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The late Carboniferous Variscan evolution of the Armorican Massif (France): magmatism, hydrothermalism and metallogenic consequences

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The late Carboniferous (330-300 Ma) Variscan evolution of the Armorican Massif (France) is characterized by the complex interaction of various processes, all linked to each other, namely deformation, magmatism, circulation of various types of fluids and related alteration and ore formation. In the Armorican Massif, the major structural feature is the lithospheric dextral South Armorican Shear Zone (SASZ), which separates two distinct domains: the low-grade metamorphic Central Armorican Domain (CAD) to the North and the high-grade South Armorican Domain (SAD) to the South. The SASZ is divided into two branches along which synkinematic peraluminous leucogranites were emplaced [1]. Leucogranites emplacements occurred simultaneously along these two branches. Indeed, the Lizio and the Questembert granites were emplaced at 315 $\pm$ 5 Ma and 315 $\pm$ 4 Ma (U-Pb on zircon) along the northern and southern branches, respectively. Supracrustal leucogranites such as the Questembert granite have been pervasively altered by fluids. The nature of the alteration and the fluids involved changed through time from a high temperature alteration by magmatic fluids expelled from the crystallizing magma to a late hydrothermal alteration triggered by a mix between metamorphic and meteoric fluids as observed in the French Massif Central [2]. $^{40}Ar/^{39}Ar$ dating of muscovite grains from the Questembert granite yielded plateau dates ranging from 319 Ma down to 303 Ma, interpreted as a 15 Ma time span of pervasive hydrothermal circulations. Highly strained mylonitic rocks sampled all along the SASZ recorded the same history, which demonstrates the regional extent of this pervasive alteration. In one sampled site, meteoric water infiltration, evidenced by an extremely low whole rock $\delta^{18}O$ of 1.7‰ has been dated at 299 $\pm$ 3 Ma (U-Pb on zircon and monazite).

This pervasive circulation of various fluids within the crust was very likely one of the most prominent ore-forming processes in the region. Indeed, deformation and associated pervasive alteration along the SASZ were responsible for element mobility, including metals. Pervasive circulation of mixed fluids with an oxydizing meteoric component may have leached Uranium from the supracrustal leucogranites. Indeed, within the Questembert granite, the highly U-depleted samples recorded a meteoric water influx (low $\delta^{18}O$ feldspar values). Along the SASZ, mineralised bodies are often hosted within N140-170° trantensional brittle structures. This is the case for example for most of the U-bearing quartz veins in the Pontivy granite [3] as well as for the polymetallic mineralisations in the Saint-Aubin-des-Châteaux quarry [4]. To date, there are no precise geochronological data available to constrain the age of these ore formations. However, tectonic considerations provide some temporal constraints. Such orientations are compatible with a roughly N-S shortening direction, which corresponds to a well characterized late Carboniferous direction [5]. Finally, this orientation around N160° is also found for a set of giant quartz veins outcropping in the SAD [6]. This set of veins, interpreted as giant tension gashes, was formed by the precipitation of silica during the upward motion of fluids, which contained a significant proportion of surface-derived meteoric water. Therefore, during the orogenic collapse in the Armorican Massif around 300 Ma, it appears probable that a meteoric water convective cycle was established. The heat advection caused by the lower crust exhumation likely provided the driving force required to sustain this cycle. The mylonitized SASZ acted as a drain for the descending meteoric fluids while giant barren quartz veins are the witnesses of their upward motions. As most of the ore bodies were emplaced in structural traps orientated in the same direction than the giant quartz veins, we suggest that most of them are formed contemporaneously following similar processes.

References

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