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Stress and Strain in Quartz Veins along the Neoarchean Cadillac-Larder Lake Fault Zone, Abitibi, Canada

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Most Archean gold deposits are associated with major structural faults such as the Cadillac-Larder Lake fault zone (CLLFZ, Superior craton) and the Boulder-Lefroy Fault (Yilgarn craton). Gold deposits are related to second-order structures, which host hydrothermal quartz vein systems. Emplacement depth is an important parameter in the crustal continuum model for orogenic gold deposits but is complex to determine in deformed terranes. The source of fluids in orogenic gold deposits also lacks consensus and could be related to deep-seated metamorphic, magmatic, or supracrustal fluids.

A total of 40 quartz veins were sampled in 23 orogenic gold deposits along the CLLFZ in Abitibi, from Val-d’Or (QC) to Kirkland Lake (ON). The CLLFZ is a major crustal structure stretching onto 250 km in the Archean Abitibi greenstone belt. The aim of this study is to determine the nature of the mineralized fluids and the dynamic of the CLLFZ after original vein crystallization.

Microstructural description of quartz veins using transmitted light microscopy and EBSD analysis allows determination of recrystallization textures, dominant dynamic recrystallization (DRX) mechanism, as well as recrystallized grain size and flow stress. Samples were collected at several depths in drill cores, as well as from underground mines and outcrops. The host rock varies from intermediate intrusive to mafic volcanic and sedimentary rocks. First results show evidence of dynamic recrystallization in most samples. Samples analyzed with EBSD display a log-normal distribution of recrystallized grain sizes that is consistent with data for natural samples such as mylonite. A 3D test shows a variation of the mean recrystallized grain size in one direction (surface plane in the vein direction). A sample in a fold hinge (Dubuisson deposit) shows variation of both DRX mechanism and mean recrystallized grain size relative to the undeformed part of the vein.

Quartz vein samples were also selected for vacuum crushing and noble gas isotopes (He, Ne, Ar, Kr, Xe) and CO_2, H_2O contents were measured from fluid inclusions. The inert behavior of noble gases prevents them from chemically interacting with their surroundings, whereas noble gas isotopes can be fractionated during geologic processes such as magmatic differentiation or hydrothermal boiling. The relative abundance and isotopic composition of noble gases in fluid inclusions can be helpful to determine the origin of these fluids. Preliminary results show lack of He and Ne, explained by their high diffusivity in quartz and the age of the samples. Two groups of samples are distinguished by high CO_2 contents and relatively little radiogenic $^{40}Ar/^{36}Ar$ ratio of less than 5,000, and CO_2-poor samples with $^{40}Ar/^{36}Ar$ ratio >18,000. Elemental ratios Kr/Ar and Xe/Ar are higher than that expected in aqueous fluids and possibly indicate fractionation by boiling or contribution from a sedimentary component, as often documented in Paleozoic and Cenozoic counterparts.

Fig. 1. Postprocessed EBSD map of sample SIL1 (Silidor deposit, Rouyn-Noranda), using MTEX add-on in Matlab and modified matlab code from Cross et al. (2017). Red grains depict relict grains or porphyroclasts; blue ones show the recrystallized grains. Dominant DRX mechanism is subgrain rotation in this case.