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Sea water chemistry in the late Paleoproterozoic: Insight from the Huangqikou formation, western part of the North China Craton

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The ~1800–800 Ma period is known as the 'Boring Billion (BB)' because of the relative stasis of the carbon isotope record during this time. However, geochemical data from the Paleo-Mesoproterozoic strata deposited in different areas indicate heterogeneity and complexity of the oxygen contents in the oceans, which hampers paleoenvironmental reconstructions from this period. In addition, very little research has been carried out on the Palaeoproterozoic strata of the North China Craton (NCC). In this study, we report analyses of U-Pb isotopes, elemental abundances, Fe speciation, and molecular markers from the Huangqikou formation in the northwestern part of the Ordos Basin (OB), NCC. The Huangqikou formation was deposited in the rift valley at about 1736 Ma. Our new data, combined with previous analyses, suggest that the warm and humid depositional environment of the Huangqikou formation in the Helanshan area evolved from a marine foreshore setting to a marine backshore setting, with increasing degree of seawater hypoxia. But a relatively oxygenated environment corresponded to the lower part. On the other hand, the Huangqikou formation in the Zhuozishan area evolved from a terrestrial deltaic environment to a marine foreshore environment, with cumulatively reducing conditions. This study points out that the late Paleoproterozoic strata deposited in the western part of the NCC might mainly formed in reduced seawater. But some degree of oxidation had occurred in the surface water during this period, which proves the oxygenation of the surface environment during the early period of Earth evolution.