The Ross Orogen of the Transantarctic Mountains in Light of the Laurentia-Gondwana Split

Edmund Stump
Department of Geology, Arizona State University, Tempe, AZ 85287

ABSTRACT
The recent hypothesis that the margins of the western United States and Antarctica were conjugate prior to the breakup of Laurentia from Gondwana is consistent with the record of events in the late Proterozoic-early Paleozoic Ross orogen of the Transantarctic Mountains. Isotopic data indicate that basement to the Ross orogen is 2.0–1.7 Ga continental crust, temporarily matching basement in the southwestern United States. The onset of activity in the Ross orogen was late Proterozoic basin development with widespread deposition of turbidites. Rifting within this basin is indicated by bimodal volcanism dated at ~750 Ma, coincident with volcanism in the basai Windermere Supergroup in North America. Actual separation is presumed to have occurred shortly before accumulation of Early Cambrian platform carbonates on the margins of both continents. Subsequent to this, the histories of the two margins evolved independently. Limited data indicate that plutonism had begun in the Ross orogen by ~550 Ma. By the Middle Cambrian an association of carbonates and bimodal volcanics was accumulating outboard of the Early Cambrian carbonate platform. Deformation, metamorphism, and voluminous plutonism culminated during the Late Cambrian with cooling ages ~500 Ma. This activity, recorded throughout widespread parts of Gondwana, occurred while the western margin of Laurentia remained passive.

INTRODUCTION
Marking the boundary between East and West Antarctica, the Transantarctic Mountains are a major intracratonic chain that extends for 3500 km across Antarctica, reaching heights >4000 m (Fig. 1). The interior or plateau flank of the Transantarctic Mountains dams the East Antarctic Ice Sheet; the front of the range rises with spectacular escarpments from the Ross and Weddell embayments and the intervening West Antarctic Ice Sheet. The present-day mountains have undergone episodic uplift since the early Cretaceous (Stump and Fitzgerald, 1992) and have been modeled as a major rift shoulder structure (Fitzgerald et al., 1986; Stern and ten Brink, 1989). The unifying geological feature of the mountains is a middle Paleozoic erosion surface (Kukul pesekan) that separates gently tilted, Devonian to Triassic sedimentary rocks (Beacon Supergroup) and Jurassic continental shelf limestones (Ferrar Group) from a Proterozoic to early Paleozoic orogenic belt (Ross orogen) (see photographs). The recent hypothesis (SWEAT) by Moores (1991), amplified by Dalliel (1991) and Hoffman (1991), that the western United States was contiguous with Antarctica during the Proterozoic, with subsequent rifting and continental drift, provides a powerful framework for interpretation of the geological history of the Ross orogen of the Transantarctic Mountains.

On a local scale, mapping in these mountains is similar to the Basin and Range, in that very good outcrops are separated by expanses of cover (ice or alluvium). On a continental scale, however, the breadth of the Transantarctic Mountains is narrow (300-0 km) compared to the Cordillera, so the spatial...
The Ross Orogen of the Transantarctic Mountains in Light of the Laurentia-Gondwana Split  
Congressional Science Fellowship  
GeoVentures 1992  
GSF Update  
Washington Report  
Penrose Conference Report  
SAGE Remarks  
In Memoriam  
GS Employment Service  
Final Announcement: Collierean Sections  
Final Announcement: Rocky Mountain Section  
Memorial Preprints  
Penrose Conference  
Meetings Calendar  
GS Bulletin and Geology Contents  
DNAG News  
Classifieds  
John C. Frye Award  

In This Issue  
Ross Orogen continued from p. 25  
record of the Ross orogen is incomplete, and the continued details of these stratigraphic sequences along the mountain is not observable. Nevertheless, the present-day Transantarctic Mountains appear to follow closely the axis of the Ross orogen, with younger ac- companied and affected blocks conserving West Antarctic, and Protoreozoic and Archean cratonic rocks making up the outcropping the periphery of East Antarctica, and presumably the crust beneath the East Antarctic Ice Sheet. A long-term view of the record of the Ross orogen is that it developed as a pассивan continental margin that was affected by a series of transcurrent episodes (e.g., the last several million years)—the first in the Late Proterozoic (Beardmore orogeny), and the latter in Cambrian-Ondytician time (Ross orogeny). How the passive margin origin- nated was not directly considered. The interaction of the tin- ing and extent of the Beardmore orogen- 

GEOLIGIC HISTORY  
Sm-Nd model ages from granitic rocks in northern Victoria Land and the western Transantarctic Mountains suggest that continental crust of Early Proterozoic age (2.0–1.7 Ga) underlies most of the Wisconsinan craton range (Borg, et al., 1990; Borg and DePaolo, 1991). The same technique indicates that much of the Columbia in the southwestern United States is underlain by rocks of similar age (Bennett and DePaolo, 1987). A Proterozoic fore- continent with these two areas matched is supported by these data. Direct links of age provinces may be difficult, however, for both Borg and DePaolo (1991) point out, fragments may have been displaced obliquely along the margins during the breakup.  

The one place in the Transantarctic Mountains where Early Proterozoic age rocks are known is in the Miller Geologic Group. In this area a variety of multiply deformed, high-grade metamorphic rocks (Nimrod Group) are contained by quartz-  

ADVERTISING  
Classifieds and display contact: Ann Crawford (303) 447-2020; fax 303-947-1133  
Printed in the U.S.A.
The Geological Society of America

Congressional Science Fellowship 1992-1993

The Geological Society of America is accepting applications for the 1992-1993 Congressional Science Fellowship. The Fellow selected will spend a year (September 1992-August 1993) in the office of a member of Congress or a congressional committee. The program provides an opportunity to gain a better understanding of science and technology issues facing Congress and to advise on a wide range of scientific issues as they pertain to public policy questions. The American Association for the Advancement of Science coordinates the program and assists the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

Criteria

The program is open to highly qualified earth scientists in early or mid-career. Candidates should have exceptional competence in some area of the earth sciences, cognizance of a broad range of matters outside the Fellow's particular area, and a strong interest in working on a range of public policy problems.

Award

The GSA Congressional Science Fellowship carries with it a $38,000 stipend, and limited health insurance, relocation, and travel allowances. The fellowship is funded by GSA and by a grant from the U.S. Geological Survey. (Employees of the USGS are ineligible to apply for this fellowship.)

To Apply

Procedures for application and detailed requirements are available in the geology departments of most colleges and universities in the United States or upon request from: Executive Director, Geological Society of America, P.O. Box 9146, Boulder, CO 80307.

DEADLINE FOR RECEIPT OF ALL APPLICATION MATERIALS IS FEBRUARY 15, 1992

The Association for Women Geoscientists Offers Funds To Finish Theses

The Association for Women Geoscientists will award three Chrysalis Scholarships on March 31, 1992. The $500 awards will be given to geo-

science Masters or Ph.D. candidates to cover expenses associated with finishing their theses. The Chrysalis Scholarship, which is open to students who have returned to school after an interruption in their education of a year or longer, the support can be used for typing or drafting expenses, child care, or anything necessary to allow a degree candidate to finish her thesis and enter a geoscience profession.

Applications should be made by February 28, 1992. The applicant should write a letter stating her background, career goals and objectives, how she will use the money, and an explanation of the length and nature of the interruption in her education. The applicant should also submit two letters of reference. The first, from her thesis advisor, should indicate when the candidate will finish her degree, what requirements are yet unfinished, and a statement of the candidate’s prospects for future contributions to the geosciences.

For information on obtaining an application or for additional information, please contact: Chrysallis Scholarship, Association for Women Geosci-

entists Foundation, Macalester College Geology Dept., 1600 Grand

Ross Orogen continued from p. 27

arenites, but the predominant lithology is a bimodal suite of volcanics with voluminous rhyolites and lesser basalts (Stump, 1983). This volcanic activity may represent lingering extensional effects of the breakup located in outer parts of the Antarctic continental margin (Dalziel, 1991).

Northern Victoria Land is composed principally of three terranes, of which the eastern two (Bowers and Robertson Bay) are allochthonous and were emplaced after or during the late stages of the Ross orogeny (e.g., Bradshaw et al., 1985; Gibson and Wright, 1985; Klettenschmidt and Tonnessen, 1987). The western, autochthonous Wilson terrane is underlain by schists and gneisses (Wilson and Lancaster metamorphics, Priestley Schist) whose protoliths were mainly graywacke and shale, with some calcareous and argillaceous rocks. For the most part, these rocks are multiply deformed and metamorphosed during the prograde metamorphic episode to amphibolite facies (Klein-Schmidt and Skinner, 1981). The majority of the K-Ar and Rb-Sr mineral dates from the Wilson terrane are between 500 and 470 Ma, typical of cooling following the Ross orogeny (Kreuzer et al., 1987). Limited Rb-Sr, whole-rock isochron dates indicate that metamorphism may have begun in places as early as 550 Ma (Adams and Hörndorf, 1991), and protoliths of minor, clast-supported organic fragments from the Priestley Formation indicates a post-Precambrian age (Lombardo et al., 1989). The metamorphosed rocks of the Wilson terrane may be Proterozoic, Early Cambrian, or both, and may straddle or postdate the continental breakup. In South Australia, by comparison, Late Proterozoic Adelaidean shelf sedimentary strata are followed by turbidites of the Early Cambrian Kankammato Group (von der Borch, 1980). Apparently, the depositional history in northern Victoria Land following the breakup was quite different from that recorded throughout the rest of the Transantarctic Mountains.

The passive or extensional continental margin changed to one of subduction with resultant compressive deformation, metamorphism, and magmatism of the Ross orogeny. The simplistic view of a Cambrian-Oydivian episode that began with folding of Early and Middle Cambrian sedimentary rocks and ended with cooling of metamorphic and plutonic rocks around 510-470 Ma has been expanded by ongoing research to recognize multiple tectonic events, manifested either locally or throughout the Transantarctic Mountains.

The onset of activity is difficult to place. Age determinations on several plutonic rocks from northern and southern Victoria Land are older than most throughout the Ross orogeny, including the Sturgeon Island granodiorite (599 ± 21 Ma; Rb-Sr, whole-rock isochron; Yorke et al., 1984), deformed, plutonic rocks of the Wilson terrane (544 ± 14 Ma, U-Pb, zircon; Black and Stennett, 1990), the Canton island granodiorite (568 ± 10 Ma; Rb-Sr, whole-rock isochron; Felder and Faure, 1980), and a granite intruding the Skelton Group (550 ± 14 Ma; U-Pb, zircon; Rowell et al., 1993). Whether one uses the Harland et al. (1990) time scale, with the Cambrian-Precambrian boundary at 570 Ma, or that of Oddie et al. (1983), with the boundary at 530 Ma, it would appear that plutonic activity had begun in parts of the orogen before deposition of Early Cambrian Shackleton Limestone. Deformation took various forms throughout the Transantarctic Mountains. A major shear zone in the Proterozoic Nimrod Group of the Miller and Geologists ranges has long been recognized; thrusting is thought to have occurred during the Early to Middle Proterozoic formation of the metamorphic rocks (Grindley, 1972). Goode et al. (1991) demonstrated a considerably oblique component to the movement with a lateral shear sense trend of the shear zone consistent with deformation during the Early to Middle Proterozoic. The shear zone is the most developed in the quartzite unit of the Nimrod Group (Jantjia and Rees, 1991), the unit with nonmetamorphic deformation of the Shackleton and Woodford Groups and its sedimentary facies are consistent with deformation in the lower lying Goldie Formation, the tectonic character of most, if not all, of the observed contacts between the Goldie and the Shackleton, and the geometry and style of folds indicates a foreland fold and thrust belt.

Thrust faulting has been identified at two places in the Transantarctic Mountains. In the Duncan Mountains, formation of the Foredeep is thrust over the Foreland (Stump, 1981). Traditionally, Duncan Formation has been correlated with Beacon Supergroup to the south and yet it is clear that this unit could represent a Cambrian slope sequence deposited outboard of the inner shelf during the Late Proterozoic (Liv Group, and later thrust upon it. At the head of Scott Glacier, La Corogne Formation is thrust over Early to Middle Proterozoic rocks (Stump and Fitzgerald, 1998). In the Pensacola Mountains, Middle Cambrian Nelson Limestone is thrust over Ordovician siliciclastic (Gambarotta Formation) to form a feature reminiscent of the Foreland. In the central Scott Glacier area, a right-lateral, strike-slip fault has juxtaposed La Corogne and Watson Formation rocks (Stump and Fitzgerald, 1988).

In the Pensacola Mountains, Middle Cambrian Nelson Limestone is thrust over Ordovician siliciclastic (Gambarotta Formation) to form a feature reminiscent of the Foreland. In the central Scott Glacier area, a right-lateral, strike-slip fault has juxtaposed La Corogne and Watson Formation rocks (Stump and Fitzgerald, 1988).

Regardless of the structural variations along the Transantarctic Mountains, a tremendous pulse of magmatism ended the Ross orogeny (e.g., Bogg et al., 1987). K-Ar and Rb-Sr dates are long between 510 and 470 Ma (Shuver and Branzatun, 1985). As research on these mountains continues, it may be useful to subdivide the Ross orogeny, as has been done for orogenic episodes in the Cordillera Blanca, as has become increasingly apparent that its evolution was complex and varied in both space and time. The history of the Ross orogen spans the breakup of Laurentia from Gondwana, the period of extension and collision, the opening of the Drake Passage and the aftermath of the event.

PANNOTIOS TECTONISM

The Ross orogeny of the Transantarctic Mountains is the Delamarian orogeny of Australia (Ruttland et al., 1981). It is the Pan-African of Africa.