Geophysical Research Abstracts
Vol. 14, EGU2012-7750, 2012
EGU General Assembly 2012

Dynamics of fluid expulsion during high-pressure devolatilization of serpentinite in subduction settings: field, petrological and textural constraints from the Almirez ultramafic massif.

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Our understanding of subduction zone processes is tightly connected to our knowledge of the cycling of volatiles in the Earth, namely the loci of devolatilization reactions and the fluid migration mechanism. The exact nature of fluid pathways at high-pressure conditions is poorly known and still highly speculative. Studies metamorphic terrains that record main dehydration reaction are, thus, an invaluable tool to decipher the mechanism for fluid expulsion. Among other dehydration reactions in subduction zones, the antigorite (Atg) breakdown is rather discontinuous, releases the largest amount of fluids (ca. 9 wt. %) and is considered to have important seismological implications. The antigorite dehydration front in the Cerro del Almirez (Betic Cordillera, Spain) offers, thus, an unique opportunity to investigate the dynamics of fluid expulsion through the study of micro- and macrotextures recorded in the prograde assemblage (chlorite harzburgite). Granoblastic texture are interspersed in decameter-sized domains with spinifex-like chl-harzburgite and were formed under similar P-T conditions ($\sim$1.6–1.9 GPa and 680–710°C). We ascribe these textures to shifts of the growth rate due to temporal and spatial fluctuations of the affinity of the Atg-breakdown reaction. These fluctuations are driven by cyclic variations of the excess fluid pressure which are ultimately controlled by the hydrodynamics of deserpentinization fluid expulsion. Crystallization at a low affinity of the reaction, correspondig to the granoblastic texture, may be attained if fluids are slowly drained out from the dehydration front. During the advancement of the dehydration front, overpressured domains are left behind preserving highly metastable Atg-serpentinite domains. Brittle failure results in a sudden drop of the fluid pressure, and a displacement of Atg equilibrium towards the prograde products that crystallizes at a high affinity of the reaction (spinifex-like texture). Evidences of brittle failure are found along grain-size reduction zones (GSRZ), a few mm to meters wide, which form roughly planar conjugate structures and crosscut the metamorphic texture. GSRZ are characterized by (1) sharp, irregular shapes and abrupt terminations contacts with undeformed metaperidotite, (2) an important reduction of the olivine grain size (60-250 μm), and (3) decrease in the opx modal amount. Analysis of olivine crystal-preferred orientations in GSRZ shows similar patterns, but a higher dispersion than in neighboring metaperidotite. These structures are interpreted as due to hydrofracturing allowing for the formation of high permeability channelways for overpressured fluids. This textural bimodality (granofels and Spinifex-like) and the record of brittle failure hence witnesses a unique example of the feedbacks between the cyclic dynamic of metamorphic fluid expulsion, the reaction rate and crystallisation of the Atg-dehydrating system.