200,000 years are obviously affected to a lesser degree than younger samples containing a lower proportion of radiogenic argon ($^{40}Ar^*$) to excess argon ($^{40}Ar_E$) and are, therefore, taken to be a truer representation of the actual age of that particular sample. Still, it must be noted that all the $^{40}Ar/^{39}Ar$ ages produced from Mount Erebus are maximum ages owing to the uncertainty of complete removal (through sample preparation) of all excess argon.

$^{40}Ar/^{39}Ar$ ages for Mount Erebus as determined in this study

Location	% Glass content	Apparent age (in thousands)	Conclusion
Summit phenocrysts	~1	48±9[a]	Excess argon—Too Old
Summit phenocrysts	~10	179±16[a]	Excess argon—Too Old
Summit phenocrysts #2	~1	49±27[a]	Excess argon—Too Old
Summit phenocrysts #2	30–40	641±27[a]	Excess argon—Too Old
Summit (bomb) glass	100	101±16[a]	Excess argon—Too Old
Lower Hut flow	<1	24±4[b]	Acceptable
Three Sister's cones	~4	26±2[b]	Acceptable
Three Sister's cones	~1	111±8[b]	Contamination?
Hooper's Shoulder	<1	36±4[b]	Acceptable
Hooper's Shoulder cone	~1	32±5[b]	Acceptable
Hooper's Shoulder cone	~5	94±15[a]	Excess argon
Cape Evans	~1	42±4[b]	Contamination?
Cape Evans	~5	32±6[b]	Acceptable
Cape Royds	~2	73±5[b]	Acceptable
Cape Royds	~20	153±32[a]	Excess argon
Cape Barne phonolite	<1	88±3[b]	Acceptable
Cape Barne phonolite	<1	91±2[b]	Acceptable
Cape Barne phonolite	~5	90±6[b]	Acceptable
Cape Barne phonolite	~5	88±4[b]	Acceptable
Bomb Peak trachyte	<1	159±2[b]	Acceptable
Aurora Cliffs trachyte	~3	197±14[a]	Acceptable
Turks Head phonolite	~2	243±5[b]	Acceptable
Turks Head plagioclase	~5	377±5[c]	Acceptable
Inaccessible Island	whole rock	542±3[b]	Acceptable
Abbott's Peak	<1	550±8[b]	Acceptable
Cape Barne basalt	whole rock	1,310±6[c]	Acceptable

[a]Ages determined from integrated or total gas age (used when no plateau is apparent).
[b]Ages determined from plateau.
[c]Ages determined from isotope correlation diagram.

Evaluation of these new data is still in progress; however, it is apparent that our new age determinations are significantly younger than those previously obtained by the conventional K/Ar method. The evolution and growth of Mount Erebus may have been much faster than previously thought.

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The antarctic crustal profile seismic project, Ross Sea, Antarctica

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The antarctic crustal profile (ACRUP) project is a multinational seismic experiment that was conducted in the Ross Sea area during the 1993–1994 austral summer under the auspices of the Italian National Research Antarctic Program (PNRA). Scientists from five research institutes in Italy, two in Germany, and two in the United States (the U.S. Geological Survey and Massachusetts Institute of Technology) participated in the experiment. This article provides a brief overview of the project and some preliminary results. More complete information on the field project is available from Della Vedova et al. (in press) and Cooper et al. (in press).

The objective of the ACRUP project was to record large-offset seismic and other geophysical data along a 400-kilometer (km) transect across the tectonic boundary between East and West Antarctica to study the deep crustal structure of the Transantarctic Mountains and adjacent Victoria Land basin in the western Ross Sea (profile 1, figure 1). The onshore part of the experiment was successfully completed, but due to severe ice-pack conditions in the western Ross Sea, the offshore part of the experiment could not be accomplished over most of the Victoria Land basin. An alternative large-offset seismic experiment, with ancillary geophysical data, was done using ocean bottom seismometers (OBS) along a 600-km transect of the southern Ross Sea, to investigate the crustal structure of the major rift basins and ridges that lie beneath the Ross Sea (profiles 2A and 2B, figure 1). Although numerous sonobuoy-seismic measurements have been made in the Ross Sea (e.g., Cochrane et al. 1993, pp. 313–335), large-offset seismic experiments using OBS to gather information on lower crust and mantle structure have been done only in the western and central Ross Sea (e.g., O'Connell and Stepp 1993, pp. 229–277; Tréhu, Behrendt, and Frisch 1993; Makris et al. 1993, pp. 277–291).

For the onshore part of the ACRUP experiments, several types of data (in addition to seismic) were recorded; these data included airborne magnetic, radio-echo-sounding, gravity, and down-hole heat-flow measurements. The seismic data were recorded along a 150-km east-west profile by 49 three-component seismometers at 3-km intervals (profile 1, figure 1). The seismometers included 25 digital REFTEK instruments (12 REFTEK instruments were provided by the U.S. Geological Survey, on loan from the IRIS-PASCALL project) and 24 German-built analog instruments. Global positioning system receivers were used to establish location, elevation, and time-reference for the seismic stations. The energy sources for the experiment were four explosion-arrays, ranging in size from 80-kilogram (kg) to 530-kg explosives, and offshore shots from a 71.5-liter air-gun array. Due to the heavy ice, the offshore shooting could be done only at the far eastern end of the planned transect.

The seismic data from the digital REFTEK instruments were downloaded onto a SUN workstation at the remote field camp directly following the experiment. An example of the data from shot A near the coast (figure 2*A*) indicates the absence of sediment beneath the site, where ice is only about 70–100 meters thick, based on radio-echo-sounding data. Refracted energy with velocities near 6 kilometers per second (km/sec) arrives at 15 km and beyond, suggesting that high-velocity crustal rocks are close to the surface. The seismic responses from shots B, C, and D (not shown) differ from those of shot A due to a thick ice cover (about 500 m) and likely thicker continental crust. Abnormally large Raleigh waves characterize the recordings and are now under study. Once analog data from German instruments have been digitized and combined with the REFTEK data, a detailed analysis of the crustal structure beneath the mountains can be completed.

A small-scale, high-resolution refraction experiment was also conducted onshore using 10 REFTEK instruments deployed near the remote camp to investigate the influence of the upper part of the ice cap on seismic-wave propagation. Four 1-kg explosions were recorded at 500 samples per second over distances to about 1,600 m. An example of one shot (figure 2*B*) illustrates that seismic propagation in firn and ice (3.8 km/sec for refracted P-wave multiples; 1.8 km/sec for SV-wave; lower for surface waves) can be distinguished from that of underlying rock (4.7 km/sec for P-waves) at distances less than about 1 km. Preliminary full-wave reflectivity studies of the data indicate that wave propagation in firn and ice is complex, with refracted turning multiples, S-wave generation, anisotropy, and strong attenuation (Zhang et al. 1994). Ice-quakes were also recorded during the study, and that data will be used to further refine the high-resolution structure of the upper part of the ice cap.

The offshore part of the ACRUP experiment was conducted aboard the Italian research vessel R/V *Explora*. Several types of geophysical data were recorded including ocean-bottom seismometers (OBS), multichannel seismic reflection, gravity, and magnetic-gradiometer. A 36–air-gun array with a total volume of 71.5 liters was used for all seismic experiments. The U.S. Geological Survey provided six digital OBS, and Italy and Germany together made available more than 30 analog OBS.

During the first part of the experiment, four OBS were

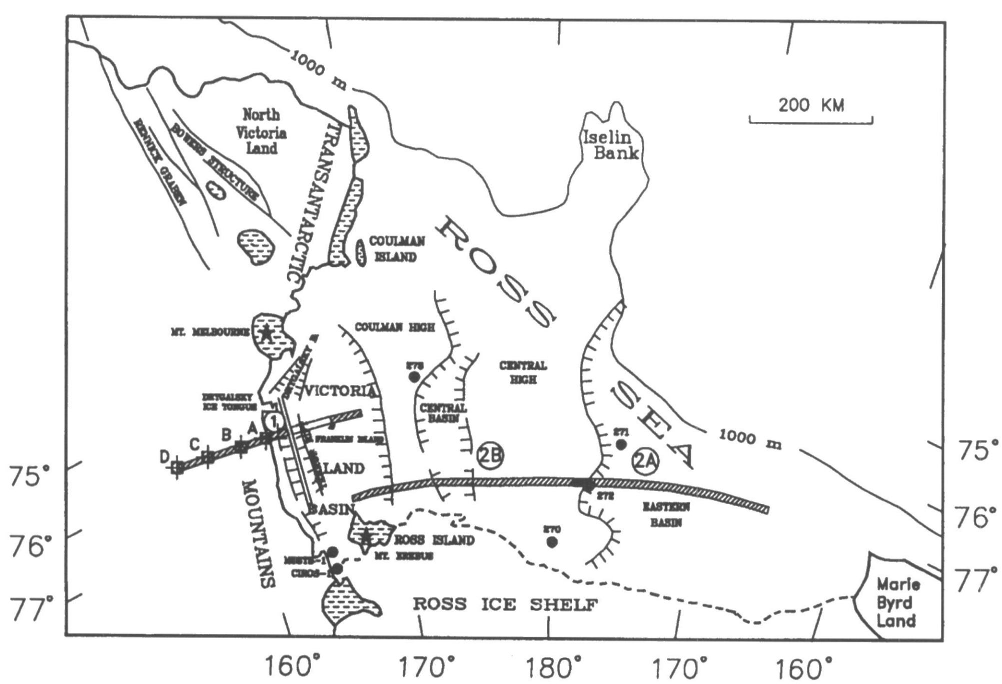

Figure 1. Map showing locations of drill sites, major structures, and ACRUP seismic transects 1, 2A, and 2B done during the 1993–1994 austral summer. Letters A to D on transect 1 show shot locations.

deployed near Franklin Island to record data at the far eastern end of profile 1 (figure 1). Multiple shots were fired as the ship circled near this location, to provide large-offset data to the full array of land seismic stations. Thereafter, the ship moved to the southern Ross Sea to record two separate and contiguous OBS transects, each about 300–350 km long. The transects were placed directly on top of previously recorded multichannel seismic-reflection profiles (BGR-02 and USGS-404) where shallow crustal structure was well known. The first transect was recorded across the Eastern basin using 26 OBS, and the second across the Victoria Land basin and Central trough using 30 OBS (profiles 2A and 2B, figure 1). OBS spacing was 10 km, but on transect 2A, there were 30- and 40-km gaps in OBS spacing at the far ends of the transect. After deploying OBS, the air-gun shots were fired every 240 m (i.e., a shot every 120 seconds) along the transects. Ten, out of the 60 OBS deployed, were not recovered.

The data from the U.S. Geological Survey digital OBS were downloaded at sea and are currently being processed and evaluated. Because most OBS data were recorded by analog instruments and these data are currently being digitized, the seismic results of the crustal transects are still preliminary. Multichannel seismic reflection (MCS) data and gravity data from this and prior studies (Cooper, Davey, and Hinz 1991, pp. 285–291) clearly show that broad sedimentary-rock-filled basins, with positive free-air gravity anomalies over the center of the basins, characterize the Ross Sea. The MCS data also show block-faulted basement structure typical of rift basins. Prior OBS studies of the Central trough (Tréhu et al., 1993, pp. 291–313) showed that the positive gravity anom-

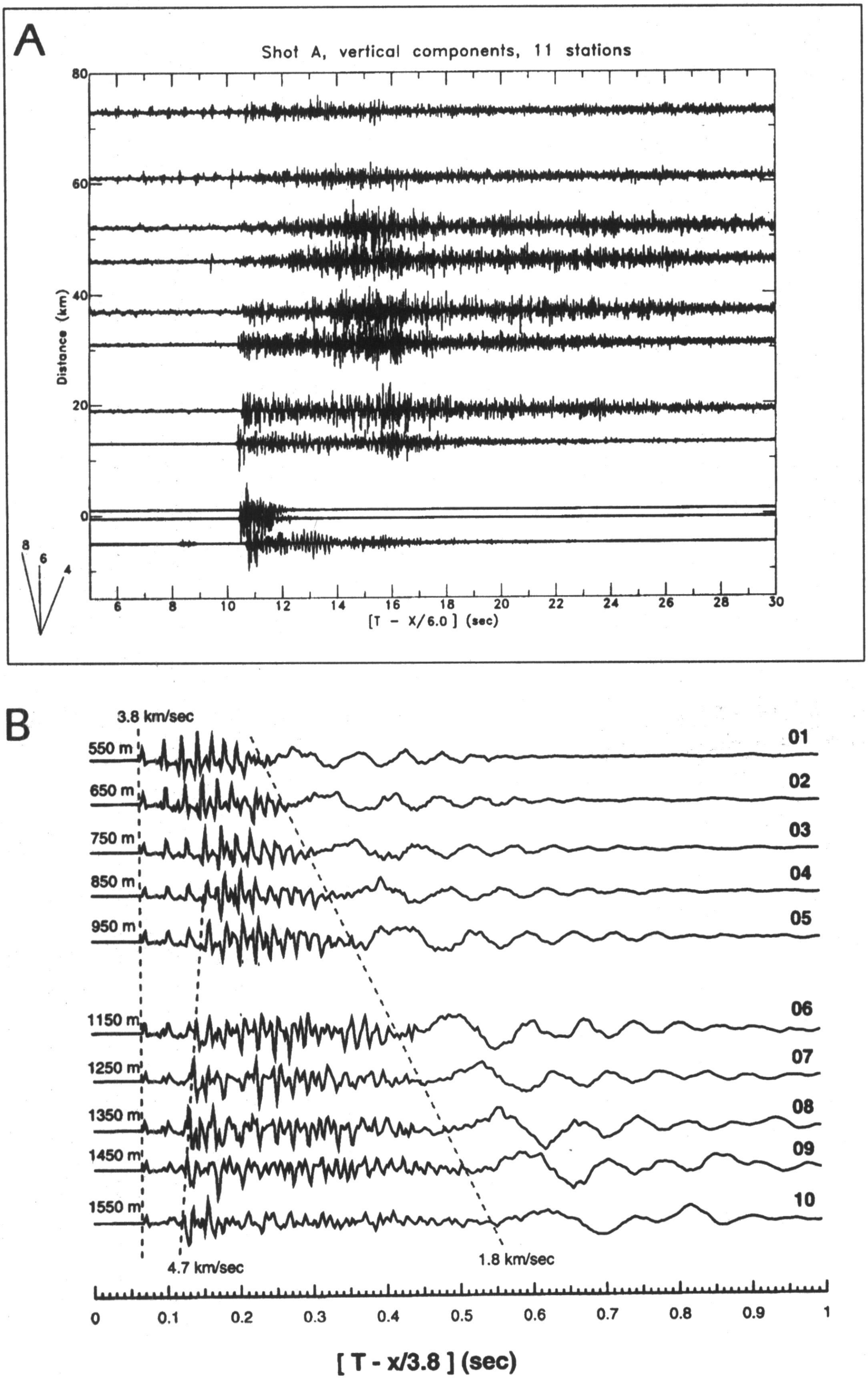

Figure 2. Examples of onshore seismic data. *A*. Data recorded along ACRUP transect 1. Shot A is near 0 km, and distances increase to the west. *B*. High-resolution data recorded near Starr Nunatak remote camp. Distance from each receiver to the shot is given at left.

aly is due to high-velocity (high-density) rocks in the lower crust beneath the center of the basin, rather than to high-velocity volcanic rocks near the base of the sedimentary section. The positive gravity anomaly in the Eastern basin is more subdued than in the Central trough. Preliminary ray-trace analysis of data from one OBS in the middle of the Eastern basin (figure 3) does not show a high-velocity layer in the lower crust, like the wedge-shape "rift cushion" seen in the Central trough. Rather, the velocities of about 6.0 to 6.5 km/sec at depths of 7 to 17 km suggest that basement crustal rocks have a continental affinity, like those recovered at DSDP site 270 (Hayes and Frakes 1975, pp. 919–942) on the Central high. The total thickness of the crust under the Eastern basin is not yet known, and its determination awaits integration of the other OBS data along the transect.

The ACRUP seismic experiments exemplify the type of scientific projects that can be accomplished only with extensive cooperation, skilled coordination, and well-organized planning of international logistic and equipment resources. Most planning for the project by Italy and Germany was done in less than 1 year prior to going into the field. The extensive data sets recorded by the project were made possible by the careful work of many people and by the graces of the good weather that prevailed throughout the project. We thank PNRA for the logistic and technical support for this program. We also thank the U.S. Antarctic Program and the U.S. Coast Guard ship *Polar Sea* for their assistance with the onshore and offshore parts of the project. This research was supported in part by National Science Foundation grant OPP 92-21362.

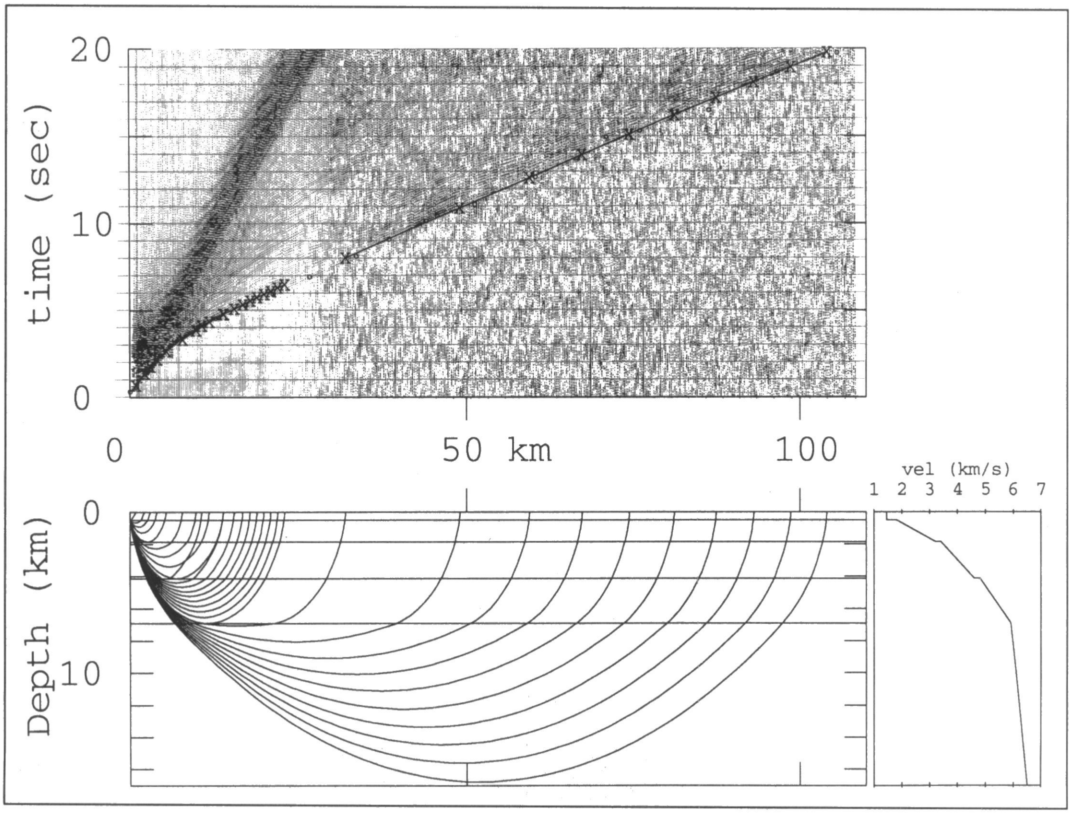

Figure 3. Seismic data and ray-trace model for OBS station 17 (midway along transect 2A). Distance increases from west to east. Refraction velocities based on ray trace arrivals ("X") that are fit to the observed data-picks ("o"). Velocities in lower crust are about 6.0 to 6.5 km/sec.

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