

# Talc- and Serpentine-like “Garnierites” from Falcondo Ni-laterite Deposit (Dominican Republic): a HRTEM approach

/ CRISTINA VILLANOVA-DE-BENAVENT (1,\*), FERNANDO NIETO (2), JOAQUÍN A. PROENZA (1), SALVADOR GALÍ (1)

(1) Departament de Cristal·lografia, Mineralogía i Dipòsits Minerals. Facultat de Geologia. Universitat de Barcelona. C/ Martí i Franquès s/n. 08028 Barcelona, Catalunya (Espanya)

(2) Departamento de Mineralogía y Petrología e Instituto Andaluz de Ciencias de la Tierra. Universidad de Granada-CSIC. Campus de Fuerteventura s/n. 18002 Granada (Espanya)

## INTRODUCTION.

“Garnierites” represent significant Ni ore minerals in the lower horizons of many Ni-laterite deposits worldwide (e.g. Freyssinet et al., 2005). They consist of a green, fine-grained mixture of hydrous Ni-bearing magnesium phyllosilicates, including serpentine, talc, sepiolite, smectite and chlorite (e.g. Brindley and Hang, 1973; Springer, 1974; Brindley et al., 1979). Thus, “garnierite” is a general descriptive term and is not recognized as a mineral species by the IMA Commission on New Mineral and Mineral Names (CNMMN). For this reason, “garnierites” have been classified as “serpentine-”, “talc-” and “clay-like garnierites”, respectively (e.g. Brindley and Maksimovic, 1974).

Furthermore, hydrated Ni-rich talc minerals have been commonly referred to as kerolite [ $Mg_3Si_4O_{10}(OH)_2 \cdot (H_2O)$ ] and pimelite [ $Ni_3Si_4O_{10}(OH)_2 \cdot (H_2O)$ ]. Pimelite was described as a hydrated Ni-talc (e.g. Springer, 1974), but was also determined to belong to the smectite group by some authors (Faust, 1966). Although kerolite is not recognized by the CNMMN, and pimelite has been recently discredited (Burke, 2006), these terms are still used nowadays (Wells et al., 2009).

Several studies on “garnierites” based on X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Electron Microprobe (EMP) themogravimetric and spectrometric techniques have been published. However, High Resolution Transmission Electron Microscopy (HRTEM) detailed studies are still scarce (Soler et al., 2008).

This work presents first HRTEM imaging and EDX microanalysis (AEM) results of talc- and serpentine-like “garnierites”

from Falcondo Ni-laterite deposit. These results are compared to those previously obtained through powder XRD and EMP (CCiT, Universitat de Barcelona).

Preliminary data allows to classify the sampled “garnierites” into two groups, which display two well distinguishable greenish colours in hand specimen:

- Bluish bright-green “garnierites” display colloform textures under the optical microscope. Their compositions plot within the talc [ $Mg_3Si_4O_{10}(OH)_2$ ] (kerolite)-willemsite [ $Ni_3Si_4O_{10}(OH)_2$ ] (pimelite) series, and their diffraction pattern shows basal spacings of  $\sim 10$  Å, so it represents a talc-like or a 10 Å-type “garnierite”.
- Yellowish pale-green “garnierites” develop cryptocrystalline aggregates under the optical microscope. These “garnierites” have variable compositions near the lizardite  $Mg_3Si_2O_5(OH)_4$  -népouite  $Ni_3Si_2O_5(OH)_4$  join and the XRD patterns present spacings of  $\sim 7$  Å, corresponding to a serpentine-like or a 7 Å-type “garnierite”.

## “GARNIERITE” OCCURRENCE IN FALCONDO NI-LATERITE DEPOSIT.

Hydrous silicate Ni-laterites in the Dominican Republic have been developed during the Miocene on the main ophiolitic peridotite belt in the Cordillera Central. This is an elongated body, 4-5 km wide and 95 km long, composed by serpentinized harzburgites, dunites and lherzolites (Lewis et al., 2006; Proenza et al., 2007).

Ni-serpentinates and “garnierites” are the main Ni-ore-bearing assemblage in the Falcondo Ni-laterite profile (Lewis et al., 2006). Both talc- and serpentine-like

“garnierites” mainly occur as mm-cm vein fillings in fractures, but also as coatings, boxworks and different kinds of breccias, within the saprolite horizon or near the unweathered peridotite, close to the base of the lateritic profile.

## METHODOLOGY.

A representative sample, containing strongly serpentinized peridotite (saprolite) cross-cut by talc-like and serpentine-like “garnierite” veins, was studied through HRTEM. This sample was prepared in polished thin section with Canada balsam. Two areas were selected: talc-like and serpentine-like, respectively. These were detached, ion-thinned by a Gatan 600 ion mill and were carbon coated. Furthermore, bluish bright-green and yellowish pale-green “garnierites” were separated by hand-picking, ground in an agate mortar and put on a copper grid. HRTEM images, electron diffraction patterns and microanalysis in STEM mode from the two detached specimens and the two grids were obtained in a Philips CM20, equipped with an EDX detector, at 200 kV (CIC, Universidad de Granada).

## RESULTS.

### HR-TEM Imaging.

The specimen containing talc-like “garnierites” presents sets of superimposed bundles and/or plates with basal spacings near 9.5 Å (Fig. 1a).

In the specimen with serpentine-like “garnierites”, talc bundles coexist with two kinds of serpentine microstructures, with spacings of about 7 Å. The first type develops sectorial fibres, with an angle of  $24^\circ$  between adjacent (001) lattice planes, so-called polygonal serpentine (Fig. 1b). The second type develops

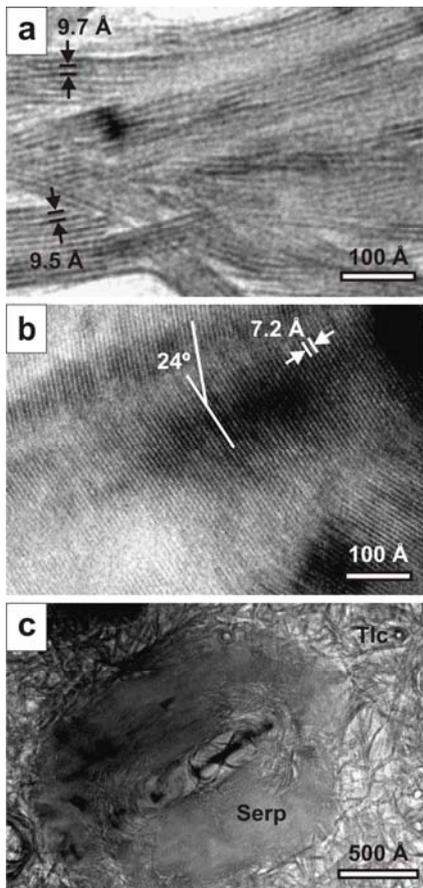
**palabras clave:** “Garnieritas”, Tipo talco, Tipo serpentina, República Dominicana, MET alta resolución.

**key words:** “Garnierites”, Talc-like, Serpentine-like, Dominican Republic, HRTEM.

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\* corresponding author: cvillanovadb@ub.edu

weakly round cylindrical fibres (Fig. 1c). Both are hollow-cored or contain talc bundles in the centre. These features were described and identified as lizardite and chrysotile, respectively, by Baronnet & Devouard (2005) and references therein.



**fig 1** HRTEM (a, b) and low magnification TEM (c) images of representative zones from the two selected areas: a) talc, b) polygonal serpentine, c) cylindrical serpentine fibres (Serp) surrounded by talc (Tlc).

**AEM data.**

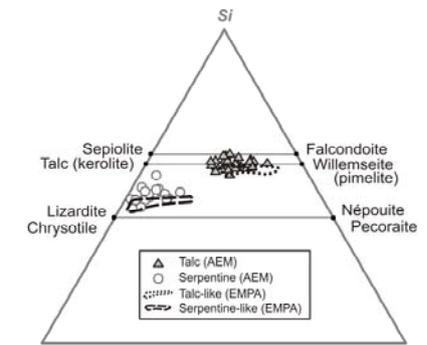
Firstly, talc analyses from both talc-like and serpentine-like “garnierites” yield high Ni contents, ranging from 1.2 to 2.3 a.p.f.u., and Al and Fe are nearly absent (<0.1 a.p.f.u.). These results determine that it corresponds to an intermediate phase of the talc (kerolite)-willemseite (pimelite) series.

Secondly, serpentine is poorer in Ni than talc (0.1-0.6 a.p.f.u.), and Al and Fe contents are low (0-0.5 and 0-0.2 a.p.f.u., respectively). Thus, serpentines can be described as nickeloan lizardite and nickeloan chrysotile.

Finally, Ca and K contents are very low in all analyzed mineral phases (<0.1

a.p.f.u.).

As shown in figure 2, AEM results plot within or near the compositional field as those previously obtained through EMPA in similar samples. Moreover, serpentine analyses are deviated towards the talc (kerolite)-willemseite (pimelite) series, due to the coexistence of serpentines with talc-like “garnierites” in the same area.



**fig 2.** AEM compositions of “garnierites” from the selected areas and the powder grids, compared with EMPA data. See text for explanation.

**CONCLUDING REMARKS.**

HRTEM imaging results are coherent with basal spacings from XRD patterns, as well as AEM data with mineral compositions provided by EMPA.

On one hand, HRTEM images of bluish bright-green mineral reveal spacings near 9.5 Å, which indicate talc-like structures, according to Brindley et al. (1977). Besides, talc EMP analyses indicate that this mineral is a hydrated variety of talc, so it belongs to the kerolite-pimelite series. These data altogether demonstrates these talc-like “garnierites” are not smectites, as previously suggested by Faust (1966). On the other hand, HRTEM images allowed to distinguish two kinds of serpentine-like microstructures in yellowish pale-green material, which correspond to lizardite and chrysotile.

Talc-like phase in both talc-like and serpentine-like “garnierite” selected specimens has pimelite compositions (or hydrated willemseite) because it is Ni-dominant and Fe-poor. These compositions suggest a supergene origin. Ni content in serpentine is much lower, but significant, so serpentines are Ni-bearing lizardite and chrysotile. Both minerals are clearly neofomed, and were precipitated from a Ni-rich solution in supergene conditions.

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