# Lithium occurrences in the deep fractured crystalline reservoirs of the Upper Rhine Graben

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GEODENERGIES
Le sous-sol pour la transition énergétique
Therma'Li

Dr Carole Glaas
carole.glaas@es.fr
ES-Géothermie
26, bd du Président Wilson
F-67000 Strasbourg, France

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# Problematics

- **Lithium is concentrated in geothermal brines embedded in fractured granitic reservoirs of the Upper Rhine Graben**
- **Geothermal Lithium could become an interesting byproduct to exploit**
- **Which minerals of the granite are bearing the Lithium ?**
- **Which is the Lithium concentration in the granite and the minerals ?**

# Problematics

- **Which minerals of the granite are bearing the Lithium ?**

**The LIBS technique will allow to localise the Lithium in granitic rock samples, based on coloured elementary maps based on the chemical elements concentration.**

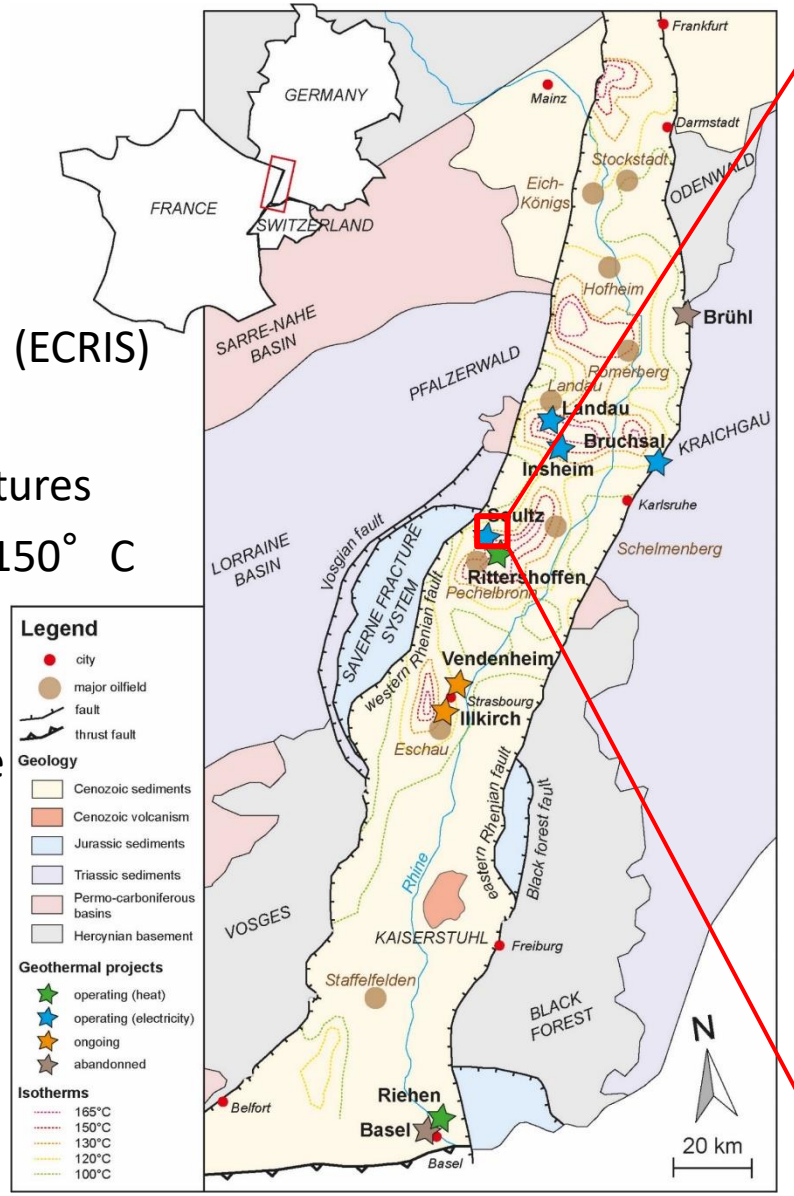
- **Which is the Lithium concentration in the granite and the minerals ?**

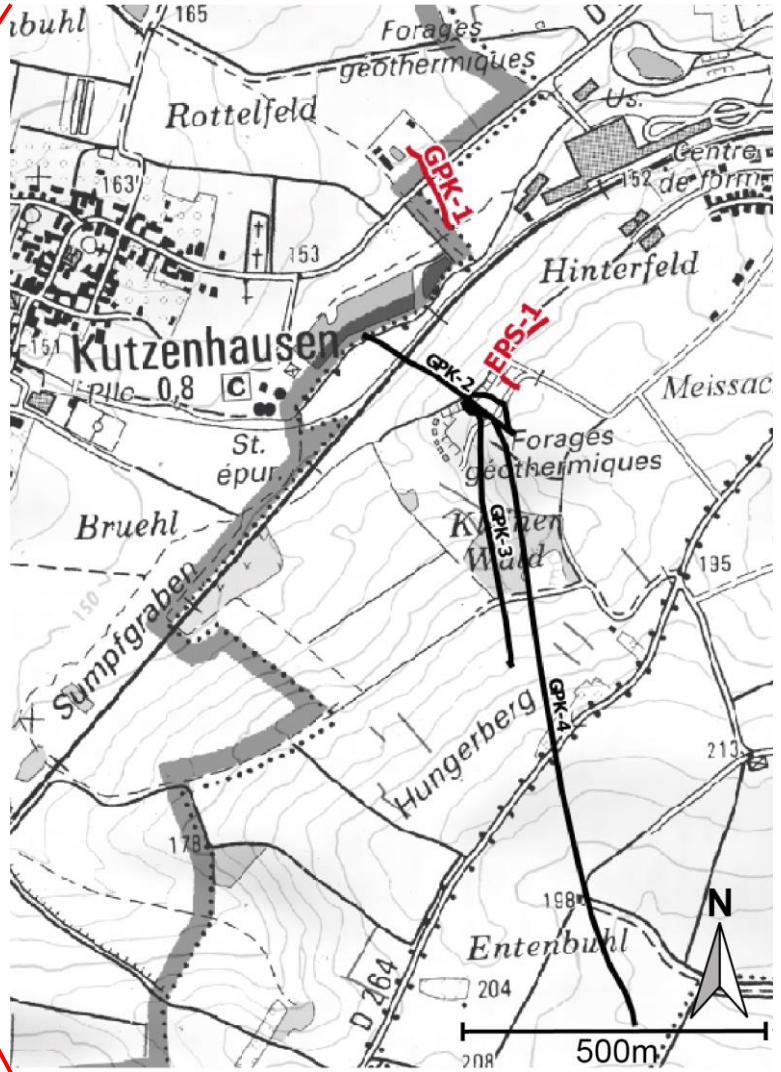
**Coupled with other techniques like bulk rock chemical analyses, the LIBS cartography could allow to obtain semi-quantitative estimate of the Lithium concentration in the rock and more specifically in the minerals.**

# Geological setting

## Upper Rhine Graben (URG)

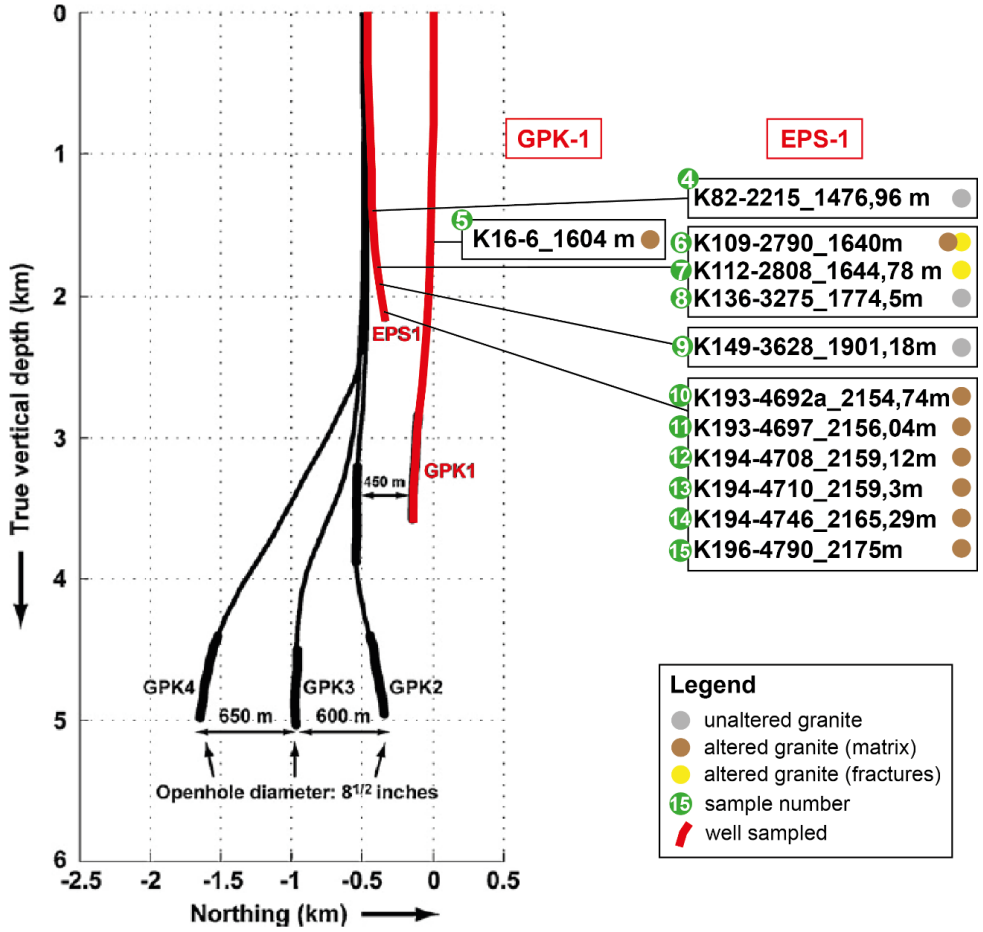
- 300 km length, 30-40 km width
- SSW-NNE direction
- Part of the European Cenozoïc Rift System (ECRIS)
- Temperature anomalies
- Fluid circulation in the nearly-vertical fractures
- Highly salted brine = NaCl type, 100g/L, >150° C
- Soultz-sous-Forêts power plant: 1.7MWe
- Rittershoffen geothermal plant: 24MWth
- Reservoir: fractured Carboniferous granite
- Lithium content in the brine: ~170ppm
- Soultz core samples

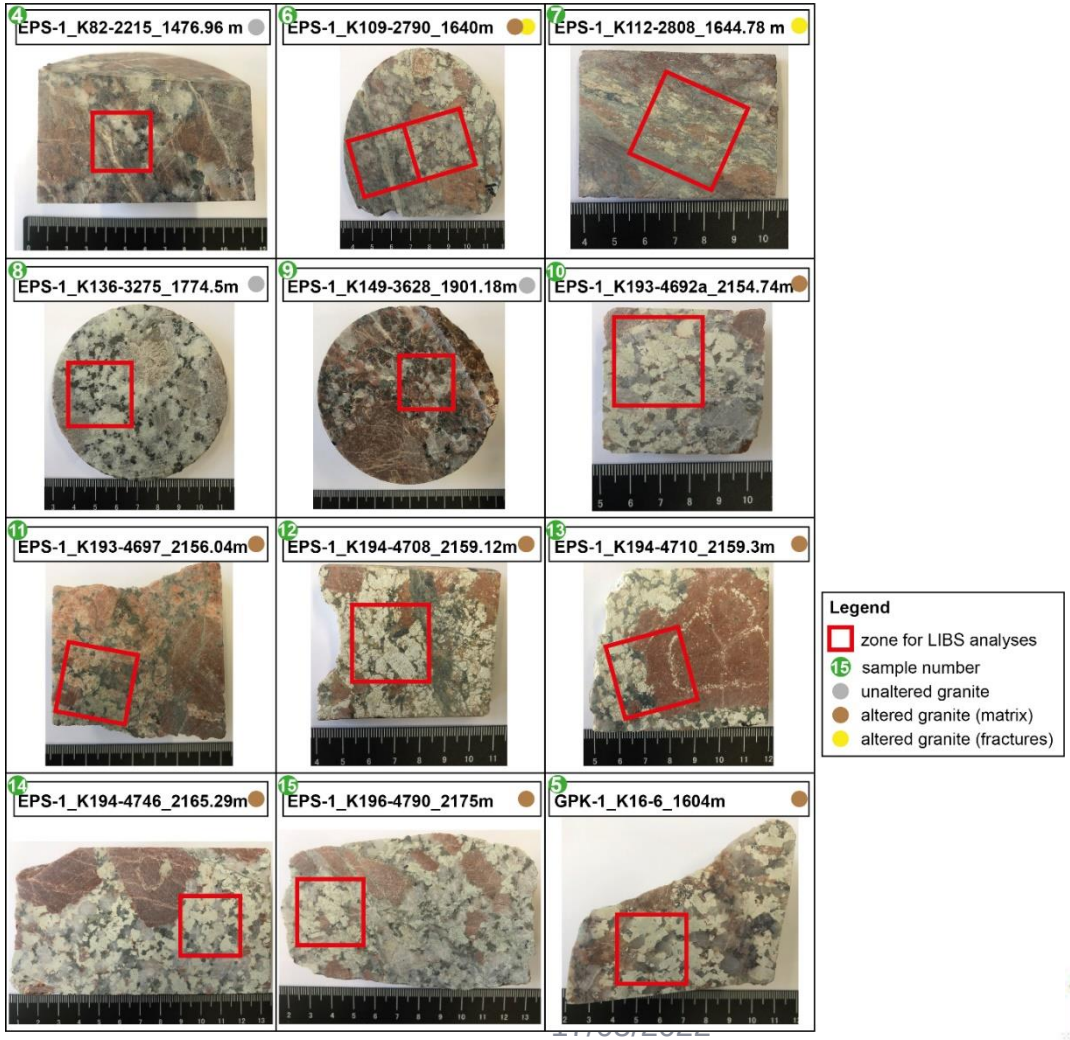


# LIBS - Data

- 12 core samples from the granite of the boreholes EPS-1 and GPK-1 (Soultz-sous-Forêts)
- unaltered granite & hydrothermally altered granite

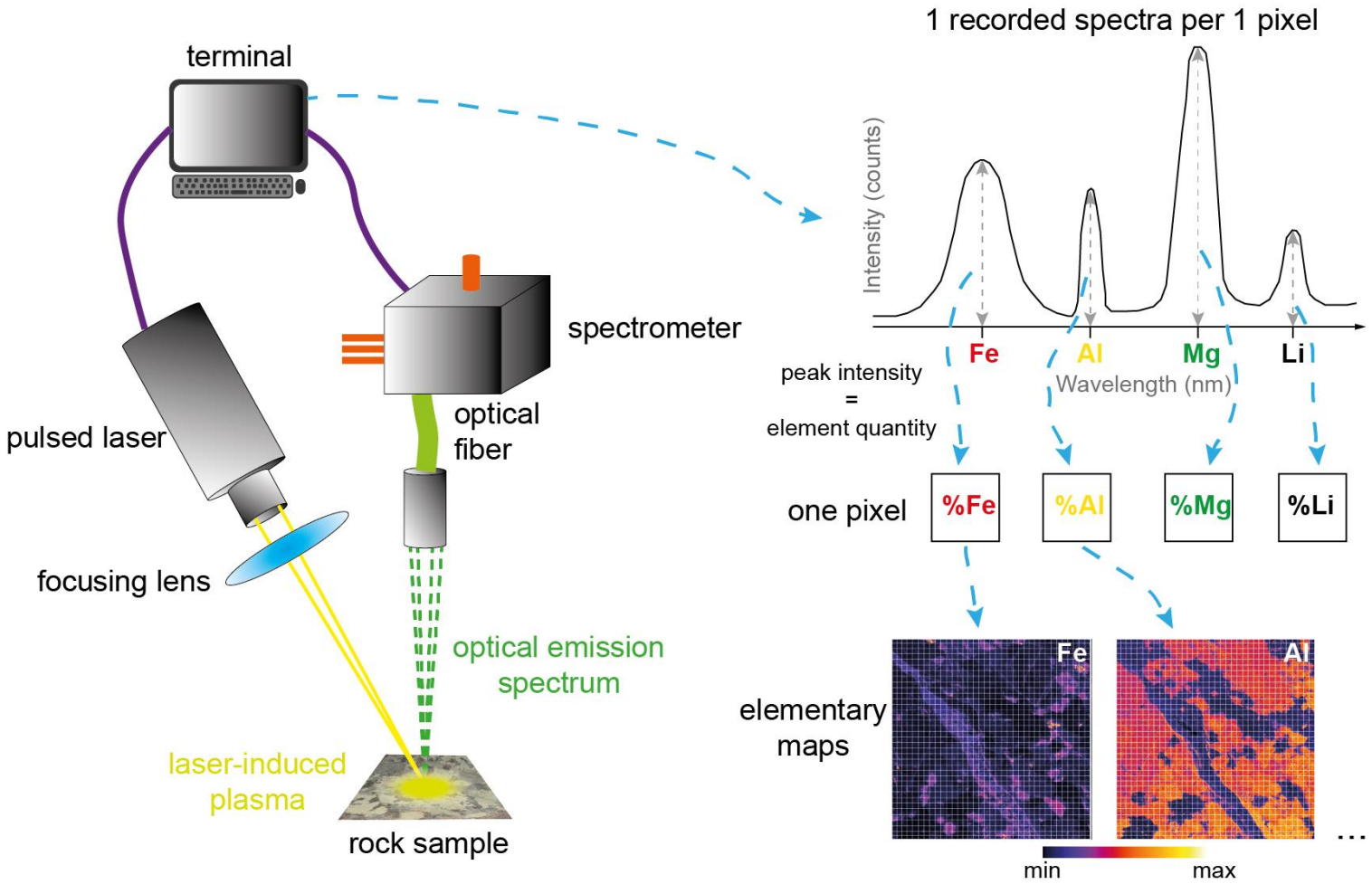


# LIBS - Method

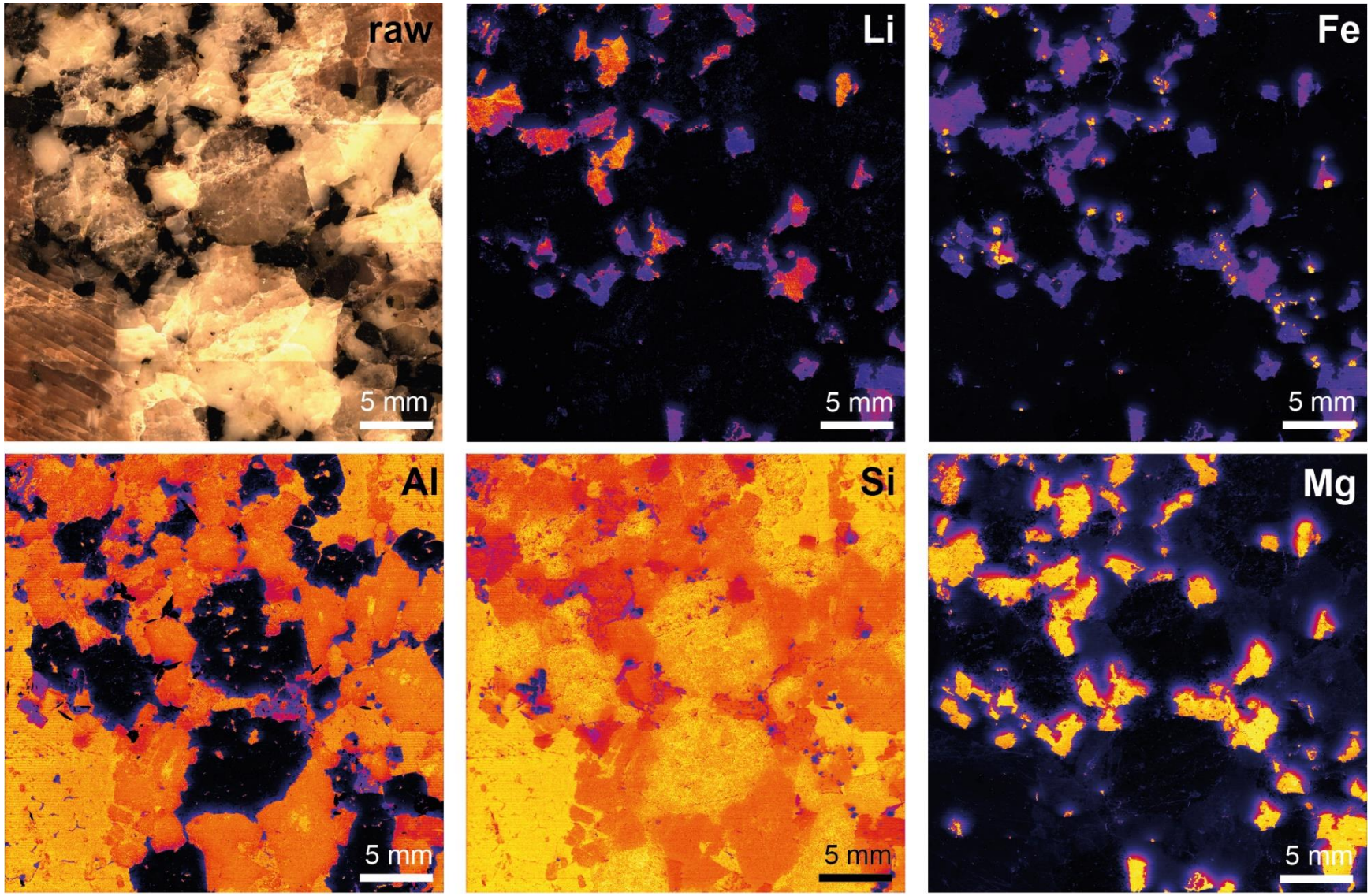
## “Laser-Induced Breakdown Spectroscopy”

Elementary analysis based on the analysis of the optical emission spectrum of a plasma generated by a laser on the surface of the sample.



# LIBS - Results: unaltered granite

**Sample 8**



# LIBS - Results: unaltered granite

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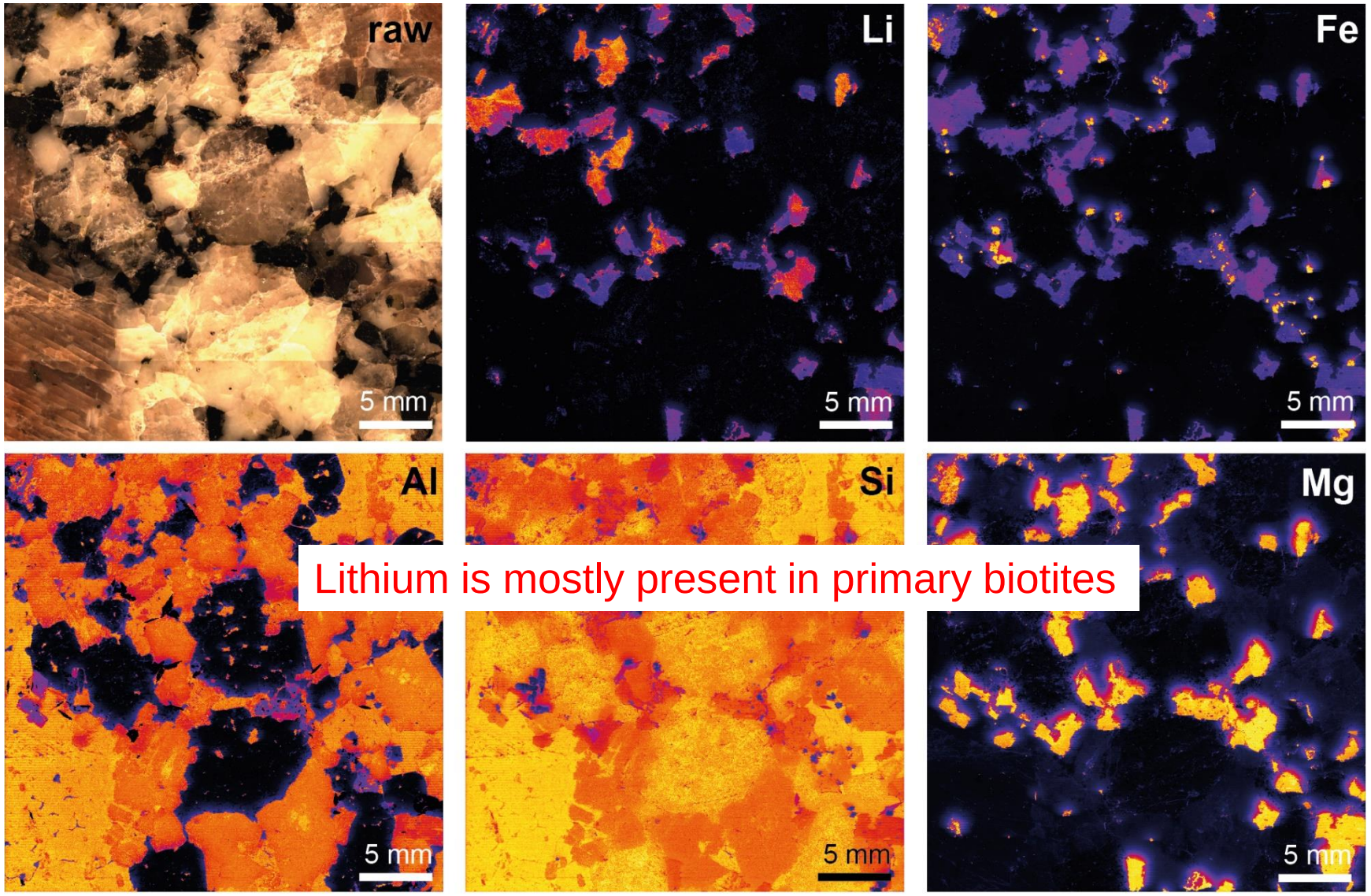
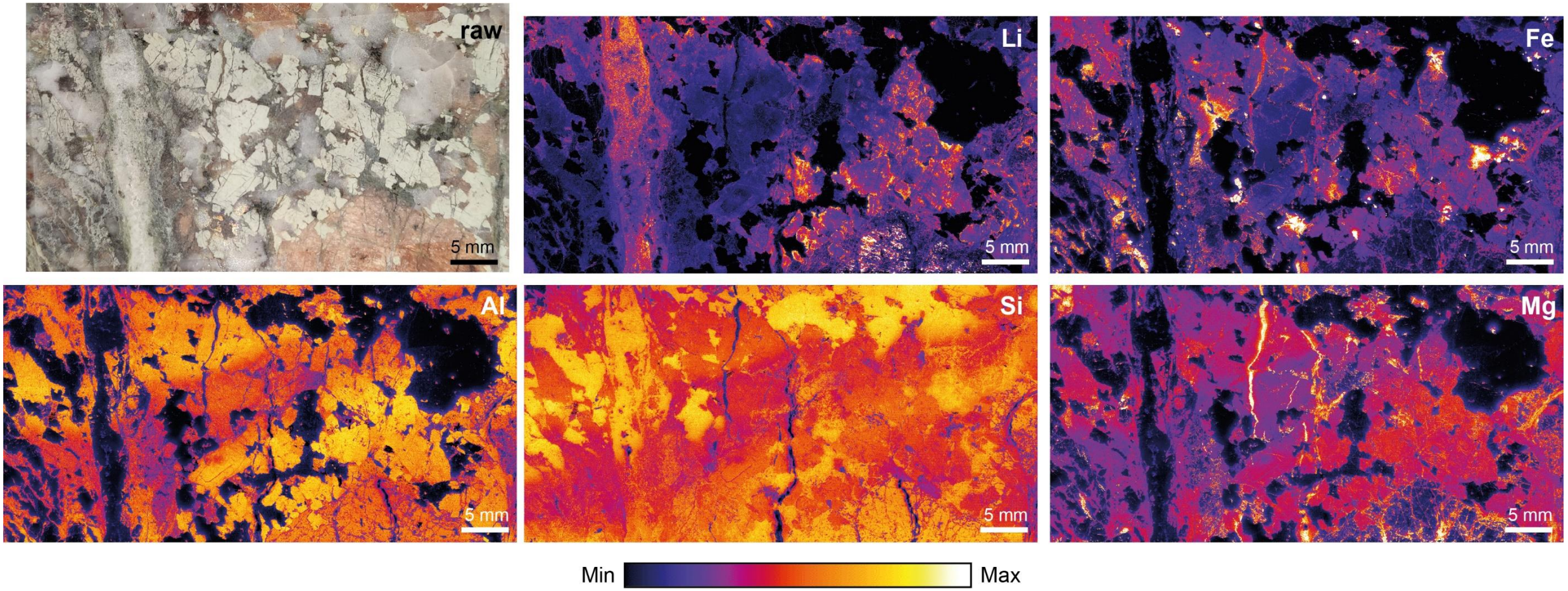


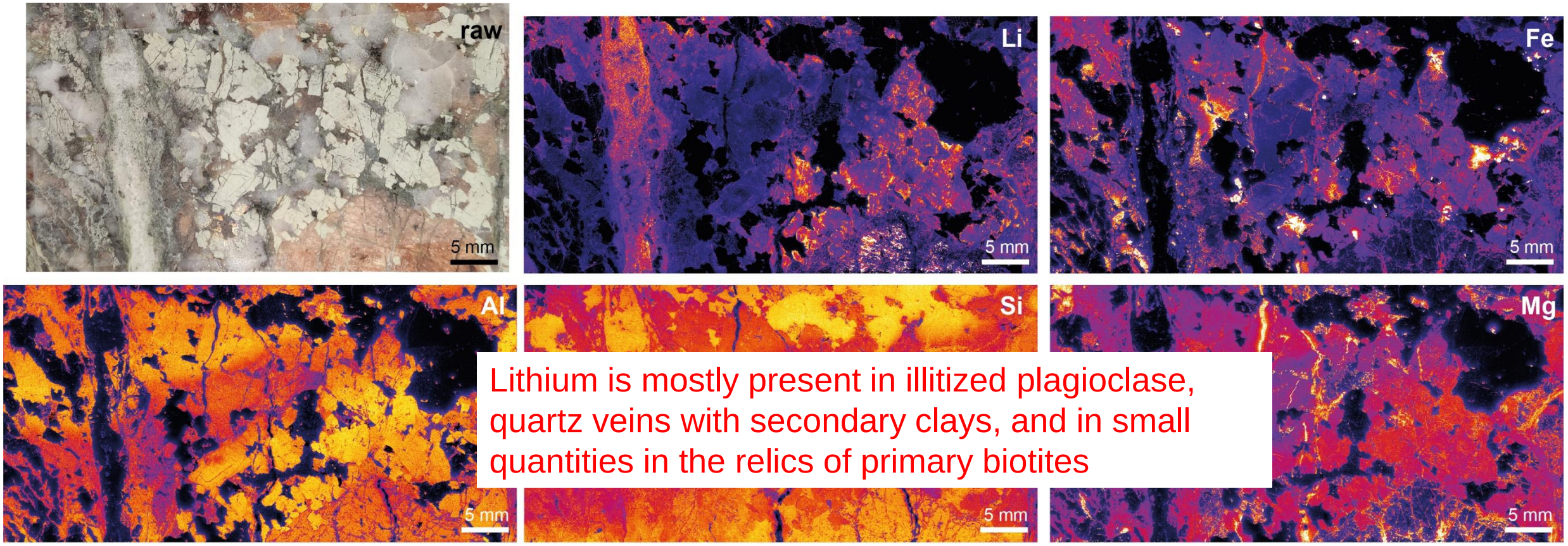
# LIBS - Results: hydrothermally altered granite

## Sample 6



# LIBS - Results: hydrothermally altered granite

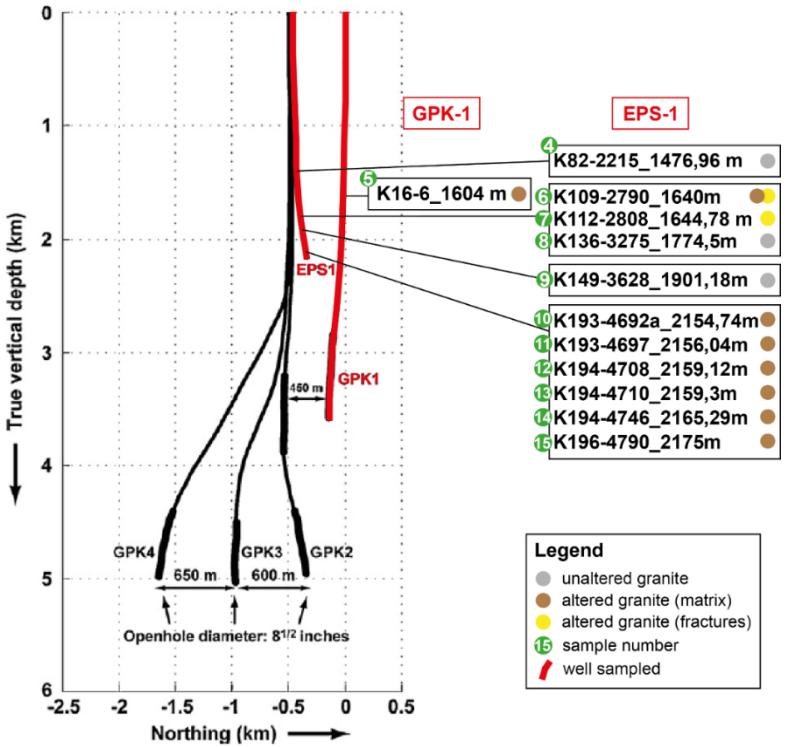
## Sample 6

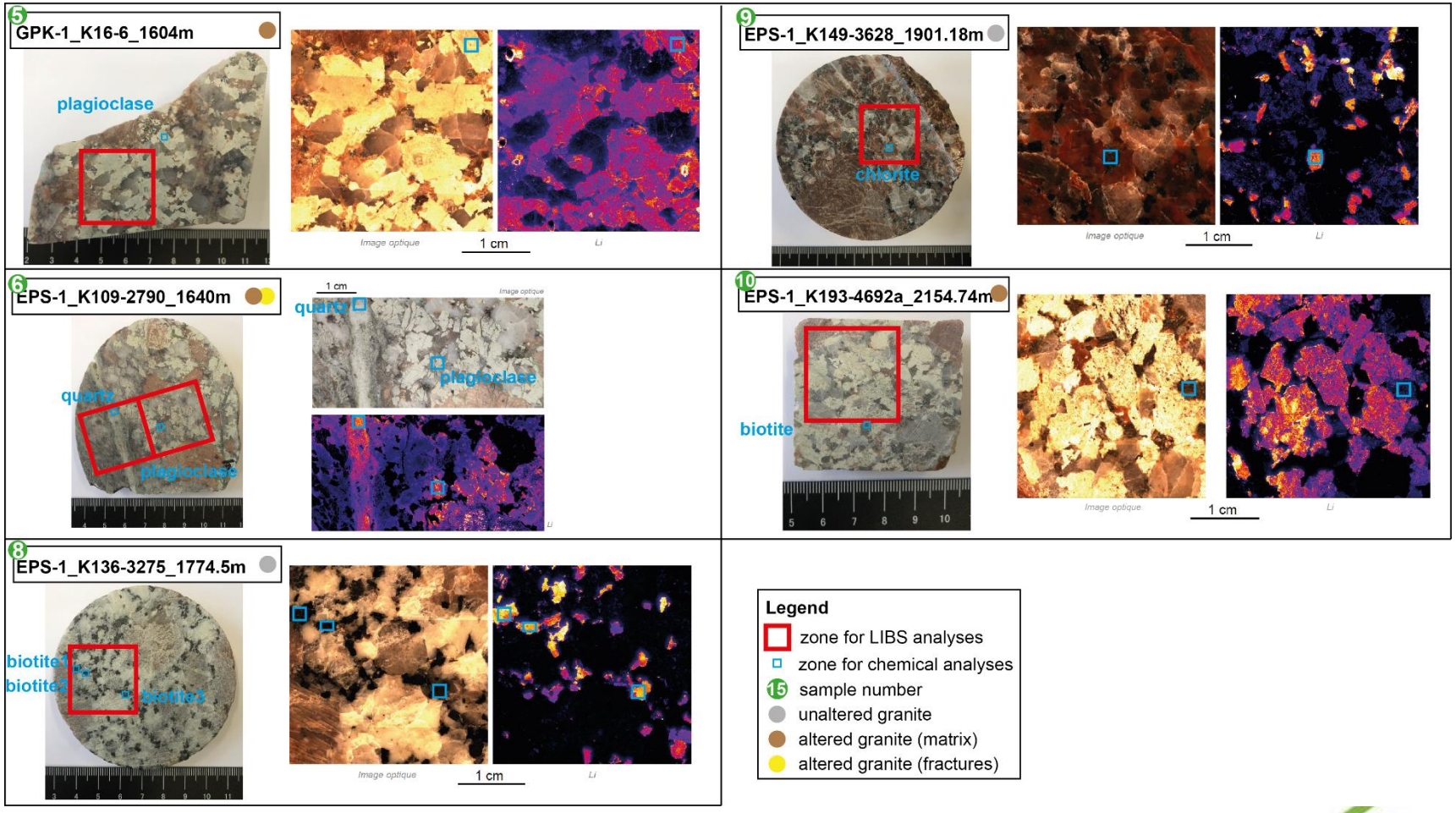



Lithium is mostly present in illitized plagioclase, quartz veins with secondary clays, and in small quantities in the relics of primary biotites

# Chemical analyses - Data

- **Targeted minerals: primary biotite, altered biotite, primary plagioclase, altered plagioclase, quartz vein**



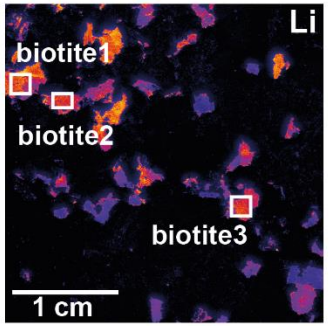




The values obtained are pourcentages in chemical elements obtained from mean values based on 36 measurements in zones varying between 1.5x1.5mm and 3x0.8mm.

# Chemical analyses - Results

Unaltered granite

**8 EPS-1_K136-3275_1774.5m**




| Element | biotite1 % | biotite1 +/- | biotite2 % | biotite2 +/- | biotite3 % | biotite3 +/- |
|---|---|---|---|---|---|---|
| Al | 6.2 | 1.1 | 1.2 | 0.2 | 3.7 | 0.6 |
| Ba | | | 0.12 | 0.03 | | |
| Ca | 0.27 | 0.09 | 0.38 | 0.12 | 1.8 | 0.6 |
| Fe | 0.59 | 0.17 | 9.2 | 2.4 | 0.0.814 | 0.0458 |
| H | | | | | | |
| K | 19.9 | 2.6 | 17.7 | 3.5 | 25.7 | 3 |
| **Li** | **0.18** | **0.02** | **0.15** | **0.03** | **0.27** | **0.03** |
| Mg | 9.8 | 1.2 | 8.6 | 1.7 | 10.1 | 1.2 |
| Na | 0.36 | 0.04 | 0.26 | 0.05 | 0.53 | 0.06 |
| O | 37.9 | 3.5 | 49.9 | 3.8 | 38.4 | 3.6 |
| Si | 17.5 | 2.7 | 10.6 | 2.2 | 19.2 | 3 |
| Ti | 0.75 | 0.18 | 1.6 | 0.6 | 0.24 | 0.04 |

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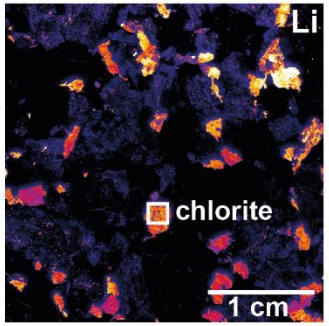
**9 EPS-1_K149-3628_1901.18m**




| Element | chlorite % | chlorite +/- |
|---|---|---|
| Al | 3.1 | 0.4 |
| Ba | | |
| Ca | 4.1 | 0.7 |
| Fe | 0.053 | 0.035 |
| H | 0.2 | 0.03 |
| K | 11.8 | 1.4 |
| **Li** | **0.13** | **0.01** |
| Mg | 11.3 | 1.6 |
| Mn | 0.22 | 0.09 |
| Na | 0.96 | 0.11 |
| O | 44.7 | 3.4 |
| Si | 23.2 | 2.9 |
| Ti | 0.2 | 0.03 |

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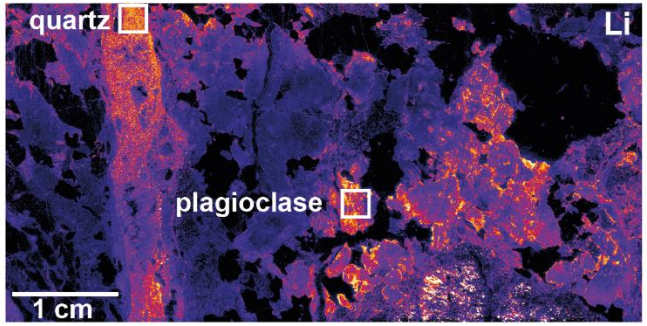
Altered granite

**6 EPS-1_K109-2790_1640m**




| Element | quartz % | quartz +/- | plagioclase % | plagioclase +/- |
|---|---|---|---|---|
| Al | 0.32 | 0.05 | 2.4 | 0.4 |
| Ba | 0.005 | 0.001 | 0.023 | 0.004 |
| Ca | 0.056 | 0.009 | 0.77 | 0.17 |
| Fe | | | | |
| H | 1.3 | 0.2 | 0.87 | 0.1 |
| K | 2.2 | 0.3 | 23.4 | 3.7 |
| **Li** | **0.045** | **0.006** | **0.043** | **0.006** |
| Mg | | | | |
| Na | 0.092 | 0.013 | 0.59 | 0.11 |
| O | 61.4 | 5.5 | 48.2 | 4.4 |
| Si | 34.5 | 5.6 | 20.9 | 3.7 |
| Ti | | | | |

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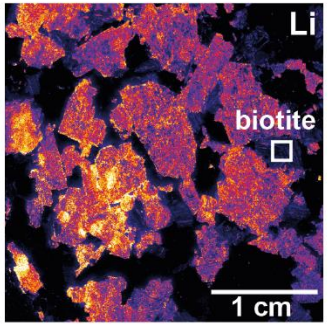
**10 EPS-1_K193-4692a_2154.74m**




| Element | biotite % | biotite +/- |
|---|---|---|
| Al | 3.7 | 0.6 |
| Ba | | |
| Ca | 1.5 | 0.3 |
| Fe | 0.21 | 0.05 |
| H | 0.25 | 0.08 |
| K | 20 | 2.6 |
| **Li** | **0.027** | **0.003** |
| Mg | 1.9 | 0.3 |
| Na | 0.64 | 0.1 |
| O | 44.3 | 3.9 |
| Si | 26.5 | 4 |
| Ti | 0.28 | 0.05 |

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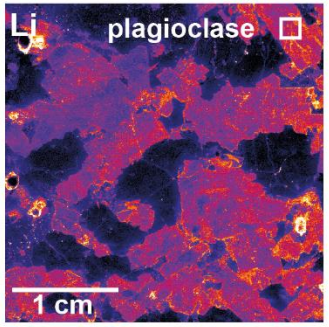
**5 GPK-1_K16-6_1604m**




| Element | plagioclase % | plagioclase +/- |
|---|---|---|
| Al | 10.3 | 1.9 |
| Ba | | |
| Ca | 2.1 | 0.6 |
| Fe | | |
| H | | |
| K | 12.7 | 1.8 |
| **Li** | **0.052** | **0.005** |
| Mg | 1.4 | 0.2 |
| Na | 3.4 | 0.7 |
| O | 44.2 | 3.8 |
| Si | 25.8 | 3.7 |
| Ti | | |

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**Legend**

- zone for LIBS analyses
- zone for chemical analyses
- 15 sample number
- unaltered granite
- altered granite (matrix)
- altered granite (fractures)

*all the chemical compositions are mean values obtained from 36 craters in zones of 1.5x1.5mm, excepted for «biotite2» on sample 8 which zone was of 3x0.8mm

# Chemical analyses - Results

Unaltered granite

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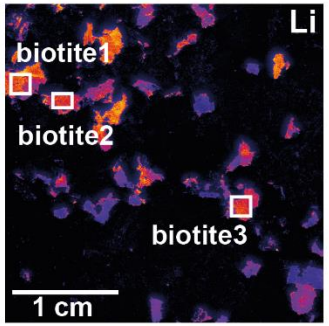


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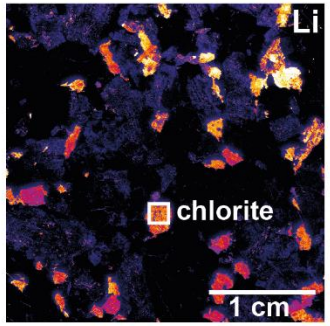


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| **Li** | **0.13** | |
| Mg | 11.3 | |
| Mn | 0.22 | |
| Na | 0.96 | |
| O | 44.7 | |
| Si | 23.2 | |
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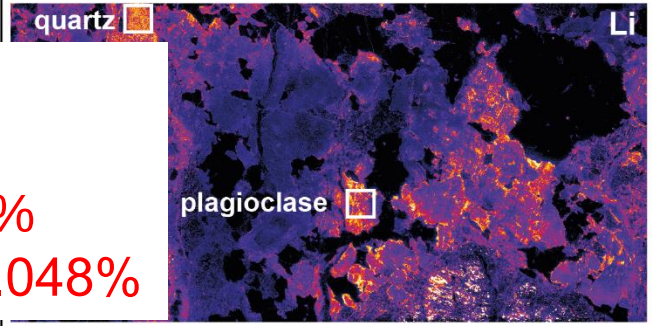
Unaltered granite :
biotites Li ≈ 0.2%
chlorite Li =0.13%

Altered granite :
biotites Li 0.02%
quartz vein 0.045%
plagioclase Li ≈ 0.048%

**6 EPS-1_K109-2790_1640m**

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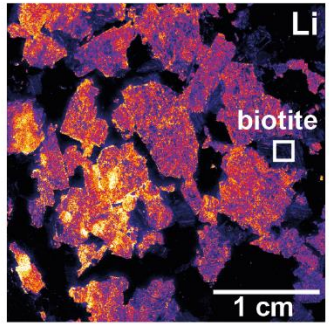


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Altered g

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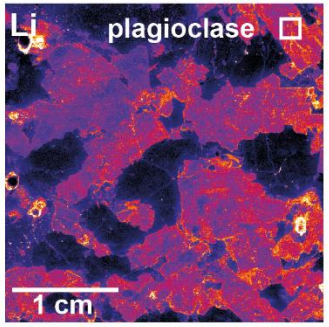


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*all the chemical compositions are mean values obtained from 36 craters in zones of 1.5x1.5mm, excepted for «biotite2» on sample 8 which zone was of 3x0.8mm



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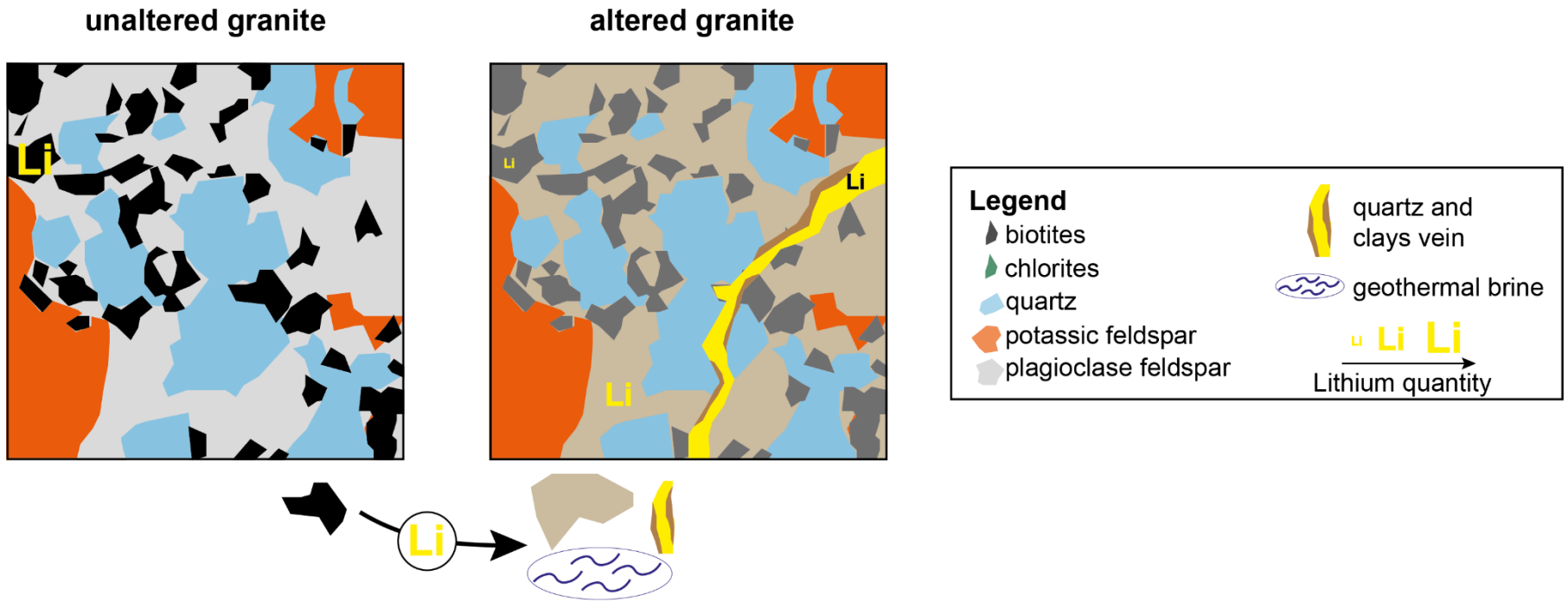
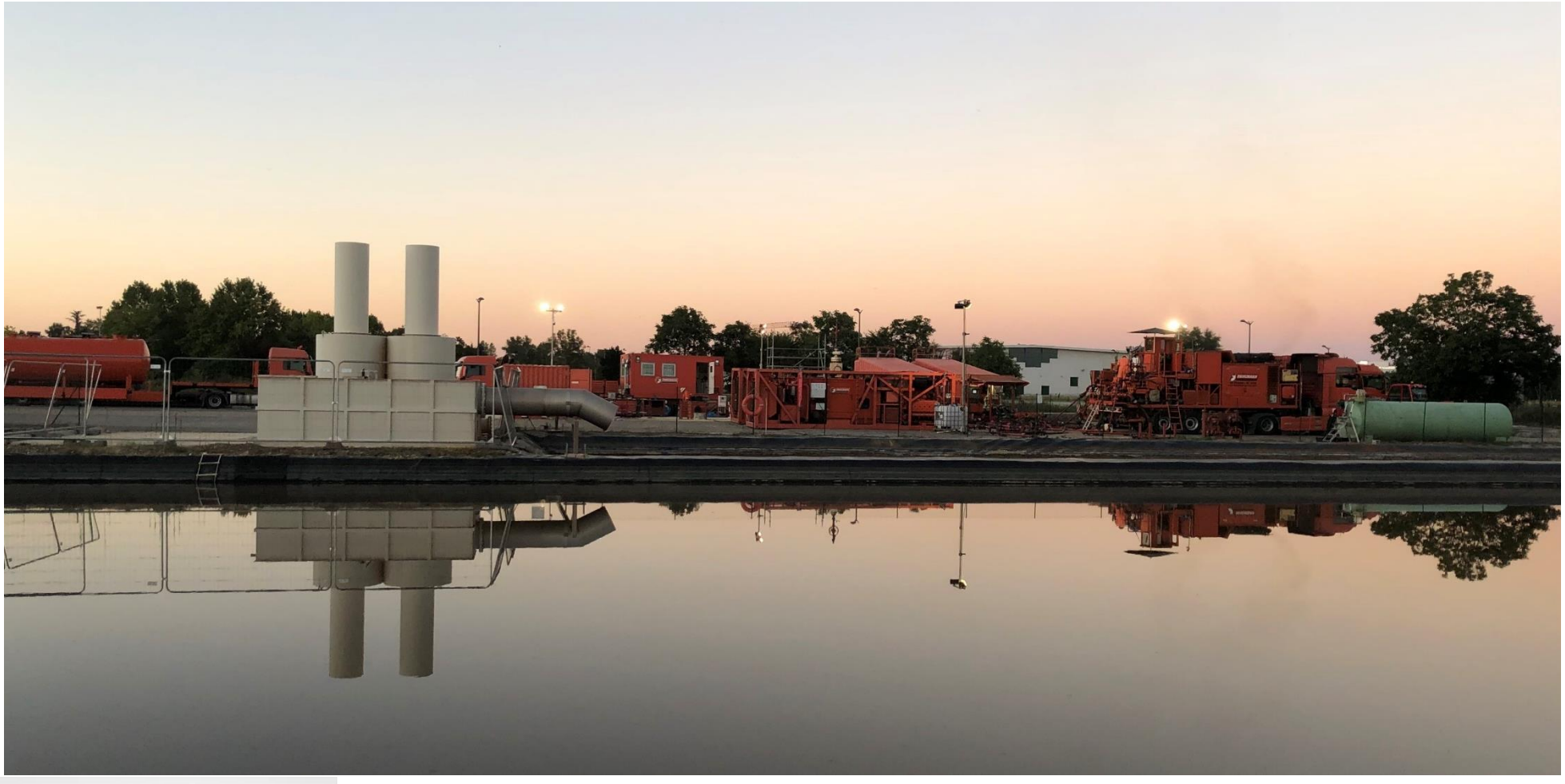
# Conclusion - Discussion

- **Unaltered granite**
- **biotites** in the sample 8 present values in Lithium around **0.15%, 0.18% and 0.27%**
- **Chlorite** in the sample 9 presents values around 0.13%.

- **Altered granite**
- the **biotite** (sample 10) presents Lithium values around **0.027%**,
- the **quartz vein** (sample 6) presents a value of Lithium around **0.045%**
- the **illitized plagioclase** presents Lithium value around **0.043%** (sample 6), and **0.052%** (sample 5).



# Thank you for your attention !



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