



## Trace elements in metapelitic schists from Alpe Sponda (Central Alps, Switzerland)

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Lenses of kyanite-cordierite-garnet-bearing paragonite-biotite schist were found in paragonite-free metapelitic rocks at Pizzo Forno, near Alpe Sponda (Simano Nappe, Central Alps). These lenses are mineralogically distinct, as they lack both quartz and staurolite, but they contain large amounts of tourmaline (up to 20–25 vol.%). Tourmaline shows strong colour zoning, which in combination with the major and trace element data indicates at least two stages of crystal growth during prograde metamorphism. Mineral equilibrium modelling based on the bulk-rock compositions yielded peak metamorphic conditions of amphibolite-facies grade ( $T = 590\text{--}660\text{ }^{\circ}\text{C}$  and  $P = 6.5\text{--}7.8\text{ kbar}$ ), which is consistent with the  $P\text{--}T$  conditions estimated previously for this part of the Central Alps. The light elements lithium and boron are strongly enriched in the Alpe Sponda samples, which therefore show unusual bulk-rock concentrations. Lithium is mainly distributed to cordierite (450 ppm) and to a lower extent to muscovite (250 ppm), biotite (180 ppm) and paragonite; all other minerals show only minor amounts of lithium. As commonly expected, boron is partitioned into tourmaline and to a much lesser amount into muscovite, whereas all other minerals have low boron contents. In addition, cordierite has a relatively high Be content, underlining the hypotheses of the presence of Na-Be cordierite.

The analysis of rare earth elements (REE) shows that all samples are enriched in low REE (LREE; La–Eu) relative to the heavy REE (HREE: Gd–Lu), and have a small negative Ce anomaly, as well as a pronounced negative Eu anomaly, which can be illustrated in a chondrite-normalised diagram. Furthermore, all minerals that do not show a distinct positive Eu anomaly (i.e. garnet, biotite, muscovite, cordierite, kyanite, chlorite and rutile) show a marked negative Ce anomaly. In addition, plagioclase and tourmaline exhibit a pronounced positive Eu anomaly but no Ce anomaly. Especially in the case of tourmaline the Alpe Sponda samples are different from reference examples and show clearly that these tourmalines are not related to metasomatites, hydrothermal veins or pegmatites. In addition, field investigations in the area of Alpe Sponda demonstrate that there is no evidence of partial melting. The layer, from which the samples were collected, can be interpreted as an evaporitic horizon within a more clay-rich environment. This is underlined by the slightly negative Ce anomaly in both bulk-rock ( $\text{Ce}/\text{Ce}^* = 0.91 \pm 0.02$ ) and mineral phases, a feature which is characteristic for continental margins ( $\text{Ce}/\text{Ce}^* = 0.9\text{--}1.3$ ) and therefore reflects the depositional location of the protolith. This is supported by a La-Th-Sc tectonic discrimination diagram, in which the Alpe Sponda samples lie in the field of continental arc but towards the field of active or passive continental margin. By using Zr instead of La as third variable our samples plot within the field of an active continental margin or close to it.