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SUBCONTINENTAL MANTLE IN THE ALPS: ITS SIGNIFICANCE FOR CONTINENTAL BREAKUP AND CONSEQUENCES FOR SUBDUCTION-ZONE PERIDOTITES

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ABSTRACT

In recent years it has increasingly been recognized that many remnants of upper mantle rocks along the Alpine chain are inconsistent with the hypothesis of being the residues of decompression melting during opening of the Tethys ocean. Instead, they represent lithospheric subcontinental mantle that was exhumed in response to passive rifting preceding opening of the Tethyan ocean. Among the peculiarities of these mantle rocks are a wide range of chemical composition, from depleted to clinopyroxene-rich fertile peridotites (Fig. 1). In many places the ultramafic rocks are directly overlain by sediments and/or cut by ophicarbonate rocks/breccias. The associated basaltic crust is reduced with respect to many ophiolite sequences. Here we present evidence that strongly serpentinized and progressively metamorphosed ultramafic rocks in the Alps are derived from exposed subcontinental mantle and that oceanic alteration of subcontinental mantle has important consequences for the interpretation of subduction zone peridotites.

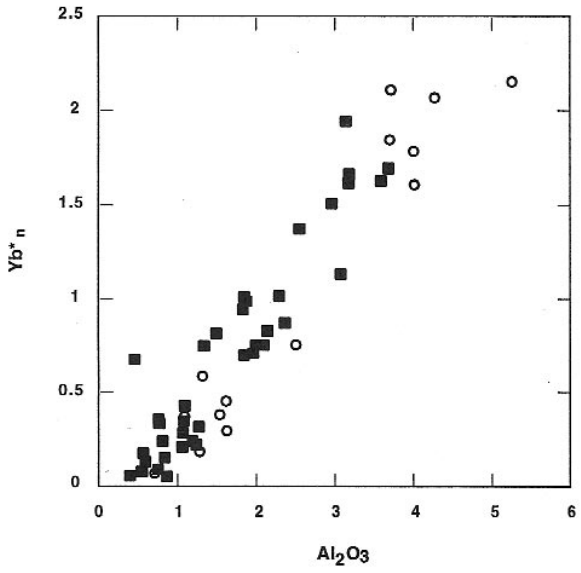

Fig. 1 - Al_2O_3 vs Yb_n for Malenco and Gagnone ultramafic rocks. Boxes: Malenco; circles, Gagnone.

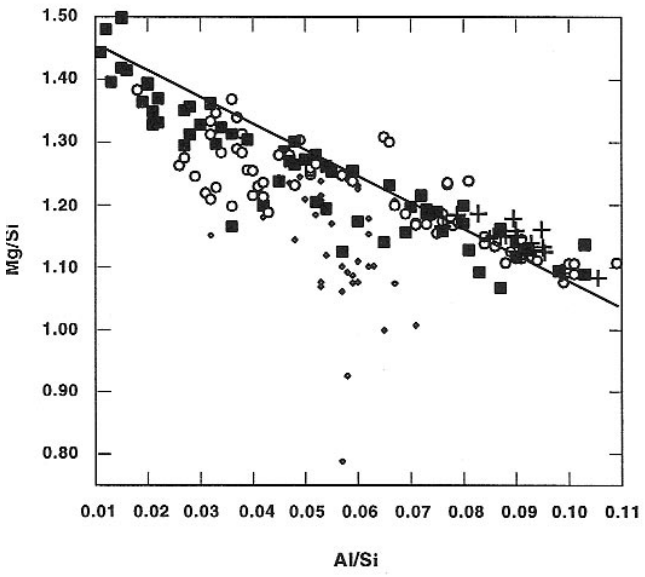

Fig. 2 - Mg/Si vs Al/Si for peridotites from the Central Alps. Crosses: external Ligurides (Rampone et al., 1995); diamonds: data from abyssal peridotites (Snow and Dick, 1995). Line shows 'terrestrial array' of Jagoutz et al. (1979).

Bulk rock compositions of weakly to completely serpentinized peridotites and chlorite peridotites from the Central Alps (Malenco, Cima di Gagnone, Fig. 1) spread from primitive upper mantle to highly refractory compositions. However, calculated mineral norms indicate that many samples are enriched in orthopyroxene at moderate molar Mg/(Mg+Fe) or Mg#. We find that many samples have a Mg/Si ratio at a given Al/Si ratio too low to be explained by variable degrees of melting only (Fig. 2). Recently, it has been proposed that high modal orthopyroxene is caused by silica-enrichment, either by melt/rock reaction (Kelemen et al., 1998), or by aqueous metasomatism in the upper mantle (Smith et al., 1998). Here we propose an alternative mechanism in that exhumation along non-volcanic passive continental margins leads to exposure and successive low-T hydrothermal alteration of cold subcontinental mantle rocks on the sea floor. At temperatures below 150°C sea water is undersaturated in most Mg-phases (Bischoff and Seyfried, 1978) and therefore Mg-loss could affect a substantial amount of exposed subcontinental peridotite.

Exhumation of cold, subcontinental mantle rocks and successive alteration on the ocean floor could explain some peculiar features of metamorphosed remnants of the Tethyan mantle rocks:

(1) Reduced or absent mafic oceanic crust allows fluids to deeply penetrate and alter the exhumed subcontinental mantle rocks so that many remnants are highly serpentinized. Mafic dikes are partially to completely altered, ei-

ther by rodingitization or Mg-metasomatism. Mg-enrichment of ferrogabbroic/ferrobasaltic dikes is potentially important for the formation of titanian-clinohumite, a widespread accessory mineral in most metamorphosed mantle rocks from the Alps (Trommsdorff and Evans, 1980).

(2) Modal orthopyroxene enrichment at comparatively low bulk rock Mg# is caused by Mg-depletion on the ocean floor and makes these rocks comparable to some abyssal peridotites (Snow and Dick, 1995), but different from cratonic mantle samples which have high modal orthopyroxene and high Mg# (Kelemen et al., 1998).

(3) Progressive Alpine metamorphism of serpentinized peridotite to eclogite facies conditions leads to the formation of orthopyroxene-rich metaperidotites in the Central Alps and Southern Spain (Trommsdorff et al., 1998). Breakdown of titanian clinohumite at eclogite facies conditions produces partially topotactic intergrowths of olivine+ilmenite (Trommsdorff and Evans, 1983).

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