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FLUID EVOLUTION DURING THE VARISCAN OROGENY: VARIATION IN PRESSURE, TEMPERATURE AND COMPOSITION

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The Stavelot-Venn Massif consists of Lower Palaeozoic strata (Lower Cambrian to Middle Ordovician), which are unconformably overlain by the Devonian and Carboniferous. This massif underwent two main orogenic phases: a Caledonian one with a probable very low-temperature metamorphism and a pronounced Variscan stage. The southern border of the Stavelot Massif underwent a Variscan greenschist facies metamorphism with an estimated temperature and pressure range of 360-420°C and 100-200 MPa respectively. Numerous thrust faults crosscut both the Lower and Upper Palaeozoic strata and have consequently a Variscan age, though they could have a Caledonian origin. Quartz-chlorite veins, associated with the different thrust faults, have been examined to deduce the source and physico-chemical (P-V-T-X) evolution of the fluids from which these minerals precipitated. Prograde metamorphism causes devolatisation reactions of minerals, which can produce a regional metamorphic fluid. The properties of this fluid can vary in space and time due to other factors like other infiltrating fluids (metamorphic, meteoric, magmatic), prolonged contact with the host-rock, and faulting, which can provide pathways for the different types of fluids. It is also commonly observed that vein sets are reactivated during orogenic events. The aim of this study is to reveal the relationship between faulting, fluid flow and metamorphism. The most powerful tools in characterising P-V-T-X properties are microscopic examinations and fluid inclusion studies.

Optically, several distinct stages of quartz formation could be recognised and a detailed paragenesis has been constructed. Microthermometric studies of the different stages revealed two-phase primary inclusions with a H_2O-NaCl-CO_2 and a H_2O-NaCl composition. Some of the more deformed quartz crystals also contain primary CO_2-N_2 inclusions. The primary inclusions are cut by secondary H_2O-NaCl inclusions. Total homogenisation temperatures of the primary H_2O-CO_2-NACl and H_2O-NaCl inclusions range trom 300°C to 415°C. These temperatures are similar for the different paragenetic stages. Salinity ranges between 2.2 and 6.9 eq.wt.% NACl. Secondary inclusions homogenise between 150°C and 22°'C and have very low salinities. Bulk fluid densities and isochores of the inclusions were calculated with the computer program FLINCOR. The geochemical investigation of chlorites, which are intergrown with quartz, provides an estimate of the temperature of chlorite formation. From empirical and thermodynamic geothermometric models, precipitation temperatures between 380°C and 435°C can be calculated. These data are used to deduce the P and T range during vein formation by crossing relationships between fluid isochores and precipitation temperatures in P-T diagrams. The calculated pressures are between 130 MPa and 280 MPa, at a temperature range of 300°C to 435°C. It has to be noted that along the thrust faults, a horizontal variation in pressure and temperature is recognised. For the studied region, local fluctuations in P and T can be explained by the rigidity of older competent strata in the region. Higher pressures and temperatures occur where the thrust faults strike against these rigid blocks.

Low salinity H_2O-CO_2-NACl fluids are commonly recognised in metamorphic terrains and are believed to originate from devolatisation reactions of minerals, eventually influenced by local fluid-rock interactions. CO_2 and N_2 on the other hand are likely generated early in the maturation history of a sedimentary basin due to the breakdown of nitrogen-rich phyllosilicates. Their presence in the oldest, most deformed quartz crystals could indicate a relic fluid.

In general, the interpreation of the P-T results can be three-fold:

(1) rapid upward flow of an overpressured fluid along a thrust fault;
(2) pressures of local metamorphic fluids are higher than the (estimated) lithostatic pressures;
(3) fluid pressures are 'near lithostatic' but at a higher pressure range (130-280 MPa) than the general estimate (100-200 Mpa).