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Permian diamictites in northeastern Asia: Their significance concerning the bipolarity of the late Paleozoic ice age

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ABSTRACT

Despite a lack of detailed sedimentologic analyses, diamictites in the Middle Permian Atkan Formation were previously interpreted as glaciomarine and glacially-influenced marine deposits. This interpretation allowed this unit to play a prominent role in paleoclimatic and biogeographical reconstructions associated with presumed bipolar glaciation during the late Paleozoic ice age (LPIA). In this sense, the LPIA is considered to be a close analog to bipolar glaciation and climate change during the Cenozoic. Here, results are presented that challenge the glacigenic interpretation for these strata and negate interpretations of the bipolar nature of the LPIA. The 400 to 1500-m-thick Atkan Formation was deposited in back-arc basins associated with activity of the Okhotsk–Taigonos volcanic arc along the leading edge of Pangea as it drifted across the North Polar Circle. The occurrence of tuffs, volcanic clasts, and glass shards indicate derivation from a nearby arc. Cooling and solidification of some clasts during sedimentation is suggested by the occurrence of clasts with embayments and protrusions that extend into the surrounding matrix, clasts with columnar-like jointing, and alteration of the matrix surrounding some clasts. CA-TIMS dating of tuff zircons indicate a late Capitanian age, which is consistent with fossils within the strata. Bedded diamictites deposited as debrites dominate. These diamictites, which occur as tens of m thick downlapping packages that thicken then thin upward, were deposited as prograding and abandoning sediment gravity-flow fans. Chaotic and folded strata formed as slumps. Graded sandstones and conglomerates were deposited as turbidites, and mudstones were deposited as mudflows, low-density turbidites, and hemipelagic deposits. Striated clasts and outsized clasts piercing bedding were not observed in the study area. Strata above and below the Atkan Formation contain abundant graded beds and deep-water trace fossils indicating deposition as turbidites. The combination of debrites, turbidites, slumps, volcanic grains (clasts, glass, and tuffs), and an absence of glacigenic indicators suggest that Atkan strata were deposited in deep-water basins associated with the development of the volcanic arc rather than due to glacial activity. These findings are significant as they require reconsideration of current views of LPIA glaciation and suggest that ice sheets were limited to Gondwana.

Contents

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