Relative Extents of the Penultimate and the Last Glacial Maxima in the Tropics

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Marine terraces and oxygen-18 in marine organisms suggest similar global ice volume during the last two glacial maxima (marine isotope stage 6, 160-140 kyr and stage 2, 30-10 kyr). But mid-latitude continental terminal moraines show more extensive ice sheets during the penultimate glacial maximum than during the last. We use terrestrial and marine records of paleoclimate to examine the relative magnitudes of the last two glacial maxima in the tropics.

We dated glacial deposits at two locations in Africa and two in South America using cosmogenic 36Cl and combined the individual records into a composite record of glaciations. The ages form two distinct groups: >230 kyr and <32 kyr. They indicate major glaciations during marine isotope stage 10 or older, stage 8, and stage 2. Deposits between stage 8 and stage 2 are absent, although the global climate was glacial at least two times, including the penultimate glacial maximum of stage 6. The apparent absence of stage 6 moraines implies that they were not deposited, or that they were deposited, but now they are covered by the more extensive stage 2 moraines. In either case, we can conclude that in the tropics the penultimate glaciation was less extensive than the Last Glacial Maximum, contrary to what has been observed or inferred elsewhere. This conclusion is corroborated by three marine records of paleoclimate: (a) the presence of a stage-6 sapropel in the Mediterranean Sea, indicating interglacial climate in tropical East Africa, while the global climate was glacial; (b) the lack of ice-volume fingerprints in the Arabian Sea sediments during stage 6; and (c) the new, alkenone-derived sea surface temperatures that are higher during stage 6 than during stage 2 by up to 4.5 degrees Celsius. Together, these glacial and marine data indicate that tropical and high-latitude climates are not necessarily covariant. During stage 2, extensive tropical glaciers coexisted with extensive high-latitude ice sheets. But during stage 6, relatively small tropical glaciers (or, perhaps, non-glacial conditions) coexisted with relatively large high-latitude ice sheets. These observations suggest that at some times tropical climates were little affected by high-latitude glacial boundary conditions, and were instead controlled by regional or zonal factors, such as insolation.