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THE EFFECT OF LATE CARBONIFEROUS EARLY PERMIAN GLACIATION ON THE DISTRIBUTION OF CONODONTS IN AUSTRALIA

BY

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The Effect of Late Carboniferous-Early Permian Glaciation on the Distribution of Conodonts in Australia

by Robert S. Nicoll

ABSTRACT

Extensive sampling and examination of marine Permian rocks in Australia has so far failed to produce conodonts. Most of the samples are from the Sakmarian (Lower Permian) Callytharra Formation in the Carnarvon Basin of Western Australia, but samples from the Perth and Canning Basins of Western Australia, the Tasmania Basin of Tasmania, the Sydney Basin in New South Wales, the Bowen Basin in Queensland, and the Bonaparte Gulf Basin in the Northern Territory have also been examined.

The lack of conodont faunas in marine Permian rocks from Australia, in comparison to their relative abundance in both Carboniferous and Triassic rocks, is believed to result from climatic change caused by extensive glaciation of the area in Late Carboniferous and Early Permian. It seems probable that the lowered temperatures of marine water in the area were below the tolerance level of the conodont organism.

Extent of Australian Permian Conodont Sampling

A total of 340 samples, averaging 3 kg each, have been collected and processed for conodonts. In the Carnarvon Basin in Western Australia 312 Permian samples were collected: 263 from the Callytharra Formation and 49 from other units (Fig. 1). In the Perth Basin of Western Australia samples have been collected from the Fossil Cliff Formation (2 samples) and in the Canning Basin from the Noonkanbah Formation (4 samples). In the Bonaparte Gulf Basin in the Northern Territory two samples from the upper marine beds have been examined, but the dominant rocks are siltstone and sandstone, which are not likely to yield conodonts as are limestones.

From eastern Australia samples have been obtained from the Bowen Basin in Queensland (11 samples), the Sydney Basin in New South Wales, and the Tasmania Basin in Tasmania (2 samples) (see Figure 1). The Sydney Basin material was of marine clastic lithology, but the Queensland and Tasmania samples are mostly marine carbonates.

No Permian conodonts have been recovered and it is concluded that conodonts of this age are absent of exceedingly rare in the southernmost basins; i.e. Perth, Carnarvon, Canning, Sydney, and Tasmania. For reasons to be discussed below more samples from the Bonaparte Gulf and Bowen Basins are needed to extend this conclusion to all of Australia.

The absence of Permian conodont faunas in Australia needs to be explained. Both Early Carboniferous and Triassic conodont faunas have been reported from Australia, and during the Permain rocks of undoubted marine origin were deposited in several Australian Basins. The first point to be considered is the world-wide distribution of Permian conodonts.

World Permian Conodont Distribution

Clark and Behnken (1971) have reviewed Permian conodont distribution. With additions to their data conodonts are now known from the Permian of Germany, Greece, Italy, Poland, Greenland, the United States, the USSR, China, Thailand, India, Iran, Pakistan, and possibly Timor. Figures 2 and 3 show the known distribution of Permian and Triassic conodont localities plotted on paleogeographic reconstructions of these periods taken from Smith et al., 1973.

As can be seen in Figure 2, Early Permian conodont occurrences are found near to or north of the Permian equator. Sakmarian (Wolfcampian) occurrences are known only from the western United States (Clark and Behnken, 1971, p. 418) and Artinskian (Leonardian) occurrences are known from the western United States, Greece (Bender and Stoppel, 1965), and China (Ching, 1960).

Using the Smith et al. (1973) reconstruction this translates as a range from 50°N to 5°S of the Permian equator for the Early Permian localities.

Late Permian conodont distribution is much wider than that of the Early Permian and localities show a range of from 30°N to 40°S latitude. It is noted, however, that localities south of 10°S, i.e. those in Iran, Pakistan, India, and Timor, are of latest Permian age. This distribution compares with a range of from 60°N to 70°S latitude for Triassic conodonts (Fig. 3).

Therefore conodont distribution appears to have expanded gradually from the earliest Permian, when conodonts are restricted to western North America, to the Triassic, when conodont distribution was nearly worldwide.

In terms of the abundance of conodont taxa there is a similar expansion from the earliest Permian to the Triassic. Clark (1972, p. 154) held that as few as 1 or 2 apparatus taxa may have survived through the Early Permian, and these were represented in terms of form taxa by 7 or 8 element species. By the Triassic there are approximately 20 form genera representing numerous apparatus taxa.

Possible Factors Responsible for Permian Conodont Distribution

The factor responsible for both the latitudinal and taxonomic contraction of conodonts in the Early Permian and their expansion in the Late Permian and Triassic would seem to have been a major world wide environmental modification that reached its peak in the Late Carboniferous or Early Permian and was gradually ameliorated until by the Triassic climatic conditions were moderate on a worldwide scale.

Differences in the environment between the Permian and Triassic could have been caused by major modification of oceanic circulation patterns, but plate tectonic activity and hence continental boundaries, as expressed by

The initiation of glaciation in the Late Carboniferous (King, 1961, p. 315-320) corresponds to a dramatic decrease in conodont taxa (Clark, 1972, fig. 6). The period of maximum glaciation in the latest Carboniferous closely corresponds to a minimum distribution and abundance of conodonts in the earliest Permian. The gradual amelioration of the climate in the later Permian corresponds to a gradual expansion of conodonts. The equitable climatic conditions of the Triassic correspond to a marked period of conodont abundance worldwide. The conclusion is drawn that the conodont organism was adapted to warm temperate or tropical conditions and could not adapt to the rapid expansion of a cold climate in the Late Carboniferous.

In terms of Australian conodont distribution the implications of such a relationship between conodonts and climate would be as follows. During the Early Permian it is unlikely that conodonts would be found far south of the Permian equator; this would include Timor, New Guinea, Australia, and New Zealand. North of the equator, that is from Indonesia northward, conodonts might be expected in Lower Permian sediments unless the open Tethys sea cooled the southern shores of this region. By the latter part of the Late Permian warm temperate to tropical conditions had extended as far south as latitude 30°S and conodonts of this age might be expected in Timor, New Guinea, and possibly northernmost Australia in the Bonaparte Gulf and Bowen Basins. In the Triassic conodonts may be expected in all marine units.

Acknowledgements

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paleogeographic reconstructions, that would have caused or allowed such modification appear to have remained relatively unchanged between these periods (see Figs. 2 and 3).

Changes in climatic conditions appear to correspond closely to the changes in conodont distribution and taxa abundance. Schwarzbach (1961, p. 264-265), discussing late Paleozoic climates, held that areas in Europe and North America were warm and humid to dry from the Carboniferous through the Permian. These areas would lie near the Permian equator and extend northward.

King (1961, p. 315-327) in a discussion of Gondwanaland paleoclimate from the Carboniferous to Triassic drew the following climatic picture for the southern hemisphere. An area of glaciation that was centered on Antarctica and extended northward on the Gondwana land mass in South Africa, South America, India, and Australia developed in the latest Carboniferous. The initiation of glaciation took place in most areas by the Late Carboniferous and probably extended into the Early Permian. By the later part of the Early Permian a gradual warming trend was extending southward and by the Late Permian there is no indication of glaciation. King (1961, p. 325) ascribed a seasonal to warm temperate climate to the southernmost parts of Gondwanaland by the Triassic.

Dickins (1974) discussed paleontologic evidence for Permian climatic conditions and established a five-stage division of the Australian Permian. Dickins held that during the Sakmarian conditions of glaciation existed throughout Australia. By the uppermost Permian, Dickins (1974, fig. 6) noted that warm temperate to tropical conditions existed as far south as the Bonaparte Gulf Basin in the Northern Territory.

Summary and Conclusion

The climatic change observed in the southern hemisphere appears to correspond closely to changes in the distribution and abundance of conodonts.

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Figure 1. Correlation chart of selected Permian localities in Australia (after Dickins, in press). The number at the top of each section refers to its location on Figure 2. The number of samples processed from each unit is indicated by the number in parenthesis.

Figure 2. Paleogeographic map of the Permian (after Smith et al., 1973) showing world distribution of Permian conodont localities and the basins studied in Australia. Mercator projection.

= Early Permian, =. Late Permian, = both,

= Australian basins, number refers to stratigraphic columns of Figure 1.

Figure 3. Paleogeographic map of the Triassic (after Smith et al., 1973) showing world distribution of Triassic conodont localities. Mercator projection.

	URAL MTS & RUSSIAN PLATFORM	NORTHERN TERRITORY: *BONAPARTE GULF BASIN* 1	WESTERN AUSTRALIA: *CANNING BASIN* 2	WESTERN AUSTRALIA: *CARNARVON BASIN* 3	WESTERN AUSTRALIA: *PERTH BASIN* 4	TASMANIA: *TASMANIA BASIN* 5	NEW SOUTH WALES: *SYDNEY BASIN* 6	QUEENSLAND: *BOWEN BASIN* 7
UPPER PERMIAN	TATARIAN	? UPPER MARINE BEDS (2)	? LIVERINGA FM (HARDMAN MEMB)	?		CYGNET CM	ILLAWARRA CM	BLACKWATER GP
UPPER PERMIAN	KAZANIAN	MIDDLE PART WITH PLANTS	LIVERINGA FM (CONDREN MEMB)	KENNEDY GP: BINTHALYA FM MUNGADAN SST	? WAGINA SST ?	FERNTREE GP MALBINA E	SHOALHAVEN GP: GERRINGONG VOLCANICS BERRY FM (2) NOWRA SST	BLENHEIM SUB-GP (6)
LOWER PERMIAN	KUNGURIAN	LOWER MARINE PART (INCL BEDS AT FOSSIL HEAD)	LIVERINGA FM (LIGHTJACK & BALGO MEMBS) NOONKANBAH FM (4)	COOLKILYA GW (7) BYRO GP: MINILYA SUB-GP (18) NEWMAN SUB-GP (6)		MALBINA A-D	WANDRA-WANDIAN SLST ULLADULLA MDST	GEBBIE SUB-GP (INCL COLLINSVILLE CM) (2)
LOWER PERMIAN	ARTINSKIAN	SANDSTONE & SILTSTONE (SOME COAL)	POOLE SST (UPPER PART)	WOORAMEL GP (17)	CARYNGINIA FM (INCL MINGENEW FM) IRWIN RIVER CM HIGH CLIFF SST	GRANGE MDST (1) BERRIEDALE LST NASSAU SLTST	CONJOLA FM (5)	TIVERTON SUB-GP (2)
LOWER PERMIAN	SAKMARIAN	POSSIBLE GLACIGENE BEDS NEAR BASE	NURA NURA MEMB OF POOLE SST GRANT FM	CALLYTHARRA FM (263) LYONS GP (1)	FOSSIL CLIFF FM (2) HOLMWOOD SH NANGETTY FM	MERSEY GP BUNDELLA MDST DARLINGTON LST (1) QUAMBY GP	?	LIZZIE CREEK VOLCANICS (1)

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Fig I. Correlation chart of selected Permian localities in Australia. The number at the top of each section refers to its location on Fig 2. The number of samples processed from each unit is indicated by the number in parenthesis.

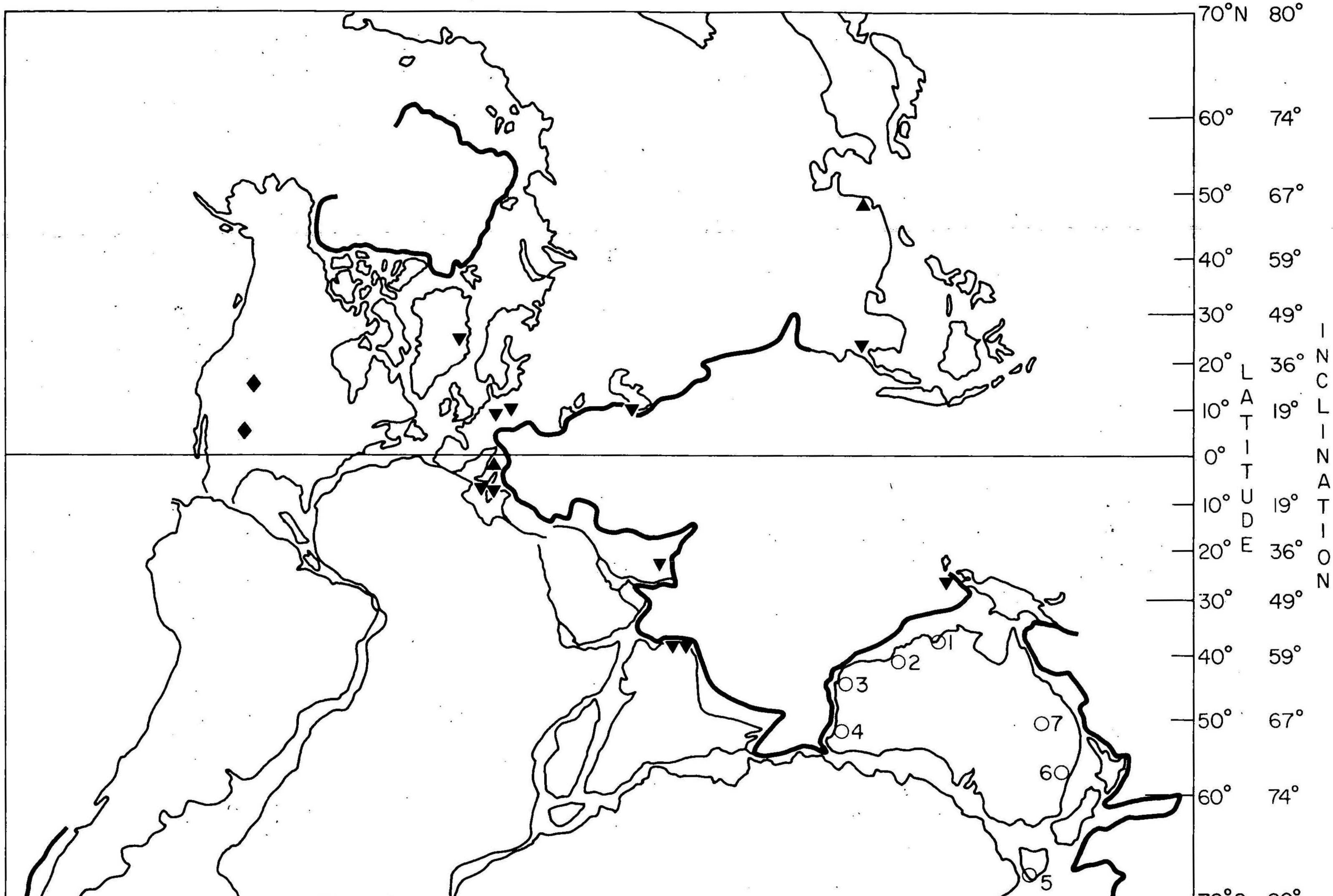

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Fig 2. Paleogeographic map of the Permian (after Smith et al, 1973) showing world distribution of Permian conodont localities and the basins studied in Australia. Mercator projection.

▲ *Lower Permian*

▼ *Upper Permian*

◆ *Lower and Upper Permian*

○6 *Australian basins (numbers refer to stratigraphic columns of Fig 1)*

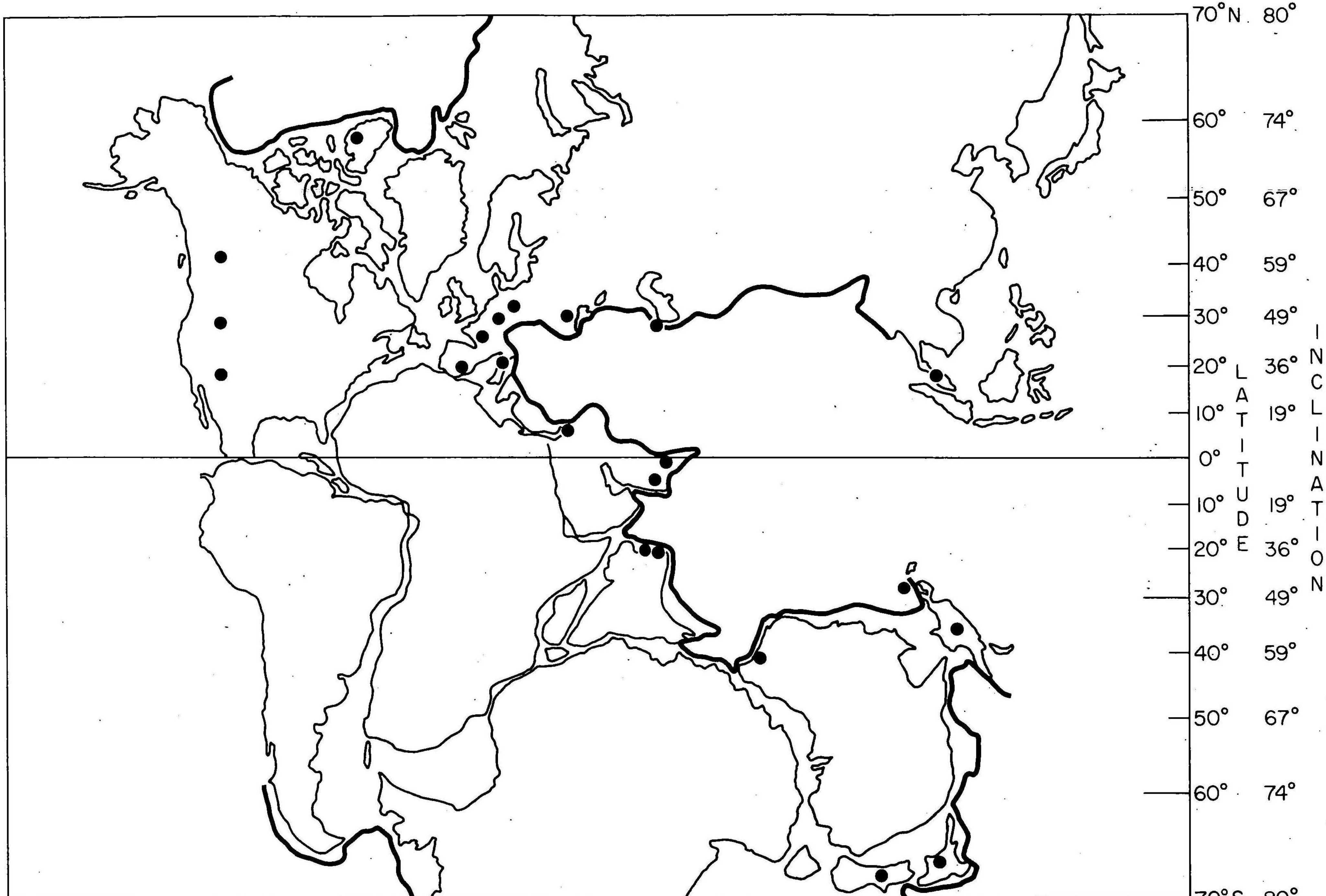

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Fig 3. Paleogeographic map of the Triassic (after Smith et al, 1973) showing world distribution of Triassic conodont localities. Mercator projection.

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