TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

The Serra do Navio manganese deposit is situated in Amapá Province, Brazil to the north west of the Amazon delta. This study presents results of an investigation into the lithostratigraphy, whole rock geochemistry and petrology of the ore-bearing metasedimentary rocks. The results are used to define a possible sedimentary protolith succession.

The metasedimentary succession at the Serra do Navio deposit is constituted of biotite schists, graphitic schists, Mn-carbonate schists, rhodochrosite marbles and Mn-calcite marbles. Biotite schist is characterized by biotite, plagioclase and quartz. It displays a well-preserved compositional layering. Biotite schist is interpreted to be a metamorphosed equivalent of shale or greywacke or volcaniclastic lithologies. A similar mineralogical assemblage to biotite schist dominates graphite schist, but it contains conspicuous amounts of graphite as well as a distinct foliation. For this reason it is interpreted to be derived from carbonaceous shale. Mn-carbonate schist is a massive coarse-grained rock characterized by an abundance of Mn-carbonates and Mn-silicates, i.e. tephroite, rhodonite and spessartine. It is interpreted to be the metamorphosed equivalent of manganiferous chert. Mn-calcite marble is characterized by Mn-calcite and rhodochrosite with subordinate tephroite, spessartine and rhodonite an assemblage thought to originate from a manganiferous carbonate rock with minor clay component. Rhodochrosite marble represents the most Mn-rich end member of the carbonate lithologies. It is characterized by abundant granular textured rhodochrosite and minor or no spessartine and biotite. Its protolith was almost certainly a manganiferous carbonate mud rock.

Fluid inclusion studies in peak metamorphic spessartine garnet at the Serra do Navio characterize three types of fluids: Type 1: an aqueous oversaturated fluid (H_2O – NaCl) Type 2: pure CH_4 and Type 3: Mixed fluids (H_2O – CH_4). The original fluid contained heterogeneously trapped CH_4 and H_2O, and then by a process of unmixing produced a mixed fluid of CH_4-H_2O. Pressure and temperature trapping conditions are constrained at 1 – 2 kbar and 400 – 500ºC. This corresponds to depths of ~ 4.2 – 5.7km at which peak metamorphism occurred.

Whole rock geochemistry shows that the carbonate lithologies and the alumo-silicates plot well removed from each other. High MnO, CaO, MgO, Co, Zn and positive Ce anomalies, characterizes the carbonate lithologies. Negative $\delta^{13}C$ values for whole rock carbonate samples illustrate that both inorganic and organic carbon were involved in the formation of the Mn-

carbonate and point to a diagenetic origin for the carbonates. Positive Ce anomalies confirm that the Mn-carbonates formed from diagenetic transformation of Mn-oxyhydroxides. The alumo-silicate rocks on the other hand are marked by high SiO_2, TiO_2, Al_2O_3, Zr and Sc as well as high ΣREE reflecting high clastic input. The high ΣREE, weak negative Eu anomaly and fairly flat REE distribution pattern all point to an old Upper Continental Crustal (UCC) provenance for the alumo-silicate rocks.

In the succession at the Serra do Navio deposit, the clastic sediments are at the base, gradually fining upwards and are succeeded by chemical sediments marking a major transgressive depositional event, which culminated in the deposition of Mn-carbonates when siliciclastic input into the basin was at a minimum. It is proposed that the siliciclastic/volcaniclastic sediments were the first to be deposited, as turbidites. Then, due to a major transgression manganese and chert were deposited with minimum terrigenuous influx. The deposition sequence was capped by deposition of carbonaceous shale that was deposited under deeper water from an anoxic water column.

The depositional model for the Serra do Navio deposit is very similar to that of the weakly metamorphosed and non-metamorphosed manganese carbonate and manganiferous chert deposits of Paleoproterozoic and Phanerozoic age.