

## **Formation of clinohumite ± spinel in dolomitic marbles from the Makrohar Granulite Belt, Central India: Evidence for Ti mobility during regional metamorphism**

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### **ABSTRACT**

The mobility of Ti, a member of high field strength elements, in metamorphic fluids is crucial to understand the recycling of commonly perceived nominally soluble elements and for mass-flux calculations during crustal processes. In this study, we present evidence for large-scale Ti mobility from a suite of clinohumite±spinel-bearing dolomitic marbles from the Makrohar area in central India. The studied rocks mostly contain dolomite and calcite (in subequal proportions) and a subordinate amount of forsterite. It commonly develops 1–5 cm thick, laterally continuous, mostly parallel, sometimes anastomosing, brown-colored clinohumite rich bands with variable spinel. Clinohumite has moderate Ti and F ( $TiO_2 = 0.55\text{--}2.88\text{ wt\%}$ ;  $F = 0.94\text{--}1.88\text{ wt\%}$ ;  $n = 32$ ). Textural and phase equilibria modeling indicate that clinohumite grew at the expense of forsterite + dolomite under static conditions due to infiltration of F- and Ti-bearing extremely  $H_2O$ -rich fluids ( $X_{CO_2} < 0.03$ ), at ~5–6 kbar pressure and ~650–700 °C temperature. The Ti and F were most likely supplied by highly channelized aqueous fluids restricted within the centimeter-thick bands. The negative volume change of the reactions further facilitated fluid ingress. The lateral continuity of the bands over several meters across multiple outcrops indicates that Ti was mobile at the meter to kilometer scale. The results are in accordance with experimental studies that solubility of Ti increases in the presence of halides and imply that Ti may be much more mobile in metamorphic fluids during regional metamorphism than previously anticipated.

**Keywords:** Clinohumite, Ti mobility, forsterite marble, textural modeling, Makrohar, Central India