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together with manganese oxides from their suspensions in marine water does not play an important part in the formation of iron-manganese nodules. Therefore the degree of intensity of reductive processes should be considered as the main factor governing the rate and intensity of deposition of ferromanganese nodules on the sea floor. The reduction intensity depends in its turn on the nature and amount of organic matter contained in oozes. A higher supply of oxygen to the bottom ooze is very favourable for iron and manganese deposition.

MINERALOGICAL STUDY OF THE MAIN MANGANESE CARBONATE-SILICATE PROTORES (QUELUZITES) FROM BRAZIL AND THEIR WEATHERING PRODUCTS

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The manganese protore of Buritirama (Para), Serra do Navio (Amapa) and Lafaiete (Minas Gerais) deposits are the result of regional metamorphism in amphibolite facies during the Transamazonic orogenetic cycle (2 b.y.) of impure carbonatic sediments. They are associated with quartzites, biotite schists and amphibolites in metasedimentary sequences.

The mineral paragenesis related to the main phases of mineral formation is listed below (Table 1).

This mineral paragenesis is interpreted with the help of thermochemical and experimental data: formation of tephroite in a fluid phase with a high CO_2/H_2O ratio; growth of pyroxenoids with increasing $CO2/H_2O$ ratio and where the activity of SiO_2 was higher. The kind of pyroxenoid structural type depends on the composition of the original carbonates.

During the main metamorphism of the impure marbles the CO_2/H_2O ratio increased due to the formation of the manganese silicates whereas in the veins the CO_2/H_2O ratio decreased with time, as indicated by the study of fluid inclusions in quartz.

The most important phenomena in veins are silica migration (some times carrying P_2O_5 and/or SO_2) and the formation of coarser grained rhodonite-quartz-apatite-(barite) or pyroxenoid-spessartite associations.

The most important retrometamorphic processes observed are the formation of Mn-amphibole and the serpentinization of tephroite and pyroxenoids.

All three protores and related rocks are deeply weathered.

In the lower parts of the water saturated zones the following mineralogical transformations can be observed: rhodochrosite-manganite, pyroxmangite-manganite, pyroxmangite-groutite, spessartite-caulinite, spessartite-lithiophorite, tephroite-nsutite and Mn-amphibole-birnessite.

Above the water table level the earlier manganese hydroxides and oxides tend to be transformed into cryptomelane and pyrolusite, of which most of the enriched ore is composed.

Table 1: Mineral paragenesis of the main phases of mineral formation.

	Main metamorphic paragenesis	*Mineral associations in veins*	*Retrometamorphic phases*
BURITIRAMA	MnC-MnP MnC-MnP-Sp MnC-T-MnP-Sp MnC-T-Pyx-Sp Br-MnP-MnC-Sp ± Acc:Pyp,Ga,Al	Rd-Sp-Ap-Ba-Qz Rd-Sp-MnC-Ap-Ba MnC-Pyx-Sp	Sp, Pyx, Rd, Qz, MnA,MnC,Ser.
LAFAIETE	MnC-Sp-C MnC-T-C MnC-Sp-T-C MnC-Pyn-Sp-C Mnc-T-Pyn-Sp-C ± Acc:Ga,Py,Pyr, Cp,Pyp,Al,Ap	Sp-Qz Qz-Sp-Rd-Ap Mnc-Pyn-MnA	MnC,MnA,Rd, Sp,Pyx,Rhc, Be,Ne,Qz, Ser.
SERRA DO NAVIO	MnC-Sp-C MnC-Sp-T-C Mnc-Pyn-Sp-C Mnc-T-Pyn-C Mnc-MnP-Sp-C ± Acc:Pyr,Py,Al, Pyp,Sph,KFe	Sp-Qz Sp-Pyn-MnC Pyx-Sp-Qz	MnA,MnC,Pyx, Qz,Py,Pyr, Ser.

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Abbreviations: Acc=accessory, Ap=apathite, Ba=barite, Be=bementite, Br=braunite, C-graphite, Cp=chalcopyrite, Ga=galaxite, KFe=K-feldspar (microcline), MnA=Mn-amphiboles, MnC=Mn-carbonates (in general of kutnahorite-rhodochrosite solid solution in the main met. paragenesis), MnP=Mn-phlogopite (in some places manganophyllite), Ne=neotocite, Py=pyrite, Pyn=pyroxenoides (when rhodonite and pyroxmangite were found), Pyp=pyrophanite, Pyr=pyrrhotite, Pyx=pyroxmangite, Qz=quartz, Rd=rhodonite, Rhc=rhodochrosite, Sp=spessartite, Sph=sphene and T=tephroite.