Creation of Quartz ID cards for source tracing using a multi-method approach as part of the ANR Quartz project: Lithium as a key element
Claire Aupart, Catherine Lerouge, Philippe Lach, Samuel Moncayo, Florian Trichard, Pierre Voinchet, Manon Boulay, Magali Rizza, Hélène Tissoux

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Quartz, because of its high resistance to weathering, is ubiquitous and abundant in fluvial sediments. Its chemistry and physical properties provide information on its formation context and subsequent history making it an interesting marker of fluvial dynamics in a source to sink approach.

One of the main objectives of the French ANR Quartz project is to use the characteristics of quartz to trace its origin within fluvial sediments by combining conventional characterization methods with dosimetric methods such as Electronic Spin Resonance (ESR) and Optically activated Luminescence (OSL) usually used for dating.

The first step to this is the characterization of the quartz signature of each of the bedrocks of the watershed of interest.

### Step 1: Mineral separation
- **Crushing (250-180 µm)**
- **HCl** (37%)
- **Magnetic separation**

### Step 2: Quartz extraction
- **I/HCl+ 2/3 H2SiF6 with agitation - 6 days**
- **LST**
- **Separation with magnetic**
- **d = 2.62 g/cm**

### Step 3: Quartz purification
- **Crushing (250-180 µm)**
- **Magnetic separation**
- **Final sieving (250-140 µm)**

Analyses are made on purified quartz grains to remove any foreign mineral signature. Especially feldspar, that has a strong OSL signature overprinting quartz signal. This is less critical for ESR.

These techniques rely on the activation of electronic traps formed by structural defects in the mineral lattice either using magnetic, luminous or thermal energy. These analytic methods are typically used for dating purposes but have shown potential for provenance studies. The origin of the OSL signal is poorly known, however the most used dating ESR centers are Al, Ti-Li, and Ti-H centers.

### Principle of Electronic Spin Resonance (ESR)
- Quartz CL emission is weak but varies according to mineral orientation and quartz origin.
- CL-spectra can be obtained using spectrometer.

### Principle of Cathodo-Luminescence (CL)
- Cathodo-luminescence’s principle relies on similar electronic traps as OSL, activated by an electronic beam.

### Principle of Optical Luminiscence (OSL) and Thermo-luminescence (TL)

### Principle of Laser Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS)

Laser ablation requires thick material to work on (at least 100 µm) as it removes matter from the sample. Quartz is a challenging mineral for laser ablation due to its hardness and transparency. To prevent excessive tearing of the sample, a more powerful laser setting is used.

This precaution is not necessary with LIBS as the laser energy required to produce plasma is much lower and does not damage the sample surface as much.

LIBS and LA-ICP-MS are complementary techniques. LIBS is more sensitive to light and volatile elements while LA-ICP-MS is most performant with heavy elements. LIBS produces quick elemental maps while LA-ICP-MS is best at punctual analyses.

### Lithium in quartz:
- Ideal quartz structure is network of SiO₄ tetrahedra linked together by their oxygen atoms.
- Tetrahedra are arranged in helicoidal structures that create channels parallel to the crystallographic c-axis.
- Some of the most common defects of the quartz lattice are atom vacancies and Si substitution.

### Common substituting atoms in quartz: Al, Ti, Ge.

Vacancies and substituting atoms may require a charge compensation to keep electronic neutrality. This role is taken by foreign cation circulating through the quartz structure in the c-axis channels.

### Li in a common charge compensating ion. As such, it contributes to one of the main ESR centers used for dating.

The best correlation between OSL and ESR signals is obtained with the Ti-Li center intensities. However, there is no relation between the OSL signal and Li. The same sample families observed using elemental analyses can be retrieved.

### First results:
Li is critical to identify families of quartz types and origin. Its maximum content is correlated to Al content.

![Graph showing the correlation between Li and Al content in various quartz types](image)

No strong correlation between ESR Ti-Li intensity and Li concentration. → Li not limited to being a compensator for Ti in Ti-Li ESR centers

A lot more to do:
- LIBS data, spectral CL data to acquire and treat
- Statistical treatment (ACP)
- Identify trace elements responsible for OSL and ESR signal
- Application to Strengbach fluvial sediments for provenance study