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Peculiar micromorphologies of the middle Neoproterozoic dolomite-magnesite association formed in a hypersaline-alkaline periglacial lake

Maciej Bojanowski[1], Beata Marciniak-Maliszewska[2], Milena Matyszczak[3], and Jan Środoń[3]
[1]Institute of Geological Sciences, Polish Academy of Sciences, Warszawa, Poland (mbojan@twarda.pan.pl)
[2]Faculty of Geology, University of Warsaw
[3]Institute of Geological Sciences, Polish Academy of Sciences, Kraków, Poland

Dolomite and magnesite are particularly abundant in the Precambrian strata, which is often explained by abnormal ocean chemistry favoring formation of these minerals in oceanic basins over other carbonates and Ca-sulfates. However, interpretation of the depositional setting is challenging in the Precambrian sequences, mainly due to the scarcity of biotic proxies and commonly significant post-depositional alteration. Therefore, combined sedimentological, mineralogical and geochemical investigations of weakly altered Precambrian sedimentary rocks emerge as the best approach to contribute to our understanding of the climatic and chemical evolution of early Earth. This study deals with the Lapichi Fm. from the East European Craton, which consists of a mixed dolomite-siliciclastic series recently dated at 710 Ma, thus deposited during the Sturtian panglaciation. What is essential, these rocks are exceptionally well preserved and have not experienced any significant alteration. They were previously interpreted to have formed in a saline marine lagoon, so they appeared to represent an ideal target for a palaeoceanographic study. Here, we present results of re-evaluation of the Lapichi Fm. using sedimentology, petrography, SEM, XRD, C, O and Sr isotopes.

Diamictites and rythmites observed in the siliciclastics of the Lapichi Fm., given that the area was positioned around 40°S during the Lapichi deposition, provide sedimentological evidence of cold climate and periglacial conditions on Baltica at low latitudes. The intercalating dolostones contain some siliciclastic material with the same characteristics, so the cold conditions continued during dolomite formation as well. Two types of dolostones are distinguished: pristine dolomicrites representing penecontemporaneous precipitates and coarser-crystalline dolomites with peculiar fabrics apparently exotic to the sedimentary dolomite, which include stellate dolomite with pyramidal terminations. We believe that these dolomites are pseudomorphic and that the precursors might have been magnesite, Ca-sulfates, aragonite, or glendonite/ikaite. Both dolomite types contain numerous micrometer-scale magnesite inclusions; in some samples authigenic K feldspars and traces of artinite were also identified, but neither $CaCO_3$ nor $CaSO_4$ minerals were found. Such mineral paragenesis confirms high salinity, Mg-rich parent fluid. Presence of hematite and goethite attests for strong seasonal fluctuations of temperature and humidity. Radiogenic Sr isotope composition, even in the case of pure dolomicrites, indicates that the rocks did not

precipitate from seawater. $\delta^{13}C$ and $\delta^{18}O$ vary, but ^{18}O enrichment is not observed. $\delta^{13}C$ cluster around 0‰, whereas $\delta^{18}O$ values are always negative, which suggests predominance of a meteoric water source, possibly meltwater. The covariance between $\delta^{13}C$ and $\delta^{18}O$ in dolomicrites supports the meteoric source and suggests a closed lake. In summary, the data contradict previous interpretation of the Lapichi Fm. depositional setting and indicate that it formed in a perennial, ice-covered, hypersaline, high-alkaline lake in an arid, periglacial setting. Although recent global climate may be far from that of the Cryogenian, we speculate that the closest possible modern analogs of the Lapichi depositional setting may be lakes in the Antarctic dry valleys, northern Great Plains of Canada, or high-altitude Tibetan or Andean playas.

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