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Coupled dichotomies of apatite and fluid composition during contact metamorphism of siliceous carbonate rocks

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ABSTRACT

The X_{CO_2} recorded by mineral-fluid equilibria in contact metamorphosed siliceous carbonates commonly defines two groups of rocks in the same aureole. One group records relatively low X_{CO_2} that results from infiltration of chemically reactive H_2O-rich fluid. The other records relatively high X_{CO_2}, up to 0.99, that results from decarbonation reactions with little or no infiltration. A complementary dichotomy in apatite compositions exists in five contact aureoles in Italy, Scotland, and the U.S.A. Apatite in the low-X_{CO_2} group is close to an F-OH solid solution. Apatite in the high-X_{CO_2} group is a relatively Cl-rich Cl-F-OH solution. The halogen content of fluid coexisting with analyzed apatite was characterized in two aureoles to determine the origin and significance of the dichotomy in apatite composition. Calculated a_{HF}/a_{H_2O}, a_{HF}/a_{HCl}, a_{HF}, and m_{F_T} (the total F molality of fluid) are systematically higher in fluid coexisting with the low-X_{CO_2} group. In contrast, a_{HCl}/a_{H_2O} in the high-X_{CO_2} group may be higher than or overlap with a_{HCl}/a_{H_2O} in the low-X_{CO_2} group. Calculated a_{HCl} and m_{Cl_T} in the high-X_{CO_2} group are lower than or overlap with a_{HCl} and m_{Cl_T} in the low-X_{CO_2} group. The Cl-rich apatites in the high-X_{CO_2} group are explained by crystallization at relatively low a_{H_2O}, a_{HF}, and m_{F_T} rather than at high a_{HCl} or m_{Cl_T}. In comparison, the F-OH apatites in the low-X_{CO_2} group formed by infiltration of rock by and equilibration with relatively H_2O-rich, high m_{F_T}/m_{Cl_T} fluid, reflecting the same metasomatic process responsible for F-rich humite-group minerals and skarns in many contact aureoles. Calculated halogen contents indicate that the non-CO_2 fraction of fluid in equilibrium with both groups had modest, seawater-like salinity, and that the reactive H_2O- and F-rich fluid that infiltrated the low-X_{CO_2} group had a plutonic source.