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Wolfsberg project of GREENPEG partner ECM – European Lithium advances

By Manfred Maxl & Dietrich Wanke, ECM; Claudia Pohl, terratec, Wolfgang Reimer, GKZ

The Wolfsberg underground mine project of European Lithium Ltd. in Carinthia (Austria) is one of the most developed lithium pegmatite exploration projects within Europe. This fact and its central position in the European Union well connected to potential consumers make this project quite unique. Close transporting, a local value chain (including the conversion plant) and high acceptance by the surrounding communities create a strong and positive feedback for the underground mining and metallurgic surface operations. The company is in the final stages of a resource extension drilling program and the finalisation of the definitive feasibility study that includes the metallurgical analysis of the proposed production process. Exploration at the Weinebene near Wolfsberg started in the 1980ies. At this time, amongst other reasons but mainly the lacking demand of lithium products was rendering the project not commercially viable. However, this has changed during the last years with the increasing demand for advanced electric storage capacity in the e-mobility sector. The demand for battery grade lithium products and the preference for local resources has made exploration essential again to develop the Wolfsberg project. The project aims to start production by 2023/2024 with an extraction of 800.000 tons of ore per annum and up to 10.000 tons of lithium hydroxide per annum with an estimated life-time of the mine of about 20 years. Further background information about the project is available on the fact sheets. ECM Lithium AT GmbH (ECM), the Austrian subsidiary of European Lithium Ltd., joined the GREENPEG project to share and gain further knowledge as well as extending the existing expertise contributing to and testing GREENPEGs toolbox, a new methodological approach on pegmatite exploration techniques. GREENPEG results will improve the knowledge on tracer minerals and related exploration methods on pegmatites and verify adjusted and advanced pegmatite exploration methods proven at demonstration sites of similar pegmatite hosted mineralisations in Spain, Portugal and Finland.

Photo: Bore hole logging at Wolfsberg (Source: terratec)

Despite limitations due to the Corona pandemic, exploration work at Weinebene continuously advances: In February 2021, an infill drilling campaign started, and is planning to obtain more than 8.000 m of core. This drilling operation as well as all other exploration work will be performed in accordance to the JORC code to ensure a high quality and transparent exploration results. This will provide more and advanced data to be used for GREENPEG investigations. The first field work under GREENPEG was carried out by Axel Müller and William Keyser from the Natural History Museum (University of Oslo) on the "halo – effect" of the lithium pegmatite mineralisation. For this type of study, whole rock samples have been taken from drill cores as well as the existing underground mine.

In the winter season 2020/2021 Freiburg-based GREENPEG Partner terratec GmbH conducted geophysical borehole measurements at the Wolfsberg site. Borehole logging allows for the geophysical-geochemical characterisation of the host rocks, the halos surrounding the pegmatites ore bodies and the pegmatite bodies themselves to facilitate the identification of undiscovered pegmatites in the future. This work investigates the geophysical 'fingerprint' of LCT-pegmatite hosted in amphibolite and mica schist which comprises the ore deposit geology at Wolfsberg. The measurements were taken at six historical borehole sites at depths between 20 and 290 m. A total of seven different state of the art probes were inserted into the boreholes using a winch. As result 16 physical-chemical rock parameters were determined (e. g. total count gamma ray, K_2O, U_3O_8, ThO_2, resistivity, conductivity, magnetic susceptibility, chargeability, acoustical and optical image). First results show that amphibolite hosted pegmatites give a clear positive total count gamma and often a positive K_2O anomaly while the magnetic susceptibility show a slightly negative anomaly. In contrast, no anomaly to negative anomalies of the total count gamma, K_2O and the magnetic susceptibility of the pegmatite ore can be observed within the mica schist hosted pegmatites. In the overall context of GREENPEG research the data will be used to refine results obtained with prospect and district scale geophysics to support the localisation of hidden pegmatites. The lithological and structural interpretation of this data refines the existing geological and tectonic model of the target which is essential for exploration companies. Furthermore, the data will be feed into the petrophysical database of European pegmatite ores and wall rocks.

In the middle of the pandemic in 2021 partners from GKZ Freiberg (Germany) visited the core shed and underground mine as part of the preparation of the first GREENPEG Focus Group Meeting. The two days´ event in September 2021 aims to introduce the public into the mine development in general and the GREENPEG project in special.

Photos: Top: Drilling operations at Wolfsberg Weinebene site
Right: "Sampling on pegmatites". (Source: GKZ)

Field work in Norway under Corona Conditions

By Carla Pueyo Lloret, UIO

Dr. Haoyang Zhou from UIO Natural History Museum visited 30 pegmatite localities covering an area of over 200 km^2 in the Tysfjord region in northern Norway. *'We determined the quartz pureness and crystallisation age of the pegmatites in Tysfjord. Surprisingly, it turned out that there are two generations of pegmatites in the area. The older pegmatites form large bodies, which are economically important due to large quartz cores (up to 100 m in diameter) of high-purity quality* (chemical impurity < 0.005%). *The younger generation of pegmatites are smaller and the quartz quality is not as good as the older pegmatites and, thus, are of no current economic potential.'* High-purity quartz is very rare in nature but is crucial for the manufactory of a suite of high-tech products like glass fibres, crucibles and glass tubes and pulps for special light applications. Over the duration of a week Haoyang collected a total of 80 quartz samples and additional rock samples to understand the origin and crystallisation of the pegmatites. The geochemical analyses of these quartz samples will reveal the volume and specific quality of the high-purity quartz resources in the pegmatite field from the prospect (<25 km^2) to district-scale (25-500 km^2) within the Tysfjord region. Haoyang measured the gamma radiation of the pegmatites and their host rocks, the Tysfjord granites, with a scintillometer.

'I was very excited. We discovered that the older pegmatites have radioactive halos of 10 to 20 meters around the pegmatite bodies. The first geochemical results from the lab match with the gamma radiation measured in the field. Concentrations of elements like uranium, thorium and lithium are higher in the halos than in the pegmatites. That is surprising.'

Haoyang is looking forward to discovering the mechanisms of the mobility of these elements during the formation of the halos, which will help us to develop more reliable geochemical strategies for the exploration of pegmatites. In the last evening of Haoyang's trip he enjoyed the tasty mushrooms he collected that grow on the Tysfjord pegmatites. Back home the experts will be working with the electron microprobe to determine the major element concentrations of the pegmatite-forming minerals in both regions.'

EuroGeoSurveys (EGS) Mineral Resources Expert Group research on CRM

by Daniel Olivera, MREG et. al.

CRM and Pegmatites

EuroGeoSurveys (EGS), the umbrella organization of the national geological services of the EU member states, is part of the research alliance made up of industry, science and specialist authorities that take on EGS with a view to CRM exploration. The geological services are a main target group for the methods developed by GREENPEG for the exploration of LCT (lithium-cesium-tantalum) und NYF (niobium-yttrium-fluorine) granitic pegmatites. These pegmatites, by the nature of their overall mineralogy, are potentially a zero-waste resource as everything in them can be used [3]. Pegmatite-hosted deposits are also important because most of their potential products are so closely linked to the production of green energy solutions. They are potentially enriched in Li, Rb, Cs, Be, Ga, Sn, Hf, Ta<>Nb, B, P, F and Y, REE, Ti, U, Th, Zr, Nb>Ta, F respectively [1,2]; approximately 30% of the raw materials identified in the latest EU CRM list. The mineral Resources Expert Group (MREG) of EuroGeoSurveys has been working on CRM for the past 15 years. The research undertaken was and is carried out within the EU-research grant programs. The MREG members and experts have also been used in EU consulting capacities on the CRM subject during this time, particularly when defining the CRM lists and often respond to requests by the EU Commission.

In 2016, the first European map of CRM was produced[9] and many EU-funded projects (e.g. EURARE [10], FRAME [11], MINDeSEA [12], SCRREEN1, 2 [13] and expert working groups, e.g. The European Rare Earths Competency Network (ERECON) [14], have delved into the subject of the CRM. SCRREEN2 will produce the next CRM map of Europe in the coming months. In the absence of salares for obtaining lithium in large quantities and at low cost from brines, Europe has inevitably turned its attention to pegmatite deposits. A reason why GREENPEG project was awarded funding in one of the last HORIZON 2020 exploration calls. The latest and most significant projects working on CRM EuroGeoSurvey MREG is partnering are FRAME [11] and MINDeSEA [12]; the former on land-based deposits and the latter on seabed deposits. Both are developing research under the umbrella of GeoERA Raw Materials [14]. The projects have already produced significant results that are feeding information into the European Geological Data Infrastructure[16] and to the EU Commission on the occurrences of the battery critical elements. Through the project consortium and the network of the MREG members, FRAME has compiled an up-to-date, homogenised data set on the energy critical elements with the contribution of countries who have previously not contributed data.

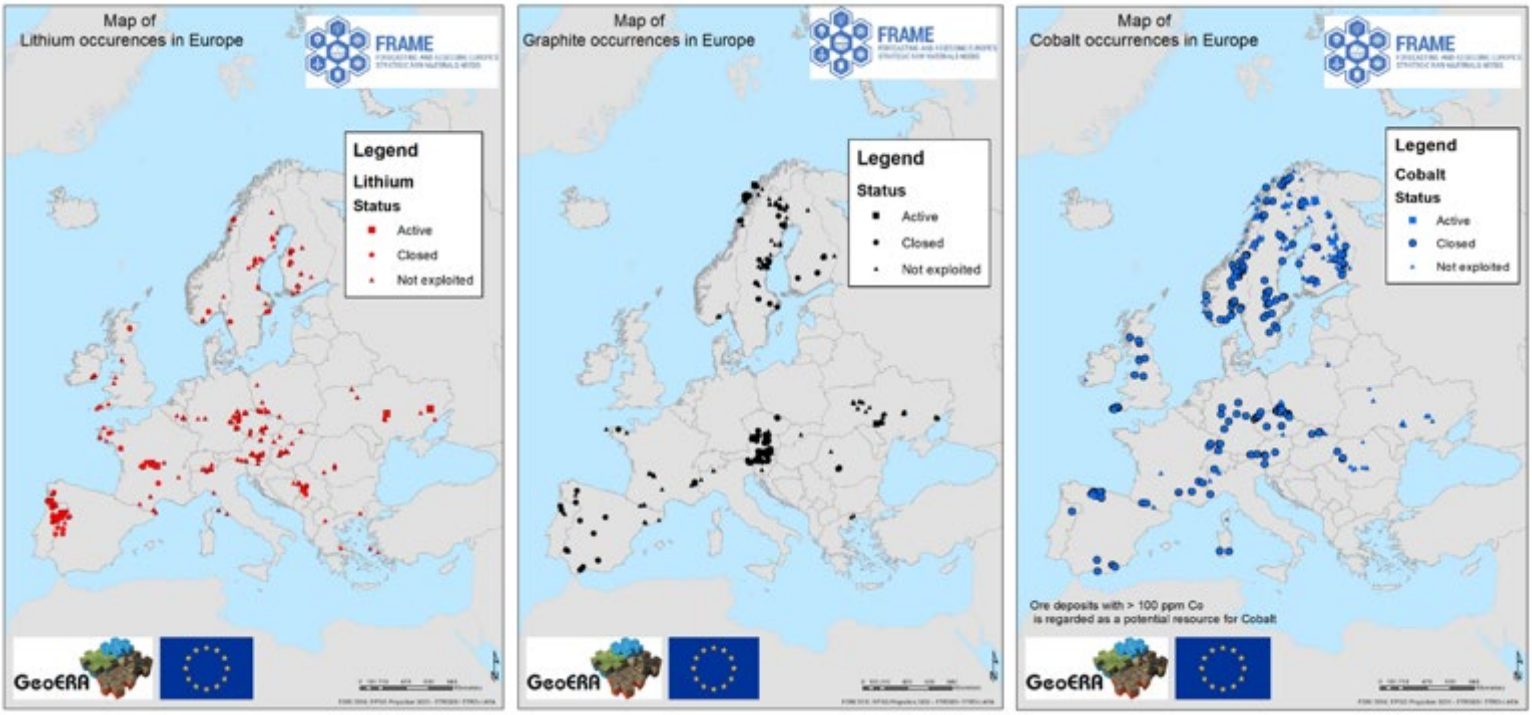

Fig. 1 – Energy Critical Element occurrences in Europe; results from FRAME WP5 research.

Current Nb-Ta research

To stem the trade in conflict minerals the EU has passed the Conflict Minerals Regulation [17] in effect from the 1st of January 2021. Under the new law EU importers of tin, tantalum, tungsten and gold will have to carry out due diligence on their resource supply chains. FRAME is undertaking a survey of the pan-European distribution of Nb-Ta mineralisation (focusing on the Iberian Peninsula and the Swedish part of the Fennoscandian Shield) to enhance their exploration interest and potential in order to produce them ethically and indigenous to the EU.

In the Iberian Peninsula, primary Nb-Ta mineralisations are genetically associated with peraluminous granites and granitic LCT-type pegmatite fields in varying geological environments [18] within the Variscan Galicia Trás-os-Montes and Central Iberian Zones. The LCT-type pegmatites generally occur as small dykes or irregular bodies characterised by variable grain size. They are concentrically and irregularly zoned, typically showing a thin border zone, a wall zone, an intermediate zone, an albite zone and a massive quartz core. Mineralisation is concentrated in the intermediate to albite zones and consists of minerals of the columbite, ixiolite and microlite types. There is also placer-type mineralisation close to the primary mineralisations [21]. In the Fennoscandian Shield, a majority of the known Nb-Ta mineralisations are hosted by rare metal pegmatites which mainly intruded late- to post-metamorphic with respect to the Svecokarelian Orogeny (c. 2.0–1.8 Ga).

In Sweden, the most important regions with Nb-Ta and Li-mineralised LCT-type granitic pegmatites are the eastern part of the Skellefte district in northern Sweden, the Västernorrland area in central Sweden, and the eastern Bergslagen province with the Stockholm area in southeast central Sweden [23]. The major LCT-pegmatite fields are located within low to medium-grade metamorphosed Svecofennian c. 1.9 Ga meta(volcano-)sedimentary successions of the Bothnian Basin, and associated with parental late-Svecokarelian, c. 1.8 Ga S-type granites [23, 24]. The dominating host minerals for Nb-Ta are (*s.l.*) columbite-tantalite and microlite-pyrochlore, as well as Nb-Ta-enriched cassiterite [21]. Overall, the areas with known LCT-type granitic pegmatites in the Bothnian Basin are very variable with regards to

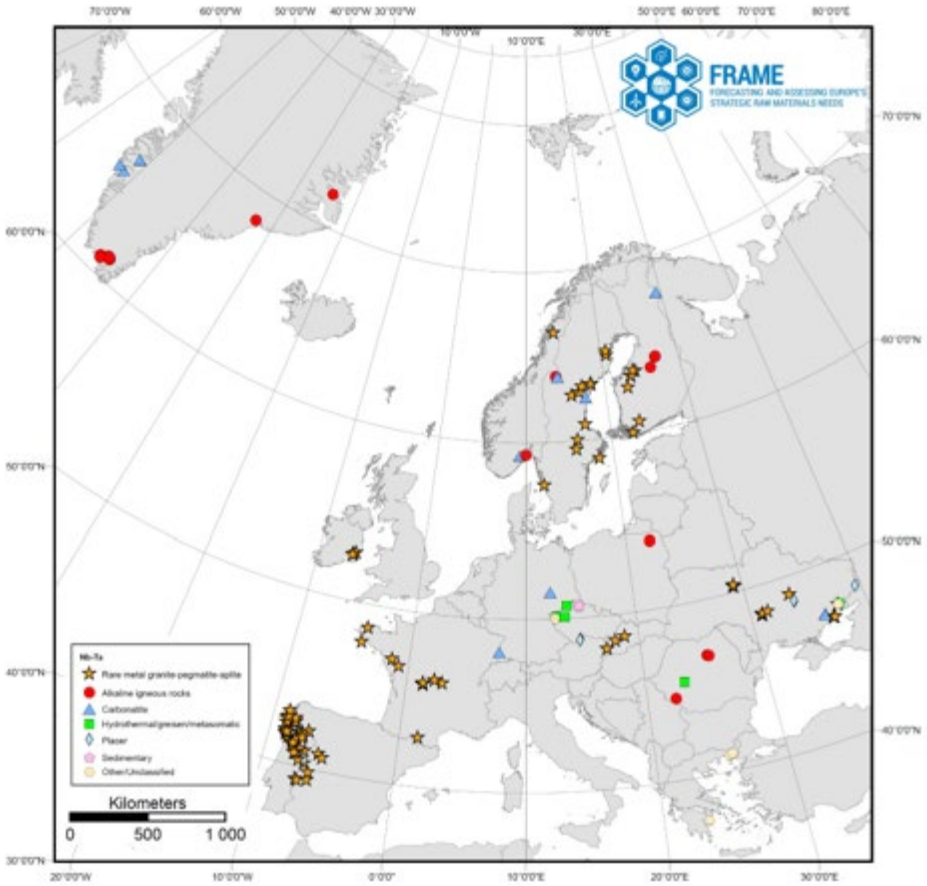

Fig. 2 – Nb and Ta mineralisations compiled by project FRAME [21].

this was mainly focused on quartz and feldspar, but locally and on a small scale, also Nb-Ta oxides were recovered [22]. Of all known pegmatites in this district, only the major Rosendal dyke system, carrying locally abundant and coarse Nb-Ta oxides such as tantalite and tapiolite (*s.l.),* has a resource estimate (historic non-compliant estimate) of 1.3 Mt at 0.021 % Ta, 0.014 % Be and 0.08 % Sn [22].

Predictability maps are based on geological features, so they provide a "geological favourability". They do not consider economic aspects nor do they presume economic viability of any future discovery. FRAME is also undertaking data driven predictability mapping of these pegmatite-hosted minerals (but not only) using the Cell Based Analysis computational method. The homogenised dataset allows for applying mathematical models to predict the next spots where mineralisation is likely to occur (e.g., Fig. 2).

Predictability maps are based on geological features, so they provide a "geological favourability". They do not consider economic aspects nor do they presume economic viability of any future discovery. Nevertheless, they provide much needed and valuable information of areas favourable for the discovery of new occurrences and thus exploration to further prove their mineral potential [21].

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bedrock exposure and must be considered as under-explored, having potential for both new findings and the development of known occurrences, perhaps most likely as combined Li-Ta-(Nb-Sn) deposits.

Several types of NYF-type granitic pegmatites also occur and are locally enriched in Nb-Ta minerals. The NYF pegmatites, however, overall have much less economic potential than the LCT-type. Sweden has no documented history of Nb-Ta mining, except for some smaller-scale extraction during operations at the Varuträsk pegmatite from 1937 to around 1951 [25].

The central and southern part of Finland hosts several LCT pegmatite fields of which many have been explored by the Geological Survey of Finland (GTK) as well as exploration companies. A recent quantitative assessment of undiscovered resources survey by GTK [19] indicated that 90% of the undiscovered lithium resources in Finland are located within either the Kaustinen permissive tract or the surrounding larger Järvi-Pohjanmaa tract. Although these pegmatites have primarily been targeted for their Li potential, some of these may also be interesting in terms of Ta and associated Nb. The c. 1.8 Ga granitic pegmatite deposits of Kemiö (Kimito) in southwestern Finland have been quarried over time, starting in the 1600s;

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Editorial

Editorial contacts: Wolfgang Reimer, GKZ Freiberg eV
Homepage: www.greenpeg.eu
Contact: contact@greenpeg.eu
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