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

**BRINES**

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

**HARD-ROCKS**

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

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

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

Hard-rock deposits
Brine deposits
Non conventional deposits

Source: Kesler et al., 2012

Source: Benson et al., 2015
Lithium Market Outlook

2015 lithium uses

- Glass/Ceramics 30%
- Rechargeable batteries 37%
- Others 9%
- Lubricants/grease 8%
- Metal powder 5%
- Polymers 5%
- Air treatment 3%
- Non-rechargeable batteries 2%
- Aluminum smelting 1%

Source: Roskill 2016

Li demand

Source: Stormcrow 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
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
## Mineral processing as a key

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Li-minerals</th>
<th>Company</th>
<th>Process</th>
<th>Industrialisation</th>
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<td>European Lithium</td>
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<td>ALL</td>
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<td>Keliber</td>
<td>Cleantech Process</td>
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<td>Cinovec</td>
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<tr>
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<td>Li micas</td>
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</table>

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

Adagoi 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

Modified after Gourcerol et al., 2019 OGR
European Lithium mineral resources

- 28 Li deposits in EU
- 8,839,750 t of Li$_2$O (4,106,355 t Li) reported in EU vs 3,125,000 t Li USGS 2019
- Various deposit types
- Various Li-bearing minerals

Modified after Gourcerol et al., 2019 OGR, in press
European Lithium mineralisations

PALEOPROTEROZOIC
NEOPROTEROZOIC

Modified after Gourcerol et al., 2019 OGR, in press
European Lithium mineralisations

CAMBRIAN-ORDOVICIAN Mn-(Fe) sediments

Modified after Gourcerol et al., 2019 OGR, in press
European Lithium mineralisations

ORDOVICIAN-DEVONIAN
(Caledonian orogeny)

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

CARBONIFEROUS – PERMIAN – Variscan orogeny

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

Moldanubian Pegmatites coeval of 2 melting events ca 333 & 325 Ma Melleton et al 2012
European Lithium mineralisations
PERMIAN / JURASSIC-CRETACEOUS / OLIGOCENE-MIOCENE

Modified after Gourcerol et al., 2019 OGR, in press
Types of European Lithium mineralisations

527 lithium occurrences, projects and deposits

Modified after Gourcerol et al., 2019 OGR, in press
European Lithium mineral resources

28 identified Li deposits in EU

Modified after Gourcerol et al., 2019 OGR, in press
Petalite crystals (light orange) surrounded by lepidolite (purple), lepidolite-petalite subtype LCT pegmatite
Ambazac, Haute-Vienne France
Conclusion

Lithium Metallogenetic model involves:

- 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.

Gourcerol et al., 2019 OGR, in press
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

Take part of it and become stake- and/or shareholder for a better way of resource management!
Roof of the high-phosphorus Beauvoir rare-metal granite
Echassières, Allier, France