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STRONTIUM-HÄLTIGE ARAGONITE UND CALCIUM-HÄLTIGE STRONTIANITE: CHEMISMUS UND KRISTALLOGRAPHISCHE DATEN

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Einige Strontium-führende Karbonate aus Leogang und aus dem Zillertal wurden kristallographisch untersucht sowie mit der Elektronenmikrosonde analysiert. Bei den aus der Lagerstätte Leogang stammenden Sr-hältigen Aragoniten findet sich eine zonare Verteilung des Sr, wobei der Gehalt von Kern zum Rand des Kristalls abnimmt. Die Sr-Werte variieren von 0,01 - 0,80 Gew.% SrO. Eine zweite Probe aus dieser Lagerstätte, in spießigen Kristallen ausgebildet, wurde als Strontianit bestimmt, der 11,3 Gew.% CaO und 0,27 Gew.% BaO enthält.

Jene von Hr. Novak als Sr-hältige Aragonite übersandte Probe aus dem Zillertal ist ebenfalls ein Strontianit mit einem CaO-Gehalt von 7,6 Gew.%. Es wird die in der Natur vorkommende Mischbarkeit von Ca-Sr-Karbonaten in Bezug auf ihre Genese (Paragenese) untersucht und diskutiert.

STABILITIES AND COMPOSITIONAL VARIATIONS OF NATURAL EPIDOTES

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Epidote occurs in a wide range of geologic environments; it has been recorded as a primary magmatic phase in deep-seated granitic plutons and as an index mineral in low- to medium-grade regional and contact metamorphosed rocks. It is also common in skarns and as hydrothermal alteration products in veins, vugs, and as a deuteric

phase in some igneous rocks. Epidote is the most common calc-silicate mineral in active geothermal systems and occurs together with quartz as epidotes in ophiolite sequences. Its parageneses in magmatic, metamorphic and hydrothermal systems and compositional variations are controlled by P, T, and rock and fluid compositions.

The stability of magmatic epidote is known primarily from the experiment of NANEY (1983) who crystallized epidote (together with plagioclase + biotite + melt) at temperatures above the solidus for a synthetic "granodiorite" (with > 4 wt% H₂O) at 8 kb. The minimum pressure for its crystallization from melt is defined by the intersection of the maximum stability P-T curve of epidote (LIOU, 1973) and the solidus curve of a granitic magma (e.g., about 6 kb for tonalite at fO₂ of the QFM buffer). At higher fO₂ conditions, the minimum P may be as low as 3 kb; magmatic epidotes may have up to 33 mole % of the pistacite component [$Ps = 100 \times Fe^{3+} / (Fe^{3+} + Al)$]. Plutonic rocks bearing magmatic epidotes of Ps 23-27 described by ZEN & HAMMARSTROM (1984) must have crystallized under fairly oxidizing conditions and moderately high pressures, corresponding to middle to lower crustal depths.

In regional metamorphic terranes, epidote first appears in the higher grade part of the zeolite facies and is stable together with laumontite. The minimum temperature for its appearance was estimated from its association with laumontite in active geothermal systems, with laumontite ± prehnite ± pumpellyite in zeolite facies metabasites, and with lawsonite ± pumpellyite in Franciscan blueschists of California. Epidote may occur at temperatures as low as 170-200 °C in active geothermal systems. The epidote + laumontite + pumpellyite assemblage of zeolite facies metabasites from Karmutsen, Vancouver Island, occurs at 170 to 190 °C and 1.1 ± 0.5 kb (CHO et al., 1986). Epidote has not been recognized in *in situ* metagraywackes of the Franciscan Complex but first appears at about 290 °C in metabasites at about 7 kb (MARUYAMA & LIOU, 1988); epidote is common in high-grade blueschists, epidote amphibolites and, more rarely, eclogites. Its low-T stability limit is highly dependent on the fO₂; under oxidizing conditions, epidote appears at lower temperatures. Thus, the assemblage epidote + hematite + aegirine + riebeckitic amphibole + quartz in metacherts may be interlayered with lawsonite-bearing mafic blueschist; such occurrence has been recorded in the Franciscan Complex (e.g., MARUYAMA & LIOU, 1988).

Available compositions of epidotes from metabasites and active geothermal systems indicate that epidote solid solution is continuous at least in the range of Ps 10 to 40 and does not show a miscibility gap. The Ps value of epidote depends on metamorphic grade, mineral assemblages, fO₂, and pH. Domain equilibrium prevails in very low-grade metamorphism, hence, compositions of epidote in a single thin section may vary according to occurrence as replacement after plagioclase or mafic minerals, or as fillings in vesicles or fractures. However, the Ps value of epidote from a low-variance assemblage varies systematically either with temperature or pressure (LIOU et al., 1987). For example, composition of epidote in the buffered assemblage Ep + pumpellyite + actinolite + (Chl + Ab + Qz) systematically changes from Ps 33 at 260 °C to nearly pure clinozoisite at about 370 °C at 5 kb. Similarly, epidote in another buffered assemblage Ep + sodic amphibole + Act (+ Chl + Qz + Ab) in the transition from the blueschist to greenschist facies decreases in Ps content with increasing pressure.

Three types of zoned epidote occur in geothermal systems: (1) complex oscillatory zoning; (2) Fe-rich cores with Al-rich rims; and (3) Al-rich cores with Fe-rich rims. Such zoning patterns could be due to variation in temperature, pressure, fO₂ or fluid composition. Recent study of epidotes from depths of 900-2400 meters (measured temperatures at 200 to 300 °C) in the State 2-14 well of the Salton Sea geothermal

system, California, demonstrated that the pH of the geothermal fluid may be the most important control (ARNASON et al., 1989).

Epidotes are stable with hematite, K-spar, albite, muscovite, quartz, calcite, and pyrite in metasediments and range from $P_s=34$ to 42 across a thin section and from 37 to 43 within an individual zoned crystal. Thermodynamic calculation using the computer program EQ3NR (WOLERY, 1983) at $T=300$ °C, $P=86$ bars, and a hypothetical 1.0 molar aqueous chloride solution in equilibrium with the above assemblage delineates a series of epidote isopleths in an fO_2 -pH plot. At a constant fO_2 defined by the HM pairs, P_s values of epidote increase with increasing pH, and a small change in pH results in a large change in epidote composition. At constant pH, the P_s value of epidote increases with increasing fO_2 , but epidote composition is less sensitive to a small change in fO_2 than to a small change in pH. Thus, for hydrothermal epidotes which crystallized in active geothermal systems, in fractures, or in epidosites, fluctuation in pH of the hydrothermal fluid could significantly affect the zoning pattern of epidote even at constant P, T, and fO_2 conditions.

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