

## **The Cana Brava asbestos chrysotile deposit (Goiás, Brasil): The mineralisation process**

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At Cana Brava, for the transformation of meta-peridotite in red serpentinite, the volume factor values lie between 0.6 and 1.3, with a clustering around  $fv = 1.0$ . Thus far, meta-peridotite has been considered to be the protolith of all the serpentinite types, and also of cross chrysotile ore. The oxidation rates of the rocks varied significantly during serpentinization. They increase in the same order as the decrease in the amount of bivalent Fe. A comparison between the amount of iron in the rocks and the cross chrysotile, and their oxidation rates show that, as the serpentinization evolved from the serpentinized peridotites to the crystallization of cross chrysotile, the oxidation and consequent transformation of FeO in  $Fe_2O_3$  occurred, and the total amount of iron in the system decreased. This relationship suggests that the serpentinization process evolved with increasing degrees of oxidation, and decreasing concentrations of FeO. The total amount of iron in the system decreased by 2.1 wt% , and the FeO was gradually transformed into  $Fe_2O_3$ . The cross chrysotile in the veinlets was the product of serpentinization with lower concentrations of FeO, and crystallized when the system reached its highest oxidation rate.

Comparing the points corresponding to the average compositions of meta-peridotite, serpentinite, the reaction fringes, and cross chrysotile with their oxidation rates allows the identification of the phases associated with serpentinization and cross chrysotile crystallization at Cana Brava. Phase 1 corresponds to the transformation of meta-peridotite in black serpentinite, then brown and red. This process evolved over the marked oxidation of ultrabasic rocks. Phase 2 was initiated under shallow, brittle conditions, and the sudden release of confining pressure that caused hydraulic fracturing, giving the appearance of a saturated aqueous fluid that crystallized the cross chrysotile in a short time. This fluid crystallized the cross chrysotile in the fractures of all of the rocks, whether they were inside, near, or far from the fractured nuclei. Both the formation of veinlets and the crystallization of cross chrysotile and magnetite were more intense in the nuclei that currently contain green serpentinite; hydraulic fracturing occurred at these points, and the intensity of the

formation and crystallization processes decreased with distance from these nuclei. Phase 3 was a consequence of the invasion of the system by water, probably meteoric or connate, which mixed with the fluid (liquid + vapor) that was released during hydraulic fracturing. The resulting aqueous solution reactivated the serpentinization of the meta-peridotite and black serpentinite, and altered the red and the brown serpentinites, initially removing free oxygen. After the removal of silica, the oxygen became bound to bivalent iron. The crystallization of magnetite  $\pm$  hematite consequently occurred in the veinlets and in the altered rocks, which generated strongly reducing conditions, and decreased the oxidation rate of the rocks. This process was quick and pervasive in the fractured nuclei, generating green serpentinite with residual red serpentinite. It was limited in locations with lower fluid/rock ratios, which led to the formation of reaction fringes at the sides of the mineralized fractures.