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Origin and depositional environment of the Early Proterozoic Makganyene Diamictite, South Africa

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Introduction

Major glaciations have been known during the Neoproterozoic and the Paleoproterozoic. Based on paleomagnetic studies, it is now widely accepted that there were low-latitude ice sheets during the Neoproterozoic. Kirschvink (1992) proposed the 'snowball Earth' hypothesis for Neoproterozoic glaciation, that is, the surface of the Earth was globally ice-covered at that time. Recently, paleomagnetic study revealed that the Makganyene Diamictite, which is considered as the glacial deposits during the Paleoproterozoic (2.4 ~ 2.2Ga) and exposed in Griqualand West area, South Africa, may have deposited at low paleolatitude of 11 +/- 5 degree. Therefore, snowball Earth event would have also occurred during the Paleoproterozoic. This may explain rapid change of redox state of the Earth's atmosphere and deposition of Kalahari Manganese Field, the world-largest manganese ore deposit in South Africa. However, there is not enough evidence to identify the Makganyene Diamictite as a glacial deposit except for one or two reports of striated clasts within this formation. Sedimentary environments of this formation have never been discussed in detail. In this study, we show the evidence for the glacial origin of this formation and discuss its sedimentary environment.

Glacial Evidences

We studied the Makganyene Diamictite Formation of the Transvaal Supergroup, exposed in Griqualand West, South Africa. The Makganyene Diamictite Formation has been interpreted as glacial deposits during the Paleoproterozoic. We discovered several ice-rafted dropstones from this formation. This is a strong evidence for the glacial origin of the Makganyene Diamictite Formation.

Sedimentary Environment

Because there are several sedimentary environments for the formation of the glacial deposits, we examined sedimentary structures of the Makganyene Diamictite Formation in detail. We found structures such as cross-bedding with graded beds suggesting the depositional condition under the influence of water flow with fluctuating velocity. Dropstones occurs within the cross beds suggesting that ice-rafting would have occurred at the same time. Based on above evidence, the sedimentary environment of the Makganyene Diamictite Formation has been either glaciofluvial or shallow glaciomarine.

We also found reddish colored laminated siltstone with rhythmical repetition of laminations. This lithology resembles the tidal rythmite found in the Neoproterozoic Elatina Formation, Australia, which is interpreted as deposited near the mouth of ebb-tidal channel. If this were the case, the sedimentary environment of this formation would have been shallow tidal sea which was occasionally covered with icebergs.

Conclusion

We found ice-rafted dropstone from the Makganyene Diamictite Formation and, therefore, confirmed the glacial origin of this formation. We also found features such as cross- and graded beddings and possible tidal rhythmite which imply shallow marine environment under the influence of tides. These results reinforce the view of low-latitude and low-relief glaciations during the Paleoproterozoic.