Mn-rich argillite bed in the Paleoproterozoic Gowganda Formation, Huronian Supergroup, Canada

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1. Introduction

Several lines of evidence suggest that the oxygen content in the atmosphere may have increased around 2.0 - 2.4 Ga. The Huronian Supergroup, Canada, is the most continuous succession which may record environmental changes during the Paleoproterozoic. Detrital uraninites of the Matinenda Formation, close to the base of the succession, would have been formed under the low oxygen condition. In contrast, there are red beds in the Gowganda Formation, the youngest glacial formation, indicating that the oxygen level was high at that time. In this study, we examine records of redox transitions in the Gowganda Formation and to discuss implications for global environmental change during the Paleoproterozoic. We report results of high-resolution analyses of drilling core samples which cover whole part of the Gowganda Formation, and discuss a possibility of the correlation with the Transvaal Supergroup in South Africa.

2. Red mudstones and Manganiferous beds

To investigate relations between colors and lithofacies, we quantified visible light spectra of rocks by the L*a*b* color system. We found that there is a 80-meters-thick red mudstone bed just above the glacial diamictites. The redness is owing to microcrystalline hematites. Therefore, the presence of the red mudstones would indicate that the oxygen level was high at that time. We also found that there are Mn-rich argillites conformably overlying the red mudstones. The enrichment of Mn occurs directly above the diamictites and total thickness of the Mn-rich horizon is about 400 meters. Based on observations by SEM and EPMA analyses, Mn-bearing minerals are mainly chlorites, and in a most Mn-rich sample (1.6 wt% MnO), there is also spessartines in addition to chlorites. Although these rocks would have subjected to greenschist metamorphism, the enrichment of Mn seems to have occurred before they underwent soft-sediment deformations. Furthermore, because chlorites are replaced by quartz along veins, secondary hydrothermal enrichment of Mn is unlikely. Mn is an elements which has high redox potential, and requires molecules of oxygen to precipitate as MnO2, Therefore enrichment of Mn in the Gowganda Formation would suggest high oxygen level just after the glaciation. Significant enrichment of Mn has been observed only at this horizon throughout the Huronian Supergroup.

3. Environmental change in the Paleoproterozoic

The Makganyene Diamictite Formation, Transvaal Supergroup, South Africa is considered as glacial sediments in the Paleoproterozoic. The Hotazel Formation overlying the Makganyene Diamictite includes the Kalahari Manganese Field, the largest sedimentary manganese ore deposit. Total amount of Mn per unit area in the Gowganda Formation is estimated to be about 20 percent of the Hotazel Formation. Stratigraphic features are very similar between these two successions: glacial diamictites, Fe-Mn deposits and overlying red sandstones. Age constraints are also consistent with each other. The Nipissing Diabase (2219+/-3.5 Ma) would have intruded before the sediments of the Gowganda Formation were lithified. On the other hand, the Hotazel Formation deposited just above the Ongeluk Lava flow (2222+/-13Ma). It is suggested that the Kalahari Manganese Field has formed as a result of atmospheric oxygen rise just after the Paleoproterozoic snowball Earth event (Kirschvink et al, 2001). Enrichment of Mn just above the glacial diamictites found in Huronian and Transvaal supergroups suggest that these two sequences would record the same global events of the global glaciation and the rise of oxygen level.