Monazite records of deformation within the Himalayan Main Central Thrust Shear Zone, NW India

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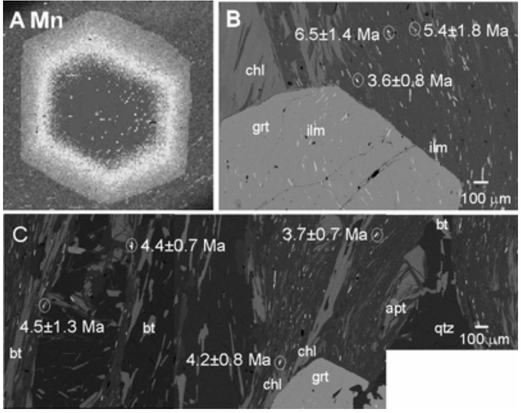
The Main Central Thrust (MCT) is the dominant crustal thickening feature in the Himalaya, largely responsible for the extreme relief and mass wasting of the range. Two samples directly beneath the MCT along the Bhagirathi River in NW India yield Th-Pb ion microprobe ages of 4.5±1.1 Ma (T= 530±25°C, P= 560±80 MPa from co-existing assemblage) (Fig. 1) and 4.3±0.1 Ma (5 grains) matrix monazite ages, suggesting Pliocene reactivation of the structure.

Figure 1 (A) X-ray Mn Map of a prograde Himalayan garnet. (B and C) Backscattered electron images of the same sample with Th-Pb ion microprobe monazite ages circled (±1σ).



Although monazite in the matrix of a sample can be affected by subsequent metamorphism and retrogression, the monazite ages reported here are consistent with a single population and the co-existing garnet preserves prograde zoning, suggesting minimal retrogression. The ages postdate or overlap activity along structures closer to the Indian foreland, and show that the zone of Indo-Asia plate convergence did not shift systematically southward from the MCT towards the foreland during the mountain building process.

Thermochemical and experimental stability of synthetic La-bearing minerals as analogues to nuclear-waste forms

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Among the crystalline nuclear waste-forms suitable for retaining radionuclides from high-level waste, two mineral structures adopted by rare-earth-elements-bearing minerals in nature, are proposed: the monazite and the apatite structures. Nevertheless, the thermochemical properties required to predict the solubility of the corresponding mineral analogues at various pressures and temperatures remain poorly known (*i.e.* formation enthalpy, third-law entropy, heat capacity, volume). Therefore, these thermochemical data were measured for one phase of each group synthesized in the La_2O_3-CaO-SiO_2-P_2O_5-H_2O system: monazite, $LaPO_4$, and La-britholite, a silicate-apatite, $Ca_2La_3(SiO_4)_3OH$. Formation enthalpies were derived from high-temperature drop-solution calorimetry using lead borate at 975 K as solvent (Bochum, Germany). Third-law entropy value was retrieved from low-temperature heat capacities measured on monazite with an adiabatic calorimeter (LCP, Orsay) in the 30-300 K range. Heat capacities (Cp) in the 143-723 K ranges were determined from differential scanning calorimetry (Kiel, Germany). Calorimetric results were combined to thermochemical data of REE aqueous species and minerals to study the solubility of monazite and silicate apatite. In order to test these thermochemical calculations, high-temperature reactivity experiments (thermal gradient, 320–400 °C over 15 cm) were undertaken under hydrothermal conditions in presence of clays and cement to simulate the near field. After two to eight months, monazite and silicate apatite were preserved with only a few evidence of partial destabilisation. In similar conditions, these minerals are much more stable than another synthetic phase proposed as ceramic for radionuclide storage, the thorium phosphate diphosphate, $Th_4(PO_4)_4P_2O_7$, which reacts with cement to form hydroxylapatite and thorianite (ThO_2). In conclusion, monazite appears as an excellent waste form for actinides in term of chemical durability whereas silicate apatite could be largely stabilised by high temperatures and basic calcium-rich solutions.