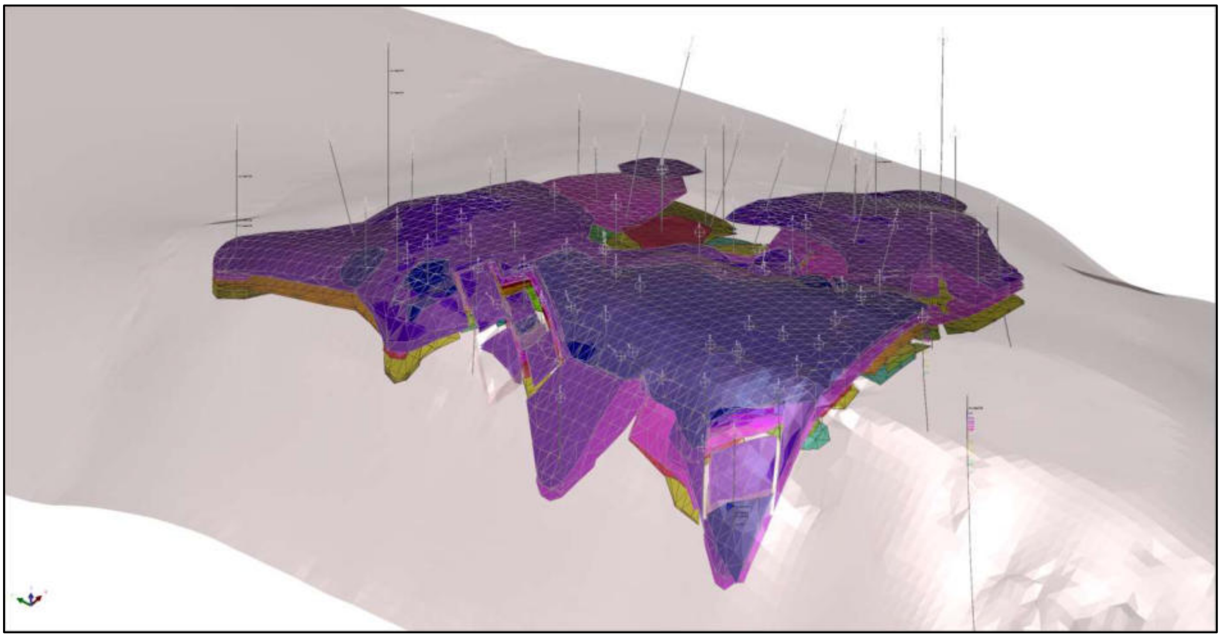


Figure 68: Albite granite dome of Zinnwald and Cínovec hosting the greisen beds, view towards north-eastward direction

It could be shown that the determination of greisenized granite has not been performed very well during former exploration campaigns compared to campaign No. (8). For some of these drill holes even no greisenized granite has been reported.

New investigations confirmed that most of the upper part of the granite cupola consists of greisenized granite. Only small domains, respectively intermediate beds, of albite granite did not underwent metasomatic alteration. One of these beds can be found adjacent to the granite contact at the north-eastern part of the deposit for example.

Consequently, only lithologic data of 23 drill holes of exploration campaign No. (8) has been used for estimation of the total volume of greisenized granite within the overall outer boundary of greisen beds of “Ore Type 1”. The infill drill holes are spread all over the deposit. Cumulated domain thickness of greisenized granite varies between 54 and 158 m. By interpolation of thickness within the deposit’s boundary a simplified volumetric model of “Ore Type 2” domain has been created.

The spatial extension of the greisen layers is presented in the following *Table 40.* The southern borders are limited by the boundary of the license area, ending at y = 5,620,847. For example, the models of the greisen beds “A”, “B” and “E” had to be cut at the Czech border.

Table 40: Spatial extension of the greisen layers of "Ore Type 1"

„Ore Type 1" Greisen bed	$Y_{min} – Y_{max}$ [UTM33]	North – South Exten-sion [m]	$X_{min} – X_{max}$ [UTM33]	East – West Exten-sion [m]	$Z_{min} – Z_{max}$ [m a.s.l.]	Z Exten-sion [m]	Mean vertical thick-ness [m]	Median vertical thick-ness [m]	Maximal vertical thick-ness [m]
A_01	5620903 - 5621938	1,035	33412548 - 33413093	545	587 - 813	225	4.4	3.7	18.1
B_01a	5620858 - 5622273	1,415	33412438 - 33413778	1,340	299 - 797	498	7.1	5.5	34.3
B_01b	5620853 - 5621958	1,105	33412553 - 33413778	1,225	298 - 763	465	5.2	4.6	15.9
B_01c	5621528 - 5621853	325	33412603 - 33412953	350	608 - 722	114	1.0	0.8	4.6
B_02a	5620853 - 5621323	470	33412448 - 33413128	680	498 - 741	244	0.8	0.5	3.4
B_02b	5620858 - 5622273	1,415	33412438 - 33413588	1,150	399 - 777	378	9.8	8.0	40.6
B_03a	5620853 - 5621878	1,025	33412533 - 33413573	1,040	417 - 755	338	5.1	3.2	20.6
B_03b	5621093 - 5621748	655	33412698 - 33412873	175	655 - 740	86	1.0	0.8	4.9
C_01	5621013 - 5621773	760	33412528 - 33412813	285	526 - 726	200	3.2	1.2	13.9
C_02	5621018 - 5621953	935	33412588 - 33413368	780	430 - 734	304	3.7	3.1	16.3
D_01	5620868 - 5622273	1,405	33412538 - 33413493	955	380 - 723	343	5.6	4.8	17.4
E_01	5620888 - 5622273	1,385	33412523 - 33413503	980	366 - 707	342	2.0	1.9	7.5
E_02	5620878 - 5622273	1,395	33412523 - 33413208	685	349 - 703	355	7.0	5.0	33.4
E_03	5620888 - 5622273	1,385	33412523 - 33413283	760	344 - 700	357	3.1	2.8	11.4
E_04	5620858 - 5621803	945	33412523 - 33413778	1,255	227 - 689	463	10.0	5.3	40.0

„Ore Type 1“ Greisen bed	$Y_{min} – Y_{max}$ [UTM33]	North – South Exten-sion [m]	$X_{min} – X_{max}$ [UTM33]	East – West Exten-sion [m]	$Z_{min} – Z_{max}$ [m a.s.l.]	Z Exten-sion [m]	Mean vertical thick-ness [m]	Median vertical thick-ness [m]	Maximal vertical thick-ness [m]
E_05	5620883 - 5621773	890	33412523 - 33413278	755	469 - 687	218	2.6	1.9	12.5
F_01	5620858 - 5622118	1,260	33412598 - 33413378	780	401 - 671	270	2.7	2.3	10.1
G_01	5620858 - 5621853	995	33412598 - 33413493	895	444 - 670	227	5.8	4.8	20.2
H_01	5621018 - 5621813	795	33412663 - 33413493	830	437 - 642	205	4.0	1.8	25.7
I_01	5620988 - 5621773	785	33412663 - 33413543	880	360 - 636	276	4.0	3.5	12.8
J_01	5621008 - 5621583	575	33412713 - 33413508	795	352 - 626	274	5.2	4.1	23.1

14.4 Density Analysis

Moisture content determinations of LÄCHELT, 1960 [242] resulted in an average of 0.5 % H_2O. Because of this low water content, no necessity existed for correcting the dry bulk density value.

Table 41 gives an overview of the bulk densities determined during different exploration campaigns. It can be stated that the greisen shows densities close to 2.7 g/cm³. Consequently, the value of 2.7 g/cm³ was applied for resource calculation of the greisen. Greisenized albite granite shows slightly lower densities around 2.65 g/cm³. Albite granite as the host rock itself was determined to have a dry bulk density of about 2.6 g/cm³. No information was available for rock porosity.

Table 41: Classification of ore types

Petrographic unit	Location	Method of determination	Bulk density [g/cm³]
Greisen	drill holes 1/54 – 27/59, 40 samples[1)]	hydrostatic weighing	2.70
Greisen	8 samples[2)]	not defined	2.72

Petrographic unit	Location	Method of determination	Bulk density [g/cm³]
Greisen	Reichtroster Weitung[3)]	DIN 18136, DIN 52105, DIN 1048, DGEG Recommendation No. 1.	2.73
Greisen, kaolinized	Reichtroster Weitung[3)]		2.48 – 2.50
Albite granite	drill hole ZGLi 01/2012 sample no. 90[4)]		2.59
Albite granite	drill hole ZGLi 01/2012 sample no. 232[4)]		2.52
Rhyolite	drill hole ZGLi 02/2012 sample no. 28[4)]		2.56
Albite granite (weak alteration to mica-greisen)	drill hole ZGLi 02/2012 sample no. 73[4)]	DIN 18136, DIN 52105, DIN 1048, DGEG Recommendation No. 1.	2.64
Albite granite (moderate alteration to mica-greisen)	drill hole ZGLi 02/2012 sample no. 160[4)]		2.63
Albite granite (intense alteration to mica-greisen)	drill hole ZGLi 02/2012 sample no. 181[4)]		2.69

1) LÄCHELT, A. (1960) [242]
2) GRUNEWALD, V. (1978b) [260]
3) KÖHLER, A. (2011): [284]
4) SOLARWORLD SOLICIUM GMBH (2013): Measurement of uniaxial pressure strength accordingly to DIN 18136, DIN 52105, DIN 1048, DGEG Recommendation No. 1.

14.5 Assay Data

A Summary of drilling campaigns data is given in *Table 42*.

Table 42: Summary of data of drilling campaigns

Expl. Campaign No.	Exploration campaign and data source (D – Germany, CZ – Czech Republic)	Type of data	Number of drill holes	Number of geological records and total length of drill holes	Number of geochemical records and respective total length	Method of geochemical analysis
(1a)	1917 - 1918	GSF DH	1	17 (195 m)	0 (0 m)	-

Expl. Cam-paign No.	Exploration campaign and data source (D – Germany, CZ – Czech Republic)	Type of data	Number of drill holes	Number of geological records and total length of drill holes	Number of geo-chemical records and respective total length	Method of geochemical analysis
	(D) HERRE					
(1b)	1917 - 1918 (D) HERRE	UG DH	1	10 (150 m)	0 (0 m)	-
(2a)	1930 – 1945 (D) Bergarchiv Freiberg, SCHILKA (2012)	GSF DH	15	242 (1,608 m)	0 (0 m)	-
(2b)	1930 – 1945 (D) Bergarchiv Freiberg, SCHILKA (2012)	UG DH	3	60 (295 m)	0 (0 m)	-
(3)	1955 (CZ) SCHILKA (2012)	GSF DH	3	74 (601 m)	0 (0 m)	-
(4a)	1951 – 1960 (D) BOLDUAN und LÄCHELT (1960)	GSF DH	17	423 (4,660 m)	Li: 401 (422 m) Sn: 401 (422 m) W: 400 (421 m)	CS + FP CS + SA CS + SA
(4b)	1951 – 1960 (D) BOLDUAN und LÄCHELT (1960)	UG DH	10	383 (1,313 m)	Li: 180 (80 m) Sn: 113 (72 m) W: 119 (75 m)	CS + FP CS + SA CS + SA
(5a)	1959 – 1972 (CZ) GEOFOND	GSF DH	95	4,376 (34,111 m)	Li: 8,704 (12,364 m) Sn: 4,100 (4,704 m) W: 3,842 (4,410 m)	CS + SA CS + XRF & WCA CS + SA
(6)	1977 – 1978 (D) GRUNEWALD (1978)	GSF DH	2	230 (1,216 m)	Li: 373 (1,216 m)[1] Sn & W: 373 (1,216 m)[1] Sn & W: 106 (104	RCS + SA RCS + SA CS + XRF

Expl. Campaign No.	Exploration campaign and data source (D – Germany, CZ – Czech Republic)	Type of data	Number of drill holes	Number of geological records and total length of drill holes	Number of geochemical records and respective total length	Method of geochemical analysis
					m)[2]	
		UG PS from galleries	-	1,350 (-)	Li: 1,341 (-) Sn: 1,342 (-) W: 1,329 (-)	PS + SA PS + SA PS + SA
(7)	1988 – 1989 (D) KÜHNE and BESSER (1988 - 1989)	GSF DH	8	684 (3,148 m)	Li: 1,188 (3,149 m)[1] Sn & W: 1,188 (3,149 m)[1] Sn & W: 397 (403 m)[2]	RCS + SA RCS + SA CS + XRF
(8a)	2012 (D) SOLARWORLD SOLICIUM GMBH (2012)	GSF DH	2	116 (543 m)	Li: 415 (401 m) Sn & W: 415 (401 m) Sn & W: 415 (401 m)	CS + ME-4ACD81(ICP-AES) CS + ME-MS81(ICP-MS) CS + ME-XRF05
		UG CHS from galleries	-	83 (at 1.5 m each)	Li: 83 (at 1.5 m each) Sn & W: 83 (at 1.5 m e.) Sn & W: 83 (at 1.5 m e.)	CHS + ME-4ACD81(ICP-AES) CHS + ME-MS81(ICP-MS) CHS + ME-XRF05
(8b)	2013 (D) SOLARWORLD SOLICIUM GMBH (2013)	GSF DH	8	303 (2,021 m)	Li: 843 (847 m) Sn: 843 (847 m) W: 843 (847 m) Sn: 1 (1 m) Li: 1 (1 m)	CS + ME-4ACD81(ICP-AES) CS + ME-MS81(ICP-MS) CS + ME-MS81(ICP-MS) CS + XRF10 CS + Li-OG63(ICP-AES)
(8c)	2017 (D) DEUTSCHE LITHIUM GMBH (2017)	GSF DH	15	951 (4,455 m)	Li: 2,660 (2,602 m) Sn: 2,660 (2,602 m) W: 2,660 (2,602 m) Li: 12 (9 m)	CS + ME-4ACD81(ICP-AES) CS + ME-MS81(ICP-MS) CS + ME-MS81(ICP-MS) CS + Li-OG63(ICP-AES)

[1)] Intervals of semi-quantitative sample assays partly or fully replaced in database by intervals of [2)] quantitative sample assays.

Sample data frequency distributions of the data collectives have been compared. As a result, data processing and statistical analysis are summarized as follows:

Table 43: Data joins used for resource and potential estimation

Component	Data collectives	Purpose	Compositing
Lithium	core sample assays of campaigns (4), (5) and (8)	compositing and anisotropic inverse distance interpolation within greisen beds, determination of mean lithium grade for greisenized granite	1-m-interval composites for drill hole greisen bed intersections none
Tin	core sample assays of campaigns (4), (7) with correction factor **0.6** and (8) without correction factor	determination of mean tin grade of low graded sample population for greisen beds, determination of mean tin grade of low graded sample population for greisenized granite	none none
Tungsten	core sample assays of campaigns (7) and (8)	determination of mean tungsten grade of low graded sample population for greisen beds determination of mean tungsten grade of low graded sample population for greisenized granite	none none
K_2O	core sample assays and channel assays of campaign (8)	determination of mean K_2O grade for greisen beds determination of mean K_2O grade for greisenized granite	none none
Na_2O	core sample assays and channel assays of campaign (8)	determination of mean Na_2O grade for greisen beds determination of mean Na_2O grade for greisenized granite	none none

Anisotropic inverse distance interpolation method provides the estimation of mineral resources for lithium within the greisen beds. It was based on 1-m-interval composites of the core sample assays of campaigns (4), (5) and (8). Derivation of overall mean grades is used for estimation of potentials only.

14.6 Assay Statistical Analyses

14.6.1 Determination of Mean Lithium Grades of Lithologic Units

The characterization of mean lithium grades is based exclusively on drill core assays of exploration campaign No. (8) (*Table 44*) and is explained below

The determination of lithologic core intervals of exploration campaign No. 8 was critically compared with the results of multi-element assay data (i.e., Li, Sn, W, SiO_2, Na_2O, K_2O, MgO, Fe_2O_3, Zn, Sc, La), drill core photographic documentation, as well as the drill cores itself.

It became evident, that lithologic core intervals of the Zinnwald lithium deposit could not always be correctly determined in the first run.
Hydrothermal bleaching activity, as well as fine grained mineral dissemination - as an effect of metasomatic alteration - can produce intervals that pretend to be unaltered granite when examined by common macroscopic methods.
In addition, although contacts between greisen, greisenized granite and unaltered granite can be sharp, they are diffuse in most cases.

Now having the knowledge of 25 in detail investigated drill holes, it is questioned that greisenized granite and unaltered granite intervals have been determined correctly during the exploration campaigns No.s (1), (2), (3) and (4).

Apart from that, it can be assumed that the actual greisen intervals were correctly described in the other campaigns because they can be clearly differentiated macroscopically. Geologists of the named campaigns did not have the opportunity to conduct a verification of their lithologic determination because drill cores have not been assayed at all or have been assayed only for the determined greisen intervals.

Table 44: Mean lithium grades of lithologic units based on drill core assays of exploration campaign No. (8)

Ore type	Petrographic key sign 2018 (2014)	Petrographic description	Apparent thickness weighted mean Li grade [ppm]	Arithm. mean Li grade [ppm]	Median Li grade [ppm]	Min Li grade [ppm]	Max Li grade [ppm]	Number of core samples
1	TGGM	mica-greisen	8,772	8,330	7,640	4,450	13,950	47
	TGQ+GM	quartz-mica-greisen	3,568	3,481	3,340	120	8,630	822
	TGQ	quartz-greisen	414	463	445	10	1,260	46

Ore type	Petrographic key sign 2018 (2014)	Petrographic description	Apparent thickness weighted mean Li grade [ppm]	Arithm. mean Li grade [ppm]	Median Li grade [ppm]	Min Li grade [ppm]	Max Li grade [ppm]	Number of core samples
2	TF	feldspatite	377	1,154	200	30	1,170	25
	scG_3a_GGM_3 (PG_GGM_3)	intense alteration to quartz-mica-greisen: albite granite	2,161	2,128	2,275	410	3,000	282
	scG_3a_GGM_2 (PG_GGM_2)	moderate alteration to quartz-mica-greisen: albite granite	1,981	1,985	2,040	420	3,000	1,137
	scG_3a_GGM_1 (PG_GGM_1)	minor alteration to quartz-mica-greisen: albite granite	1,373	1,377	1,375	400	3,070	1,198
	scG_3a (PG)	albite granite	739	736	775	80	1,140	340
2	scG_3c_GGM_1 (UG_GGM_1)	minor alteration to quartz-mica-greisen: porphyritic microgranite	1,061	1,081	1,000	300	2,470	77
	sG_3c (UG)	porphyritic microgranite	307	303	290	20	900	130
	tpYl_1a (Yl)	rhyolite	291	291	230	50	800	35

14.6.2 Summary Statistics of Drill Core Assays of Exploration Campaign No. 8

A detailed statistical characterization of the data from the exploration campaign No. (8) for domains of "Ore Type 1" - Greisen and "Ore Type 2" - greisenized granite is presented below.

The following charts show histograms of all drill core assays of exploration campaign No. (8) for sample interval lengths, lithium, tin, tungsten, K_2O and Na_2O grades.

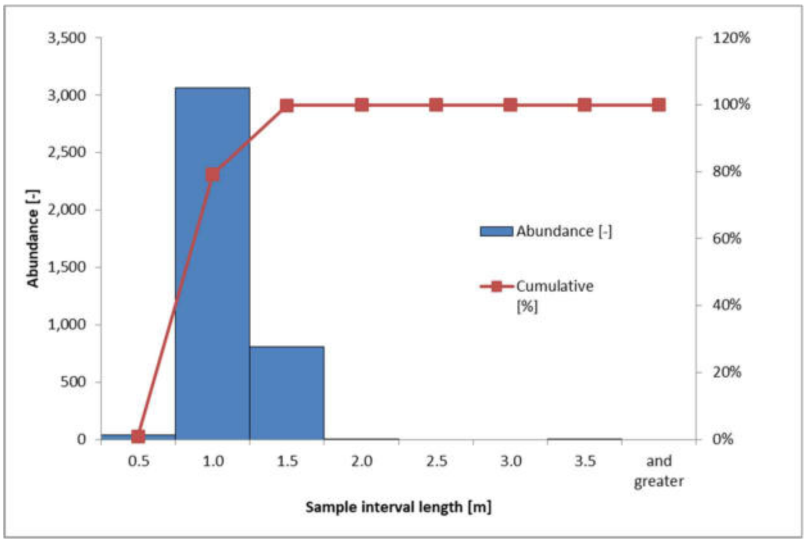


Figure 69: Abundances of all sample interval lengths of exploration campaign No. (8)

A total of 3,918 drill core samples have been collected. Most of sample intervals show a length of 1 m. Minimum length accounts for 0.25 m, maximum length for 3.50 m.

Lithium grades show normal frequency distributions where greisen mean values account for 3,000 to 4,000 ppm and greisenized granite mean values account for 1,500 to 2,000 ppm.

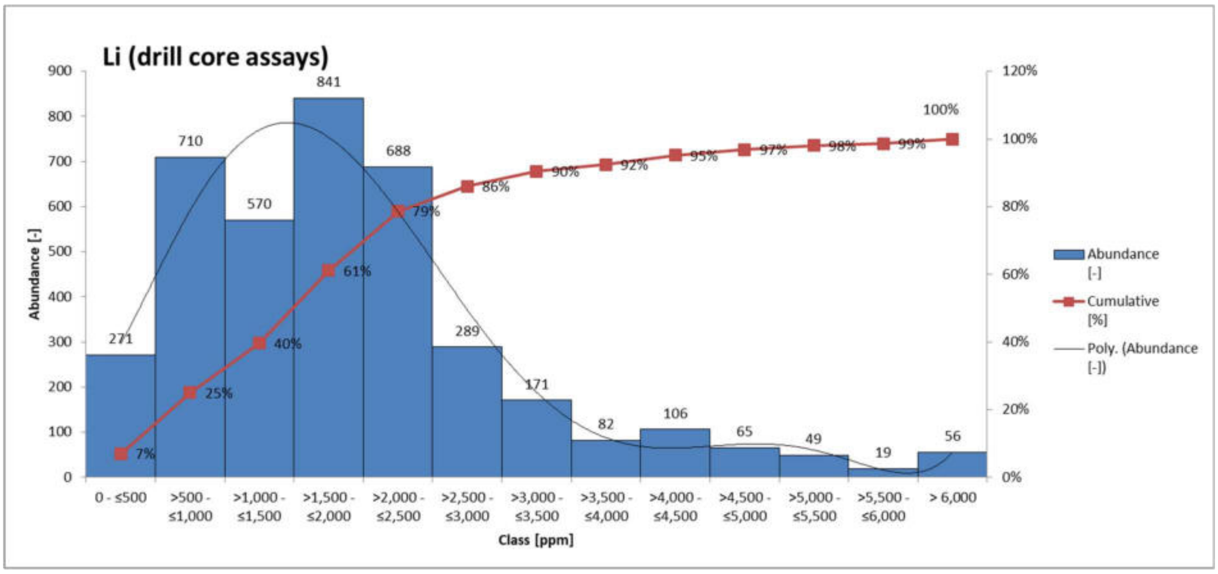


Figure 70: Abundances of all lithium drill core assays of exploration campaign No. (8)

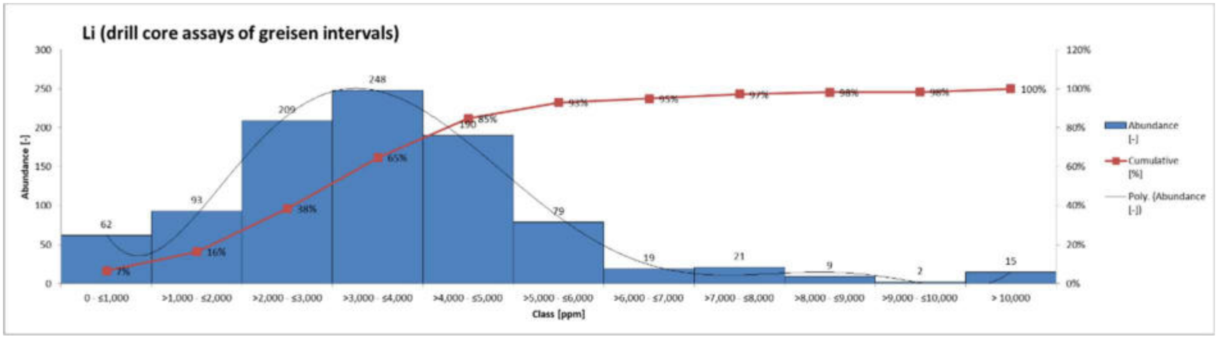


Figure 71: Abundances of greisen lithium drill core assays of exploration campaign No. (8)

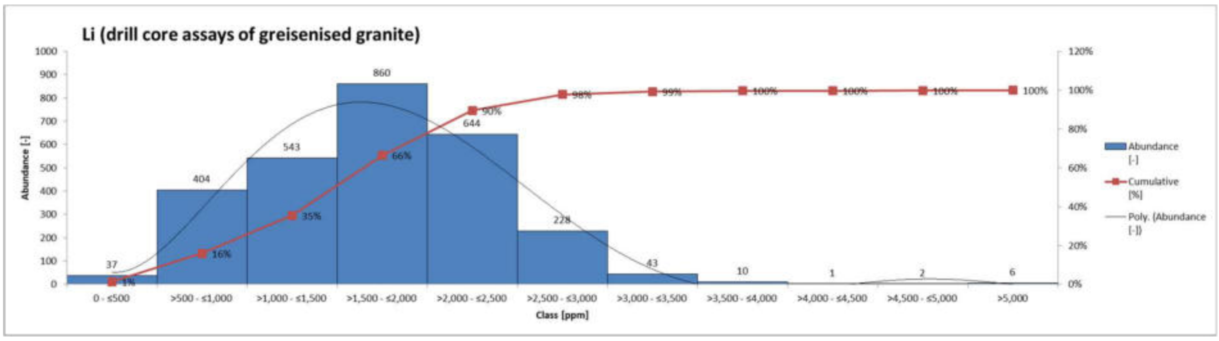


Figure 72: Abundances of greisenized granite lithium drill core assays of exploration campaign No. (8)

Tin grade frequency distributions indicate three generations of mineralization:

(1) background mineralization of around 35 ppm

(2) low grade mineralization of around 300 ppm (disseminated cassiterite)

(3) high grade mineralization of around 2,000 ppm (cassiterite veins)

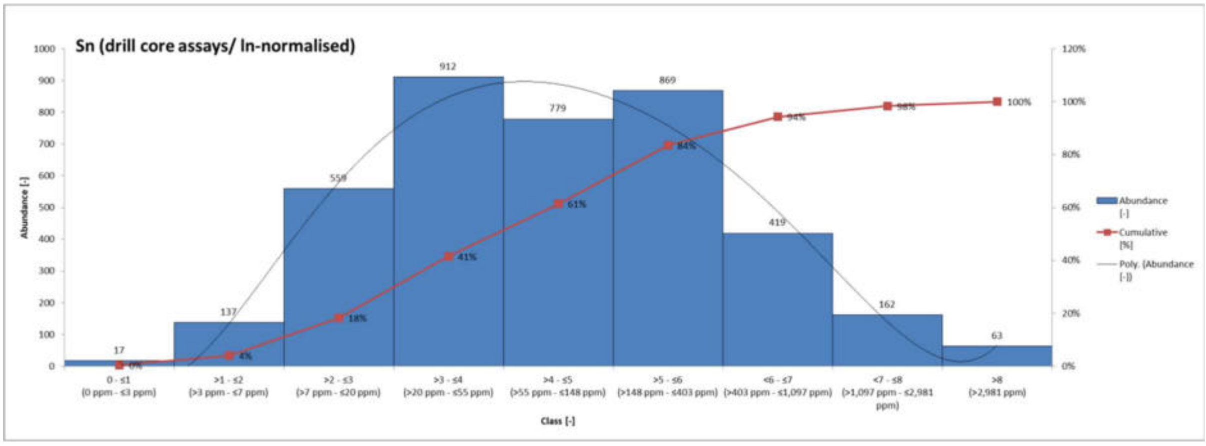


Figure 73: Abundances of all tin drill core assays of exploration campaign No. (8)

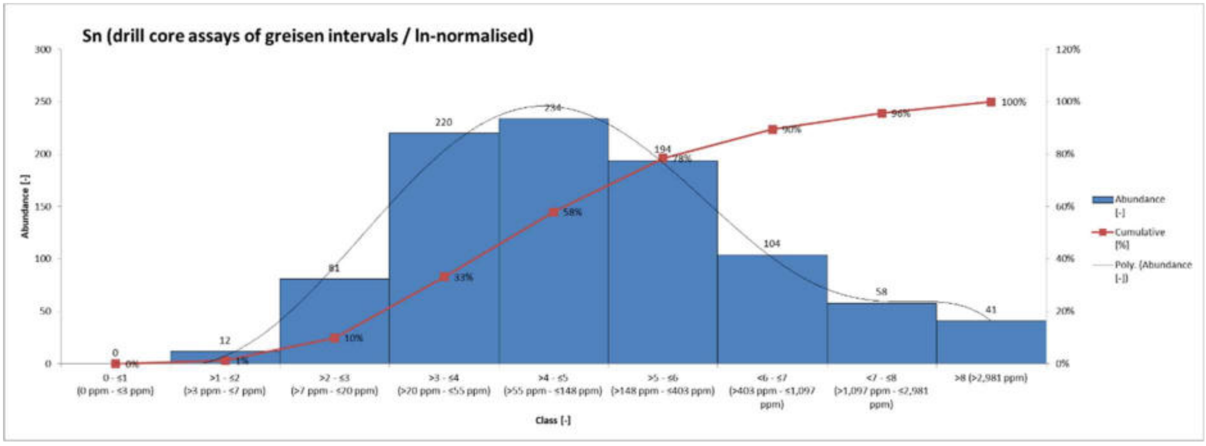


Figure 74: Abundances of greisen tin drill core assays of exploration campaign No. (8)

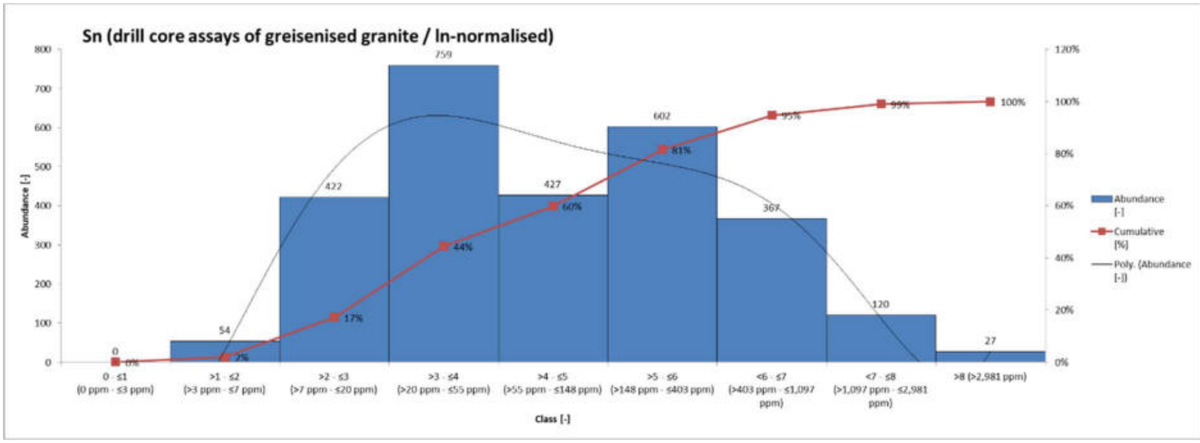


Figure 75: Abundances of greisenized granite tin drill core assays of exploration campaign No. (8)

Tungsten grades tend to be mostly below 100 ppm. There is evidence of three generations of mineralization:

(1) background mineralization of around 35 ppm

(2) low grade mineralization of around 300 ppm (disseminated)

(3) high grade mineralization of around 2,000 ppm (accumulated veins)

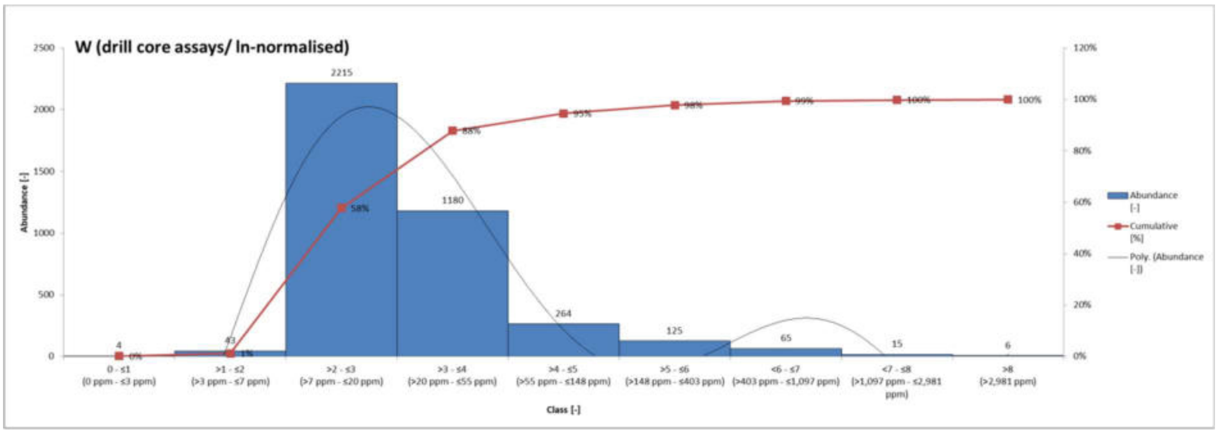


Figure 76: Abundances of all tungsten drill core assays of exploration campaign No. (8)

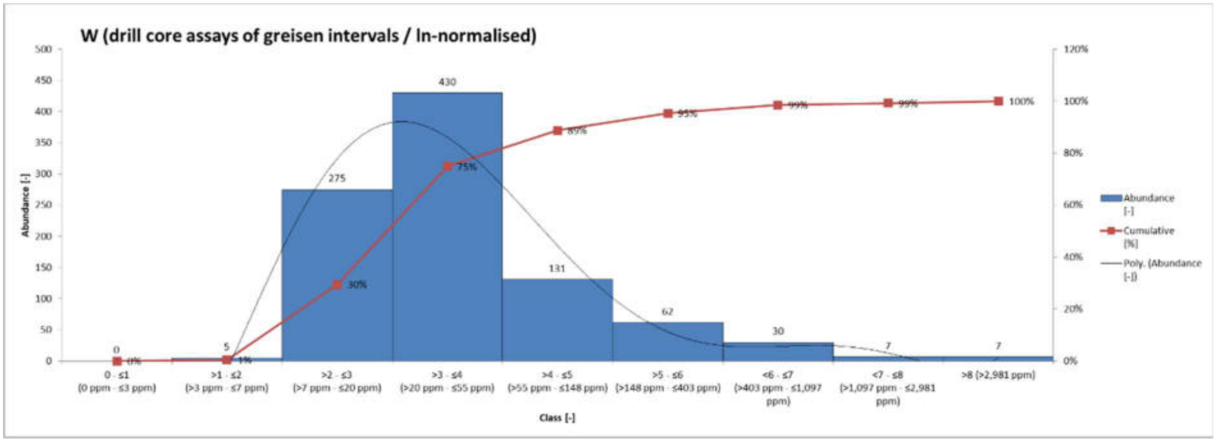


Figure 77: Abundances of greisen tungsten drill core assays of exploration campaign No. (8)

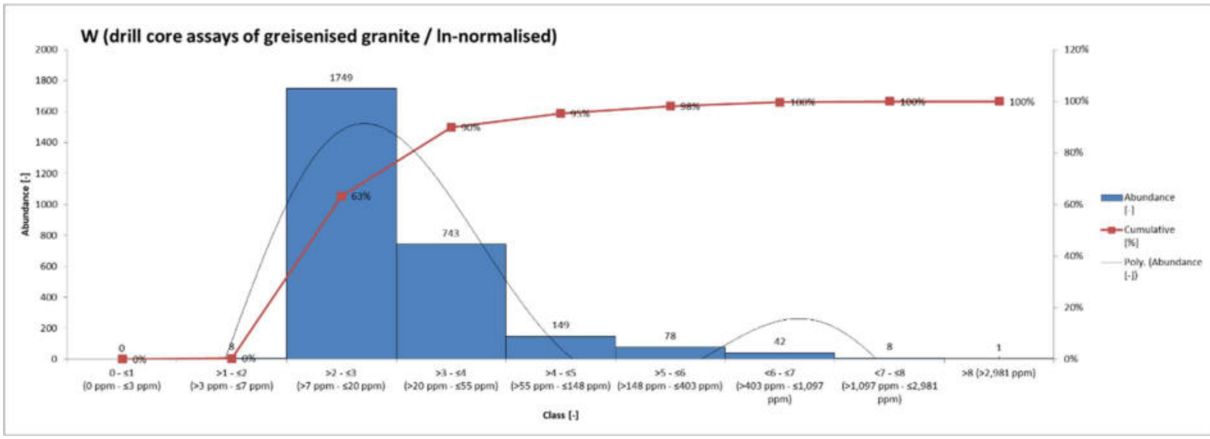


Figure 78: Abundances of greisenized granite tungsten drill core assays of exploration campaign No. (8)

The mean K_2O grades of greisen beds (~ 3 wt.%) are lower than those of greisenized granite (3 - 4 wt.%) or other lithologic units.

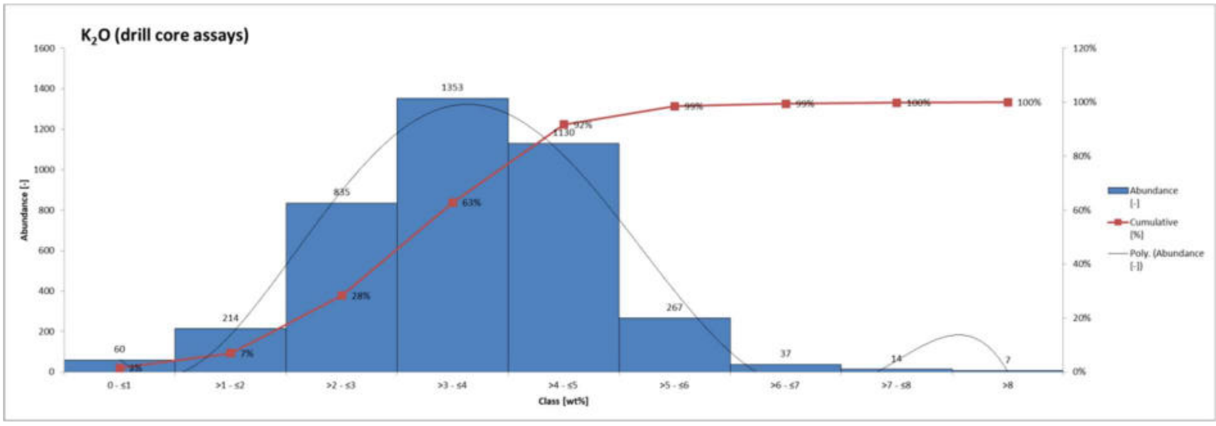


Figure 79: Abundances of all K_2O drill core assays of exploration campaign No. (8)

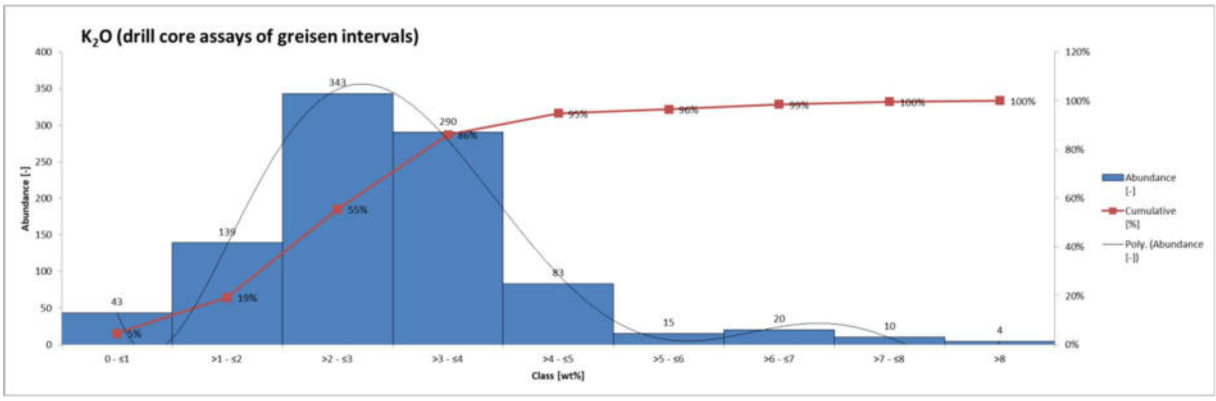


Figure 80: Abundances of greisen K_2O drill core assays of exploration campaign No. (8)

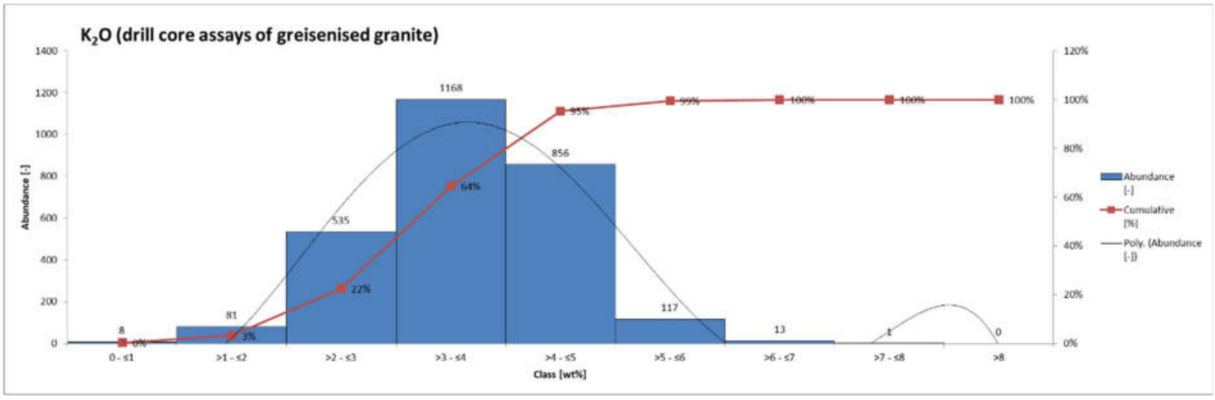


Figure 81: Abundances of greisenized granite K_2O drill core assays of exploration campaign No. (8)

Na_2O grades show two populations which can be correlated with the intensity of metasomatic alteration. Greisen beds show mean grades of 0.03 to 0.04 wt.%, whereas greisenized granite shows mean grades of 2.0 to 3.0 wt.%. Thus, Na_2O can be used in the Zinnwald deposit as geochemical criterion for distinguishing greisens from greisenized granite or unaltered granite.

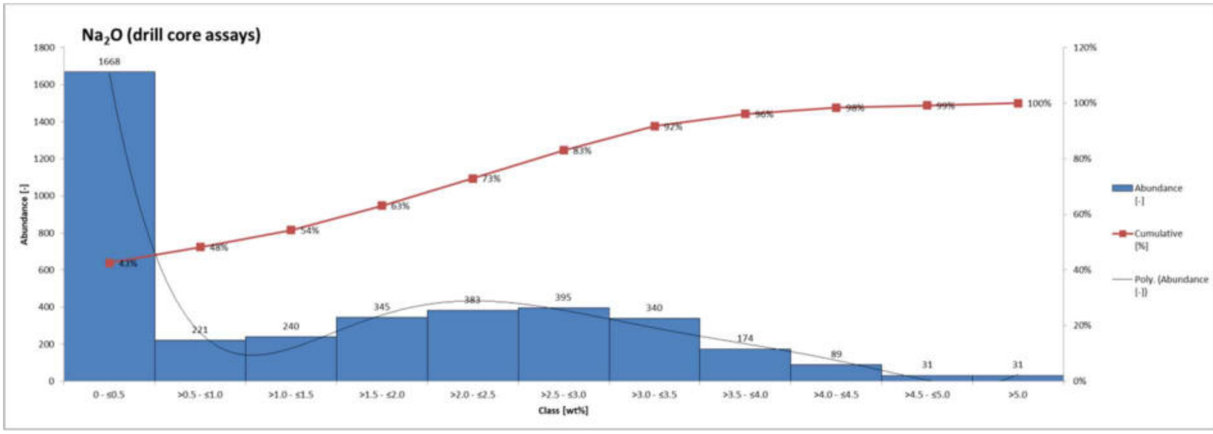


Figure 82: Abundances of all Na_2O drill core assays of exploration campaign No. (8)

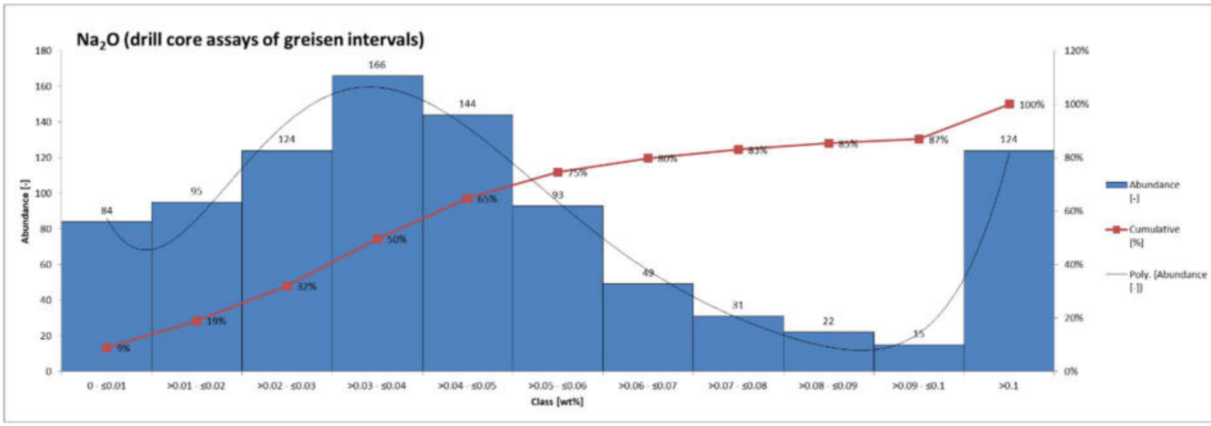


Figure 83: Abundances of greisen bed Na_2O drill core assays of exploration campaign No. (8)

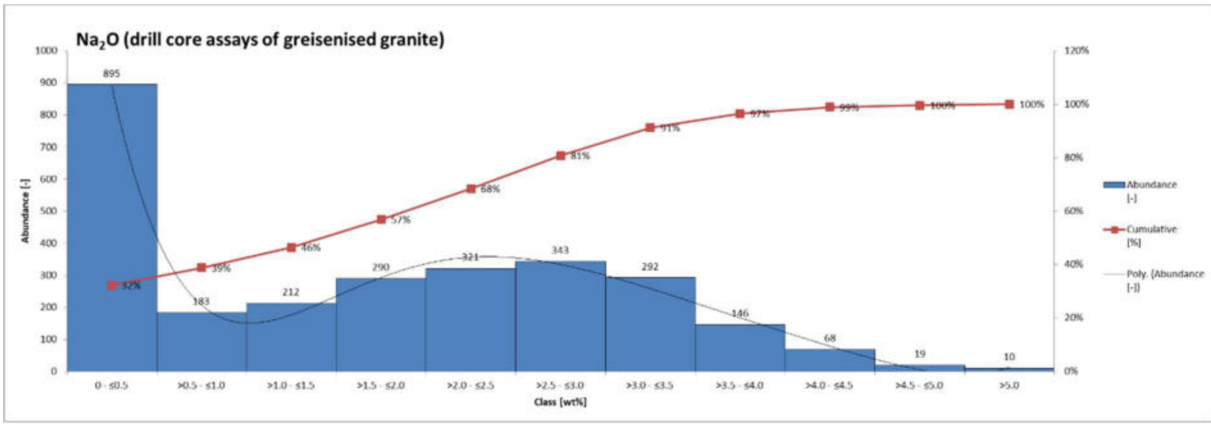


Figure 84: Abundances of greisenized granite Na_2O drill core assays of exploration campaign No. (8)

Table 45: Comparison of summary statistical parameters for lithium of exploration campaign No. (8)

Greisen assays

Lithium (Li) Core samples + Na2O2 digestion ICP-MS			
Parameter	Value		Unit
Samples	948		[-]
Minimum	10		[ppm]
Maximum	13,950		[ppm]
Arithm. Mean	3,555		[ppm]
Median	3,320		[ppm]
5% Quantile	760		[ppm]
25% Quantile	2,408		[ppm]
75% Quantile	4,435		[ppm]
95% Quantile	6,967		[ppm]
Standard Deviation	1,939		[ppm]
Variance	3,760,318		[ppm²]
Coefficient of Variation	0.55		[-]

Greisenized granite assays

Lithium (Li) Core samples + Na2O2 digestion ICP-MS			
Parameter	Value		Unit
Samples	2,779		[-]
Minimum	50		[ppm]
Maximum	7,010		[ppm]
Arithm. Mean	1,735		[ppm]
Median	1,760		[ppm]
5% Quantile	740		[ppm]
25% Quantile	1,250		[ppm]
75% Quantile	2,140		[ppm]
95% Quantile	2,750		[ppm]
Standard Deviation	665		[ppm]
Variance	442,134		[ppm²]
Coefficient of Variation	0.38		[-]

Table 46: Comparison of summary statistical parameters for tin of exploration campaign No. (8)

Greisen assays

Tin (Sn) Core samples + Na2O2 digestion ICP-MS			
Parameter	Value		Unit
Samples	945		[-]
Minimum	2		[ppm]
Maximum	10,000		[ppm]
Arithm. Mean	527		[ppm]
Median	108		[ppm]
5% Quantile	14		[ppm]
25% Quantile	40		[ppm]
75% Quantile	340		[ppm]
95% Quantile	2,570		[ppm]
Standard Deviation	1,376		[ppm]
Variance	1,893,336		[ppm²]
Coefficient of Variation	2.61		[-]

Greisenized granite assays

Tin (Sn) Core samples + Na2O2 digestion ICP-MS			
Parameter	Value		Unit
Samples	2,779		[-]
Minimum	2		[ppm]
Maximum	10,000		[ppm]
Arithm. Mean	277		[ppm]
Median	78		[ppm]
5% Quantile	11		[ppm]
25% Quantile	26		[ppm]
75% Quantile	263		[ppm]
95% Quantile	1,131		[ppm]
Standard Deviation	591		[ppm]
Variance	348,873		[ppm²]
Coefficient of Variation	2.13		[-]

Table 47: Comparison of summary statistical parameters for tungsten of exploration campaign No. (8)

Greisen assays

Tungsten (W) Core samples + Na2O2 digestion ICP-MS			
Parameter	**Value**		**Unit**
Samples	948		[-]
Minimum	5		[ppm]
Maximum	9,500		[ppm]
Arithm. Mean	138		[ppm]
Median	30		[ppm]
5% Quantile	11		[ppm]
25% Quantile	19		[ppm]
75% Quantile	54		[ppm]
95% Quantile	358		[ppm]
Standard Deviation	671		[ppm]
Variance	450,425		[ppm²]
Coefficient of Variation	4.86		[-]

Greisenized granite assays

Tungsten (W) Core samples + Na2O2 digestion ICP-MS			
Parameter	**Value**		**Unit**
Samples	2,779		[-]
Minimum	3		[ppm]
Maximum	3,180		[ppm]
Arithm. Mean	44		[ppm]
Median	17		[ppm]
5% Quantile	10		[ppm]
25% Quantile	13		[ppm]
75% Quantile	29		[ppm]
95% Quantile	136		[ppm]
Standard Deviation	129		[ppm]
Variance	16,747		[ppm²]
Coefficient of Variation	2.97		[-]

Table 48: Comparison of summary statistical parameters for K_2O of exploration campaign No. (8)

Greisen assays

Potassium oxide (K_2O) Core samples + ICP-AES			
Parameter	**Value**		**Unit**
Samples	948		[-]
Minimum	0.03		[wt%]
Maximum	8.88		[wt%]
Arithm. Mean	2.96		[wt%]
Median	2.88		[wt%]
5% Quantile	1.09		[wt%]
25% Quantile	2.26		[wt%]
75% Quantile	3.53		[wt%]
95% Quantile	5.12		[wt%]
Standard Deviation	1.28		[wt%]
Variance	1.63		[(wt%)²]
Coefficient of Variation	0.43		[-]

Greisenized granite assays

Potassium oxide (K_2O) Core samples + ICP-AES			
Parameter	**Value**		**Unit**
Samples	2,780		[-]
Minimum	0.70		[wt%]
Maximum	7.18		[wt%]
Arithm. Mean	3.65		[wt%]
Median	3.67		[wt%]
5% Quantile	2.20		[wt%]
25% Quantile	3.08		[wt%]
75% Quantile	4.24		[wt%]
95% Quantile	4.98		[wt%]
Standard Deviation	0.87		[wt%]
Variance	0.76		[(wt%)²]
Coefficient of Variation	0.24		[-]

Table 49: Comparison of summary statistical parameters for Na_2O of exploration campaign No. (8)

Greisen assays

Sodium oxide (Na_2O) Core samples + ICP-AES			
Parameter	**Value**		**Unit**
Samples	948		[-]
Minimum	0.01		[wt%]
Maximum	4.40		[wt%]
Arithm. Mean	0.16		[wt%]
Median	0.05		[wt%]
5% Quantile	0.01		[wt%]
25% Quantile	0.03		[wt%]
75% Quantile	0.07		[wt%]
95% Quantile	0.94		[wt%]
Standard Deviation	0.48		[wt%]
Variance	0.23		[(wt%)²]
Coefficient of Variation	2.94		[-]

Greisenized granite assays

Sodium oxide (Na_2O) Core samples + ICP-AES			
Parameter	**Value**		**Unit**
Samples	2,780		[-]
Minimum	0.01		[wt%]
Maximum	6.09		[wt%]
Arithm. Mean	1.65		[wt%]
Median	1.68		[wt%]
5% Quantile	0.03		[wt%]
25% Quantile	0.11		[wt%]
75% Quantile	2.77		[wt%]
95% Quantile	3.79		[wt%]
Standard Deviation	1.35		[wt%]
Variance	1.82		[(wt%)²]
Coefficient of Variation	0.82		[-]

Boxplots of the assays (Figure 85, Figure 86) clearly display the differences in lithium frequency distributions of greisen and greisenized granite. Tin and tungsten grades are slightly enriched in greisen whereas K_2O and Na_2O grades are depleted.

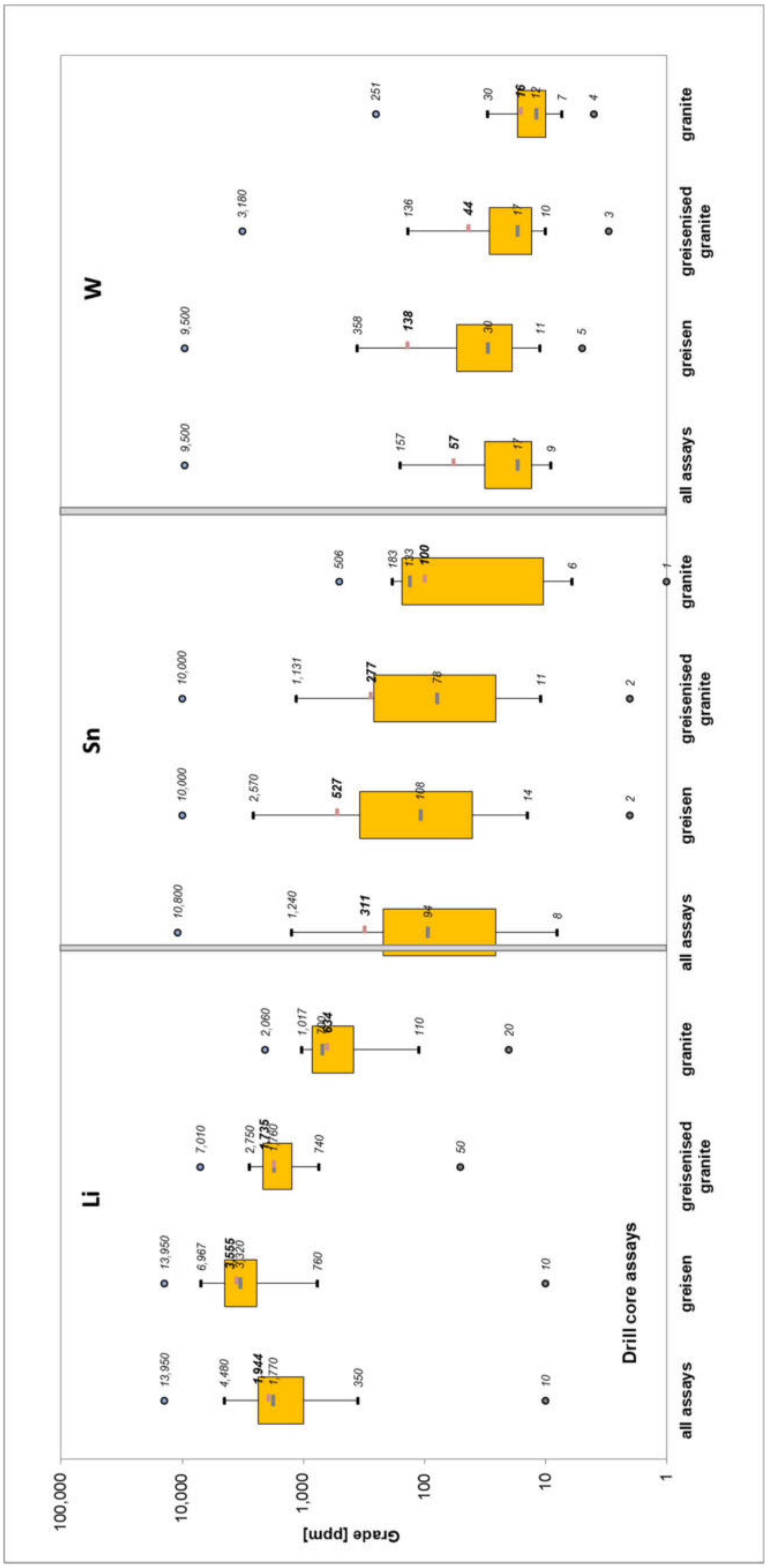


Figure 85: Boxplots of drill core assays of Li, Sn and W of exploration campaign No. (8)

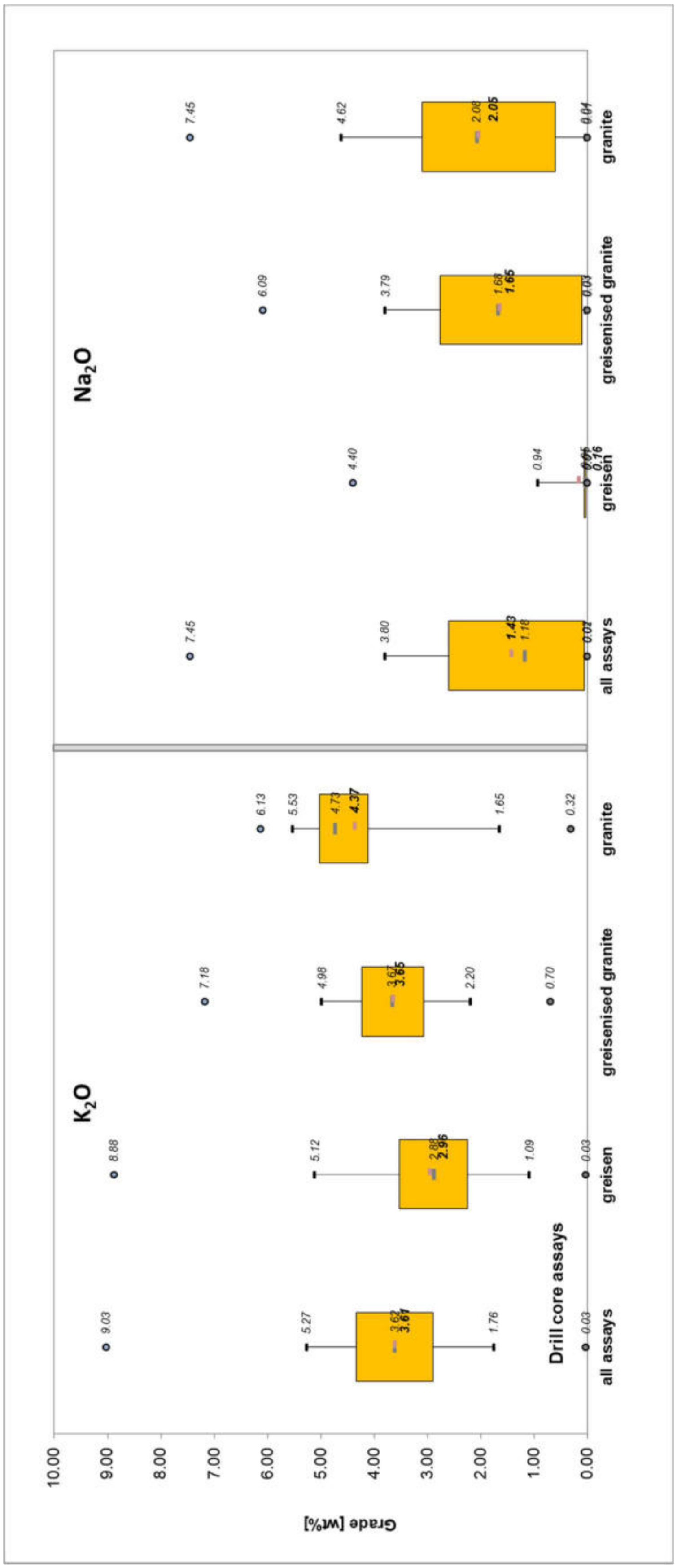


Figure 86: Boxplots of drill core assays of K_2O and Na_2O of exploration campaign No. (8)

Regarding the correlation matrix of exploration campaign No. (8) no significant relationships between the selected components lithium, tin, tungsten and Na_2O could be found (see *Table 50*). Only for Li and K_2O a linear correlation was found in the greisen beds, probably referred to the joint occurrence of these components in the mineral zinnwaldite ($KLiFeAl(AlSi_3)O_{10}(OH,F)_2$).

Table 50: Drill core assays exploration campaign No. (8), linear coefficient of correlation R²

		Li	Sn	W	K_2O	Na_2O
all assays	**Li**	1.00				
	Sn	0.19	1.00			
	W	0.15	0.20	1.00		
	K_2O	-0.09	0.06	-0.02	1.00	
	Na_2O	-0.37	-0.10	-0.07	0.08	1.00
assays of greisen	**Li**	1.00				
	Sn	0.13	1.00			
	W	0.10	0.09	1.00		
	K_2O	**0.67**	0.06	0.12	1.00	
	Na_2O	-0.08	-0.03	-0.04	0.04	1.00
assays of greisenised granite	**Li**	1.00				
	Sn	0.07	1.00			
	W	0.07	0.41	1.00		
	K_2O	-0.29	0.14	0.04	1.00	
	Na_2O	-0.22	-0.05	-0.05	-0.08	1.00

14.6.3 Summary Statistics of Drill Core Assays of Data Joins

Drill core assay data of exploration campaigns No.s (4), (5), and (8) has been merged for the purpose of resource estimation of “Ore Type 1” – greisen beds as shown in *Table 51.*

Raw data obtained from statistical calculations performed for the several exploration campaigns was extracted from the database, analyzed and summarized.

The analysis included:

- summarized statistic parameters of all exploration campaigns
- boxplots
- determination of outlier grades (see *Table 52*)

Prior to the statistical analysis, all data below the laboratory detection limit (sometimes presented as “0” in the older reports) have been substituted by the half the lower detection limit value (see *Table 51*).

Table 51: Substitution of values below the lower detection limit of the raw data

Exploration campaign No.	Li	Sn	W
(4)	No assays below detection limit	No assays below detection limit	No assays below detection limit
(5)	8 substitutions for drill core assays (0 replaced by 50 ppm)	No assays below detection limit	120 substitutions for drill core assays (0 replaced by 50 ppm)
(6)	No assays below detection limit	No assays below detection limit	38 substitutions for drill core assays (0 replaced by 5 ppm)
(7)	No assays below detection limit	26 substitutions for drill core assays (0 replaced by 5 ppm)	157 substitutions for drill core assays (0 replaced by 5 ppm)
(8)	No assays below detection limit	2 substitutions for drill core assays (1 replaced by 0.5 ppm)	1 substitution for drill core assays (1 replaced by 0.5 ppm)
	K_2O	**Na_2O**	
(8)	29 substitutions for drill core assays (0.01 re-placed by 0.005 ppm)	No assays below detection limit	

The following tables and figures summarize the statistical analysis of the merged data sets.

Table 52: Summary statistics of the greisen bed lithium drill core assays

Lithium						
Greisen bed	A	B 01	B 02	B 03	C	D
Number of composites	139	564	491	169	129	187
5% Quantile [ppm]	595	958	900	900	1,381	741
25% Quantile [ppm]	1,090	2,100	2,175	1,858	2,280	2,180
75% Quantile [ppm]	3,395	3,900	4,100	3,994	4,390	3,733
95% Quantile [ppm]	4,707	5,324	5,660	5,260	7,215	5,368
Median [ppm]	2,400	2,923	3,205	2,700	3,300	3,000
Arithmetic Mean [ppm]	2,484	3,034	3,296	2,962	3,646	3,041
Minimum [ppm]	100	20	100	0	400	100
Maximum [ppm]	9,400	14,817	14,073	13,950	13,000	8,686
Standard Deviation [ppm]	1,674	1,519	1,665	1,740	2,172	1,448
Variance [ppm²]	2,780,804	2,303,288	2,765,135	3,010,618	4,682,436	2,086,102
Coefficient of Variation [-]	0.67	0.50	0.51	0.59	0.60	0.48
Greisen bed	E	F	G	H	I	J
Number of composites	514	79	121	85	53	43
5% Quantile [ppm]	808	960	430	800	96	704
25% Quantile [ppm]	1,890	1,879	1,997	2,170	2,050	1,301
75% Quantile [ppm]	3,957	3,568	3,500	4,460	3,881	2,585
95% Quantile [ppm]	6,470	5,399	7,120	7,690	4,918	7,246
Median [ppm]	2,880	2,830	2,780	3,300	2,910	1,740
Arithmetic Mean [ppm]	3,129	2,841	3,014	3,737	2,759	2,298
Minimum [ppm]	150	570	10	476	30	230
Maximum [ppm]	12,350	6,820	10,311	12,400	5,170	9,210
Standard Deviation [ppm]	1,882	1,379	1,950	2,332	1,448	1,937
Variance [ppm²]	3,536,694	1,876,547	3,771,818	5,374,978	2,057,795	3,664,597
Coefficient of Variation [-]	0.60	0.49	0.65	0.62	0.52	0.84

Lithium grades of greisen bed intersection intervals, comprising greisen intervals and interburden, are characterized by the following boxplots:

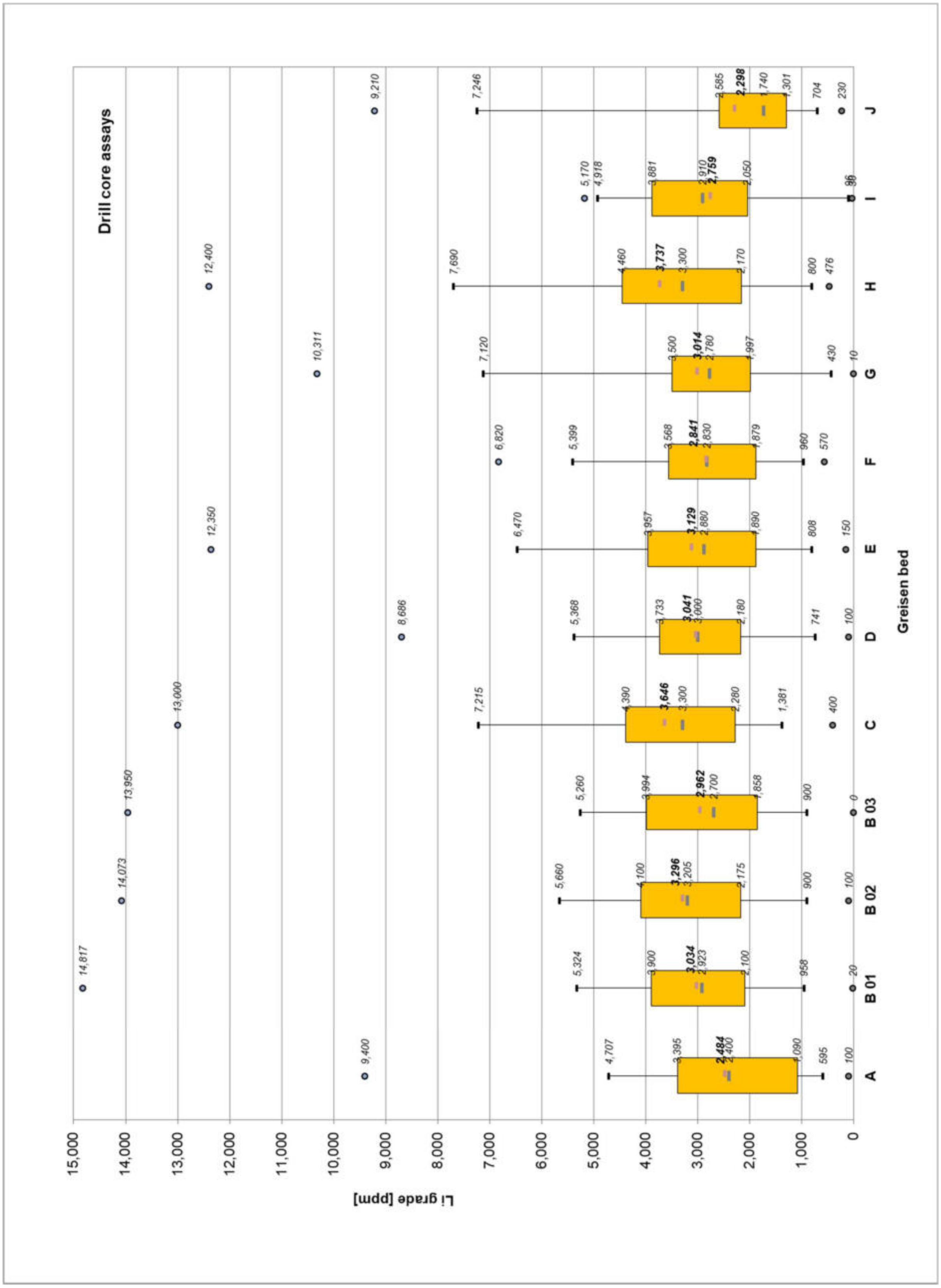


Figure 87: Boxplots of merged Li drill core assay data comparison of individual greisen beds

14.7 Grade Capping

Based on statistical evaluation, 83 lithium grade values exceeding 7,000 ppm had to be substituted by the threshold value before using them for compositing. Furthermore, 11 tin and 3 tungsten grade values exceeded the threshold of 10,000 ppm and had to be truncated. The same applies to 71 K_2O grade values that had to be cut at 60,000 ppm *(*see *Table 53)*. All top-cut thresholds are based on testing of outliers of the components' frequency distributions for greisen lithology.

Table 53: Top-cut Li, Sn, W and K_2O grades

Component	**Li**	**Sn**	**W**	**K_2O**
Top-cut threshold [ppm]	7,000	10,000	10,000	60,000
Number of top-cut grade values [-]	83	11	3	71

14.8 Compositing

Compositing has been done for Li drill core assays within greisen bed intersections only. This is because of the lack of reliable drill core assays of tin, tungsten, potassium oxide and sodium oxide and because of the lack of correct distinction of greisenized zones throughout the various exploration campaigns.

Tin and tungsten grades generally tend to be very low within greisen beds and greisenized granite except for some singular intervals that might be related to veins, small seams or stockworks having only a local spatial extension. Potassium oxide and sodium oxide core sample assays are available only for exploration campaign No. (8). Consequently tin, tungsten and potassium oxide are estimated as potentials and are reported by ore volume / tonnage and a mean grade.

Li core sample assays of the exploration campaigns No.s (4), (5) and (8) were composited downhole with a 1 m interval length. Small intervals of less than 0.5 m length were appended to the neighboring 1 m interval.

All ore bed interval intersections with ≥ 80 % sampled apparent interval thickness were used for Li resource classification. The midpoints of the concerned interval intersections were applied to interpolate classification zones within the greisen beds based on the anisotropic reach parameter of the inverse distance interpolation process.

Interval intersections with less than 80 % sampled apparent thickness were neither used for interpolation nor for resource classification. Thus, resource classes near these intersection intervals were controlled by the next intersection intervals with ≥ 80 % sampled apparent interval thickness.

Table 54: Summary of the drill hole intersections within the greisen beds

Greisen bed	Number of drill hole intersections	Number of drill hole intersections assayed for Li by ≥ 80% of the length	Number of drill hole intersections assayed for Sn by ≥ 80% of the length	Number of drill hole intersections assayed for W by ≥ 80% of the length	Number of drill hole intersections assayed for K_2O by ≥ 80% of the length
A	27	18	16	15	5
B 01	86	54	51	43	28
B 02	62	41	37	31	15
B 03	45	27	22	20	13
C	45	27	26	21	12
D	36	26	26	20	12
E	104	65	63	52	39
F	27	19	19	17	13
G	25	18	14	11	9
H	18	14	13	11	7
I	15	9	9	8	7
J	12	8	8	8	7
K	1	0	0	0	0
Yet not classified	91	52	57	56	18

14.9 Composite Statistical Analysis

14.9.1 Lithium Composites

The following *Table 55* summarizes the general statistics of the composites.

Table 55: Summary statistics of the 1 m composite intervals of the lithium drill core assays

Lithium						
Greisen bed	A	B 01	B 02	B 03	C	D
Number of composites	113	438	368	120	79	131
5% Quantile [ppm]	707	1,100	938	869	1,632	925
25% Quantile [ppm]	1,200	2,285	2,362	2,143	2,698	2,200
75% Quantile [ppm]	3,332	3,808	4,043	3,723	4,605	3,923
95% Quantile [ppm]	4,382	4,896	5,203	5,182	6,553	5,299
Median [ppm]	2,040	3,025	3,251	2,896	3,576	3,101
Arithmetic Mean [ppm]	2,263	3,028	3,185	2,994	3,707	3,139
Minimum [ppm]	500	29	100	0	1,050	102
Maximum [ppm]	4,900	7,000	7,000	7,000	7,000	7,000
Standard Deviation [ppm]	1,226	1,186	1,293	1,341	1,413	1,357
Variance [ppm²]	1,489,479	1,403,718	1,667,876	1,783,831	1,972,230	1,826,811
Coefficient of Variation [-]	0.54	0.39	0.41	0.45	0.38	0.43
Greisen bed	E	F	G	H	I	J
Number of composites	321	51	91	71	30	27
5% Quantile [ppm]	1,282	1,495	309	941	450	830
25% Quantile [ppm]	2,300	2,398	2,034	2,270	2,547	1,443
75% Quantile [ppm]	4,138	3,823	3,398	4,365	3,114	3,004
95% Quantile [ppm]	5,925	5,775	4,905	7,000	4,694	7,000
Median [ppm]	3,147	3,251	2,750	3,390	2,919	2,493
Arithmetic Mean [ppm]	3,318	3,261	2,785	3,572	2,848	2,650
Minimum [ppm]	150	685	90	500	142	511
Maximum [ppm]	7,000	6,820	7,000	7,000	5,170	7,000
Standard Deviation [ppm]	1,452	1,237	1,382	1,805	1,114	1,832
Variance [ppm²]	2,100,532	1,500,641	1,887,614	3,213,728	1,198,614	3,233,496
Coefficient of Variation [-]	0.44	0.38	0.50	0.51	0.39	0.69

Figure 88 presents a boxplot of composited lithium grades for the individual greisen beds.

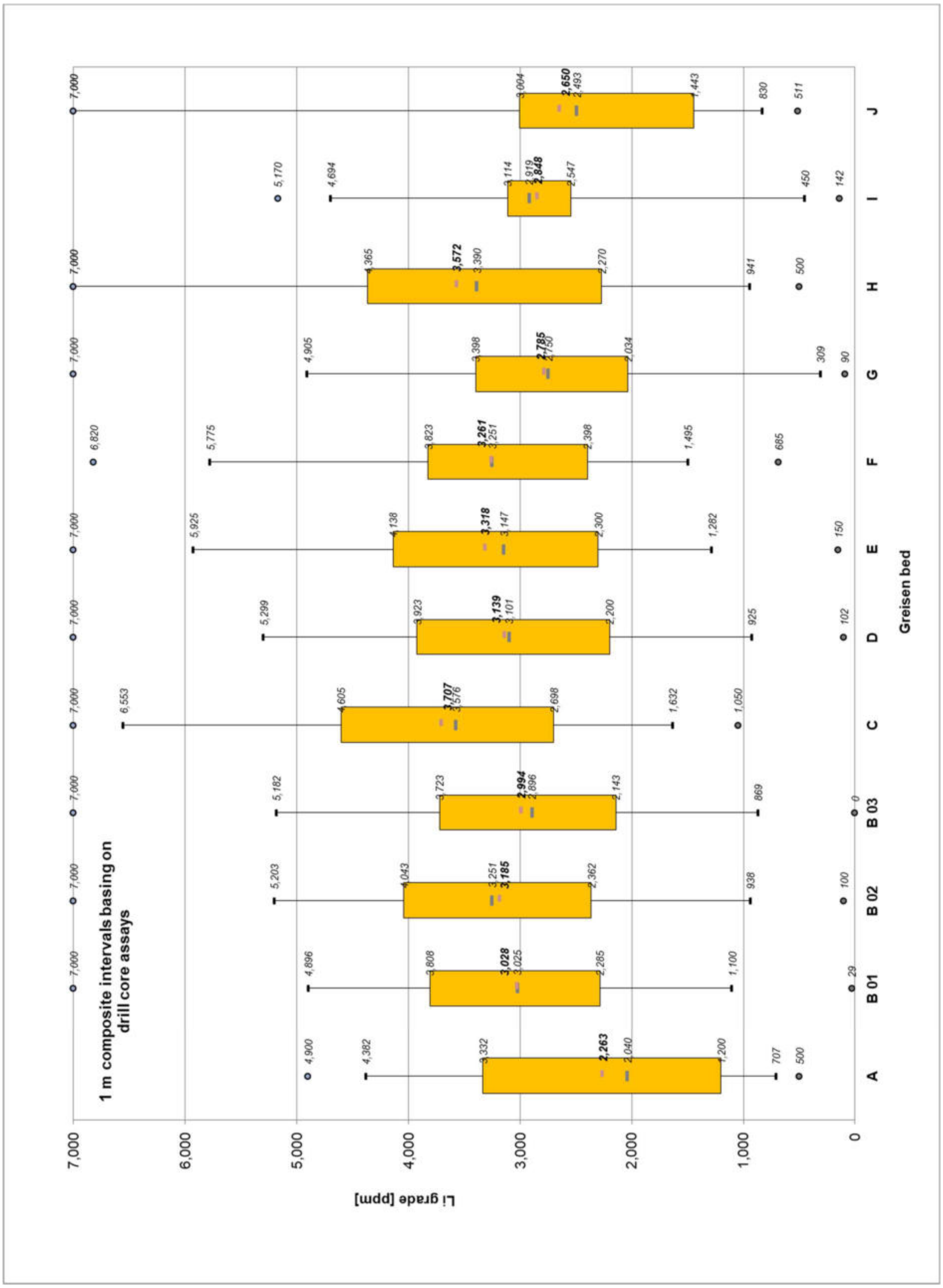


Figure 88: Boxplots of 1 m interval Li grade composites for individual greisen beds

14.9.2 Tin, Tungsten and Potassium Oxide Composites

Summary statics of drill core assays composited by length of ore intervals of “Ore Type 1” are displayed below.

Table 56: Summary statistics of the drill core assays composited by length of ore intervals of “Ore Type 1”

Component	Li	Sn	W	K_2O
Number of composites	326	304	257	167
5% Quantile [ppm]	900	14	5	13,780
25% Quantile [ppm]	2,102	54	17	25,185
75% Quantile [ppm]	3,697	700	185	38,015
95% Quantile [ppm]	5,859	2,175	800	49,245
Median [ppm]	3,012	252	35	31,150
Arithmetic Mean [ppm]	3,039	574	262	31,444
Minimum [ppm]	0	0	0	5,550
Maximum [ppm]	7,000	10,000	10,000	60,000
Standard Deviation [ppm]	1,385	1,003	891	10,653
Variance [ppm^2]	1,912,579	1,002,738	790,439	112,800,013
Coefficient of Variation [-]	0.46	1.75	3.39	0.34

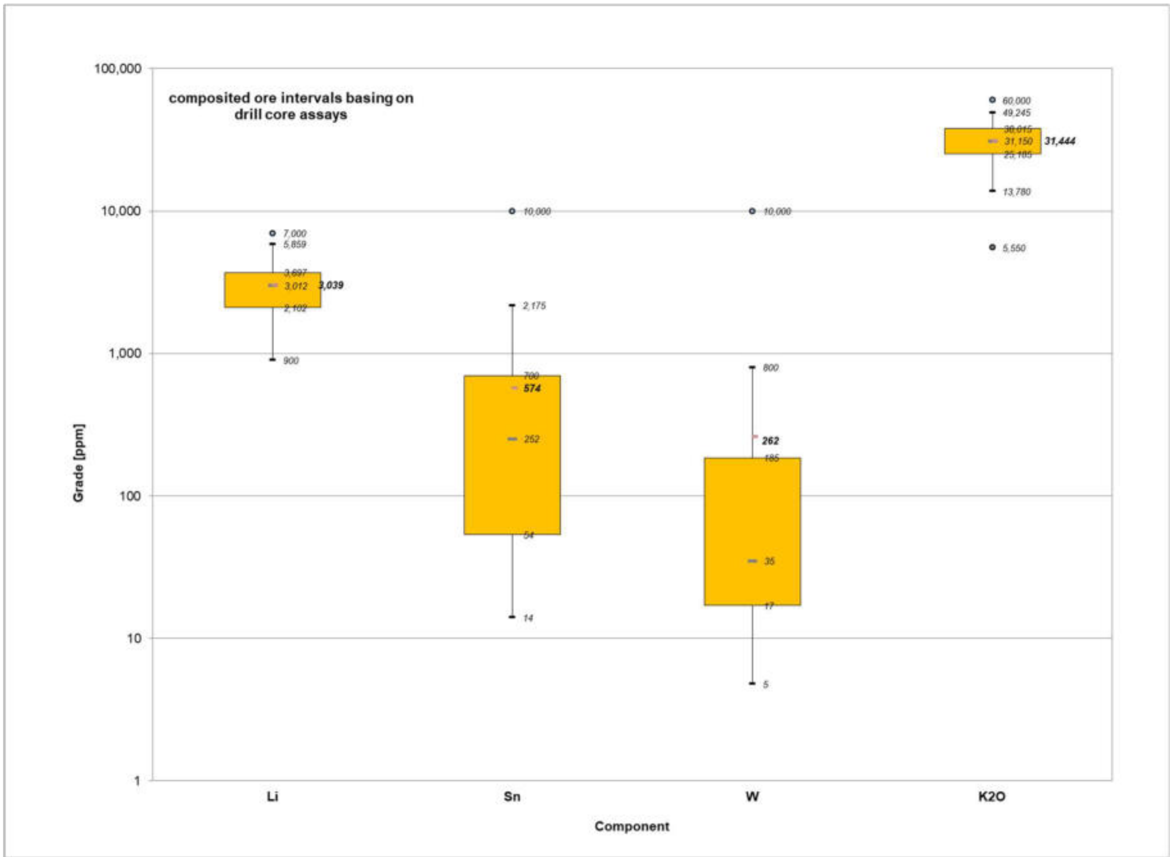


Figure 89: Box plots of the drill core assays composited by length of ore intervals of “Ore Type 1”

14.10 Composite Variographic Analyses

The classification of the lithium resources is based on a geostatistical spatial analysis of the 1 m composites of the lithium grades within the greisen ore bodies, which is characterized by a normal frequency distribution.

It is assumed that the intensity of the lithium mineralization has a layered pattern that is parallel to the bottom and top boundary of the greisen beds. Therefore, grade variations in x- and y-direction are generally lower compared to z-direction.

To make use of the knowledge of the mineralization genesis process, composite points were projected to a planar zone surrounding the central plane of the greisen beds. This equates to a coordinate transformation in vertical direction (unfolding). Geostatistical variogram analysis was performed based upon the entire transformed composite data keeping a space of 1,000 m in vertical direction between the data collectives of each greisen bed in order to not cross the composite points of adjacent greisen beds in the process of analysis.

The resulting semivariograms are presented in *Figure 90* to *Figure 92*.

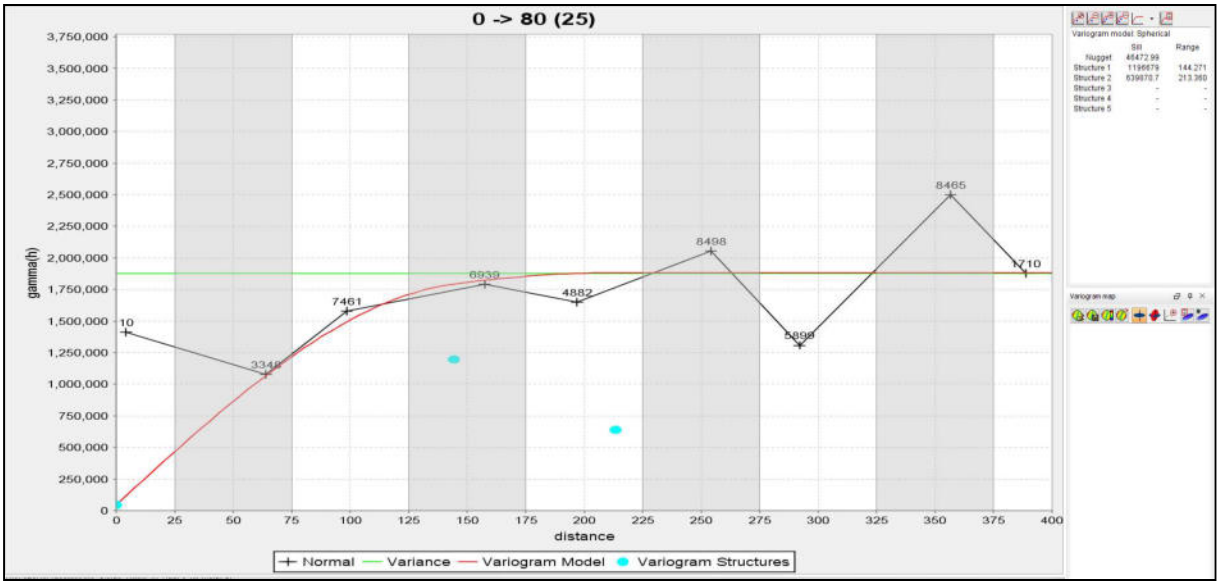


Figure 90: Semivariogram of the major axis of lithium composites of the greisen beds

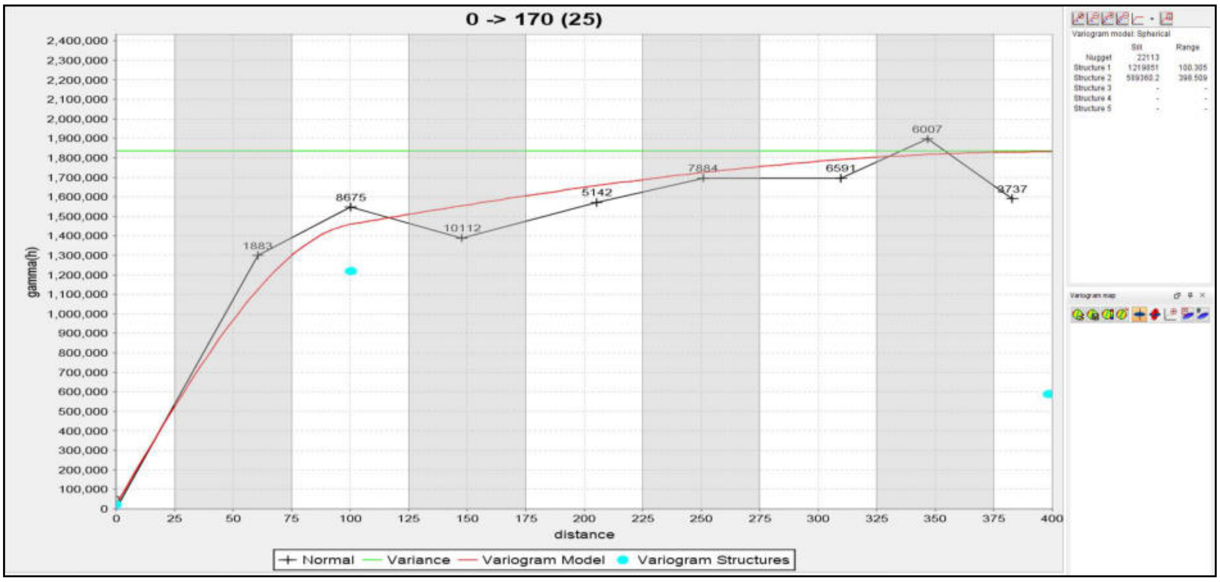


Figure 91: Semivariogram of the semi-major axis of lithium composites of the greisen beds

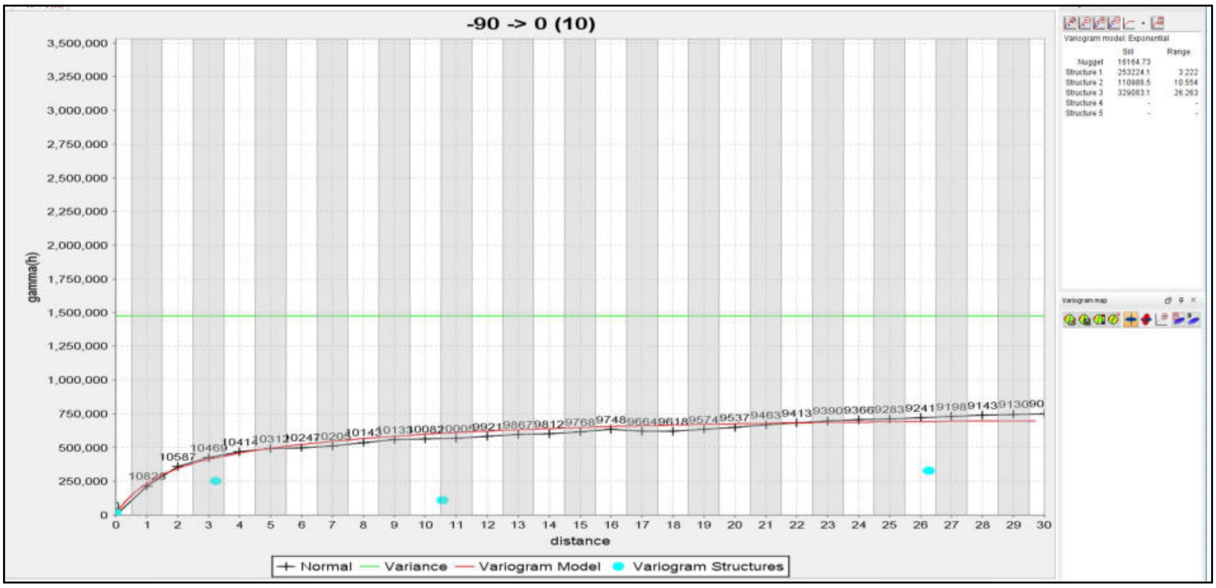


Figure 92: Semivariogram of the minor axis of lithium composites of the greisen beds

Semivariograms reveal evidence for up to 3 structures of the Li mineralization.

Table 57: Variogram parameters

Parameter	1. Structure	2. Structure	3. Structure
Major (bearing of the interpolation ellipsoid) angle: 80°	Sill: 120,000 range: 145 m	Sill: 640,000 range: 213 m	
Semi-major (plunge of the interpolation ellipsoid) angle: 350°	Sill: 222,000 range: 100 m	Sill: 589,000 range: 399 m	
Minor (dip of the interpolation ellipsoid) downhole	Nugget: 16,000 Sill: 253,000 range: 3.2 m	Sill: 111,000 range: 10.6 m	Sill: 329,000 range: 26.3 m

The range of the geostatistical relationship between lithium grades of the first structure accounts for 145 m, having an azimuth of 80° (major axis), and 100 m, having an azimuth of 350° (semi-major axis) within the greisen beds. The minor axis dips with 90° and shows a range of around 3 m (equates to the vertical cross section of the greisen beds). Ranges of the first structure have been used as crucial parameters of resource classification.

Ranges of the semi-major axis have to be regarded with caution. There is evidence that the real range of the first structure accounts for a value between 60 and 100 m. This confirms with comparable Li greisen and pegmatite deposits worldwide. However, in the case of the Zinnwald lithium deposit the semi-major still cannot be determined exactly due to the mean drill hole spacing of around 150 m. Only few sample assay pairs show smaller distances than 100 m.

14.11 Prospects for Eventual Economic Extraction

Concerning the minimum vertical thickness of an economically mineable greisen bed ore, a value of 2 m was chosen as a reasonable measure.

The consequent limitation of the lithium orebodies was not done with the 3D geological model only but also in the block model by using the interpolated vertical thickness as a limitation parameter in a database query.

Based on the current process development the mining cut-off was calculated at 2,500 ppm lithium as the base case.

Alternative scenarios were calculated with cut-off grades 0 ppm, 1,000 ppm, 2,000 ppm and 3,000 ppm Li.

Based on the vertical thickness the linear productivity of the Li mineralization was calculated in order to include potential high-grade intervals with vertical thicknesses below 2 m of the block model into the resource estimate.

Lithium linear productivity is the product of vertical greisen bed thickness and lithium grade.

Depending on the minimum vertical thickness and the lithium cut-off grades, linear productivity Li cut-off grades are:

4,000 ppm * m, 4,500 ppm * m, 5,000 ppm * m, 5,500 ppm * m and 6,000 ppm * m.

14.12 Block Model Construction

Empty block models had to be defined for each greisen bed. A horizontal discretization of 5 m x 5 m was chosen. The vertical blocking was set to 1 m due to the minimum thickness of economically minable ore beds of 2 m and in order to consider sufficiently the significantly differing lithium grades in vertical direction as found in the drill hole sample data.

No sub-blocking was applied. *Table 58* gives an overview of the block model parameterization:

Table 58: Parameterization of the block model

Parameter	x	y	z
Minimum [UTM33]	33,412,400	5,620,800	200 m
Maximum [UTM33]	33,413,800	5,622,300	850 m
Extent	1,400 m	1,500 m	650 m
Parent Block	5 m	5 m	1 m
Sub Block	-	-	-
Max. Number of Blocks [-]	54,600,000		

To reduce the random-access memory requirements, the block models have been constrained by the greisen bed top and bottom boundary planes as defined in the geological model. All blocks intersecting the boundary planes or located inside the beds were assigned to the constrained block model. In general, mineralized portions have not been extrapolated more than 50 m from drill holes collar position. As an additional boundary the German-Czech borderline was included.

14.13 Grade Interpolation

Since lithium assay data collectives are limited, especially for the less extensive greisen beds, inverse distance interpolation procedure was chosen to transfer the statistical characteristics of the sample data into a spatially distribution of grades within the block model.

Kriging interpolation algorithm has not been applied yet to estimate the lithium resource. However, geostatistical analysis reveals that lithium is Gaussian distributed and shows a very low coefficient of variation and a very low nugget value as well. Lithium appears to be homogeneously distributed within the greisen beds. For this reason, the inverse distance method is used to interpolate grades, even for such a large drill hole spacing like in the case of Zinnwald.

The following parameterization of the search ellipsoid of the anisotropic inverse distance interpolation was chosen:

Table 59: Parameters chosen for search ellipsoid of the anisotropic inverse distance interpolation

Parameter	Value
Minimum number of composites to apply	1
Maximum number of composites to apply	10
Maximum number of composites per drill hole	1
Maximum horizontal search radius of the ellipsoid (major)	290 m (twice the major range)
Maximum horizontal search radius of the ellipsoid (semi-major)	200 m (twice the semi-major range)
Maximum vertical search radius of the ellipsoid (minor and vertical constraint)	100 m

The inverse distance interpolation results were assigned to a planar block model as an intermediate step. Therefore, lithium composite points had to be projected to a planar zone surrounding the central plane of the greisen beds. Vertical discretization of composites from different greisen beds was handled by storing them in different files being used for the interpolation and by constraining the interpolation process to each greisen bed. Then interpolated lithium grades were projected in vertical direction to the true spatial location in a second block model.

14.14 Block Model Validation

Validation of the geological model of "Ore Type 1"

A simplified 3D surface model, based on the thickness of drill hole ore intervals of "Ore Type 1" (greisen + interburden) below 740 m a.s.l., has been created to prove the corresponding total greisen volume of the block model. Calculations resulted in a total volume of

21.5 million m³ (58.1 MT, 2.7 t/m³)

which almost equals the total volume of all greisen beds (19.9 million m³, 53.8 MT, 2.7 t/m³) reported from the block model.

Block model validation

Block model validation has been done by comparing percentile graphs of raw sample assay grades, composite grades and interpolated grades of the block center points.

The percentile graph on the following page, representing a summary of all “Ore Type 1” lithium assay data, composite point and block center point lithium grade data, reveals that there is a good congruence between the grade frequency distributions. Accordingly, lithium grades have been properly assigned to the block model by inverse distance interpolation.

Slight deviations are caused due to effects of the interpolation procedure leading to average the grades with increasing distance to the next sample point.

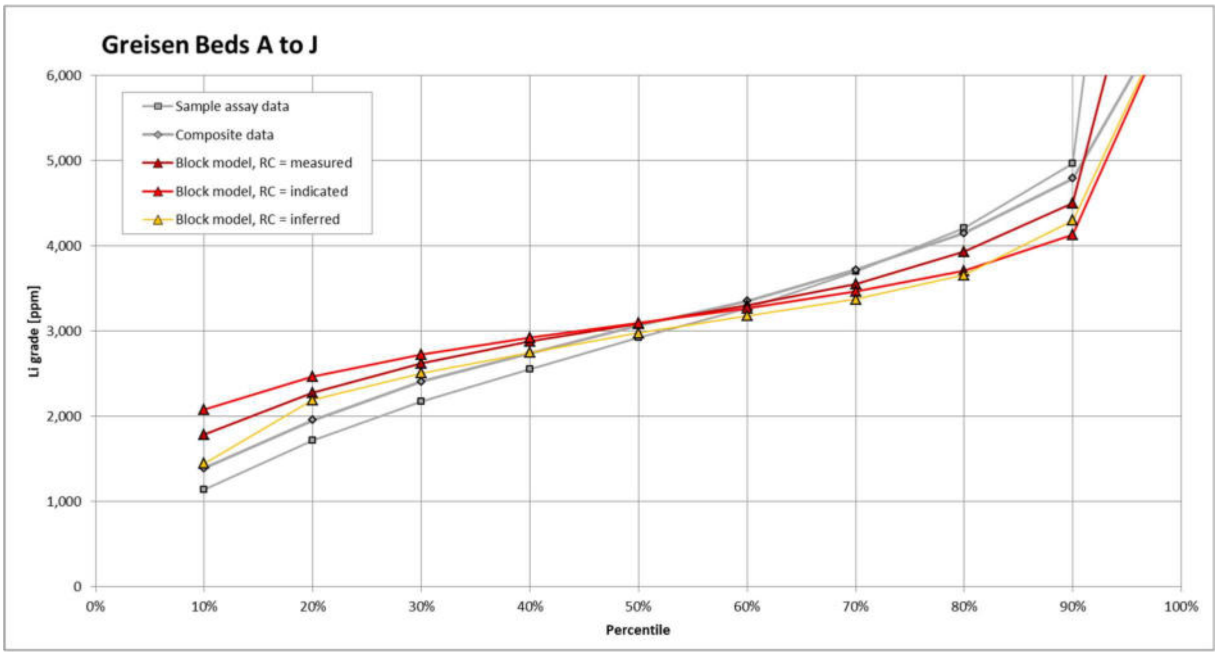


Figure 93: Percentile chart of lithium drill core assays compared to composite and block model center point lithium grades

Table 60: Comparison of percentiles of lithium grades from drill core assays, composites and block model

			Percentile				
	Class of data	Number of values	10%	20%	30%	40%	50%
All greisen beds	Sample assay data	2,574	1,143	1,714	2,170	2,555	2,926
	Composites	1,840	1,390	1,955	2,409	2,737	3,063
	Block model, RC = measured	557,216	1,788	2,278	2,622	2,877	3,089
	Block model, RC = indicated	469,958	2,081	2,470	2,721	2,919	3,094
	Block model, RC = inferred	133,305	1,445	2,194	2,507	2,750	2,976
	Class of data	Number of values	60%	70%	80%	90%	100%
All greisen beds	Sample assay data	2,574	3,270	3,700	4,210	4,964	14,817
	Composites	1,840	3,352	3,717	4,147	4,790	7,000
	Block model, RC = measured	557,216	3,302	3,552	3,929	4,502	9,403
	Block model, RC = indicated	469,958	3,271	3,464	3,704	4,126	6,979
	Block model, RC = inferred	133,305	3,180	3,375	3,656	4,298	7,000

Comparison of the arithmetic mean of lithium grades shows a good accordance between drill core assays, 1 m composites and block model interpolation by inverse distance method.

Table 61: Comparison of arithmetic means of lithium grades from drill core assays, composites and block model

Parameter	Drill core assays		1 m composites		Inverse distance interpolation	
			Measured	Indicated	Inferred	Total
"Ore Type 1" Arithmetic Mean Li [ppm]	3,098	3,105	3,126	3,097	2,958	3,095

14.15 Mineral Resource Classification

14.15.1 Preface

The lithium resource and the potential of Li, Sn, W and K_2O represent the German part of the Zinnwald lithium deposit below a level of 740 m a.s.l. Resource and potential cover greisen bed ("Ore Type 1") and greisenized granite ("Ore Type 2") lithologic domains.

The Mineral Resources of the Zinnwald property were estimated in conformity with generally accepted CIM "Estimation of Mineral Resource and Mineral Reserve Best Practices Guidelines". G.E.O.S. is not aware of any known environmental, permitting, legal, title, taxation, socio-economic, marketing or other relevant issues that could potentially affect this estimate of Mineral Resources. The Mineral Resources may be affected by further infill and exploration drilling which may result in an increase or decrease of a future Mineral Resource estimate. The Mineral Resources may also be affected by assessments of mining, environmental, processing, permitting, taxation, socio-economic and other factors in the future.

The resource estimate was completed by Matthias Helbig, a Senior Consultant (resource geologist at G.E.O.S.). The effective date of this resource estimate is September 30th, 2018.

14.15.2 Mineral Resource Classification

Lithium Mineral Resource of Greisen Beds ("Ore Type 1")

Variogram ranges (see *Chapter 14.10*) have been used as a measure to derive contiguous zones classifying the lithium mineral resource.

Core sample assays were used only from the drill holes. Furthermore, more than 80 % of the intersected greisen interval had to be assayed to generate a classification zoning surrounding the drill hole intersection interval. The criteria used to classify the resource are summarized as follows:

- "**Measured"** – High level of confidence in data quality, high level of confidence in grade estimation, geological and grade continuity. For the greisen beds ("Ore Type 1") the necessary horizontal distance to drill hole samples accounts for ≤ 73 m in east to west direction and ≤ 50 m in north to south direction as supported by the variogram ranges. A single greisen bed body must be intersected and sampled by at least two drill holes according to the above defined rules. Estimation uncertainty ratio accounts for ± 20 %.

- "**Indicated"** – Moderate level of confidence in data quality, moderate level of confidence in grade estimation, geological and grade continuity. More widely spaced drill hole sample data. Horizontal distance to drill hole samples accounts for > 73 m to ≤ 145 m in east to west direction and > 50 m to ≤ 100 m in north to south direction. A single greisen bed body must be intersected and sampled by at least two drill holes according to the above defined rules. Estimation uncertainty ratio accounts for ± 40 %.

- "**Inferred"** – Moderate level of confidence in data quality, low level of confidence in grade estimation, geological and grade continuity. Sparse drilling data compared to variogram ranges: spacing of > 145 m to ≤ 290 m in east to west direction and > 100 m to ≤ 200 m in north to south direction. A single greisen bed body must be intersected and sampled by at least one drill hole according to the above defined rules. Estimation uncertainty ratio accounts for ± 80 %.

Anisotropic inverse distance interpolation was used to estimate the lithium grades within the greisen bed envelopes. The results have been verified by a simplified grid-based 2D model using inverse distance algorithm. In general, resources have not been extrapolated more than 50 m beyond individual drill hole intersections within the greisen beds (half of the range of the semi-major).

Sn, W and K_2O Potential of Greisen Beds ("Ore Type 1")

Tin and tungsten weighted mean grades measured in the greisen bed intervals (drill core samples) of the exploration campaigns No.s (4), (5) and (8) were interpolated by inverse distance algorithm. Mean grades of the minor elements are reported for each of the greisen beds of "Ore Type 1".

The K_2O weighted mean grade measured in the greisen bed intervals (drill core samples) of exploration campaign No. (8) was interpolated by inverse distance algorithm also. Mean grades of K_2O are reported for each of the greisen beds of "Ore Type 1".

Li, Sn, W and K_2O Potential of Greisenized Granite ("Ore Type 2")

The volume of greisenized granite was derived from a simplified 2D grid-based model. The volume then was multiplied by the bulk density in order to estimate the total tonnage. The weighted means of lithium, tin, tungsten and K_2O grade, obtained from drill core sample assays of exploration campaigns No. (8), were applied to the total tonnage of greisenized granite.

14.16 Mineral Resource Statement

14.16.1 Lithium Mineral Inventory

The Mineral Inventory of lithium was estimated from the block model on the base of a 0 ppm cut-off and without a constraint of minimum thickness of the geological bodies of "Ore Type 1".

Table 62: Lithium Mineral Inventory of Zinnwald, German part below 740 m a.s.l. level

Mineral inventory "Ore Type 1"	Volume [10^6 m^3]	Tonnage [10^6 tonnes]	Mean Li grade [ppm]
Total	***19.9***	***53.8***	***3,100***

14.16.2 Lithium Mineral Resource – Base Case "Ore Type 1"

According to prospects for eventual economic extraction (minimum vertical thickness of greisen beds = 2 m, cut-off value Li = 2,500 ppm) the Lithium Mineral Resource shown below has been calculated for the German part of the Zinnwald lithium deposit and below 740 m a.s.l. as the Base Case "Ore Type 1". It has been compared with the case zero (minimum vertical thickness of greisen beds = 2 m, cut-off-value Li = 0 ppm) to determine the internal dilution of the orebodies.

Table 63: Lithium Mineral Resource of Zinnwald Deposit, German part below 740 m a.s.l. – Base Case "Ore Type 1" Summary

Resource classification "Ore Type 1" greisen beds	**Ore volume [10^3 m^3]**	**Ore tonnage [10^3 tonnes]**	**Mean Li grade [ppm]**	**Ore volume [10^3 m^3]**	**Ore tonnage [10^3 tonnes]**	**Mean Li grade [ppm]**
	Vertical thickness ≥ 2 m, cut-off Li = 2,500 ppm			**Vertical thickness ≥ 2 m, cut-off Li = 0 ppm**		
Measured	6,855	18,510	3,630	8,954	24,176	3,246
Indicated	6,296	17,000	3,399	8,046	21,725	3,114
Inferred	1,802	4,865	3,549	2,675	7,224	2,995
Demonstrated *(Measured+Indicated)*	***13,152***	***35,510***	***3,519***	***17,000***	***45,901***	***3,183***
	Internal Dilution					
Total *(Measured+Indicated+Inferred)*	***4,722***	***12,749***	***2,001***			

In accordance to

Table 64, greisen beds "B" and "E" are the most important ore bodies of the Zinnwald lithium deposit and comprise around 71 % of the Demonstrated Resource of "Ore Type 1".

The mean lithium grade for all greisen beds is remarkably higher than 3,000 ppm.

Table 64: Lithium Mineral Resource of Zinnwald Deposit, German part below 740 m a.s.l. – Base Case “Ore Type 1” greisen beds A - E

Resource classification "Ore Type 1" - greisen beds		**Cut-off grade Li = 2,500 ppm, below the Tiefer-Bünau-Stollen level (≤ 740 m NN), thickness of greisen beds ≥ 2 m**		
Greisen bed	**Resource classification**	**Ore volume [m³]**	**Ore tonnage [tonnes]**	**Mean lithium grade [ppm]**
A	Measured	7,525	20,318	3,227
	Indicated	5,150	13,905	3,284
	Inferred	7,050	19,035	2,732
	Demonstrated *(Measured+Indicated)*	***12,675***	***34,223***	***3,250***
B	Measured	3,358,750	9,068,627	3,569
	Indicated	2,874,075	7,760,004	3,359
	Inferred	425,650	1,149,256	3,392
	Demonstrated *(Measured+Indicated)*	***6,232,825***	***16,828,631***	***3,472***
C	Measured	311,375	840,713	3,919
	Indicated	226,000	610,201	3,452
	Inferred	226,400	611,280	3,495
	Demonstrated *(Measured+Indicated)*	***537,375***	***1,450,914***	***3,723***
D	Measured	576,650	1,556,955	3,644
	Indicated	473,275	1,277,843	3,544
	Inferred	279,375	754,313	3,341
	Demonstrated *(Measured+Indicated)*	***1,049,925***	***2,834,798***	***3,599***
E	Measured	1,553,700	4,194,991	3,757
	Indicated	1,552,525	4,191,819	3,379
	Inferred	604,850	1,633,097	3,376

	Demonstrated *(Measured+Indicated)*	***3,106,225***	***8,386,810***	***3,568***

Table 65: Lithium Mineral Resource of Zinnwald Deposit, German part below 740 m a.s.l. – Base Case “Ore Type 1” greisen beds F - J

Resource classification "Ore Type 1" - greisen beds		Cut-off grade Li = 2,500 ppm, below the Tiefer-Bünau-Stollen level (≤ 740 m NN), thickness of greisen beds ≥ 2 m		
Greisen bed	**Resource classification**	**Ore volume [m³]**	**Ore tonnage [tonnes]**	**Mean lithium grade [ppm]**
F	Measured	247,200	667,440	3,620
	Indicated	314,075	848,003	3,491
	Inferred	33,000	89,100	3,817
	Demonstrated *(Measured+Indicated)*	***561,275***	***1,515,443***	***3,548***
G	Measured	365,000	985,500	3,456
	Indicated	281,150	759,105	3,134
	Inferred	21,525	58,118	2,610
	Demonstrated *(Measured+Indicated)*	***646,150***	***1,744,605***	***3,316***
H	Measured	27,675	74,723	3,024
	Indicated	18,725	50,558	2,680
	Inferred	158,975	429,233	5,228
	Demonstrated *(Measured+Indicated)*	***46,400***	***125,281***	***2,885***
I	Measured	184,775	498,893	3,198
	Indicated	252,575	681,953	3,416
	Inferred	28,125	75,938	3,625
	Demonstrated *(Measured+Indicated)*	***437,350***	***1,180,846***	***3,324***
J	Measured	223,050	602,235	3,964
	Indicated	298,925	807,098	3,804
	Inferred	17,150	46,305	2,929
	Demonstrated *(Measured+Indicated)*	***521,975***	***1,409,333***	***3,872***

14.16.3 Lithium Resource – Alternative Cut-Off Grades

The *Table 66* shows a summary of mean lithium grades and ore tonnages for cases with a minimum vertical thickness of the greisen beds of 2 m and a lithium cut-off grade of 2,500 ppm (Base Case) as well as alternative lithium cut-off grades of 0 / 1,000 / 2,000 / 3,000 ppm.

Table 66: Lithium Mineral Resource of Zinnwald Deposit, German part below 740 m a.s.l. – Cases "Ore Type 1"

Resource classification "Ore Type 1" greisen beds	Ore volume [10^3 m³]	Ore tonnage [10^3 tonnes]	Mean Li grade [ppm]	Ore volume [10^3 m³]	Ore tonnage [10^3 tonnes]	Mean Li grade [ppm]
	Vertical thickness ≥ 2 m, cut-off Li = 0 ppm (case zero)			**Vertical thickness ≥ 2 m, cut-off Li = 1,000 ppm**		
Measured	8,954	24,176	3,246	8,649	23,353	3,318
Indicated	8,046	21,725	3,114	7,893	21,312	3,146
Inferred	2,675	7,224	2,995	2,488	6,719	3,143
Demonstrated *(Measured+Indicated)*	***17,000***	***45,901***	***3,183***	***16,543***	***44,666***	***3,236***
	Vertical thickness ≥ 2 m, cut-off Li = 2,000 ppm			**Vertical thickness ≥ 2 m, cut-off Li = 2,500 ppm (Base Case)**		
Measured	7,825	21,128	3,472	6,855	18,510	3,630
Indicated	7,273	19,637	3,256	6,296	17,000	3,399
Inferred	2,179	5,883	3,341	1,802	4,865	3,549
Demonstrated *(Measured+Indicated)*	***15,098***	***40,766***	***3,368***	***13,152***	***35,510***	***3,519***
	Vertical thickness ≥ 2 m, cut-off Li = 3,000 ppm					
Measured	5,177	13,979	3,897			
Indicated	4,496	12,139	3,642			
Inferred	1,291	3,485	3,857			
Demonstrated *(Measured+Indicated)*	***9,673***	***26,119***	***3,778***			

14.16.4 Potential of Li, Sn, W and K_2O

Sn, W and K_2O Potential of Greisen Beds ("Ore Type 1")

The Potential of Sn, W and K_2O have been estimated for the greisen beds as mean grades for "Ore Type 1" for the German part of the Zinnwald lithium deposit and below 740 m a.s.l.

Table 67: Minor Elements' Potential of Zinnwald Deposits, German part below 740 m a.s.l. – Base Case "Ore Type 1"

"Ore Type 1" - greisen beds		Cut-off grade Li = 2,500 ppm, below the Tiefer-Bünau-Stollen level (≤ 740 m NN), thickness of greisen beds ≥ 2 m				
Greisen bed	**Sum**	**Ore volume [10^3 m^3]**	**Ore tonnage [10^3 tonnes]**	**Mean tin grade [ppm]**	**Mean tungsten grade [ppm]**	**Mean potassium oxide grade [wt.%]**
A	***Sub Total***	19	53	1,115	371	3.2
B	***Sub Total***	6,658	17,977	692	142	2.9
C	***Sub Total***	763	2,062	651	704	3.4
D	***Sub Total***	1,329	3,589	360	51	3.1
E	***Sub Total***	3,711	10,019	510	51	3.3
F	***Sub Total***	594	1,604	368	324	3.7
G	***Sub Total***	667	1,802	95	39	3.0
H	***Sub Total***	205	554	135	37	3.7
I	***Sub Total***	465	1,256	58	32	2.7
J	***Sub Total***	539	1,455	35	29	2.9
All greisen beds together	***Total***	***14,954***	***40,376***	***525***	***134***	***3.1***

Base Case "Ore Type 1" (with a total volume of rounded 15 million cubic meters and a tonnage of 40 million tonnes) overall mean tin grade accounts for approximately 500 ppm, mean tungsten grade for approximately 100 ppm and mean potassium oxide grade for approximately 3.1 wt.%.

Li, Sn, W and K_2O Potential of Greisenized Granite ("Ore Type 2")

The Potential of Li, Sn, W and K_2O of the greisenized granite domain ("Ore Type 2") have been estimated as a Mineral Inventory. Multiplication of domain volume, domain dry bulk rock density and domain mean component grades from statistical analysis of data of exploration campaign No. (8) has been applied for the German part of the Zinnwald lithium deposit and below 740 m a.s.l.

"Ore Type 2" is estimated to approx. 81 million cubic meters containig 214 million tonnes (2.65 t/m³) of ore. With regard to exploration campaign No. (8) "Ore Type 2" has a mean lithium grade of approximately 1,700 ppm. Mean tin grade accounts for approximately 270 ppm, mean tungsten grade for approximately 40 ppm and mean potassium oxide grade for approximately 3.6 wt.%.

The above mentioned grades of minor elements represent the overall mean contents in the ore types. Veins, seams and locally occurring tin greisen stockworks which are embedded in the ore type bodies might show significant higher grades.

14.17 Grade-Tonnage Curves

Grade-tonnage curves and tables have been prepared for evaluation of the Lithium Mineral Resource estimate of “Ore Type 1” below 740 m a.s.l. (see *Figure 94*). Curves of ore tonnage and mean lithium grade vs. cut-off grades are regular shapes and do not reveal evidence of errors of the resource estimate.

Table 68: Grade-tonnage curve parameters of the Lithium Mineral Resource estimate of “Ore Type 1”

Lithium cut-off [ppm]	Greisen bed volume "Ore Type 1" [10^3 m^3]	Greisen bed tonnage "Ore Type 1" [10^3 t]	Mean lithium grade [ppm]
0	19,687	53,157	3,158
250	19,676	53,126	3,158
500	19,642	53,034	3,161
750	19,556	52,801	3,169
1,000	19,302	52,117	3,196
1,250	19,031	51,385	3,224
1,500	18,775	50,694	3,246
1,750	18,397	49,674	3,279
2,000	17,939	48,437	3,315
2,250	17,277	46,649	3,365
2,500	16,288	43,979	3,434
2,750	14,954	40,376	3,523
3,000	13,161	35,535	3,640

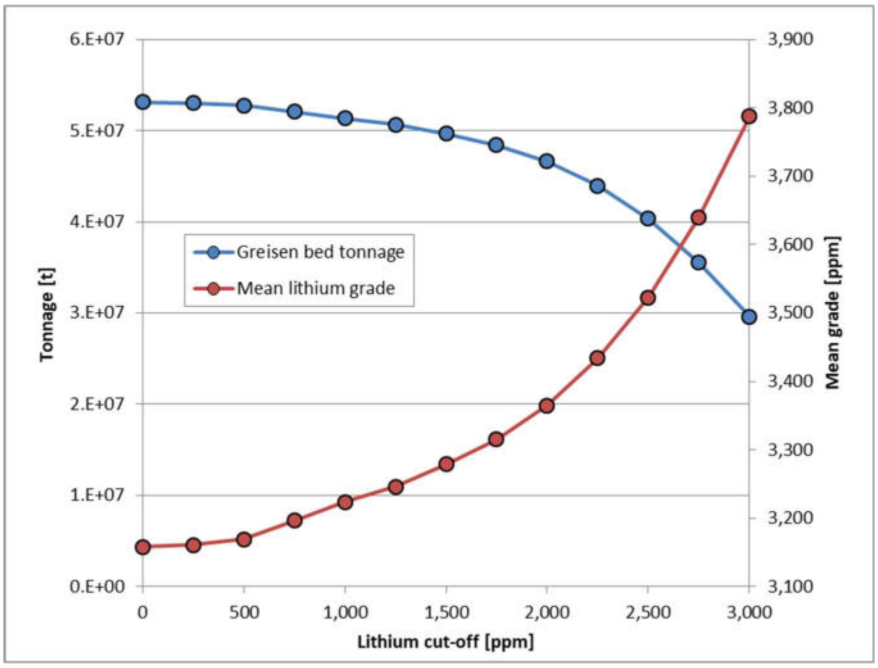


Figure 94: Grade-tonnage curves of the Lithium Mineral Resource of “Ore Type 1”

14.18 Comparison with Historic Resource Estimates

The Zinnwald lithium deposit was explored for lithium in campaigns No.s (4), (6) and (8). Greisen tonnage and mean grades are only directly comparable for campaigns No.s (4) and (8). Campaign (6) focused on the investigation of tin and tungsten mineralizations (total sums are only intended for the comparison with historic values).

Table 69: Comparison of the Li ore resource and its average Li, Sn and W grades, according to the individual exploration campaigns

Exploration campaign No.	Resource class	Volume [10^3 m³]	Tonnage [10^3 tonnes]	Mean Li grade [ppm]	Mean Sn grade [ppm]	Mean W grade [ppm]
(4) Bolduan und Lächelt (1960) [248]	C_1+C_2 (Greisen intersection interval thickness ≥ 2 m, cut-off = 2,000 ppm)	4,000 1,000 200 Sum C_1+C_2	10,700 2,800 500 Sum C_1+C_2	3,000	Prognostic mean grade 500	Prognostic mean grade 200

Exploration campaign No.	Resource class	Volume [10³ m³]	Tonnage [10³ tonnes]	Mean Li grade [ppm]	Mean Sn grade [ppm]	Mean W grade [ppm]
		5,000	13,500			
(6) GRUNEWALD (1978b) [260]	No classification (Greisen drill hole intersection interval thickness ≥ 5 m, cut-off = 0 ppm)	5,980	16,100	3,000	Not calculated for Li ore	Not calculated for Li ore
(8a – 8b) SWS (2013)	Measured / Indicated / Inferred (Vertical thickness ≥ 2 m; cut-off = 2,000 ppm)	4,234 6,848 4,051 Sum 15,133	11,431 18,490 10,939 Sum 40,860	3,529 3,446 3,578 Mean grade 3,505	Potential Mean grade approx. 400	Potential Mean grade approx. 80
	Potential of greisen	approx. 900	approx. 2,400	approx. 3,200	approx. 400	approx. 80
	Potential of greisenized granite	approx. 44,000	approx. 117,000	approx. 1,800	approx. 240	approx. 40
(8a – 8c) DL (2018)	Measured / Indicated / Inferred (Vertical thickness ≥ 2 m; cut-off = 2,000 ppm)	9,371 6,308 1,597 Total 17,277	25,303 17,033 4,312 Total 46,649	3,446 3,228 3,425 Mean grade 3,365	Potential Mean grade 509	Potential Mean grade 129

Exploration campaign No.	Resource class	Volume [10^3 m³]	Tonnage [10^3 tonnes]	Mean Li grade [ppm]	Mean Sn grade [ppm]	Mean W grade [ppm]
	Potential of greisen	-	-	-	-	-
	Potential of greisenized granite	approx. 81,000	approx. 214,000	approx. 1,700	approx. 270	approx. 40

If the geological data of campaigns (5), (6), (7) and (8) as well as the lithium assay data of campaigns (5) and (8) are also taken into account, it can be summarized that the lithium resource of "Ore Type 1" has more than tripled compared to Exploration Campaign No. 4.

Comparison of expected cumulated ore interval thickness ("Ore Type 1") of the 2017 drilling campaign against demonstrated cumulated ore interval thickness yielded values of 383 m vs. 510 m. Expected length weighted mean grade was 3,068 ppm Li. Demonstrated grade was 3,380 ppm Li.

Like the 2014 campaign before, expected ore parameters have been exceeded by the demonstrated ore parameters. Consequently, findings of the last two drilling campaigns 8b and 8c substantiate a continuous growth of the estimated lithium resource.

14.19 Risk Assessment of the Demonstrated Lithium Mineral Resource

The overall error range of the resource estimation results from the interaction of the uncertainty ratios of different input factors, which are:

1. Errors and lack of drill hole survey data, especially for data before exploration campaign No. (7)
2. Errors of geochemical analysis, especially for data of exploration campaign No. (4)
3. Errors of data acquisition
4. Uncertainties of the 3D modelled geological shapes of the greisen beds
5. Lack of sufficient spatial data density, especially for greisen beds with small extension, preventing the ability to perform a reliable geostatistical analysis

The before mentioned error factors are summarized as estimation uncertainty ratios, which are ± 20 % for the class measured and ± 40 % for the class indicated. Application of these factors to the estimated and classified ore tonnages results in the corresponding tolerance intervals.

Figure 95 gives an overview of the band of uncertainty that is associated with the Demonstrated Lithium Mineral Resource. The shown ratio must be considered for the economic evaluation and determination of Mineral Reserves.

For the example of the base case scenario (cut-off grade lithium = 2,500 ppm, minimum vertical thickness of the greisen beds = 2 m) the tolerance band of demonstrated greisen ore tonnage in place reaches from 25.0 million tonnes to 46.0 million tonnes which equals a range of ± 30 %. The estimated value accounts for 35.5 million tonnes.

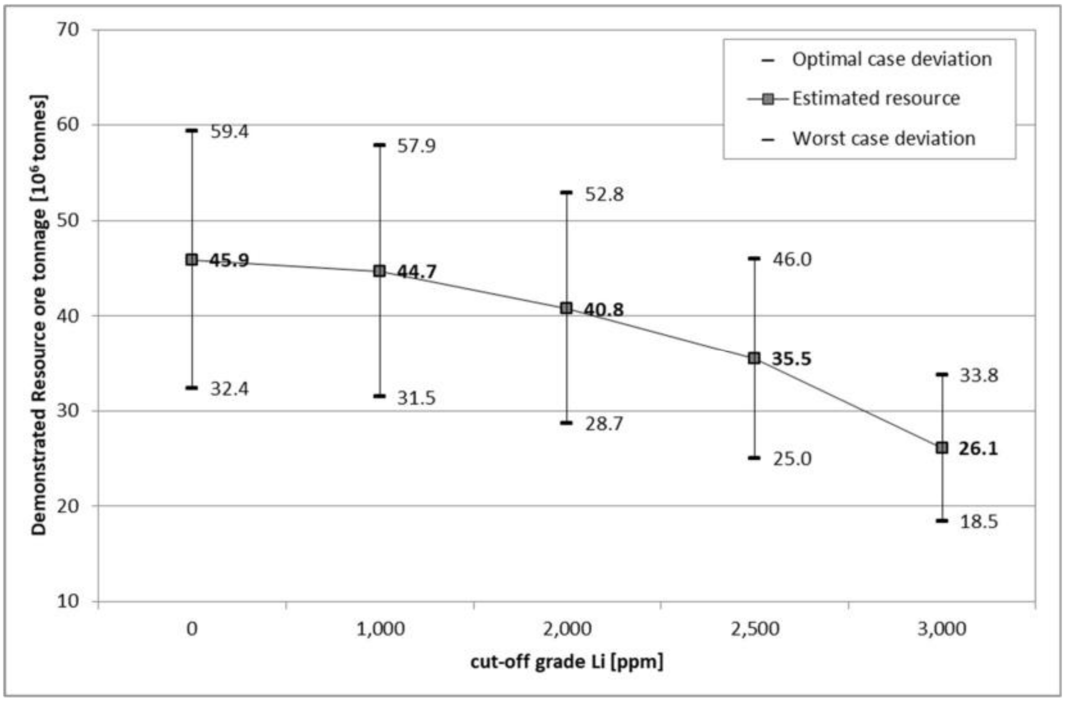


Figure 95: Tolerance intervals of the Demonstrated Resource tonnage

For the total Demonstrated Resource the tolerance band encompasses values from 32.4 to 59.4 million tonnes of ore whereas the estimated value accounts for 45.9 million tonnes. Consequently, the range of uncertainty equals ± 29 %.

Assuming an uncertainty ratio of ± 10 %, the mean grade of the Demonstrated Lithium Mineral Resource at a cut-off of 2,500 ppm will vary between 3,160 ppm and 3,870 ppm (see *Figure 96*).

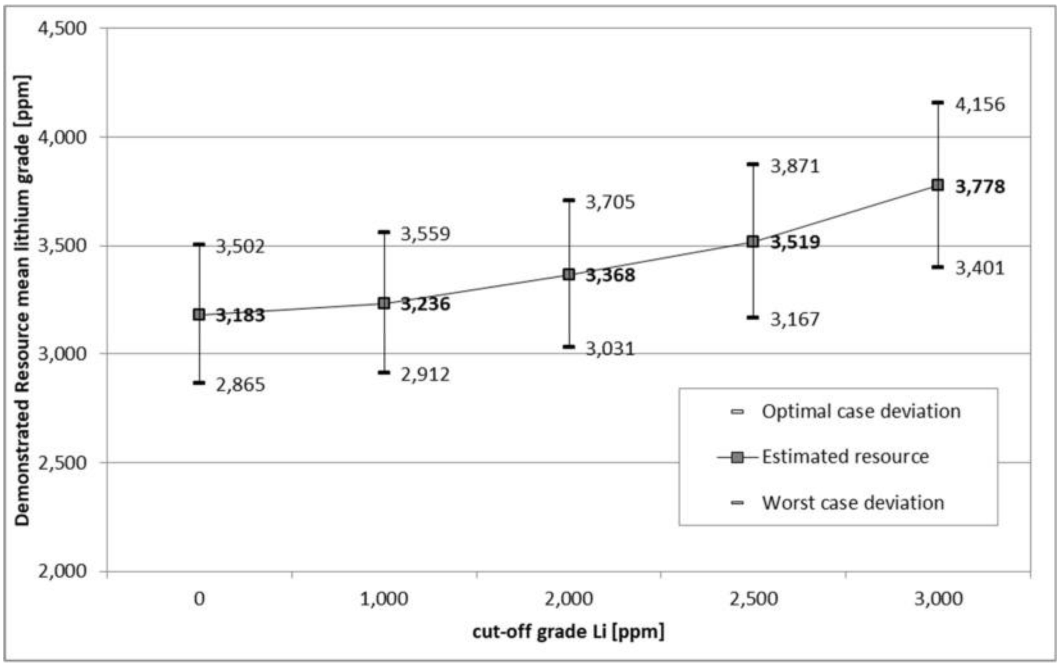


Figure 96: Tolerance intervals of the mean lithium grade of the Demonstrated Resource

15 Mineral Reserve Estimates

15.1 Introduction

"Modifying Factors" are considerations used to convert Mineral Resources to Mineral Reserves. These include, but are not restricted to, mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors. A Mineral Reserve is the economically mineable part of a Measured and / or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur, when the material is mined or extracted (CIM Definition Standard). Generally, a Probable Mineral Reserve is the economically viable part of an Indicated Mineral Resource; a Measured Mineral Resource can be transferred to a Proven Reserve.

Mining and beneficiation circumstances for the Zinnwald Lithium Project are favorable. Considering and resolving the modifying factors, the Mineral Resource can be substantially transferred to a Mineral Reserve.

15.2 Inputs to Mineral Reserve

The Mineral Reserve of the Zinnwald lithium deposit describes the economically mineable part of the Mineral Resource. It considers the preparation and development of the whole deposit as well as the technological development of an exemplary selected mine sublevel.

All calculations are based on the volumetric assessment of the digital deposit model and the resultingblock model, which was created using the SURPAC V. 6.7 software. The overlap of the planned mine openings with the sub-blocks of the model were classified and assigned to the block model. This allowed a differentiated balancing of the volumes and tonnages of the Mineral Reserve including dilution.

All following figures are rounded to reflect the relative accuracy of the estimate and have been used to derive sub-totals, totals and weighted averages. Such calculations consequently introduce a margin of error. Where this occurs, it was not considered to be essential. Totals may not add due to rounding.

A classification of ore and waste rock material (wall rock) was conducted in the areas of the planned mine openings. The basis for this procedure is the already performed geological delineation of the orebodies within the deposit model:

1. Lithium ore conform to the estimation parameters (Li grade ≥ 2,500 ppm and [minimum thickness ≥ 2 m or linear productivity ≥ 5,000 ppm * m], essentially consisting of greisen)
2. Interbeds, which are included in the geometric construction of the orebodies, predominantly consisting of not parameter compatible greisen, greisenized albite granite and subordinate albite granite
3. Wall rock (rocks outside the ore bodies mainly consisting of greisenized albite granite and subordinate albite granite)
4. Not classified (zones outside the tenement)

Volumes of material belonging to outer and inner dilution exhibit lithium grades > zero. Predominately greisenized granite accompanies the orebodies. It shows mean lithium grades of approx. 1,700 ppm. Inner dilution mostly consists of greisen and greisenized granite that shows mean lithium grades of approx. 1,900 ppm.
For calculation of the tonnage, the volumetric assessment of the block model was combined with the average density of the rocks (*Table 70*).

Table 70: Rock densities for the calculation of bulk tonnage

Ore Class	Density [t/m³]
Greisen (parameter conform lithium ore)	2.70
Interbeds (inner dilution)	2.63
Wallrock (outer dilution)	2.63

The portion of the geological lithium resource, which is blocked by safety pillars surrounding already existing mineworkings, or which cannot be mined economically due to the isolation of ore bodies or to an insignificant ore thickness, was a priori excluded ("blocking out", see *Figure* 97*).*

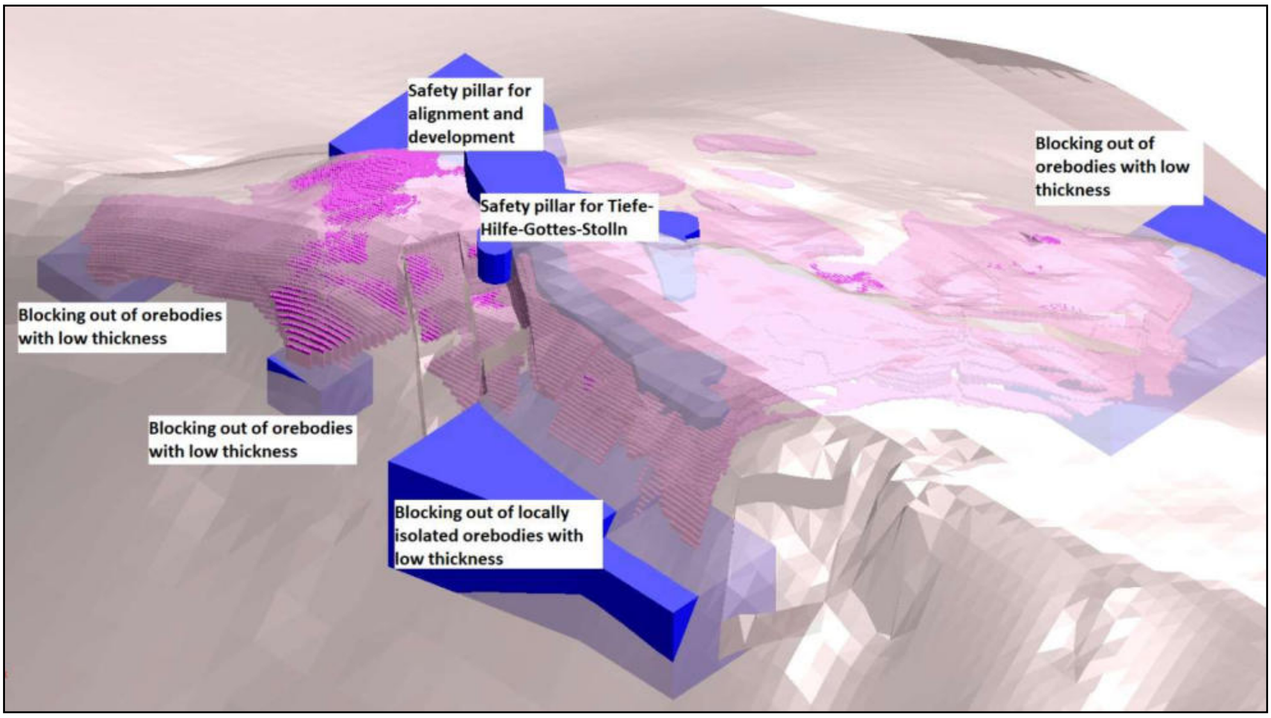


Figure 97: Blocking out of the not mineable lithium resource (view from SW)

The resource calculation for the entire Zinnwald deposit (German part) shows a combined Measured and Indicated Mineral Resource of 13,152,000 m³ / 35,510,000 t with an average lithium grade of 3,519 ppm (see *Item 14).* The additional Inferred Mineral Resource amounts to 1,802,000 m³ / 4,865,000 t with an average lithium grade of 3,549 ppm. These numbers are valid for the mineralized area below the level 740 m a.s.l. located in the tenement of DL.
By deducting the portions of safety pillars and uneconomic ore blocks of the deposit, the combined Measured and Indicated Mineral Resource is reduced to 12,170,000 m³ / 32,860,000 t with an average lithium content of 3,534 ppm.

Accordingly, the Demonstrated Mineral Resource of the Zinnwald lithium deposit was at first modified by the factor 0.93 (-7 %).

15.3 Mineable Lithium Reserves of Sublevel +556 m a.s.l to +564 m a.s.l.

The horizontal slice between +556 m a.s.l. and +564 m a.s.l. was selected as representative mine sublevel to determine the mining loss by means of a detailed mine design. It is located in the middle between the more or less consistently ore bearing zones of the sublevels in the hanging wall and the predominantly irregular and isolated ore bearing zones of the sublevels in the footwall (see *Figure* 98). It represents the normal situation for the expected mining conditions of the deposit. Calculated ratios of recoveries and losses have then been projected onto the total resource.

15.4 Optimization of Exploitation

15.4.1 Methodology

The Mineral Reserve was estimated for two mining schemes based on sublevel stoping with longitudinal stopes. Both cases take into consideration that about 7 % of the total Demonstrated Mineral Resource cannot be mined. Based on this reduced resource, Mineral Reserves have been estimated for both Case No.1 and Case No. 2.
Case No. 1 is referred to as “Standard Mining Technology and Optimized Backfill”. Backfill material is characterized by a compressive strength value of at least 4 to 5 MPa which allows a reduced pillar width of 2 m. Case No. 1 is regarded as the normal case suggested for the future mining procedure of the Zinnwald lithium deposit, which can be specifically adjusted to locally changing geological conditions. Case No. 2 is referred to as “Standard Mining Technology and Standard Backfill”. In this case backfill material is characterized by a compressive strength value of at least 2 MPa which requires a pillar width of 3 m.

15.4.2 Case No. 1: “Standard Mining Technology and Optimized Backfill”

Case 1 includes maximum dimensions of the rooms of 7 m x 7 m with 2 m wide safety pillars and 1 m thick horizontal roof pillars. Dimensions of cross-sectional profiles can be reduced to 3 m x 3 m if necessary and are limited by the technical equipment and mining technology. A minimum pillar width of 2 m requires at least a compressive strength parameter of 4 to 5 MPa for the backfill material. This pillar reduction and the demands on the compressive strength behaviour can be afforded by an increase of self-hardening backfill additives.

This result in 7 % of loss by safety pillars of already existing mineworkings and by uneconomic ore blocks combined with a calculated 32 % of mining loss to a total recovery of about 63 % of the combined Measured and Indicated Mineral Resource. Internal dilution accounts for roughly 8 % and external dilution for about 20 %.

15.4.3 Case No. 2: "Standard Mining Technology and Standard Backfill"

Case 2 includes maximum dimensions of the rooms of 7 m x 7 m with 3 m wide safety pillars and 1 m thick horizontal roof pillars. Dimensions of the cross-sectional profiles can be reduced to 3 m x 3 m if necessary and are limited by the technical equipment and the mining technology. A minimum pillar width of 3 m requires a compressive strength parameter of at least 2 MPa for the backfill material.

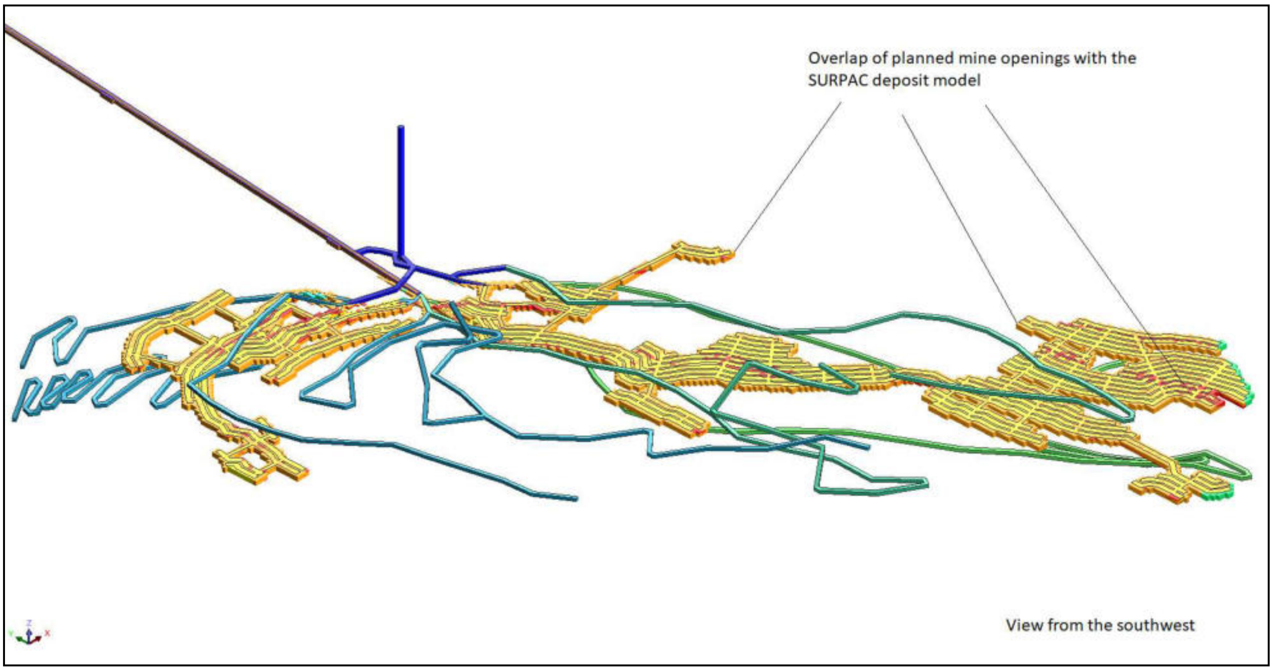


Figure 98: Overlap of the planned mine openings with the deposit model (Sublevel +556 m a.s.l. to +564 m a.s.l., view from SW)

About 7 % of loss by safety pillars of already existing mineworkings and by uneconomic ore blocks combined with a calculated 41 % of mining loss will result in a total recovery of about 54 % of the combined Measured and Indicated Mineral Resource. Internal dilution accounts for roughly 8 % and external dilution for about 20 %.

15.4.4 Summary of Recoveries and Losses

Mining losses with respect to the parameter conform lithium ore and the processing recoveries (ore benefication and metallurgical processing) are summarized in the table below:

Table 71: Summary of losses and recoveries

Determining Factor	Mining Loss Case No. 1	Mining Loss Case No. 2	Recovery
(1) Safety pillars and uneconomic ore blocks (estimated for whole deposit)	-7 %	-7 %	
(2) Mining loss (estimated for sublevel 556 m a.s.l. to 564 m a.s.l.)	-32 %	-41 %	
(3) Total loss out of (1) and (2)	**-37 %**	**-46 %**	
(4) Mechanical processing (processing tests of DL)			92 %
(5) Leaching process (processing tests of DL)			87 %
(6) Crystallization process (processing tests of DL)			95 %
(7) Total recovery out of (4), (5) and (6)			**76 %**

15.5 Mineral Reserves of the Zinnwald Lithium Deposit

15.5.1 Case No. 1: "Standard Mining Technology and Optimized Backfill"

CIM Definition Standards were followed for the calculation of the Mineral Reserves which were generated using the September 30th, 2018, version of the Zinnwald deposit resource model (see *chapter 14*).

Mineral Reserves are reported at a 2,500 ppm Li cut-off grade and below 740 m a.s.l. inside the German state territory and are part of the Mineral Resource.

Implying losses and dilution, a total Mineral Reserve of rounded 31 Mt results for mining case no. 1, which is available for processing (*Table 72*). The **lithium metal** content accounts for **94 kt**, with 78 kt lithium belonging to parameter conform ore, 5 kt to inner dilution (interbeds) and 11 kt to outer dilution (wall rock).

The portion of the Proven Mineral Reserve accounts for 16.5 Mt of ore including dilution and contains 51 kt lithium metal. This corresponds to 54 % of the total lithium metal reserve. The Probable Mineral Reserve is 14.7 Mt of ore, including dilution, with a content of 43 kt lithium metal. It comprises 46 % of the total lithium metal reserve.

Table 72: Mineral Reserve (Lithium), Case No. 1

Category	Ore and Dilution Tonnage [kt]	Li Grade [ppm]	Li Metal Content [kt]
Mineral Reserve considering mining loss and dilution of case No. 1			
(1) Parameter conform ore	22,270 (71 %)	3,500	78
(2) Internal dilution	2,632 (8 %)	1,929	5
(3) External dilution	6,300 (20 %)	1,700	11
(4) Total Mineral Reserve (1+2+3)	**31,203 (100 %)**	**3,004**	**94 (100 %)**
(5) Proven Mineral Reserve	**16,504 (53 %)**	**3,075**	**51 (54 %)**
(6) Probable Mineral Reserve	**14,699 (47 %)**	**2,933**	**43 (46 %)**

15.5.2 Case No. 2: “Standard Mining Technology and Standard Backfill”

A total Mineral Reserve of rounded 27 Mt result for mining case no. 2 (Table 73). The **lithium metal** content accounts for **81 kt**, with 68 kt lithium belonging to parameter conform ore, 4 kt to inner dilution (interbeds) and 9 kt to outer dilution (wall rock).

The portion of the Proven Mineral Reserve accounts for 14.3 Mt of ore including dilution and contains 44 kt lithium metal. This corresponds to 54 % of the total lithium metal reserve.

The Probable Mineral Reserve is 12.7 Mt of ore including dilution and contains 37 kt lithium metal. It comprises 46 % of the total lithium metal reserve.

Table 73: Mineral Reserve (Lithium), Case No. 2

Category	Ore and Dilution Tonnage [kt]	Li Grade [ppm]	Li Content [kt]
Mineral Reserve considering mining loss and dilution of case No. 2			
(1) Parameter conform ore	19,292 (71 %)	3,500	68
(2) Internal dilution	2,280 (8 %)	1,929	4
(3) External dilution	5,500 (20 %)	1,700	9
(4) Total Mineral Reserve out of (1+2+3)	**27,072 (100 %)**	**3,002**	**81 (100 %)**
(5) Proven Mineral Reserve	**14,319 (53 %)**	**3,073**	**44 (54 %)**
(6) Probable Mineral Reserve	**12,753 (47 %)**	**2,931**	**37 (46 %)**

16 Mining Methods

16.1 Introduction

The detailed engineering of mine design along with CAPEX and OPEX estimation (±10 %) was prepared by G.E.O.S.. The mining operation for the Project is planned as an underground mine development using a main ramp for the access to the mine and for ore transportation from the mine to the surface and straight to Freiberg, 50 km away from Zinnwald. The mine technology will be a common load-haul-dump (LHD) room and pillar technology with subsequent backfill using self-hardening material. Furthermore, the design of the underground mine has to consider that there are no impacts on the surface.

Based on the key figures of the overall project, the mine has to be designed for an annual output of 1,800 t of Li metal. With reference to the reserve estimation (see *Item 15*) this corresponds to an annual ore production between 500.000 to 600.000 t.

Preparation and development of the deposit will take place by the main ramp and a ventilation shaft as follows:

– Ramp collar at the Europark

- Shaft collar in the north of the deposit
- Routing towards north
- Main hauling by truck
- Ventilation with intake shaft and return air ramp
- Optional involvement of additional mine openings for ventilation purposes
- Utilization of “Tiefe-Hilfe-Gottes” gallery (THG) for water drainage

Main Ramp

- Man haulage (first emergency exit)
- Ore transport
- Transports for underground supply
- Return air
- Temporary water drainage
- Waste clean-up
- Communication

Ventilation shaft

- Intake air
- Second emergency exit

Other preparation openings

- Ventilation bore hole (optional, if required)
- Adit to THG gallery for water drainage
- Treatment station for mine water prior to its release into the run-off waters

A connection between the new mine openings and the existing visitor mine will be prevented. Water drainage of the ancient mine by the “Tiefe-Bünau” and the THG galleries will be maintained. An exception is a short adit from the ventilation shaft towards the THG gallery that will be used for the drainage of the mine. This adit has to be constructed in such a way that uncontrolled flooding of the mine with water from the THG is excluded. In addition, in the central part of the deposit a safety pillar of at least 25 m has to be maintained against the historic mine workings.

Simplifying, the deposit structure represents an anticline, at the flanks of which the ore bodies plunge below 400 m a.s.l.. The main ramp reaches the deposit in the north at +560 m a.s.l. in the foot wall of the anticline vertex. The deposit itself will be developed via short ramps and sublevels with a spacing of 8 m, initially focussing on the deeper portions of the deposit.

The following mining fields are geologically and technologically defined:

- North field
- East field
- West field
- Central field

Development and extraction take place in the following order:

1. North field +560 m level
2. East field +560 m level
3. North field (below +560 m a.s.l.)
4. East field (below +560 m a.s.l.)
5. North field (above +560 m a.s.l.)
6. East field (above +560 m a.s.l.)
7. West field
8. Central field

The inclined development ramps are planned with a cross section of 5.0 by 4.5 m and will be constructed along the footwall boundaries of the ore bodies by conventional drilling and blasting technology. The different sublevels are planned in a vertical distance of 8.0 m. At first, a sublevel crosscut will be prepared through the ore body up to its hanging wall boundary. With respect to the mining technique, turning radii are to be met for the development ramps with an inner radius of not less than 6 m and an outer radius not less than 11 m. In the extraction level the inner radius should not be below 5 m.

The mine development will be carried out under distinct ventilation conditions. After the development of the mine infrastructure by a sublevel crosscut, an intake air ramp will be provided at the hanging wall boundary of the deposit. Steady ventilation will be warranted by the connection of the intake air ramp with the development / return air ramp via the sublevel crosscut. At appropriate locations, chutes have to be driven which will connect several sublevels. The chutes serve for an optimization of the haulage and the stockpiling and homogenization of the crude ore.

With respect to the best possible adjustment to the deposit structure and the prevention of mining losses, a mining technology consisting of sublevel stoping with longitudinal stopes and optimized self-hardening backfill was chosen. Mining consists of two extraction steps:

- 1st Extraction Step: Construction of pillar roads with a standard cross section of 5.0 by 4.0 m with permanently stable dimensioning (e.g. 5.0 m width on +560 m level) and a horizontal roof pillar thickness of 4.0 m. This extraction step is still accompanied with 70 % systematic mining losses.

- 2nd Extraction Step: Systematic reduction of pillars and horizontal roof pillars depending on the local conditions (deposit shape, geotechnical conditions, etc.) to a dimension of up to 7,0 by 7,0 m. Thus, it is possible to reduce the systematic mining losses down to 30 %.

The first extraction step can be downward and upward directed, whereas the second step has to be upward directed beginning at the deepest part of the deposit.

For an optimal development of the mine and a steady output of ore material, the initial development of the mine within the first years will be focused onto the deeper ore bodies (below +560 m) of the north and east field. The deepest planned sublevels are in the north field at +392 m (ore slice +388 to +396 m level) and in the east field at +360 m (ore slice +356 to +364 m level). The uppermost mineable sublevel will be at +688 m (ore slice +684 to +692 m level), to guarantee a minimum distance towards the historic mine workings. Furthermore, as long as a safety pillar of at least 25 m towards the historic mine workings is maintained, it is also possible to mine the ore bodies above the +688 m sublevel.

The course of the preparation ramps and the dimensioning of the rooms were developed and optimized on the basis of the actual deposit model. To ensure a selective extraction of the ore bodies, an anticipatory exploration with core drilling is envisaged. In addition, a conventional advance by drilling and blasting with 4 m round depth is planned to reduce the outer dilution. Finally, chutes connecting several sublevels serve for an optimization of the haulage, the stockpiling and the homogenization of the crude ore.

On the other hand, the chutes allow decoupling of the extraction level (wheel loader) from the haulage level (dumper, conventional trucks). However, the arrangement and geometry of the chutes has to be adapted to the local geological and geotechnical conditions. Loading of the chutes will be done by LHD technique. To ensure a daily output of 2,088 t, about 5 extraction workings, which will be mined in parallel, are necessary. Therefore, three wheel loaders with a payload of about 7 t are planned for the transport of the ore to the chutes. Surface haulage and transport of the ore from the mine site directly to the external processing done will be done by dump trucks with about 30 t loading capacity.

16.2 Mine Production Schedule

The mine production schedule is based on the 3D ore deposit and block model as well as on the requirement that at least 1,800 t of Li are produced every year. Accordingly, the necessary ore blocks were selected from the various sublevels and assembled into annual slices. This selection also considers a targeted development and sustainable exploitation of the deposit. Based on the two-stage extraction described above, the annual production consists of the following components:

- Preparatory openings
- Selective Mining
- Complete Mining
- Subsequent Mining

The individual components are defined as follows:

Selective Mining:

Preferred mining considers only the high grade ore blocks of the respective sublevel. These ore blocks represent to 80 % blocks with a productivity of ≥ 24 [ppm*m], 30 % with a productivity of ≥ 16 [ppm*m] and 20 % of the remaining masses. The preferential extraction initially considers only the first extraction step. The resulting openings (5 m x 4 m) are permanently stable and are kept open for a longer period until the second stage of extraction will take place during the subsequent mining.

Subsequent Mining:

The subsequent mining considers the remaining ore blocks that are not mined during the preferential mining. These ore blocks represent to 20 % blocks with a productivity of ≥ 24 [ppm*m], 68 % with a productivity of ≥ 16 [ppm*m] and 78 % of the remaining masses. The subsequent mining now only includes the second extraction step where the existing champers are expended to their final dimension of 7 m x 7 m. Immediately after extraction, this chamber has to be re-filled with backfill.

Complete Mining

Complete mining refers to the total extraction of the ore reserves from the sublevel, excluding the volumes which are blocked by the preparatory openings. These ore blocks represent to 100 %

blocks with a productivity ≥ 24 [ppm*m], 98 % of blocks with a productivity ≥ 16 [ppm*m] and 98 % of the remaining masses.

Preparatory openings

It is planned that the predominant portions of the preparation openings are driven within ore blocks. Consequently, this material can be counted towards the annual mine production. For simplification, it was supposed, that 2 % of these ore blocks have a productivity ≥ 16 [ppm*m] and 2 % of the remaining ore volumes are located inside the preparation drifts.

The annual mine production therefore consists of a blend of higher-grade and lower-grade or average-grade ore blocks under consideration of a Li metal content of at least 1,800 t/a. Consequently, the annual output varies between 500,000 and 600,000 t crude ore. The average mined tonnage over the project live time of 30 years is 573,362 t at a grade of 3,140 ppm Li. However, in order to make the project more viable and to reduce the payback time for the investment the average mined tonnage of the first 5 years of production is 522,000 t at a grade of 3,400 ppm Li. This is achieved due to mining of higher grade ores during the development of the mine.

As visible in the mine production plan, selective mining predominates the first years of production. This is necessary for the targeted development of the mine to its deepest levels in connection with the fastest possible start of the backfill operation. Although the selective mining is targeted on the extraction of higher grade ores within the first years of operation, ore quality and grade are still on a high level. From the 20th year of operation, a constant ouput of 1,800 t/a Li can be achieved with a maximum mine production of 600,000 t/a.

The following table summarizes the mine production plan.

Table 74: Mine production plan

Year of Operation	Year 1	Year 2				Year 3				Year 4	Year 5
Quarter		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
Mine Production	Constr.	Constr.	Constr.	Commiss.	Mining	Ramp-up	Ramp-up	Ramp-up	Full Pro-duction	Full Mining	Full Mining
Ramp up					40 %	70 %	85 %	95 %	100 %	100 %	
ROM [t]					52,221	92,200	112,129	128,594	132,823	523,417	501,534
Li content [t]					162	340	353	409	450	1,801	1,803
Plant Feed Grade (ppm)					3,100	3,686	3,152	3,177	3,389	3,441	3,596
Tailings Management:											
Quartz Sand Tailings [t] for further utilization					41,024	68,694	87,681	100,333	101,686	398,836	376,789
Leached Roasted Product Tailings [t] for backfill					18,300	38,420	39,959	46,191	50,892	203,619	203,887
Permanent Backfill [t]					0	0	0	0	0	0	47,968
Intermediate Storage [t]					18,300	38,420	39,959	46,191	50,892	203,619	155,920

Year of Operation	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17
Quarter												
Mine Production	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining
Ramp up												
ROM [t]	511,556	532,916	560,549	576,166	558,107	543,399	543,134	553,321	576,357	592,993	598,439	602,465
Li content [t]	1,805	1,801	1,804	1,803	1,805	1,805	1,803	1,806	1,810	1,803	1,803	1,808
Plant Feed Grade (ppm)					3,233	3,322	3,320	3,264	3,140	3,040	3,012	3,000
Tailings Management:												
Quartz Sand Tailings [t] for further utilization					433,278	418,528	418,412	428,388	451,178	468,306	473,744	477,423
Leached Roasted Product Tailings [t] for backfill					204,024	204,093	203,849	204,193	204,596	203,791	203,806	204,372
Permanent Backfill [t]	95,020	104,473	67,075	96,521	126,138	96,054	199,775	203,550	165,254	203,550	203,550	136,427
Intermediate Storage [t]					77,886	108,039	4,074	644	39,343	241	255	67,945

Year of Operation	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28
Quarter											
Mine Production	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining	Full Mining
Ramp up											
ROM [t]	604,111	601,183	597,254	592,210	588,384	597,015	597,015	597,015	597,015	597,015	597,015
Li content [t]	1,807	1,808	1,808	1,812	1,816	1,810	1,810	1,810	1,810	1,810	1,810
Plant Feed Grade (ppm)					3,087	3,032	3,032	3,032	3,032	3,032	3,032
Tailings Management:											
Quartz Sand Tailings [t] for further utilization					462,754	471,812	471,812	471,812	471,812	471,812	471,812
Leached Roasted Product Tailings [t] for backfill					205,333	204,635	204,635	204,635	204,635	204,635	204,635
Permanent Backfill [t]	203,550	203,550	188,534	140,753	164,421	164,421	164,421	164,421	164,421	164,421	164,421
Intermediate Storage [t]					40,913	40,215	40,215	40,215	40,215	40,215	40,215

Year of Operation	Year 29	Year 30	Year 31	Year 32
Quarter				
Mine Production	Full Mining	Full Mining	Full Mining	Full Mining
Ramp up				
ROM [t]	597,015	597,015	597,015	604,478
Li content [t]	1,810	1,810	1,810	1,810
Plant Feed Grade (ppm)				
Tailings Management:				
Quartz Sand Tailings [t] for further utilization				
Leached Roasted Product Tailings [t] for backfill				
Permanent Backfill [t]	164,421	164,421	164,421	164,421
Intermediate Storage [t]				

16.3 Water Management

The predominant proportion of the mine drainage water between the surface and +750 m a.s.l. (Tiefer-Bünau-Gallery level) and +720 m a.s.l. (THG level) is drained through these galleries. Furthermore, they will have the function of a head drainage in the hanging wall to the deposit and thus will prevent the uncontrolled inflow of ground and surface water into the new mine.The remaining mine water is collected underground in pump sumps and pumped into a central mine water treatment plant at the arrival point of the development ramp. There, the mine water will be processed (i.e. sedimentation of solids, neutralization). Thereafter, the water is used as process water for drilling and especially for backfilling.

Excess water is treated the same way and will be pumped via the ventilation shaft towards the level of the THG gallery and drained off. The amount of excess water will change during operation and primaily depends on the backfill opertions. As backfill will first commence after 3 years, a bigger volume of mine water has to be discharged into the THG-gallery during this time. After achievement of a regular operation, the discharge volume will decrease and from time to time it is possible that no water has to be pumped out of the mine. According to the hydrogeological model [105] the supply of the backfill plant can be secured by mine water. If this should not be the case a complementary pipeline in the ventilation shaft will temporary provide water from the THG gallery.

16.4 Tailings Management

16.4.1 Overview

The goal of DL is to minimize the amount of tailings material, which has to be permanently stored in the environment. The tailings comprise the waste rock material that had to be mined for the preparation and development of the mine (ramp, ventilation shaft, underground infrastructure etc.) and the residues that were generated from the ROM during mechanical and metallurgical processing.

The tailings management concept of DL is based on three columns:

- Backfill within the mine
- Commercial utilization
- Permanent disposal

To enhance the viability and sustainability of the project and to reduce the environmental impact, the first two mentioned columns are favored.

The waste rock which has to be mined in order to develop the mine (e.g. ramp, ventilation shaft) comprises loose rock masses of microgranite, rhyolite and granite. The tailings generated during the mechanical and metallurgical processes comprise two types. A “quartz-sand” tailing generated during the mechanical processing of the greisen ore within the processing plant and a “leached roasted product” tailing generated as residue from the metallurgical process. The “quartz-sand” tailings represent basically a sharp-edged crushed grit to fine sand (< 0.1 to 1.25 mm grainsize) and predominantly consist of quartz (> 80 %) and of subordinate to minor zinnwaldite, topaz, feldspars and clay [133]. The “leached roasted product” tailings represent a fine-grained earthy material (0.1 to 1 mm grain size) consisting of a mixture of quartz, anhydrite / gypsum, calcium-aluminum silicates, iron oxides, corundum and others [184].

Based on the project outline of 5,115 t/a LiF, about 397,000 t/a “quartz sand” tailings and about 177,000 t/a (dry) “leached roasted product” tailings are generated and are available for further utilization.

The following sections summarize the concept for the tailings management.

16.4.2 Waste Rock Material from Mine Development

The waste rock which has to be mined in order to develop the mine includes loose rock masses of rhyolite and granite. It comprises approx. 145,000 t for the ramp, approx. 13,000 t for the ventilation shaft and approx. 50,000 t for other underground infrastructure (e.g. explosive storage, water management, ventilation), respectively. The mined-out materials will be further used as building material (e.g. gravel) for forest roads and in the local and regional building industry ([117], [152]). If necessary, this material can be temporarily stored in old quarries and used to a later time [170].

The development drifts to the individual mining fields and ore bodies are planned to be mined within ore bodies. If additional waste rock has to be mined during active operation, this material will be used for construction purposes (e.g. roadway construction) within the mine or is used as backfill.

16.5 Backfill

Backfilling of the mined-out openings serves for a minimization of waste management costs, the prevention of inner and outer subsidence damages, the minimization of mining loss and the minimization of radon entry into the mine and thus enhances the sustainability and profitability of the Zinnwald Lithium Project.

Due to the successive development of the mine, first backfilling can start in year three of operation. However, due to selective mining of high grade ore blocks and the development of the mine towards its deepest portions, the backfill capacity is rather limited within the first 10 years of operation (*Table 75*). As the possibilities of utilization of the "leached roasted product" tailings are limited, they should be preferentially used as backfill material. About 177,000 t/a "leached roasted product" taillings are available for backfill within the mine. Consequently, as summarized in *Table 75* about 50,000 to 177,000 t of "leached roasted product" tailings cannot be used as back fill material within the first 10 years of operation.

However, as lined out in the mine plan (*Table 74*) about 522,000 t are mined every year. Furthermore, to achieve the annual production target of 1,800 t contained Li, the chosen mining technique will predominantly use the first extraction step for the first 10 years of operation. The resulting chambers have a dimension of 5 m by 4 m and are stable over long terms. The second extraction step in these areas will start not prior to year 17 of production. Consequently, these chambers are available and can serve as temporary storage area for the excess masses of "leached roasted product" tailings during the first 10 years of operation. These chambers are provided with a bottom seal made of plastic film, filled with "leached roasted product" tailings by truck and/or wheel loader. Subsequently, the chambers are sealed by a dam construction, and accumulating water is collected and fed into the mine water treatment plant.

Starting from the year 10 of operation, a sufficient volume in mined-out chambers is available. Thus, the intermediate storage can be gradually dismantled, the contained "leached roasted product" is supplied to the permanent backfill procedure and the second extraction step can be performed in these portions of the mine.

Table 75: Quantities and volume fractions of the available backfill capacity

Year of operation	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**	**Ø**
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**		
Tonnage ore	**107,770**	**213,483**	**234,723**	**150,698**	**216.855**	**283,397**	**215,807**	**448,840**	**520,616**	**371,279**	**585,908**	**494,922**	**306,513**	**537,745**	**587,647**	**423,584**	**316,232**	**369,408**	**6,385,426**	**354,746**
Open volume	39,915	79,068	86,934	55,814	80.317	104,962	79,929	166,237	192,821	137,511	217,003	183,304	113,523	199,165	217,647	156,883	117,123	136,818	2,364,973	131,387
Backfill volume	37,919	75,114	82,588	53,024	76.301	99,714	75,932	157,925	183,180	130,635	206,153	174,139	107,847	189.206	206,765	149,039	111,267	129,977	2,246,724	124,818
Backfill tonnage	**75,838**	**150,229**	**165,175**	**106,047**	**152.602**	**199,428**	**151,864**	**315,850**	**366,359**	**261,270**	**412,306**	**348,278**	**215,694**	**378,413**	**413,529**	**298,078**	**222,534**	**259,954**	**4,493,448**	**249,636**
Tonnage LFA	18,960	37,557	41,294	26,512	38.150	49,857	37,966	78,963	91,590	65,318	103,076	87,070	53,924	94,603	103,382	74,519	55,633	64,988	1,123,362	62,409
Tonnage incl. water	15,168	30,046	33,035	21,209	30.520	39,886	30,373	63,170	73,272	52,254	82,461	69,656	43,139	75,683	82,706	59,616	44,507	51,991	898,690	49,927
Tonnage roasted product	**41,711**	**82,626**	**90,846**	**58,326**	**83.931**	**109,685**	**83,525**	**173,718**	**177,000**	**143,699**	**177,000**	**177,000**	**118,632**	**177,000**	**177,000**	**163,943**	**122,393**	**142,974**	**2,301,009**	**127,834**
Tonnage waste rock									24,498		49,768	14,553		31,127	50,441					

For the permanent backfill it is intended that the chambers are almost completely were filled (> 90 %) with self-hardening backfill. The content of the binder content should be minimized as much as possible. For the prevention of inner and outer subsidence damages and for the minimization of mining loss, backfill material should have a compressive strength parameter of 3 to 5 MPa after 28 days.

The backfill material will be produced in a mixing plant and pumped by a slurry pump via backfill pipes (DN 150 / DN 125) to the disposal site. Prior to backfilling the chambers will be sealed by a shotcrete reinforced wall. In order to achieve an almost complete filling and thus the minimization of voids in the roof, the backfill should be fed through bore holes from the sublevel above. The mixing plant will be constructed within the surface facilities at the Europark Altenberg. The individual components (tailings, lignite filter ash, water) will be mixed to a pumpable slurry and pumped underground through the ramp by backfill pipes. In the backfill station at the base of the ramp the backfill material will be tumbled to avoid a segregation of the components. This backfill station consists of buffer storage, hydraulic power unit slurry pump and a control station.

The backfill mixture consists of “leached roasted product” tailings from the metallurgical processing, a binder or binder substitute and water. Lignite filter ash (LFA) shall act as binder. Alternatively, it is also possible to use “quartz-sand” tailings instead of or proportionally to the “leached roasted product” tailings. According to the Pre-Feasibility Study [78] compressive strength parameters of 4 to 5 MPa are achieved by a binder portion of 25 %. Furthermore, a pumpable backfill should have a water content of about 30 %. However, the backfill receipt has still to be optimized by laboratory investigations or by pilot tests in due course and/or during the first three years of operation in order to achieve the requirements of the official backfill regulations and the specifications on the compressive strength parameters and eluate behaviour [391].

The balance of materials (see *Table 76*) refers to the average backfill volume during the operational phase of the mine. The average was estimated for 18 years starting from the 3rd operational year up to the 20th operation year. The backfilling of the mined openings (volume of preparatory work, first and second mining steps) follows immediately after the second mining step and has to be carried out upwards-directed from the deepest parts of the deposit.

Table 76: Balance of backfill materials

Subject	Amount/year	Unit	Amount/hour	Unit
			Basics: 4,500 operation hours	
Ø relevant crude ore tonnage	354,746	t/a	78.8	t/h
Density crude ore	2.700	t/m³	2.700	t/m³
Volume of rooms	131,387	m³/a	29.2	m³/h
Grade of backfill	95.00	%	95.00	%
Volume of backfill	**124,818**	**m³/a**	**27.7**	**m³/h**
Density backfill material	2.000	t/m³	2.000	t/m³
Tonnage backfill material	**249,636**	**t/a**	**55.5**	**t/h**
Portion LFA	25	M. %	25	M. %
Tonnage FFA	62,409	t/a	13.9	t/h
Density LFA	0.850	t/m³	0.850	M. %
Volume LFA	73,422	m³/a	16.3	m³/h
Portion roasted product	55	M. %	55	M. %
Tonnage roasted product	137.00	t/a	30.5	t/h
Density roasted product	1.100	t/m³	1.100	t/m³
Volume roasted product	124,818	m³/a	27.7	m³/h
Portion bound water (A/Z = 0.8)	20	M. %	20	M. %
Tonnage water	49,927	t/a	11.1	t/h
Density water	0.997	t/m³	0.997	t/m³
Volume water	50,077	m³/a	11.1	m³/h
Portion process water	30	M. %	30	M. %
Tonnage water	74,891	t/a	16.6	t/h
Density water	0.997	t/m³	0.997	t/m³
Volume water	75,116	m³/a	16.7	m³/h
Portion waste rock	0	M. %	0	M. %
Tonnage waste rock	0	t/a	0	t/h
Piled density waste rock	1.400	t/m³	1.400	t/m³
Volume waste rock	0	m³/a	0	m³/h

According to the backfill receipt [78], a balance of materials results as follows (average mass portions):

- 55 % “leached roasted product”
- 25 % lignite filter ash
- 20 % water
- 0 % quartz sand tailings

The water portion depends on the quality of the binder. In addition, a portion of 30 % water has to be used for the initial mixture in order to make the slurry pumpable. Excess water, not necessary for the binding process (hydration), will be dehydrated and is transferred into the mine drainage system. Subsequently, the water of the mine drainage will be returned to the backfill process. The volume loss of the backfill body by the hardening process has to be compensated by further backfilling. The mixture balance is based on a water / ash portion of 0.8 and a backfill rate of > 90 %.

16.5.1 Tailings of chemical processing (“leached roasted product”)

It is planned to use the total available amount of “leached roasted product” tailings for backfill. The “leached roasted product” tailings will be delivered by trucks from the metallurgical plant and stored in stationary silos. For this purpose, it is intended to use empty voyages of the ore trucks returning from the processing plant in Freiberg back to Altenberg.
A regulated back fill operation requires a stock for one day backfill production. This corresponds to approx. 500 m³ and is realized with two 250 m^3 silos. Filling of the silos will be normally accomplished by mechanically haul-off (e.g. by spiral conveyor). The required amount of the roasted product will be added directly to the mixing plant. The conveying equipment has to be adapted to greater volumes as compared to the backfill balance, because neither 100 % availability nor a 100 % utilization of the plant can be secured.

16.5.2 Tailings of mechanical processing (“quartz sand”)

“Quartz sand” tailings are produced as by-product from the beneficiation process. If necessary, a portion of the tailings can be used as backfill material and must be handled (i.e. transport, storage) in the same manner as described for the “leached roasted product” tailings.

16.5.3 Lignite filter ash

About 62,400 t of lignite filter ash have to be provided per year (see *Table 76*). Due to changing availabilities, about two to three daily outputs shall be stockpiled (800 m³) at the facilities in Altenberg.

Filling of the silos will be normally accomplished by pressurized air of about 2 to 2.5 bar, the haul-off mechanically (e.g. by spiral conveyor) or pneumatic. The required amount of the lignite filter ash will be added directly to the mixing plant. The conveying equipment has to be adapted to greater volumes as compared to the backfill balance (a minimum of factor 1.3), because neither a 100 % availability nor a 100 % utilization of the plant can be secured.

16.5.4 Water

About 75,000 m³/a of water are required for the backfill operation. Thirty percent of this amount is only required as process water to ensure pumpability of the slurry and will be recycled within the water management of the mine (see *Item 16.3*) The portion of the bound water depends on the binder quality. It is estimated, that about 20 % will remain in the backfill body (A/Z = 0.8). The excess water will not bind and will be transferred into the mine drainage system. Subsequently, the water of the mine drainage will be returned to the backfill process. The water will be supplied from the mine drainage system and by rain water, which has to be stored in an appropriate tank on surface. The dimensioning of the tank has to guarantee technological safety of the backfill mixture and of the transport. Therefore, the stock shall secure operation for one hour (50 m³) and thus also ensure the flushing of the pipes. The water will be directly added from the tank via pipe to the mixing plant. In the plant the water will be introduced by a sprinkling system.

16.5.6 Commercial Utilization

About 210,000 t/a of the total 397,000 t/a “quartz sand” tailings are intended for subsequent treatment in the building industry. This includes:

- Cement plant: 100,000 t/a [143]
- Lime sandstone production: 30,000 t/a
- Concrete production: 30,000 t/a [120]
- Local construction company: 50,000 t/a [117]

Furthermore, additional customers and uses for the utilization of the remaining 60,000 t/a of the “quartz sand” tailings are currently evaluated (e.g. second cement plant).

Some ideas for the utilization of the “leached roasted product” tailings in the building industry were developed so far. This includes:

- Use as additive for concrete or lime sandstone production (e.g. as pigment or heat storage material)
- Use as iron and aluminium source in the cement production process

Therefore, some test works in cooperation with possible customers and specialized institutes are necessary.

16.5.7 Permanent Disposal

The permanent disposal of the “quartz sand” tailings is possible in old quarries and/or in old mines within the Erzgebirge region. These sites can store about 250,000 t/a ([163], [170]). However, a further utilization of the “quartz sand” tailings is intended and favored. The permanent disposal should be interpreted as backup, if certain customers are omitted and the remaining customers cannot handle the amounts of tailings.

As demonstrated above, at a full operation of the mine it is possible, that the complete amount of the “leached roasted product” tailings is required for the backfill of the mined-out portions of the deposit. However, as shown in the mine plan, backfilling will first commence in year three of production and full backfill capacity will not be reached until production year 10. It is expected, that the excess masses of the “leached roasted product” tailings can be temporarily stored in the mine. If this is not possible and no other alternatives exist, some portions of the tailings have to be stored permanently elsewhere. Permanent disposal is possible at disposal sites and salt mines in Saxony-Anhalt ([213], [214]). Other possibilities are currently evaluated and negotiated. However, to make the project fully independent, it is intended to proceed with the development of an own tailings storage facility (i.e. “IAA Bielatal”) in the immediate vicinity (3 km) of the processing plant [101].

16.6 Mining Equipment

16.6.1 Production Schedule Parameters

The overall production schedule parameters are:

- Ore extraction average 573,362 t/a

-	Concentrate production	average 124,420 t/a
-	Leached roasted product (backfill)	approx. 177.000 t/a (dry)

16.6.2 Equipment Requirements

The selection of the necessary equipment depends significantly on the required extraction rate. Furthermore, the mine plan shows that the equipment has to handle a varying annual production between 500,000 to 600,000 t. Considering a maximum production of 600,000 t/a and 250 working days per year (five working days per week), the average daily extraction rate amounts to 2,400 t. Based on 4,500 effective operating hours (250 days x 3 shifts x 6 hours), an extraction rate of 111.1 t/h is required. This time factor already includes a loss of efficiency by dysfunctions and corresponds to the availability of the equipment (e.g. wheel loader, dumper), which is estimated to be 85 %.

Blasting during the first extraction step will create a heading of 5 m width, 4 m height and 4 m depth and corresponds to about 160 t per round. Thus, 5 rounds per shift are necessary. The drilling jumbos are able to prepare two extraction sites per shift. Consequently, three drill jumbos are required for production. The scenario for charging of the drillholes is similar. Two charging machines are required for charging of the five extraction sites per shift. The pump module of the supplier of the explosives will be installed on an appropriate carrier.

Transport of the crude ore from the mine workings to the chutes is envisaged by wheel loaders with a payload capacity of 7 t. They are used within distances up to 300 m. Travel time with an average speed of 12 km/h amounts to about 3 min/cycle. One minute for loading, 0.5 minutes for unloading and 0.5 minutes for e.g. waiting time is supposed. Complete duration of a mobile loader operation cycle accounts for 6 minutes. Besides loading operation, the mobile loaders are scheduled also for additional work like ramming and road construction.

As the transport of the ROM from the mine chutes or bunkers to the processing facility in Freiberg will be operated by a third party transport, cycles and number of necessary trucks are not considered in detail. Transportation costs are covered within the financial model (see *Item 21*).

16.7 Mine Personnel

The mine personnel plan summarizes 71 employees (see *Table 77*.)

Table 77: Mine personnel estimation

Title / Qualification	Personnel per shift	Number of shifts	Personnel factor	Total personnel
Head of mine	1	1	1.00	1
Mining engineer	1	1	1.00	1
Mining geologist	1	1	1.00	1
Facility manager	1	1	1.00	1
Lab assistant	1	1	1.00	1
Office	1	1	1.00	1
Foremen	1	3	1.00	3
Miner (Digger)	5	3	1.25	20
Auxiliary Staff	1	3	1.25	4
Driver	3	3	1.25	12
Mechanic, electrician	3	3	1.25	12
Blaster	4	2	1.00	8
Backfilling	2	3	1.00	6
Total	**25**			**71**

The mine personnel plan is estimated for 32 production years (see *Table 78*). The majority of the working force will be required already in year 3. With respect to the expected work and the planning of the mine technique purchase, the mine personnel and the workshop personnel will not start in the years 2 and 3 with the full manning level. The required personnel increase with ramp-up of the mine and the commissioning of the backfill plant in operational year 3.

Table 78: Mine personnel plan

Title / Qualification	Head-count	Year of Operation	Year 1	Year 2				Year 3				Year 4	Year 5-32
		Quarter		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
		Phase	Constr.	Constr.	Constr.	Commiss.	Ramp-up	Ramp-up	Ramp-up	Ramp-up	Full Prod.	Full Prod.	Full Prod.
		Ramp up					40 %	70 %	85 %	95 %	100 %	100 %	
Head of mine	1					1	1	1	1	1	1	1	1
Mine engineer	1				1	1	1	1	1	1	1	1	1
Mine geologist	1				1	1	1	1	1	1	1	1	1
Facility manager	1					1	1	1	1	1	1	1	1
Lab assistant	1					1	1	1	1	1	1	1	1
Office	1					1	1	1	1	1	1	1	1
Foreman	3					3	3	3	3	3	3	3	3
Miner	20				2-6	8-15	20	20	20	20	20	20	20
Auxiliary Staff	4					4	4	4	4	4	4	4	4
Driver	12					12	12	12	12	12	12	12	12
Mechanic, electrican	12					12	12	12	12	12	12	12	12
Blaster	8					8	8	8	8	8	8	8	8
Backfilling	6											0-6	6
Total	**71**				**4-8**	**53-60**	**65**	**65**	**65**	**65**	**65**	**65-71**	**71**

17 Recovery Methods

17.1 Summary Flowsheet

During the FS different flowsheet options were investigated for the recovery of lithium from the zinnwaldite greisen ore. Following test work, which is discussed in *Section 13*, and economic evaluations, the flowsheet selected for the FS is based on calcium sulfate – calcium carbonate roasting.

The Zinnwald Lithium Process Plant is designed to process 573,362 t/a of ROM feed, at an average grade of 0.314 wt.% Li, to produce a minimum 5,112 t/a of battery grade LiF (equivalent to 7,285 t/a LCE or 8,274 t/a $LiOH \cdot H_2O$) and 31,950 t/a of K_2SO_4 byproduct. The potassium sulfate produced is expected to be sold as a sulfate of potash (SOP) fertilizer.

The flowsheet consists of the following major unit processes:

- Comminution followed by beneficiation using magnetic separation to recover a lithium mica concentrate
- Calcium sulfate / carbonate roasting, which converts the lithium and potassium to water soluble Li_2SO_4 and K_2SO_4 in the presence of anhydrite or gypsum and limestone
- A hydrometallurgical section where the roasted product is leached in water to form an impure Li_2SO_4 aqueous pregnant leach solution (PLS). Impurities are then removed from the PLS using precipitation and ion exchange prior to the precipitation of battery grade lithium fluoride.
- Potassium sulfate is recovered from the mother liquor using crystallization and selective dissolution.

A simplified illustration of the flowsheet is displayed in *Figure 99.*

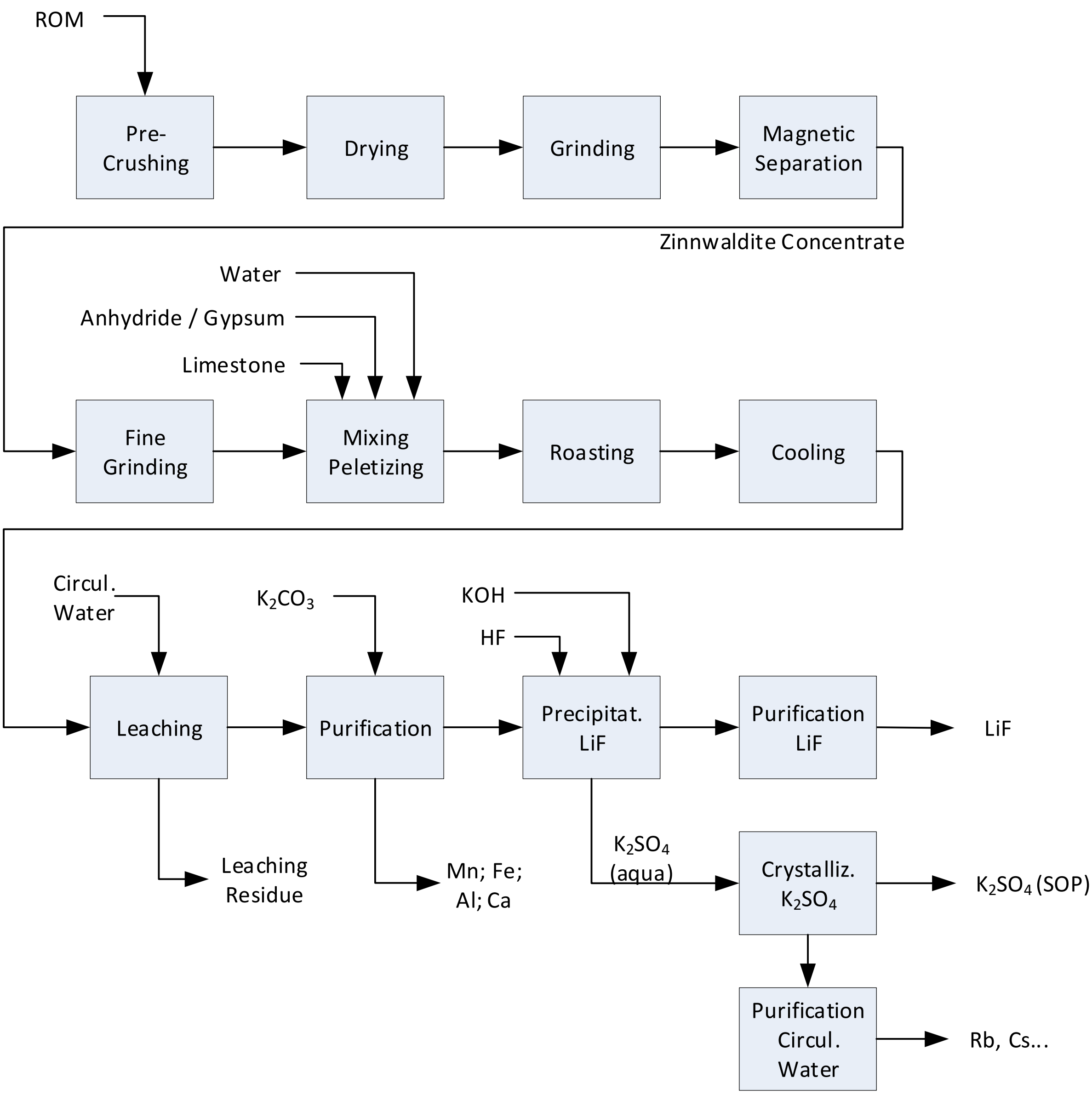


Figure 99: Summary flowsheet of the processing and extraction process

17.2 Process Design Criteria

The beneficiation plant will operate 24 h/d, using three 8 h shifts per day from Monday to Friday, 260 d/a. The extraction plant is a continuous 24 h/d operation, using three 8 h shifts per day, 7 days per week, 365 d/a. Design plant availabilities are 96 % (6,000 h/a) for the beneficiation plant and 91 % (8,000 h/a) for the extraction plant.

The key Process Design Criterias (PDC) were used in developing the mass balance that forms the basis for the sizing of process plant equipment. The key elements were derived from the metallurgical test work program (*Section 13*).

Selected aspects of the PDC are summarized in [203].

Table 79: Process Design Criteria Summary

Description	Units	Nominal Case	Design Case (120 %)
Overall Lithium Recovery	%	76.04	76.04
Beneficiation			
ROM feed rate (dry)	t/h	83.3	100.0
ROM feed grade (dry)	wt.% Li	0.33	0.33
Mass recovery to concentrate	wt %	25.0	25.0
Lithium recovery to concentrate	wt.%	92.0	92.0
Extraction			
Pyrometallurgy (Feed rate kiln mixture)	t/h	30.0	36.0
Hydrometallurgy (leach liquior clearified)	t/h	42.6	42.6
Leach lithium recovery	wt.%	87.0	87.0
LiF precipitation recovery	wt.%	95.0	95.0
Target product grade LiF	wt.%	> 99.5	> 99.5
Target product grade SOP	wt.%	> 99.5	> 99.5
Target LiF production	t/a	5,115	5,115

17.3 Beneficiation Circuit Process Description

This chapter provides the process description corresponding to the FS process flow diagrams (PFDs) produced for the processing plant.

Figure 100 displays the layout of the processing plant.

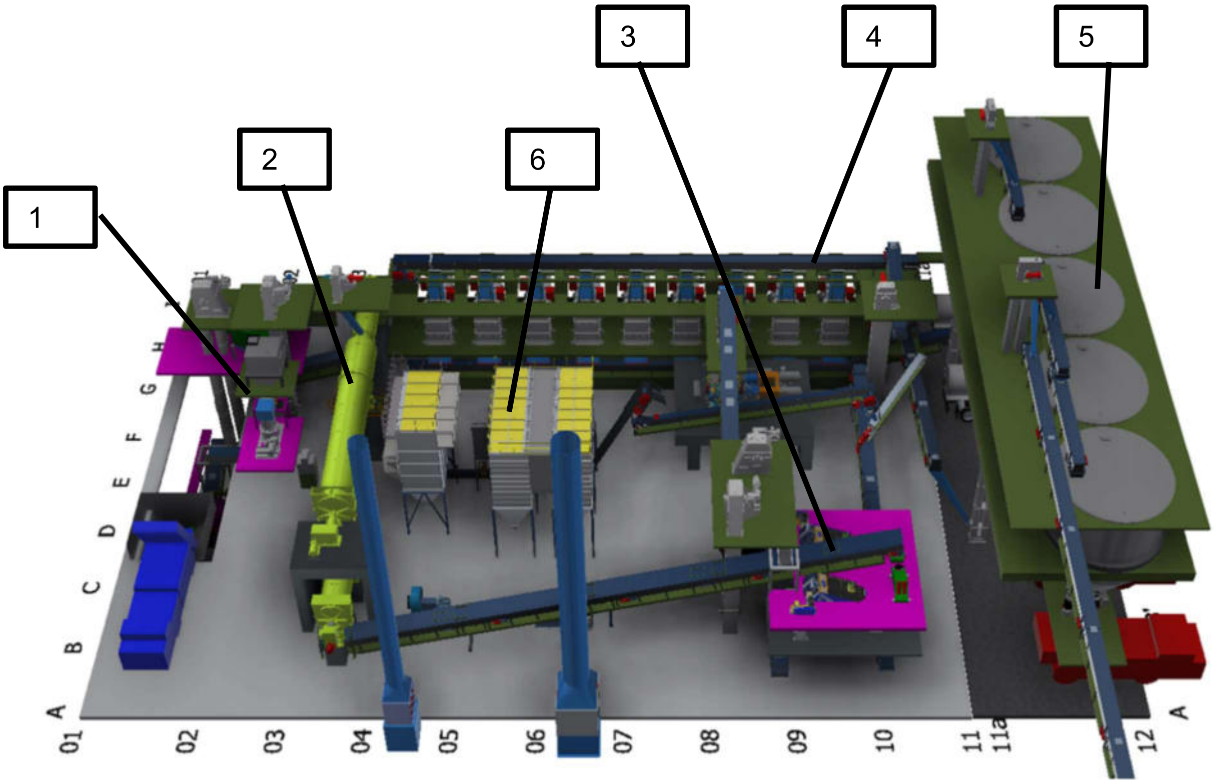


Figure 100: Processing plant layout (1: Pre-crushing; 2: Drying and cooling of the ore; 3: HPGR grinding and screening circuit; 4: Magnetic separation; 5: Product storage and loading; 6: Dust collection [203])

17.3.1 Pre-Crushing

The run of mine (ROM) material is fed into the processing plant by dump trucks. The material has a maximum particle size of 500 mm and a maximum moisture content of 6 wt.%. The ore is fed to the feed hopper which has a storage capacity of approximately 60 t and thus can store up to 2 truckloads to ensure a continuous material flow into the plant. During dumping of the ROM into the hopper, fine water mist is sprayed onto the material to prevent excessive dust generation.

The material is discharged from the hopper by a variable speed vibrating feeder, which continuously feeds the raw material at a controlled rate via a scalping screen to the jaw crusher. The jaw crusher is equipped with a hydraulic jack hammer to break large rocks that block the inlet of the crusher. The area is monitored remotely and controlled from the control room.

The fine material from the scalping screen and the crushed product from the jaw crusher are collected by a belt conveyor and transferred to a bucket elevator, which elevates the material to the crushing circuit vibrating screen.

The screen separates the material into fines below 25 mm particle size and coarse plus 25 mm. The coarse material is fed to the bucket elevator, which feeds the feed hopper of the cone crusher. The feed hopper is equipped with load cells to monitor the material level in the bin and material continuously feeds the cone crusher by a vibrating feeder which is controlled by the plant operator. The crushed material from both crushing stages is circulated back to the screen by belt conveyor and bucket elevator. A belt conveyor collects the crushed materials from the first and the second comminution step, this belt is equipped with a magnetic separator to remove tramp metal.

The fine screen product is transferred via a belt conveyor and bucket elevator to the drying section.

17.3.2 Drying and Cooling

The drying section is continuously fed via a belt conveyor and bucket elevator, which feeds the rotary dryer. In addition, the belt conveyor is equipped with belt scale to monitor the mass flow into the dryer.

The material is dried with hot air produced by a hot gas generator. The temperature of the hot drying air is controlled by the exhaust air temperature of the dryer. To ensure a continuous material discharge, a constant moisture content of 0.2 wt.% and an exhaust air temperature of 105°C are required.

After drying, the dried material is fed to a rotary cooler to cool the material below 60°C. This is required to ensure good performance of the downstream magnetic separators. The rotary cooler is operated with ambient air. To save energy, this pre-heated cooling air is recycled to the dryer and used as drying air.

An exhaust air fan pulls the hot air from the dryer and the corresponding bag house filter, where dust is collected. The cleaned exhaust air is emitted via a stack into the environment. The collected dust is recycled into the processing plant by using screw feeder and rotary valve.

All fans are equipped with sound absorbers to reduce the sound emissions in the plant and its surroundings.

17.3.3 HPGR Grinding and Screening

The dried and cooled material is discharged from the cooler by belt conveyor and fed to two parallel screens. The belt conveyor is equipped with two belt scales, one to measure the material flow from the cooler and a second scale that measures screen feed that also includes the high pressure grinding roll (HPGR) product. A magnet is used to remove tramp metal from the HPGR feed.

Each screen is equipped with a vibrating feeder to ensure proper material distribution over the complete screen width. The double-deck screens separate the material flow into 3 fractions - the coarse fraction (plus 4 mm), the middle fraction (between 1.25 and 4 mm) and the fines fraction (below 1.25 mm). After screening the coarse fraction and the middle fraction are combined.

The plus 1.25 mm coarse fraction is collected from both screens by a belt conveyor and fed to the HPGR feed hopper via a bucket elevator and belt conveyor. The minus 1.25 mm fines are collected from each screen with belt conveyors and fed to the fine magnetic separation section via a bucket elevator and belt conveyor. The belt conveyor is equipped with a belt scale.

The HPGR feed hopper is equipped with load cells to monitor the level in the hopper and the speed of the HPGR is controlled to ensure a constant level in the hopper.

17.3.4 Magnetic Separation

The magnetic separation circuit is fed by belt conveyor which feeds the material onto a drag conveyor. This conveyor distributes the complete material flow equally to 9 magnetic separator lines, each line consists of two magnetic separator units. The drag conveyor is equipped with nine slide gates so that each line can be isolated. Below the slide gates, every line has a feed hopper which serves as a buffer for the magnetic separators and enables the material distribution to the several lines.

The magnetic separators consist of three stages. The first stage includes magnetic drum separators which remove tramp metal. The second and third stages consist of high-intensity magnetic drums.

The throughput of the separators is adjusted by vibrating feeders. Depending on the total plant throughput and the settings of the crushing and grinding circuits, the total mass flow to the magnetic separation sections may vary. In this case, the last line fed by the drag conveyor will get an increasing or decreasing amount from the feed hopper.

The magnetic product from the magnetic separator section is collected by drag conveyors and fed to the product storage section. The non-magnetic tailings from the magnetic separator section is collected by drag conveyors and fed to the tailing storage section.

17.3.5 Concentrate and Tailings Storage and Loading

The plant produces two products, lithium mica concentrate and ”quartz sand” tailings. Therefore, product bins for both products are installed.

The lithium mica concentrate product is collected from the magnetic separator section and transferred using a series of belt conveyors and a bucket elevator to the storage bins. A belt scale is installed on the bin feed conveyor and load cells are used to monitor the level in each bin. Product from the bins is loaded pneumatically into silo trucks.

Bins are installed for the storage of “quartz sand” tailings. The tailings bin loading system is similar to the lithium mica concentrate arrangement and also pneumatically loaded into dump trucks or silo trucks.

17.3.6 Dedusting System

A bag house filter is provided to collect dust from within the processing plant. The dust is collected from all de-dusting points installed at each equipment and transferred via a piping network to the bag house. An exhaust air fan provides the required air flow through the system and exhausts the cleaned air via a stack into the environment.

To de-dust the magnetic separators, a small baghouse filter is provided. This separate filter is used to adjust the air flow from the magnetic separator. There, the air flow is lower compared to the main dust collection system and hence enables a more accurate and efficient operation of the magnetic separators.

The collected dust from all filters, as well as the dryer de-dusting system, is recycled to the processing plant by a trough chain conveyor.

All exhaust air fans are equipped with sound absorbers to reduce noise in the plant and its surroundings.

17.4 Extraction and Precipitation

The objective of the extraction circuit is to produce battery grade lithium fluoride (LiF) and potassium sulfate (SOP, K_2SO_4) as by-product. The Li and K is extracted from the lithium mica (zinnwaldite) concentrate by roasting with anhydrite ($CaSO_4$) and limestone ($CaCO_3$) followed by water leaching of sulfates. The dissolved impurities (Ca, Mg, Na, Cs and Rb) are removed and K is recovered as a sulfate salt by-product.

17.4.1 Pyrometallurgy

17.4.1.1 Grinding of Zinnwaldite Concentrate

Prior to the thermal processing of zinnwaldite, the concentrate is ground to a coarse powder (< 315 µm). This is done to facilitate the mixing with additives and enables the mixed powder to be granulated. Test work showed that the best option for grinding the lamellar zinnwaldite concentrate is by a vertical roller mill. The 1.8 m diameter vertical roller mill selected for this aplication includes a 60,000 m³/h air classifier.

17.4.1.2 Pelletizing

The ground zinnwaldite concentrate, together with the additives (limestone, anhydrite or flue-gas desulfurization (FGD)-gypsum), is fed to two separate mixing and pelletizing lines. The mixing takes place in 0.8 m diameter by 3.0 m long ploughshare mixers followed by granulation in 4.5 m diameter pelletizing discs. In this process, barren solution is recycled from the potassium sulfate crystallization circuit and used as binding agent. The potassium sulfate content in this solution enhances the strength of the undried green pellets.

17.4.1.3 Drying, Roasting and Cooling

The pelletized feed is roasted at a temperature of 950 °C to 1,050 °C for 30 minutes using a direct fired rotary kiln. The green pellets are screened and dried in a fluidized bed dryer prior to feeding the roaster. With pre-drying the roasting kiln can be sized smaller and the energy efficiency of the process is improved.

To minimize energy consumptiuon, hot air for the fluidized bed dryer is recycled from the dust-free clean exhaust air of the rotary kiln. Also, the colder dryer outlet exhaust air is used for the cooling of the rotary kiln exhaust air. Moreover, the dust free waste exhaust air, which is not recycled to the fluidized bed dryer, feeds a gas / steam heat exchanger to produce steam for downstream processes.

Entained dust and very fine pellets discharged from the dryer with the exhaust air are recovered via two cyclones and recirculated to the pelletizer feed mixer. The exhaust air is directed to a dry scrubber which utilizes an absorbent as a neutralizing agent. The adsorbent is filtered and partially recirculated to the reactor. The remaining portion is transported to a separate silo for disposal or is recycled to the pelletizing circuit.

The 2.4 m diameter by 19.0 m long fluidized bed dryer is operated with 84,000 Nm³/h fuildizing air at a temperature of 380 °C.

The rotary roasting kiln has an inner diameter of 3.4 m and a length of 61.0 m. The natural gas burner is operated at a design thermal power of 24.0 MW. Ambient air is used to cool the kiln outlet product in a rotary cooler to a temperature of 55 °C.

The cooled calcined pellets are weighed and transferred for further treatment in the hydrometallurgical plant by conveyor belt.

The block diagram in *Figure 101* highlights the main processing steps of the roasting circuit. *Figure 102* to *Figure 104* shows the top view and the layout of the roasting plant based on the FS basic engineering [208].

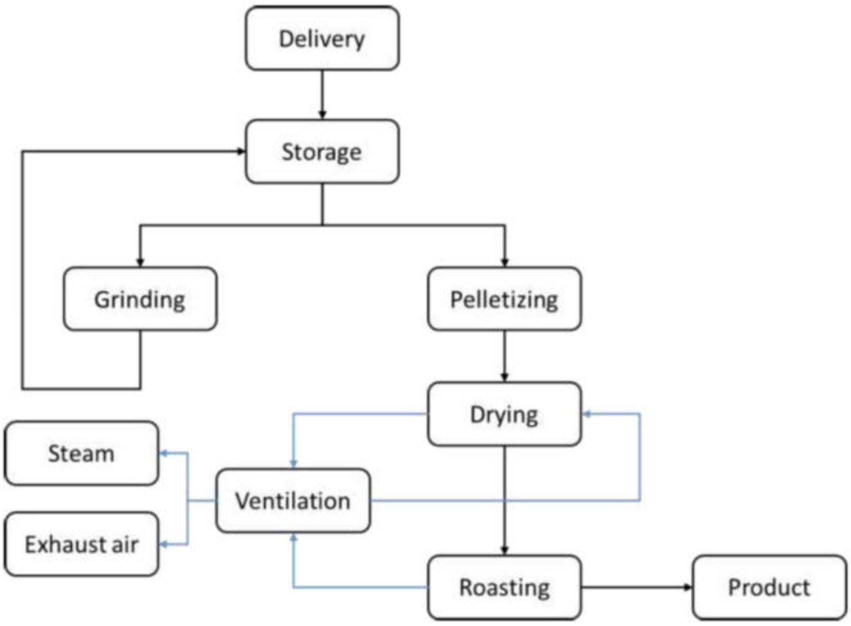


Figure 101: Block flow diagram of the roasting process

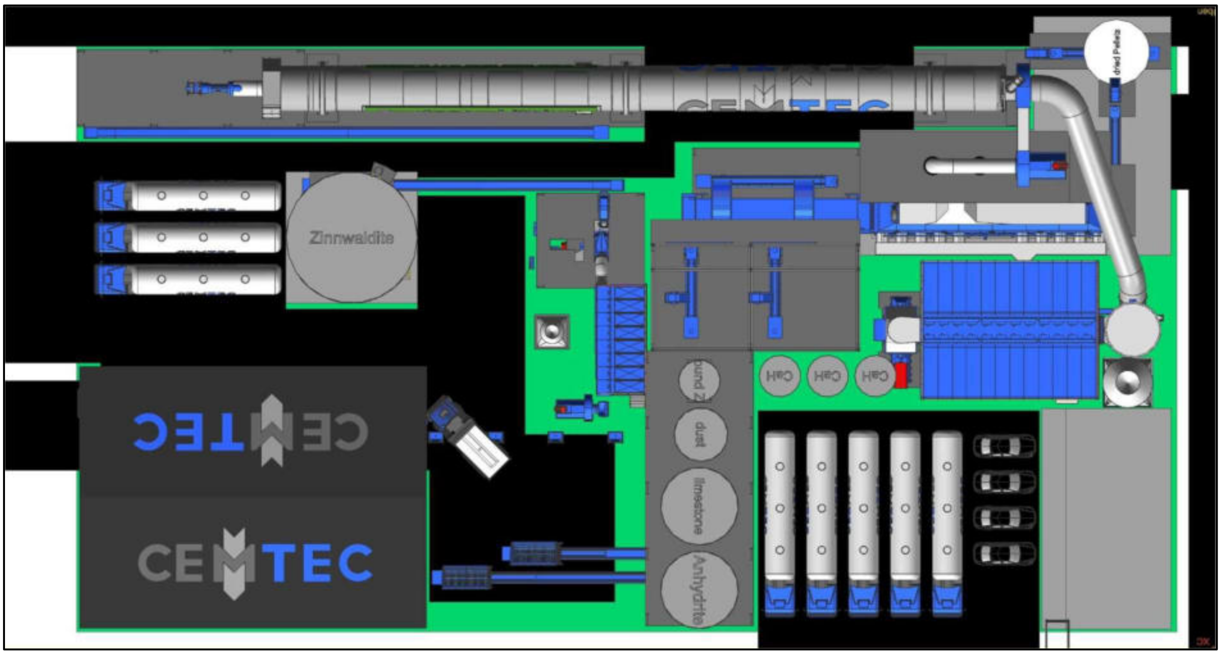


Figure 102: Plan view of the roasting plant [208]

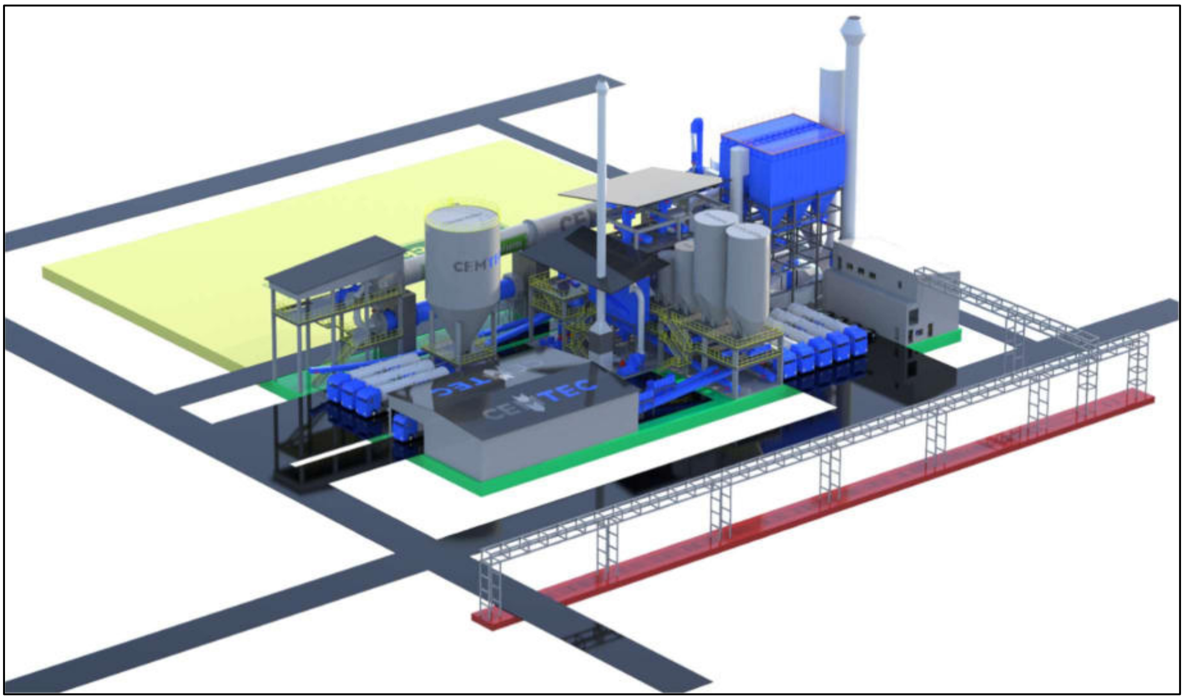


Figure 103: Layout of the roasting plant (View North to South with open buildings) [208]

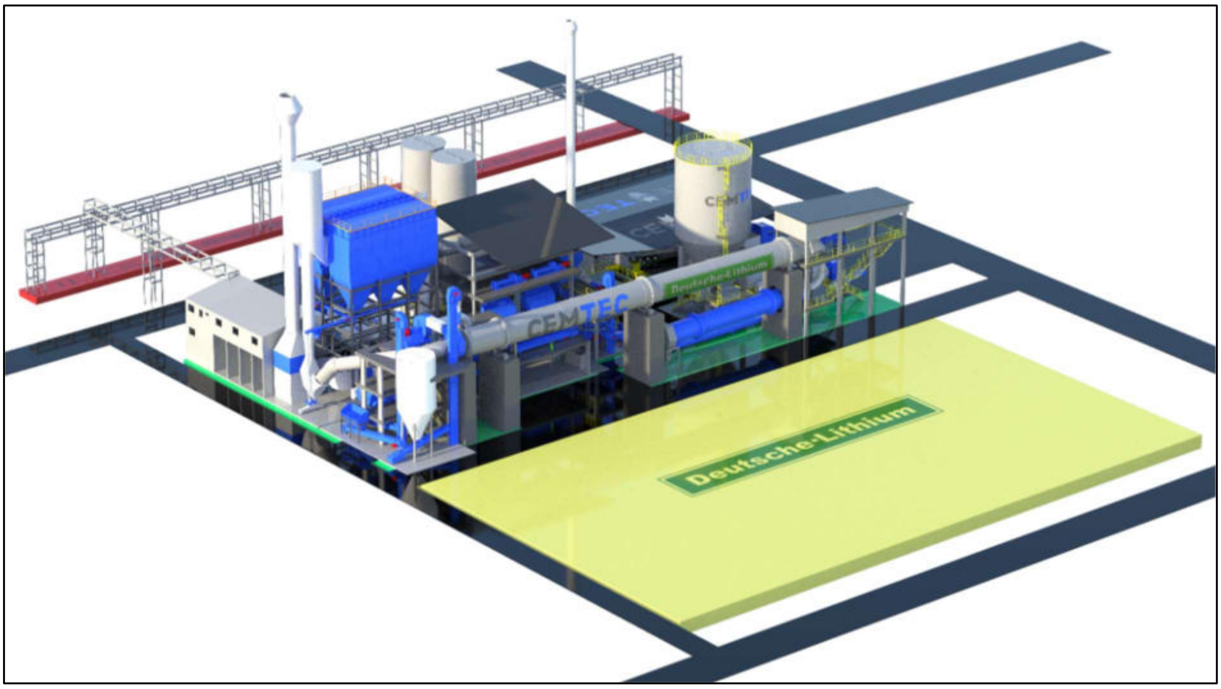


Figure 104: Layout of the roasting plant (South to North with open buildings) [208]

17.4.2 Hydrometallurgy

The hydrometallurgical process has been designed by K-UTEC and ERCOSPLAN based on the results of the test work and their own experience.

Based on this process flowsheet developed for the FS [160] Ampроma GmbH has prepared the basic engineering to support a study with an accuracy of ±10 % for areas 300, 400, 500 and 600 [212]. In addition, Amproma GmbH has completed the basic engineering for the production of potassium fluoride solution from potassium hydroxide and hydrofluoric acid.

Flexibility has been built into the hydrometallurgy process for the alternative production of lithium carbonate by substituting reagents KOH and HF with K_2CO_3 and carrying out minor modifications to the design.

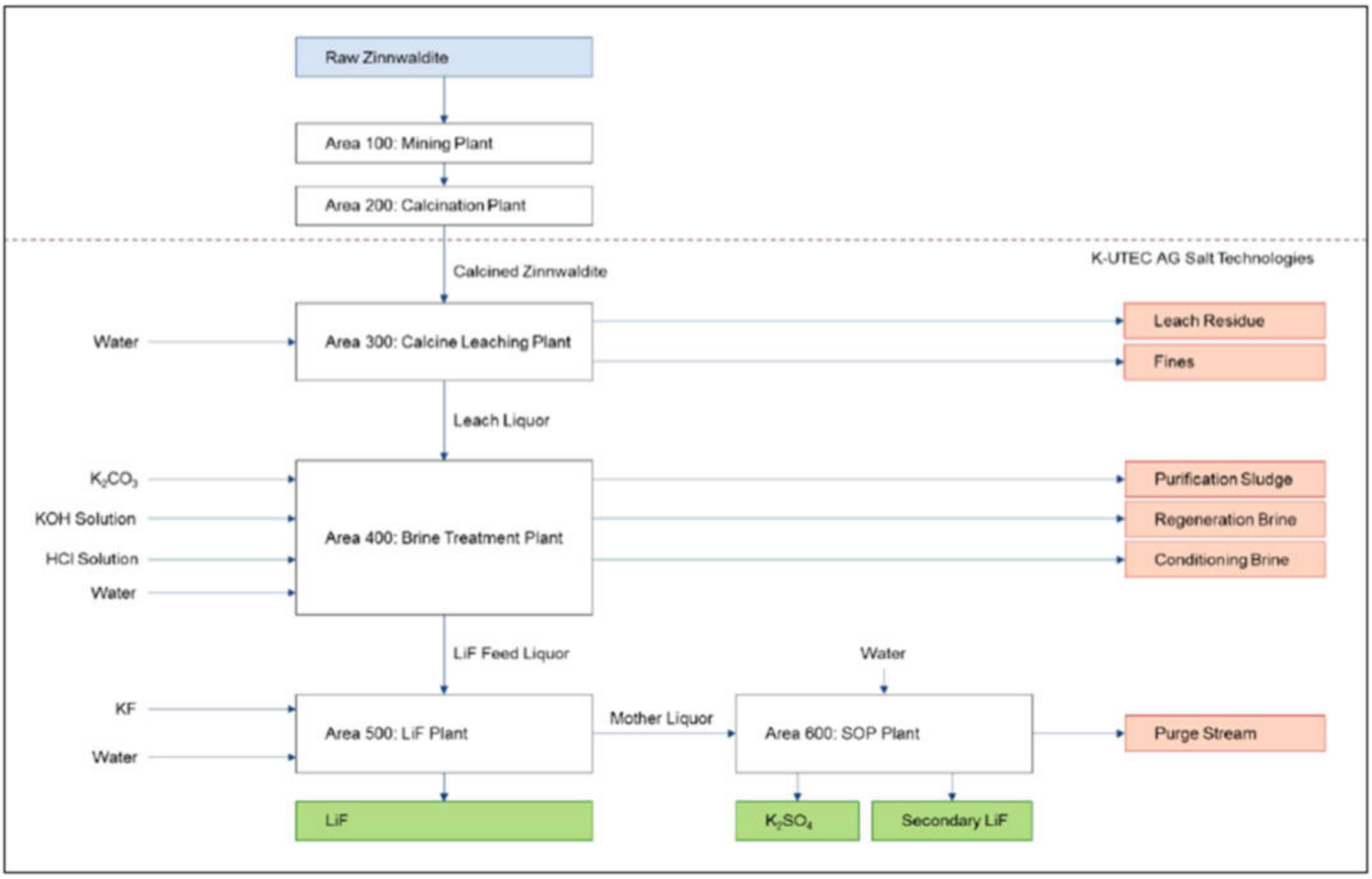


Figure 105: Simplified flowsheet of the zinnwaldite process of Deutsche Lithium [160]

17.4.2.1 Milling of Roasted Product

The roasted product, which is stored in two 120 t bins, is conveyed to a mill (e.g. a hammer mill) in order to reduce the particle size of this material to less than 1 mm.

17.4.2.2 Leaching and Residual Removal

The milled roasted product is fed to the leaching reactor via a hopper and conveyor system.

During leaching, lithium sulfate (Li_2SO_4), along with water soluble metal-sulfate impurities of magnesium, calcium, rubidium, cesium, sodium, and potassium, is transferred from the roasted product slurry into solution. The leached slurry product is pumped to the leach thickener, the overflow from which is transferred to the purification circuit while the thickener underflow slurry is filtered, washed and stored. The recovered filter wash water is re-used in the leach reactor.

17.4.2.3 Purification

During the purification process impurities from mother liquor are removed by the following steps.

Potassium carbonate (K_2CO_3) is added which converts metal-sulfates to metal-carbonates while producing potassium sulfate. Potassium hydroxide (KOH) is also added in order to precipitate magnesium hydroxide. The product from the purification reactors is pumped to the filter feed tank before being filtered in plate and frame filters.

After filtration the purified solution is pumped through an ion exchange column system to remove additional calcium and magnesium.

17.4.2.4 Precipitation of Lithium Fluoride

The precipitation of lithium fluoride takes place in precipitation reactors by the addition of potassium fluoride solution. The potassium fluoride solution (30 wt.%) is prepared in a separate neutralization reactor using potassium hydroxide and hydrofluoric acid.

17.4.2.5 Lithium Fluoride Drying and Packaging

After precipitation the suspension is filtered, washed and finally dried.

A valve controls the rate of product feeding the lithium packaging system via the lithium fluoride product storage silo and bagging feeder.

Bulk-bags are semi-automatically filled and placed onto pallets for storage. A forklift then transfers the loaded bags into a shipping container.

17.4.2.6 SOP- Crystallization

SOP crystallization takes place with a three-stage evaporation unit with mechanical vapor compression and three-stage cooling crystallization to separate the LiF from the SOP.

17.4.2.7 Potassium Sulfate Drying and Packaging

The potassium sulfate is transferred from the crystallizer to the natural gas fired indirect heated dryer via a screw feeder.

Exhaust gas from the dryer is extracted through the potassium sulfate dryer baghouse by an induced draft fan. Entrained solids are returned to the dryer solids discharge stream. The captured dust and the dryer discharge are transported to the potassium sulfate product bin via a bucket elevator. A rotary valve controls the amount of product going to the potassium sulfate packaging plant via a feeder.

Bulk-bags are semi-automatically filled and placed onto pallets for storage. A forklift then transfers the loaded bags into a shipping container.

17.5 Services

17.5.1 Reagents

Reagents used in the process include the following:

- FGD-gypsum: Supplied by truck (tipper) stored on a stockpile, reclaimed by front-end-loader (FEL) and dumped into a feed bin ([109], [111], [119], [162])
- Anhydrite: Supplied by silo truck and stored in a closed steel silo [162]
- Limestone powder: Delivered to site in silo trucks and stored in a closed steel silo ([161], [176], [188], [189], [191])
- Absorbent ("Sorbacal SPS", high performance high porosity hydrated lime): Used in the gas scrubber to neutralize exhaust gasses discharging the kiln. It is supplied in silo trucks and stored in a closed steel silo [188]
- Hydrofluoric acid: Supplied by train in vessels and stored in a specially designed tank [98]
- Potassium hydroxide: Supplied in solid form by truck and stored on palettes in the warehouse [123]
- Potassium carbonate: Supplied in solid form by truck and stored on palettes in the warehouse [123]
- Hydrochloric acid: Supplied by truck and stored in a special tank designed for aqueous solution of HCl

17.5.2 Water Services

Water services include:

- Process water: Used to prevent excessive dust generation before pre-crushing of the ROM and for pelletizing
- Potable water: Used for sanitary facilities

- Raw water: Used for leaching of roasted material
- Filtered water: Used to desolve SOP in the process
- Demineralized water (via reverse osmosis and ion exchange / condensate cooling): Used for LiF washing
- Cooling water: Used for cooling crystallization of SOP and for cooling of reactor vessels of KF manufacturing

17.5.3 Other Services

Other services include:

- Natural gas: Supplied to the plant via a main pipeline
- Electrical power supply: From the local power grid. (backup with emergency power supply system)
- Compressed air: Produced by a compressor
- Steam: Produced by a natural gas fired steam boiler package

17.6 Equipment Selection

Major equipment selected for the FS was undertaken via budgetary enquiries to multiple vendors. Scope descriptions and process data sheets were prepared for each equipment package to allow budgetary quotation preparation by vendors. These budget quotations were technically and commercially evaluated in order to determine the suitable selection of equipment for the Zinnwald Lithium project.

18 Project Infrastructure

The Zinnwald Lithium project comprises two infrastructural units, the Zinnwald lithium deposit and mining sites in Zinnwald and Altenberg as well as the site for mechanical and metallurgical processing *(*see *Figure 106*).

For the determination of the preferred processing site four different locations (Table 80) were considered which include Bautzen (Saxony), Bitterfeld (Saxony Anhalt), Freiberg (Saxony) and Schwarzheide (Brandenburg). These were evaluated according to the selection criteria availability of real estate, availability of resources (energy, natural gas, water, steam), approvability [183], [153], [108]) and accessibility (distance to mine site, connection to public infrastructure). In addition, it was considered whether the mechanical processing plant will be built at the mining site or be integrated into a metallurgical plant. The differences in connecting conditions and costs for electricity, gas and water are only insignificant for the four sites [196]. The prices for electricity and gas and the resulting network charges are essentially at the same level. Taxes and charges for electricity and gas are uniformly regulated throughout the Federal Republic of Germany. *Table 80* provides the key-data for the considered sites.

According to the current information and planning status, Freiberg emerges as the preferred site for the mechanical and metallurgical processing plant.

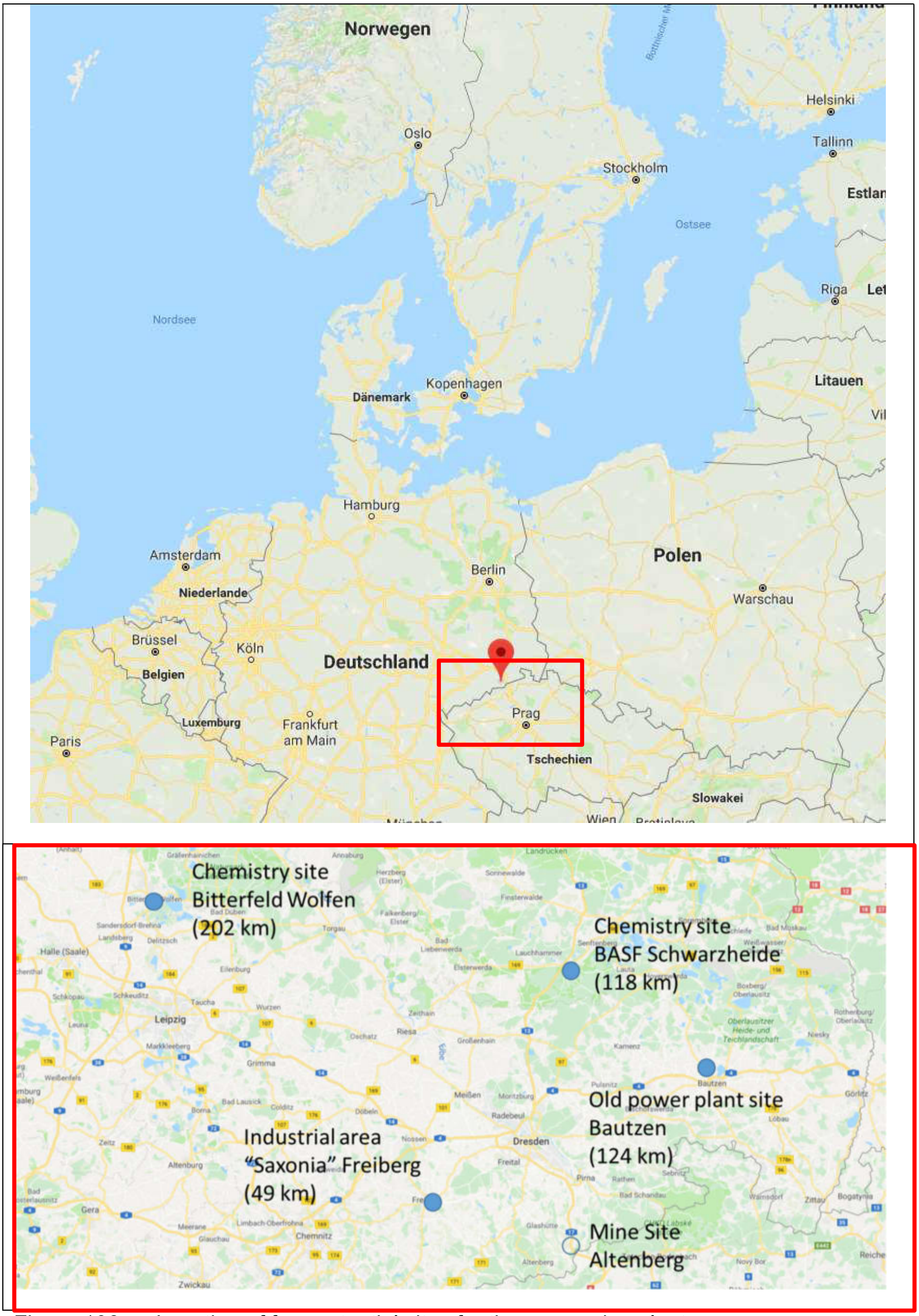


Figure 106: Location of four potential sites for the processing plants

Table 80: Comparison of the four considered sites of the processing plants

Process Plant Site	Freiberg	Schwarzheide	Bitterfeld	Bautzen
	[204]	[118]	[121]	[187]
	[199]	[116]		
Distance from Deposit	49 km	120 km	202 km	124 km
Annual Trans-portation Costs	8,139,952 EUR	16,329,173 EUR	23,754,653 EUR	17,402,847 EUR
Approvability of the Plants	Yes	Yes	Yes	Not yet
Area Type	Industrial area	Chemical site	Chemical site	Old power plant site
Comments	Former usage for synthetic fuel production, rebuilding necessary	Liquidator is owner		Currently no planning right on the site
Usable Land Size	31,600 m²	24,000 m²	31,000 m²	No information
Public Road Connection	Yes	Yes	Yes	Yes
Railway Connection	Yes	Yes	Yes	No
Availability of Sufficient Electricity	Yes	Yes	Yes	Yes
Availability of Sufficient Natural Gas	Yes	Yes	Yes	Yes
Water	Yes	Yes	Yes	No Information
Cooling Wa-ter	Own cooling system	Own cooling system	Own cooling system	Own cooling system
Steam	About external service provi-ders	Yes	About external service providers	About external service pro-viders

18.1 Project Infrastructure of Mining Site Altenberg

Planning of the infrastructure and the operational and administrative facilities ([178], [179]) in Altenberg was carried out by the Baubüro Freiberg (BBF). DL is in negotiations with the owners of the property. A draft contract has already been prepared for one property [104]. The remaining land is owned by the city of Altenberg. The city has signaled great interest in the implementation of the project and has agreedto sale the remaining properties [202].

The whole area around the mining site is part of the proposed World Heritage Nomination Erzgebirge / Krušnohoří Mining Region. There is no impact to the DL project ([106], [126], [146], [148]).

The design of the infrastructure and the buildings around the ventilation shaft is part of the mine planning [190].

The mechanical processing plant as considered in the present feasibility study is located at theprocessing site in Freiberg.

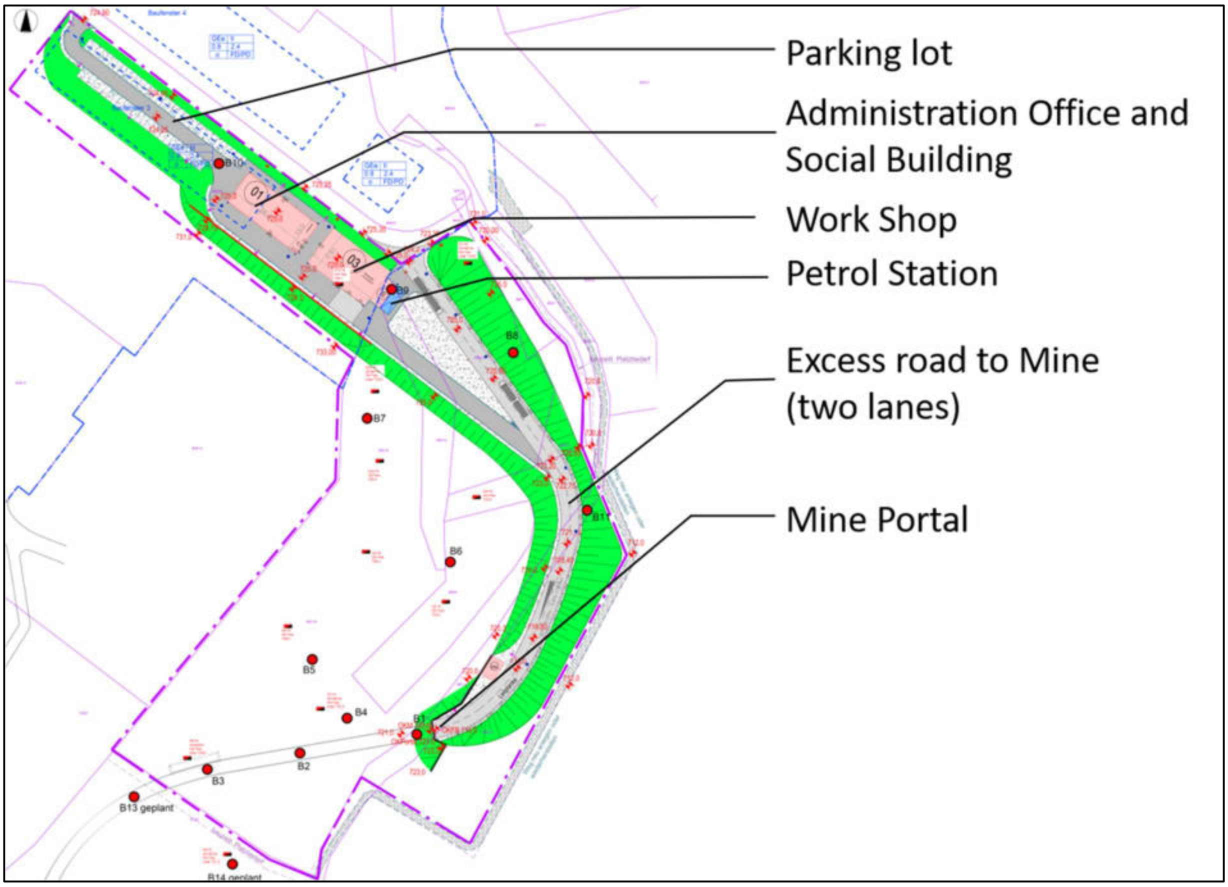


Figure 107: Map of the planned mining facilities in Altenberg

18.1.1 Site Access Roads

The property in Zinnwald and the mine site in Altenberg are in an area with a well developed infrastructure. The mining site has a connection to the public road network. The next federal road (B170) is 600 m away. The motorway A17 (Dresden-Prague) is located about 18 km to the east and is reached via the state road S174 (*Figure 108).*

Figure 108: Altenberg road map [google maps]

18.1.2 Traffic Management

The additional traffic caused by the mining operation can be handled by the existing public transport network [134].

18.1.3 Natural Gas

Natural Gas is available on the processing site. The owner of the natural gas network is Enso Netz GmbH.

18.1.4 Electrical Power

Electrical power is available on the processing site. The owner of the natural electrical power network is the Enso Netz GmbH.

18.1.5 Water Supply

The mining site is inside the coverage of the waterworks of Altenberg which belongs to the Wasserversorgung (Water Service) Weißeritz GmbH. The need of potable water for sanitary purposes is secured.

18.1.6 Sewage Treatment

Sewage water is sent to the public sewage water disposal unit and will be processed in the sewage water plant Technische Dienste Altenberg (TDA) that belongs to the town Altenberg.

18.1.7 Facilities on Mining Site

18.1.7.1 Mine secure

Access to mine site area is permitted only to staff and suppliers. The operating area is video-monitored. In addition, the access to the mine is secured by a gate which is locked when the mine is not in operation (e.g. weekend). This will prevent that unauthorized persons unnoticed enter the mine, as well as that straying animals get lost in the mine.

18.1.7.2 Mining Office Building

The mining office is intended to house mining and administration staff with respective offices. The first part of the building includes a reception area, offices, a conference / training room, photocopy and printer area, and kitchen and toilets.

The second part of the building provides the locker rooms for the mining staff. They are divided in compartments for men and women with showers. The third part of the building includes rooms for the laboratory and a control center for the mine and the mining site.

The building also serves for connection of electrical power, natural gas and potable water.

18.1.7.3 Workshop and Warehouse

The workshop and warehouse include a repair shop for mining vehicles, mechanical and electrical workshops, and high-bay racking for spare parts of the mining equipment. It provides offices for maintenance supervisors and warehouse staff.

18.1.7.4 Mine Infrastructure

The mine infrastructure will include:

- Hardstand area (unsealed)
- Tyre change pad
- Vehicle wash down area
- Electric power supply
- Potable water supply
- Diesel fuel supply with day tank and high volume bowser
- Workshop shed with crib room, ablution, and offices
- Explosives magazine (remote location)

18.2 Project Infrastructure Processing Site

Based on the current information and planning status, Freiberg is the preferred location and is considered in the FS. This preferred site includes both, the mechanical processing as well as the metallurgical plant.

Freiberg is located in southeastern Germany on the northern edge of the Erzgebirge. The city is located 35 km west of Dresden, the capital of the Free State of Saxony, and 200 km south of Berlin, the capital of Germany. The site in Freiberg is located within the industrial area “Saxonia”. Freiberg is the county seat of the district “Mittelsachsen” (in the proper sense “Central Saxony”). Freiberg is fully developed and connected to the public road and train network. The main advantage of this location is the short distance to the deposit.

Furthermore, the approvability of the site already exists as it was previously used for the production of synthetic diesel (*Figure 109*). However, as this abandoned plant is still on site, it has to be dismantled prior to a further use for this project. Negotiations for the acquisition of the real estate are currently underway and a cost estimate for the demolition of the buildings is listed in [181]. However, the demolition costs are almost completely covered due to a recovery of residual materials (i.e. steel) [181]. Figure 109 provides an overview plan of the planned production site.

Figure 109: Processing site in Freiberg, former synthetic fuel production site. Size 280 m N-S, 220 m E-W

18.2.1 Roads

Freiberg is located in an area with well developed Infrastructure. The processing site is connected to the public road and train network. The next federal road (B173) which connects Dresden und Chemnitz is within a distance of 400 m. The connection to the motorway A17 (Dresden-Prague) is possible 29 km to the east via the federal road B173 (Figure 110). Towards north the processing site can be reached via motorways A4 (17 km) or A13 (23 km) via federal road B101. The mining site in Altenberg / Zinnwald is located about 49 km to the southeast and can be reached via several federal and state roads.

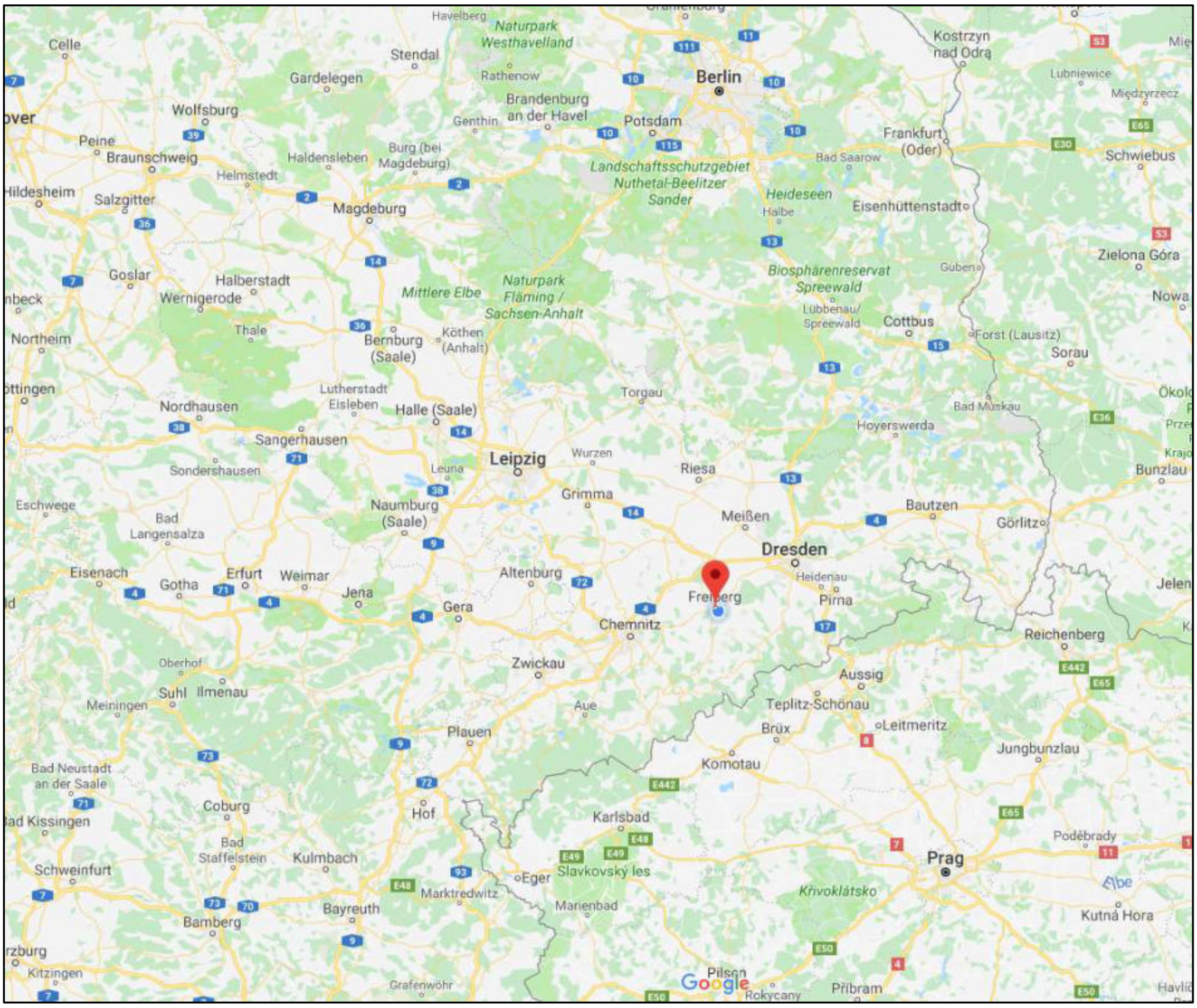


Figure 110: Road infrastructure of the planned processing site in Freiberg

18.2.2 Train

The processing site has a rail connection to the Sachsen-Franken-Magistrale, which connects Freiberg with the major north-south railway lines between Hamburg-Berlin-Prague and Hamburg-Leipzig-München. This railway network is used by both public and freight transport.

18.2.3 Port Access and Product Delivery

Next ports for product delivery are:

- Szczecin (PL) (378 km) on the Baltic sea reachable via motorways A13 and A11
- Rostock (456 km) on the Baltic Sea reachable via motorways A13 and A19
- Hamburg (483 km) on the North Sea reachable via motorways A14 and A7

Alternatively, these ports can also be approached by train.

18.2.4 Traffic Management

The traffic generated by the processing site activities can be taken through the public road network.

18.2.5 Natural Gas

Natural Gas is available on the processing site. The owner of the natural gas network is the Stadtwerke Freiberg GmbH. A price forecast for the years 2020 and 2021 was drawn up by Stadtwerke Freiberg. The gas price was used in the financial model [200].

18.2.6 Electrical Power

Electrical power is available on the processing site. The owner of the electricity network is the Stadtwerke Freiberg GmbH. A price forecast for the years 2020 and 2021 was drawn up by Stadtwerke Freiberg [199]. This is inclusive of all taxes and levies. Due to the high electricity cost intensity, DL can apply for an exemption from the energy feed-in tarif [343]. In this way, the feed-in compensation will be reduced to 15 % of the original feed-in tarif starting from a consumption of more than 1,000,000 KWh per year. For 2019, the energy feed-in tarif is 6.405 ct/KWh. The resulting price for electricity was calculated in [196]. In the financial model, the electricity price was set with exemption from the energy feed-in tariff.

18.2.7 Steam Supply

Steam for lithium salt production will be provided by a contractor [209].

18.2.8 Water Supply

The processing site is inside the coverage of the municipal Wasserzweckverband Freiberg [207]. The need for potable water is secured. Additionally, the industrial area Saxonia has a separate connection to a service water reservoir.

18.2.9 Sewage Treatment

Sewage water is sent to the public sewage water disposal unit and will be processed in the sewage water plant Freiberg which belongs to the company Freiberger Abwasserbeseitigung.

18.2.10 Facilities on Processing Site

18.2.10.1 Mineral Processing Plant – Beneficiation

The process plant building comprises the ore processing hall and silos to store ore ROM from Altenberg and quartz sand tailings. It provides a service connection room for electricity, natural gas and water, a small cloakroom and sanitary facilities. The produced zinnwaldite concentrate is directly transferred towards the pyrometallurgical process plant.

18.2.10.2 Pyrometallurgical Processing Plant Buildings

The pyrometallurgical plant provides a processing hall for grinding, mixing and pelletizing of the zinnwaldite concentrate with anhydride and limestone. The processing hall includes a control office, a service connection room for electricity, gas and water, as well as a cloakroom and sanitary facilities. This building is in the immediate vicinity to a plant which contains the drying unit, the rotary kiln and the cooler for the roasted product. Next to these buildings are silos for limestone and zinnwaldite concentrate storage. The anhydrite is dumped in another hall.

18.2.10.3 Hydrometallurgical Processing Plant Building

The hydrometallurgical plant is predominantly designed as an open chemical plant and includes a leaching unit for the roasted product, a purification unit for leaching water, a potassium fluoride solution production with hydrofluoric acid and potassium hydroxide as feedstock, a precipitation unit for lithium fluoride from the leaching water with potassium fluoride solution and a potassium sulfide (SOP) crystallization unit. The hydrometallurgical plant includes a control office as well as a small cloakroom and sanitary facilities. Next to the plant are silos for storage of the leached roasted product tailings and the SOP product. Lithium fluoride is stored in a storage building within separate silo units, or in big packs or smaller units.

18.2.10.4 Administration Office Building

The administration office building is intended to house all processing site and administration staff with respective offices. One part of the building includes a reception area, offices, a conference / training room, photocopy and printer area, and kitchen and sanitary facilities.
The other part of the building comprises the locker rooms for the processing personnel. The locker rooms are subdivided in compartments for men and women including showers. The third part of the building comprises the laboratory and space for control activity for the processing plants and processing site. The fully-functional sample preparation and chemical laboratory is designed for a nominal capacity of 200 samples per day. The number of process samples is estimated to be 25 samples per day from the mine, 75 samples per day from the mineral processing plant and 100 samples per day from the metallurgical plant. Samples for environmental monitoring will be sent off-site for analysis.

18.2.10.5 Workshop and Warehouse

The workshop and warehouse will comprise a repair shop, mechanical and electrical workshops, a workshop for pumps and high-bay racking for spare parts of the processing plants. It provides offices for maintenance supervisors and warehouse staff.

18.2.10.6 Storage

A storage building is located next to the hydrometallurgical plant where lithium fluoride is packaged in 25 kg bags on pallets or in big bags. A part of this storage is also used to store other required chemicals.

18.2.10.7 Gate house

The gatehouse has an office, a security turnstile and boom gate, a drug / alcohol testing area, kitchen and canteen and sanitary facilities.

19 Market Studies and Contracts

19.1 Introduction and Deutsche Lithium's Business Model

The significant growth in lithium demand over the past 30 years was initially driven by the development of lithium batteries for the portable electronics industries. Since the 1990s and 2000s it has been the predominant battery chemistry for cell phones and laptop computers and with the more recent growth focused on the hybrid and electric vehicle industry. All of these utilize lithium carbonate (Li_2CO_3) and lithium hydroxide (LiOH) products in the battery cathode and lithium fluoride (LiF) and lithium phosphate ($LiPF_6$) in the battery electrolyte.

Since the early 1990's, the majority of new lithium deposits have been developed in remote areas, such as the salt lakes and mountain ranges in South America or in remote parts of Australia, Canada and China. These remote locations, with limited access to infrastructure, technical labour and downstream chemicals has resulted in lithium producers tending to focus on the production of simple lithium compounds such as lithium carbonate. The lithium carbonate is then shipped to secondary chemical processing sites with access to downstream infrastructure, mainly in Asia, and is used to form a variety of higher-grade and higher-value downstream lithium compounds. *Figure 111* depicts the value chain for the production of lithium compounds based on lithium carbonate [198].

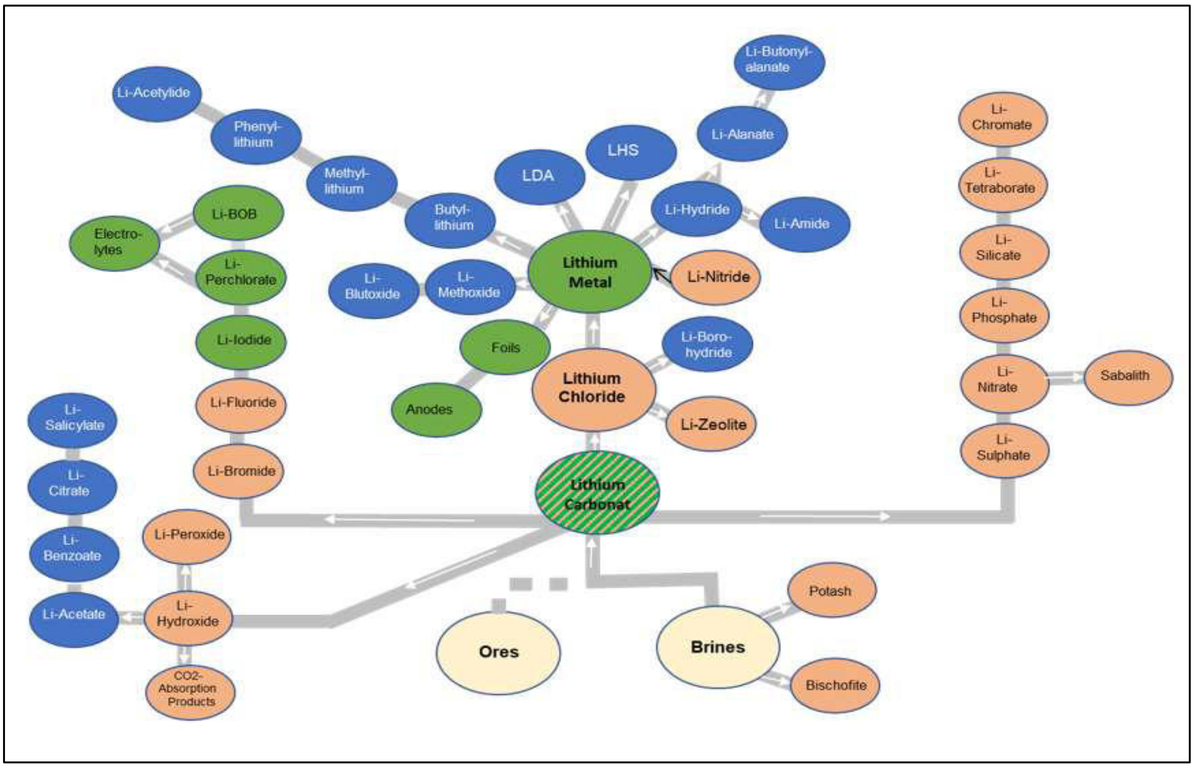


Figure 111: Lithium Tree [198]

At present, these downstream producers dissolve the lithium carbonate in water and precipitate higher value lithium compounds like LiF or $LiOH \cdot H_2O$. *Figure 112* shows the lithium demand by compounds for 2018.

For example, $LiPF_6$, the predominant conducting salt in lithium batteries, is produced from lithium fluoride and phosphor trichloride. The required lithium fluoride must then be produced by the $LiPF_6$ producer from lithium carbonate.

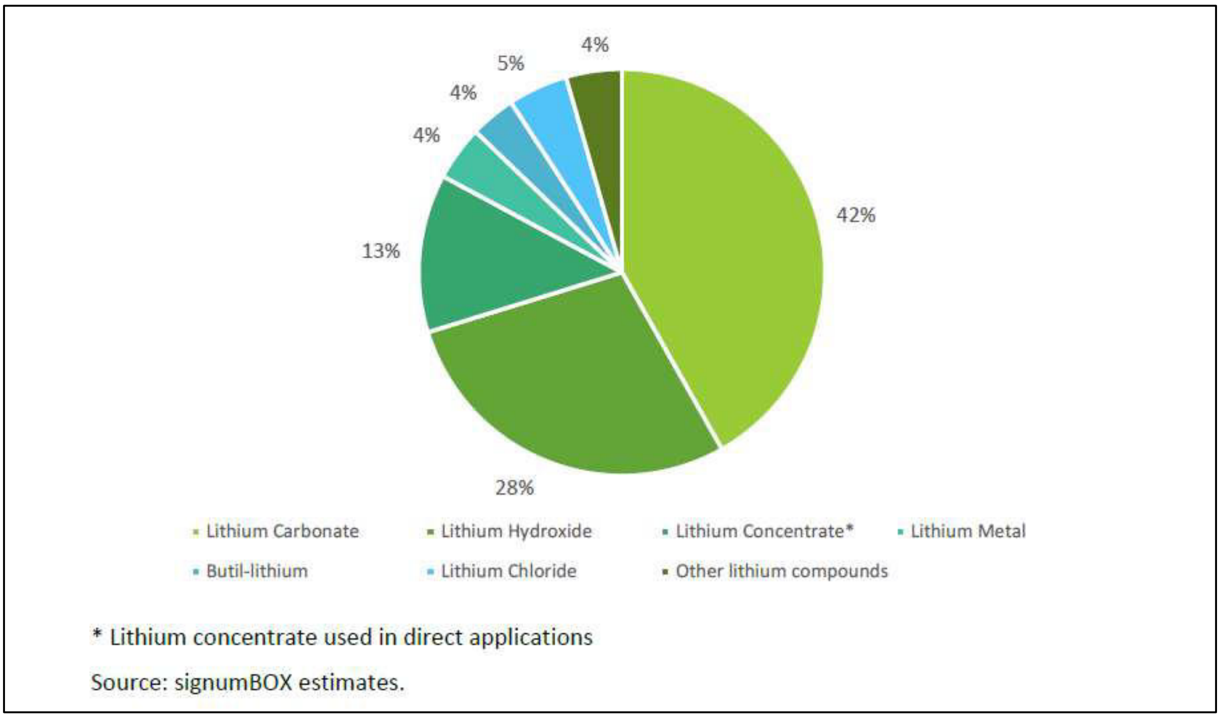


Figure 112: Lithium demand by compound – 2018 [198]

The Zinnwald Lithium Project is located in the Dresden region in the center of Germany and has access to well-developed infrastructure, such as cheap natural gas from the German gas grid, as well as a skilled workforce from the local chemical industries. This provides an opportunity to focus on the production of high value downstream lithium products, rather than spodumene concentrates or lower-value lithium carbonate products. With an abundant supply of fluorspar / hydrofluoric acid available in the close vicinity, DL has chosen to focus on lithium fluoride production. Lithium fluoride (LiF) is an important component in the manufacturing process of $LiPF_6$, which is the most important conducting salt in lithium-ion batteries.

The FS has been developed on a planned average annual production capacity of 5,112 t/a lithium fluoride (7,285 t LCE, 8,274 t $LiOH \cdot H_2O$). Whilst the FS is based solely on the production of lithium fluoride, DL has also established the possibility to produce battery-grade lithium carbonate directly from the lithium mica concentrate with only minimal modifications to the chemical plant circuits.

Furthermore, preliminary testwork has shown that the Zinnwald process flowsheet can also produce other lithium compounds such as $LiOH \cdot H_2O$ or Li_3PO_4. Only minimal modifications would be necessary in the hydrometallurgy plant in order to produce $LiOH \cdot H_2O$ with an expected annual production capacity of 8,500 t $LiOH \cdot H_2O$ or 7,800 t Li_3PO_4.

19.1.1 Lithium Market

Lithium is used in a variety of industrial applications, the most relevant of which is energy storage (via lithium batteries). This is also the fastest growing sector for lithium due to rising demand in both the automotive industry and the portable consumer electronics industry. For 2018, the split of end use for the broader lithium market was as per *Figure 113*.

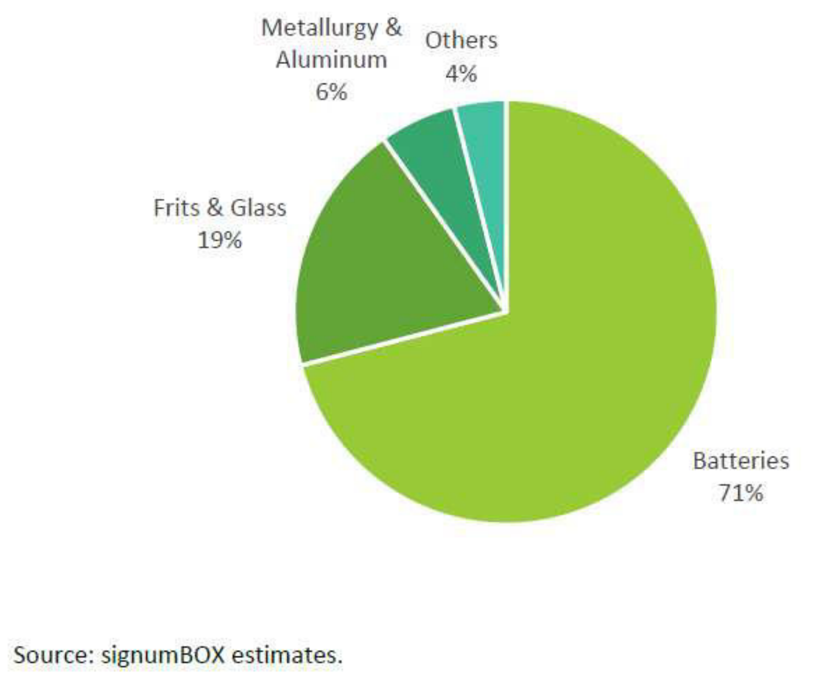


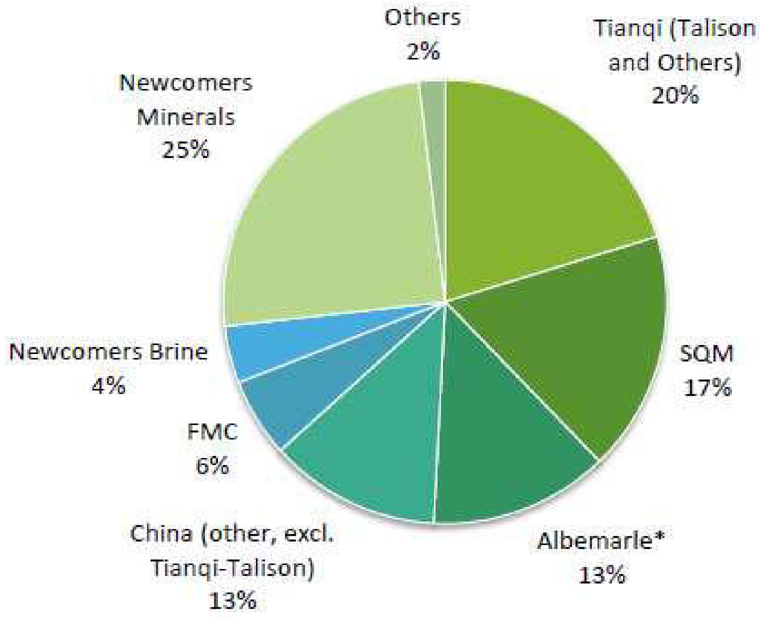
Figure 113: Li_2CO_3 consumption, main applications – 2018 [198]

One of the most valuable uses of lithium is as a component of high energy-density rechargeable lithium-ion batteries. Lithium-ion batteries represent the fastest growing industrial demand for lithium. The use of lithium-ion batteries in electric powered forms of transport is expected to have a major influence on the lithium market. Because of concerns over carbon dioxide footprint and increasing hydrocarbon fuel cost, lithium is expected to become even more important in large batteries for powering all-electric and hybrid vehicles. Lithium batteries already enjoy a sizeable market, powering laptop computers, cordless heavy-duty power tools and hand-held electronic devices.

Due to the quantum of lithium used in electric vehicle batteries, the electrification of the transport sector has the potential to affect a step change in demand for lithium. While electric vehicles currently represent only ~1 % of global annual vehicle sales, the number of electric vehicles sold has increased by 30 to 50 % per year in recent years.

As economies of scale and improvements in energy density and increased competition combine to lower the cost of electric vehicles, it can be expected that high levels of growth could continue. In addition, the regulatory environment in many key markets is shifting in favor of electrification of transport. Several countries including France and the UK have announced the future banning of vehicles powered by fossil fuels and China, currently the largest automotive market in the world, has put in place requirements for manufacturers to significantly increase the volumes of electrified vehicles sold.

Lithium supply is currently dominated by the four producers Tianqi, SQM, Albermale and FMC, who jointly account for an estimated 56 % of forecast global lithium production in 2019. SignumBox estimates total lithium supply in 2019 as 360,000 tons LCE. The following chart (*Figure 114*) shows the estimated market share by producer.



*Albemarle includes operations in Chile and in the US.

Source: signumBOX estimates.

Figure 114: Global lithium market share by company – 2019 [198]

Historically, most of the lithium production has been from brine producers, but the share coming from mineral resources has increased significantly in recent years from about 34 % in 2009 to approx. 44 % in 2017.

The largest producer of lithium minerals is Australia which currently accounts for some 20 % of contained LCE produced globally. However, all the lithium minerals produced in Australia are shipped to China as low grade, low-value 4-6 % Li_2O spodumene concentrates, where some are sold directly into the glass and ceramics industry and some converted into downstream products.

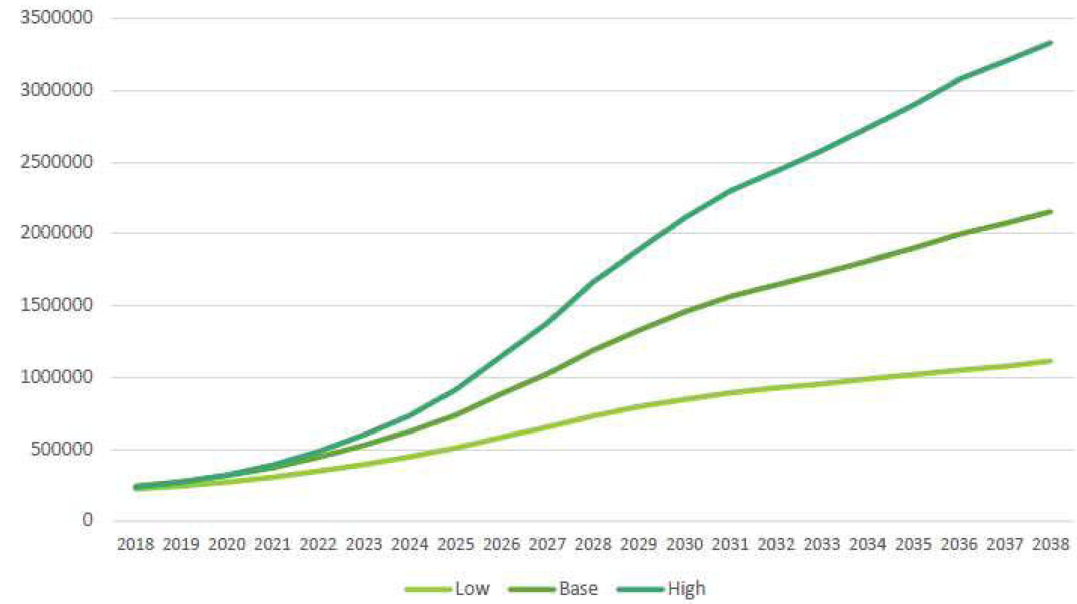
As a result of this access to spodumene concentrates, China is now the largest lithium chemical producer with a share of approx. 34 %, followed by Chile with a share of approx. 30 %. In terms of production costs, the Chilean brine producers enjoy a significant advantage given the fact that there is no mining and crushing involved and their location in arid regions enables them to utilize evaporative drying. This allows them to occupy the bottom quartile of the cost curve. Mineral producers, on the other hand, have additional costs associated with hard rock mining and processing and usually do not benefit from the integration of the chemical conversion.

In contrast to most mineral producers, DL has a major cost advantage, because its lithium mica deposit is close to the other required chemical sides inputs and thus can carry out a direct conversion of lithium mica to high-value lithium compounds (e.g. LiF, LiOH·H2O). It is also strategically placed for direct supply to German domestic end-users that require high-grade lithium compounds.

19.1.2 Demand Forecast

The lithium market (as expressed in terms of volume of LCE) is currently growing in excess of 15 % per annum and in value terms has more than doubled since 2014/15 to approx. 2.9 billion USD. In its base scenario SignumBox forecasts that annual growth over the next 20 years will average 11.6 %. The bulk of the growth is due to increasing demand from the battery sector implying continued strong growth for battery grade carbonate, hydroxide and fluoride products.

SignumBox has performed a bottom-up demand forecast for lithium in which they have estimated the use of lithium in each of its applications. They have estimated three different demand scenarios broadly varying based on different potential outcomes for general economic growth and, most importantly, the development of the electric vehicle ("EV") market, which is anticipated to be the primary driver of battery demand.



Source: signumBOX estimates.

Figure 115: Estimation of total lithium demand (in tons of LCE) [198]

The Base Scenario of SignumBox considers the demand of lithium for lithium products (LCE) growing from 245,000 tonnes in 2018 to over 2,000,000 tonnes in 2038. Currently, EV battery demand is approximately 45 % of demand. By 2038 it is expected to be over 90 % of demand. The three demand scenarios are summarized in *Table 81.*

Table 81: Summary of the demand scenarios estimated by signumBox [198] (in tons of LCE)

Scenario / Application		2018	2020	2025	2030	2035	2038
Base Scenario		244,500	318,748	740,436	1,457,271	1,900,576	2,154,018
	Batteries	112,144	172,168	526,372	1,152,418	1,612,941	1,877,990
	Rest	132,357	146,580	214,064	304,853	287,635	276,028
Low Scenario		224,847	272,971	509,481	848,974	1,019,789	1,115,150
	Batteries	95,402	133,448	328,741	622,222	805,990	907,101
	Rest	129,445	139,523	180,740	226,753	213,799	208,049
High Scenario		237,795	323,191	915,669	2,109,818	2,898,386	3,329,624
	Batteries	105,965	174,902	675,084	1,720,093	2,524,833	2,972,928
	Rest	131,830	148,289	240,586	389,725	373,553	356,696

19.1.3 Supply Forecast

Historically, the majority of lithium production has come from brine producers in Chile and Argentina, however recent new mine developments in Australia have significantly increased pegmatite concentrate production for sale to China. The following graphs illustrate the evolution of lithium supply from brines (*Figure 116*) and from pegmatites (*Figure 117*).

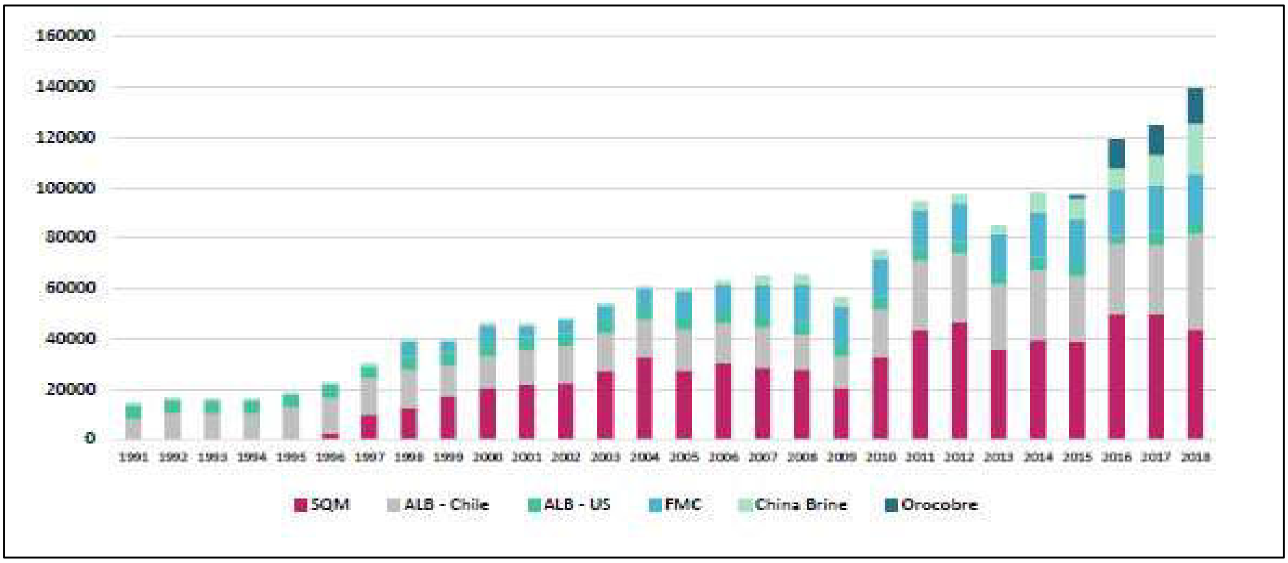


Figure 116: Lithium supply from brine sources (in tons of LCE) [198]

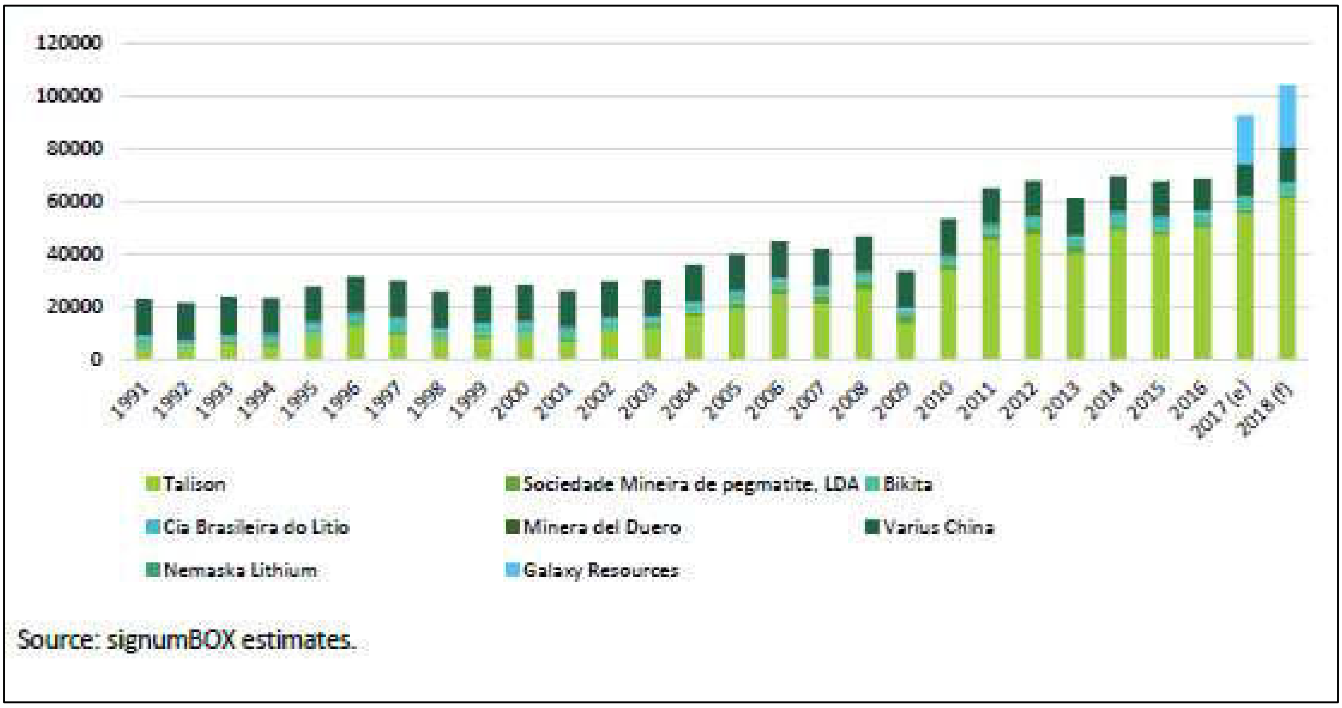


Figure 117: Lithium production from spodumene concentrates, chemical and technical grade (in tons of LCE) [198]

19.1.4 Lithium Carbonate / Lithium Hydroxide Price and Forecast – end 2018

SignumBox estimates that lithium carbonate prices (average grades) on long-term supply contracts will slightly recover from the downward trend observed towards the end of 2018. The averaged price was 12,670 USD/t during November 2018; this is 1.5 % higher than its estimate for

October. Lithium hydroxide prices observed a 2.9 % increase compared with October, averaging 17,140 USD/t (*Figure 118*).

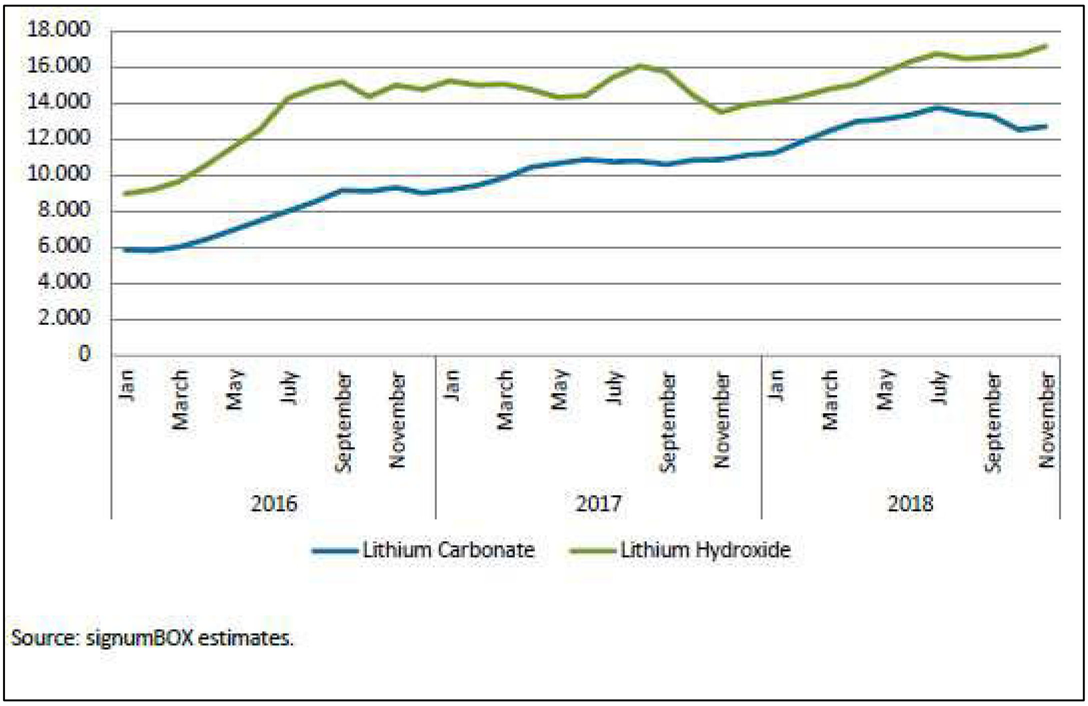


Figure 118: Lithium carbonate and hydroxide prices (USD/t, average grades) [198]

Furthermore, Signumbox's price forecasts take into account the gap between demand and future production capacity. It is expected that the lithium hydroxide market will be tighter than the lithium carbonate market, because the growth in lithium hydroxide demand will be greater than the growth in lithium carbonate demand for its use as cathode material in high nickel cathode materials such as NCA and NMC. In addition, it will take more time for lithium hydroxide production capacity to adjust to the demand, and it has a higher marginal cost. All these factors will push higher lithium hydroxide prices.

The long term prices forecasts for both lithium carbonate and lithium hydroxide are shown in *Table 82.*

In 2020, the market price for lithium carbonate and lithium hydroxide dropped down to prices of apprx. 8,500 USD/t for lithium carbonate and 10,000 USD/t for lithium hydroxide, respectively. The reason for these very low prices is the delay of up to 12 months in the EV sector. On the other side there are some forecasts available, considering this delay and predicting a shortage of lithium compounds starting 2023/2024 [442]. From DL point of view, this shortage in 2023/2024 will raise the prices of the lithium compounds at least to the predict level listed in Table 82. Therefore, DL remains with the statements on the market outlook as they are listed in this BFS.

This view is further supported by the recent study of the European Commission [443] [444] that defined and listed lithium as a critical raw material.

Table 82: Long term prices for lithium carbonate and lithium hydroxide (CIF, in USD/t) [198]

	Low range	High range	Expected
Li_2CO_3 – Average	10,100	13,300	11,500
Li_2CO_3 – Battery Grade	14,500	15,700	15,700
LiOH – Average	14,100	19,700	16,300
LiOH – Battery Grade	18,500	26,300	20,600

19.2 Lithium Fluoride

Lithium fluoride has a number of uses, including electrolytes, metallurgical applications, optics and molten salts. The fastest growing demand for LiF is its use for lithium batteries in the manufacture of the conducting salt $LiPF_6$. $LiPF_6$ serves as the “shuttle” in the battery electrolyte which “ships” the lithium ion between the cathode and the anode. Approximately 95 % of all lithium battery electrolytes use $LiPF_6$.

19.2.1 Lithium Fluoride Demand Forecast

SignumBox Chile (www.signumbox.com) has provided the Company with its detailed 20 years analysis of the wider global lithium market. The Fraunhofer Institute in Germany (www.fraunhofer.de) has provided a detailed analysis of the electrolyte / LiF market. These reports can be summarised as follows:

- By 2037, SignumBox anticipates global annual demand for lithium chemicals to reach about 1,700,000 t of LCE in their base scenario, compared to the current 360,000 t in 2019, equating to an average annual growth rate of about 11.5 % over the next 20 years.
- Contract prices for battery grade lithium carbonate products have increased significantly since Q3 2015 from a global average price of lithium carbonate of approx. 6,000 USD/t to over approx. 12,000 USD/t (Q2, 2019).
- SignumBox estimates total demand for electrolyte materials reached 142,000 t in 2018; this represents a 11.4 % growth compared with 2017, with a value of 4 billion USD. It expects annual demand to grow to over 230,000 t by 2030.

- Fraunhofer estimates mid-case consumption of LiF in electrolyte production will be in the range 20,000 t to 40,000 t annually by 2030, depending on LiF density remaining in the range from 5 % to 10 % in the electrolyte.

Fraunhofer Institute is Europe's largest application-oriented research organization and is deeply involved in the development of supply / demand models for the German electric vehicle industry. Fraunhofer estimates mid-case LiF demand of some 10,000 t LiF per year in 2025 growing to approximately 40,000 t per year by 2030, as shown in Table 83 based on the available battery technology and the increasing number of EVs predicted by Fraunhofer study 2018, shown in *Figure 119* [381].

Table 83: Amount of LiF required for $LiPF_6$ synthesis, calculated by Fraunhofer [211]

Year	LiF [t], 9 % electrolyte	LiF [t], 13 % electrolyte
2025	9,613	13,885
2030	41,198	59,508
2035	79,649	115,049
2040	105,741	152,737

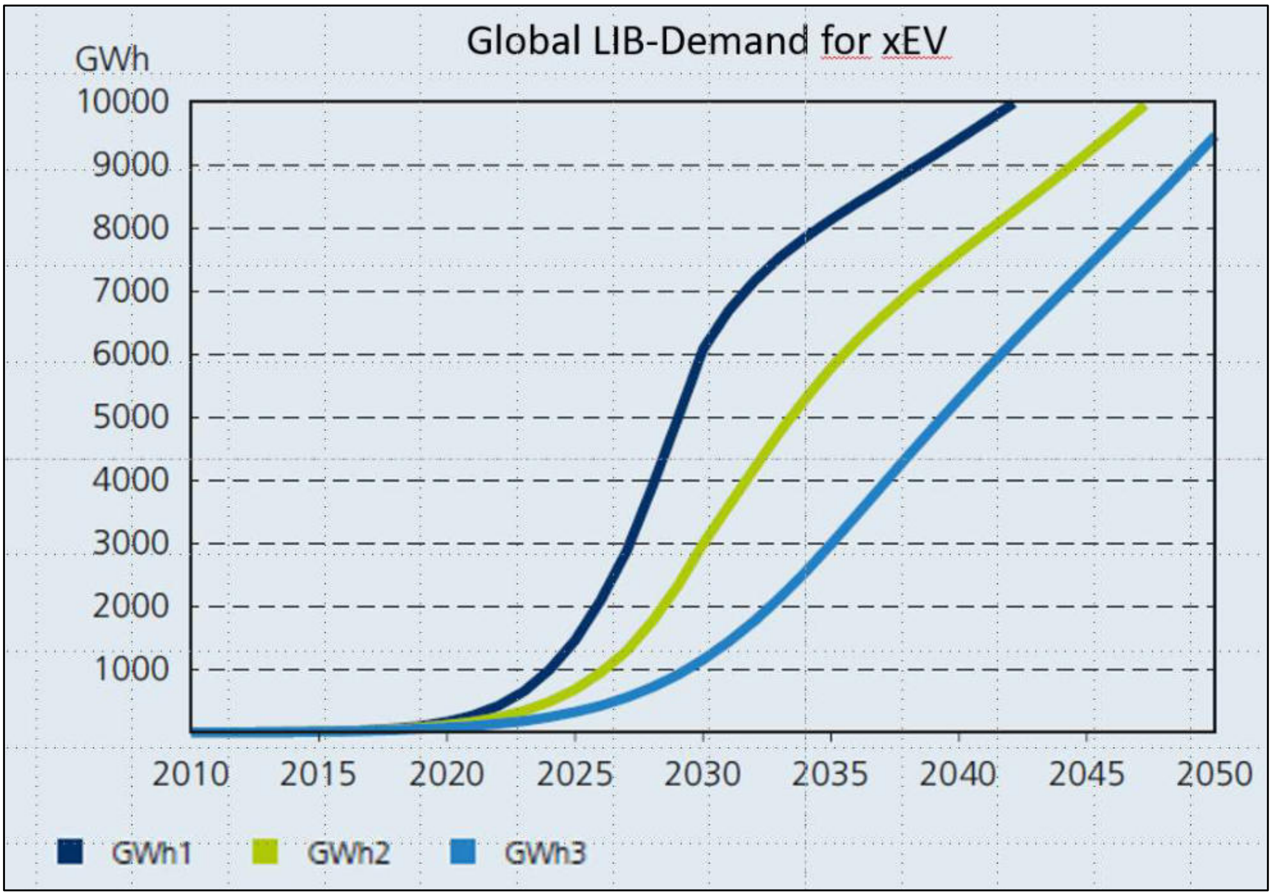


Figure 119: Global LiB-Demand for Electro Vehicles [381]. GWh1 – Scenario 1: "Politically enforced and OEM-supported diffusion"; GWh2 – Scenario 2: "Forced diffusion"; GWh3 – Scenario 3: "early diffusion". Parameterization based on real global development 2010-2018

19.2.2 Lithium Fluoride Price Forecast

The lithium fluoride price in the past and the estimation of its further development by Zion Market Research [167] is shown in *Figure 120* to Figure 122 below. Starting in 2002, the price remained at a stabile high level and is estimated to be between 26 and 28 USD/kg in the years 2020 - 2030.

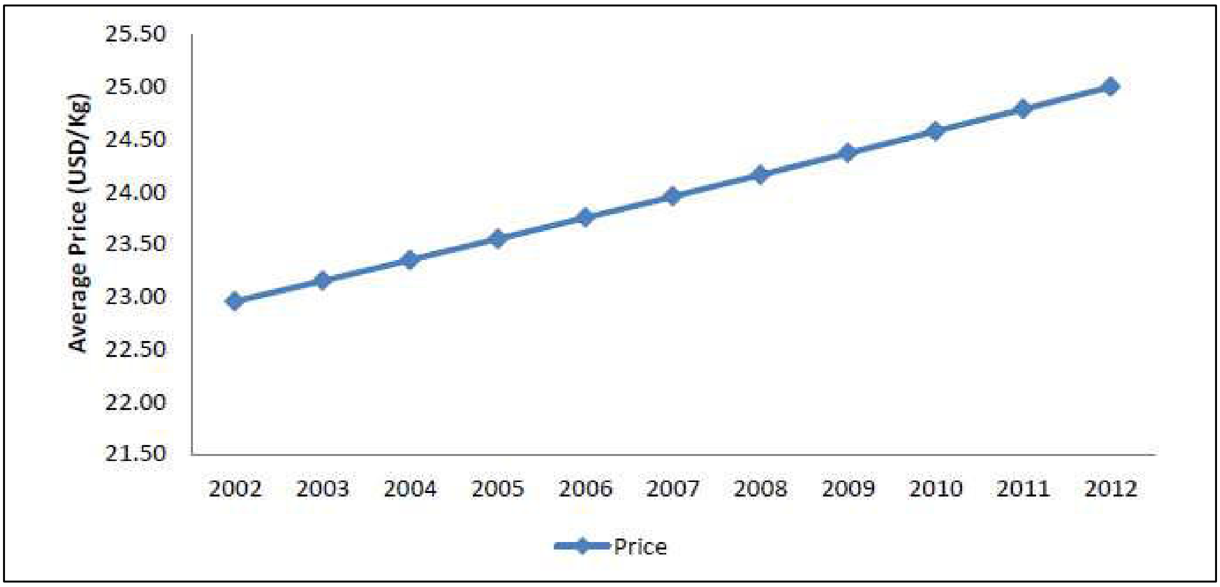


Figure 120: Historic data (2002–2012) - Global lithium fluoride market price (USD/Kg) [167]

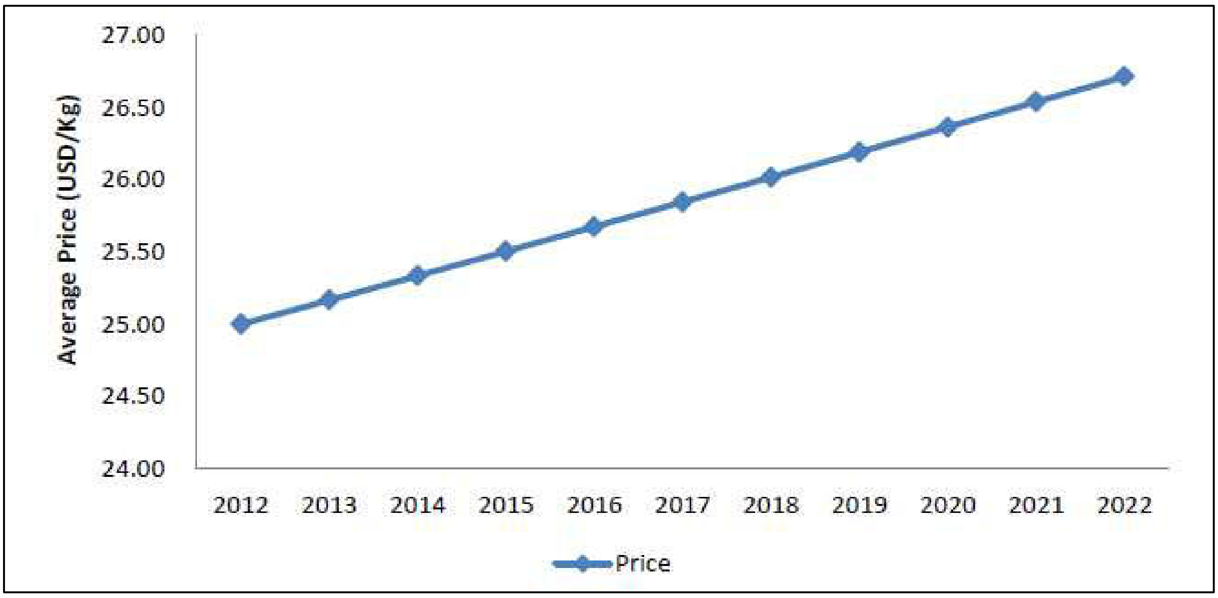


Figure 121: Forecast (2012 - 2022) - Global lithium fluoride market price (USD/Kg) [167]

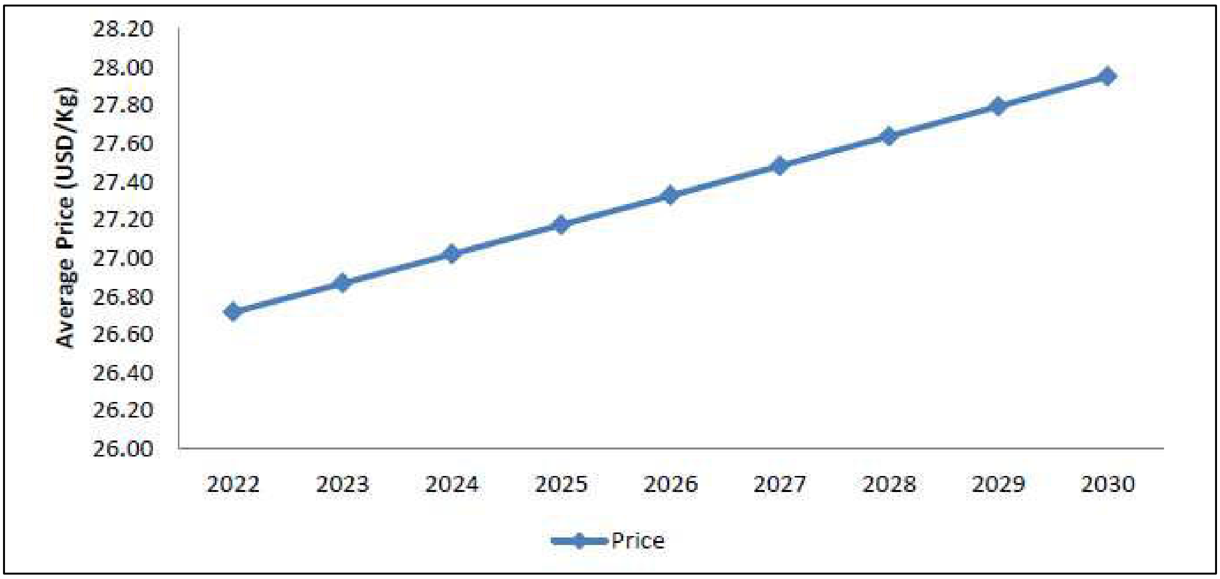


Figure 122: Forecast (2022 - 2030) - Global lithium fluoride market price (USD/Kg) [167]

To verify the predicted LiF price level published by Zion Market Research, SignumBox calculated an estimate of future lithium fluoride prices based on manufacturing costs for lithium fluoride production that apply the standard manufacturing process with neutralization of lithium carbonate by hydrofluoric acid, as follows:

- 75 % of material costs (lithium carbonate, hydrofluoric acid) using 1.42 t lithium carbonate and 0.77 t hydrofluoric acid to produce 1 t lithium fluoride at 100 % lithium yield
- 25°% of manufacturing costs like labour, media, energy and depreciation [166]

SignumBox forecasts that lithium carbonate prices (technical grade) would range from 10,100 USD/t to 13,300 USD/t. Therefore, lithium fluoride direct production cost would range between 15,800 USD/t and 20,400 USD/t. Once labour, energy and depreciation costs were included, total costs would range between 22,700 USD/t and 27,200 USD/t (*Table 84*).

Table 84: Long term prices – Lithium fluoride production [198]

Scenario	Low	Expected	High
Li_2CO_3 Technical Grade (USD/t)	10,100	11,500	13,300
LiF (LCE) - USD/t	14,342	16,330	18,886
HF (USD 2,000/t)*	1,540	1,540	1,540
Labour, Energy, Media Depreciation*	6,843	6,843	6,843
LiF Direct Cost (USD/t)	15,882	17,870	20,426
LiF Total Manufacturing Cost (USD/t)	22,725	24,713	27,269
*Information provided by the customer			

*The applied HF price level in *Table 84* is based on commercial offers by established HF manufactures ([98], [103])

Considering the calculated LiF costs in *Table 84* and including a margin of 10 %, then the lowest price would be 25,000 USD/t LiF and the highest price 29,996 USD/t LiF. These results are in the same range as those identified by Zion Market Research [167].

DL has used a price of **22,000 EUR/t** LiF in the financial model for this FS.

19.3 Potassium Sulfate

The primary by-product produced is potassium sulfate (K_2SO_4 or sulfate of potassium “SOP”).

SOP is a high value fertilizer with particular application for producers of fruits, vegetables and nuts. The global demand for SOP is currently approx. 8 Mt and is in deficit. Especially total soluble SOP is in deficit because of the high demand of aqueous SOP-solutions for fertilization in greenhouses. Global production capacity is predominantly located in China, but there are also production capacities in Europe ([165], [194]).

Based on a production of 5,000 t/a LiF, approx. 32,000 t SOP can be produced per year. DL discussed with a local manufacturer of SOP to establish a long term offtake agreement for the SOP produced at Zinnwald at a price of 425 EUR/t [194]. DL will also sell high-quality SOP to the chemical industry for a higher price. The mixed SOP price level assumed in the financial model is 500 EUR/t.

20 Environmental Studies, Permitting and Social or Commmunity Impact

20.1 Introduction

An EIA pre-study for the mining activities has been prepared and applied for [37] based on the German Mining Act standards as follows:

- Land use of the project 10 ha
- forest use of the project below 1 ha
- water handling in the mine below 100,000 m³/a

The Mining Authority of Saxony (SOBA) decided in March 2018 that an EIA has not to be carried through [40]. The permit process can follow a simplified model called Facultative Frame Operation Plan – FFOP ("fakultativer Rahmenbetriebsplan"). In November 2018, DL started this permit process. The application was submitted to the Mining Authority in June 2019 [440] and the process is still ongoing. All stated impacts by the Project were categorized as not substantially considerable. The impacts and their valuation are described in the next subitems.

20.2 Permits

The following permissions and decisions are included in the permission of the Facultative Frame Operation Plan which will be granted by the SOBA:

Table 85: Permissions and decisions included in the Facultative Frame Operation Plan Permission by SOBA

Sig.	Included Permission
ME 1	Water use permission for mine drainage and discharge, incl. exception of limitations in the high flood generating area "Zinnwald – Altenberg", in detail: a) Water use permission for mine drainage and discharge of mine water during construction of the main access (ramp) b) Water use permission for mine drainage and discharge of mine water during construction of the ventilation shaft c) Water use permission for mine drainage and discharge of mine water during the regular operation

Sig.	Included Permission
	d) Water use permission for application of mine water from the “Tiefe-Hilfe-Gottes” Gallery e) Water use permission for direct discharge of surface water from roofs and surface area dewatering the surface plant f) Water use permission for the storage of surface water (precipitation storage reservoir) g) Water use permission for a technical installation for water discharge into surface water h) Water use permission for discharge of substances into groundwater
ME 2	Permission for exception of § 21 Repository Site Selection Act (StandAG)
ME 3	Compatibility of the project with the European Water Framework Directive (EU-Wasserrahmenrichtlinie - WRRL)
ME 4	Permission for exception of area protection (Landscape Protection Area “Oberes Osterzgebir-ge”)

The following permissions and decisions are not included in the FFOP. They will be granted separately by the local authorities or in a different permission process, guided by the SOBA.

Table 86: Separate permissions and decisions

Sign.	Permission / Decision	Authority
GE 1	Permission according to Federal Emission Protection Act (BImSchG) for construction and operation of the processing plant, including construction permission according to §§ 66, 72 Construction Law of Saxony (SächsBauO)	Mining Authority of Saxony
GE 2	Special Operation Plan (“Sonderbetriebsplan” - SBP) for construction and operation of the processing plant	Mining Authority of Saxony
GE 3	Construction Permission for surface installations	Lower Building Authority
GE 4	Special Operation Plan for surface installations	Mining Authority of Saxony
GE 5	Forest conversion (longtime, temporary) and afforestation according to §§ 8 and 10 Forest Law of Saxony (SächsWaldG)	State company Sachsenforst (state owned forest); Lower Forest Authority (private and municipal forest)
GE 6	Preservation Permission	Lower Preservation Authority

Sign.	Permission / Decision	Authority
GE 7	Permission for exception of manner protection according to § 45 Abs. 7 Federal Nature Protection Act (BNatSchG)	Lower Nature Protection Authority

20.3 Legitimations regarding Regional Planning and Constructional Planning

The framework for mineral resources in the Regional Planning is defined in the Land Development Plan of Saxony 2013 (“Landesentwicklungsplan Sachsen“). Mineral resources are shown in detail in special information maps of the Land Development Plan. In map no. 11 – “ore and spar prospective area”, the project area is defined as „ore prospective“.
The Regional Plan of Upper Elbe / Eastern Erzgebirge Region (status 2nd proceeding) refers to the ore- and spar-prospective areas in the region. The tin deposits in the Altenberg region are stated in this document with particular significance.

The constructional plan for the project area “Europark Altenberg PA 1“ is approved since March 01, 2000, and is accompanied by a granted Green Regulation Plan (“Grünordnungsplan”). Some expansions of the Europark are in the planning stage. The town of Altenberg is the responsible planning authority and has declared a development freeze as act of favour for the Zinnwald lithium project of DL [95].

20.4 Specification and Assessment of the Anticipated Environmental Impacts

20.4.1 Preface

Based on DL’s “Application of preliminary examination of individual case according to § 3a (1) Environmental Compatibility Examination Act” as of February 21, 2018 [37], the Mining Authority of Saxony accomplished an Environmental Examination Screening and granted at April 19, 2018, the following results [40]:

- The project dimensions and technical parameters according to § 1 No. 1 - 8 Environmental Compatibility Examination Act Mining (UVP-V Bergbau) do not exceed the legal limits.

- The project dimensions and parameters according to No. 9 Environmental Compatibility Examination Act Mining (UVP-V Bergbau) in connection with appendix 1 Environmental Compatibility Examination Law (UVPG) do not exceed the legal limits.

- An Environmental Impact Analysis (EIA) is not necessary.

- A border crossing environmental examination is not necessary.

- The project does not belong to the categories of the Abnormal Occurence Act (StörfallVO).

20.4.2 Specification and Estimation of the Anticipated Emissions and Other Substantial Impacts

20.4.2.1 Air Pollution

Air pollution aspects of the project are described in the expert study “Dust Prognosis” (see [132]). According to the results of the dust prognosis, the emissions and immissions were defined as not relevant for the surrounding public area.

20.4.2.2 Noise Exposure

Noise exposure, based on Technical Guideline Noise (TA Lärm) was investigated in the expert study “Noise Prognosis” (see [145]).
Relevant emissions by traffic are limited on surface transportation within the operation area, which only takes place at working days and is limited in the time window between 06:00 a.m. and 10:00 p.m.
According to the results of the noise prognosis, the immissions at the nearest immission locations were defined as not relevant.

20.4.2.3 Waste Treatment

Details of waste volume and handling with waste will be described in the permission documents according to Federal Emission Protection Act (Bundesimmissionsschutzgesetz - BImSchG).

20.4.2.4 Sewage Disposal

Details of sewage volume and handling with sewage will be described in the permission documents according to Federal Emission Protection Act (Bundesimmissionsschutzgesetz - BImSchG).

20.4.2.5 Water Polluting Substances

Details of volume and handling of water polluting substances will be described in Special Operation Plan Waste and in the permission documents according to Federal Emission Protection Act (Bundesimmissionsschutzgesetz - BImSchG).

20.4.2.6 Blasting Vibrations

The development and operation of the mine will proceed with conventional underground drilling and blasting technology. On basis of the legal standards and regulations, a blasting technology was developed to follow the limits of vibrations for surface buildings and installations and to guarantee a blasting technology without impacts on the public [135]. To reduce the impacts by blasting vibrations it is scheduled that during night time (10:00 p.m. to 06:00 a.m.) no blasts take place.

20.4.2.7 Site Evaluation

No residential houses are located in the direct neighborhood of the project area. The distance to the next residential houses is in excess of at least 200 m. The ventilation shaft is located within the forest outside of the settlement of Zinnwald.

20.5 Environmental Impact, including Interaction and Effects with Respect to Nature Conservation and Species Protection

20.5.1 Human Beings and Human health

Impacts on human beings during the development and operation of the project cannot be completely excluded. All potential emissions will be reduced by technical and organizational measures to avoid health risks, e.g.:

- Prevention of noise-intensive work in evening- und night-times
- Noise-reduction installments at the ventilation shaft
- Housing of noise-intensive installations

20.5.2 Animals, Plants, Biodiversity

Impacts on animals, plants and biodiversity result predominantly from the surface activities of the project. Impacts on species were investigated and examined in a Species Protection Study [174]. Possible impacts could include:

- Habitat loss by cutting and rooting of trees
- Influence on noise-sensible species
- Influence on habitats by traffic
- Influence on light-sensible species at night
- Influence on surface based species by blasting (noise and seismic shaking)

These impacts will be reduced by prevention and reduction measures.

20.5.3 Soil

The soil in the planned project area (i.e. surface plant) is historically biased and has already lost its natural functions. Sealing by the project will have a further impact on the soil. These effects will be compensated by several reduction measures.

20.5.4 Water

All project relevant aspects of water (groundwater, surface water, mine water) drainage were discussed in an expert study on the compatibility of the project with the European Water Framework Directive (see [174]).

20.5.5 Air

During operation, air quality can be influenced by dust during loading and / or transportation of materials on surface. Potential air pollution was investigated in an expert study on dust prognosis (see [132]). This study found no rule violations.

20.5.6 Climate

An influence on the regional climate can be excluded because all climate relevant effects (local heating, dust, exhaust, sealing of surface) are very limited in time and space.

20.5.7 Landscape and Recreation

The area of the surface plant is already covered by old industrial installations and is characterized by the commercial use as industrial area. The industrial area in the Europark Altenberg is without any significance for recreation and tourism. However, although felling of trees for the installation of the project makes the industrial area more visible from distance, impacts on the landscape are not expected.

The touristic path „Aschergraben" is cut by the ramp line, but its function will be further guaranteed by shifting the path line. The weather shaft in the forest near Zinnwald has no influence on landscape and recreational functions due to its small space requirement. Cultural and Other Tangible Assets
In the Europark Altenberg area two protected buildings are in touch with the project (historical shaft building "Arno-Lippmann-Schacht" and the historical surface dewatering channel "Aschergraben"). Both historical objects are not in conflict with the project. The view to these protected objects will not be obstructed.

The whole area around the mining site is part of the proposed World Heritage Nomination Erzgebirge/Krušnohoří Mining Region. There is no impact to the DL project ([106], [126], [146], [148]).

The historical stone bridge at the “Lange Gasse”, crossing the small river near the area of the planned weather shaft, will remain untouched.

20.5.8 Conflict Analysis

The identified environmental impacts do not meet considerable impairments. Remaining environmental impacts will be reduced essentially by technological measures (reducing of noise and dust emission, operating times) as well as by prevention and compensation.

20.6 Measures for Prevention, Reduction and Compensation of Natural Impacts

Various measures are being considered to prevent and reduce the natural impact of the project. Measures for prevention and reduction of impacts are listed in the following table.

Table 87: Measures for prevention and reduction of impacts

Sign.	Title	Volume
S1	Protection of single trees during construction and operation period (surface infrastructure and weather-shaft area)	
S2	Protection fence along the zone of uprooting	~ 360 m
S3	Minimum distance between buildings and forest	
S4	Protection of touristic infrastructure (touristic path “Aschergraben”)	~ 235 m
S5	Measures for protection of waters	
S6	Temporary amphibian and reptile protection fence	~ 490 m
S7	Catching of snakes before start of construction	min. 3 times
S8	Development of habitat areas for snakes	2 stonewalls, both 5 m long
S9	Scaring of snakes within the construction area	

The following table summarizes the planned measures for balance and compensation of natural impacts [142]:

Table 88: Balance and compensation measures

Nr.	Title	Volume
A1	Afforesting with local tree species	
A2	Recultivation of the construction area	1,429 m^2
A3	Extensive roof greening	5,180 m^2
E1	Compensation measure according to § 7 SächsÖkoVO "Demolition of a holiday object in Altenberg"	7,231 m^2, ~ 130,000 ecopoints
E2	Demolition / Unsealing at the former dairy cattle facility in Fürstenwalde	4,700 m^2
E3	Demolition / Unsealing at the former residential house, parcel 74/9, Fürstenwalde	1,500 m^2
E4	Demolition / Unsealing at the former residential house, parcel 56/1, Fürstenwalde	4,000 m^2
E5	Compensation measure according to § 7 SächsÖkoVO "Development of two fence rows in Obercarsdorf"	5,100 m^2, ~ 112,200 ecopoints; 2,800 m^2, ~ 61,600 ecopoints

The following measures for species protection (VA) and balance measures (CEF) are defined in measure regulations [142].

Table 89: Balance measures for species protection

Sign.	Title
VA1	Ecologic supervision during construction
VA2	Trimming and uprooting of trees outside of reproduction period
VA3	Insect nurture and bat compatible lighting
CEF1	Compensation installations for tree hole breeders
CEF2	Compensation quarters for bats

Following these measures, all natural impacts will be fully compensated and impacts will be avoided as much as possible.

20.7 Remaining Inevitable Effects and Exposures

Remaining inevitable effects and exposures of the project are:

- Loss of forest area
- Loss of living space for animals and plants
- Raising of accident risks by construction and operation of surface and underground installations

20.8 Operation Safety and Neighbourhood Protection

For operation safety and neighbourhood protection, the German acts and regulations have to be considered and implemented which are listed in *Item 27.8.* Based on these legislations, a health & safety document has to be established with all necessary technical and organizational measures, including risk and hazard analysis.

Technical details will be defined in Special Operation Plans, which have to be granted by the mining authority, e.g.:

- Special Operation Plan Processing
- Special Operation Plan Installation and Equipment
- Special Operation Plan Ventilation
- Special Operation Plan Blasting
- Special Operation Plan Mine Drainage
- Special Operation Plan Mine Rescue

<u>Radiation protection</u>

Underground mine workings ("Activities", according to Radiation Protection Act – Strahlenschutzgesetz - StrlSchG [383]) are legally defined as "Working fields with higher exposition to Radon". The average annual activity concentration range of Radon-222 in these working fields is 300 Bq/m³. The limit of effective dosage is 20 mSv/a. For the mine an effective ventilation system was planned, that at all time guarantees that the Radon concentrations for the employees are below the legal limits.

<u>Safeguarding of unauthorized persons</u>

The operation area in the Europark Altenberg, the ramp portal and the exit of the ventilation shaft will be safeguarded against trespassing by unauthorized persons during mine and site development as well as in the whole operation period of the project.

Trespassing of external guests is only allowed in attendance and with the necessary health and safety equipment.

Mining rescue

Until the establishment of a fully equipped company-own rescue team, DL will arrange service contracts with rescue teams of other mining companies of Saxony, accompanied by training of company-own local guides for the support of external rescue teams.
Equipment, training and operation of mine rescue are subject to the legal guidelines and standard operation procedures for mining rescue ("Leitlinien des Deutschen Ausschusses für das Grubenrettungswesen für Organisation, Ausstattung und Einsatz von Grubenwehren") and have to be approved by the Mining Authority of Saxony in a "Special Operation Plan Mine Rescue".

20.9 Processing and Metallurgical Plant

Ore processing and the production of LiF will be achieved in a combined plant for mechanical processing, pyrometallurgy and hydrometallurgy in an industrial location in Freiberg.
This plant will be built in the immediate vicinity to a metallurgical plant for the treatment of zinc oxide from steel dust. Furthermore, to the southeast of the planned site one of the largest lead smelters in Europe is located. The chosen property itself was formerly used for the production of synthetic fuel from renewable resources. The approval of the plant requires an application according to the Federal Emission Protection Act (BImSchG – Bundesimmissionschutzgesetz) and will be processed by the district office of the county Mittelsachsen. The compilation of the documents for this application includes all relevant data regarding different influences on humans and the environment. Due to the previous use, the site is ideally suited for the construction of the process plants.

21 Capital and Operating Costs

21.1 Capital Costs

The overall capital cost estimate is summarized in *Table 90*. This estimate has a base date of the first quarter 2019 (Q1 2019) and an accuracy range of ± 10 %. All costs are in Euro.

It has been compiled by DL supported by eXnet and is based on the basic engineering cost estimation from:

- G.E.O.S. for mining capital costs
- KÖPPERN for beneficiation capital costs
- CEMTEC for pyrometallurgical capital costs
- AMPROMA for hydrometallurgical costs and
- BBF for infrastructure, ground levelling and building capital costs

Table 90: Estimated Capital Cost for the execution of the project

Area	M EUR
Mining equipment, infrastructure and site	27.4
Beneficiation / mineral processing plant	23.3
Chemical plant	82.0
Property and general on-site infrastructure	10.6
EPCM / Project management	14.9
Contingency	15.8
Subsidies / grants	-15.00
Total:	**158.9**

21.1.1 Mining Capital Costs

The mining capital cost estimate was developed by G.E.O.S. and BBF. The initial mining capital cost is estimated at 27.4 M EUR and includes the following items:

- 4.2 M EUR for an administrative building and workshop for the maintenance of mining equipment
- 2.9 M EUR for the construction of roads and surface access infrastructure
- 11.9 M EUR for the mine ramp and underground infrastructure

- 5.7 M EUR for the construction of the ventilation shaft, general ventilation and associated equipment

In the Financial Model in year 4 a capital cost of 3.7 M EUR is also included for the construction of a backfill plant and associated infrastructure within the mine to enable the storage of roasted leached product in the cavities produced by the mining operation. The mining capital cost excludes the cost of mining drilling equipment, front end loaders and haul trucks as these are included in operating expenditure in the Financial Model.

21.1.2 Direct Capital Costs – Processing and Chemical Plant

The capital cost estimates for the Processing and Chemical plant are shown in *Table 91.* The process plant capital cost estimate is based on an on-site processing plant covering the following main processes to produce battery-grade lithium fluoride and includes all equipment:

- mechanical processing
- pyrometallurgy
- hydrometallurgy

The basic capital costs include the following indirect costs:

- Temporary construction facilities
- Transport expenses for permanent and temporary equipment and materials
- First fill reagents
- Spares

Table 91: Capital cost estimates for Processing and Chemical plant

Area	**M EUR**
Mechanical processing: equipment + installation + packaging + transport	16.3
Mechanical processing: building for mechanical processing plant	7.0
Pyrometallurgy: equipment + transport + packaging + erection + commissioning	25.9
Pyrometallurgy: buildings (steel construction) + civil works	8.0
Hydrometallurgy: equipment + installation + assembly + packaging + transportation	35.6
Hydrometallurgy: building	12.5
Total:	**128.2**

21.1.2.1 Mechanical Processing Plant

The mechanical processing capital cost estimate was developed by KÖPPERN. The initial capital cost is estimated at 23.3 M EUR and includes:

- 7.0 M EUR for the construction of the processing plant
- 5.1 M EUR for the crushing, drying and grinding circuits
- 4.8 M EUR for the magnetic separation circuit
- 2.5 M EUR for the loading and de-dusting circuits and
- 3.8 M EUR for installation and commissioning of the operational circuits and includes spare parts for the construction phase

21.1.2.2 Chemical Plant

The capital cost estimate for the chemical plant, which comprises the pyrometallurgy and hydrometallurgy circuits was developed by CEMTEC and AMPROMA. The initial capital cost for the chemical plant as whole is estimated at 82.0 M EUR and includes:

- For the pyrometallurgy circuit:
  - 8.0 M EUR for the construction of the pyrometallurgy plant building
  - 18.5 M EUR for the mechanical equipment and electrical infrastructure
  - 7.3 M EUR for the transport, erection and commissioning of the circuit, including all spare parts for the construction and commissioning phases

- For the hydrometallyrgy circuit:
  - 12.4 M EUR for the construction of the hydrometallurgy plant building
  - 30.1 M EUR for the mechanical equipment and electrical infrastructure
  - 5.5 M EUR for the transport, erection and commissioning of the circuit, including all spare parts for the construction and commissioning

21.1.3 Property and General On-Site Infrastructure

The cost estimate for the purchase of property and the construction of general on-site infrastructure was developed by DL in conjunction with BBF. The initial capital cost is estimated at 10.6 M EUR and includes:

- 3.3 M EUR for the purchase of the land in Freiberg to house the processing and chemical plants and includes the cost of dismantling any existing buildings

- 2.9 M EUR for the construction of offices, canteen, changing areas and other general administrative infrastructure
- 3.7 M EUR for the on-site cooling plant for the processing and chemical plants

21.1.4 EPC and Project Management

Engineering, project management, project controls, procurement and contracting, and site construction management (EPCM) costs have been developed based on the planned construction and commissioning timetable and expected engineering deliverables. These costs include the estimates for the engineers' detailed design work. In general, the following assumptions have been included in the financial model for EPCM costs:

- 2 % of the basic capital cost for all equipment and the construction of buildings and general infrastructure
- 17 % of the basic capital cost for the processing and chemical circuits

21.1.5 Contingencies

Contingency refers to costs that will probably occur based on past experience, but with some uncertainty with respect to how and where it will be spent. These uncertainties are risks to the project that are often referred to as "known-unknowns". A cost contingency of 10 % of the total cost has been applied based on the total project costs.

21.1.6 Subsidies and Grants

In the European Union and Germany it is possible to get subsidies for industrial investments based on well established laws and precedents. DL estimates, that it will receive local grants and subsidies in the amount of 15.0 M EUR from the Free State of Saxony over the course of the construction period, on the basis of:

- small or mid-sized company at the start of the project execution
- the amount of capex will be in a range of 50 – 80 M EUR
- investment will take place in the sector of chemical processing
- investment will take place in the industrial sector of the former German Democratic Republic

21.1.7 Exclusions and Assumptions

The following items are specifically excluded from the estimate at this level of study:

- allowances for special incentives (schedule, safety or others)
- cost changes due to currency fluctuation and escalation
- force majeure issues
- finance charges and interest during construction
- sunk costs
- future scope changes
- mine closure and rehabilitation costs
- costs for community relations and services
- relocation or preservation costs, delays and redesign work associated with any antiquities and sacred sites
- all costs associated with weather delays including flooding or resulting construction labor stand-down costs

The following assumptions underlie this estimate:

- the design is as detailed in the relevant sections of this report
- suitably qualified and experienced construction labor will be available at the time of the project execution
- no extremes in weather will be experienced during the construction phase and as such no allowances are included for flooding or construction labor stand-down costs
- geotechnical design data was partly assumed due to the lack of geotechnical information at the proposed plant site and the access road corridor in Altenberg
- gas turbine power station and gas supply pipeline are supplied by the local vendor

21.2 Operating Costs

The operating cost estimate uses prices finalized in Q1 2019 and is considered to have an accuracy of ± 10 %. All costs have been attributed to the production of battery-grade lithium fluoride. The chemical circuits produce a by-product of potassium sulfate (“SOP"), which can be sold as a potash fertilizer, and the financial model treats this as co-product credit revenue with no associated direct costs. *Table 92* summarizes the average overall operating costs per tonne of LiF produced over the 30 year life of mine plan of the Financial Model.

The operating cost estimate has been compiled by DL supported by eXnet and is based on the basic estimates received from:

- G.E.O.S. for mining operating costs
- KÖPPERN for mechanical process operating costs
- CEMTEC for pyrometallurgical operating costs
- AMPROMA for hydrometallurgical operating costs

Table 92: Operating Costs per tonne LiF – 30 year average

Category	**EUR/t LiF**
Mining	2,525
Mechanical Processing	2,699
Chemical Processing	7,448
Environmental and Central	386
Total Direct Operating Costs per tonne	**13,058**
G&A	607
Total Cost per tonne	**13,665**

21.2.1 Mining Operating Costs

The mining operating costs have been calculated based on a mixture of leased and owner operated equipment to accomplish the mine production schedule. It includes the maintenance of mine infrastructure and work areas, the re-handling of backfill material from the temporary stockpiles and the maintenance of equipment. The following table summarizes the average overall mining costs over the 30 year life of mine plan.

Table 93: Average annual Mine Operating Costs over 30 year mine plan

Category	**M EUR/a**
Costs of material and services	9.7
Personnel expenditure	3.3
Rentals & leasing costs for mine equipment	1.7
Administration (allocated to “Mining”)	0.8
Total	**15.3**

Mining Costs comprise four main categories:

- Costs of material and services includes:
  - 1.8 M EUR p.a for electricity based on quotes from local power supplier ENSO (0.1283 EUR/kWh)
  - 2.0 M EUR p.a. for equipment maintenance and wear costs based on the recommendations of the mining equipment manufacturers, which equates to 20 % of the cost of mining equipment. It also includes the costs of ongoing spare parts.
  - 1.9 M EUR p.a. for explosives based on quotations and calculation by G.E.O.S.
- Personnel expenditure is based on the labor headcount and paremeters detailed in *Table 94* below. It is based on labor rates of the organization VBGU using “Tarifvereinbarung des Verbandes Bergbau, Geologie und Umwelt (VBGU)” and the following assumptions:
  - Shift system is a Monday to Friday 3 shift system with 8 hours per shift
  - Day shift will work 8 hours
  - burdens and other labor costs included at 30 % of the base salary

- 1.7 M EUR p.a. for the lease of mining equipment and machinery

- 22 % allocation of general administrative costs based on the relative proportion of total direct costs that relate to mining operations.

Table 94 summarizes the maximum number of mine workers. In total, 71 employees will work in the mine and mining administration.

Table 94: Mining Labor at full capacity

Job Title	Sector	Number
Foreman	Industrial	3.0
Miner (Digger)	Industrial	20.0
Auxiliary staff	Industrial	4.0
Driver	Industrial	12.0
Mechanic, electrician	Industrial	12.0
Blaster	Industrial	8.0
Head of mine	Mining	1.0
Geologist	Mining	1.0
Mine engineer	Mining	1.0
Facility manager	Mining	1.0
Lab assistant	Mining	1.0

Job Title	Sector	Number
Backfilling	Mining	6.0
Office	Industrial / Mining	1.0
Total		**71.0**

21.2.2 Process Plant Operating Costs

Table 95 summarizes the average overall beneficiation and mechanical processing costs over the 30 year life of mine plan.

Table 95: Average Annual Mechanical Processing Operating Costs over 30 Year Mine Plan

Category	M EUR/a
Costs of material and services	12.3
Personnel expenditures	1.5
Admin (allocated to "Mechanical Processing")	0.7
Total	**14.5**

Mechanical processing costs comprise three main categories:

- The costs of material and services in *Table 95* include:
  - 5.9 M EUR p.a. for the disposal of quartz sand tailings to various domestic German end users
  - 2.2 M EUR p.a. for electricity and gas costs – further details on consumption parameters are included in *Table 99* below
  - 3.0 M EUR p.a. for the transportation of mined ore to the processing plant

- Personnel expenditure is based on the labor headcount and parameters detailed in *Table 96* below. It is based on labor rates of the "Tarifvertrag OST - IGBCE November 2017" – the official document negotiated between the union IGBCE and the chemical industry and the following assumptions:
  - Shift workers work 8 h shift, 5 days (Monday to Friday) 24 h system
  - Day workers 8 h Shift, Monday to Friday
  - Burdens included at 30 % of the base salary

- 21 % allocation of general administrative costs based on the relative proportion of total direct costs that relate to mechanical processing operations

Table 96: Mechanical Processing Plant Labor

Job Title	Sector	Number
Measuring station / Control Station / Operator	Industrial	5.0
Electrician	Industrial	5.0
Mechanics / Filter	Industrial	10.0
Shift supervisor / Foreman	Industrial	5.0
Logistics	Industrial	5.0
Operating Engineer	Process	1.0
Total		**31.0**

21.2.3 Chemical Plant Operating Costs

*Table 97 s*ummarizes the average overall chemical operating costs over the 30 year life of mine plan.

Table 97: Average Annual Chemical Operating Costs over 30 Year Mine Plan

Category	M EUR/a
Costs of material and services	34.8
Personnel expenditures	3.5
Admin (allocated to "Chemical Processing")	2.0
Total	**40.0**

Chemical Costs comprise three main categories:

- The costs of material and services in *Table 97* include:
  - 8.4 M EUR p.a. for electricity and gas costs in the pyrometallurgical circuit and 3.6 M EUR p.a. in the hydrometallurgical circuit. Further details on consumption parameters are included in *Table 99* below.
  - 1.6 M EUR p.a. on maintenance, including ongoing spare parts. It has been estimated at 3-5 % of capital cost by area and based on costs in similar plants and advice from equipment manufacturers.
  - 1.4 M EUR p.a. for the disposal of tailings of the roasting and leaching processes initially to external sites and then to be stored in the back-fill areas within the mine.
  - 4.3 M EUR p.a. for reagents used in the pyrometallurgical plant. Further details on consumption parameters are included in *Table 98* below.

  - 6.6 M EUR p.a. for the use of consumption of hydrofluoric acid and 7.6 M EUR p.a. for the consumption of potassium hydroxide in the hydrometallurgical plant. Further details on consumption parameters are included in *Table 99* below.

- Personnel expenditure is based on the labor headcount and parameters detailed in Table 98 below. It is based on labor rates of the “Tarifvertrag OST - IGBCE November 2017” – the official document negotiated between the union IGBCE and the chemical industry and the following assumptions:
  - Shift workers work 8 h shift, 7 days, 24 h system
  - Day workers 8 h Shift, Monday to Friday – hydrometallurgical plant only
  - Burdens included at 20 % of the base salary

- 21 % allocation of general administrative costs based on the relative proportion of total direct costs that relate to mechanical processing operations

Table 98: Chemical Processing Plant Labor

Job Title	Sector	Number
Control station (roasting + chemistry)	Industrial	5.0
Operator roasting	Industrial	5.0
Shift supervisor roasting	Industrial	5.0
Technical service + maintenance roasting	Industrial	10.0
Logistics operator roasting	Industrial	5.0
Lab assistant QA roasting	Process	5.0
Engineer QA roasting	Process	1.0
Manager logistics roasting + chemistry	Admin	1.0
Lab manager roasting +chemistry	Admin	1.0
Office roasting + chemistry	Admin	1.0
Logistics operator chemistry	Industrial	5.0
Shift supervisor chemistry	Industrial	5.0
Technical service + maintenance chemistry	Industrial	5.0
Operator chemistry	Industrial	5.0
Lab assistants QA day shift chemistry	Process	5.0
Lab assistant QA chemistry	Process	5.0
IT roasting + chemistry	Admin	1.0
Chemist process QA	Process	1.0
Chemist R&D + QA	Process	1.0
Total:		**72.0**

21.2.4 Power Consumption and Costs

The power consumption (*Table 99*) has been calculated for the mine, mechanical processing plant and chemical processing plant based on the installed equipment (i.e. excluding standby equipment) multiplied by the load factor. The power consumption is included in the basic engineering documentation as well.

The unit power cost used was received from the local power supplier in Altenberg (ENSO) and Freiberg (Freiberger Stadtwerke). DL has reduced these unit power costs by the EEG-discount-act because of the fulfilled criteria (power consumption and percentage of costs). However, this has to be confirmed by the authorities.

- Mine in Altenberg: 0.1283 EUR/kWh
- Mechanical processing and chemical processing in Freiberg: 0.1059 EUR/kWh

Table 99: Project Power Consumption and Cost – Summary

Area	Base Parameter	Units - kWh	Cost per EUR/kWh	Average Annual Consumption - kWh
Mine	Fixed Costs		0.128	10,731,088
Mechanical Processing (Electricity)	Per mined tonne	15.5	0.106	8,887,110
Mechanical Processing (Gas)	Per mined tonne	80.0	0.028	45,868,956
Pyrometallurgy (Electricity)	Per tonne ZWD Concentrate	202.4	0.106	25,183,744
Pyrometallurgy (Gas)	Per tonne ZWD Concentrate	1,639.4	0.028	203,970,744
Hydrometallurgy (Electricity)	Per tonne LiF	6,323.9	0.106	32,328,202
Hydrometallurgy (Gas)	Per tonne LiF	1,310.9	0.028	6,701,467
Environmental (Electricity)	Per tonne LiF	1,194.7	0.106	6,107,104

21.2.5 Process Plant Reagent and Consumable Costs

Reagent consumption costs were based on test work consumption rates and process design calculations, where available. Where reagent usage data was not available from test work, consumption rates from the experience of G.E.O.S., KÖPPERN, CEMTEC, ERCOSPLAN and AMPROMA were used (*Table 100*).

Table 100: Annual Reagents and Consumables Operating Cost Estimate

Area	Base Paramter	Units - Tonne	Costs EUR/t	Average Annual Consumption - Tonnes
Recycling Gypsum	Per tonne ZWD Conc.	0.20	19.5	24,884
FGD Gypsum	Per tonne ZWD Conc.	0.26	17.1	32,349
Limestone powder	Per tonne ZWD Conc.	0.40	29.0	49,768
Calcium hydroxide	Per tonne ZWD Conc.	0.03	238.0	3,583
Hydrofluoric acid	Per tonne LiF	0.76	1,700.0	3,897
Potassium hydroxide	Per tonne LiF	2.15	690.0	10,992

21.2.6 General and Administration Operating Costs

General and Administration include finance, human resources, health, safety, R&D and environment staff as itemized below in *Table 101.* It also includes items such as software licenses, mobile equipment, etc.

Table 101: Administration Labor Summary

Job Title	Sector	Number
Administration		
Chief Executive Officer (CEO)	Admin	1.0
Chief Financial Officer (CFO)	Admin	1.0
Personal of acc. / HR / Purch / IT	Admin	5.0
Office	Admin	1.0
Subtotal		*8.0*
Distribution and Marketing		
Personal of D&M	D&M	1.0
Office	D&M	0.5
Subtotal		*1.5*
Total		**8.5**

22 Economic Analysis

An analysis of the projected capital expenditures, revenues, operating expenses and corporate taxes was prepared on an annual basis to determine the estimated pre- and post-tax cashflows from the Project.

The economic analysis assumes the Project is 100 % equity financed. The economic analysis includes the project life comprising 18 months of detailed engineering and construction, followed by 3 months of commissioning and thereafter approximately 30 years of operation as per mine plan developed by G.E.O.S. This economic analysis solely realizes to costs and revenues incurred from the commencement of construction on for the 30 year mine plan. Any historic costs incurred by DL, such as exploration, technical studies and permitting are not included.

The key inputs to the economic analysis are shown in *Table 102:*

Table 102: Key Inputs for Economic Analysis

Category	Units	Value
Lithium fluoride (LiF) Price	EUR/t LiF	22,000
K_2SO_4 Price	EUR/t K_2SO_4	500
Hydroflouric acid (HF) Price	EUR/t HF	1,700
Potassium hydroxide (KOH) Price	EUR/t KOH	690
Mechanical Process Recovery rate	%	92
Chemical-Roasting Recovery rate	%	87
Chemical-Chemical Recovery rate	%	95
Corporate Tax Rate	%	30.9

The average annual revenue (total) is 128.4 M EUR over the 30 years of operation. Average annual earning before interest, taxes and depreciation is 58.5 M EUR. German federal income tax depreciation and percentage depletion rules were applied to the appropriate capital assets and income categories to calculate the regular corporation tax burdens. A basic corporation tax rate of 30.9 % has been assumed together with a 100,000 EUR/a Mining Royalty Tax due to the Government of Saxony. The Project annual cash flow is shown in *Table 103*.

Table 103: Project Annual cash flow – Summary

Category	Unit	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7 - 32
Stage of Operations		Life of Mine	Con-struction	Con-struction & Comis-sioning	Ramp-up of Produc-tion	Full Produc-tion	Full Produc-tion	Full Produc-tion	Average
LiF	t	153,821.2	-	460	4,411	5,119	5,125	5,129	5,138
K_2SO_4	t	961,382.5	-	2,875	27,568	31,992	32,034	32,058	32,110
Total Reve-nue	M EUR	3,859.2	-	9.8	107.7	128.4	128.8	128.9	129.1
OPEX	M EUR	2,113.5	0.8	16.8	59.2	67.6	68.3	68.8	70.5
CAPEX	M EUR	177.6	113.2	45.7	0.5	4.2	0.5	0.5	0.5
Pre-tax Cash Flow	M EUR	1,559.2	(107.1)	(63.7)	41.5	56.6	60.0	59.6	58.2
Pre-tax NPV (8 %)	M EUR	427.8							
Post-tax Cashflow	M EUR	1,073.5	(107.1)	(63.7)	33.8	41.5	45.1	44.9	41.5
Post-tax NPV (8 %)	M EUR	270.0							

The project is currently estimated to have a payback period of 6.1 years. The economic analysis indicates a pre-tax Net Present Value (NPV), discounted at 8 %, of approximately 427.8 M EUR with an Internal Rate of Return (IRR) of approximately 27.4 %. The post-tax NPV is approximately 270 M EUR and the post-tax IRR is 21.5 %.

A sensitivity analysis on the base case NPV at different discount rates is shown in *Table 104.*

Table 104: Sensitivity Analysis Discount Rate Impact (k EUR)

Discount Rate	Base Case Pre-Tax NPV	Base Case Post-Tax NPV
0 %	1,559.2	1,073.5
2 %	1,093.5	743.7
4 %	785.3	524.9
6 %	575.2	375.3
8 %	427.8	270.0
10 %	321.5	193.8

A sensitivity analysis has been conducted to determine the effect on post-tax NPV (8 %) of 270 M EUR and post-tax IRR of 21.5 % from the base LiF price, operating cost and capital costs. Variations from +30 % to -30 % for each have been used in modelling. The analysis shows the

Project is significantly more sensitive to the lithium fluoride price than it is to CAPEX or OPEX. As shown in *Table 105* and *Figure 123* an increase of 30 % in the average lithium fluoride price, from 22,000 EUR/t to 28,600 EUR/t, increases the post-tax NPV from 270.0 M EUR to 510.7 M EUR.

Table 105: Sensitivity Analysis post-tax NPV (8 %, MEUR)

Difference	LiF - Price	Operating Costs	Capital Costs
-30 %	30.0	402.1	310.9
-20 %	109.9	358.1	297.1
-10 %	189.8	314.1	283.3
Base	270.0	270.0	270.0
10 %	349.7	225.7	256.2
20 %	429.9	181.9	242.9
30 %	510.7	138.0	229.1

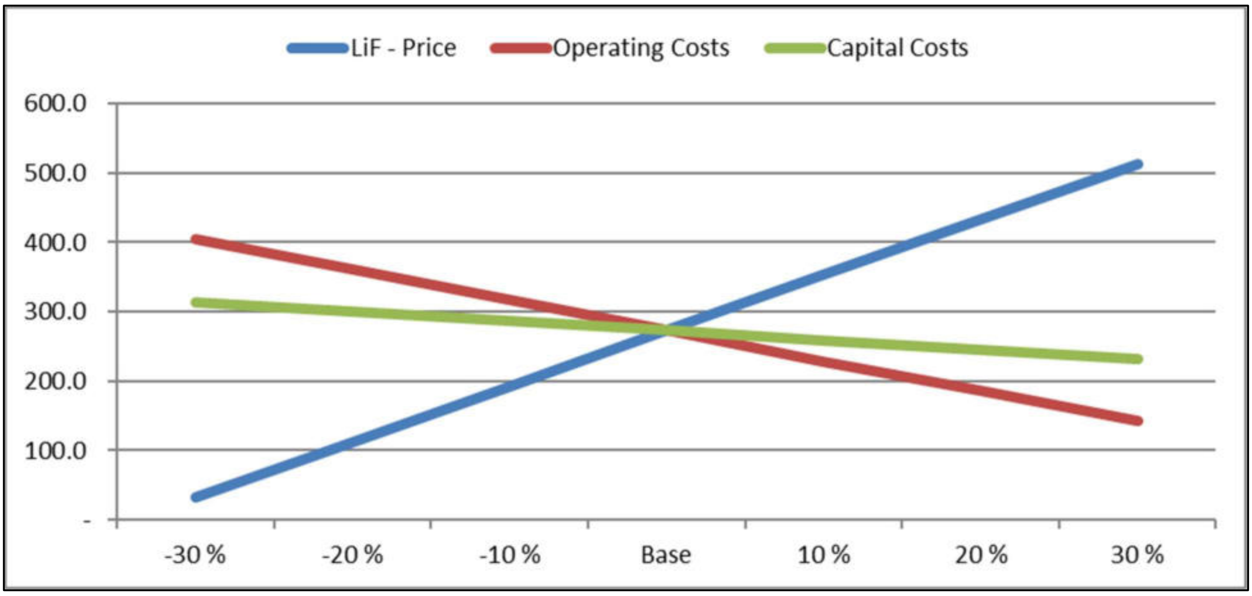


Figure 123: Sensitivity Analysis on post-tax NPV

A decrease of 30 % in the average lithium fluoride price, from 22,000 EUR/t to 15,400 EUR/t, decreases the post-tax NPV (8 %) from 270.0 M EUR to 30 M EUR. As shown in *Table 106*, an increase of 30 % in the lithium fluoride price to 28,600 EUR/t increases the post-tax IRR to 31.2 %, while a decrease of 30 % in the lithium fluoride price to 15,400 EUR/t decreases the post-tax IRR to 9.8 %.

Table 106: Sensitivity Analysis post-tax IRR (%)

Difference	LiF - Price	Operating Costs	Capital Costs
-30 %	9.8 %	27.1 %	28.1 %
-20 %	14.1 %	25.3 %	25.4 %
-10 %	17.9 %	23.4 %	23.2 %
Base	21.5 %	21.5 %	21.5 %
10 %	24.8 %	19.5 %	19.9 %
20 %	28.0 %	17.5 %	18.6 %
30 %	31.2 %	15.4 %	17.4 %

23 Adjacent Properties

Located north of the Zinnwald property, the Deutsche Lithium GmbH possesses the exploration license “Falkenhain” with an area of 2,957,000, m^2. This license was granted on the 18th of December 2017 according to the German Mining Law (BBergG § 7) for cesium, gallium, germanium, gold, indium, lanthanum and lanthanoids, lithium, molybdenum, niobium, rubidium, scandium, silver, tantalum, bismuth, tungsten, yttrium, zinc, and tin. It represents, however, basically a lithium target. The permission is limited until the 21st of December 2022.

Furthermore the Deutsche Lithium GmbH applied for the exploration license “Altenberg DL” according to German Mining Law (BBergG § 7) for the same elements in an area of 42,252,700 m^2, directly bordering in the East, North and West of its mining license “Zinnwald”. This license is closing the gap in the area between the mining property “Zinnwald” and the exploration license “Falkenhain”. It represents another lithium target. This license was granted on the 07th of March 2019 and is valid until the 15th of February 2024.

The Falkenhain tenement is surrounded by the exploration license “Hegelshöhe”, which was granted on the 12th of January 2018 to Trilithium Erzgebirge GmbH München / Germany (Trilithium), which is an affiliate of Lithium Australia NL. In addition, Trilithium owns the exploration permit of the Sn-Li target Sadisdorf, which is located NW of Hegelshöhe. Sadisdorf was acquired by Trilithium from Deutsche Rohstoff AG, Heidelberg / Germany in 2018. In March 2019 Trilithium has announced a PFS for the Sadisdorf deposit.On the territory of the Czech Republic, close to the German Zinnwald property, Geomet s.r.o., a wholly owned subsidiary of European Metals Holding Limited, West Perth / Australia, controls the exploration and preliminary mining licences over the Cínovec lithium / tin project. A preliminary feasibility study was completed in 2017.

24 Other Relevant Data and Information

24.1 Implementation Schedule

The Company is continuously in contact with the authorities in Altenberg and Zinnwald (mayor, municipal council) to update the information on the Project. Furthermore, DL has informed the inhabitants of Zinnwald and Altenberg about the project via newspapers and information meetings. Over the next months, the Company will push the Zinnwald Lithium Project through the project development stages and complete a detailed engineering in Q2 2021. The following preliminary indicative timetable is proposed:

- Q2 2019: finalize NI 43-101, FS / BFS
- Q2 2020: update NI 43 101
- Q2 – Q4 2020: financing and fund raising period
- Q3 2020: update NI43-100
- Q1 2021 – Q2 2021: EPC bidding process
- Q2 2021: commence detail engineering
- Q4 2021: commence long lead equipment procurement
- Q1 2022: commence site preparation works
- Q4 2023: commence commissioning
- Q2 2024: ramp up

Table 107 summarizes the manufacturing duration of the long lead items identified by this FS.

Table 107: Manufacturing Duration of the Long Lead Items

Equipment Package and Site Preparation	Lead Time EXW (weeks)
Ramp	112
Ventilation Shaft	50
Mineral Processing Equipment	50
Rotary Kiln	56
Evaporator and Crystallizer	44

24.2 Ramp-up Schedule

The Zinnwald ramp-up schedule was based on the experience of the companies, which have prepared the basic engineering, and of external consultants.

Mining:

- G.E.O.S. Ingenieurgesellschaft mbH
- Prof. Wolfgang Schilka (former managing director of EFS – Erzgebirgische Fluss- und Schwerspatwerke)
- Prof. Dr. Egon Fahning (former professor for underground mining at Technical University Bergakademie Freiberg)

Mineral processing:

- Richard Gowans (CEO of Micon International Ltd.)
- Dr. Henning Morgenroth (CEO of UVR-FIA)
- KÖPPERN

Pyrometallurgy:

- CEMTEC: 6 months from ramp-up to 100 % after complete installation of the equipment [177]
- Richard Gowans (CEO of Micon International Ltd.)

Hydrometallurgy:

- AMPROMA
- ERCOSPLAN
- EVATHERM

The Zinnwald Lithium Project can be characterized by the following criteria:

1. Technology development (Existing or new technology)

The Zinnwald lithium processing plant consists of components of an existing technology, some of which have limited use on an industrial scale in the lithium processing industry. However, the technology is established and used in other industries.

Components of the mineral processing are state of the art. Dry high-gradient magnetic separation has not previously been used in beneficiation of lithium ore but is utilized in other industries. The roasting technique is utilized in other industries but has not previously been used in a lithium fluoride plant. Evaporators and crystallizers are typically used for the recovery of alkali sulfates. Lithium fluoride precipitation is used in existing lithium fluoride plants using aqueous solutions of lithium carbonate and hydrofluoric acid.

2. Test work (Limited pilot plant testing with 50 t Ore, 10 t concentrate and 2 t roast)
Bench scale and bulk scale test work has been carried out to optimize the performance.

3. Process Design (Standard equipment and sizes selected)
The process design has been prepared by well-experienced companies. The process itself incorporates mixed batch and continuous sequences. Materials of construction are more complex than average. Because of the well-developed industrial area in Saxony there will be favorable options to acquire experienced operation personnel for the processing and pyrometallurgical plants.

4. Flowsheet (Complex multiproduct hydrometallurgical circuits with a minimum of plants in operation)
The Zinnwald-Lithium flowsheet is considered to represent a complex hydrometallurgical plant with simple basic operations.

5. Project development (No shortcut in study work, i.e. PFS and FS completed prior to working out the design details)
The Project is developed with the help of adequate study phases to detail the design without shortcuts. The ramp-up schedule of the Project is:

- Ramp-up production period: 12 months
- Production quantities per quarter: Q1: 40%
Q2: 70%
Q3: 85%
Q4: 95%
- After the first 12 months 100% in year 2 and onwards

25 Interpretation and Conclusions

The following notes describe the key interpretations and conclusions as well as risks and opportunities identified in the FS that need to be considered during the further project execution.

The results of this study confirm the development of a 573,362 t/a underground mine with a mine life for more than 30 years, followed by mechanical processing (crusher and magnetic concentrator) and the installation of a lithium fluoride production plant in Freiberg / Germany with a nominal capacity of 5,112 t/a lithium fluoride (equivalent to 7,285 t/a LCE or 8,274 t/a $LiOH \cdot H_2O$) and 31,950 t/a potassium sulfate as by-product. The magnetic concentrator produces 124,420 t/a mica concentrate.

The Zinnwald Lithium Project is substantial in size with apotential to produce 150,000 t of lithium fluoride over a timespan of 30 years. It has a robust average grade compared with the cut-off grade which suggests a potential to operate with a considerable profit margin.

25.1 Geology

The Project comprises the development of an underground mine for the extraction of lithium-rich greisen ores. These contain a combined Measured and Indicated Mineral Resource of 35.51 Mt with an rounded average grade of 0.35 wt.% Li or 0.75 wt.% Li_2O. The resource is calculated according to the following modifying factors:

- Cut-off grade lithium = 2,500 ppm
- Resource only below the “Tiefer-Bünau-Stollen” level (≤ 740 m a.s.l.)
- Vertical thickness of greisen beds ≥ 2 m
- Dry bulk density 2.7 t/m³

The mineral resources are reported in accordance with the Canadian Securities Administrators National Instrument 43-101 and have been estimated in conformity with generally accepted “Estimation of Mineral Resource and Mineral Reserves Best Practices Guidelines” of CIM.

Several previous exploration campaigns had already indicated the lithium mineralization in the German portion below the old Zinnwald / Cínovec underground mine, which ceased owing to the depletion of the tin and tungsten mineral resources. In the case of lithium, a first systematic exploration in Germany began in 1954. From 2012 on, SWS and its successor DL implemented a comprehensive data base and contributed to the verification of the data by its own drilling programs consisting of 25 drill holes and by underground channel sampling.

The geological model of ten parallel to subparallel stretching mineralized horizons emplaced along the cupola of the Zinnwald granite was demonstrated and improved. The interpreted greisen beds were used for digital construction of CAD sections of the conceptual geological model with SURPAC^{TM} (version 6.6). Anisotropic inverse distance interpolation was applied for the estimation of lithium resources within the greisen beds.

An authoritative mineral resource was assessed comprising inferred, indicated and measured categories. The potential of Sn, W and K_2O was estimated at a total volume of rounded 15 million cubic meters and a tonnage of 40 million tons of greisen containing approximate overall average grades of 500 ppm tin, 100 ppm tungsten and 3.1 wt.% potassium oxide.

At the present time significant risks with respect to the mineral resource have not been identified that would inhibit the development of the property. Minor risks are represented by the lack of reliable drill hole survey data, especially for data before campaign No. (7) and by inaccurate geochemical assays for data of exploration campaign No. (4). Uncertainties of the 3D modelled geological shapes of the greisen beds and the lack of a sufficient spatial data density, in particular for greisen beds with small extensions, prevent in places a geostatistical analysis in detail.

Solutions for mining and beneficiation of the Zinnwald lithium ore were successfully implemented. By assessing a mining technology, based on a common LHD supported room and pillar technology with subsequent backfill, the Mineral Resource was substantially transferred to a Mineral Reserve. The Mineral Reserve is part of the Mineral Resource and is therefore reported at a 2,500 ppm Li cut-off grade and below 740 m a.s.l. inside the German state territory. It considers mining loss by preparation and development work and is inclusive of diluting material. It is referenced as ROM ore delivered to the plant.

The Mineral Reserve consists of a Proven Mineral Reserve with 16.5 Mt of ore including dilution, which contains 51 kt lithium metal. This corresponds to 54 % of the total lithium metal reserve. The Probable Mineral Reserve accounts for 14.7 Mt of ore including dilution with a content of 43 kt lithium metal. It comprises 46 % of the total lithium metal reserve.

25.2 Mining

Since the completion of the PFS according to PERC in 2014, infill drilling has improved the confidence of the resource model mirrored by moving 87 % of the Measured and Indicated Mineral Resources into the Proven and Probable Mineral Reserve categories.

Geotechnical work has improved the reliability of underground mining especially with respect to the proven and probable reserves and the mine plan. Detailed basic engineering has improved the mine design and the design of the mine infrastructure on surface.

The key aspects for mining risks of the Project are:

The mining technology requires backfill of the mined-out portions of the deposit. The backfill is planned to consist of a mixture of "leached roasted product" tailings (177,000 t/a), lignite filter ash (62,500 t/a) as binding agent and water. The availability of lignite filter ash is expected to decrease significantly during mine life, as the German government will decide the gradual exit from lignite power production until 2038. Alternative sources for lignite filter ash can be found in Czech Republic or Poland. In addition, negotiations and contracts might be undertaken with the operators of the power generation plants to generate a sufficient stock pile of lignite filter ash, as they already do for FGD-gypsum. If not, lignite filter ash has to be substituted by cement, which will be more expensive and thus will have a significant impact on the opex structure of the mining operation.

According to the current state of the project, it cannot be assumed that enough water can be collected in the mine to produce the backfill suspension. Otherwise, additional water has to be provided from the service water pipe or from the "Tiefe Bühnau Stollen" addit.

If stricter emission limit values (EU Directives) should come into force, it may be necessary to adapt the ventilation concept and convert the LHD technology from diesel to electric drive [195].

During the course of the Project after the completion of the mine design, it became apparent that the project is economically more viable, when the mechanical processing plant is located at the site of the chemical processing plant. It was therefore decided that the ROM is directly loaded onto road-legal trucks within the mine and then transported to the central location of the processing plant in Freiberg. The dimension of the ramp allows the truck passage without any problem. However, the temporary storage of the ROM in appropriate bunkers as well as the loading has to be considered in more detail during the next planning step.

25.3 Process Plant

Flowsheet development and variability test work has shown that the process flowsheet is robust and stable at a feasibility level under technical conditions for the mineral processing steps and the pyrometallurgical tests and under semi-technical and laboratory conditions for hydrometallurgical steps. The ability to produce high pure lithium fluoride in a range of 99.0 to 99.5 wt.% and by-products has been confirmed. The target purity of lithium fluoride is comparable with the technical specifications of the market leader for lithium fluoride.

Although the project is considered viable, there have been risks identified that could impact delivery or economics. The key risks for beneficiation are:

- On-time delivery of critical packages (kiln, crystallizer / evaporator) still requiring design development work
- Adverse outcomes in the design development work for critical equipment packages may result in a detrimental cost impact, potentially linked to materials of construction for key components, especially for the hydrometallurgy plant.
- It could be necessary, that the quality of lithium fluoride has to be improved because of the demand of customers. Lithium fluoride with purity of 99.9 wt.% is on the market.
- Hydrofluoric acid is a significant contributor to the operating expense. The outcome of commercial pricing negotiations may have an impact on the forecast operating cost.
- Availability of anhydrite / gypsum for roasting process. The roasting technology requires anhydrite / gypsum, which is being supplied as FGD-gypsum (65,000 t/a) from nearby lignite power generation plants. The availability of FGD-gypsum is expected to decrease significantly during project live as the German government will decide the gradual exit from lignite power production until 2038. Although, the operators of the lignite power generation plants already have considered the economic meaning of FGD-gypsum and are currently building up stock piles, the security of supply remains questionable. Alternative sources for FGD-gypsum might be found in Czech Republic or Poland. Otherwise, gypsum / anhydrite must be substituted by recycled gypsum or natural resources which may have an impact on the opex structure of the pyrometallurgical plant.
- Production of different SOP qualities is variable and depends on process parameters. The designed capacity of the SOP crystallization circuit is 32,000 t/a.

25.4 Infrastructure

The FS has shown that the infrastructure required for the project can be delivered. The key risk aspects for the infrastructure are:

- Securing of real estates in Altenberg for the mine site and in Freiberg for the processing site can have significant impact on the project especially regarding the transportation opex.

- The deposit and the real estate for the mine site in Altenberg are located in an area which has been applied for UNESCO World Heritage. Based on letters and guarantees by the government of the State Saxony, the city of Altenberg and the National Heritage Authority there is no impact on the Project.

25.5 Environment

To-date, the project has already partly received and can expect to receive all necessary environmental permits and licenses.

They environmental key risks that may impact the project include:

- A delay of the water rights approval by the District Office (Landratsamt) may hold up the start of operations.
- The BImSchG – Permit process for the processing plant can delay the project by a late start of the necessary engineering work. A typical BImSchG – Permit process takes approx. 9 - 12 months. There is sufficient time for an application, if the engineering is finalized 6 months before the execution start of the project.

25.6 Lithium Fluoride Market

The market research has shown that the upcoming increase of EV's and the demands of the lithium battery market will lead to a strong increase of lithium fluoride demand. It is recommended to secure lithium fluoride off-take by signing supply contracts with potential customers. The release of the FS will provide the basis for the next stage of off-take negotiations.

26 Recommendations

The following subsections summarize the recommendations and the forward work plan for the Project.

26.1 Geology / Exploration

No further exploration is currently planned by the company following the completion of the Feasibility Study. Further work may be planned as part of the pre-production plan.

The Zinnwald lithium deposit is open to the west and at least one additional drill hole west of the hole ZGLi 11/2017 is recommended. Generally, the actual mineral resource categories can be upgraded by additional drilling due to the reduction of the drill hole distances. The potential of the Sn-W (Nb-Ta) mineralization in the meta-albite granite is worth to be furthermore investigated.

In order to ensure small-scale features, such as detailed ore body contours, grades, minor faults etc., an anticipatory exploration by drilling has to be undertaken underground during the development of the mine. This can be done during the excavation of the development adits within the respective mine fields. The drill spacing is yet to be confirmed and should fit to the size of the mining panel.

26.2 Mining

The actual planning status is sufficient to open the designed mine. To optimize the full project and to minimize further risks additional recommendations include:

- Based on the prepared basic engineering, it is recommended to start the EPC bidding process for the ramp and for the ventilation shaft separately.
- The tailings storage location agreements and tailings usage agreements are actually executed by non-binding Letters of Intention (LOI) with several companies. It is recommended to start binding contract negotiations directly after the start of the execution of the project.
- The landfill IAA Bielatal in close vicinity to the mine in Altenberg / Zinnwald is still a good option for tailings storage. Expert studies have been carried out with convenient results [88]. It is recommended to continue the negotiations with the state company LMBV as owner of the landfill IAA Bielatal to finalize the contracts [129].

- The backfilling procedure with the “leached roasted product” tailings is the only long-term storage opportunity for this material until now. The permit process at the mining authorities for intermediate storage of “leached roasted product” tailings and final backfill is ongoing. It is important to receive the permit before executing the project.
- The ground for the mine site in Altenberg is owned by the state company LMBV and by the town of Altenberg. Negotiations with both are ongoing to buy the real estates. It is recommended to finalize the negotiations and to sign the contracts as soon as possible.
- In addition, it is recommended that the subsoil investigations at the planned location of the mine portal have to be carried out precisely in order to better assess the subsoil situation and the associated effort for ramp construction.
- The ventilation concept should be optimized and secured by modelling [195]. It should also consider expected stricter limits (EU directives) regarding pollutant emissions (especially diesel exhaust gases).
- During the preliminary review of the facultative framework operational plan (fakultativer Rahmenbetriebsplan), it was pointed out that a border security post has to be developed to prevent the impact of the planned mining activity on the territory of the Czech Republic (CZ). Further discussions with the SOBA and the relevant authorities in CZ are necessary.
- Update of the underground logistics as it is intended to load the ROM directly from underground storage bunkers onto road-legal trucks.

26.3 Process Plant

The Test work carried out for the FS is sufficient and delivered all data to prepare the basic engineering. To optimize the full project, some test work is recommended to find out further cost reduction potential. The additional test work for optimization should focus on the following aspects:

- Test work production of 50 t ore sample (2nd part of 100 t sample 2017) to produce feed for kiln testing
- Test work to recover tin (cassiterite) and tungsten (wolframite) as additional by-product
- Test work to check whether a tunnel kiln will be better in process stability and cheaper as a rotary kiln
- Evaluation of in-house grinding of limestone chunks to flour with the aim to reduce cost for additives (OPEX)
- Test work to enhance the recovery rate to > 90 wt.% during the roasting and leaching process

- Test work to optimize the recipe for the roasting process (K_2SO_4 and limestone)
- Test work to improve the quality of LiF from 99.5 wt.% to 99.9 wt.% purity by reducing the $CaSO_4$ impurities
- Evaluation of beth method for lithium fluoride and potassium sulphate product analysis
- Check of Basic Engineering (BE) prepared by AMPROMA for SOP crystallization by K+S before EPC bidding process for SOP
- Test work for usage of “quartz sand” tailings for concrete and lime sand brick manufacturing
- Test work for usage of “leached roasted product” tailings for colored brick production

26.4 Infrastructure

It is recommended to negotiate and sign the following contracts before the start of execution of the project:

- contracts for real estate (LMBV, City of Altenberg) in the “Europark” Altenberg (mining portal) and the site of the ventilation shaft in Zinnwald (Sachsenforst)
- contract for real estate Choren in the industrial area “Saxonia” in Freiberg
- contracts for real estates in the industrial area “Saxonia” in Freiberg
- service contract for power, natural gas and steam with local power company in Freiberg
- supply contracts for HF, anhydrite, limestone, KOH

Furthermore, it is recommended to start the EPC bidding process for mineral processing, pyrometallurgy and hydrometallurgy based on the prepared basic engineering. It is recommended to negotiate one contract for pyro- and hydrometallurgy and one contract for mineral processing plant.

Application of BimSchG permits for the mechanical processing and metallurgical plants in Freiberg has to be started after finalizing the building design as base for the permission planning.

Application of Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) for potassium sulphate and lithium fluoride according to Regulation EG 1907/2006 should be conducted.

The electricity prices quoted in the financial model includes the exemption from the cost share under the energy feed-in law (Umlage nach dem Energieeinspeisegesetz - EEG). This exemption has still to be applied for. According to the current status of the project an approvement is expected.

26.5 Environment

In accordance with the German Mining Act (Bundesberggesetz - BBergG) an environmental impact assessment is not necessary for the Zinnwald Lithium Project ([37], [40]). The necessary additional environmental concerns were worked out as part of the preparation of the optional framework operating plan (fakultativer Rahmenbetriebsplan, see [142] and [156]).

Based on these results it is recommended:

- A site-wide project to count animals to be done from March to October and to be included in the construction permit / main operation plan § 52 ff. BBergG (Hauptbetriebsplan) for the mine site in Altenberg.
- To apply for a temporary water discharge permit for the discharge of the groundwater during the mine construction. This concerns the Hanggraben creek for the construction of the ramp at Altenberg, as well as the Aschergraben creek for the construction of the ventilation shaft in Zinnwald. Preparation and negotiation of environmental countervailing measures (Ausgleichsmaßnahmen) according the landscape conservation measures concept have to be done.

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