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Waning of the Late Paleozoic Ice Age and the Pangea B to Pangea A Transformation in the Permian

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The Late Paleozoic Ice Age (LPIA) was comprised of pulses of glaciation in high to mid-southern latitude regions of Gondwana (southern Africa and South America, India, Antarctica) from the mid-Carboniferous (∼330 Ma) to a pronounced reduction of ice sheets in the Early Permian (by ∼290 Ma) and culminating with the demise of Alpine ice sheets in eastern Australia in the Late Permian (∼260 Ma) (1, 2). The LGIA corresponds to a time interval of reduced atmospheric CO_2 concentration as shown in a variety of records, which along with oxygen isotope proxies for at least the Permian (3), indicate that atmospheric CO_2 was the primary driver of ice sheet and climate variability. The waning phases of the LPIA coincided with a major (albeit still contentious) tectonic event in the Permian: the transformation of the pole-to-pole supercontinent Pangea from a 'B' configuration, with the northwestern margin of South America adjacent to eastern North America in the Early Permian, to the classic pre-drift Pangea A configuration with the northwestern margin of Africa now against eastern North America in the Late Permian (4). The transformation occurred along a dextral shear zone between the southern (Gondwana) and northern (Laurasia) continental assemblies that ran obliquely within the tropical belt and was active between ∼280 Ma and 260 Ma (5). An unanticipated result of the transformation was about a 20% reduction of land area in the equatorial humid belt (5°S to 5°N). This may have had two reinforcing and testable effects on climate: less uptake of atmospheric CO_2 from the reduction of land area subject to intense weathering in the potent warm and wet equatorial belt, plus an ancillary decrease in surface albedo in the tropical heat engine from the larger areal fraction of darker ocean water. We speculate that the increased greenhouse effect from lowered weathering uptake of CO_2 and a marginally lower albedo allowed global climate to ameliorate sufficiently to make continental ice sheets contract and to ultimately cause the termination of the LPIA. The Emeishan large igneous province in China that erupted at ∼260 Ma may have produced a transient and reinforcing input of CO_2 but its major effect was probably a longer term CO_2 drawdown from enhanced weathering from residing in an equatorial setting for the rest of the Permian.

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