

Fission-track investigations of lithotectonic history: Northern Victoria Land, 1993

T.F. REDFIELD, *Department of Geology, Arizona State University, Tempe, Arizona 85287-1404*

P.G. FITZGERALD, *Department of Geosciences, University of Arizona, Tucson, Arizona 85721*

M. ROBERTS, *Southern Alps Guiding, Mount Cook, South Island, New Zealand*

Fission-track data in the Transantarctic Mountains show that the uplift/denudation history of the range has been episodic. Separate events have been resolved at approximately 115 million years, approximately 85 million years, and approximately 55 million years (Gleadow and Fitzgerald 1987). In northern Victoria Land, a reconnaissance fission-track study (Fitzgerald and Gleadow 1988) determined that the uplift/denudation responsible for the formation of the Transantarctic Mountains there began in the early Cenozoic approximately 55 million years ago. During the 1991–1992 field season, our field party collected fission-track samples from northern Victoria Land to identify the presence or absence of an older uplift/denudation event (Fitzgerald et al., *Antarctic Journal*, in this issue). Severe weather and logistical problems precluded a sampling effort beyond our primary objective, Mount Adam [4,010 meters (m)]. During the latter third of the 1992–1993 field season, we were able to use the U.S. Coast Guard cutter *Polar Sea* to conduct helicopter-supported fission-track sampling traverses near Terra Nova Bay, to enlarge our database and link existing data from southern Victoria Land and northern Victoria Land. (See figure 1.)

During the fifth and sixth German Antarctic North Victoria Land EXpeditions (GANOVEX), collected gravity data revealed a large coast-parallel bouguer gravity gradient (Redfield and Behrendt 1992), similar to the gradient discovered by Smithson (1972). Redfield and Behrendt (1992) postulated that the coastal anomaly, of approximately 100 milliGals (mgal) amplitude, stems from a deep-seated structural discontinuity. Using a U.S. Geological Survey gravity meter, borrowed from the corridor aerogeophysics of southeast the Ross transect zone (CASERTZ) field party, we took the opportunity provided by the *Polar Sea* cruise to complete the 1992 coastal gravity transect. These data, combined with apatite fission-track dates from the coastal gravity sites, will help us constrain the overall crustal structure of the Transantarctic Mountains.

Between 21 and 27 January 1993, the *Polar Sea* was dedicated to the fission-track sampling program. During the sea voyage to and from Terra Nova Bay, with helicopter support, gravity measurements and fission-track samples were collected at coastal outcrops approximately 15 kilometers (km) apart. Elevations were determined barometrically. To minimize elevation errors and best constrain gravity terrain corrections, sites were chosen at or near sea level, with as little topography as possible. To minimize ice-thickness uncertainties (and to permit fission-track sampling!) gravity measurements were made on rock outcrops. During the correction

procedures, mass deficiencies caused by adjacent ocean basins and glaciers were estimated using models similar to those presented by Kienle, Redfield, and Goodliffe (1992). Two known gravity base stations (McMurdo Station and Gondwana Station) were measured during the survey. The gravity meter (LaCoste and Romberg G-191) behaved well, drift was negligible, and power was easily maintained. Gravity data are presented in figure 2.

Upon arrival at Terra Nova Bay, two vertical fission-track profiles were obtained. After a helicopter emplacement at the

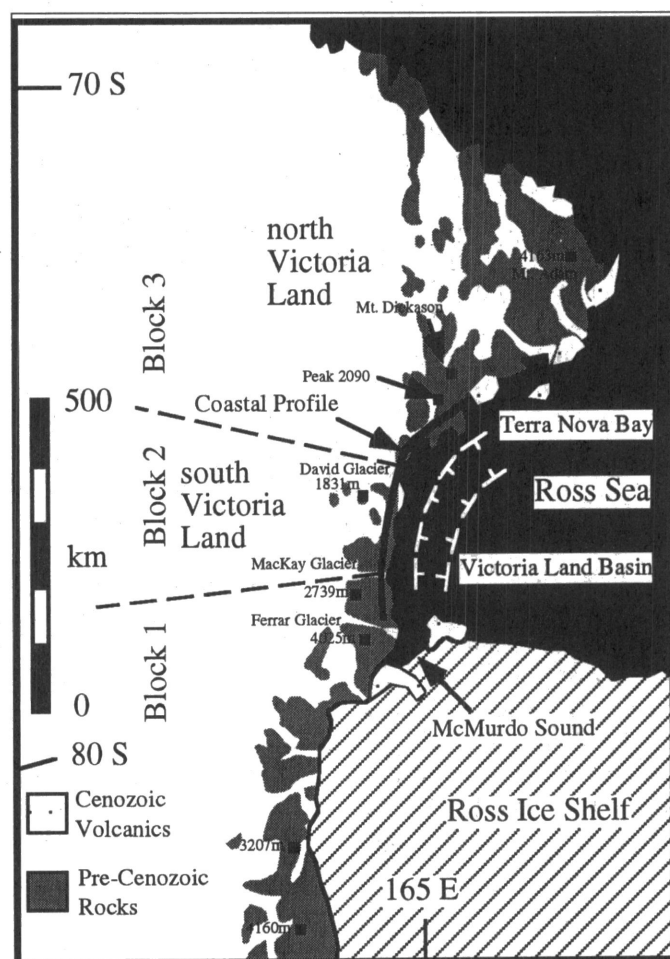


Figure 1. Location map showing the area of the Transantarctic Mountains studied by Redfield, Fitzgerald, and Roberts during the latter portion of the 1992–1993 season. The location of the coast-parallel gravity and fission-track profiles is shown with a heavy line. Dashed lines schematically show our division of the Transantarctic Mountains north of McMurdo Sound into three crustal blocks.

Station	Mgal	Elevation (m)	Dec. Lat.	Dec. Long.	Ob Grav	IGF Grav	Free Air Anomaly	Bouguer Anomaly
McMurdo 57	6627.91	35	77.85	166.67	982973	982987	-3	-7
Cape Bernacchi	6608.60	5	77.50	163.85	982953	982974	-19	-19
Dunlop Island	6586.18	5	77.24	163.52	982931	982964	-31	-32
Cape Roberts	6560.52	0	77.04	163.18	982905	982956	-50	-50
Cape Ross	6534.75	30	76.73	163.01	982880	982943	-55	-58
Tripp Island	6506.66	15	76.63	162.72	982851	982939	-83	-85
Starr Nunatak	6461.29	200	75.90	162.92	982806	982909	-41	-63
Cape Hickey	6510.30	5	76.08	162.72	982855	982916	-60	-60
Cape Day	6514.67	5	76.30	162.72	982859	982926	-65	-65
McMurdo 57	6627.68	35	77.85	166.67	982972	982987	-4	-8
982972.72	McMurdo 57 gravity value							

Figure 2. Table showing reduced gravity data collected between McMurdo Sound and Terra Nova Bay.

summit of Peak 2090, eight samples were collected during a 1,500-m descent on foot. Weather conditions and technical considerations precluded greater sampling density and entailed an unscheduled camp. The second vertical profile, obtained 24 January 1993 with helicopter support between the Gondwana Station (0 m) and near Mount Dickason (1,850 m), also consists of eight samples. This profile may be affected by intervening structures postdating apatite fission-track retention. If so, we may be able to place constraints upon local tectonic offsets (see, for example, Fitzgerald 1992) through direct comparison with the Peak 2090 profile.

Based on gravity data, Redfield and Behrendt (1992) suggested that the Transantarctic Mountains may be broken into discrete tectonic blocks between northern Victoria Land and McMurdo Station, placing a major crustal break at about the latitude of the Drygalski Ice Tongue. Fitzgerald (1992) postulated that the MaKay Glacier also may harbor a large range-transverse structure. Gravity and flexural modeling (Redfield, Grimm, and Fitzgerald in preparation), using gravity data from Smithson (1972), Robinson and Spletstoesser (1984), Redfield and Behrendt (1992), Kienle et al., (1992), and the 1992–1993 field season, suggests that the Transantarctic Mountains may be supported by a crustal root, held in suppression by the east antarctic elastic lithosphere. The crustal blocks constituting the Transantarctic Mountains may operate on a semi-independent basis, each block upwarped and supported by a local crustal root. This flexural isostasy, and the consequent lithospheric rigidity, may possibly be what has maintained the aseismic Transantarctic Mountains in the absence of lateral buttressing in an actively extensional environment for at least 55 million years.

We thank the crews of the U.S. Coast Guard cutter *Polar Sea* and the Aviation Deck for outstanding logistical support. Redfield thanks the U.S. Geological Survey for the loan of LaCoste and Romberg gravity meter G-191 during the

1992–1993 field season. This work was supported by National Science Foundation grant OPP 91-17441.

References

- Fitzgerald, P.G. 1992. The Transantarctic Mountains of southern Victoria Land: The application of apatite fission track analysis to a rift shoulder uplift. *Tectonics*, 11(3), 634-662.
- Fitzgerald, P.G., and A.J.W. Gleadow. 1988. Fission track geochronology, tectonics, and structure of the Transantarctic Mountains in northern Victoria Land, Antarctica. In *Chemical geology* (Vol. 73, isotope geoscience section). Amsterdam: Elsevier Science Publishers.
- Fitzgerald, P.G., T.F. Redfield, P.M. Goldstrand, and C. Hobbs. 1993. Geologic and fission track studies in the Heritage Range, Ellsworth Mountains, and nunataks of West Antarctica. *Antarctic Journal of the U.S.*, 28(5).
- Gleadow, A.J.W., and P.G. Fitzgerald. 1987. Uplift history and structure of the Transantarctic Mountains: New evidence from apatite fission track dating of basement apatites in the Dry Valleys area, southern Victoria Land. *Earth and Planetary Science Letters*, 82, 1–4.
- Kienle, J., T. Redfield, and A. Goodliffe. 1992. Gravity study of the Mt. Melbourne Quadrangle and the lower Rennick Glacier area in north Victoria Land, Antarctica, and the relation of the Rennick Graben structure to rifting processes in the Ross Sea. In Y. Yoshida, K. Kaminuma, and K. Shiraishi (Eds.), *Recent progress in antarctic earth science*. Tokyo: Terra Scientific.
- Redfield, T.F., and J.C. Behrendt. 1992. Preliminary gravity modelling across the Transantarctic Mountains. In Y. Yoshida, K. Kaminuma, and K. Shiraishi (Eds.), *Recent progress in antarctic earth science*. Tokyo: Terra Scientific.
- Redfield, T.F., R.E. Grimm, and P.G. Fitzgerald. In preparation. The Transantarctic Mountains and the breakup of Gondwana underplating, uplift, and flexural suppression. *Geology*.
- Robinson, E.S., and J.F. Spletstoesser. 1984. Structure of the Transantarctic Mountains determined from geophysical surveys. In M. Turner and J. Spletstoesser (Eds.), *Geology of the central Transantarctic Mountains* (Antarctic Research Series, Vol. 36). Washington, D.C.: American Geophysical Union.
- Smithson, S.B. 1972. Gravity interpretation in the Transantarctic Mountains near McMurdo Sound, Antarctica. *Geological Society of America Bulletin*, 83, 3437–3442.