Quartz oxygen isotope systematics and the fluid source for Au-Ag-Bi-Te-Se-bearing polymetallic vein deposits in southwestern Sweden

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An over-arching project aim, of which the present study forms a part, is to bridge and expand existing observations and datasets from noble and critical metal-rich polymetallic vein deposits in SW Sweden, using new ore mineralogy and petrography and light stable isotope and fluid inclusion data. Earlier stable isotope studies of the polymetallic Dalsland-Värmland veins in SW Sweden are mainly those of Johansson (1985) and Alm et al. (2003, and references therein). While Johansson´s work was focused on sulphur isotopes, the latter group reported oxygen isotope compositions of vein quartz from the Harnäs and Intakan vein deposits in Värmland. Their quartz $\delta^{18}O$ data from Harnäs exhibited a relatively narrow range, between +10.9 and +12.8 per mil (SMOW), with two analyses yielding slightly lighter compositions, at +7.2 and +9.7 per mil. Notably, the latter two were from a cross-cutting veinlet. The quartz samples from the Intakan vein at +11.5 and +11.6 per mil, basically overlap with the Harnäs data. Our new dataset include $\delta^{18}O_{Qz}$ (all reported as per mil values relative to SMOW) from vein deposits at Knollen (+12.5-12.9), Vassvik (+12.6-12.7), Kilane (+14.5), Nötön (+7.2), Värmlands Nysäter (+7.2-8.5), Vegerbol (+10-11.4), Karlsbol (+11.9) and Glava (+9.9-14.5). Based on the quartz-H_2O fractionation data of Matsuhisa et al. (1979), Alm and co-workers calculated the oxygen isotopic compositions of a fluid in equilibrium with precipitated quartz at an average temperature of 200 °C (from fluid inclusion data) for the early stage of vein formation at Harnäs and Intakan; these fluid composition ($\delta^{18}O$) ranges were -0.7 to +1.2, and -0.1 to 0.0 per mil, respectively, whereas the later vein yielded fluid compositions (based on a temperature of 75 °C) of -14.6 and -17.0 per mil. The calculated fluid $\delta^{18}O$ values for the early vein stage cluster closely around zero per mil, i.e., well correlated with a seawater source. Yet, as argued by Alm et al. (2003), the known geological setting of the vein systems and their host rocks clearly speaks against this interpretation. They further noted that the fluid $\delta^{18}O$ (range) is seemingly too light for a metasedimentary source, while a (primary) magmatic source was deemed unlikely because of the lack of known coeval magmatic activity in the area, and hence assumed that a metamorphic fluid with some input from meteoric water is the most likely interpretation. Utilising additional new fluid inclusion data from various Dalsland-Värmland veins (preliminarily reported by Jonsson & Broman 2020), we find that a significant part of our new $\delta^{18}O_{Qz}$ data fit in a similar fluid model. Combining all analytical data and observations from these vein deposits, including the character and nature of evolution of fluids and mineralisations, their regional extent, the lack of correlation with known penecontemporaneous intrusive rocks in most areas as well as the direct links to active brittle tectonism, suggest a vein formation scenario featuring a singular type of successively cooled, upwards migrating, originally deep metamorphic fluid, that variably mixed with meteoric water in a more shallow crustal setting. The noted metal tenor variability between veins and vein fields is proposed to mainly depend on locally dominant (deep) host lithologies and specific depth of vein formation.

References

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