

# Petrology and Geochemistry of Hydrated Peridotites and Serpentinites from the Villa Clara Mélange, Central Cuba

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## INTRODUCTION

The "northern ophiolite belt" of Cuba is considered an obducted ophiolitic sheet bearing mantle and crustal sections formed after the Mid-Late Jurassic rifting of Pangea in the region and the ensuing Jurassic-Cretaceous drift of the Americas and formation of the Proto-Caribbean (i.e., Central Atlantic) oceanic basin (Iturralde-Vinent, 1998). The ophiolitic body in the Villa Clara region (Central Cuba) is essentially made of hydrated peridotites and serpentinites, but also contains dismembered bodies of ophiolite-related crustal rocks and exotic tectonic blocks including high-P subduction-related rocks and volcanic-arc related rocks.

Available petrological, geochemical, stratigraphical, paleontological and geochronological data indicate that formation of rock bodies and the Villa Clara serpentinitic mélange itself was a long lasting process that started in the late Jurassic and finished during the late Eocene when the mélange finally obducted over the Bahamas section of the passive margin of North America (García-Casco et al., 2006). The mélange hence provides critical information on the tectonic divergent and convergent interactions of the Caribbean and North American plates during ca. 100 My.

We illustrate here this complex evolution by means of a characterization of the (meta) ultramafic rocks of the mélange.

## GEOLOGICAL SETTING

The Villa Clara serpentinite-matrix

mélange (VCSM, Central Cuba) encompasses tectonic bodies of an ophiolite suite, bodies formed at depth in a subduction channel (high-P blocks of eclogite, garnet amphibolite, amphibolite, blueschist, greenschist, quartzite, metapelite and antigorite), bodies of volcanic-arc sequences and of unrelated platform-derived sediments. The ophiolitic bodies are composed mostly of hydrated ultramafic rocks (serpentinised mantle peridotites and serpentinites s.s.), though fragments of layered and isotropic gabbros, diabase, basalt and pelagic sediments are also present (García-Casco et al., 2002, 2006).

## RESULTS

On the basis of field relations, whole-rock composition, mineral assemblages, textures, and mineral chemistry, four main groups of (meta) ultramafic rocks are distinguished: Group I (abyssal peridotites), Group II (subducted abyssal serpentinites), Group III (upper plate serpentinites), and Group IV (antigorites).

### Group I

This group is mainly composed of hydrated lherzolite and clinopyroxene-rich harzburgite, which have porphyroclastic texture with strongly deformed orthopyroxene porphyroclasts. Pseudomorphic replacements after olivine are common, including serpentine minerals (mixtures of lizardite and chrysotile) in a mesh texture. Accessory pale-brownish Cr-

spinel grains are anhedral and rimmed by Cr-magnetite and chlorite.

The olivine compositions are in the range of Mg#~90 with NiO content between 0.01-0.51 wt%. Opx compositions fall in the range of Mg#=93-95 with Al<sub>2</sub>O<sub>3</sub> and Cr<sub>2</sub>O<sub>3</sub> contents of 3.38-5.41 and 0.42-0.80 wt%, respectively. Cpx has Mg#=91-92, Al<sub>2</sub>O<sub>3</sub>=4.11-7.50 wt% and Cr<sub>2</sub>O<sub>3</sub>=0.65-1.40 wt%. Cr-spinel compositions (Cr#<0.2, Mg#>73; TiO<sub>2</sub><0.08 wt%) plot in the Olivine-Spinel Mantle Array (OSMA) in the field of abyssal peridotites. Pyroxene and Cr-spinel compositions indicate fertile abyssal peridotites. Figure 1 shows that Cr-spinel from Group I has the same composition of Cr-spinel from the Monte del Estado Peridotite (Puerto Rico) (Marchesi et al., 2011). Bulk rock compositions of the hydrated peridotites have values of 1.77-3.09wt% Al<sub>2</sub>O<sub>3</sub>, 0.06-0.10wt% TiO<sub>2</sub>. The chondrite-normalized REE patterns are flat, with positive slope, depleted in LREE and slightly enriched in HREE.

### Group II

These rocks are extensively serpentinised and display pseudomorphic textures. Textural differences between mesh-texture lizardite and bastite indicate that most of the serpentinised peridotites were predominantly harzburgite. Serpentinites also contain minor chrysotile, chlorite and magnetite and relicts of primary brownish Cr-rich spinel (in unaltered cores), partially oxidized to ferrian chromite and magnetite.

**palabras clave:** Serpentinitas, Peridotitas abisales, Zona de supra-subducción, Cuba Central

**key words:** Serpentinites, Abyssal Peridotites, Supra-subduction Zone, Central Cuba

Antigorite was not observed.

Cr-rich spinel has  $Cr\#=0.41-0.45$ ,  $Mg\#=0.54-0.58$ ,  $Fe^{3+\#}=0.04-0.05$ , and  $TiO_2=0.15-0.25wt\%$ . These compositions suggest either abyssal or forearc setting (Fig. 1). However, the  $Al_2O_3$  contents (2.47-2.74 wt%) and the REE patterns of group II peridotites are similar to those of group I, suggesting an abyssal affinity.

### Group III

This group is predominantly made of harzburgite. The petrographic features of these rocks resemble those of group II peridotites, including the presence of relic Cr-spinel.

However, Cr-spinel from group III has the highest  $Cr\# (>0.52)$  and the lowest  $Mg\#(<0.63)$ , with  $Fe^{3+\#}=0.02-0.07$  and  $TiO_2 =0.07-0.18wt\%$  (Fig. 1), and the rocks are depleted in  $Al_2O_3$  (0.28-0.99wt%) compared to groups I, II and IV. The chondrite-normalized REE patterns have a U-shape, hence enriched in LREE and HREE and depleted in MREE. This pattern is characteristic of interaction of LREE-depleted residual mantle peridotites with LREE-enriched melt likely derived from the subducting slab (Dupuis et al., 2005).

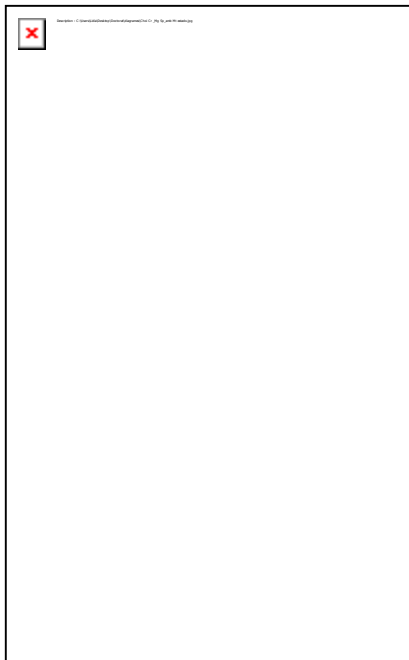


fig 1.  $100Cr/(Cr+Al)$  vs  $100Mg/(Mg+Fe^{2+})$  of spinel.(Choi et al., 2008). Blue line shows the composition of Cr-spinels of Monte del Estado (Puerto Rico; Marchesi et al., 2011).

### Group IV

This group is made of antigorites devoid of pseudomorphic textures and characterized by interpenetrating laths of antigorite. This type of rock is typically associated with HP blocks of MORB-derived eclogite and amphibolite, indicating metamorphism at depth in a subduction channel. The samples consist mainly of antigorite (>90%), with minor magnesite-dolomite and Cr-spinel grains completely transformed to magnetite. Locally, some samples contain tremolite.

Bulk rock compositions, with  $Al_2O_3$  (1.98-2.02 wt%) and REE patterns similar to groups I and II, suggest a MOR affinity and formation in an abyssal setting.

### CONCLUSIONS

Petrography and whole-rock and mineral chemistries of ultramafic rocks of the VCSM suggest the presence of rocks formed and evolved in contrasted tectonic settings.

Abyssal peridotites (groups I, II and IV) indicate the presence of fragments of the Proto-Caribbean (Atlantic) oceanic basin that started to form in the late Jurassic. Abyssal group I fragments were incorporated into the serpentinitic mélangé during arc-continent collision (latest Cretaceous to Eocene) and/or before collision as blocks of the downgoing oceanic lithosphere and were trapped in the subduction channel. Group I peridotites is the second example described to date in the Greater Antilles (after Monte del Estado peridotite; Marchesi et al., 2011) of the ancient Proto-Caribbean lithospheric mantle.

Abyssal group II peridotites also represent the Proto-Caribbean lithosphere. However, they were subducted to shallow depths and transferred to the supra-subduction zone fore-arc/arc environment during pre-collision times (early Cretaceous-latest Cretaceous). As a result, these rocks intermingled with the depleted fore-arc peridotites of group III.

Abyssal group IV peridotites represent Proto-Caribbean lithosphere subducted to great depth (60-70 km). Metamorphism and fluid-rock interaction in the subduction environment formed antigorites, which

were transferred to the subduction channel developed in the Caribbean-Proto-Caribbean plate interface. Here, they intermingled with subducted MORB eclogites forming a deep-seated melange that exhumed along the plate interface during the Cretaceous, and mixed with the shallower abyssal-forearc melange made of groups I, II and III.

In conclusion, hydrated ultramafic rocks in the VCSM represent varied tectonic environments including subducted and non-subducted mantle lithosphere of the Proto-Caribbean oceanic arm of the Central Atlantic, generated by seafloor spreading between North and South America since the late Jurassic after the break-up of Pangea, and Caribbean (Pacific Farallon)-derived lithospheric domains of the Cretaceous fore-arc.

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