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Fluid Inclusion characteristics of syn-late orogenic Co-Ni-Cu-Au deposits in the Siegerland District of the Rhenish Massif, Germany

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The Siegerland District is located in the fold-and-thrust-belt of the Rhenish Massif and hosts various syn- late orogenic vein-hosted hydrothermal mineralization types. Peak-metamorphism and deformation occurred at 312-316 $\pm$ 10 Ma (Ahrendt et al., 1978) at pT-conditions of 280 - 320 °C and 0.7 - 1.4 kbar (Hein, 1993).
The district is known for synorogenic siderite-quartz mineralization formed during peak-metamorphic conditions. At least 4 syn-late orogenic mineralization types are distinguished: Co-Ni-Cu-Au, Pb-Zn-Cu, Sb-Au and hematite-digenite-bornite mineralization (Hellmann et al., 2012b).
Co-Ni-Cu-Au mineralization of the Siegerland District belongs to the recently defined class of metasediment hosted synorogenic Co-Cu-Au deposits (i.e. Slack et al, 2010). Ore minerals are Fe-Co-Ni sulpharsenides, bearing invisible gold, chalcopyrite, and minor As-bearing pyrite. The gangue is quartz. The alteration mineralogy comprises chlorite, illite-muscovite and quartz. The epigenetic quartz veins are closely related to the formation of reverse faults (Hellmann et al., 2011a).
Microthermometric studies of fluid inclusions concerning the relationship between mineralization and microstructures have not been done so far for this deposit-class and this will be addressed here.
Fluid inclusions are investigated in hydrothermally formed vein-quartz, selected from Co-Ni-Cu-Au mineralization bearing veins showing only minor overprints by later mineralization types. Two quartz generations are distinguished: subhedral quartz-I showing growth zonation and fine grained, recrystallized- and newly formed quartz-II grains forming irregular masses and fracture fillings in quartz-I. Co-Ni-Fe sulpharsenides and chalcopyrite are closely intergrown with quartz-II, implying their contemperaneous formation.
However, fluid inclusions in quartz-II are often small, therefore fluid inclusions in quartz-I have been mostly investigated. In total, 180 inclusions from 4 different deposits have been studied.
The fluid inclusions are located on healed intragranular trails in quartz-I grains and subordinate in quartz-II. The inclusions are 5-20 [U+F06D]m in size and are aqueous biphase (L+V) showing a constant L/V ratio of 4. Homogenization is always to the liquid with Th (L) = 170-250°C (202°C mean). The salinity is moderate, with a range in Tm between -8 to -3°C, corresponding to 5 - 10 mass-% NaCl eq. (8.2 mass-% mean). There is no difference between fluid inclusions investigated in quartz-I and quartz-II. Despite the common occurrence of siderite in synorogenic siderite-quartz-veins, carbonate is absent in the alteration assemblage, implying a low CO_2-activity in the fluids.
Isochore calculations, combined with the paleo-geothermal gradient deduced for peak metamorphic conditions (Oncken, 1991) shows that the trapping temperature of the fluid is likely in the range between 220-300°C.
The study shows that Co-Ni-Cu-Au mineralization has formed at the district scale from a relative homogeneous, aqueous fluid of moderate salinity, which may have been derived from the devolatilization of the sedimentary pile in deeper crustal regions.
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