i9 Carboniferous tillites < climatic zones >

> The problem of Permian [since revised to Carboniferous] glaciation remains an insoluble enigma, unless the straightforward inference is accepted that all the continents except Antarctica lay well to the south of the present positions and that the southern continents were grouped together around the South Pole. —Arthur Holmes, 1944.[1]

Till, which is the most widespread sedimentary evidence of Pleistocene glaciation, is nowhere stone. A principle (admittedly to be used with caution) is that the degree of lithification of a sedimentary rock is an indication of its age.

In 1855, A. C. Ramsay described conglomerates in England that were in every respect similar to till and boulder clay *except* that unlike those Pleistocene glacials, which are unconsolidated sedimentary rocks (sediments), they are consolidated (indurated) sedimentary rocks of lithified till and lithified boulder clay called *tillite* ("till stone," Gk. suffix *-ite,* connected). A Permian age was assigned by Ramsey to the tillites he described and "contemporaneous" tillites in India were described the next year by brothers William Thomas (1832-1905) and Henry Francis Blanford (1834-1893).[2] The age of these Gondwanide tillites has since been revised to Carboniferous. But when in India, tillite was first recognized, its stratigraphic position beneath coal measures was merely indicative of its antiquity as the age of the overlying Gondwanide coals was not certain.

The tillite formation in India is found (when restored by reversing the graben faulting of its occurrences) to be widespread upon a vast, horizontal, glaciated pavement. This rules out the possibility that the tillites were mountain glacial deposits. The movement of the ice across peninsular India was toward the north, as glaciated pavement striations, chatter marks and roches moutonnées attest. This flow direction would still have surprised even had it been known that the Himalayas did not exist when the glaciation occurred. For how, in tropical peninsular India, had a continental glacier (ice sheet) existed with its lowland snowfield to the south (and so even nearer the equator)?

To add to the amazement, tillites of similar age, and also deposited by continental glaciers, were found in South Australia in 1859, in South Africa in 1870,[3] and in Brazil in 1888.

The foregoing evidence of an ancient continental glaciation in India and the southern continents, summarized by Suess in *The Face of the Earth*, 1883-1909,[4] did not escape Wegener's attention!

A world with such climatic zoning was impossible for a trained meteorologist (which Wegener was) to accept. Only if the continents had been south of their present locations! Moving the continents south and closing the oceans between them reconstructs a single land [5] with a northern realm, later named "Laurasia" by du Toit in 1927,[6] that straddled the equator and was comprised of what are now North America, Europe and Asia, and a southern realm, for which Wegener used the name "Gondwanaland" *after* Suess, 1885,[7] that contained the south pole and was comprised of what are now India and the southern continents. With that paleogeography, the geologically recorded paleoclimate of the Late Paleozoic makes sense. "This evidence," wrote an excited Wegener, "is so compelling that by comparison all other criteria must take a backseat."

Wegener's use of this information to cinch his argument (initially in 1912) for the reality of a primordial continent emergent in the primordial world-enveloping ocean that Suess in 1885 had named "Panthalassa" (Gk. "all ocean"),[8] was summarized by Holmes: [1]

> A glance at [***Figure i9.1***] shows that the glaciated lands now occupy a considerable area of the tropics on both sides of the Equator. With the continents in their present positions such a distribution of ice-sheets is hopelessly inexplicable. The suggestion that Gondwanaland rose from sea level to a plateau so enormously high that it was above the snow line is negatived by ample evidence that it was nowhere very high. But whether it was or not, the tropics could not have been glaciated down to sea level without the development of still greater ice sheets over the northern lands. ... On the other hand the great Carboniferous coal forests were flourishing from North America to China while

> Gondwanaland lay under ice. Moreover, deposits of laterite and bauxite that could only have formed in a tropical climate are found in the Upper Carboniferous of the United States (Kentucky and Ohio), Scotland (Ayrshire), Germany, Russia (south of the Moscow basin), and China (Shantung).
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> The inference that the equatorial zone of the time is roughly indicated by this lateritic belt is irresistible.

An ice age in Gondwanaland, could easily explain the tillite formation. In Wegener's reconstruction of that realm (***Figure i9.2***), the furthest extent of the ice sheet would have been to latitudes no lower (i.e. no nearer the equator) than those reached by ice sheets during the Pleistocene. ❑

Figure i9.1 The distribution of tillites (white areas) of Carboniferous age. The directions of glacial striations that mark the bedrock on which the glacial formation rests are shown by a heavy (black) line or an arrow where the direction of ice movement is clearly record by chatter marks and roches moutonnées. Map *after* Fig. 259*, in The Principles of Geology* by *Arthur Holmes*, 1944.[1]

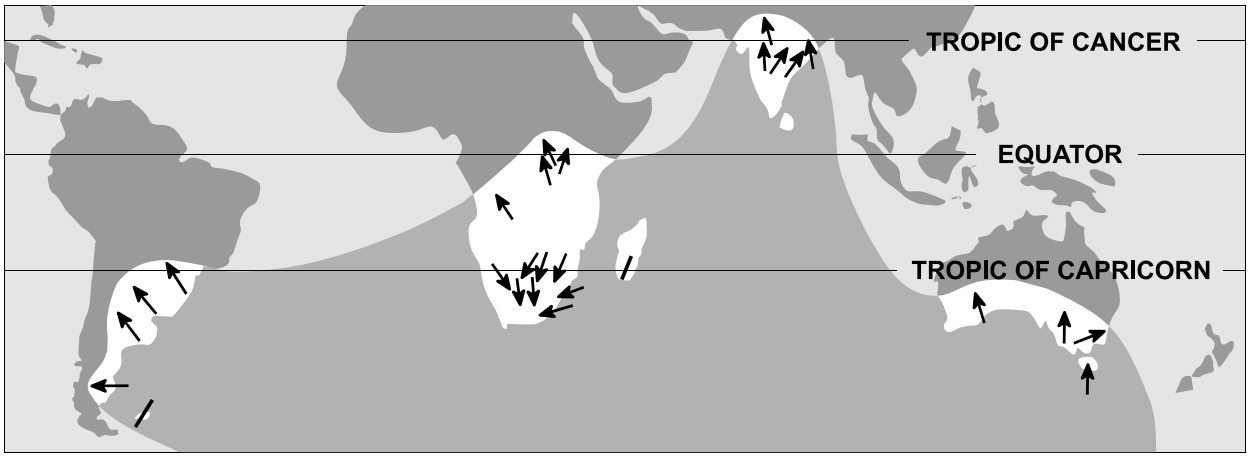
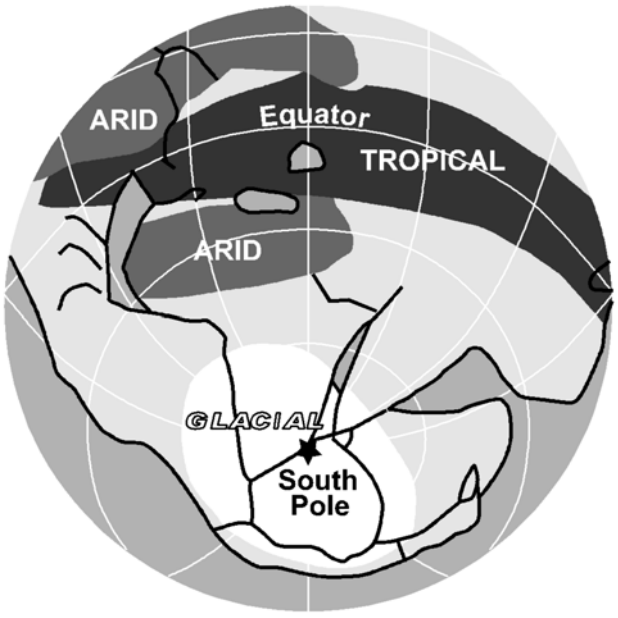


Figure i9.2 [9] *After* Wladimir Peter Köppen & Wegener's reconstruction in 1924 of a primordial continental assemblage in the Late Carboniferous. The heavy line is drawn to the outer edge of the continental shelves of continental blocks in the assemblage. Paleoclimatic zones for which he nad evidence are shown. Also shown is the extent of an ice sheet (provisionally for Antarctica) that known tillites record.



Today, the geology of Antarctica is almost entirely hidden by an ice sheet that was briefly absent 23 million years ago and had begun to accumulate 34 million years ago. Where the geology of Antarctica is exposed in the central Transantarctic Mountains, Victoria Land, and the Darwin Glacier region, modern studies find that Permian deposition in Antarctica occurred in ice-marginal, periglacial, glaciomarine, glaciolacustrine, and glacially influenced marine or lacustrine settings, and, for the Carboniferous, this map should be redrawn to show the area of Antarctica to be ice sheet free.[10]