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Mineralogical and geochemical study of clastic sedimentary rocks in Barberton greenstone belt, South Africa

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Cyanobacteria became active and oxidize surface ocean water in Archean. However, chronological constraint is still uncertain as to when ocean water became oxic. Some redox sensitive minerals in clastic sediments are often used to indicate the absence or presence of oxidative weathering, oxic sea water and diagenesis. Clastic sedimentary rocks in Barberton Greenstone Belt are studied by many previous investigators. However, detailed examination of redox sensitive minerals and elements are rare. Therefore, we set objectives of the present study (1) to investigate mineralogical and geochemical characteristics of clastic sedimentary rocks deposited in shallow water environments in ca.3.2Ga Moodies Group, (2) to discuss the origin of redox sensitive minerals in clastic sediments and (3) to decipher the redox conditions of the surface environments at the time of Moodies sedimentation.

We examined clastic sedimentary rocks (mainly sandstone) of the Joes Luck Formation in the Moodies Group. Samples were collected from drilled core collections of Sheba mine. All samples are belonging to Eureka Syncline blocks. Those samples are not affected by modern weathering.

The examined sandstones contained rounded quartz, K-feldspar, albite, minor zircon, and rutile. These minerals were detrital origins mainly from felsic crustal materials. Rounded chromite also occurs and we interpret that such chromite is a weathering product from mafic to ultramafic rocks. Rounded chromite is always surrounded by forming aggregates Cr-rich micas, and chromite never occurs without micas. We interpret that chromite was protected by micas, and survived from dissolution during weathering, transportation and diagenesis. Detrital pyrite and uraninite were not seen in these samples. Those mineral features indirectly indicate that presence of oxidative weathering, transportation and/or diagenesis at the sedimentation of Moodies Group. Geochemical analyses of the bulk samples indicate that most elements (e.g., Ti, Zr and V) are correlated to Al. Therefore, chemistry of examined samples are controlled by detrital components. On the other hand, Cu, Pb, Mn, and Mo are not correlated to Al, and apparently enriched in clastic sediments. Cu and Pb were mobilized in sediments during early to late diagenesis associated with late sulfide formations. Enrichment of Mn and Mo in the examined samples more reflected precipitation process from ocean water and diagenesis. In particular, enrichment of Mo is found in some samples with moderate amount of organic carbon. This suggests that Mo was dissolved in Moodies ocean water as oxidized species, and then reduced by microbial activities followed by sedimentation with organic matter. Overall results of this study suggested that oxygenic phototrophs already flourished in the photic zone of the 3.2 Ga ocean, making surface ocean water oxic.

Keywords: Cyanobacteria, Chromite, Barberton, RSE