

Stability of “Garnierites” in the Falcondo Nickel Lateritic Deposit, Dominican Republic

/SALVADOR GALÍ (1,*), JOSEP M. SOLER (2), JOAQUÍN A. PROENZA (1), JOHN F. LEWIS (3), ESPERANZA TAULER (1), MANUEL LABRADOR (1)

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

(2) Institut de Ciències de la Terra Jaume Almera (CSIC), Lluís Solé i Sabarís s/n, 08028 Barcelona, Spain

(3) Department of Earth and Environmental Sciences, The George Washington University, Washington, D.C. 20052, U.S.A.

INTRODUCTION.

The main Ni-bearing minerals in Falcondo lateritic deposit are hydrated Mg-Ni silicates (serpentine and “garnierites”) occurring in the saprolite horizon. Garnierite is generally used as a field term referring to wide variety of clay-like nickel-bearing hydrous silicates with a characteristic green color (Brindley et al., 1973). The main minerals are nepouite (Ni lizardite), willemseite (Ni talc), and falcondoite (Ni sepiolite). The minerals form several solid solution series that can be discussed in terms of the system Mg-Ni-Si-H₂O. The majority of garnierites are precipitated from solution at ambient temperature.

In this contribution we show that garnierites, in the form of two solid solutions or three solid solutions plus quartz, can be precipitated from solution under near equilibrium conditions. A more frequent observation is the equilibrium between two solids (two solid solutions or one solid solution and quartz), or simply a single solid that may be a solid solution or quartz.

SOURCE AND DATA.

The equilibrium constants used in this approach have two different origins: experimental for the Mg end members, and predicted for Ni phases (e.g. Tardy and Garrels, 1974; Golightly, 1981). In both cases, the differences between reported experimental values by different authors, or calculated values with different models give a crude estimation of the errors involved. The analyses of mixtures supposed to precipitate in equilibrium were used as a constraint to reduce the choice between different reported or calculated logK values.

RESULTS AND DISCUSSION.

In figure 1 a stability diagram in the variables $\log[(aMg^{+2}+aNi^{+2})/aH^{+2}]$, $\log aSiO_2(aq)$ allows the representation of the stability fields of the relevant Mg, Ni phyllosilicate solid solutions. The six straight lines correspond to the solubilities of the six end members (serpentine, Spr; nepouite, Nep; talc, Tlc; willemseite, Wil; sepiolite, Sep; falcondoite, Fal). The stability diagram delimits the stability field of each Ni-bearing phyllosilicate and quartz. For each field, only one of these solids is in equilibrium. Along the boundaries delimiting the fields, (curves ST, TSep, SSep and SepQ), two solids are in equilibrium with the solution. Three of these curves intersect in one point (coordinates: -4.3938, 14.0022) which is an invariant point. The solids in equilibrium with the aqueous solution are three solid solutions: $Srp_{0.747}Nep_{0.253}$, $Tlc_{0.353}Wil_{0.647}$ and $Sep_{0.340}Fal_{0.660}$.

Based on the proposed activity diagram and the Lippmann diagrams, the aqueous and solid solutions can be characterized, and the following parameters assigned: for the solution, $a_{Mg^{+2}}$, $a_{Ni^{+2}}$, $a_{SiO_2(aq)}$ and $a_{H^{+}}$; for the solids in equilibrium, x_{Mg} and $(1-x_{Mg})=x_{Ni}$.

The boundary between Spr-Nep and Tlc-Wil (curve ST) displays a pronounced change of slope. From the midpoint to the Mg end, this boundary runs virtually parallel to the $\log[(aMg^{+2}+aNi^{+2})/aH^{+2}]$ axis, so that an increase in the activity of Ni in solution may favour the precipitation of Tlc-Wil solid solution, because in the diagram, the activity and activity ratio of Ni⁺² increases downwards.

Figure 1 suggests that two main temporal and spatial trends are related with the formation of Ni enriched supergene phases. On the one hand there is the increase of Ni⁺² in the solutions percolating through or embedding the altered parent rock. This can be explained basically by the leaching of Ni retained in goethite in the limonitic horizon by meteoric waters, and the repeated cycle of congruent dissolution of Ni-poor phyllosilicates followed by equilibrium precipitation of Ni-rich phyllosilicates.

On the other hand, there is an increase in the silica activity, with the formation of a great variety of different forms of silicification (Golightly, 1981; Freyssinet et al., 2005). In summary (see figure 1), the evolution of garnierites can be depicted by a trend pointing downwards (Ni enrichment) and to the right (increase of silica activity).

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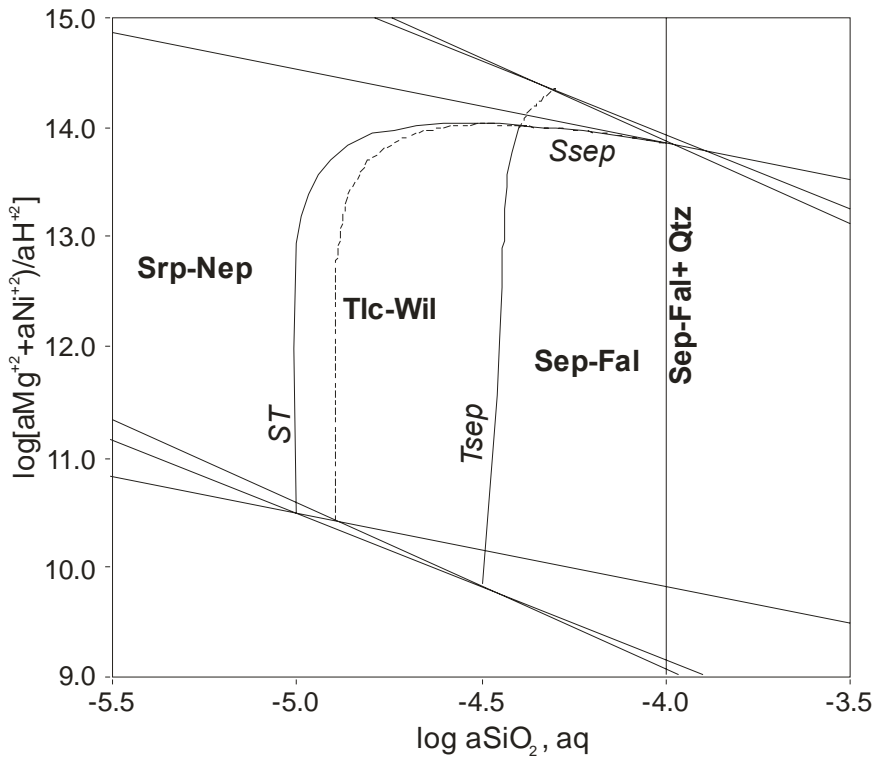


fig 1. Equilibrium path for three pairs of solid solutions: *Srp-Nep*+*Tlc-Wil*; *Tlc-Wil*+*Sep-Fal*; *Srp-Nep*+*Sep-Fal*. Dashed lines are metaestable extensions of these equilibria. Vertical line at $\log a\text{SiO}_2, \text{aq} = -4$ gives equilibrium between quartz+*Sep-Fal*.

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