The potential of monazite for fission-track dating

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Monazite has not previously been datable by the fissiontrack (FT) method because the high abundances of REEs and Th preclude the neutron irradiation used to determine U in the conventional approach. The REEs, particularly Gd and Sm, cause significant neutron self-shielding and serious nuclear heating during irradiation. Also, the very high Th/U ratio can lead to production of unwanted ²³²Th fission-tracks. The potential of monazite for FT dating has therefore not been pursued since the only published attempt by Shukoljukov and Komarov (1970). These authors used a nuclear emulsion method to estimate the uranium abundance.

Direct determination of U in monazite by laser-ablation ICP-MS, or electron microprobe analysis, overcomes these analytical problems and opens the way for routine FT dating of monazites (Gleadow et al. 2002). Using a hot HCl tracketching procedure (based on Shukoljukov and Komarov, 1970), we have determined fission track ages on monazites from a variety of teconic settings. The resulting FT ages are very much younger even than co-existing apatite FT ages, suggesting that monazite may have potential as an extremely low-temperature thermochronometer.

Preliminary annealing experiments suggest that fissiontracks in monazite anneal at lower temperatures than in apatite, but probably not to the degree suggested by the very young ages. It is possible, therefore, that some kind of ionisation annealing (e.g. Ouchani et al. 1997) is operating due to the very high alpha doses received by natural monazites, principally from Th decay. If confirmed, such a non-thermal track annealing mechanism would have important implications for the interpretation of fission-track ages in monazite (and probably also other minerals). More work needs to be done in order to resolve this issue but the potential for obtaining new insights into low-temperature processes makes further investigation of the monazite-FT system attractive.

References

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Coupled dichotomies of apatite and fluid composition in contact metamorphosed siliceous carbonates

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The X_{CO2} 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_{CO2} that results from infiltration of chemically reactive H₂O-rich fluid. The other records relatively high X_{CO2} , 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 U.S.A. Apatite in the low- X_{CO2} group is close to an F-OH solid solution. Apatite in the high- X_{CO2} 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 $a_{\rm HF}/a_{\rm H2O}$, $a_{\rm HF}$, $m_{\rm FT}$ (total F molality), $m_{\rm FT}/m_{\rm CIT}$ and $a_{\rm HF}/a_{\rm HCl}$ are systematically higher in fluid coexisting with the low- X_{CO2} group. In contrast, a_{HCI}/a_{H2O} in the high-X_{CO2} group may be higher than or overlap with $a_{\rm HCl}/a_{\rm H2O}$ in the low- $X_{\rm CO2}$ group. Calculated $a_{\rm HCl}$ and $m_{\rm ClT}$ in the high- X_{CO2} group are lower than or overlap with a_{HC1} and $m_{\rm CIT}$ in the low- $X_{\rm CO2}$ group. The Cl-rich apatites in the high- $X_{\rm CO2}$ group are explained by crystallization at very low $a_{\rm H2O}$ and relatively low $a_{\rm HF}$ (which suppress the OH- and Fcomponents of apatite) rather than at high a_{HCl} or m_{ClT} . The F-OH apatites in the low- X_{CO2} group formed by infiltration of rock by and equilibration with relatively H2O-rich, high $m_{\rm FT}/m_{\rm CIT}$ fluid. Calculated halogen contents indicate that the non-CO₂ fraction of fluid in equilibrium with both groups had modest, seawater-like salinity and that the reactive H2O- and F-rich fluid that infiltrated the low- X_{CO2} group had a plutonic source.