Segregation Processes in Metamorphism: the Role of Nucleation

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The composition of veins is often assumed to reflect the composition of the fluids from which they form, but where veins form by segregation from the surrounding rocks, it may be that the nature of the minerals that nucleate in the vein actually determines the composition, and hence dictates what segregates. Pelitic schists in eastern Connemara, Ireland, experienced low-P, high-T regional metamorphism and exhibit a progression from staurolite zone to andalusite-staurolite assemblages. However andalusite appears in schist-hosted veins at slightly lower grades than in the schist itself, often forming veins that are over 75% andalusite, with quartz and minor muscovite. Andalusite veins are only present in staurolite schists but the wall rocks are not immediately depleted in Al-silicate. One interpretation of the veins is that they arise through selective nucleation of andalusite in fracture walls when the staurolite – muscovite breakdown reaction is first overstepped. This nucleation pattern in turn drives progressive concentration of Al-silicate into the fracture to form a vein.

We have carried out hydrothermal experiments which appear to mimic the effect of nucleation-controlled segregation in a closed system. Small cylinders of fine grained honfels, with a central hole drilled out for part of their length, were loaded in gold capsules with water or NaCl solution and run for periods of up to 3 months, generally at 400°C and 3kbar. Two starting rocks were used: a cordierite – K-feldspar hornfels and a two-pyroxene basaltic hornfels.

At the end of the experiments the basaltic hornfels cores were coated with fine-grained, honeycomb-textured saponite, but coarser saponite lined the central cavity, and was particularly well-developed in the experiment with 3M NaCl fluid. Orthopyroxene in the rock core was partially replaced by saponite but also developed secondary porosity. Pelitic hornfels with 3M NaCl developed albite overgrowths on K-feldspar which grew into the central cavity, while an experiment at 500°C with pure water developed euhedral quatz crystals in the central cavity, which was lined with new mica growths.

The experiments all took place in closed systems and resulted in segregation of material into the central cavity provided, and to a lesser extent to space between core and capsule. Analyses of water extracted from runs with basaltic hornfels show that Na, K and Ca concentrations were much greater than those of Mg and Al, whereas the saponite is near to the Mg-end member with several percent Al.

We conclude that the composition of the material that segregated was dictated by the composition of the phases that nucleated, and was not closely related to the composition of the fluid. These results emphasise the difficulty in identifying the role of segregation in forming veins from consideration of mass transfer distances, since the transport step is not initially rate-limiting.

Sulfur and Lead Isotopic compositions of Hetaoping Pb-Zn Deposit, Baoshan, China

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Located in the northern of Baoshan block, the Hetaoping Pb-Zn deposit is one of the most important types of Pb-Zn deposit at the northern-middle section of Lancangjiang tectonic-metallogenic belt in Western Yunnan Province. Strata exposed in the ore area range from Upper Sinian to Cambrian in age. The deposit consists of five sectors with a total reserve of over 2.0 million tons of Pb+Zn. Its orebody is vein in shape and hosted in skarn and marbleized limestone of the Upper Cambrian Hetaoping Formation, and controlled by Baichonghe anticline and SN-trending compresso-tensional interstratal faults. Skarnized, silicification, marbleization and pyritization is dominant wall-rock alteration.

Systematic studies on the sulfur and lead isotope compositions of sulfide minerals, ore and regional strata shows that: (1) the sulfur isotopic compositions of most sulfide minerals are characterized by relatively lower positive values with a narrow variation range (0.95‰~7.20‰, mean value=4.88‰), which is consistent with that of hydrothermal type deposits related to the intermediate-acid granitic intrusion in Baoshan region, but different from that of sulfate in Cambrian oceans. Moreover, some sulfide minerals interfused by reductive sulfur of strata also show higher sulfur isotopic compositions, relative to that of magmatic sulfur. It is suggested that the sulfur in the ore-forming fluids of the deposit deived mainly from deep magma chamber and partly from the Cambrian submarine sulfates. Normally, the sulfur isotope compositions of different sulfide minerals display the trend of $\delta^{34}S_{sphalerite} > \delta^{34}S_{chalcopyrite} > \delta^{34}S_{galena}$, implying the sulfur in the ore-forming fluids of the ore field had already reached isotopic equilibrium. The results of sulfur isotopic geothermometer show there is a relatively high temperature(415~488°C) mineralizing stage in this deposit; (2) The consistent lead isotopic compositions in galena and sphalerite are characterized by the the feature of the upper crustal lead with high μ value (>9.58) and low radiogenic lead isotopic composition, which are different from that of Cambrian strata, but and similar to that of Yanshanian - Himalayan crust type granites in Baoshan region, indicate that the ore lead of this deposit probably came from the upper crustal rocks with high concentration of U and Th. The concealed intermediate-acid intrusive rocks may be the important source of lead, while the strata (e.g. Hetaoping Formation) also contribute some lead to the deposit.

It is suggested that the Hetaoping deposit belong to middle-high temperature skarn type Pb-Zn deposit related to concealed intermediate-acid crust type intrusive rocks, the magmatic hydrothermal might play an important role during the mineralization process.

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