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Investigation of Philippine Garnierites: A close look on their Mineralogy, Geochemistry and Nickel Association

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The Philippines is host to several nickel laterite deposits from the weathering of ultramafic sections of its ophiolites and ophiolite complexes distributed from north to south of the archipelago. It is within three of these deposits that garnierites, hydrous nickel magnesium silicates, were collected. They are characterized by their green color and usually occur as fillings of millimeter to centimeter thick veins and coatings in the nickeliferous saprolite horizon. The aim of this research is to investigate the similarities and differences of different Philippine garnierites through detailed characterization of their mineralogy, morphology, major and trace element geochemistry, nickel association, and spectral bands. X-ray diffraction (XRD) analyses, with corresponding X-ray fluorescence (XRF) data, show that the garnierites from mining areas in Surigao and Davao (Mindanao Island, Southern Philippines) are dominantly composed of species from the serpentine group. However, species of the talc group is also seen in some samples. On the other hand, samples from Zambales (Luzon Island, Northern Philippines) are made up of falcondoite, species of pyrophyllite-talc, serpentine, chlorite, or an intimate mixture of these minerals. It is also good to note that high chromium (7-18%) containing samples within this area were collected. However, these could not be classified as garnierites despite having the same field characteristics because they are not mainly composed of phyllosilicates and have low Ni content. Additionally, some serpentine veins, found in fractured bedrocks and saprolitic rocks, cannot be classified as garnierite due to low Ni content (<1%). Electron micrographs reveal a variety of morphological forms: rod-shaped, platy or foliated, scaly, and fibrous. Three spectral regions have been observed using infra-red (IR) spectroscopy: 3700 cm^{-1}-3400 cm^{-1} absorption bands associated with –OH stretching vibration region, 950 cm^{-1}-900 cm^{-1} bands associated with the Si-O-Si stretching vibration region, and the 650 cm^{-1}-600 cm^{-1} bands which are associated with either Si-O bending or –OH libration. Noted nickel concentrations in some samples reach up to 20%. Sequential extraction results show that more than 90% of the nickel in garnierites is concentrated via substitution rather than adsorption. No significant correlation between nickel and other trace elements, except for cobalt, is observed from trace element analysis conducted using inductively-coupled plasma mass spectrometry (ICP-MS). It is suggested that garnierite samples from different nickel laterite deposits should be collected and analyzed to better understand the nature of the Philippine garnierites. Also, thermal and dissolution kinetics studies could contribute greatly on how Ni and other economically important elements can be extracted efficiently from this type of deposit.