A model for formation of marine manganese nodules.
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Manganese nodules from the Western and Central Pacific Ocean are composed of two microscopically homogeneous phases, that is, 10Å manganite and δ-MnO_2 phase. The chemical and mineralogical properties, distribution patterns in a respective nodule, and regional occurrence of these two constituents differ significantly, suggesting the distinct difference in their geneses. The 10Å manganite phase is a monomineralic aggregate rich in heavy metals such as copper and nickel, while the δ-MnO_2 phase is a submicroscopic mixture of colloidal particles of poorly crystalline δ-MnO_2 (2-line form) and amourphous iron hydroxides with a considerable amount of minute detrital materials. The 10Å manganite phase develops on the bottom surface of nodules and in small spherical nodules buried within the sediments, and is considered to have been formed from the interstitial waters of bottom sediments. The enrichment of heavy metals in this phase would be related to the diagenesis of the sediments. The δ-MnO_2 phase generally occurs on the surface of nodules and crusts which contacts with sea water, and would have been formed by the accumulation of settling colloidal particles of ferromanganese materials. This model of formation well explains the occurrence, mineralogical and compositional variation, and morphology of manganese nodules, and suggests the growth history of nodules such as the overturn on the sea floor during their growth, based on the characteristic internal structure of individual nodules.

The Manganese Ore Deposit of Azul, Brazil
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The manganese deposits of Azul are situated in the Itacaiunas River Area, Pará, Brazil. The local lithostratigraphic sequence (Azul Member, upper part of the Rio Fresco Formation) is the following : jaspilite, carbonaceous manganese limestone, carbonaceous manganese shale, clay-silstone and sandstones.

The two protores, i.e. manganese limestone and manganese shale, were deeply weathered, giving rise to superficial manganese enriched materials, "Grained Manganese Ore" (11,5 x 10^6 tons, 46% Mn) and "Pelitic Manganese Ore" (27 x 10^6 tons, 28,5% Mn). The manganese released from weathered rhodocrosite was precipitated as ino- and phyllomanganates which were partially transformed into cryptomelane. On the rocks of this area, the following features may be observed from depth : weathering of microcline and chlorite (80m), dissolution of quartz (~40m), complete transformation of illite (≈35m) and continuous increase of kaolinite. Near 20m, one can note the appearance of gibbsite, goethite and hematite, which increase up to surface.

Detrital ores were formed under superficial conditions. These are "Manganiferous Pisolites", "Manganiferous Canga", "Blocks and Manganiferous Plaquettes" (16,3 x 10^6 tons of concentrate, 1/8", 42,6% Mn). Cryptomelane, pyrolusite, lithiophorite and buserite are the main manganese minerals besides iron oxides and hydroxides and gibbsite from desilication of kaolinite.

Several aspects of these deposits are very similar to those of Moanda, Gabon, of about the same age.

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