



HAL
open science

Occurrences of energy critical elements; Lithium – Cobalt and Graphite in Europe, a preliminary overview.

Håvard Gautneb, Janja Knežević, Eric Gloaguen, Jérémie Melleton, Blandine Gourcerol, Tuomo Törmänen

► To cite this version:

Håvard Gautneb, Janja Knežević, Eric Gloaguen, Jérémie Melleton, Blandine Gourcerol, et al.. Occurrences of energy critical elements; Lithium – Cobalt and Graphite in Europe, a preliminary overview.. SGA 2019 - 15th Biennial Meeting of the Society for Geology Applied to Mineral Deposits, Aug 2019, Glasgow, United Kingdom. hal-02113443

HAL Id: hal-02113443

<https://brgm.hal.science/hal-02113443v1>

Submitted on 20 Sep 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Occurrences of energy- critical elements; Lithium Cobalt and Graphite in Europe, an overview.

Håvard Gautneb¹, Janja Knežević Solberg¹, Eric Gloaguen², Jérémie Melleton², Blandine Gourcerol², Tuomo Törmänen³
1) Geological Survey of Norway 2) BRGM France 3) Geological Survey of Finland



This project has received funding from the European Union's Horizon 2020 research and Innovation programme under grant agreement No 731166

The Geological Surveys of Europe

Abstract:

There are, based on extracts from the national mineral resource databases of the EuroGeoSurvey members, 1195 occurrences of Li, Co and graphite in Europe, 17 of these are active mines. This compilation is part of work package 5 of the FRAME project (Forecasting and Assessing Europe's Strategic Raw Materials needs) a section within the framework of the GeoERA project. The data collected classify the occurrences according to their genetic type, their occurrence type and production status. We regard in this compilation all Co locations with a mean Co >100ppm as occurrences for Co. For the other commodities, Li bearing minerals or graphite must be positively identified or explored for to be included.

Methodology

We collected from European Geological Surveys basic geographical information, status (active/closed/not exploited), occurrence type (occurrence/prospect/deposit) and genetic type for each occurrence. We show the distribution of Li, Co and graphite occurrences in different EU countries (Fig. 1) and their locations and classification according to their genetic types, in Fig 2, 3 and 4.

Results: Lithium

Spatial distribution

The distribution of lithium in Europe shows a **strong clustering** (Fig. 2) highlighting the Li potential of the Variscan belt of south and central Europe.

Deposit types

High-grade Li deposits (Gourcerol et al., 2019; Gloaguen et al., 2018) are represented by:

- Li-rich **LCT pegmatites**
- **Rare metal granites** (Melleton et al., 2015)
- **Atypical stratiform deposits** such as Jadar, encountered in intramontane lacustrine evaporate basins

Medium-grade Li deposits (Gourcerol et al., 2019) are represented by:

- hydrothermal deposits such as **greisens**
- **Li-bearing quartz veins** associated with some peraluminous rare metal granites.

Other types (Gloaguen et al., 2018)

Li-rich (tosudite) **hydrothermal alteration aureole** around gold quartz veins; **Cookeite/lithiophorite in black shales** (Dauphiné: ave. 441 ppm Li₂O, up to 1 847 ppm) or in **bauxite deposits and Mn(Fe) deposits**. Li-rich clays (hectorite) are presently unknown in the EU.

Lithium carrier

Lithium is hosted by various minerals such as phosphates (amblygonite, montebrazite, triphylite), inosilicate (spodumene), phyllosilicates (lepidolite series, zinnwaldite, petalite) and scarce borosilicate (jadarite). Co-products are generally Ta, Nb, Sn, Be.

Examples, grades & tonnages

Jadar-type Li deposits occur in Serbia and Bosnia. In 2017, the total mineral resources report 135.7 Mt of ore at a grade of 1.86 % Li₂O and 15.4 % B₂O₃ (Rio Tinto, 2017) that represents a giant deposit of 2.524 Mt of Li₂O. / Wolfsberg pegmatites, Austria (236 366.46t Li₂O – grade 1.0%) / Sepeda pegmatites, Portugal (221 728.1t Li₂O – grade 1.0%). / Beauvoir rare-metal granite, France (375 000t Li₂O – grade 0.78%) / Cinovec greisen (Czech Republic, 5 652 990.2t Li₂O – grade 0.4 Li₂O). / Argemela quartz-amblygonite veins mine (Portugal, 80 400t Li₂O – grade 0.4%).

Results: Cobalt

Spatial distribution

Most of the known Co-bearing deposits and showings in Europe are clustered in the Nordic countries (Finland, Sweden and Norway). Deposits are more scattered throughout southern-central Europe (Fig. 3). The deposits in the Nordic countries mostly represent magmatic Ni-Cu and Fe-Ti-V deposits and VMS deposits, whereas elsewhere in Europe genetic types are more varied from sediment-hosted, to lateritic and 5-element vein types, among others a common minor constituent in a number of different ore types.

Main deposit types:

- **stratiform sediment-hosted** deposits (60%)
- **magmatic Ni-Cu-Co-PGE** deposits (23%)
- **lateritic Ni-Co** deposits (15%), cobalt is recovered as a by-product (10-90 % recovery, Mudd et al., 2013).

Other types of deposits containing Co

IOCG, VMS (Besshi-type), 5-element vein deposits, black-shale hosted Ni-Cu-Zn deposits, and Fe-Cu-skarn deposits (Slack et al., 2017). Co-grades are between 0.01-0.1%.

Examples, grades & tonnages

The only active mines producing cobalt are located in Finland. Kevitsa mine in northern Finland is a large low-grade Ni-Cu-PGE deposit, which produced 591 t of Co in 2018. Kytlylahti mine is a small-sized Outokumpu-type Cu-Zn-Ni-Co deposit, which produced 278 t of Co in 2018 (New Boliden, 2019). Terrafame is a large, low-grade black-shale hosted Zn-Ni-Cu-Co mine which produces Co as by-product to Ni and Zn, but production figures for Co are not published (2013: 286 t). The highest grades occur in sediment-hosted deposits of the Central African Copper Belt (0.1-1.1% Co), lateritic Ni deposits (0.1-0.22% Co), some VMS deposit-types (Windy Craggy 0.66% Co, Outokumpu-type deposits 0.1-0.25% Co), and 5-element vein deposits and ultramafic-hosted hydrothermal deposits (up to %-level, e.g. Dobsina, Bou Azzer; Hitzman et al. 2017, Slack et al. 2017).

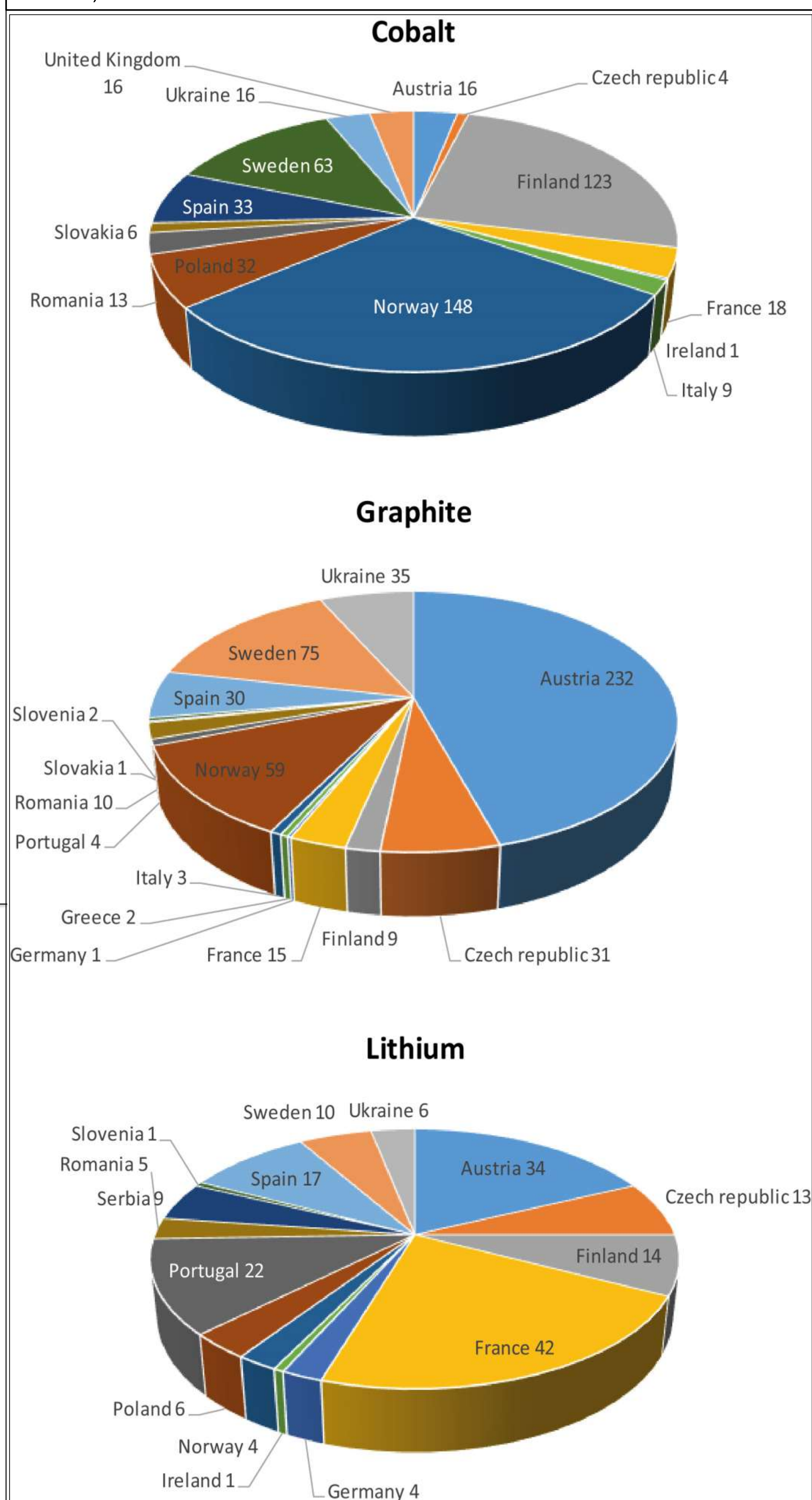


Fig. 1 The distribution of occurrences within the different European nations.

Results: Graphite

Spatial distribution

Graphite is a common mineral in metamorphic rocks throughout Europe, however it is rare to find economically interesting deposits. The bulk of the graphite occurrences occur in Archaean and Proterozoic rocks of Northern Europe and Ukraine. In addition, a number of amorphous graphite occurrences are found in Phanerozoic rocks in Austria.

Deposit types

The graphite bearing rocks are typically organic rich paragneiss often associated with carbonates and iron formations.

In well-investigated areas (for instance in Norway) the graphite deposits show polyphasal deformation and are most commonly associated with upper amphibolite or granulite facies metamorphism (Gautneb et al., 2017). Graphite deposits are very good electrical conductors and are relatively easy to locate using geophysical methods.

We have in this study, divided graphite occurrences into **flake and amorphous types** which make up the bulk of the deposits. There are also a large number of showings where the genetic type is unknown. Vein deposits are known in Europe, but are mostly geological curiosities (Luque et al 2014).

Examples, grades & tonnages

Active mines are situated in Ukraine, Austria and Norway. The graphite contents vary from 2-3% up to over 40% (Gautneb & Tveten 2000). The Trælen deposit in Norway is the world's richest graphite deposit in current production with an average ore grade of 31%, and 1.8 Mt proven reserves.

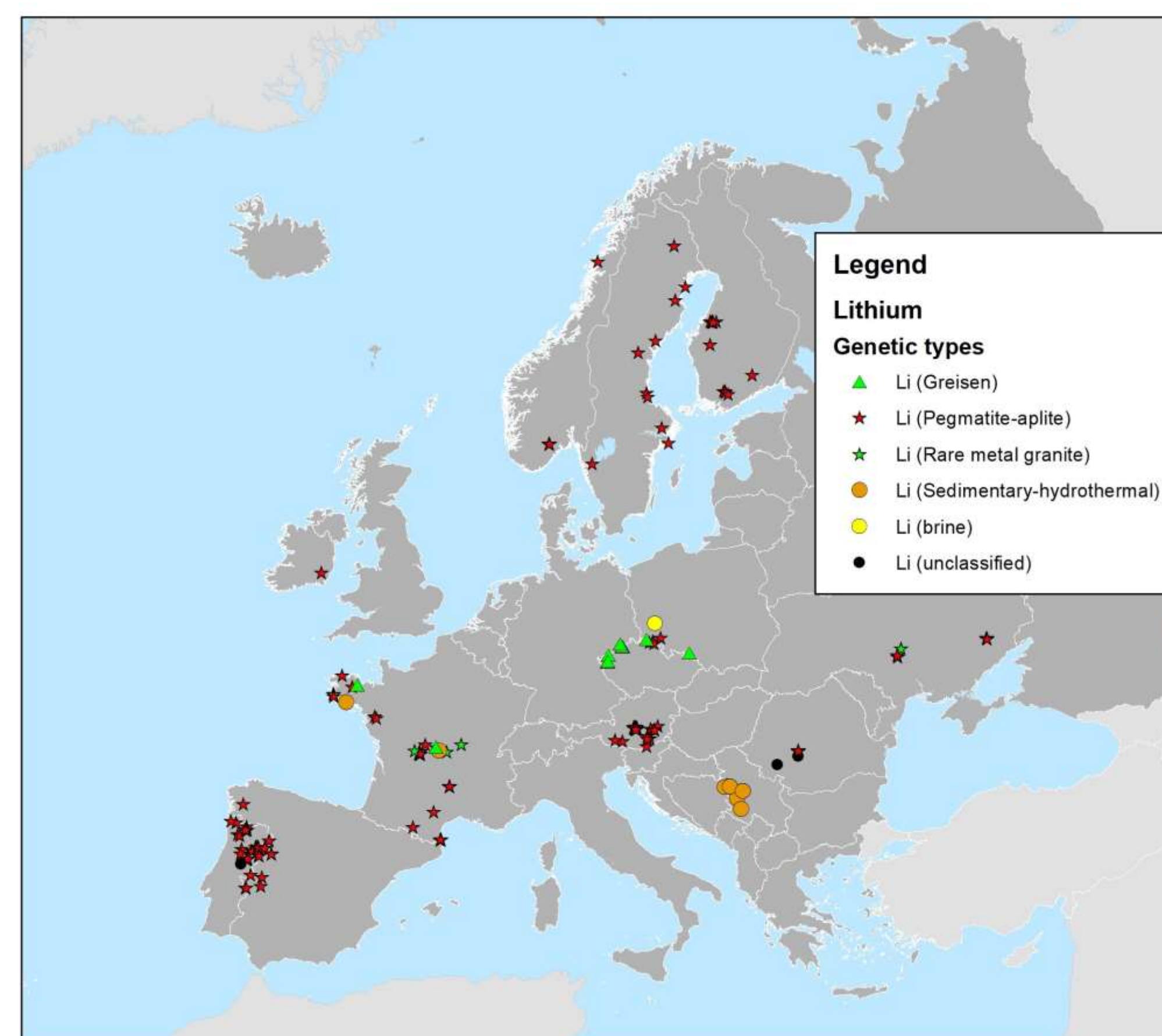


Fig. 2 The genetic types of Li- occurrences in Europe.

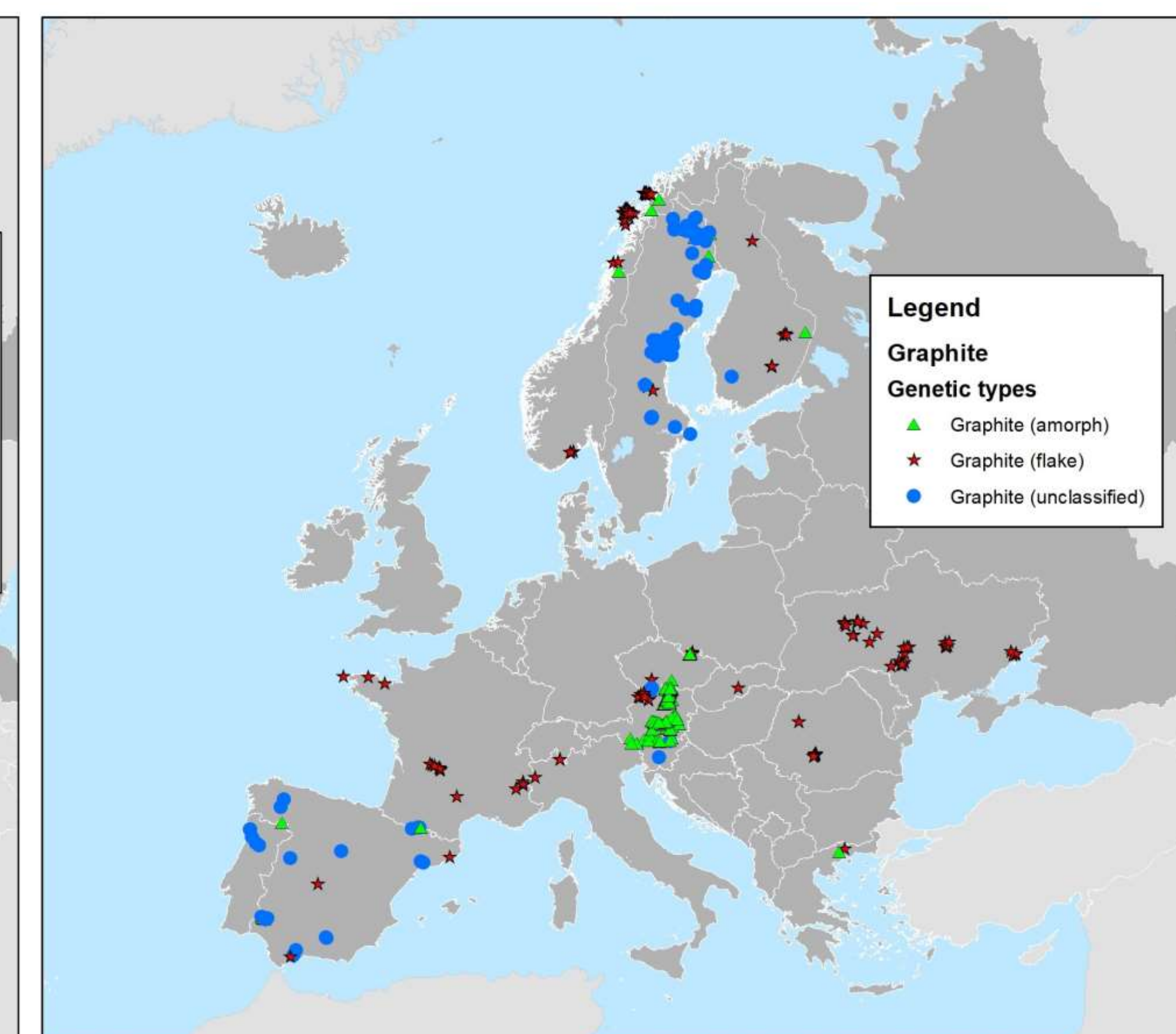


Fig. 4 The genetic types of graphite occurrences in Europe.

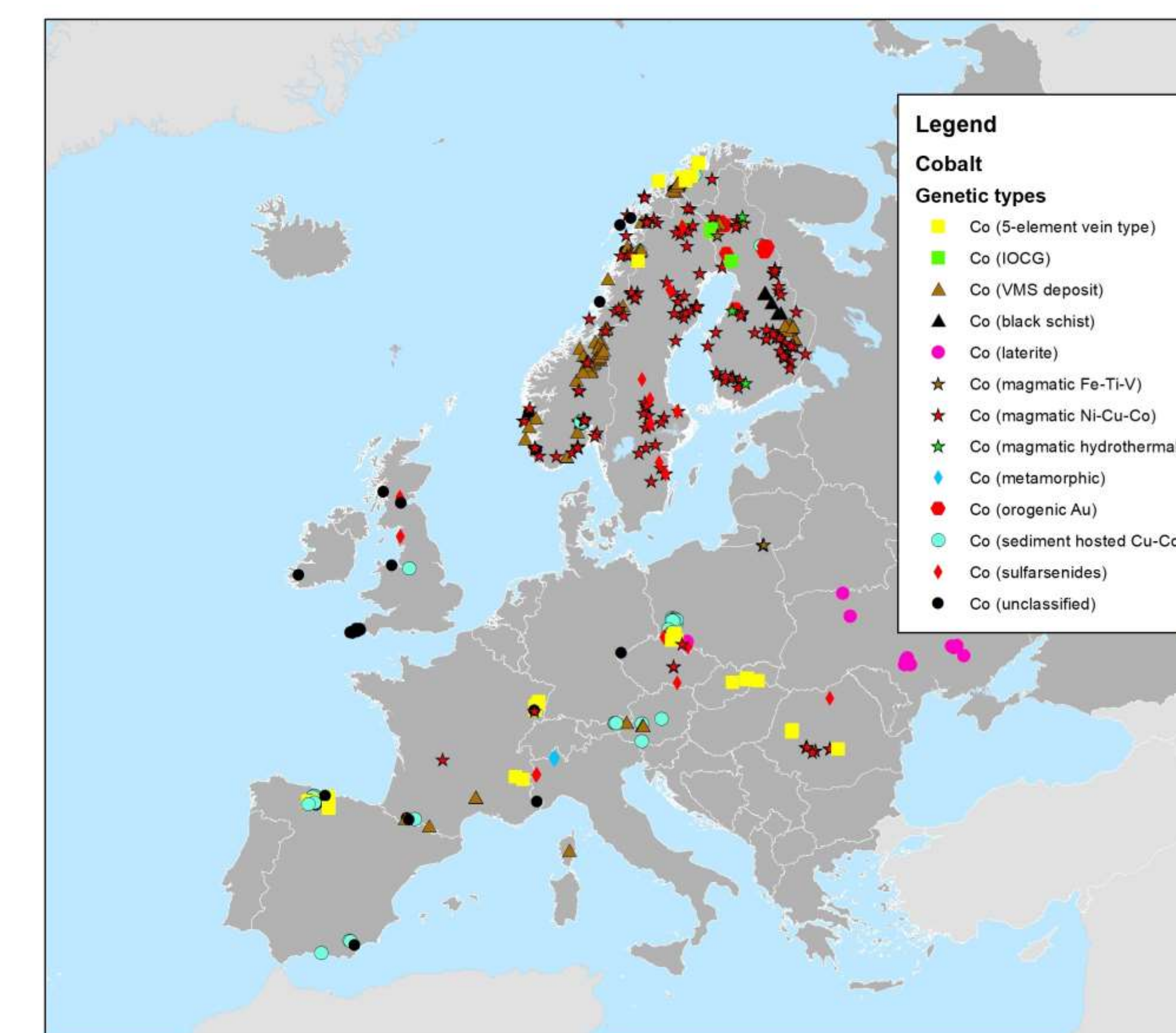


Fig. 3 The genetic types of Co- occurrences in Europe.

Based on contributions from authors and from: Anders Hallberg (SGU), Daniel de Oliveira (LNEG), Boris Malyuk (GIU), Klemen Teran (GeoZs), Stanislav Soltes (SGIDS) Stanislav Mikulski (PGI), Roberto Martinez Orio (IGME Spain), Sebastian Pfeleiderer (GBA), Antje Wittenberg (BGR), Petr Rambousek (CGS), Mauro Lucarini (ISPRA), Eoin McGrath (GSI) Zoltan Horvath (MBFSZ), Kostas Laskarides (IGME Greece), George Tudor (IGR).

References

- Gautneb H. & Tveten E. 2000. The geology, exploration and characterisation of graphite deposits in the Jennestad area, north Norway. Norges geologiske undersøkelse Bull. 436, 67-74.
- Gautneb, H., Knežević, J., Johannessen N.E., Vianik J.E., Engvik, A., Davidsen B., & Renning J.E., 2017. Geological and ore dressing investigations of graphite occurrences in Bø, Sortland, Hadsel and Øksnes municipalities, Vesterålen, Nordland County, Northern Norway. NGU report 2017.015.
- Gloaguen E., Melleton J., Lefebvre G., Tourlière B., Yart S., Gourcerol B. 2018. Ressources métropolitaines en lithium et analyse du potentiel par méthodes de prédictivité. Public report BRGM/RP-68321-FR, 126p. <http://infoterre.brgm.fr/rappports/RP-68321-FR.pdf>
- Gourcerol B., Gloaguen E., Melleton J., Tuduri J., Galiegue X. 2019. Re-assessing the European lithium resource potential – A review of hard-rock resources and metallurgy. Ore Geology Reviews, in press. doi: 10.1016/j.oregeorev.2019.04.015
- Hitzman, M.W., Bookstrom, A.A., Slack, J.F., Zientek, M.L., 2017. Cobalt—Styles of deposits and the search for primary deposits: U.S. Geological Survey Open-File Report 2017–1155, 47 p.
- Luque F.J., Huizenga J.-M., Crespo-Feo E., Wada, H., Ortega L., Barrenechea J.F. 2014. Vein graphite deposits: geological setting, origin and economic significance. Mineralium Deposita, Vol. 49, 261-277.
- Melleton J., Gloaguen E., Frei D. 2015. Rare-elements (Li-Be-Ta-Sn-Nb) magmatism in the European Variscan belt, a review. 13th SGA biennial meeting, 24-27 August 2015, Nancy, France. Proceedings, vol. 2:807-810.
- Mudd G.M., Weng, Z., Jowitt, S.M., Turnbull, J.D., Graedel, T.E. 2013. Quantifying the recoverable resources of by-product metals: The case of cobalt. Ore Geology Reviews, Vol. 55, 87-98.
- New Boliden 2019. Stable production, lower grades and metal prices. New Boliden Q4 and full year 2018 report. 37 p. http://www.riontinto.com/documents/170302_Increase_to_Jadar_Project_Mineral_Resources.pdf
- Rio Tinto, 2017. Notice to ASX. Increase to Jadar Project Mineral Resources 2 March 2017, 22p. http://www.riontinto.com/documents/170302_Increase_to_Jadar_Project_Mineral_Resources.pdf
- Slack, J.F., Kimball, B.E., Shedd, K.B., 2017. Cobalt, chap. F of Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply. U.S. Geological Survey Professional Paper 1802, p. F1–F40.
- Stanley C., Jones G.C., Rumsey M.S., Blake C., Roberts A.C., Stirling J.A.R., Carpenter G.J.C., Whitfield P.S., Grice J.D., and Lepage Y., 2007. Jadarite, LiNaSiB3O7(OH), a new mineral species from the Jadar Basin, Serbia; European Journal of Mineralogy, Vol. 19, 575-580.
- Stojadinovic U., Matenco L., Andriessen P., Toljic M., Rundic L., and Ducea M., 2017. Structure and provenance of Late Cretaceous-Miocene sediments located near the NE Dinarides margin: Inferences from kinematics of orogenic building and subsequent extensional collapse. Tectonophysics, Vol. 710-711, 184-204