Mineralogical and geochemical zoning at high-temperature contacts as a fonction of CO_2 pressure: An example from Romanian skarns

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Obviously mineral zoning occurs in two high-temperature skarn deposits: Cornet Hill and Măgureaua Vaţei (Metaliferi Massif, Apuseni Mountains, Romania). In both occurrences, an extensive metasomatism affected Tithonic - Kimmeridgian reef limestones of the Căpâlnaş-Techereu unit. The magmatic Upper Cretaceous intrusions at the contact are monzodioritic to quartz-monzodioritic.

The metasomatic mineral zoning is defined by the predominance of a mineral species and is, from the outer to the inner part of the metasomatic area: (1) calcite (marble) / tilleyite / spurrite + perovskite / wollastonite + gehlenite + vesuvianite / wollastonite + grossular / quartz monzonite at Cornet Hill (CH) and (2) calcite (marble) / wollastonite + titanian andradite + vesuvianite / gehlenite + grossular at Măgureaua Vaţei (MV). Differences in mineral zoning and in crystal chemistry of mineral species are principally due to the different pressures of volatile components (i.e., CO_2, SO_3, H_2O) which are higher at MV and lower at CH. Silicate-carbonates (e.g., spurrite, tilleyite) and hydrous or hydroxyl-bearing silicate-carbonates (e.g., scawtite, fukalite) are restricted to the CH skarn area. Sulfate-bearing mineral species (i.e., ellestadite-OH, thaumasite) are more common at CH, whereas a silicate-bearing apatite occurs at MV.

The hydrothermal alteration results in a restricted association of hydroxyl-bearing minerals at MV (i.e., xonotlite, hibschite, thomsonite), whereas at CH the association also includes afwillite, gismondine, tobermorite, riversideite.

Chemical geothermometry of geothermal fluids: past, present, and future

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Most water geothermometers, including the Na-K and silica functions were initially derived on a purely empirical basis. Long ago, geochemists observed a general decrease in Na/K ratio and a general increase in SiO_2 concentration of thermal waters with increasing temperatures. The first geothermometers were based on these empirical correlations. Studies of hydrothermal alteration mineralogy developing in high-temperature hydrothermal systems as well as modeling of both mineral-solution equilibria and irreversible mass transfer taking place during water-rock interaction suggested that geothermometers are governed by equilibrium reactions between hydrothermal minerals and the aqueous solution under reservoir conditions. A new generation of geothermometric techniques was consequently proposed and a theoretical justification for water geothermometers was found.

Moreover, a different approach to geothermometry, based on speciation-saturation calculations carried out at different temperatures, was also suggested. It was shown that the saturation indexes with respect to a number of plausible hydrothermal alteration minerals converge to 0 at the equilibrium temperature, if the geothermal water is in equilibrium with the considered minerals.

Also gas geothermometers were initially empirical or partly empirical and were later improved by introduction of vapor-liquid distribution coefficients into equilibrium relations. The importance of addition to or removal from equilibrium liquids of equilibrium vapors was thus demostrated. This approach was later extended to fumarolic gas discharges. Besides, geothermometric functions involving the H_2/Ar and H_2/N_2 ratios were proposed, based on the hypothesis that Ar and N_2 are present in hydrothermal fluids in relative contents close to those of air-saturated groundwater.

In addition to provide a condensed history of chemical geothermometry, this presentation also intends to review main geothermometers and related graphical tools, trying to emphasize advantages and limitations and to give practical hints to the user. Future developments are also briefly considered.

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