publicly available on such terms as it may prescribe;

(c) as regards Conference Documents or Information Documents of the I-XIIth Consultative Meeting, and Conference Documents of the XIIIth Consultative Meeting, and subsequent Meetings, as well as Information Documents that have not been identified in accordance with paragragh (a) above as intended to be publicly available, Consultative Parties will consider in what circumstances such Documents may be made publicly available, with a view to discussing the matter further at the XIIIth Consultative Meeting;

(5) invite the depository Government to examine the question of information about the Antarctic Treaty System, including publicly available documents arising from Consultative Meetings, with a view to identifying and cataloging publicly available information about the System and identifying the sources from which such information can be obtained; and

(6) "The Operation of the Antarctic Treaty System" be included on the Agenda of the XIII Consultative Meeting.

XII-7. Historic Sites and Monuments

The Representatives,

Recalling Recommendations I-IX, V-4, VI-14 and VII-9

Recommend to their Governments that the following historic monument be added to the "List of Historic Monuments Identified and Described by the Proposing Government or Governments" annexed to Recommendation VII-9 and that thereafter it be accorded the respect and protection required by the Recommendations recalled above:

44. Plaque erected at the temporary Indian station "Dakshin Gangotri," Princess Astrid Kyst, Dronning Maud Land, listing the names of the members of the First Indian Antarctic Expedition which landed nearby on 9 January 1982. (Lat. 70°45°S., Long. 11°38°E.)

XII-8. SCAR Assistance to Consultative Parties

The Representatives,

Recognizing that the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions comprises a unique assemblage of knowledge and expertise in antarctic scientific fields;

Noting with appreciation the advice provided to the Antarctic Treaty Consultative Parties by SCAR in response to various requests,

Being aware that under its Constitution SCAR is charged with "furthering the coordination of scientific activity in Antarctica, with a view to framing a scientific program of circumpolar scope and significance";

Being aware that the assistance requested of SCAR by the Consultative Parties imposes additional demands on scarce resources;

Recommend to their Governments:

That they consider in the light of its expertise and past assistance any requests that may be made by their national committees for additional funding to meet costs to SCAR of responding to requests for advice by the Antarctic Treaty Consultative Parties.

Geological studies in the Patagonian Andes: R/V *Hero* Cruises 82-5 and 83-5

During May and June 1982 and July 1983, the scientific parties on the R/V *Hero* studied the geology and geophysics of the southern Andes between 46°40'S and 52°S; the table lists the dates and scientific personnel for these cruises. *Hero* operates in South American waters during the austral winter, when ice limits operations in antarctic waters.

Our scientific objectives were to provide information on various aspects of the geological and tectonic evolution of the southern Andes. Specifically, we wished to obtain data on the uplift history of this region, to study the petrological and geochemical evolution of the Patagonian batholith, and to study the regional gravity field. To meet these objectives, we conducted reconnaissance mapping of bedrock and surficial geology, collected gravity data primarily along east-west transects (figure 1), and collected numerous bedrock and surficial samples for laboratory analysis. This work also extends northward investigations of the tectonic evolution of the Scotia Arc.

Patagonian batholith

The Patagonian batholith, a linear outcrop of igneous rock along the Pacific margin of southern South America, extends northward from Cape Horn for more than 2,000 kilometers but rarely exceeds 100 kilometers in width. We made a number of transects through this batholith to obtain samples for geochronological and geochemical analyses.

Although the batholith is not mapped in detail, sampling over a wide area allowed us to define the considerable lithological variation that exists within the batholith. The most common lithologies encountered were medium- to coarse-grained biotite and biotite-hornblende tonalite and grandodiorite. Fairly mafic, fine- to medium-grained diorite also makes up a considerable portion of the batholith. Other, less abundant lithologies observed were K-feldspar-bearing granite, coarse-grained biotite tonalite, and gabbro. We mapped one peraluminous (garnet- and muscovite-bearing) granite near the south end of Isla Wellington.

Most of the batholith is homogeneous over wide areas (texturally massive), although we found some foliated deposits. Also, some large areas within the batholith are cut by numerous mafic dikes and irregular bodies of diabase.

Where we observed contact zones, most were sharp with little or no ring-shaped zones surrounding the igneous intrusion (contact metamorphic aureole). In the Fiordo Vargas area, however, we noted a wide contact zone between metamorphic Late Paleozoic basement rocks and a complex of tonalitic to dioritic plutons. At this locality, numerous igneous (mafic) and basement xenoliths are incorporated within the margin of the plutonic complex.

The Patagonian batholith has been eroded to a level deep enough so that little of its original cover is exposed. Nonetheless, an area of intermediate (andesitic) volcanic rocks, mapped in a longitudinally central area, may represent a portion of this cover.

We collected over 250 samples from the batholith. Geochronological analyses—fission track, potassium-argon (K-Ar), rubidium-strontium (Rb-Sr), uranium-lead (U-Pb), and neodymium-samarium (Nd-Sm)—will give ages of the intrusion and cooling from which uplift rates and times will be estimated. Geochemical analyses (major and minor element and isotopic) will provide information on the petrological and geochemical evolution of the batholith and the underlying crust and mantle.

Pre-batholithic terranes

The Patagonian batholith intrudes a large terrane of variably metamorphosed country rocks. During reconnaissance we mapped the metamorphic rocks east and west of the batholith and in roof pendants (remnants of older rocks overlying the batholith). Lithologies encountered include metamorphosed sandstone-shale sequences, mafic-ultramafic schist and gneiss, and marble. These sequences correlate with other pre-Late Jurassic basement complexes exposed elsewhere in the southern Andes.

We also sampled the basement terrane to the west of the batholith for geochronologic (Ar-Ar and Nd-Sm), isotopic, paleontologic, and paleomagnetic analyses.

Cenozoic geology

Because the scientific party of *Hero* cruise 79-5 had observed numerous Cenozoic uplifted features, we paid considerable attention to Cenozoic deposits and erosional features (such as terraces and ice-carved surfaces) during cruises 82-5 and 83-5. We measured over 100 ice-flow directions (figure 2); these measurements suggest that the present fjordland topography strongly controlled the direction of ice flow over

Personnel and cruise dates for *Hero* cruises 82-5 and 83-5.

R/V Hero *cruise:*	*82-5*	*83-5*
Cruise Dates	11 May to 10 June 1982	5-29 July 1983
Cruise Track	Punta Arenas, Chile to Punta Arenas, Chile	Punta Arenas, Chile to Puerto Montt, Chile
Chief Scientist	Eric Nelson Co-Principal Investigator Geology Department Colorado School of Mines Golden, Colorado	Eric Nelson
Other Scientists	Randall Forsythe Co-Principal Investigator Geology Department, Rutgers University, New Brunswick New Jersey	Randall Forsythe
	Constantino Mpodosis Servicio Nacional de Geologia y Mineria, Santiago, Chile	Hannes Brueckner Lamont-Doherty Geological Observatory, Palisades, N.Y. and Department Earth & Environmental Sciences Queens College New York, New York
	Karleen Davis Department of Geological Sciences State University of New York Albany, New York	
		Miguel Herve Servicio Nacional de Geologia y Mineria, Santiago, Chile
	Jay Stravers Institute of Arctic and Alpine Research University of Colorado, Boulder, Colorado	Eric Leonard Geology Department Colorado College Colorado Springs, Colorado
		Salvador Harambour Geological Assistant University of Chile Santiago, Chile
		Jose Manuel Soffia Geological Assistant University of Chile Santiago, Chile

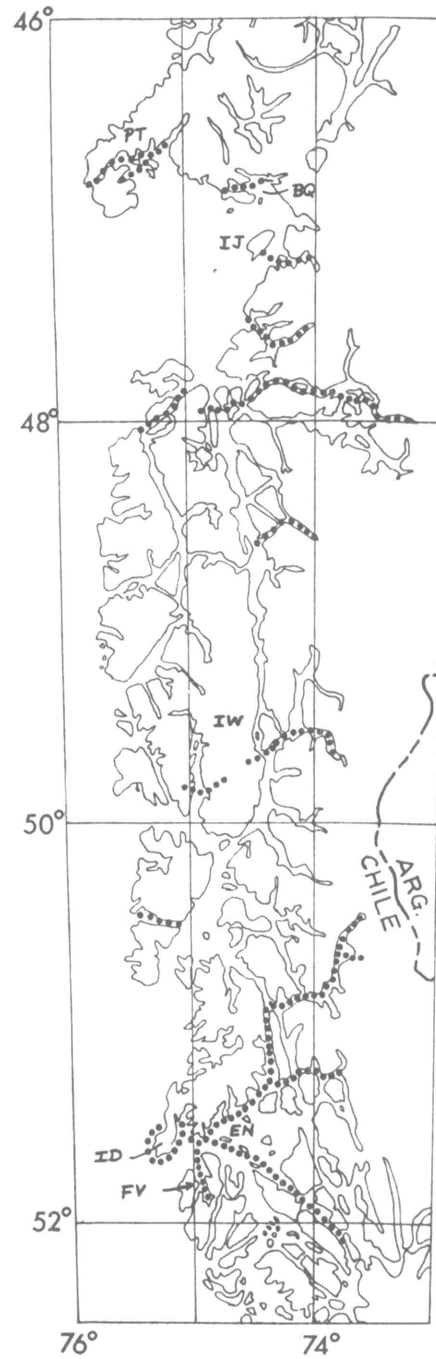
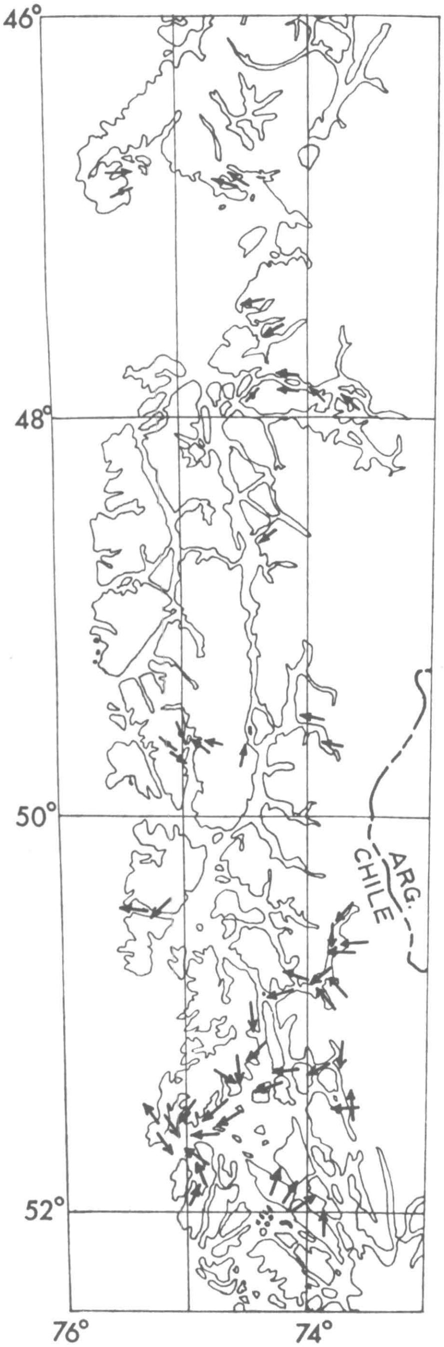


Figure 1. Partial ship track of R/V *Hero* during cruises 82-5 and 83-5. Dotted lines represent transects along which geological and geophysical data were collected. The abbreviations on this figure indicate the following sites: IW (Isla Wellington), FV (Fiordo Vargas), ID (Isla Diego de Almagro), EN (Estrecho Nelson), IJ (Isla Javier), PT (Peninsula Taitao), and BQ (Bahia San Quintin).

most of the area during the last glacial maximum. Most of the high peaks in the area show evidence of having been glaciated. This suggests that an extensive ice sheet may have covered the area at one time.

Other erosional features observed include uplifted wave(?)-cut terraces and notches cut into exposures of Late Paleozoic limestone. We used a sextant and the ship's radar to measure the elevations of some remarkably planar, high-elevation terraces along the rugged southwestern margin of Isla Diego de Almagro. The three most prominent levels were 246, 197, and 143 meters above sea level. A lower but more extensive terrace (approximately 10 to 20 meters above sea level) was observed in the area of Estrecho Nelson. The origin of this extensive terrace, as well as the high Pacific-margin terraces, remains enigmatic. Although we recognized numerous other Pacific-margin terraces and uplifted features on aerial photos between 48° and 50° south latitude, we were unable to visit these areas because of mechanical problems with the *Hero* and a lack of official Chilean permission to navigate along some critical access routes.

Figure 2. Quaternary ice flow directions. Line with dot indicates known flow orientation, but flow-sense is unknown.



Considering the size of the area studied, we observed very few depositional glacial features, even though the area appears to have undergone extensive glaciation. Erratic boulders and gravels are almost entirely locally derived except along the Pacific margin. In this area we discovered enigmatic clasts of porphyritic volcanic rocks. Surficial glacial and glaciomarine deposits that we mapped and sampled include the following:

- till
- glaciomarine diamict
- glaciomarine gravels
- ice contact gravels (kame terrace)
- ice-dammed lake delta sands and varved clays
- marine deltaic sands and gravels (bottomset, foreset, and topset beds)
- marine beach sands and gravels
- shell-bearing marine clays
- peat and other organics

We collected over 110 samples from these deposits. Preliminary radiocarbon ages of 1,570 and 3,650 years were obtained from shell samples in terraces measured at 2.0 and 7.5 meters above sea level respectively. Amino acid racemization, biostratigraphic (palynological), and further radiocarbon analyses will help build the Late Quaternary glacial chronology of the region.

In the Golfo de Penas area we mapped major Tertiary and Quaternary clastic sedimentary deposits. A sequence of faulted and tilted marine mudstones, siltstones, and sandstones were found on Isla Javier and in the Peninsula Taitao area. In the Taitao area portions of the marine strata are conformably overlain by submarine, intermediate volcanic units. The probable basal unit of this section is a very coarse conglomerate containing predominantly clasts of the underlying pre-Late Jurassic basement. Preliminary micropaleontological data suggest that at least some of the marine strata are no older than middle Miocene (R.K. Olson, personal communication, 1983).

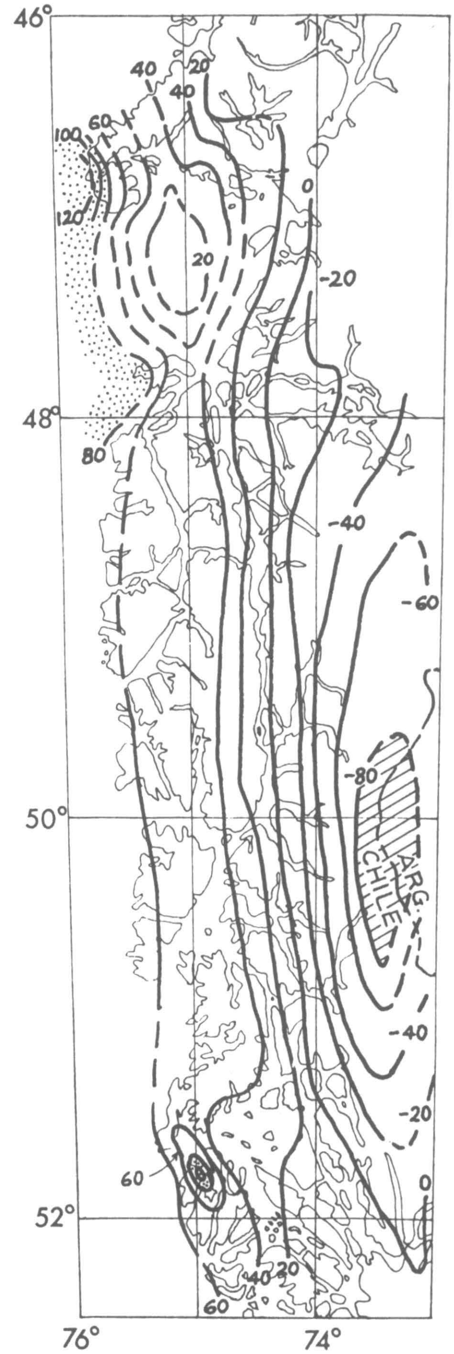


Figure 3. Generalized Bouguer gravity anomaly map of a portion of the southern Andes. Contour interval = 20 mgals. Areas with dots indicate values greater than +80 mgals; those with diagonal slashes indicate values less than -80 mgals.

This sequence of clastic and volcanic rocks is cut by silicic-to-intermediate epizonal intrusions. A sequence of horizontal, poorly lithified, Quaternary mudstones and sandstones was also mapped in the Bahia San Quintin area. These rocks are probably of glaciolacustrine origin and may or may not have been uplifted.

We collected samples in these Cenozoic sequences from 18 sites for pollen and foraminifera studies and from 5 sites for macrofossil studies. Samples from the Cenozoic volcanic and plutonic rocks presently are being analyzed for major and trace element abundances. Preliminary data suggest that these rocks have a calc-alkaline affinity.

Structural data

Mesozoic and Cenozoic ductile and brittle simple shear deformations have resulted in a complex fault and fracture pattern in the region. Immediately south of the Golfo de Penas region, mesoscopic east/west-trending faults predominate and have mainly right lateral offset. These faults cut most plutonic rocks in the area and are probably Cenozoic in age. North of the Golfo de Penas, mesoscopic north/west-trending faults predominate and have both normal (e.g., on Isla Javier) and left lateral (e.g., Taitao area) components of movement. These faults cut Tertiary and Quaternary(?) strata and are likely to be systematically related to the development of Cenozoic depositional centers in the Golfo de Penas.

Gravity data

To study the large-scale crustal structure of the southern Andes we took over 400 gravity readings along nine generally east-west transects (figure 1). The results of the gravity survey show both regional and local variations in the Bouguer anomaly field (figure 3). Bouguer anomalies are derived by correcting the observed gravity for latitude, variations in elevation, and the mass of material between the observation site and sea level. Bouguer anomalies range from -80 to +120 milligals (mgal) and are the most extreme values yet measured in this region of the Andes. The lowest negative anomalies are located along the topographic axis of the Andes, and reflect the great crustal thickness below this axis. The highest positive anomalies are located over pre-late Jurassic, mafic-ultramafic basement complexes (unusually dense rocks), which may partially account for the high values.

Regionally, anomaly values generally increase from east to west along most profiles located west of the Andean topographic divide. Regional north-south gradients in the Bouguer field suggest that the Andes have major variations in crustal thickness, with minimums around 47-48°S and 52-53°S and a maximum at 50°S (figure 3). Abrupt north-south variations in the field at about 48°S may indicate a major east-west structural boundary in the Andes. Other local anomalies, suggestive of major changes in crustal structure, exist over pre-Late Jurassic mafic and ultramafic complexes of the Estrecho Nelson area, over Tertiary strata on Peninsula Taitao, and over the extreme western portion of Peninsula Taitao (figure 2).

Conclusion

During *Hero* cruises 82-5 and 83-5 we made numerous geological and geophysical observations that included bedrock and structural mapping in the Patagonian batholith, in the pre-Late Jurassic basement, and in Cenozoic supracrustal sequences. Various laboratory analyses are underway on the bedrock and surficial samples collected during the cruises. We have produced the first generalized Bouguer anomaly map of the southern Andes from extensive measurement of the regional gravity field.

These data, when combined with data from past and planned *Hero* cruises near the southern Andes, will add significantly to our understanding of the complex geological evolution of this remote region. From these data we are beginning to develop conceptual models for such geologic and tectonic processes as the origin of granitic batholiths, the geological effects on the continent of oceanic ridge-trench collision, and the mechanisms for uplift and segmentation in Andean-type orogens.

NSF research grants EAR 82-06646 to E. Nelson, EAR 82-06100 to R. Forsthye, and EAR 83-07604 to E. Nelson and D. Elthon are supporting this work. *Hero* cruises in Chile's 200-nautical-mile zone are conducted with the assistance and permission of the Chilean government. In June 1983 the U. S. and Chilean governments signed an agreement which outlines a cooperative plan for research conducted aboard *Hero*.

—Eric Nelson, Geology Department, Colorado School of Mines, Golden, Colorado 80401, and Randall Forsythe, Department of Geological Sciences, Rutgers University, New Brunswick, New Jersey 08903.

Reference

Olson, R. K. 1983. Personal communication. (Department of Geological Sciences, Rutgers University, New Brunswick, New Jersey 08903.)

Estimated ages and temperatures of South Pole ice

Ice-coring has become a major component of the U.S. research program at the South Pole. We carried out a simple model simulation of the history of the South Pole ice; our results are reported in this note. We based the model on the assumption that the relevant sector of the east antarctic ice sheet is in a state of zero net mass balance. The results, therefore, are unlikely to match exactly data acquired in the field but should define orders of magnitude to be expected from actual core and borehole measurements.

Data

We constructed the topography for the simulation from the 1:15-million-scale map of the ice sheet surface and bedrock elevations published in the Soviet *Atlas of Antarctica* (Bakayev, 1966). Figure 1 shows flowlines through South Pole. The heavy, full line in the figure is constructed orthogonally to the surface elevation contours and extends back 980 kilometers to a point near 82°S 71°E on the antarctic plateau above the western edge of the Gamburtsev Subglacial Mountains (80°30'S 76°E). The surface and bedrock elevation profiles of the South Pole flowline are shown in figure 2. An alternative possibility, that the South Pole ice comes from the secondary "Titan Dome" 200 kilometers to the south (heavy dashed line) was also investigated but must be discounted because of mass flux considerations discussed later.

The accumulation values along the line are not well known; therefore, they have been constructed to match the latest South Pole accumulation estimate (8.8 centimeters of ice per year) obtained by A. Gow (personal communication) from a 200-meter ice core extracted in 1981 (Kuivinen, Holdsworth, and Gow 1983). Over most of the central plateau, a low value (2 cen-