HP terranes exhumation in an active margin setting: geology, petrology and geochemistry of the raspas complex in SW Ecuador

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The Andean Range along the western side of South America is a typical example of an active margin tectonic setting, where the oceanic crust of the Nazca plate subducts under the South American continent. Since the advent of plate tectonics, high-pressure metamorphic rocks are recognised as an essential characteristic of convergent plate boundaries. The main reasons that drove this study to focus on the tectono-metamorphic evolution of high-pressures terranes in SW Ecuador are due to the peculiarity of the Raspas Complex geology. In fact the Raspas Complex contains one of the few eclogitic bodies in the northern Andes and it is localised on the western side of the Andean chain in an active margin context. The rarity of the occurrence of eclogites and blueschists in such a geological framework let to identify the El Oro province as a key area to obtain new and important insights into the Andean geodynamic and the exhumation processes.

A detailed field analysis of the Raspas Complex area represented the starting point of this study, followed by the petrological and geochemical characterisation of the HP units, namely the El Toro ultramafites, the Raspas metabasites and the Raspas metapelites. Field investigations allowed: i) to re-define the "Raspas Complex" as an independent tectono-metamorphic unit; ii) to discover a tectono-metamorphic blueschist-facies terrane, named the Arenillas-Panupali unit; iii) to define the Piedras-Amphibolites unit as an independent tectono-metamorphic body underplated to the Tahuin Group continental block. The geochemical study revealed for the HP mafic rocks oceanic plateau affinities, while the Arenillas-Panupali and Piedras metabasites are consistent with a N-MORB origin. The HP metaperidotites are typical of moderately depleted mantle peridotites. Mineral assemblages and microtextures of the El Toro formation rocks allowed to define a main body of metaperidotites with pyroxenite layers (now diopside-amphibole-chlorite-rich bands) . A subordinate ultramafic banded intrusion is composed by olivine rich bands alternated to amphibole-diopside-chlorite bands. Basic dykes crosscut the ultramafic body. The metamorphic evolution of the El Toro ultramafic unit is resumed in two main phases: the former is related to recrystallisation during mantle decompression with temperature decrease until oceanic metamorphism conditions. The younger is mainly related to the subduction of the ultramafic unit. Pristine mantle peridotites, with pyroxenite layers, were characterized by spinel-facies assemblages, indicative of equilibrium recrystallisation at moderate pressure conditions (P ranging 10-20 Kb). The subduction related metamorphic evolution of the ultramafic body reached eclogite facies conditions at temperature not higher than 500-550°C.

Raspas metabasites are composed of eclogites, garnet-amphibolites and blueschists. The bulk-rock chemistry indicate different protholiths for the eclogites and the garnet-amphibolites, while the observed parageneses indicate that they experienced the same P-T conditions. At peak conditions temperatures gave averaged values of ~580°±50°C, and the pressure yielded by the eclogites average around ~19kbar. The blueschist chemical and petrographic characters are consistent with a retrograde stage of the eclogites stating the transition from the eclogite-facies to the high-T blueschist-facies. The Raspas metapelites show the garnet-chloritoid-kyanite eclogite-facies key assemblage yielding metamorphic peak conditions estimated at about 20 kbar, 550-600°C. The observed decrease in temperature following peak pressure conditions provides severe constraints on the exhumation mechanism of the eclogite-facies rocks, because it means that a low geothermal gradient was still stable during exhumation. Such a process is consistent with an active margin setting where subduction of relatively cold oceanic crust continues below the accreted material during its exhumation, and/or that the exhumation rate, whatever its mechanism, is much faster than the thermal relaxation of the thickened crust. A fast exhumation rate would explain the excellent preservation of the high pressure parageneses.

The new data provided by this study coupled with the geodynamic framework allow to propose a "two steps" exhumation model for the Raspas Complex HP rocks. The first step refers to the Late Jurassic/Early Cretaceous drastic geodynamic change resulting in a northeastward rotation of the subduction direction. At this moment the Raspas eclogites start their rapid retrograde path backward along the pristine subduction plane representing at that time a strike-slip regional discontinuity. The second step is concerned with the last exhumation path and is correlated to the crustal thinning following the Celica-Lancones pull-apart basin opening (105-85 Ma). Late Cretaceous evolution of the basin indicates the transition to compressive conditions with possible expulsion of the underplated Raspas lithologies.