COMPOSITION AND DISSOLUTION KINETICS OF GARNIERITE (Mg-Ni SILICATE) FROM THE LOMA DE HIERRO NICKEL-LATERITE DEPOSIT (VENEZUELA)

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The composition and structure of a sample of garnierite (Mg-Ni silicate) from the Loma de Hierro Ni-laterite deposit (Venezuela) has been determined by means of X-Ray Diffraction (XRD), Transmission Electron Microscopy (TEM) and Electron Microprobe (EM) analyses. This garnierite sample was collected from a vein in the parent rock of the laterite deposit (serpentinized peridotite; Fig. 1).

The XRD diffractogram showed peaks at 7 Å and 10 Å, characteristic of the structures of serpentine and talc, respectively. TEM analyses revealed that different areas of the sample (at scales of tens of nanometers) were characterized by either a 7 Å or 10 Å spacing (Fig. 2). The chemical composition was obtained from the EM analyses (average of 15 measurements). The sample had a very homogeneous composition, dominated by Si, Mg and Ni. The (Mg+Ni)/Si ratio was equal to 0.92. This value allowed the calculation of a stoichiometric formula for this garnierite sample, which is given by $Mg_{2.91}Ni_{0.09}Si_{3.27}O_{8.17}(OH)_{2.74}$. This formula corresponds to a mixture of Ni-containing serpentine (37 mol%) and talc (63 mol%).

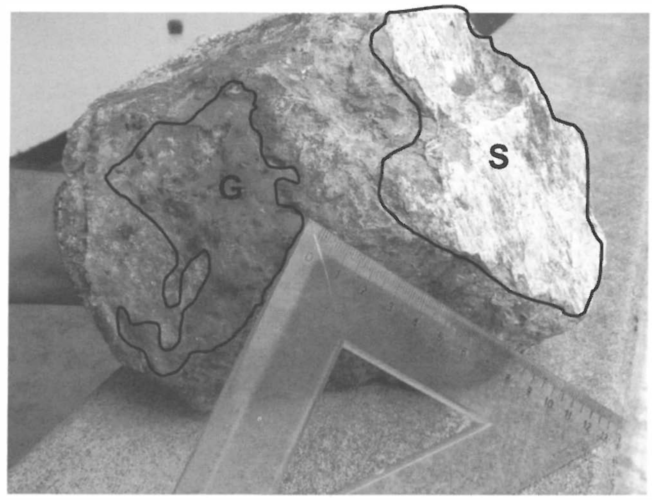

Figure 1: Photogragh of a sample of serpentinized peridotite. The bulk of the sample is peridotite. The crust on the left-hand-side is garnierite (G). The crust on the right-hand-side is serpentine (S).

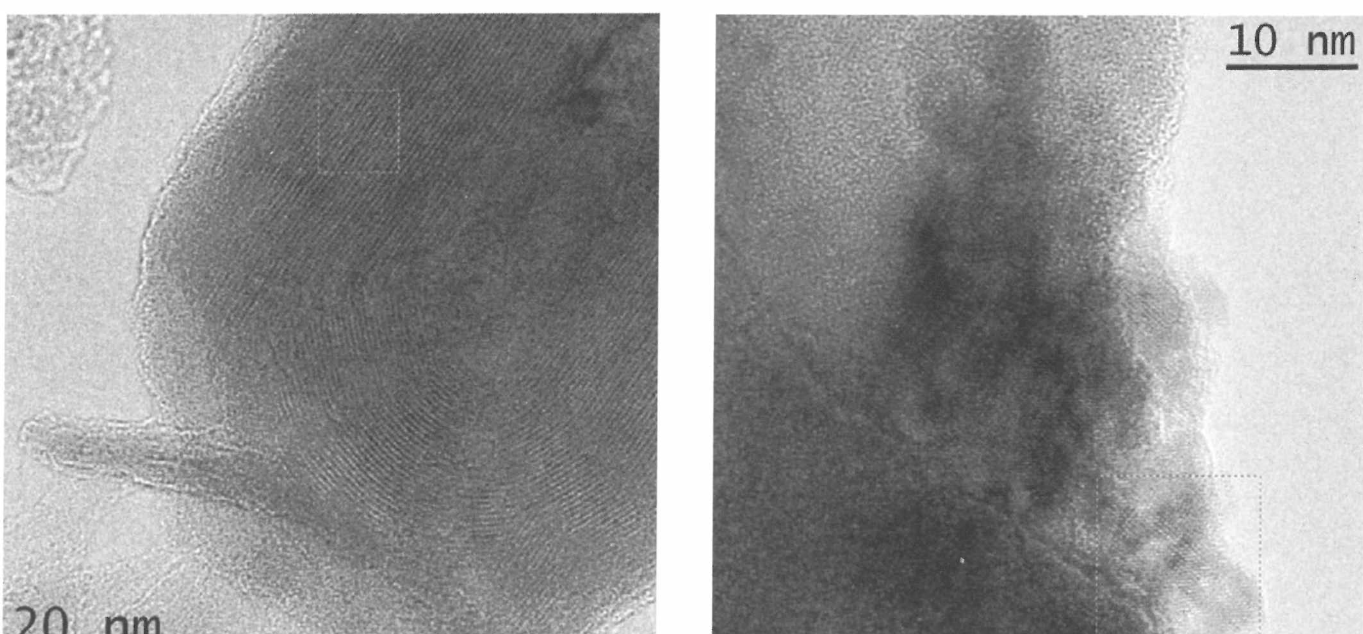

Figure 2: High resolution TEM images showing areas of the garnierite sample characterized by different structural spacings (areas within small squares). (a) 7.3 Å spacing, corresponding to a serpentine-type structure. (b) 9.8 Å spacing, corresponding to a talc-type structure.

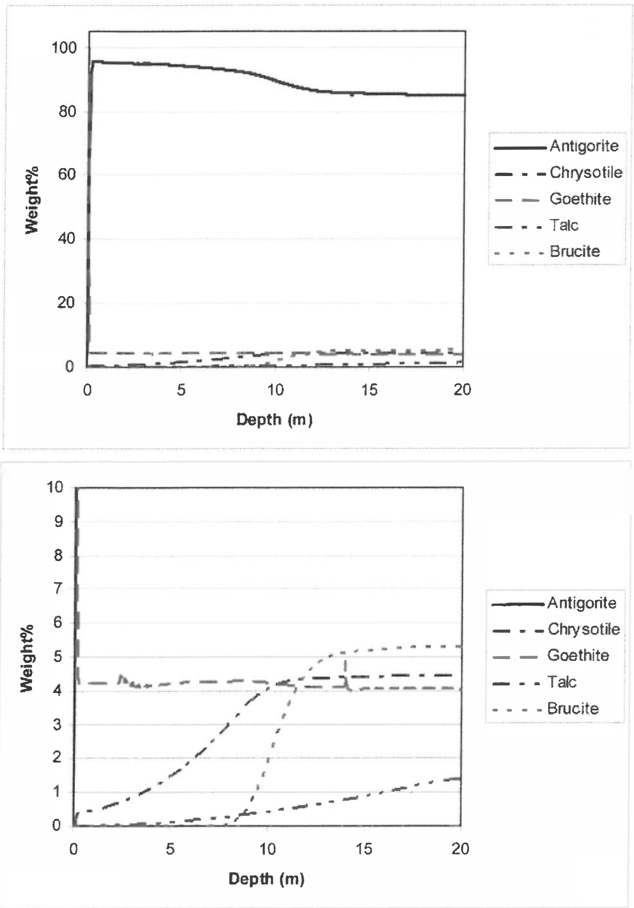

Figure 3: Results of a 1D reactive transport model corresponding to infiltration of water through a serpentinized peridotite during 200 000 years. The graphs show mineral content (wt%) vs. depth. The composition of the parent rock in the simulation was: forsterite 18vol%, fayalite 2%, enstatite 10vol%, antigorite 15vol%, chrysotile 15vol%, porosity 40%. The large value of porosity simulates a heavily fractured rock. The flow of water is constant, with a value of 1 $m^3/m^2/y$.

Flow-through experiments were performed to measure dissolution rates at different pH values and under far-from-equilibrium conditions. At steady state, the stoichiometry of the solutions at the outlet of the flow-through cells was different from what would correspond to stoichiometric dissolution of garnierite. Since these solutions were undersaturated with respect to possible secondary precipitates, the results seem to indicate the different contributions of Ni-containing serpentine and talc to the total dissolution rate. The relative contribution from serpentine to the total rate increases with decreasing pH, in the near-neutral to acidic range.

It is currently planned to collect garnierite samples from different depths in a same weathering profile, in order to detect possible trends in the serpentine/talc ratio of the samples and its correlation with Ni content. Preliminary reactive transport calculations using a simplified concept suggest that the serpentine/talc ratio of the garnierite samples could decrease with increasing depth (Fig. 3), correlating with a decrease in Ni content. The calculations were performed with the CRUNCH reactive transport program, which corresponds to the latest development of the GIMRT/OS3D software package (Steefel, 1998: Steefel and Yabusaki, 1996). The calculations take into account advective and dispersive solute transport coupled with mineral reaction. Mineral dissolution and precipitation are described through reaction rate laws. The rate laws implemented in the simulations are based on the results of laboratory experiments published in the scientific literature.

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