PALEOGEOGRAPHIC EVOLUTION OF THE ROSS SECTOR DURING THE CENOZOIC

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Abstract: The Cenozoic and perhaps latest Mesozoic history of the Ross Sector* was dominated by a major tectonic episode during which the Transantarctic Mountains and Ross embayment developed. A Transantarctic Passage between East and West Antarctica may have provided for a Pacific-Atlantic marine connection early in the history of the Victoria Orogeny. Both terrestrial and marine environments existed under early temperate and subsequent glacial climatic conditions.

1. Introduction

A more complete understanding of the structural evolution in the Transantarctic Mountains and Ross embayment regions has emerged following the deep stratigraphic sampling and associated geophysical studies undertaken during the Dry Valley Drilling Project (Sites 1–15), Deep Sea Drilling Project (Leg 28, Sites 270–273) and Ross Ice Shelf Project (Site J9) (Fig. 1). Information gained from surface studies and drilling provides a new body of information on the long terrestrial and significantly shorter marine histories of the Transantarctic Mountains and the dominantly marine history of the Ross embayment. Much of the stratigraphic record for both areas has been destroyed by relatively recent erosion (<5 m.y.) caused by grounded ice shelves and ice sheets. Nevertheless, even these destructive events are useful in deciphering a multiple glacial history.

2. Early Investigations and Hypotheses

The recognition of major block-faulting, the delineation of the *Antarctic Horst* and the possible existence of a present day marine graben (Senkungsfeld) connection between the Ross and Weddell Seas were among the major topics discussed in early publications on the structural geology of the Ross Sector (FERRAR, 1907; PRIESTLEY and DAVID, 1912; GREGORY, 1912; DAVID and PRIESTLEY, 1914; TAYLOR,

* As used herein, the term Ross Sector refers to an area which includes the Transantarctic Mountains (535000 km^2), the Ross Sea shallower than 1000 m (439000 km^2), and the Ross Ice Shelf (540000 km^2). The Ross Sector has a total area of approximately 1.5 million km^2, an area about the size of Alaska or the combined areas of Great Britain, the Netherlands, Belgium, France, Spain and Portugal.

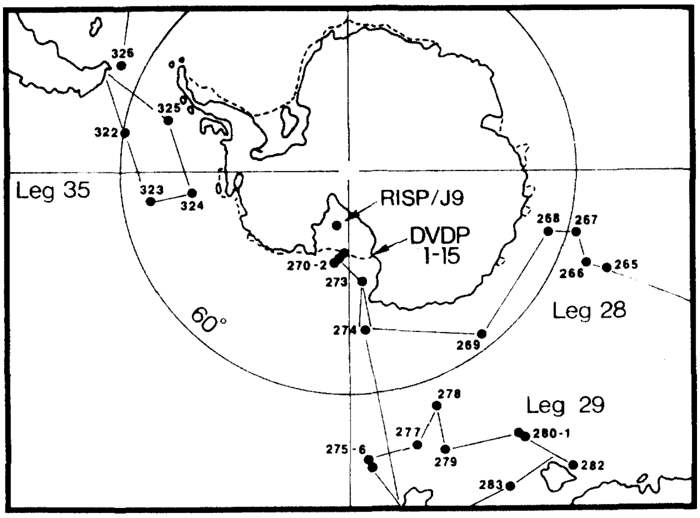

Fig. 1. Location of Deep Sea Drilling Project, Dry Valley Drilling Project, and Ross Ice Shelf Drilling Project drillsites in and around Antarctica.

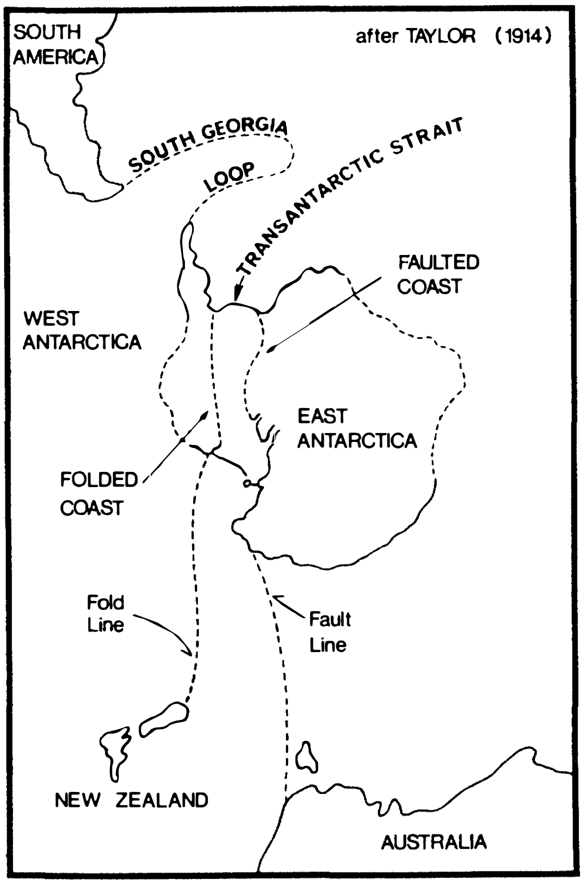

Fig. 2. Position of proposed Transantarctic Strait, redrawn from TAYLOR *(1914).*

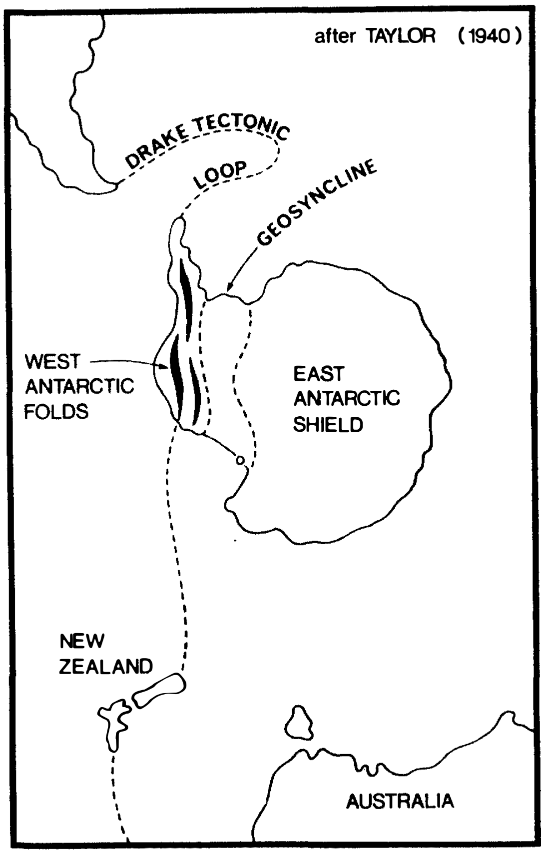

Fig. 3. Suggested position of a geosyncline linking the Ross and Weddell Seas, redrawn from TAYLOR *(1940).*

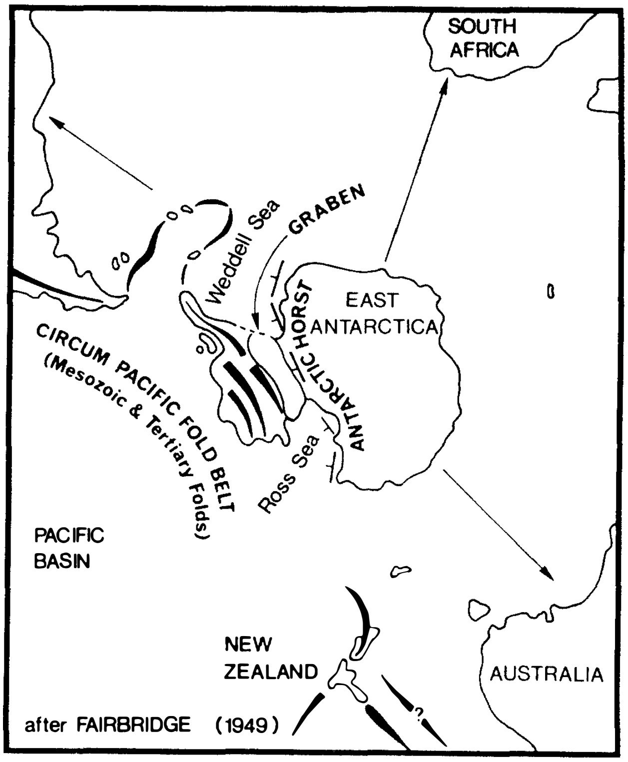

Fig. 4. Geotectonic map of Antarctica, redrawn from FAIRBRIDGE (1949).

1914; GOULD, 1935; TAYLOR, 1940; FAIRBRIDGE, 1952) (Figs. 2, 3, 4). The existence and fault style of the Transantarctic Mountains (*Antarctic Horst* of DAVID) is generally accepted today but geophysical studies suggest that a wide and direct marine connection (*strait* of TAYLOR) between the *present day* Ross and Weddell Seas does not exist (BENTLEY, 1972).

It is clearly apparent that the elevation of the Transantarctic Mountains and depression of the Ross embayment are closely related events. However, up until very recently investigations of the two areas have been practically divorced from each other. Most effort has been concentrated in the uplifted areas. Most investigators of structural problems in this area subscribe to the belief that the elevation of the Transantarctic Mountains is a Tertiary event. Although probably correct, little concrete evidence has been cited in support of this proposition. Mountain building in pre-glacial times, meaning pre-Pleistocene in older literature, has been proposed. Uplift is also said to have resulted from isostatic adjustment following the recession of ice load. Volcanic eruptions centered on or close to major faults were cited as evidence in favor of Tertiary uplift. However, similarity to well-dated volcanic suites in other continents rather than absolute age obtained from McMurdo volcanic group rocks were used in assigning volcanism and concomitant tectonism to the

Tertiary. Absolute ages from Ross Sector volcanic rocks are mostly late Miocene or younger. Major faulting and orogeny, although probably active in the Late Miocene, was certainly well underway in early and pre-Miocene times. GUNN and WARREN (1962) proposed the name *Victoria Orogeny* for the uplift of the Transantarctic Mountains and suggested an upper Tertiary to Quaternary time span. This name should be retained but with temporal and geographic limits expanded to include Cenozoic and even late Mesozoic crustal movements in both the montane areas and the Ross embayment.

3. Recent Investigations

It is now known from micropaleontological and sedimentological evidence that parts of the Transantarctic Mountains and Ross embayment exhibit contrasting and opposite histories. Successions located on the coastal edge of the Taylor Valley

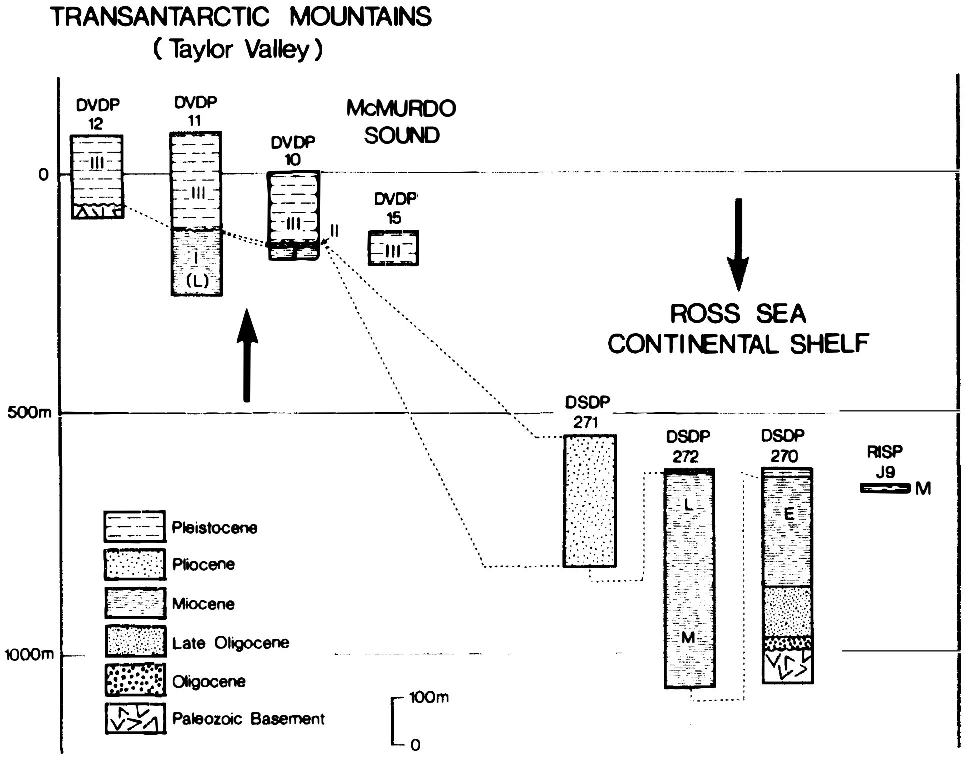

Fig. 5. Cenozoic drillhole successions from the central Transantarctic Mountains and southern Ross Sea. Successions are plotted against present sea level. Successions from the two areas are separated by major faulting. Successions in theTransantarctic Mountains show evidence of shallowing upwards (regression); those from the Ross embayment display deepening upwards (transgression). In the DVDP drillholes, roman numerals I-III refer to foraminiferal zones proposed by WEBB and WRENN (1979). Letters E, M, L refer to early, middle and late Miocene.

uplifted block (DVDP 8–11) exhibit marked shallowing between the Late Miocene and Pleistocene from inner bathyal to littoral depths (WEBB and WRENN, 1979; WRENN and WEBB, 1979) (Figs. 5, 6). Progressive shallowing and eventual regression of marine waters from Taylor Valley was interpreted as evidence in favor of crustal uplift over the past 5 m.y. An even earlier record of bathymetric variation can be obtained by deeper drilling in eastern Taylor Valley. Over four hundred kilometers east of Taylor Valley, at DSDP Sites 270–272, a sedimentary succession totalling more than 1100 m passes upward from supralittoral Oligocene to inner bathyal Miocene and Pliocene (WEBB in HAYS *et al.*, 1975, p. 226) (Figs. 5, 6). Progressive deepening or transgression by marine waters over crystalline basement at Site 270 was interpreted as evidence in favor of crustal depression. Major vertical displacements have occurred between the uplifted Transantarctic Mountain block and downthrown Ross embayment block in the areas discussed. Displacement probably occurred on the major fault which follows the Victoria Land coast at latitude 77°S. Displacements involving several thousands of meters have also been reported along the eastern side of the Transantarctic Mountains by BARRETT (1965) and WONG

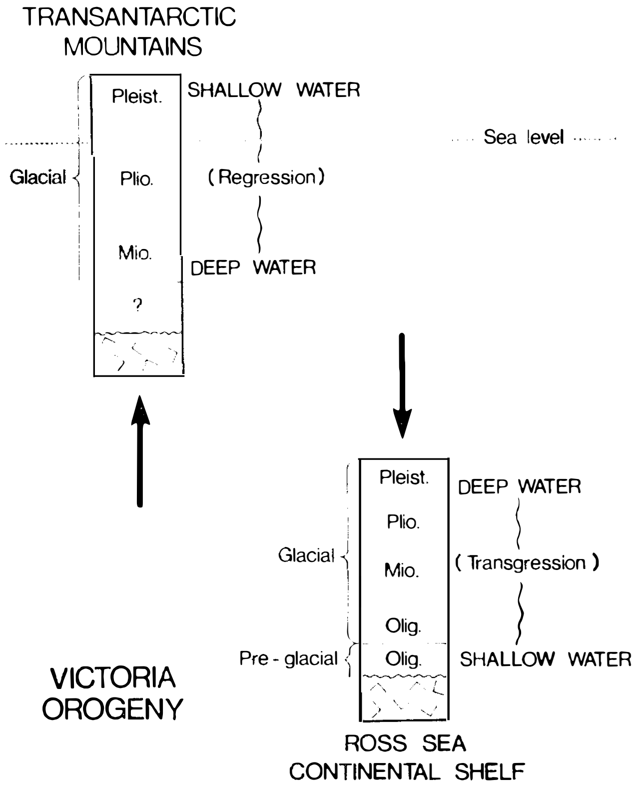

Fig. 6. Schematic representation of successions shown in Fig. 5, emphasizing regressions and uplift in the Transantarctic Mountains and transgression and depression in the Ross Sea embayment.

and CHRISTOFFEL (1978). Further detailed biostratigraphic investigation coupled with further drilling should allow more accurate pinpointing of active and quiescent periods during the span of the Victoria Orogeny.

We might expect a situation where the locus of uplift or depression shifts geographically during the life of the orogeny. Rapid lateral shifts of sediment thicknesses, local biofacies, significant disconformities etc. are to be anticipated in the Ross embayment if local tectonism and basin formation prevailed.

Leg 28 (DSDP) results show that a bathyal bathymetry occurred over part of the Ross embayment in the mid Miocene (HAYS *et al.,* 1975). The discovery of bathyal mid Miocene sediments at RISP Site J9, 450 km south of Site 270, greatly enlarges the geographic extent of this marine basin. Bathyal-depth pre-Miocene sediments are not yet known from the Ross embayment but could well be present. The southernmost extent of deepwater mid Cenozoic sediments is a major question at this time. While the existence of a major present day Ross-Weddell connection is no longer likely, the possibility of a major Cenozoic connection between the two areas cannot be discounted. If such a *Transantarctic Passage* did exist in the early and mid Cenozoic it would provide an important link between two major oceans. A circum East Antarctic ocean current might well have followed this passage providing a dispersal avenue for both high latitude pelagic and benthic biota. The opening of the Drake Passage around 20 m.y. ago might be expected to affect the current flow and distribution of biota via a Transantarctic Passage. The significance of such a seaway would certainly have diminished with the growth of ice sheets and thick floating and grounded ice shelves on and between East and West Antarctica, late in the Cenozoic.

4. Concluding Remarks and Acknowledgments

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