Na- Al-Rich metamorphic Clinopyroxe in peridotites from a Fossil Subduction Channel: Sierra del Convento mélange (Eastern Cuba)

IDAEL FRANCISCO BLANCO-QUINTERO (1,*), CONCEPCIÓN LAZARO (2), JUAN CÁRDENAS-PÁRRAGA (2), LIDIA BUTJOSA (3), KENYA NUÑEZ-CAMBRA (4), JOAQUÍN A. PROENZA (3), ANTONIO GARCÍA-CASCO (2,5)
(1) Departamento de Geociencias, Universidad de los Andes, Cra 1 No 18A – 70, IP-201, Bogotá, Colombia.
(2) Departamento de Mineralogía y Petrología, Facultad de Ciencias, Universidad de Granada, Fuentenueva s/n, 18002-Granada, España
(3) Departament de Cristal.lografia, Mineralogia i Dipòsits Minerals, Universitat de Barcelona, Martí i Franquès s/n, 08028-Barcelona, España
(4) Instituto de Geología y paleontología, Vía Blanca y Carretera Central, La Habana, Cuba
(5) Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Fuentenueva s/n, 18002-Granada, España

INTRODUCTION

Subduction channels are formed by a serpentinite matrix and high- to ultra-high pressure, U(HP), blocks of the subducting plate and the overlying fore-arc mantle (mantle wedge). Exhumed fragments of the subduction channels are, hence, characterized by mélanges containing a variety of U(HP) rocks and mafic-ultramafic materials. In addition, collision stages in oceanic environments involve tectonic slices of shallow ophiolitic material, formed in arc, fore-arc or back-arc environments. These ophiolitic bodies may be tectonically disrupted and mixed with fragments of HP mélanges, forming complex mélanges made of low and high pressure material (including ophiolitic rocks) within a serpentinite matrix.

This scenario occurs in eastern Cuba, as exemplified by the Cretaceous Sierra del Convento mélange. The mélange is made of a matrix of schistose serpentinite that contains massive metamorphic blocks composed of moderate- to high-P basic/pelitic rocks (García-Casco et al., 2008). Jadeite deposits have been described in the mélange, resulting from crystallization of fluids evolved from trondhjemitic melts formed during wet melting of subducted MORB (mid ocean ridge basalt) amphibolites at 50 km depth in the subducion channel (García-Casco et al., 2009, Cardenas-Párraga et al., 2012). The mélange formed during Cretaceous to earliest Tertiary times in a context of tectonic interaction between the Caribbean and North American plates. A variety of ultramafic rocks (in terms of texture and composition) are present in the mélange. We provide here a petrological study of serpentinites from the mélange, in order to decipher the context of formation and PT conditions of metamorphism.

ANALYTICAL TECHNIQUES

Mineral compositions were obtained by means of WDS with a CAMECA SX-100 microprobe (CIC, University of Granada) operated at 15 kV and 15 nA. Elemental X-ray images were obtained with the same machine operated at 15 kV, 150 nA beam current, step (pixel) size of 5 μm and counting time of 30 ms. The images consist of the X-ray signals of Kα lines of the elements (colour coded; expressed in counts/nA/s) corrected for 3.5 μs deadtime. The atomic concentration of elements per formula units is abbreviated apfu. The magnesium (Mg#) and chromium (Cr#) numbers of minerals is calculated as [Mg/(Mg+Fe^{2+})] and [Cr/(Cr+Al)], respectively. Mineral abbreviations are after Whitney and Evans (2010).

RESULTS

The metamorphic HP blocks in the Sierra del Convento mélange occur within sheared serpentinite matrix at the base of the Sierra del Convento Massif, in contact with the underlying volcanic arc Purial Complex (García-Casco et al., 2008). Two structural levels are found in the mélange: (I) the mélange s.s., at the base of the unit, bearing HP rocks in a sheared serpentinite matrix, and (II) a megablock of ultramafic materials (~250 m thick) that overlies the latter. The ultramafic matrix of the mélange is antigorite serpentinite, while the megablock is composed of variably serpentinized rocks showing relict Cpx crystals and serpentinites lacking pyroxenes but bearing relict Cr-spinel.

The serpentinitic matrix of the mélange is made of antigorite serpentinite rocks consisting mainly of antigorite (up to 95-97 %) and minor talc (Fig. 1a), similar to the matrix of La Corea mélange (Blanco-Quintero et al., 2011). Antigorite grains are partially replaced by magnesite. Systematically the Cr-spinel is transformed to ferrian-chromite and magnetite mantled by chlorite. Antigorite has low Al (0.11-0.25 apfu), Na (<0.005 apfu) and Mg# (0.89-0.91) contents.

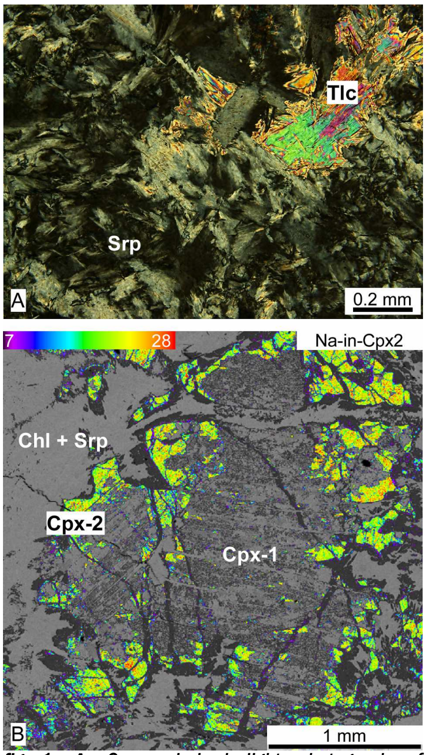

*fig 1. **A.** Cross-polarized light photograph of antigorite serpentinite; replacement of antigorite by talc is observed; **B.** X-ray image of clinopyroxene-bearing serpentinite showing Na-rich Cpx (Cpx-2) surrounding/replacing primary Cpx crystals (Cpx-1).*

The megablock of ultramafic rocks that overlies the mélange is largely

palabras clave: Canal de Subducción, serpentinita, clinopiroxeno | *key words:* Subduction Channel, serpentinite, clinopyroxene

* corresponding author: *if.blanco@uniandes.edu.co*

serpentinized. Two different rock types are present: serpentinite mainly formed by serpentine minerals and minor Cr-spinel grains, and serpentinite showing areas of granoblastic texture with relict, larger, and smaller, neoformed, diopsidic clinopyroxene. The former type of rock has unaltered spinel group mineral crystals having Cr# (0.45-0.51) and Mg# (0.53-0-62). These values are similar to spinel group minerals from the Moa-Baracoa harzburgite (Cr#=0.45-055), but lower than those of the Mayarí harzburgite (Cr#= 0.53-0.67; Marchesi et al., 2006). The serpentine group minerals have Al=0.13-0.35 apfu, Mg#= 0.91-0.92 and very low Na contents (<0.006 apfu).

The rocks showing relicts of bastitized clinopyroxene up to 3-4 mm in size (Fig. 1b) have chlorite and serpentine in the matrix. No primary Cr-spinel is found, although transformation to ferri-chromite is common. These serpentinites have Mg#=0.97-0.98, Al <0.27 apfu and very low Na (<0.005 apfu). Primary clinopyroxenes (Cpx1) bear rims of newly formed clinopyroxene (Cpx2) rich in Na and Al (Fig. 2). The latter grains are finer grained and less altered. The Cpx1 is diopsidic in composition (≈ En46-48 Wo48-50), with Si contents ranging 1.99–2.00 apfu, Mg# = 0.91–0.95, and very low Al (<0.02 apfu) and Na (<0.02 apfu). On the other hand, Cpx2 have lower Si contents ranging 1.83 – 1.93 apfu, Mg# =0.90–1.00, and relatively high concentrations of Al (0.22 – 0.31 apfu) and Na (0.08 – 0.15 apfu). These chemical variations from the diopsidic end-member can be described by the combination of the exchange vectors jadeite NaAl-$Ca_{-1}Mg_{-1}$ and Tschermak AlAl-$Mg_{-1}Si_{-1}$.

DISCUSSION AND CONCLUSIONS

Two hypotheses may explain the presence of secondary Na-Al-rich pyroxene in the Sierra del Convento Massif: a) HP sediment-derived fluids in the channel (or mantle wedge) related to the fluids that formed jadeite deposits (García-Casco et al., 2009, Cárdenas-Párraga et al., 2012), or b) UHP conditions during metamorphism.

UHP conditions have not been described in the Cuban mélanges. However, the nearby Cuaba Gneiss (Rio San Juan Complex, Dominican Republic) underwent UHP conditions (e.g., Abbott et al., 2005, 2007). In this complex olivine clinopyroxenite and garnet-bearing ultramafic rocks indicate UHP conditions. However Grt-bearing peridotites have not been found to date in the Cuban mélange, though Al- and Na-rich clinopyroxene in the Sierra del Convento mélange is similar to Cpx described in UHP complexes (e.g. in the Apennines, Italy; Rampone et al., 1995 and Dabie-Sulu, China; Zhang et al., 2000; Fig. 3). This hypothesis indicates that the ultramafic megablock represents a fragment of the subducted mantle incorporated into the channel at depth.

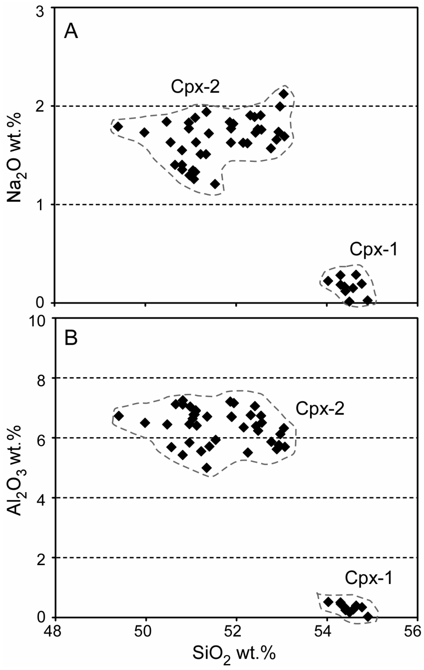

fig 2. Na_2O and Al_2O_3 versus SiO_2 in clinopyroxenes.

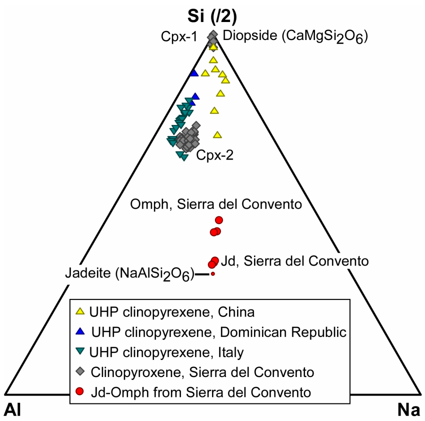

fig 3. Si-Na-Al diagram showing the differences between Cpx1 and Cpx2, and the similarity of Cpx2 to pyroxenes from UHP complexes. Jadeite and omphacite compositions from Sierra del Convento (Cárdenas-Párraga et al., 2012) are plotted for comparison.

Alternatively, the formation by pervasive fluid-rock interaction in the subduction channel (as indicated by metasomatic rocks) could be more effective, taking into account the mélange characteristics (i.e., the trondhjemite and jadeite rocks, the absence of UHP conditions in other blocks) and the similarity with other supra-subduction rocks (Marchesi et al., 2006). Following this argument, the Na-Al-rich clinopyroxenes would form in the mantle wedge (near to the slab-mantle interface) by the remobilization of the Al and Na (e.g., from sediments) and interaction with ultramafic materials. This means that the ultramafic megablock in the Sierra del Convento mélange represents a fragment of the mantle wedge affected by the infiltration of slab-derived fluids that metasomatized the mantle rocks. However, more data are necessary to better understand the genesis and PT conditions of formation.

ACKNOWLEDGEMENTS.

We appreciate financial support from Spanish MICINN project CGL2012-36263 and the FAPA project (Universidad de los Andes).

REFERENCES.

*Abbott, R.N et al., 2005. UHP magma paragenesis, garnet peridotite and garnet clinopyroxenite: An example from the Dominican Republic. International Geology Review, **47**, 233-247.*

*Abbott, R.N. et al., 2007. UHP magma paragenesis revisited, olivine clinopyroxenite and garnet-bearing ultramafic rocks from the Cuaba Gneiss, Rio San Juan Complex, Dominican Republic. International Geology Review **49**, 572–586*

*Blanco-Quintero, I.F. et al., 2011. Serpentinites and serpentinites within a fossil subdution channel: La Corea melange, eastern Cuba. Geologica Acta **9** (**3-4**), 389-405.*

*Cárdenas-Párraga, J et al., 2012. Hydrothermal origin and age of jadeitites from Sierra del Convento Mélange (Eastern Cuba). European Journal of Mineralogy, **24**, 313-331.*

*García-Casco A. et al., (2008) Partial melting and counterclockwise P-T path of subducted oceanic crust (Sierra del Convento mélange, Cuba). J Petrol **49**, 129-161.*

*García-Casco, A. et al., (2009): A new jadeitite jade locality (Sierra del Convento, Cuba): First report and some petrological and archaeological implications. Contrib Mineral Petrol **158**, 1-26.*

*Marchesi, C. et al., 2006. Petrogenesis of highly depleted peridotites and gabbroic rocks from the Mayarí-Baracoa Ophiolitic Belt (eastern Cuba). Contributions to Mineralogy and Petrology, **151**, 717-736.*

*Rampone, E. et al., 1995. Petrology, mineral and isotope geochemistry of the External Liguride peridotites (northern Apennine, Italy). Journal of Petrology **36**, 81–105.*

*Whitney, D.L. et al., 2010. Abbreviations for names of rock-forming minerals. American Mineralogist **95**, 185–187.*

*Zhang, R.Y. et al., 2000. Petrochemical constraints for dual origin of garnet peridotites from the Dabie-Sulu UHP terrane, eastern-central China. Journal of Metamorphic Geology, **18**, 149–166.*