

CHALLENGES IN COUPLED ON-LINE-ON-MINE-REAL-TIME MINERALOGICAL AND CHEMICAL ANALYSES ON DRILL CORES

SOLSA CONSORTIUM:

CÉDRIC DUÉE (1), BEATE ORBERGER (2*), NICOLAS MAUBEC (1), VALÉRIE LAPERCHE(1), LAURE CAPAR (1), ANNE BOURGUIGNON (1), XAVIER BOURRAT (1), YASSINE EL MENDILI (3), STEPHANIE GASCOIN (3), DANIEL CHATEIGNER (3), CELINE RODRIGUEZ (2), ANNE SALAÜN (2), MONIQUE LE GUEN (2), THANH BUI (2), GINO MARIOTTO (4), MARCO GIAROLA (4), ARUN KUMAR (4), NICOLA DALDOSSO,(4), MARCO ZANATTA (4), LUCA LUTTEROTTI (5), EVGENY BOROVIN (5), MAURO BORTOLOTTI (5), MARIA SECCHI (5), MAURIZIO MONTAGNA (6), HENRY PILLIÈRE (7), THOMAS LEFEVRE (7) FONS EIJKELKAMP (8), HARM NOLTE (8), PETER KOERT (8), SAULIUS GRAZULIS (9), FABIEN TROTET (2/10), MOHAMED KADAR (2/10), KAREN DEVAUX (2/10)

(1) BRGM, 3 avenue Claude Guillemin, BP 36009, 45060 Orléans Cédex 2, France; (2) ERAMET, 1 Avenue Albert Einstein, 78190 Trappes, France; Université Paris Sud, GEOPS, Bât 504, 91405 Orsay, France; (3) Normandie Université, CRISMAT-ENSICAEN, UMR CNRS 6508, Université de Caen Normandie, 14050 Caen, France; (4) University of Verona, Department of Computer Science, 37134 Verona, Italy; (5) University of Trento, Industrial Engineering Department, 38123 Trento, Italy; (6) University of Trento, Physics Department, 38123 Trento, Italy; (7) ThermoFisher, 71 rue d'Orléans, 45410 Artenay, France; (8) Royal Eijkelkamp, Uitmaat 8, ER Giesbeek, The Netherlands; (9) Vilnius University Institute of Biotechnology, 10223 Vilnius, Lietuva (Lithuania); (10) ERAMET-SLN, Nouméa, New Caledonia

Drill core materials from contrasting lithologies (sandstone, coarse granite, peridotite and siliceous breccia), were analysed to benchmark analytical conditions for XRF, XRD, hyperspectral and Raman spectrometers for on-line-real-time-on-mine analyses in the frame of the SOLSA project (<http://www.solsa-mining.eu>) sponsored by the EU-H2020 Raw Material program. We tested: (1) a multi-technique approach on sample surfaces (20 x 20 mm²); (2) surface roughness effects on the different analyses. Five surface states were selected: (1) sonic and diamond drilled, (2) diamond-saw cut, (3) 6 µm polished, (4) 0.25 µm polished (5) powdered (< 80 µm). The following techniques were used: (1) portable X-ray fluorescence spectroscopy (pXRF), (2) portable infra-red spectroscopy (pIR), (3) Raman spectroscopy (4) laboratory XRD. The results obtained on the selected lithologies can be summarised as follows: **Peridotite** hosts 57 wt.% serpentine, 29 wt.% forsterite, 11 wt.% enstatite, 3 wt.% talc and traces of amphibole (XRD), while pIR only indicates serpentine. Raman spectroscopy clearly detects the ubiquitous presence of lizardite and forsterite. Grains of enstatite, quartz, anatase, rutile, pyrite, magnetite, maghemite and goethite were detected in selected regions. pXRF analyses on powders indicate 22 wt.% Si, 21 wt.% Mg, 6 wt.% Fe, 90 ppm V, 40 ppm Ti, 2200 ppm Ni, 1400 ppm Cr, 40 ppm Zn and 900 ppm Mn. Analyses of drilled, cut and polished surfaces show higher values for Si, Mg and Ti, similar contents of Fe, Ni, Zn, Mn, and variable contents of V and Cr compared to those of powder samples. **Granite** (XRD) is composed of 27 wt.% quartz, 20 wt.% microcline, 28 wt.% albite, 24 wt.% mica and/or illite and 1 wt.% chlorite. pIR shows the presence of bound water and illite, in agreement with XRD analyses. Raman spectroscopy confirms the presence of quartz, albite, identifies mica as muscovite and detects gypsum, magnesium sulphate, rutile, anatase, calcite and hematite. pXRF on powders' surface indicate 39 wt.% Si, 9.2 wt.% Al, 0.55 wt.% Ca, 4.2 wt.% K, 95 ppm Zr, 60 ppm Sr, 300 ppm Ba, 43 ppm Zn, 38 ppm Pb, 0.9 wt.% Fe, 136 ppm V, 960 ppm Ti. Analyses of drilled, cut and polished surfaces show higher Si contents (42–46 wt.%), and variable contents of the other elements. Cr was detected during polished surface analyses (235–324 ppm). These heterogeneous results are due to the coarse grain size. **Sandstone** is composed of 100 wt.% quartz (XRD). pIR indicates the presence of bound water, illite or montmorillonite. Raman spectroscopy, besides quartz, detects anatase, pyrite, maghemite, goethite and zircon. pXRF on powder shows 55 wt.% Si, 132 ppm Zr, 0.02 wt.% Fe, 55 ppm V, 358 ppm Ti and traces of Ca and K. Analyses of such surfaces give lower concentrations, in particular for Zr (50–100 ppm), Ti (99–256 ppm). Fe, heterogeneously distributed (260–600 ppm), is related to iron oxihydroxides. **Breccia** contains 100 vol.% of quartz with traces of hematite and goethite (XRD). pIR shows water molecules and goethite. Raman spectroscopy confirms quartz, and hematite and goethite, and adds hedenbergite, forsterite, calcite, magnetite and maghemite. pXRF on powder indicates 53 wt. % Si, 1.7 wt. % Fe, 3700 ppm Ni and 780 ppm Cr. Sawn surfaces give lowest trace element values. As for sandstone, analyses on the drilled, cut and polished surfaces give generally lower concentration and highly variable (241–1520 ppm Ni; 12 ppm–1.2 wt.% Fe, 86–480 ppm Cr). The major challenges of combined on-line sensor are the various sizes probed by the techniques, from cm (IR) to mm (pXRF) down to microns (Raman spectroscopy). Heterogeneous and coarse grained materials need a high number of analyses to give reliable mean results (time consuming). Methods such as IR and XRF need surface proximity, in order to optimize signal output. Major technological

developments are needed to design the on-line setup. Finally, it is recommended to build-up an adequate Raman database.