



OVERVIEW AND ASSESSMENT OF THE EUROPEAN LITHIUM RESOURCES

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*Layered aplites with unidirectionnal solidification texture, lepidolite-petalite subtype LCT pegmatite
Ambazac, Haute-Vienne France*

Introduction

Salar in Bolivia



BRINES

- Li-rich **lacustrine evaporates**
- Relatively **recent**, enclosed, **tectonically active** basins
- In an **arid to hyper-arid** climate

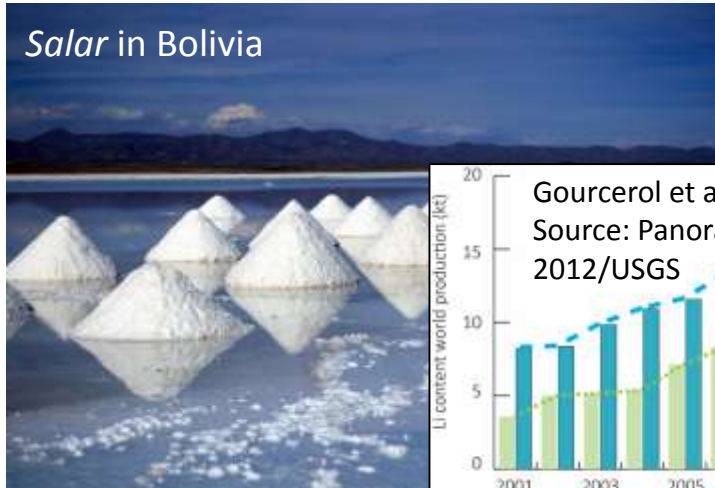
Spodumene pegmatite, Spain



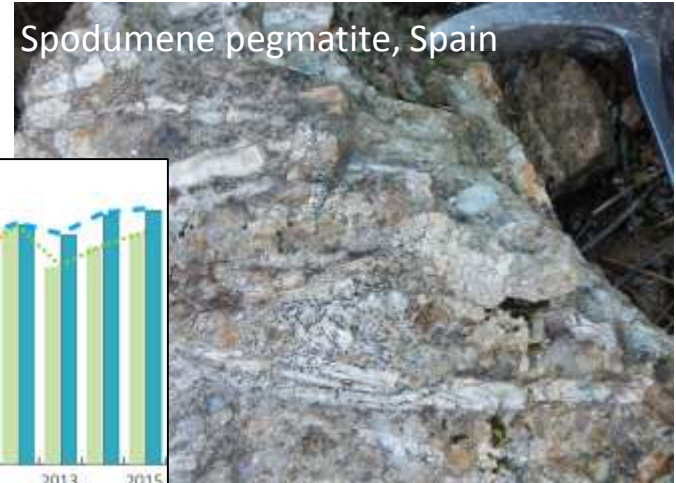
HARD-ROCKS

- Li-rich mineralization in **magmatic** and/or **sedimentary** rocks
- Related to **endogeneous** or **exogeneous** processes
- Widespread varieties of **Li-bearing minerals**

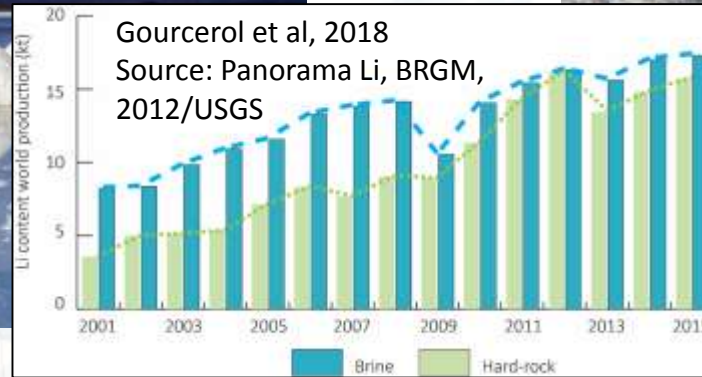
Introduction



Salar in Bolivia



Spodumene pegmatite, Spain



BRINES

HARD-ROCKS

- 2018 lithium production <35% (USGS, 2019)
- Resources > 30 Mt Li (USGS, 2019)
- Finite resource (known salars)

- **2018 Lithium production >64%** (USGS, 2019)
- Resources > 20 Mt Li (USGS, 2019)
- Open resource (Australia 7.7 Mt Li)

Introduction



- Blue + Brine deposits
- Red square Hard-rock deposits
- Green star Non conventional deposits

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Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

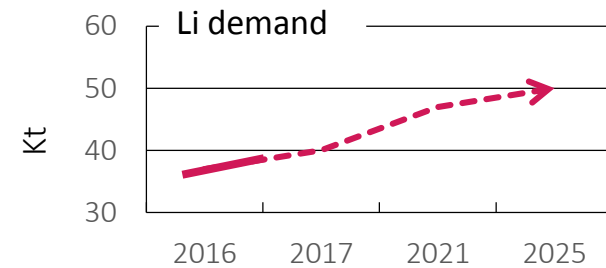
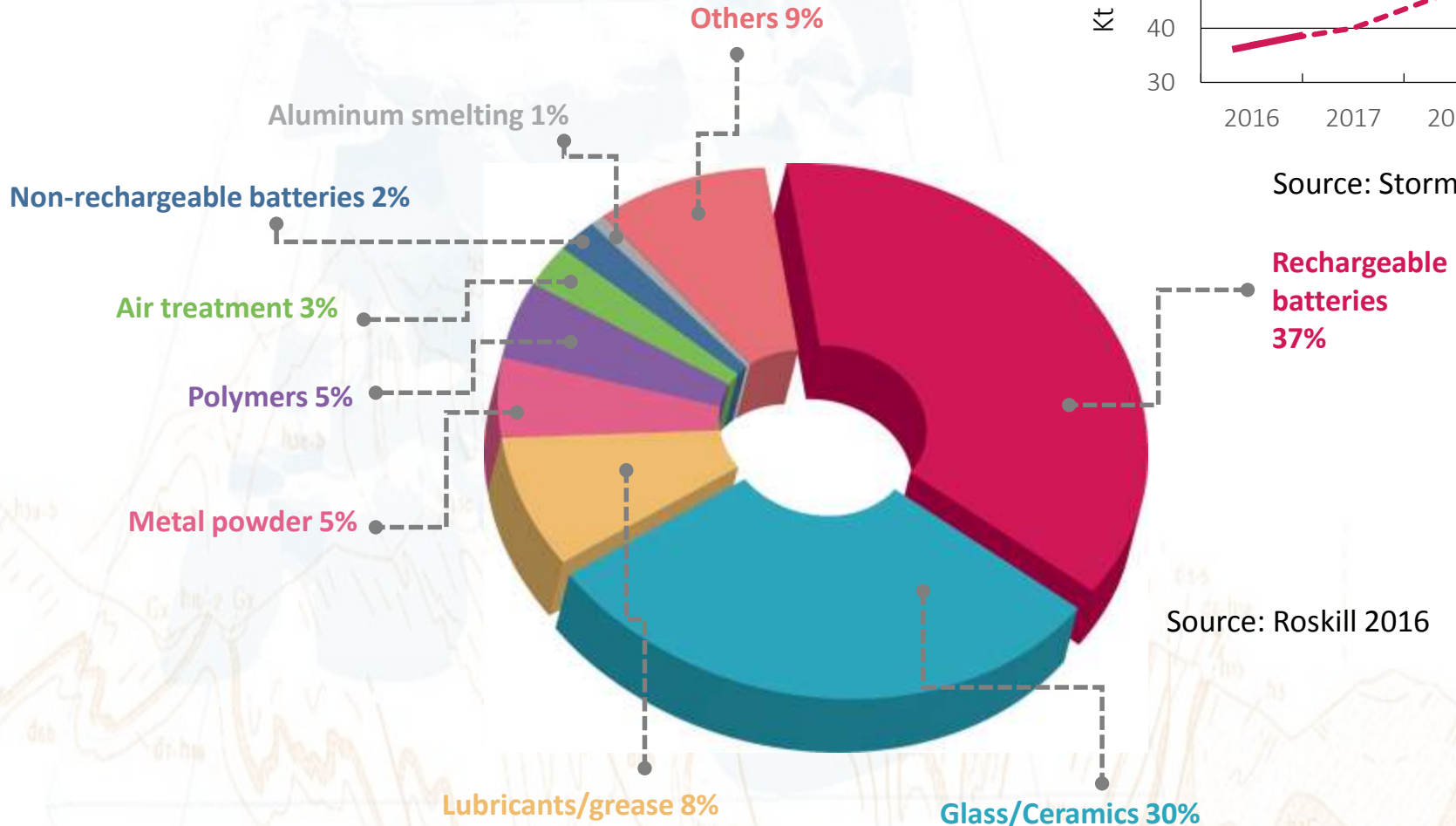
Review

Global lithium resources: Relative importance of pegmatite, brine and other deposits

Stephen E. Kesler ^{a,*}, Paul W. Gruber ^b, Pablo A. Medina ^c, Gregory A. Keoleian ^c, Mark P. Everson ^d, Timothy J. Wallington ^d

Lithium Market Outlook

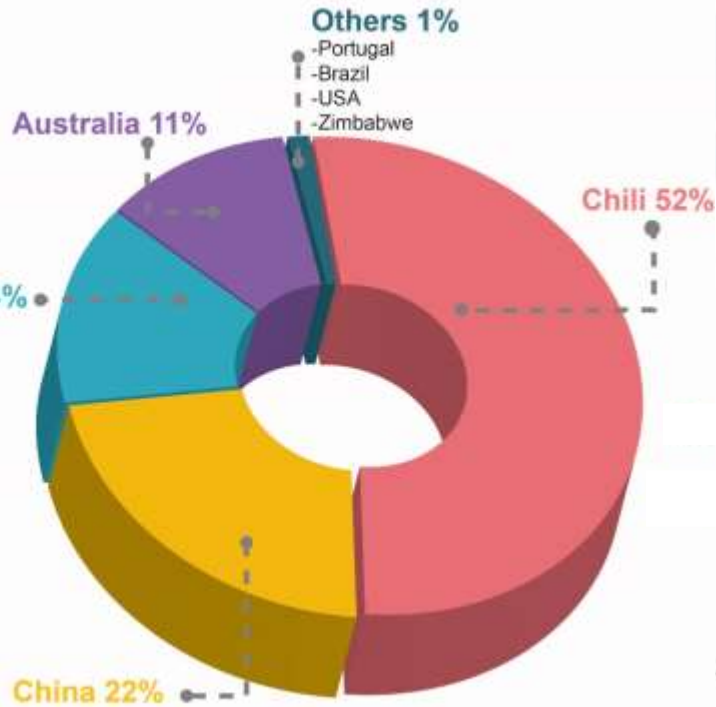
2015 lithium uses



Source: Stormcrow 2017

Source: Roskill 2016

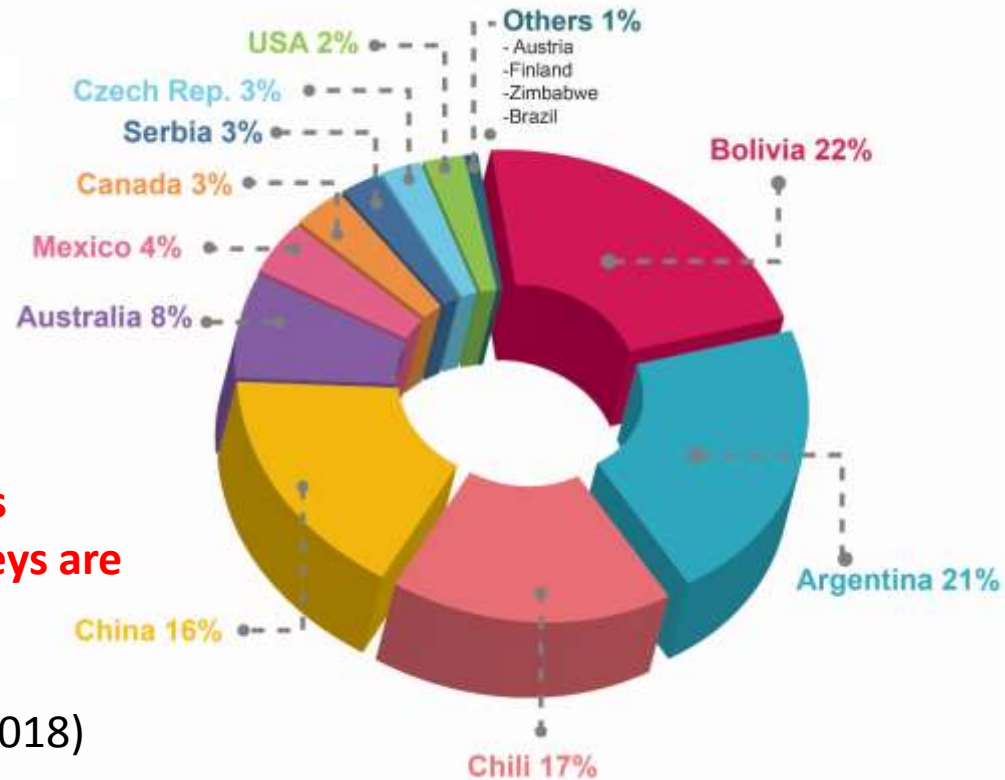
Totales Reserves: 14.5 Mt



2018 Total Resources: 62 Mt (USGS, 2019)

Issue on data constraints

Total Resources: 40.7 Mt



Source: USGS 2017

Most of national Li mineral resources assessment & potential by geological surveys are not available

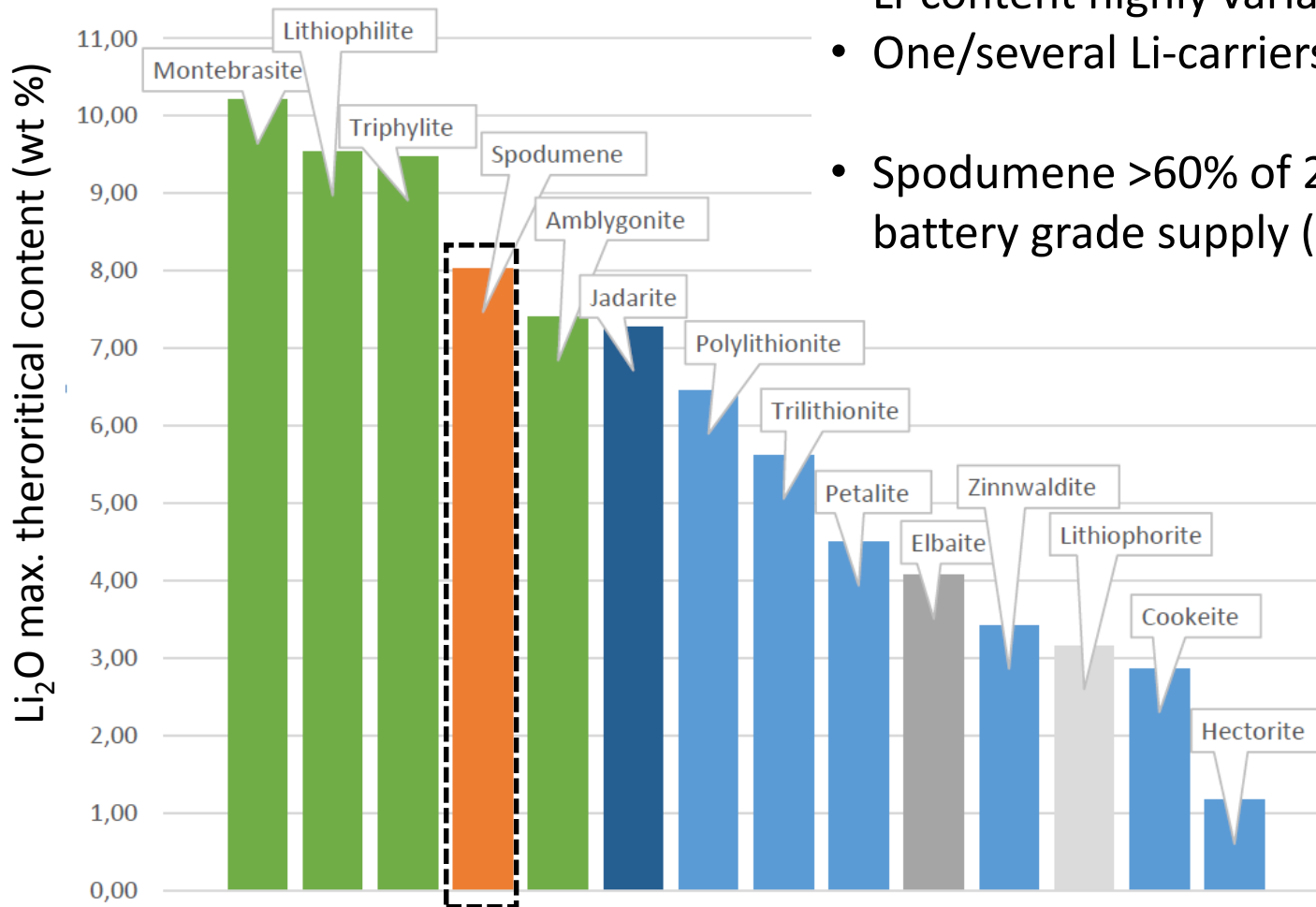
→ Dec. 2018 for France (Gloaguen et al 2018)

→ Ongoing H2020 GeoERA FRAME project

Source: BGS 2016, Roskill 2016, SNL 2017

Li-bearing minerals

- Widespread varieties of **Li-bearing minerals**
- Li-content highly variable
- One/several Li-carriers in ores
- Spodumene >60% of 2018 world Li battery grade supply (USGS, 2019)



Gloaguen et al, 2018
Source: International Mineralogical Association

Green: phosphates, light blue: phyllosilicates, orange: inosilicates, dark blue: Nesosilicates, dark grey: cyclosilicates, light grey: hydroxydes.

Mineral processing as a key

Deposit	Li-minerals	Company	Process	Industrialisation
Alvarroes	Lepidolite, zinnwaldite	Lepidico	L-Max [®]	2019
Wolfsberg	Spodumene	European Lithium		2020
ALL	Spodumene	Keliber	Cleantech Process	2020
Jadar	Jadarite	Rio Tinto	Bundoora Integrated Continuous Chemical Pilot Plant (BICCPP)	2023
Cinovec	Zinnwaldite	European metals	Sileach [™] hydrometallurgical process	20XX
Sadisdorf	Zinnwaldite, lepidolite	Lithium Australia/Tin International AG	Sileach [™] hydrometallurgical process	20XX
Valdefl6rez San Jos6	Li micas	Infinity Lithium Corporation Ltd		XXXX

Modified from Gloaguen et al, 2018

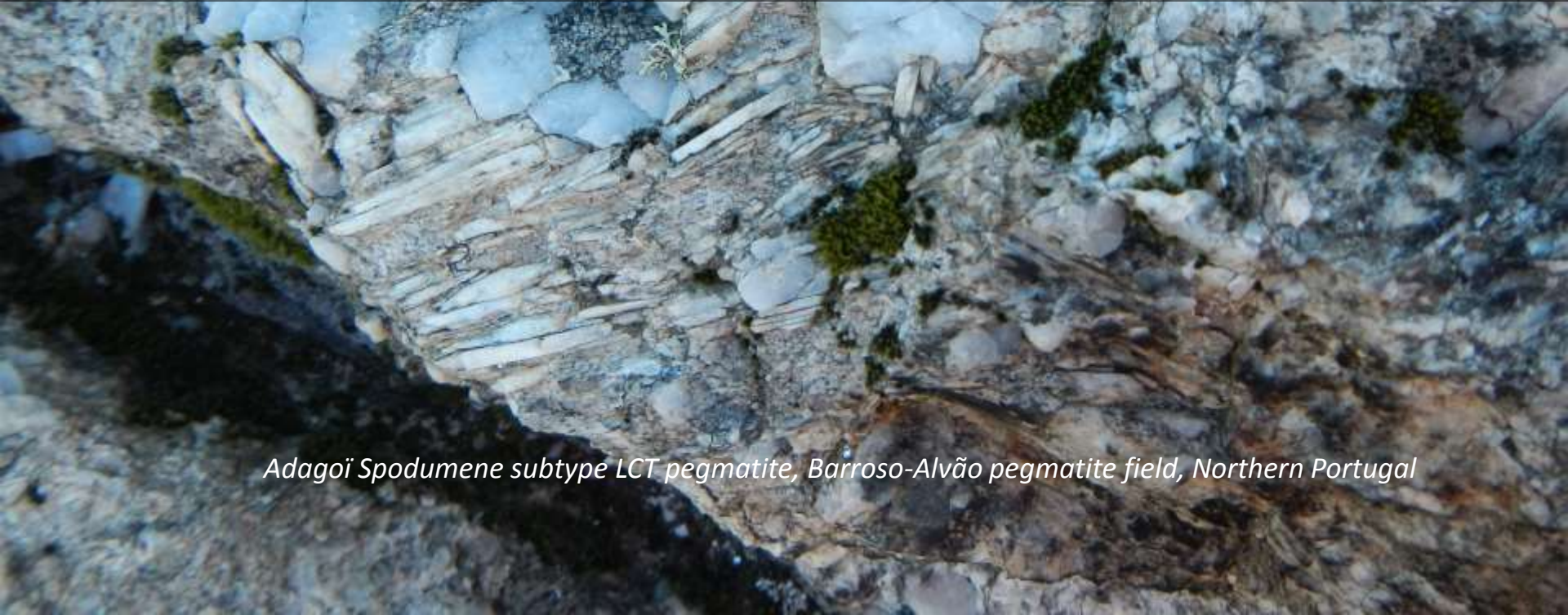
Compilation of European *hard-rock* lithium occurrences & deposits

Lithium resources related to **seawater, geothermal or oilfield brines** are NOT considered in this study.

- ✓ Made by **collecting information** from **geological survey, exploration & mining companies** and **publications**.
- ✓ Mineral resource, reserve and production data were gathered from available published data by exploration and mining companies, such as technical and annual reports, from data repositories (e.g., <https://sedar.com>) and from geological surveys.
- ✓ Based on CRIRSCO (Committee for Mineral Reserves International Reporting Standards) compliant estimates and historical (before 1995) estimates.



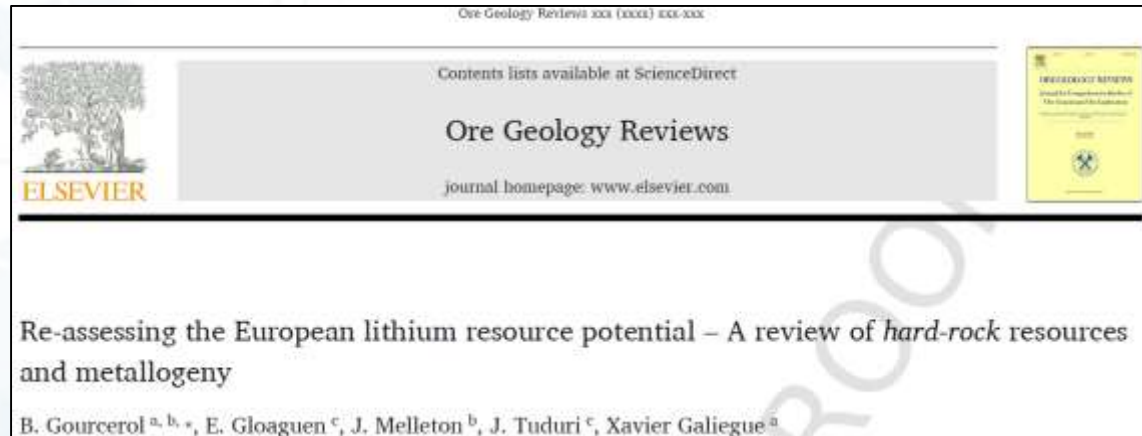
RESULTS



Adagoï Spodumene subtype LCT pegmatite, Barroso-Alvão pegmatite field, Northern Portugal

Compilation of European *hard-rock* lithium occurrences & deposits

527 lithium occurrences and deposits



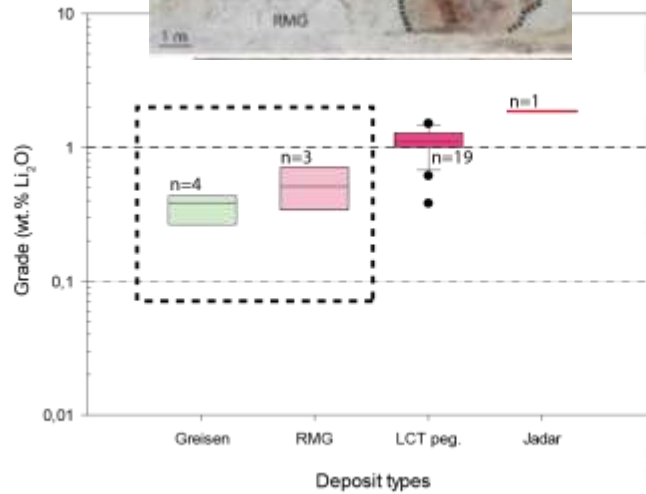
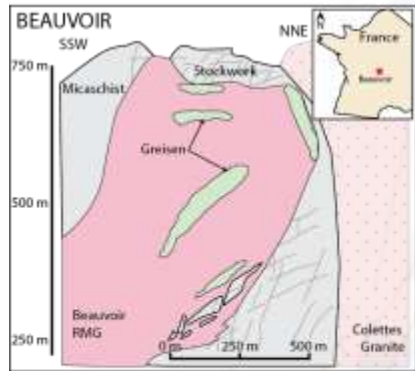
This is almost **five times more** than the previous **Mineral4EU-ProMine** (<http://minerals4eu.brgm-rec.fr/>) inventory (Cassard et al., 2015).

According to our compilation (and previous ones, e.g., Christmann et al., 2015), **two distinct categories** of lithium deposits and occurrences are found in Europe:

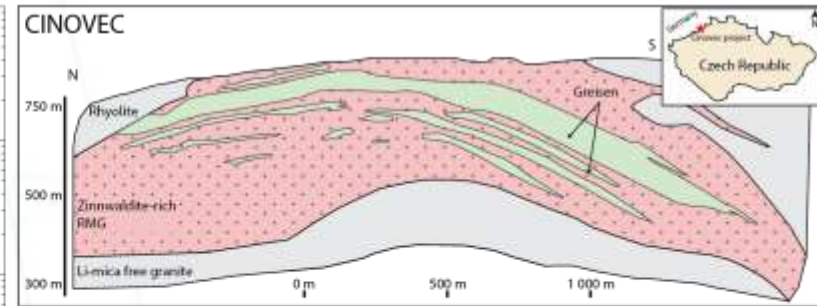
- 1) Magmatic-related
- 2) Sedimentary/hydrothermal-related deposits

European Lithium mineral resources

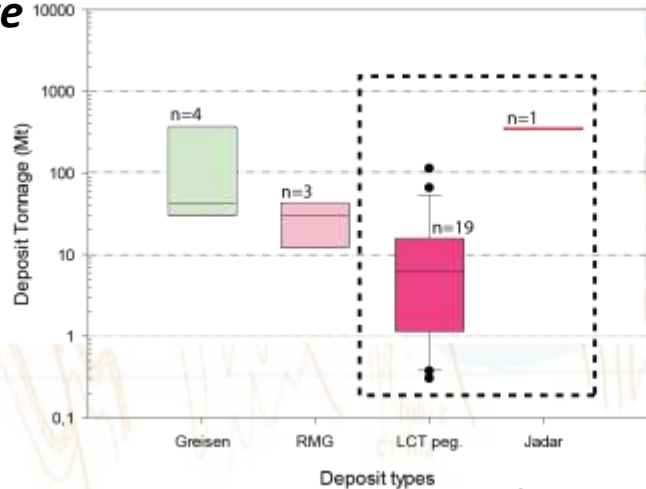
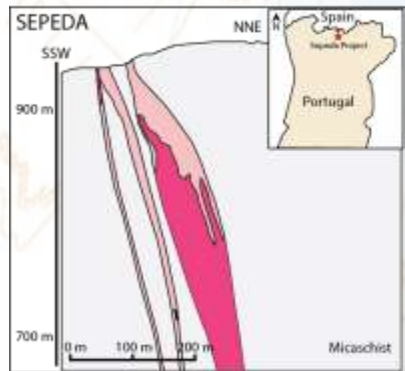
Rare metal granite



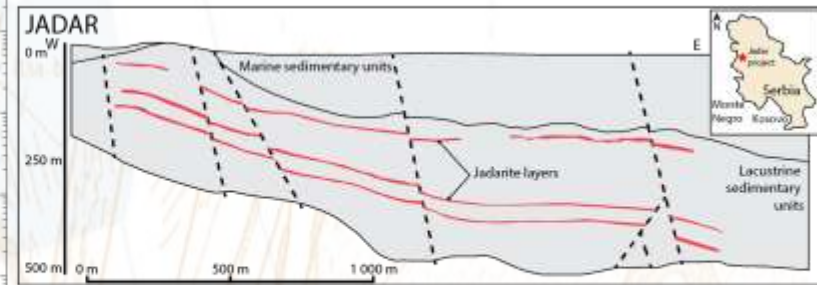
Greisen over rare metal granite



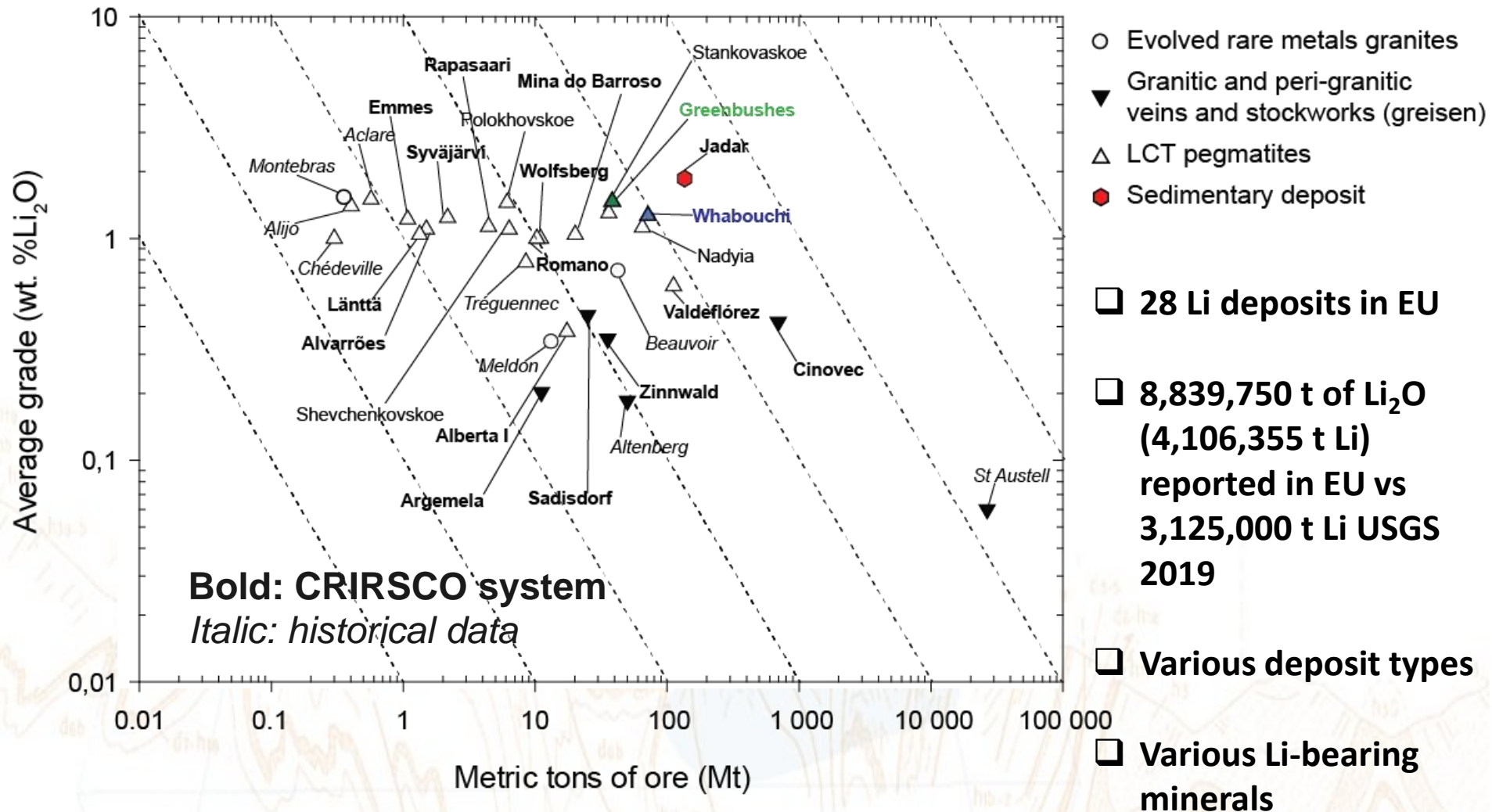
Rare metal pegmatite



Li-rich sedimentary layer

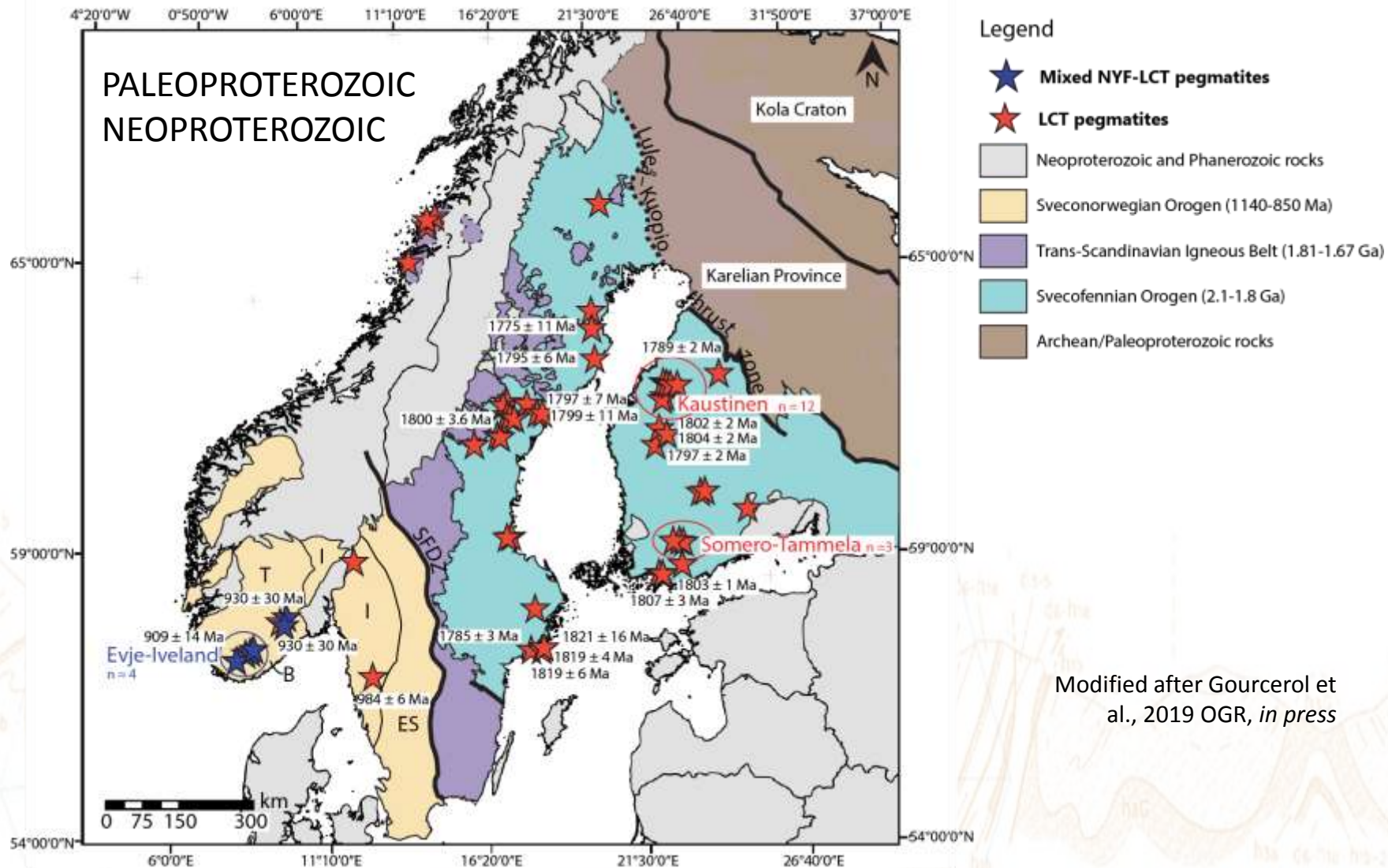


European Lithium mineral resources



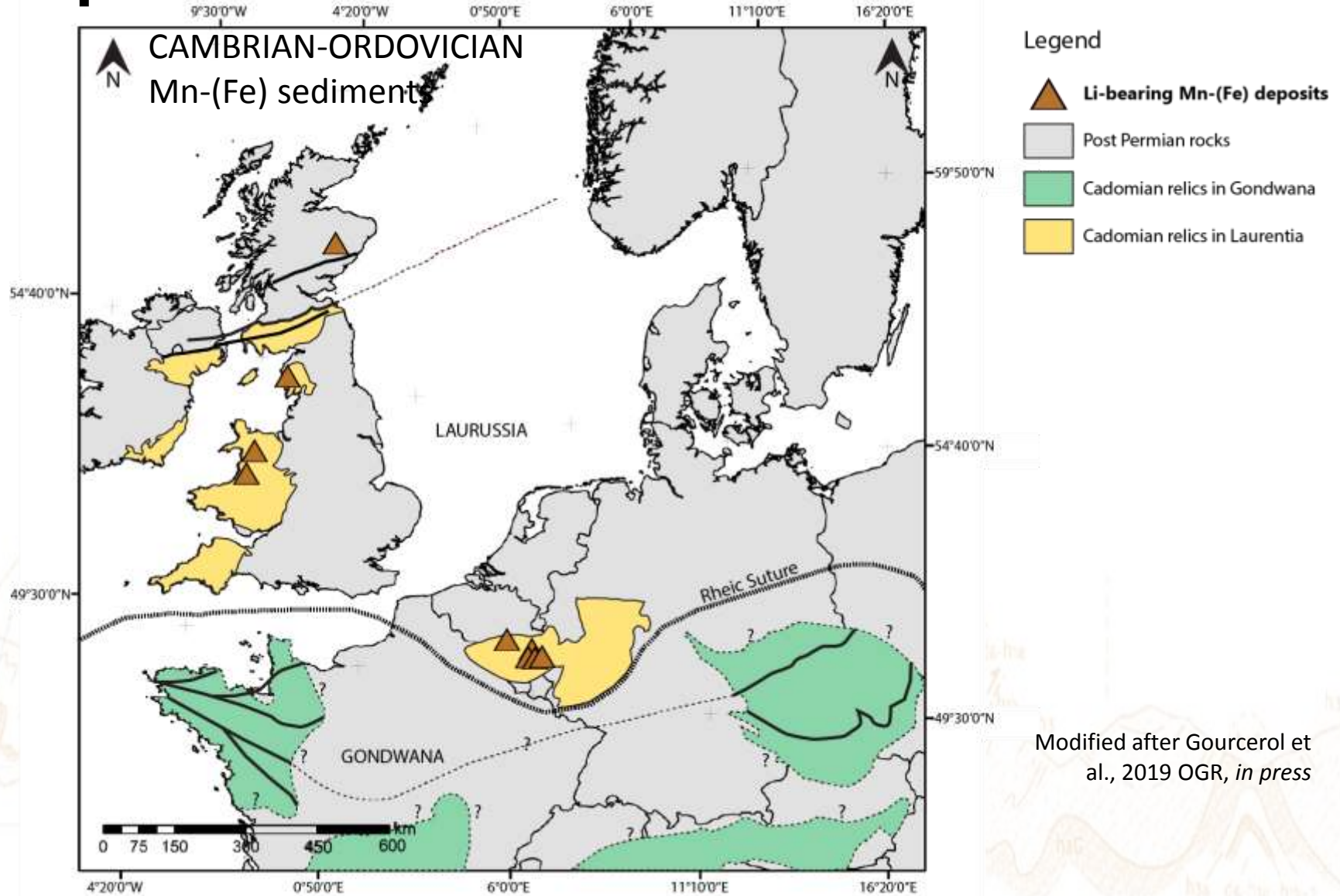
Modified after Gourcerol et al., 2019 OGR, *in press*

European Lithium mineralisations



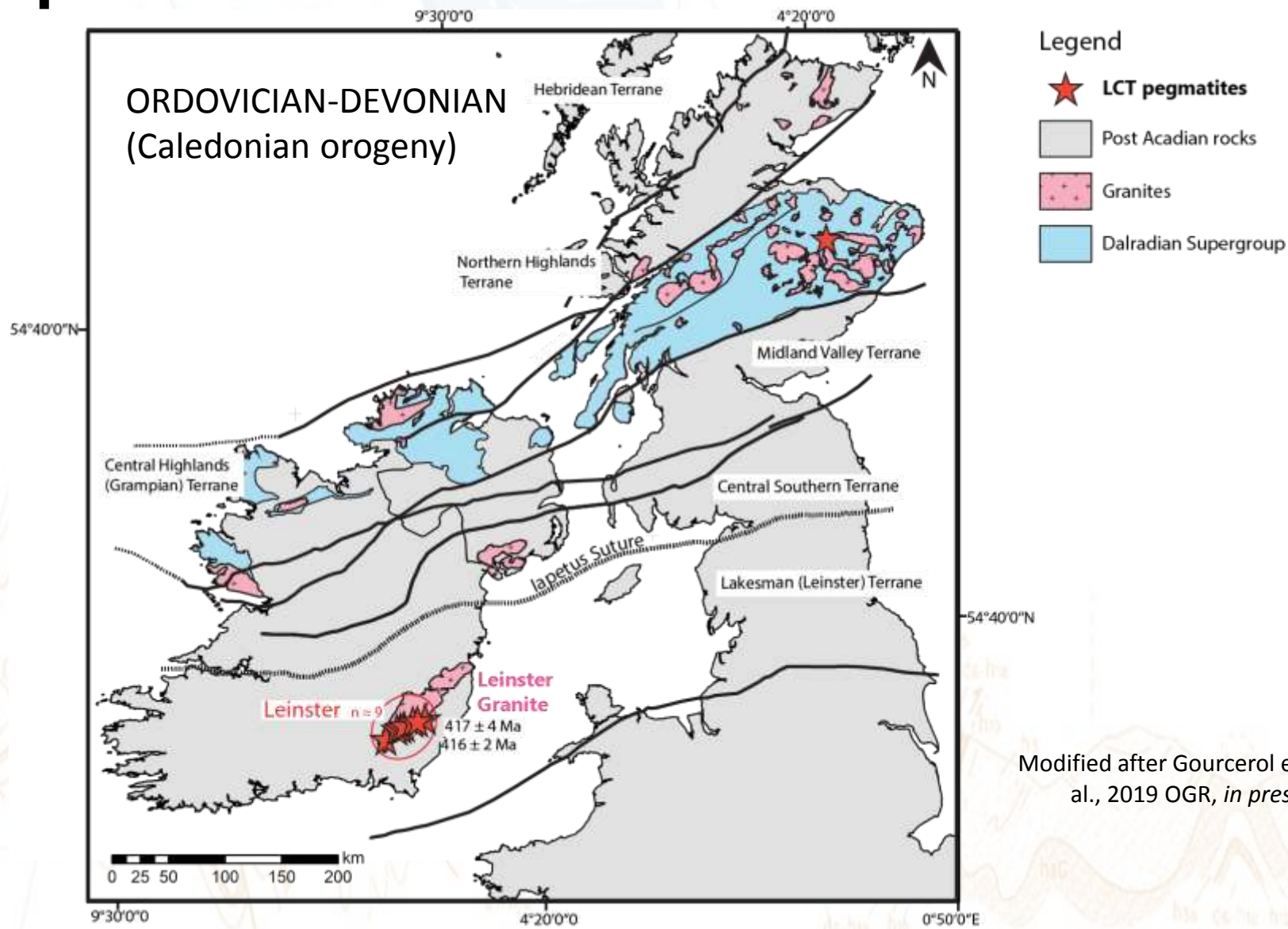
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European Lithium mineralisations



Modified after Gourcerol et al., 2019 OGR, *in press*

European Lithium mineralisations

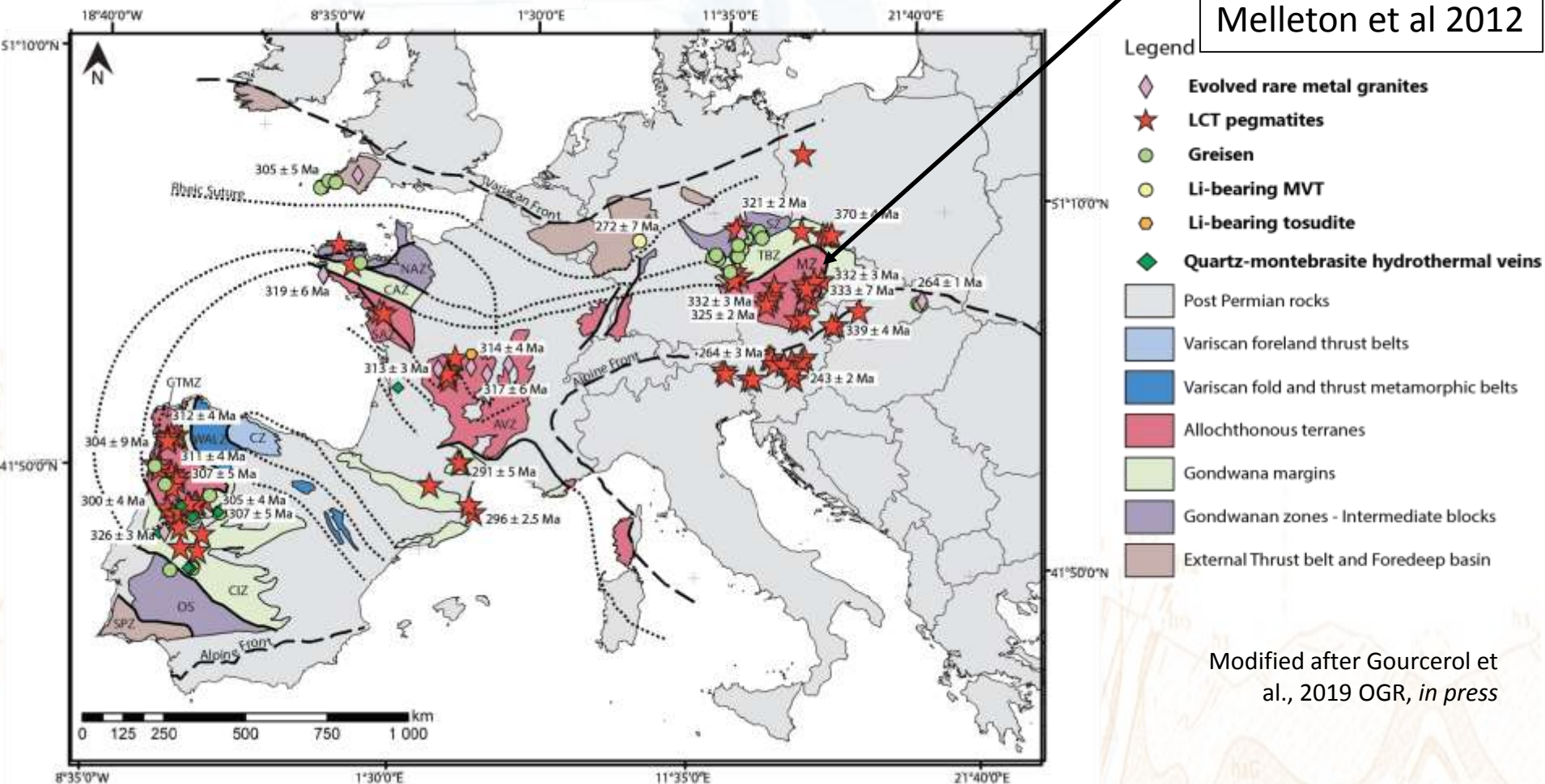


Modified after Gourcerol et al., 2019 OGR, *in press*

European Lithium mineralisations

CARBONIFEROUS – PERMIAN – Variscan orogeny

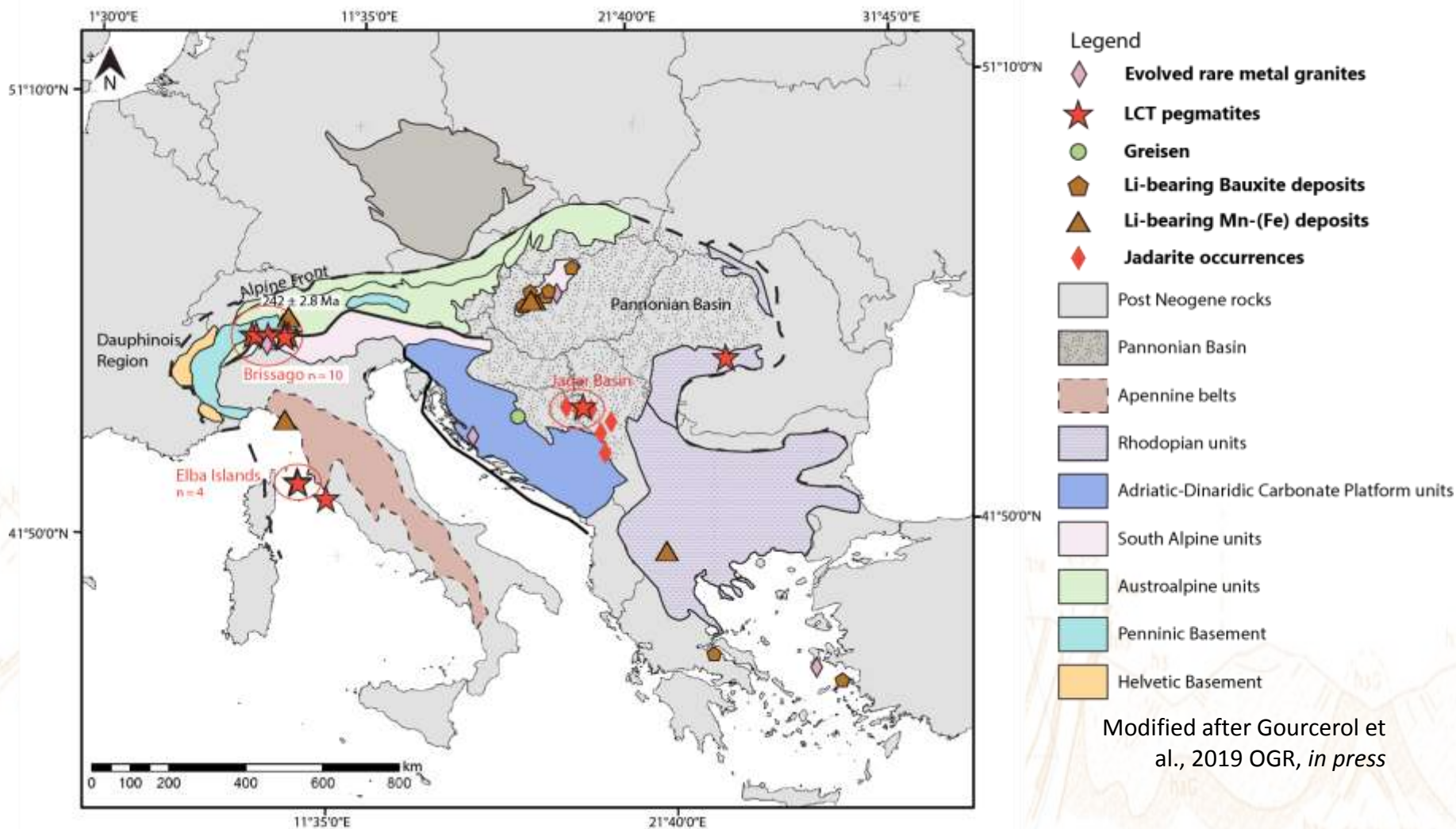
Moldanubian
Pegmatites coeval
of 2 melting events
ca 333 & 325 Ma
Melleton et al 2012



Modified after Gourcerol et al., 2019 OGR, *in press*

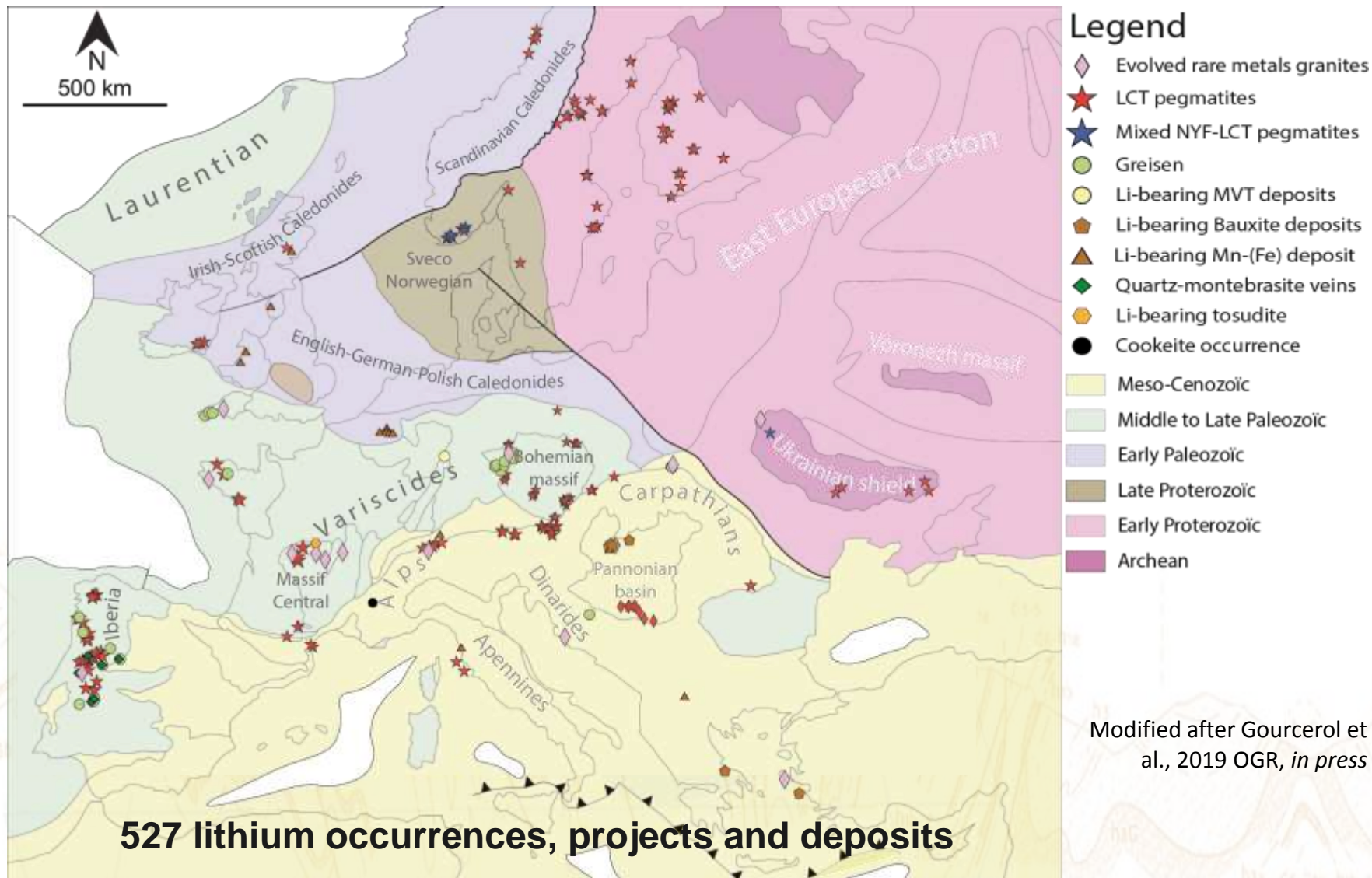
European Lithium mineralisations

PERMIAN / JURASSIC-CRETACEOUS / OLIGOCENE-MIOCENE



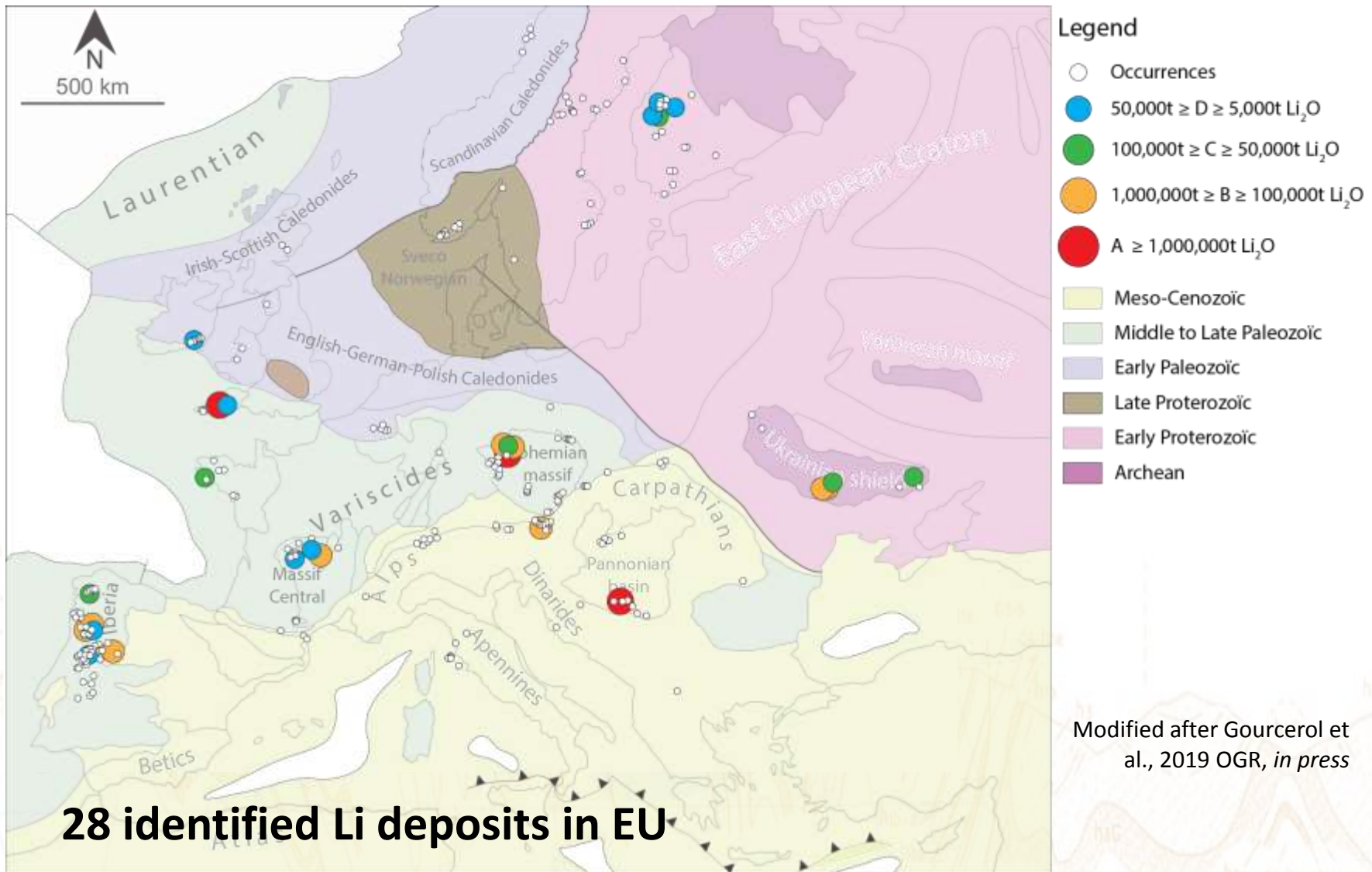
Modified after Gourcerol et al., 2019 OGR, *in press*

Types of European Lithium mineralisations



Modified after Gourcerol et al., 2019 OGR, *in press*

European Lithium mineral resources



Modified after Gourcerol et al., 2019 OGR, *in press*



CONCLUSION

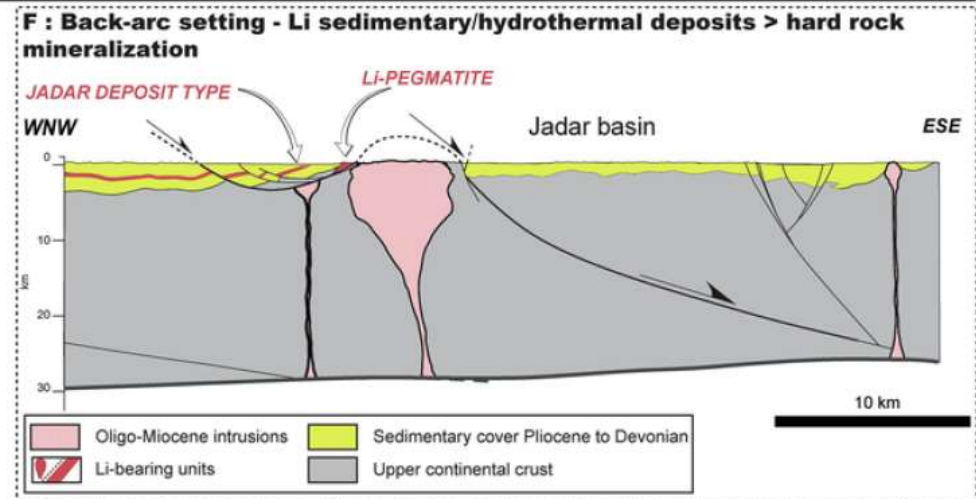
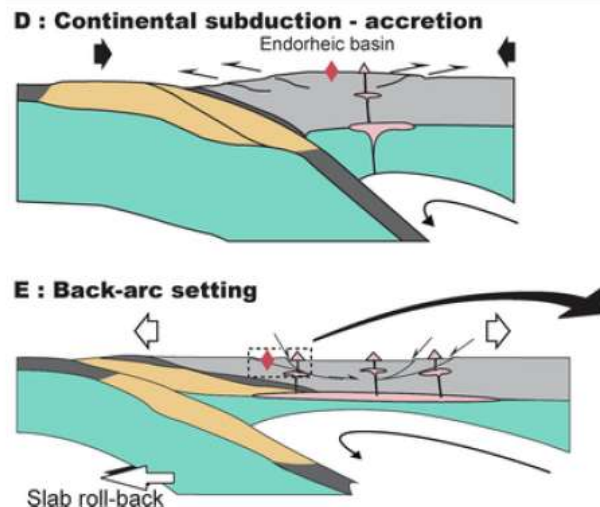
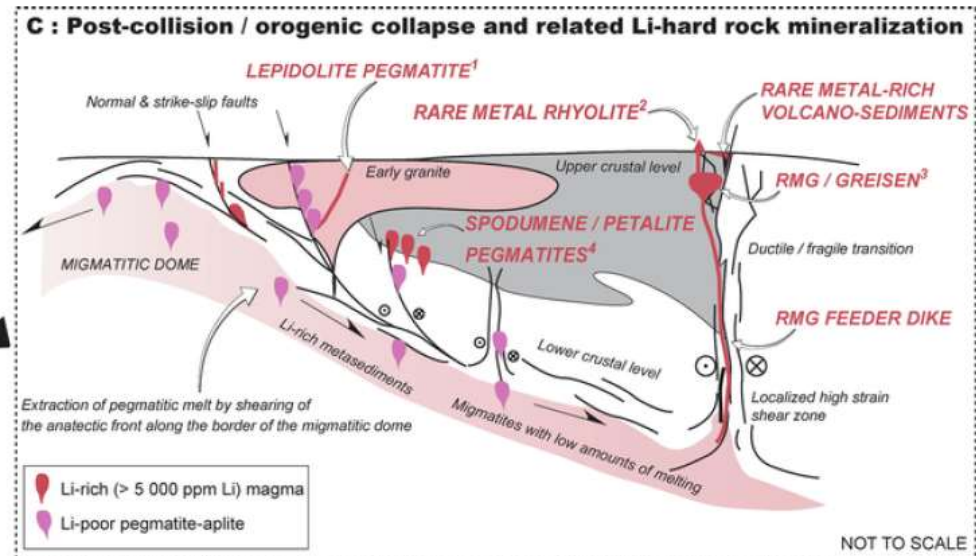
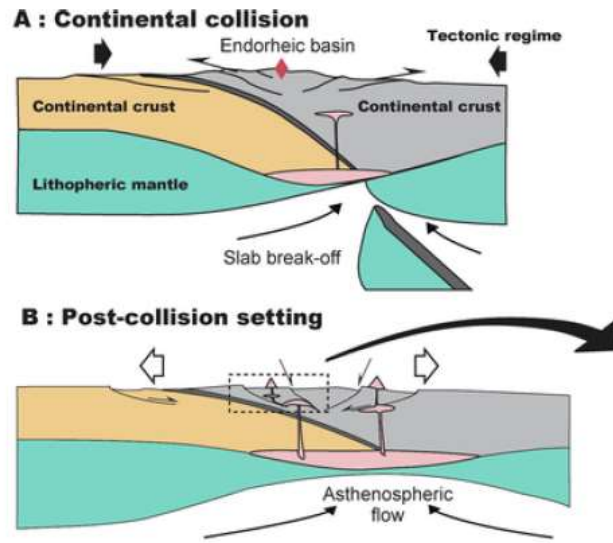
*Petalite crystals (light orange) surrounded by lepidolite (purple), lepidolite-petalite subtype LCT pegmatite
Ambazac, Haute-Vienne France*

Conclusion

Lithium Metallogenetic model involves:

Gourcerol et al., 2019 OGR, *in press*

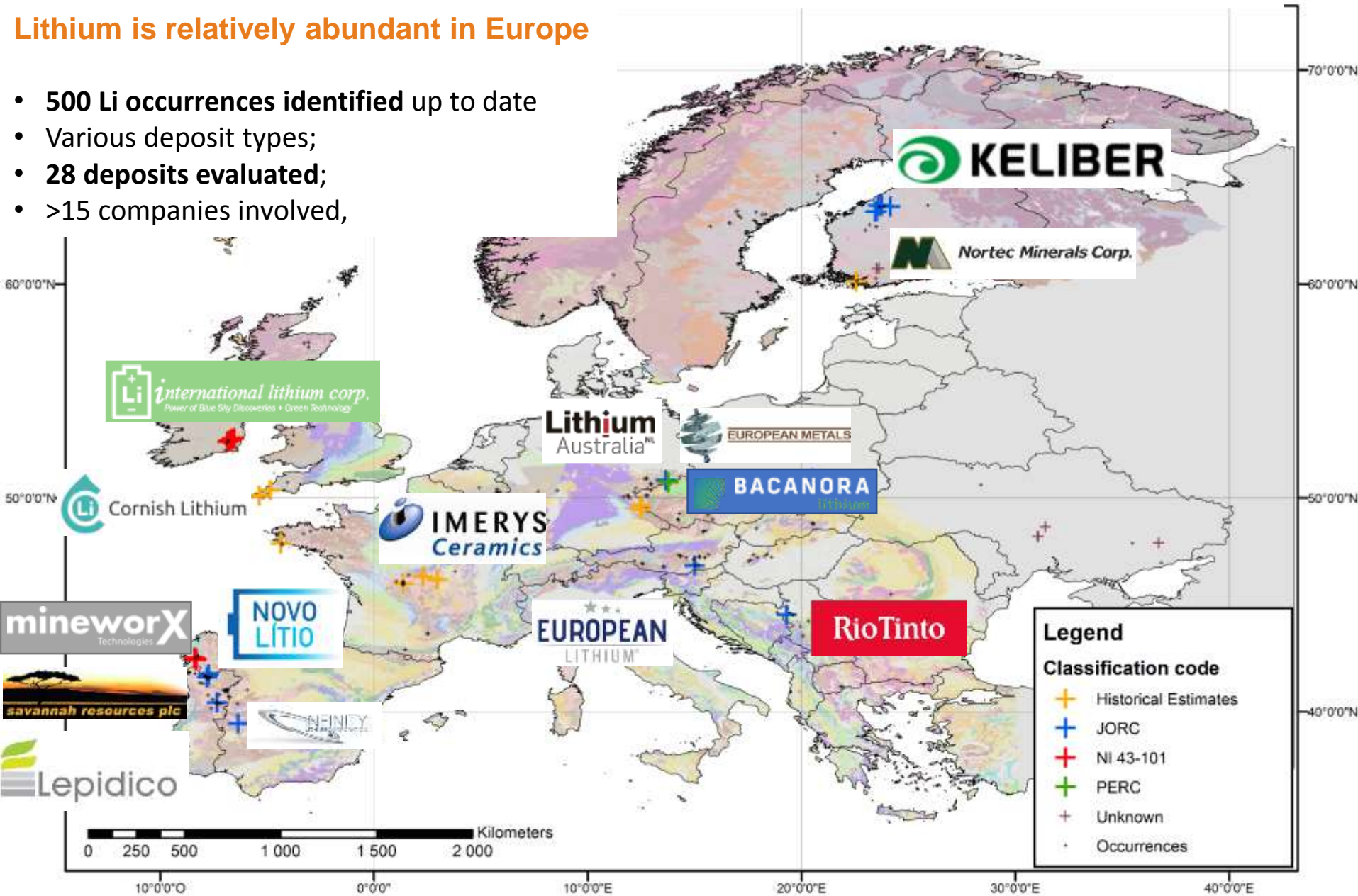
- a **pre-existing Li-rich source** related either to paleoenvironmental sedimentation conditions or a crustal anomaly;
- presence of **lithospheric thickening**;
- a regional or local **extensional** regime;
- existence of **fracture sets** acting as channel ways.



Conclusion

Lithium is relatively abundant in Europe

- 500 Li occurrences identified up to date
- Various deposit types;
- 28 deposits evaluated;
- >15 companies involved,



European Lithium Institute AISBL

<https://www.lithium-institute.eu/>

Main objectives:

- ✓ **Linkage of partners along the whole lithium value chain** to generate focused international cooperation
- ✓ **Generation of projects, roadmaps and strategies** based on comprehensive **interdisciplinary competences**
- ✓ **Increase the visibility of ELI members** and their common objectives for policy and founding authorities



Executive Management



Knowledge Triangle

• Industry Committee chaired by



• Education Committee chaired by



• Research Committee chaired by

KU LEUVEN

<p>Exploration and Mining</p> <p>Chaired by</p>	<p>Processing and Recycling</p> <p>Chaired by</p>	<p>Materials and Components</p> <p>Chaired by</p>	<p>Design and Manufacturing</p> <p>Chaired by</p>
<p>Circular Economy and Predictive Modelling</p> <p>Chaired by</p>	<p>Business Models and Applications</p> <p>Chaired by</p>		



Take part of it and become stake- and/or shareholder for a better way of resource management!



THANK YOU FOR YOUR ATTENTION

*Roof of the high-phosphorus Beauvoir rare-metal granite
Echassières, Allier, France*

