Trans-Alaska Lithosphere Investigation—Program Prospectus

U.S. GEOLOGICAL SURVEY CIRCULAR 984

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COVER

Deep seismic reflection profiling along the Trans-Alaska Lithosphere Investigation transect near Donnelly Dome, with the Alaska Range in the background. The five trucks in the foreground vibrate the ground in unison, sending out compressional seismic waves which reflect off velocity discontinuities within the upper lithosphere and return to the surface where they are recorded by an array of seismographs. In this survey, contracted by the U.S. Geological Survey in 1986, the signals were recorded by a 30-km linear array of 1,024 groups of seismographs deployed symmetrically about the vibrator trucks. Figure 7 (p. 14) shows an example of the data obtained.

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Trans-Alaska Lithosphere Investigation—Program Prospectus

David B. Stone, Robert A. Page *and* John N. Davies, *Editors*

SUMMARY

This prospectus presents the rationale and framework for a major cooperative investigation of the Alaskan lithosphere--the Trans-Alaska Lithosphere Investigation, or TALI. TALI focuses on a north-south transect, extending from the active convergent Pacific margin to the passive rifted Arctic margin, following the trans-Alaska oil pipeline corridor (fig. 1). The route samples an exceptionally broad variety of geologic structures and problems along its 1,400-km length.

Goals.--The goals of the Trans-Alaska Lithosphere Investigation are to

- o Determine the structure, composition and evolution of the Alaskan lithosphere,
- o Examine the role of accretion tectonics in the growth of Alaska, and
- o Investigate the post-amalgamation behavior of Alaska and the origin of major geologic features--mountain chains, sedimentary basins, regional fault zones, seismic belts, and volcanoes.

The primary objective of TALI is to obtain a continuous geologic and geophysical profile across Alaska by the end of this decade. Particular emphasis is placed on seismic-reflection and -refraction profiling and other geophysical methods to resolve the structure of the crust and underlying mantle and to relate surface geology to structures at depth inferred from geophysics.

Benefits.--TALI will substantially improve knowledge of the State's geologic framework, especially in the subsurface, and will yield new insights into the geologic processes that have shaped the crust.

Improved knowledge of the geologic framework will

- o Facilitate evaluation of the State's oil and mineral potential, and
- o Provide a regional context in which to interpret detailed subsurface studies completed by industry and others along the transect corridor.

New insights into geologic processes will help to

- o Resolve fundamental questions relating to the evolution of continents and to the movements and collisions of the diverse microplates and terranes that constitute the Alaskan crust,
- o Elucidate the origin of Alaska's oil and mineral resources and the causes of the State's earthquakes and volcanoes, and
- o Decipher the geologic development of western North America and the Pacific rim.

Organization.--TALI is a cooperative effort among Federal and State agencies, universities, and the petroleum and mineral industries.

TALI is promoted and coordinated by a three-person committee with representatives from the U.S. Geological Survey (USGS), the Alaska Division of Geological and Geophysical Surveys (ADGGS), and the University of Alaska, Fairbanks (UAF). This committee disseminates information on the objectives, plans, and progress of TALI and seeks to stimulate collaboration among potential investigators.

An advisory committee, consisting of scientists from industry, government, and academia, is being established to review periodically the aims and accomplishments of TALI, to recommend topics for and priorities of future work, and to foster participation and cooperation.

The TALI organization, consisting of the coordinating and advisory committees, provides information and recommendations to participants and funding sources but does not engage in funding activities.

Studies directly focused on TALI have been initiated by the USGS, in its Trans-Alaska Crustal Transect (TACT) project, and by Rice University and the UAF with support from the Department of Energy, the National Science Foundation, and the petroleum industry. The ADGGS and individual scientists from several universities and companies are collaborating in many of these studies. The total support for these studies in 1985 was about $2

million. Many other geologic and geophysical investigations that contribute to the goals of TALI are also being conducted by industry, universities, and government along or near the transect corridor.

INTRODUCTION

The importance of determining the deep geologic structure of Alaska has become increasingly apparent over the last few years. Both the long-term search for petroleum and mineral resources and the advent of the concept that Alaska is composed of diverse geologic terranes accreted to western North America demand physical measurements of crustal structure in Alaska. The exciting successes in elucidating crustal structure in the conterminous United States with modern geophysical techniques suggest that applying these techniques to investigation of the Alaskan lithosphere would yield dramatic new insights into the structure, composition, and evolution of the Alaskan crust and into fundamental tectonic processes that are poorly understood at present.

To stimulate investigation of the Alaskan lithosphere, the U.S. Geological Survey (USGS), the Alaska Division of Geological and Geophysical Surveys (ADGGS), the University of Alaska, Fairbanks (UAF), and Rice University are promoting a cooperative geophysical and geological transect of the crust and upper mantle, the Trans-Alaska Lithosphere Investigation (TALI). The primary route of the transect follows the north-south corridor of the trans-Alaska oil pipeline between Prudhoe Bay and Valdez (fig. 1) and extends offshore across the Pacific and Arctic continental margins.

TALI is a coordinated multidisciplinary effort among government, academic, and industry scientists and institutions. Coordination is provided by a modest organization consisting of two committees (fig. 2). A small coordinating committee provides day-to-day coordination. The editors of this prospectus are serving as the coordinating committee by promoting TALI and disseminating information on the objectives, plans, and progress of TALI. An advisory committee, consisting of scientists from industry, government, and academia, is being established to review periodically the aims and accomplishments of TALI, to recommend topics for and priorities of future work, and to foster participation and cooperation. Participants in TALI are directly responsible for securing support for their work from whatever source is appropriate. The TALI organization does not serve as a vehicle for securing or disbursing funds, nor does it conduct research projects.

This program prospectus outlines major problems to be addressed by TALI and enumerates relevant opportunities for research. The purpose of the prospectus is to define a framework within which a coordinated multidisciplinary program can evolve. We hope that it will be useful both to investigators who wish to pursue a particular study and to agencies and companies that are asked to support a particular effort. The ultimate scope and accomplishments of TALI will depend on the interests of those who choose to participate in the program and their success in obtaining funds to support the work. No detailed timetable for the program is presented, but it is hoped that the transect can be completed by the end of this decade.

TALI seeks to focus a number of complementary geologic and geophysical investigations of the lithosphere on a common corridor. Because of the multidisciplinary character of the transect, the ultimate success and contribution of TALI depends heavily on collaboration and communication between the various disciplines and scientists and on the integration and synthesis of a broad variety of geologic and geophysical data. Not only will the data come from different disciplines, but they will be collected over a wide range of scale and density and will pertain to different time intervals. It is critical that synthesis be encouraged and supported, especially in the later years of TALI when the support for collection of new data is declining.

The USGS, University of Alaska, Rice University, and ADGGS are actively engaged in studies contributing to TALI. Individual scientists from several universities and companies are participating or collaborating. These studies are summarized at the end of this report. Other institutions are currently seeking support for future studies or considering future participation.

Acknowledgments--Many of the ideas and words in this prospectus originated at a workshop cosponsored by the ADGGS, National Science Foundation, USGS, and University of Alaska in May 1984. The workshop participants are listed in the Appendix. Additional ideas were contributed by colleagues not present at the workshop, including E. L. Ambos, A. W. Bally, Michael Churkin, W. D. Mooney, J. S. Oldow, and W. K. Wallace. Particular recognition is due to George Plafker, W. J. Nokleberg, D. L. Campbell, Arthur Grantz, and T. P. Miller for their contributions to this document.

IMPORTANCE OF STUDYING ALASKA

A crustal transect across Alaska has important implications from many points of view. In terms of understanding global geology and the large-scale dynamic interactions involved with plate motions, Alaska is uniquely situated between the actively spreading Arctic Ocean and the relatively northward-moving Pacific plate (fig. 1). To a first approximation, Alaska is simply part of the North American plate, but on a finer scale Alaska includes smaller plates or blocks that are slowly moving with respect to North America and whose boundaries currently are not fully defined. An example from the TALI corridor in southern Alaska is the Wrangell

Figure 1.--Location of Alaska in relation to Arctic and Pacific Oceans. Also shown are Arctic spreading center, Aleutian megathrust, Fairweather-Queen Charlotte (F-QC) transform fault, and relative motion vector of Pacific plate. TALI transect corridor follows trans-Alaska pipeline onshore (dashed line). Approximate lateral boundaries (solid lines) of maps in figures 4, 6 and 8 are also shown.

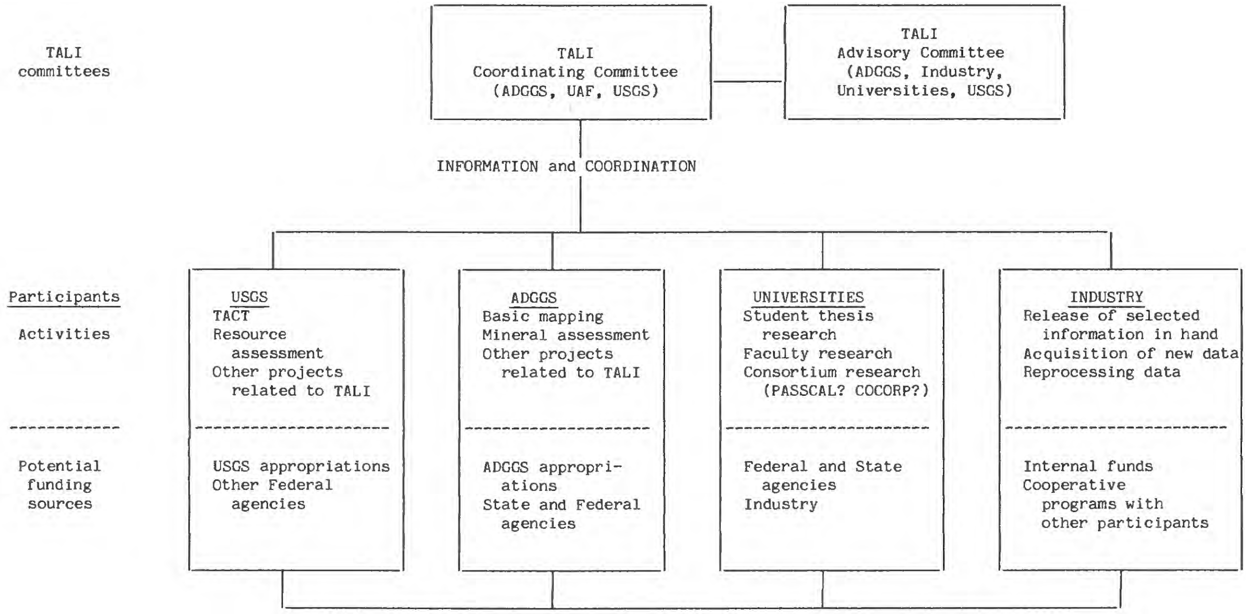


Figure 2.--Organizational chart showing formal structure of TALI, operational relations among TALI committees and program participants, and participants' activities and potential funding sources. Considerable exchange between participant boxes is expected in regard to research collaboration and in regard to support, both direct funding and indirect support such as logistics, information exchange, data processing, and so forth.

block, which is bounded on the north by the Denali fault, on the east by the Totschunda and Fairweather faults, and on the south by the Aleutian trench and the Chugach-St. Elias fault system; its western boundary is ill defined.

On a continental scale, the proposed transect will provide a cross-sectional view across an entire continent, from an active convergent margin to a passive rifted margin, in a distance of only 1,400 km. The new information to be obtained concerning the structure of the crust and upper mantle is critical for deciphering the evolution of Alaska; by analogy, it will also contribute to understanding the evolution of much of North America. For example, the TALI route traverses features that to some degree have equivalents in the conterminous United States: the Coast Ranges (Chugach Mountains), the Sierra Nevada (the Talkeetna Mountains and southern Alaska Range), the Rockies (the Brooks Range), and the Cretaceous basin deposits of the Great Plains (the Arctic Slope).

By pursuing a program of deep sounding with all the available tools of geology and geophysics, significant new information on the nature of the lithosphere may be forthcoming. Such studies will fit well with the targets of opportunity in the solid earth sciences as proposed to the White House by the Committee on Science, Engineering, and Public Policy (COSEPUP), and with the stated aims and goals of both the U.S. Geodynamics Commission and the International Lithosphere Program.

The concept that continental growth involves accretion of allochthonous (foreign) terranes driven by plate tectonic processes was largely spawned in southern Alaska and western Canada and has developed into a unifying theme for circum-Pacific geology. Although it is widely recognized that Alaska comprises a tectonic mosaic of accreted crustal terranes, the deep structure of these terranes is unknown, as are the details of their development. We do not know, for example, how deeply the terranes extend, on what they are founded, and whether they are stacked one on top of another. Answers to these problems are fundamental to understanding the geology of Alaska and the evolution of western North America.

From the economic point of view, a transect such as that proposed here has a high potential to add significantly to our understanding of the origin and mode of emplacement of the various mineral deposits associated with the different tectonic settings found within Alaska, and may also resolve some of the many riddles concerning the origin of the major oil reserves of Arctic Alaska. The tectonostratigraphic terrane concept already forms the framework for some new exploration strategies in western North America in particular, and the circum-Pacific region in general, but the detailed information necessary for efficient exploration planning is lacking. Detailed geologic surface mapping combined with all the available geophysical techniques can extend geological interpretations to considerable depth. This is particularly important because large sections of the crust can be faulted over one another, for hundreds of kilometers. Such extensive low-angle faulting within the crust may hide large economic mineral or energy resources from discovery by conventional surface exploration techniques; younger, potentially productive rock sequences may be buried beneath crystalline rock sequences previously interpreted as "basement," as found, for example, in the Wind River Mountains in Wyoming and the southern Appalachian Mountains in the southeastern United States. To explore for subsurface deposits thus requires models of geologic and tectonic development that can predict possible target areas beneath rocks of low economic potential. Although our knowledge of the tectonic development of Alaska is at present fragmentary, it could improve dramatically with the information that a crustal transect can provide. Information of this sort would also apply indirectly to tectonic models of similar areas such as western North America and the rest of the circum-Pacific.

TRANSECT ROUTE AND GEOLOGIC PROBLEMS

The TALI route crosses Alaska from the active convergent Pacific continental margin to the passive Arctic margin. Over its course, the transect samples an exceptionally wide variety of major geologic features -- active and fossil subduction zones, offscraped accretionary terranes, accreted oceanic and continental microplates, major structural boundaries, large-scale overthrust belts, sedimentary basins, and rifted margins (figs. 3 and 4). There is no other place in North America where a transcontinental transect only 1,400 km long could examine such a diversity of major geologic features. The rocks along the transect route span the evolutionary history of the Alaskan crust from Paleozoic and older rocks that are possibly related to the North American craton to the rocks of the Yakutat terrane, currently being accreted along the convergent Pacific margin. The transect therefore provides exceptional opportunities to elucidate the development of the Alaskan crust and to investigate and understand the types of tectonic processes that have shaped the geology of Alaska in the past and are continuing in the present.

Following the north-south oil pipeline corridor from Valdez to Prudhoe Bay, the entire onshore part of the TALI route is accessible by road. Such access greatly simplifies logistics and reduces costs of geophysical and geological investigations. TALI will incorporate several supplementary profiles intersecting the primary north-south route to

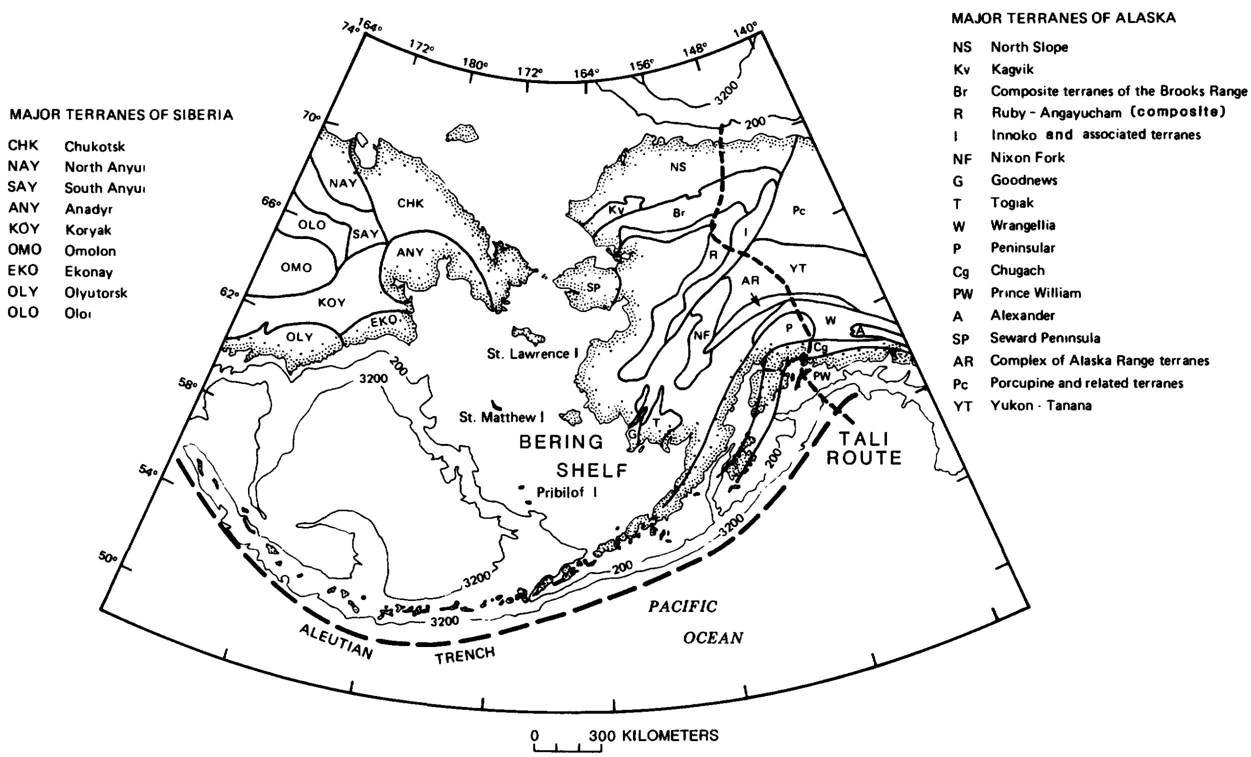


Figure 3.--Route of TALI transect, shown in relation to tectonostratigraphic terranes of Alaska (modified from D. L. Jones and others, 1981, U.S. Geological Survey Open-File Report 81-792) and Siberia (after D. G. Howell and others, 1985, Preliminary tectonostratigraphic terrane map of the circum-Pacific region, American Association of Petroleum Geologists).

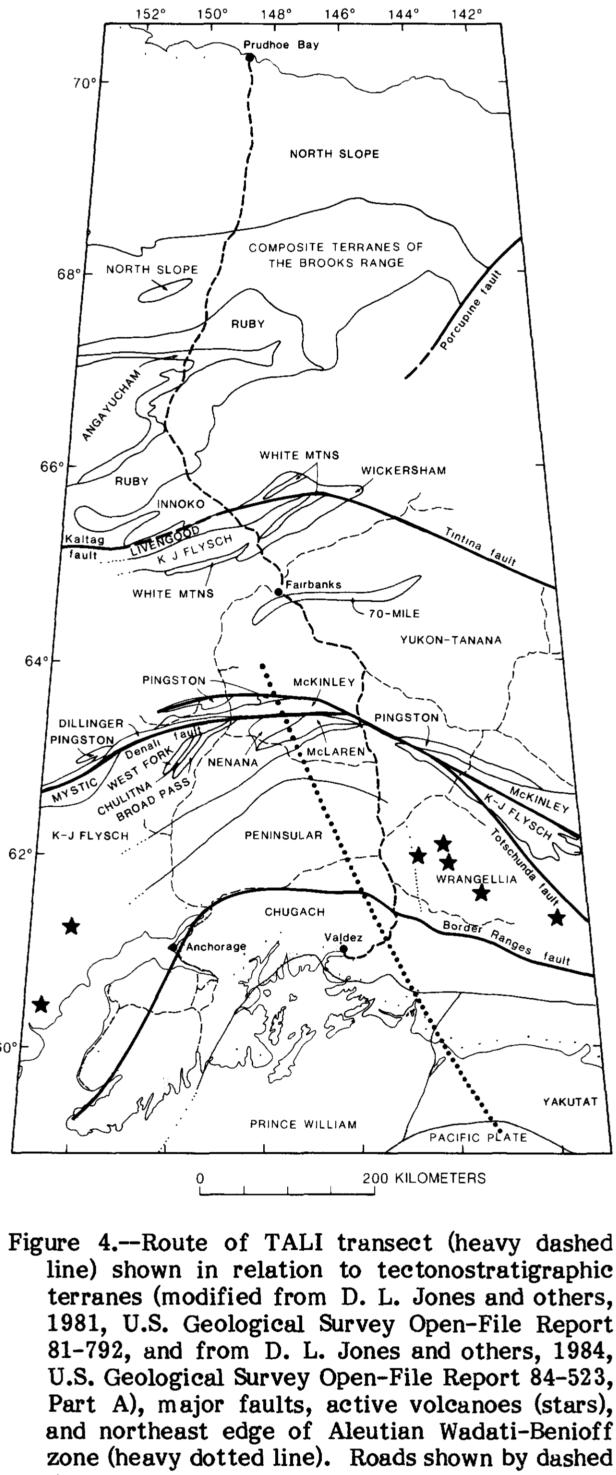


Figure 4.--Route of TALI transect (heavy dashed line) shown in relation to tectonostratigraphic terranes (modified from D. L. Jones and others, 1981, U.S. Geological Survey Open-File Report 81-792, and from D. L. Jones and others, 1984, U.S. Geological Survey Open-File Report 84-523, Part A), major faults, active volcanoes (stars), and northeast edge of Aleutian Wadati-Benioff zone (heavy dotted line). Roads shown by dashed lines.

resolve the three-dimensional aspects of structure. Some of the supplementary profiles will take advantage of the few highways that exist within the State (fig. 4). The transect route crosses several areas that have been the focus of intensive geological studies by the USGS, ADGGS, and others, most notably offshore in the northern Gulf of Alaska and the Beaufort Sea, and onshore in the Cordova, Valdez, Mount Hayes, Big Delta, Fairbanks, Livengood, Chandalar, Wiseman, and Philip Smith quadrangles, and along a transect across the eastern Yukon-Koyukuk province and the Brooks Range.

In southern Alaska, the transect will examine the structural and seismic details of convergence between the Pacific and North American plates in the region of normal convergence at the eastern end of the Aleutian trench. Major questions to be addressed are the configuration of the continental crust and evidence for late Cenozoic subduction of oceanic crust and its sedimentary cover along the most active convergent margin in the continental United States. Knowledge about the structural character and history of the potentially petroliferous Cenozoic continental margin basin bordering the Gulf of Alaska and of the late Mesozoic and Paleogene terranes of Prince William Sound and the Chugach Mountains will provide insight into continental margin accretion mechanics. Northward, the route crosses the Mesozoic and Cenozoic accretionary sequences near the axis of the Alaska orocline, where detailed analysis of the extraordinarily well exposed structures could provide important information on the oroclinal process. The Contact fault and related structures represent the inner margin of an Eocene or younger suture between the late Mesozoic Chugach and Paleogene Prince William terranes. The well-exposed Border Ranges fault system, a probable subduction zone suture, separates the offscraped deep-sea accretionary terranes of the Pacific margin from the extensive microplate terranes of south-central Alaska. The subsurface configuration and nature of both of these major fault zones require detailed study.

Between the Border Ranges fault and the northern strands of the Denali fault, the transect crosses a remarkable collage of far-traveled exotic microplates and slivers set in a matrix of flysch basins that are believed to have agglomerated to south-central Alaska in late Mesozoic and later time. The route traverses the Peninsular-Wrangellia (composite) terrane, which consists of a late Paleozoic arc sequence locally overlain by rocks showing a distinctive variable lithology. The crustal structure of the Peninsular and Wrangellia terranes and the nature and configuration of the suture bounding the concealed contact between them should be investigated in detail. Additionally, the process and history of agglomeration of these terranes, as well as subsequent "continentalization" by continued compression, extensive plutonism, and some volcanism in latest Cretaceous and Tertiary time, are major problems for study. The possible relation of Eocene volcanism, major sutures, and strike-slip faults of this region to plate convergence, continental accretion, and the Alaska orocline is a major problem, as is the puzzling paucity of arc-related volcanic rocks landward of the presumed major late Mesozoic and Tertiary convergent margins of Alaska.

In central Alaska, the transect will cross the Alaska Range and the Denali fault. The Denali fault is excellently exposed along the pipeline route, and its major splay, the Hines Creek fault, is exposed immediately to the west. The dual role of the Denali fault system as a late Mesozoic collision suture and as a Cenozoic strike-slip fault that absorbs lateral slip between the Pacific and North American plates is of great interest. Between the Denali fault and Hines Creek fault are a collage of narrow, fragmented late Paleozoic to Mesozoic terranes with oceanic affinities, including the Windy, McKinley, and Pingston terranes. These small terranes are important to study because they separate mainly oceanic terranes to the south, which are in part allochthonous with respect to North America, from various crystalline terranes to the north in the Yukon-Tanana Upland, which are possibly autochthonous with respect to North America.

The crystalline terranes of the Yukon-Tanana Upland, which extend northward beyond Fairbanks, consist of a variety of metamorphosed sedimentary, volcanic, and plutonic rocks with a complex geologic history, probably extending back to the Proterozoic. Along its northern margin in the Livengood area, the Yukon-Tanana Upland is bordered by a collage of crustal slices of Paleozoic through Jurassic age with both oceanic and continental margin affinities. These terranes are in part bounded by and in part disrupted by the Kaltag and Tintina fault systems, which have had large pre-Eocene strike-slip displacements. The nature and extent of sutures along the margins of, and within, the Yukon-Tanana Upland, and the extent and configuration of crystalline terranes within the Upland, are all important problems.

The route traverses the eastern apex of the triangular Yukon-Koyukuk province near the headwaters of the Koyukuk River. The Cretaceous marine and nonmarine strata of this province are surrounded by obducted dismembered ophiolites, which may mark ancient continental margins. The origin and subsequent deformation of this basin are probably related to tectonic processes at other late Mesozoic and early Tertiary margins in Alaska. The transect will provide data on the nature of the crust, possibly oceanic, beneath this basin and the subsurface configuration of the major structural boundaries.

Along the north flank of the Yukon-Koyukuk basin ophiolitic rocks are obducted over rocks of the Brooks Range at a major tectonic boundary known as the Kobuk suture zone. The Brooks Range and North Slope of Alaska are underlain by the parauthochtonous Arctic continental platform, and by a belt of schist and marble along its southern margin. A critical area of investigation is the relationship of the metamorphic belt of the Brooks Range to the root zone of the extensive northward-directed thrust sheets, including obducted ultramafic rocks, that overlie the Arctic platform in the Brooks Range and its northern foothills. The episode of major crustal shortening was apparently dominantly Early Cretaceous in age. The relative timing of thrust episodes and uplift to events in the Yukon-Koyukuk basin to the south, and in the Colville foredeep and Canada Basin to the north, are important to understanding the origin of these regional features.

The Arctic platform or Arctic Alaska plate extends to the outer continental shelf in the Beaufort Sea, where it is overlain by about 10 km of virtually undeformed prograded continental terrace deposits. These deposits conceal a deep half-graben, apparently part of a rifted continental margin. One interpretation is that this rifted margin may have resulted from counterclockwise rotation of Arctic Alaska from Arctic Canada to form the southern Canada Basin, but alternative explanations have been proposed. From the outer shelf, the platform bends sharply basinward, presumably in a zone of transitional crust, to the oceanic Canada Basin of the Arctic Ocean. The continental terrace deposits that overlie the transition zone are strongly rotated and slivered by listric gravity faults. Important problems are the age and geometry of rifting, the configuration of the crust in the transition zone, the temporal relation of rifting to events in the Brooks Range and Canada Basin, and the evolution of the sedimentary basins of the continental terrace and the Canada Basin.

RESEARCH PROBLEMS

A wide variety of research problems await to be addressed by TALI. Many of these problems were introduced in the previous section in a geographical context; here we discuss these and other research topics in a generic context. The construction of Alaska through the accretion of terranes is a topic of major importance for TALI; however, equally important are the evolution of the continent after amalgamation, the genesis of geologic resources, and current tectonics and related earthquake and volcanic activity.

Tectonostratigraphic terranes

Until recently, the geological history of Alaska has been interpreted under the assumption that Alaska is fundamentally continental in structure and an integral part of the North American continent. This assumption led to many complex scenarios to explain the great variations in rock type from one area to the next. With the realization in the last few years that many areas of Alaska are a collage of crustal fragments or tectonostratigraphic terranes (fig. 4), many of which have moved considerable distances with respect to each other, a whole new interpretation of both the overall and local geology is possible.

Tectonostratigraphic terranes are defined as fault-bounded geologic entities of regional extent, each characterized by a geologic history that is different from the histories of contiguous terranes. This does not imply that the terranes are all exotic, simply that they are different from their neighbors. The recognition of the boundaries of terranes often has to rely on indirect observations such as linear magnetic and gravity anomalies. It is possible that terranes are stacked vertically as well as juxtaposed horizontally, particularly in parts of Interior or south-central Alaska. For example, the base of the Chulitna terrane is a major thrust fault with much younger rocks forming the lower plate. Over fifty terranes have been proposed in Alaska.

The transect corridor crosses some key sequences of terranes. One such sequence, in the Livengood district, probably consists of many rootless slivers. A task for TALI is to unravel the structural relations of these slivers and their history of emplacement. The obvious techniques to apply are seismic reflection and refraction and deep electrical sounding to determine the thickness of the terranes; detailed geochemical studies, particularly isotope geochemistry, to determine the genesis of crustal units; and basic geologic and geophysical mapping to determine the lateral boundaries of the terranes.

"Basement" of accreted terranes

Traditionally, Alaska has been considered as being built upon a "continental" basement; however, the whole question of the nature of continental crust worldwide is being reexamined. Fundamental differences clearly exist between continental and oceanic crust, but in the case of Alaska, it is doubtful that much of the crust is truly continental in nature. Much of Alaska may be composed of stacked terranes rafted in by the motion of oceanic plates, and these terranes may be stacked deeply enough to resemble continental crust geophysically. The seismic investigations that are ongoing, and those proposed as part of the transect studies, should help resolve this question and determine which, if any, parts of "basement Alaska" can be clearly labeled as belonging to continental North America.

An example of our lack of knowledge regarding the basement of Alaska is found in the Brooks Range and Arctic Alaska. Models for the basement beneath the stacked slivers of continental margin rocks that compose the Brooks Range range from subducted oceanic lithosphere to Precambrian crystalline basement. Widely different models can also be found in the literature for the Alaska Range and southern Alaska. True continental crust of the North American craton may exist in the Tindir area near the Canadian border. However, even this area, with its similarities to the Canadian shield, is being questioned as possibly being a terrane that was rafted in from further south.

Depth to Moho

Few seismic determinations have been made of the depth to the Mohorovicic discontinuity beneath Alaska, and many of the determinations are based on limited data. For example, estimates of about 50 km for the crustal thickness beneath the Copper River basin and the northern Chugach Mountains near the southern end of the transect are based on unreversed seismic-refraction profiles obtained in 1955 by the Carnegie Institution of Washington. Reversed seismic-refraction profiles shot by the U.S. Geological Survey in 1984 reveal that along the TALI transect corridor the northern Chugach Mountains are underlain to depths of at least 40 km by a north-dipping stacked sequence of paired low- and high-velocity layers that are interpreted as slices of subducted oceanic crust and upper mantle (fig. 5). Thus, the concept of a single simple Moho discontinuity is not applicable everywhere. Estimates of depth to Moho elsewhere along the transect route are about 40 km beneath the Alaska Range and about 30-35 km beneath Fairbanks. Precise seismic measurements are needed to resolve the configuration of the crust and to confirm and interpret the variations in crustal thickness across Alaska suggested by available seismic measurements and gravity modeling.

Until recently, seismic-refraction methods have provided the most precise information about the depth and configuration of the Moho. Seismic-reflection techniques, however, are now capable of resolving this discontinuity. COCORP profiles in the contiguous United States typically resolve the discontinuity either as the lower boundary of a reflective lower crust or as a strong reflector or band of reflectors. Simply mapping the depth to, and character of, the Moho along sections of the transect route would contribute greatly to interpretations of the geologic evolution of Alaska.

Orogeny and deformation of the lithosphere

The Alaskan crust has been shaped by a variety of deformational processes; understanding the mechanics and history of these processes is one of the primary challenges for TALI. Among problems inviting study are the existence of roots beneath the three major mountain ranges traversed by the transect--the Chugach, Alaska, and Brooks Ranges; the relative roles of isostasy and flexure in supporting the Alaskan topography; the thermal and deformational history of basins and mountain ranges; the mechanics of active low-angle subduction along the Pacific margin, continental accretion, thin-skinned obduction in the Brooks Range, and rifting along the Arctic margin. A broad range of geologic and geophysical techniques can contribute information important to these problems, including geobarometry, structural analyses, microfabric studies, seismic investigations, gravity and magnetic modeling, and heat-flow studies.

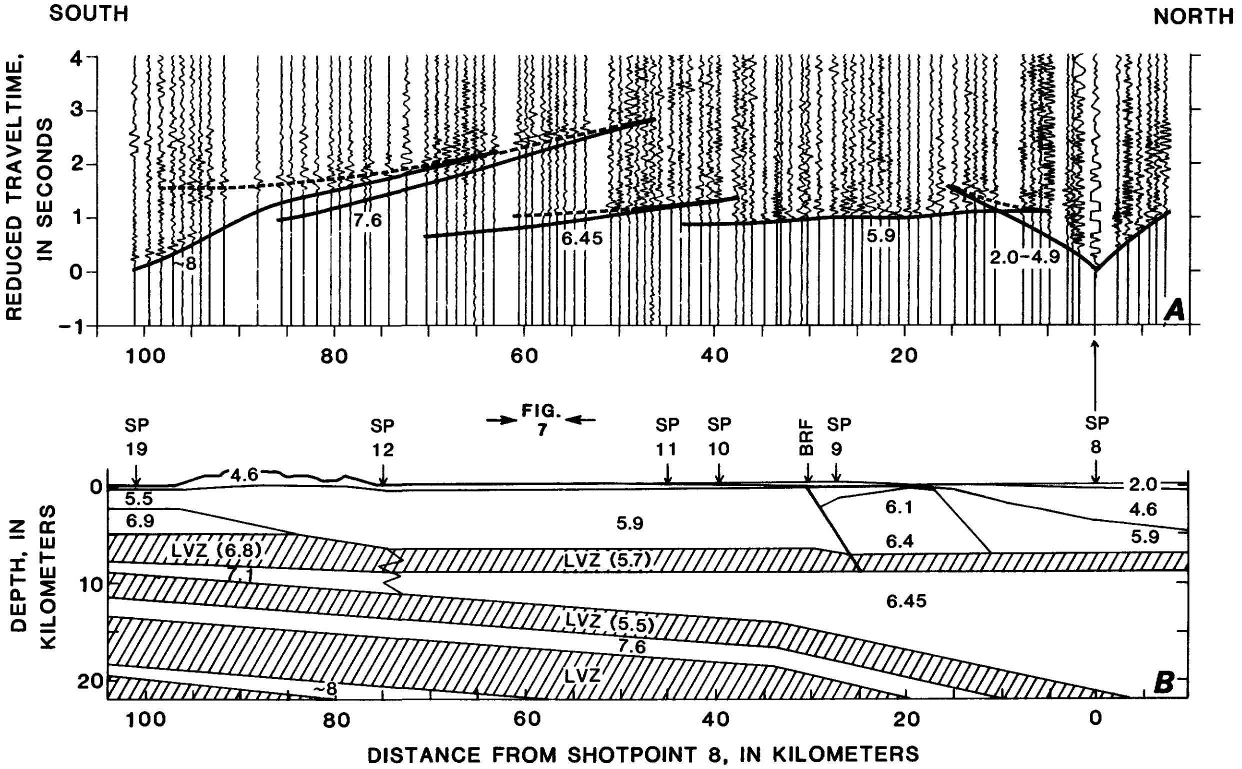


Figure 5.--Seismic record section and P-wave velocity model along TALI transect in northern Chugach Mountains and southern Copper River Basin, between about 61° and 62° N. latitude (after R. A. Page and others, 1986, Geology, v. 14, p. 501). A, Record section from shotpoint 8 at north end of seismic-refraction profile. Each vertical line is a seismogram from an individual site, range of which is indicated by position of seismogram along horizontal axis. Traveltimes are reduced by distance divided by 6 km/s. Solid lines indicate refraction branches; dashed lines, reflection branches. Numbers are P-wave seismic velocities (km/s) in layers in model below. B, Velocity model determined using data from indicated shotpoints (SP 8-12, 19) and one shotpoint off section to north. Low-velocity zones (LVZ's) are hachured. Velocities and thickness of LVZ's are not well constrained. Arrows indicate positions of shotpoints along profile. BRF, Border Ranges fault. Location of vertical seismic-reflection section in figure 7 is indicated.

Subduction and magmagenesis

The TALI corridor crosses such a variety of tectonic settings that a large range of styles of magmagenesis is accessible to study. The Gulf of Alaska, Talkeetna Mountains, and Alaska Range contain plutonic belts of Tertiary, Mesozoic, and Paleozoic ages, respectively. The Wrangell volcanic pile covers over 10,000 km^2 and is one of the largest in the world. The northern end of the Aleutian Wadati-Benioff zone, north of Cook Inlet, is interesting because that segment of the Aleutian subduction zone has no active volcanoes associated with it (fig. 4). It is likely that important constraints on the mechanics and chemistry of magmagenesis can be found by comparing segments of subduction zones without volcanoes to those that have them. The Gulf of Alaska is an especially interesting place in this regard because it encompasses the transition from the classic subduction zone in the Alaska Peninsula region to an anomalous zone of high seismicity and no volcanoes in the Prince William Sound-Talkeetna Mountains area, to an equally anomalous but contrasting zone of low seismicity and major volcanism in the Copper River-Wrangell Mountains area. The key to the lack of volcanoes associated with the Prince William Sound segment of the subduction zone may be the set of conditions that give rise to its buoyancy. Increased buoyancy would cause a shallow angle of plate descent, which might lead to significant differences in the amounts of water and sediments that are subducted as well as possible differences in the temperature along the trajectory of subduction. The TALI program could provide critical information regarding the age, temperature, and density of the material being subducted in the central Gulf of Alaska.

Major fault systems

Faulting has obviously played a major role in shaping the complex geology of Alaska. The transect route crosses several major fault systems of varying character, age, and history, ranging from the active Aleutian megathrust along the Pacific margin to the reactivated strike-slip Denali, Tintina, and Kobuk-South Fork fault systems, to the Cretaceous and Tertiary normal faults of the rifted Arctic margin. Although many faults have been mapped and investigated at the surface, little is known about the geometry and behavior of most faults at depth, particularly below a few kilometers. Two problems of particular interest are the configuration and nature of faults within major suture zones, such as the Border Ranges, Kaltag, and Kobuk fault zones, and the configuration of the extensive thrust sheets composing the Brooks Range. As demonstrated elsewhere, faults recognized at the surface often can be traced to great depths within the crust using seismic-reflection profiling. The reactivation of old fault systems is another topic of interest. A case example is the Denali fault system—a collision suture in the late Mesozoic, a part of which has been reactivated as a strike-slip fault in late Cenozoic time.

Neotectonics

The current tectonic framework of southern Alaska is well understood relative to the Interior or northern Alaska. Southeast Alaska is dominated by transform faulting, and the directions of motion correspond well with the relative motion between the Pacific and North American plates. Southwestern Alaska, particularly from the Alaska Peninsula out into the Aleutian Arc, has a "textbook" subduction zone. South-central Alaska is more complex inasmuch as it includes the transition between the transform system to the east and the subduction zone to the west. The northern edge of the subducted Pacific plate, as delineated by earthquake hypocenters, extends several hundred kilometers inland from both the trench and the continental shelf (fig. 6). The eastern edge of the Aleutian segment of the underriding Pacific plate can be more or less located by the sudden decrease in earthquake activity to the east (approximately along dotted line, fig. 6).

Although the northwest-dipping subducting plate associated with the Aleutian volcanic arc is clearly defined by seismicity, only a few hypocenters indicate the subducting slab associated with the Wrangell volcanoes. This slab dips north-northeast at an oblique angle to the Pacific-North American relative motion vector. The extrapolated 100-km depth contour on the slab lies beneath the active Mount Wrangell volcano. Southeast of the Wrangell volcanic pile is a fault-bounded block known as the Yakutat terrane or block which is presently docking against Alaska. It appears to be moving more slowly than the Pacific plate, and thus is moving with respect to both Alaska and the Pacific plate. The transect crosses the boundary between the well-defined Aleutian and the poorly understood Wrangell Wadati-Benioff zones and should resolve the nature of the boundary or transition between these two subducted plate

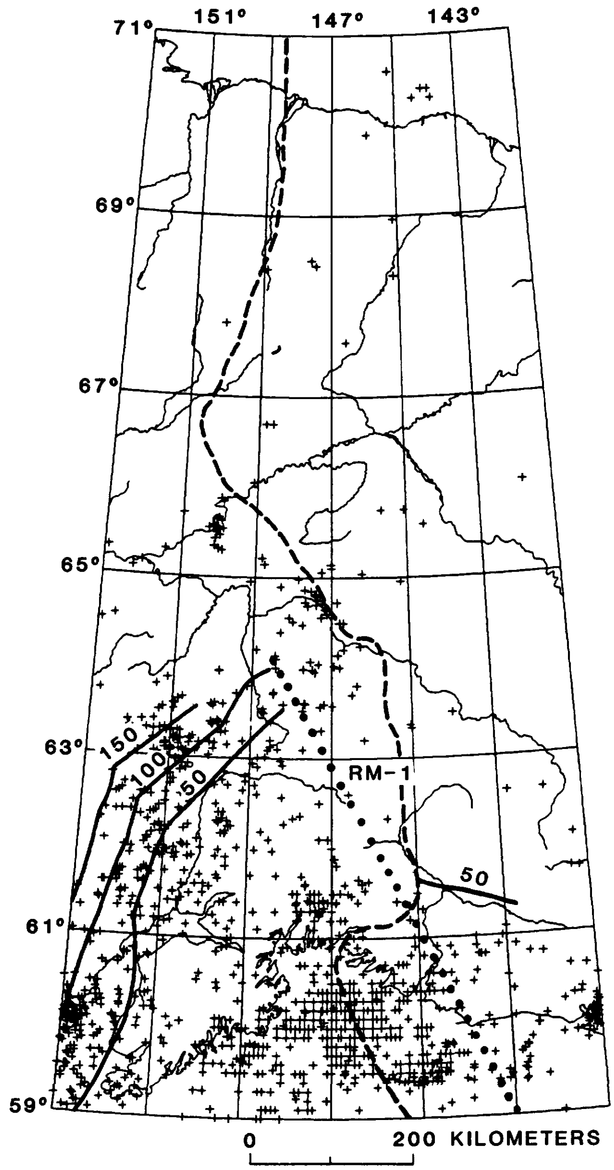


Figure 6.—Epicenters of earthquakes of magnitude M≥4.0 in vicinity of TALI transect (dashed line), 1900-1983 (from ADGGS files). Focal depth contours at 50-, 100- and 150-km levels are shown together with section of small circle (dotted line) about relative motion pole of Pacific and North American plates (RM-1).

segments.

Northern Alaska is commonly depicted as simply part of the North American plate, the Eurasian-North American plate boundary being somewhere in Siberia. However, the various plate boundaries drawn through Siberia and Sakhalin Island, or through Kamchatka, produce relative motion anomalies on global reconstructions. This suggests the possibility that a Bering Sea plate exists, which then leads to the question as to the location of its eastern boundary. It is possible that the belt of diffuse seismicity crossing the Brooks Range southwestward from the Mackenzie Delta region represents a deforming plate boundary. The proposed transect crosses this diffuse seismic trend, and it is possible that new information on the depth to Moho and basement structure will produce evidence for or against such a deformational plate boundary.

Oroclinal bending

In his now classic paper of 1958, S. Warren Carey defined the term orocline using the curved Alaska Range as one example. He explained the origin of the Alaska orocline as due to bending at the hinge between the Eurasian and North American continents as a result of the opening of the Atlantic Ocean. Subsequent attempts to investigate the orocline hypothesis have not so much disproved it as demonstrated other possible processes, such as the accretion of exotic tectonostratigraphic terranes.

The oroclinal bending concept applies not only to features such as the Alaska Range and the Brooks Range, which in Carey's model were supposed to have bent as part of a bending of the whole crust or lithosphere, but also to decoupled slices of crust. This mechanism has been proposed to explain the curvature in plan view of some of the accreted terranes of southern Alaska. It is supposed that they acquired their present curvature as the result of colliding with a curved backstop; the lithospheric plate on which they were carried was presumably subducted. Both of these oroclinal bending processes may have operated in Alaska, and if so, evidence may be combined in the paleomagnetic record and in crustal and subcrustal structures, particularly in the configuration of the underlying lithosphere.

The Brooks Range oroclines are defined in different ways by different authors. A somewhat subtle concave-northward curvature may be explained by compression between the Eurasian and North American plates. There is also the bend to the south if the eastern end of the Brooks Range structure is connected to the Rocky Mountain system. Many tectonic models depend on this connection, or the connection to the Canadian Arctic. Though this is not a problem that could be tackled directly by the present transect study, information on the deep structure beneath the Brooks Range will help constrain the possible models.

Earthquake hazards

In the assessment of seismic risk, often least understood are the basic seismotectonic and geologic facts on which estimates of the earthquake hazard are founded. These facts include considerations such as the geometry of the Wadati-Benioff zone, the activity of various fault segments, and the delineation of seismotectonic zones. Our understanding of these fundamental geological facts evolves slowly, in concert with the development of information from many disciplines; rarely can fundamental advances be made in the course of the risk analysis for a given project because the scope of investigation, resources, and time frame are all too limited. Therefore projects such as TALI can make important contributions to the assessment of earthquake hazards in Alaska, both because of the new information that will be developed and because of the synthesis of geological and geophysical information that it will encourage. In southern coastal Alaska, the TALI corridor includes the presently active plate boundary where basic questions exist as to the depth and lateral extent of the Pacific plate beneath Alaska, especially under the Wrangell volcanoes. In south-central Alaska, the corridor crosses several suture zones and transform faults, such as the Border Ranges and Denali fault systems. In the Interior, it crosses the Fairbanks and Rampart seismic zones, areas of persistent seismic activity that are not yet associated with any specific structures. In northern Alaska, the corridor crosses the Kaltag-Yukon-Porcupine and Kobuk-South Fork fault systems and the many thrust sheets of the Brooks Range. In each of these areas, the potential is high for developing new information on the activity or capability of specific fault systems and for making a major advance in our understanding of the basic seismotectonic framework of Alaska.

Volcano hazards

The Wrangell Mountains in south-central Alaska are a cluster of largely post-Pliocene calc-alkaline andesitic volcanoes. The edifices are closely spaced, reach elevations up to 5,000 m and have had extremely high eruption rates as compared to other arc-type volcanoes around the Pacific rim. The Wrangell volcanoes are among the largest volcanoes in the world to be found at a convergent plate margin. A Wadati-Benioff zone associated with the Wrangell Mountains has recently been defined, suggesting that post-Pliocene volcanism is linked to a subducted plate segment that is possibly attached to the leading edge of the Yakutat block (terrane). The Wrangell volcanic pile of late Tertiary through Quaternary age is not related to the underlying Paleozoic and Mesozoic basement (the Wrangellia terrane). A major geophysical anomaly associated with the Wrangell volcanoes is a regional gravity low in excess of 150 mGal amplitude, the origin of which is not well understood.

Fundamental tectonic and volcanologic questions related to the unique Wrangell volcanoes, which could be answered by nearby TALI traverses, include structure of the crust, origin of the mass deficiency beneath the Wrangells, extent and configuration of the subducting plate, thickness and relationship of the Wrangell volcanic rocks to the Wrangellia terrane, and unusually high effusive rates of Wrangell volcanism. Related to the latter point are obvious volcanic hazard concerns that need to be addressed. For example, a late Quaternary volcanic debris flow from Mount Wrangell reached the Copper River near the Richardson Highway--a distance of about 45 km. The Wrangell Mountains may be the source of some of the very large ash deposits found in Alaska. Detailed geochemical studies including isotope geochemistry could shed some light on the source regions of the unusual Wrangell lavas.

Metallogenesis

It has long been known that certain kinds of mineral deposits are associated with specific geologic settings, but it is only in recent years that some of the cause-and-effect relationships have been discovered. An example is the direct observation of mineral-rich hot springs in the rift valleys associated with submarine spreading centers, and the recognition of economic mineral deposits that originally developed in such settings. In general, it appears that major metal ore deposits are generated near, or are related to spreading centers and subduction zones. Since it is now recognized that much of Alaska is made up of fragments of crust rafted in from elsewhere, and that many of these fragments have been associated with subduction zones before and(or) during the accretion process, the location of these fossil zones would be an aid to mineral exploration. The converse of this is the identification of the tectonic settings from studies of mineral deposits. An example is the hypothesis of a failed rift for the generation of the Brooks Range mineralized belt. In either case, the identification of ancient tectonic boundaries within the jumble of Alaskan terranes could significantly enhance mineral exploration strategies.

Basin analysis

Nearly every field of geology and geophysics can contribute substantially to the geologic analysis of basins; hence the multidisciplinary studies planned for TALI will aid greatly in our understanding of Alaskan basins. In particular, the plans for TALI that include detailed geologic mapping as well as radiometric and biostratigraphic dating will give new insight into basin history, stratigraphy, and structure. One profile through a basin cannot adequately characterize the detailed stratigraphy and structure of parts of the basin that are remote from wells and outcrops. However, regional crustal features that control the location and configuration of basins may be sufficiently well characterized by a single line or section. Study of seismic-reflection data together with available outcrop and well data can illuminate the relationship between the regional crustal structure and the broader aspects of basin stratigraphy and structure, such as regional faults, unconformities, and major changes in depositional style. The evolution and thermal history of a basin can be analyzed by combining seismic-reflection data and information about heat flow and the metamorphic pathways of rocks that floor or border the basin.

Geothermal resources

The southern part of the TALI corridor traverses the Copper River basin, an area which includes a region near Mount Wrangell volcano that has a moderate to high potential for geothermal energy recovery. The rate of volcanic activity in the Wrangell Mountains has been about five times greater than that reported for other circum-Pacific volcanoes. It is probable that a large amount of heat has been transferred into the upper crust. Mount Wrangell is still active, and Mount Drum was active less than 200,000 years ago. Residual heat reservoirs may be quite near the surface in the vicinity of these volcanoes. The basic geological and geophysical studies planned for the USGS TACT project will help to constrain models for the development of the Wrangell volcanoes. Other studies are needed to constrain models of the heat budget for the Wrangell area. It is possible that a significant energy source could be developed here.

RESEARCH TECHNIQUES

The challenging problems in Alaskan geology and tectonic evolution are best addressed by application of a broad range of complementary research techniques drawn from different earth-science disciplines. Because investigation of Alaskan geology in its third dimension--depth--is a major thrust of TALI, geophysical methods, and particularly seismic techniques, will play a vital role.

Seismological

Seismological techniques provide valuable constraints on earth structure and rock composition when used in conjunction with geologic and laboratory techniques, well data, and other deep sounding techniques, including gravity, aeromagnetic, and magnetotelluric methods. For example, the geologic nature of a buried seismic discontinuity recognized in a seismic record can be interpreted if the discontinuity can be traced to the surface. As another example, knowledge of rock velocity in combination with resistivity provides a powerful constraint on rock composition.

A major development that could benefit TALI is the Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) initiated by IRIS (Incorporated Research Institutes in Seismology). PASSCAL is a collaborative effort of more than 40 universities and research institutions to design, build, and operate a 1,000-element seismic array to investigate the structure, physical properties, and earthquake physics of the continental lithosphere. The elements of this proposed array would be portable digital seismic recorders that would obtain data over a broad band of frequencies with a high dynamic range. An array of such recorders would undoubtedly facilitate and enhance many of the seismological investigations that might be proposed as part of TALI; however, several critical seismic studies can be implemented with existing instrumentation.

Artificial sources

Refraction and wide-angle reflection profiling

Seismic-refraction and wide-angle seismic-reflection profiling yield estimates of lateral velocity variations and depths to velocity discontinuities within the crust and upper mantle. The technique is capable of resolving structural variations on the order of a few kilometers and velocity variations of a few percent. Spread lengths of 100 to 200 km and relatively large explosions (1,000 kg) are required to determine structure in the upper and lower crust, but longer spreads and even larger explosions are generally necessary to investigate the Moho and upper mantle. This technique is therefore suited for investigating seismic structure of sufficiently large tectonostratigraphic terranes where velocity contrasts within and between terranes exceed a few percent. The lower crustal structure of the terranes, including the deep structure of mountain ranges and variations in depths of Moho, is addressable by seismic-refraction techniques once the upper crustal structure is known. The seismic-refraction technique is already producing exciting results from southern Alaska. Initial USGS seismic-refraction profiles in the Chugach Mountains reveal a complex lithosphere comprising thin accretionary terranes overlying stacked slices of inferred subduction assemblages of oceanic crust and upper mantle (fig. 5). Experiments that can be performed with large explosions include acquisition of new profiles, extension and densification of existing profiles, and amplitude studies to determine seismic attenuation and velocity gradients.

Vertical reflection profiling

Vertical seismic-reflection profiling is the principal geophysical tool of the petroleum industry for exploring sedimentary basins with fine resolution of stratigraphy and geological structure. In the last decade, seismic-reflection profiling of the continental crust has become an important means for exploring deep crustal structure with greater resolution than any other geophysical technique. Vertical reflection profiling can reveal the configuration of both simple and complex crustal structure with high resolution. Reflection profiling, especially when large offsets are used, also provides information on seismic velocities. Where deep crustal reflections can be traced to shallow depths and correlated with surface geologic features, the method is exceptionally powerful.

Reflection profiling will surely provide critical information on Alaska's complex near-surface geology and its heterogeneous crust of accreted terranes. A realistic goal for TALI is a complete end-to-end seismic-reflection profiling study of the trans-Alaska oil pipeline route. To stimulate interest in this goal, the USGS in 1986 contracted acquisition of two demonstration profiles in southern Alaska--one in the Chugach Mountains and southern Copper River Basin, crossing the Border Ranges suture zone, and one in the Alaska Range, crossing the Denali fault. Both profiles successfully imaged crustal reflectors. Field records south of the Border Ranges fault, for example, reveal prominent horizontal and gently dipping, anastomosing reflections in the depth range 15 to 35 km (fig. 7). In combination, the refraction and reflection data provide powerful constraints on interpretations of the structure of the upper lithosphere.

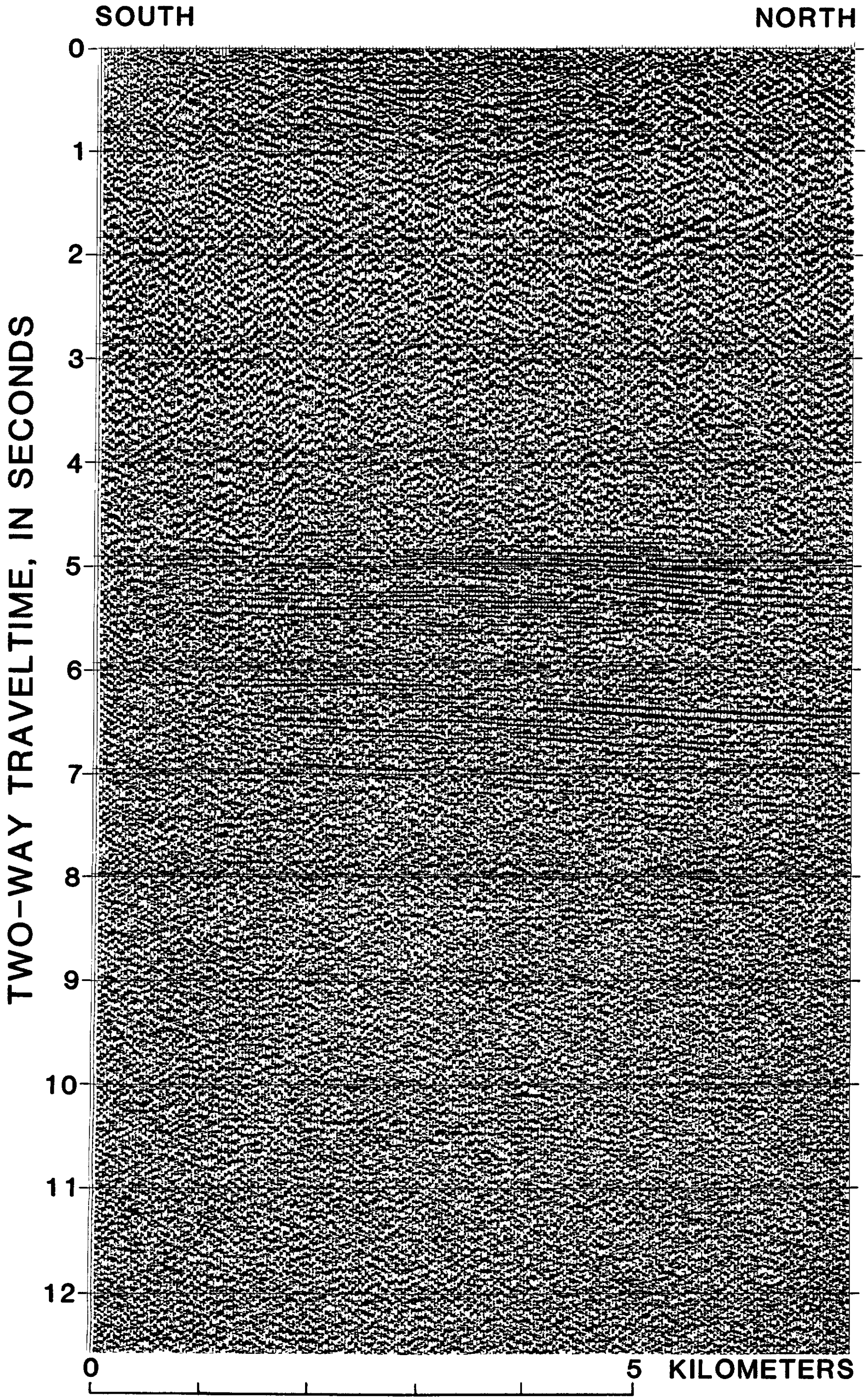
Marine profiling

Marine studies including seismic-reflection, seismic-refraction, and dredge sampling could provide essential constraints on the structure of the Alaskan continental margins. In particular, seismic profiling could yield information on the configuration of the North American-Pacific plate boundary at depth, the structures developed within the overriding plate, and the geometry of the subducting oceanic slab. Seismic-refraction data complement vertical reflection data by providing more detailed velocity information and by sampling the earth over different ray paths and at different frequencies. When combined with test well data and seafloor sampling, seismic data can yield information on the timing of deformational events and the nature of the reflective seismic horizons. Single-ship, large-source-array, and two-ship marine studies are particularly powerful ways to obtain seismic profiles.

Earthquake sources

Seismic imaging

It is important to supplement knowledge of crustal structure obtained by seismic refraction and reflection with information on the deep structure of the lithosphere and asthenosphere. Techniques using the arrival-time residuals of seismic waves


SOUTH
NORTH
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
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5
6
7
8
9
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11
12
0
5 KILOMETERS

from teleseismic and regional earthquakes are the most useful for investigating the earth to depths significantly below the Moho. Deep imaging of the earth's crust and upper mantle using these techniques has provided fundamental information about tectonic processes related to hot spots, subduction zones, rift zones, plate boundaries, and intraplate volcanic centers. Three-dimensional inversion and tomographic techniques can be used to delineate heterogeneities in the crust and mantle associated with a subducting plate.

The resolution of teleseismic-residual techniques for delineating velocity anomalies is about 5 km horizontally and 10 km vertically, depending upon the density and configuration of the seismic array used for recording the teleseisms. Velocity variations as small as 0.5 percent can be measured. Using intermediate-period seismometers in the arrays, shear waves can be recorded so that shear-wave traveltime residuals can also be modeled. Modeling shear-wave velocity anomalies simultaneously with P-wave anomalies allows a more definitive interpretation of the physical and thermal properites of the modeled volume. In addition to teleseisms, the large number of deep earthquakes occurring in southern Alaska itself can be used to model the subduction zone there, as has been done in Japan. P- and S-wave amplitude data from teleseisms and regional earthquakes can support estimates of the spatial variation of seismic attenuation to provide additional constraints on the structure and physical properties in the deep crust and upper mantle.

Seismicity studies

Precise earthquake hypocenters can be used to delineate buried active faults. Such structures often are not amenable to investigation by seismic refraction or reflection because they either are too deeply buried or juxtapose rocks of similar velocities or densities. The distribution of seismicity also provides important clues in regard to the rheological properties and stress conditions at depth within the lithosphere.

Figure 7.--Vertical seismic-reflection section from the northern Chugach Mountains, southern Alaska. See figure 5 for location. Strongly reflective character of section between 5 and 10.5 s is consistent with layered sequence of alternating low and high velocities inferred from refraction/wide-angle reflection survey (fig. 5). Horizontal axis, distance along profile. Vertical axis, two-way traveltime; 1 s approximately equals 3 km. Section is partial brute stack produced in field. Seismometer group interval, 30 m; vibrator interval, 120 m. Fold of data increases from 1 at edges of record to about 30 in center.

Hypocenters of earthquakes large enough to be recorded at teleseismic distances can be determined to accuracies of several kilometers, provided the traveltimes are precisely measured and the velocities of seismic waves to the recording stations are adequately known. Frequently, the location accuracy of large historic earthquakes can be improved by relocating the events using specially calibrated traveltimes. Shocks recorded by dense regional seismograph arrays can be located to accuracies approaching 1 km if the regional velocity structure is adequately known. Hypocentral resolution, or accuracy of relative locations among adjacent shocks, typically exceeds absolute accuracy, because it is limited only by errors in measuring arrival times. Thus, the configuration and orientation of a buried seismogenic feature may be determined more accurately then its actual location.

Seismicity studies can contribute to the solution of several important problems. Among them are the extent, continuity, and configuration of subducted lithosphere beneath southern Alaska and, in particular, between the Aleutian and Wrangell Wadati-Benioff zones; the styles of faulting and rates of seismic deformation on the Aleutian and Wrangell megathrusts and within the overriding and subducting plates in southern coastal Alaska; the relation of seismicity to mapped or geophysically inferred geologic structures and lithology; the reactivation of ancient faults and sutures; and the seismotectonic framework of Alaska. The solution of many of these problems requires the temporary deployment of seismograph arrays either to supplement clusters of existing seismograph stations (fig. 8) or to provide seismograph coverage where none currently exists.

Focal mechanism studies

Focal mechanism studies include both traditional double-couple interpretations of P-wave first motions and S-wave polarizations, and seismic-moment tensor solutions which have become routinely possible with the advent of a worldwide set of digital seismograms. Each of these techniques provides information that is grossly interpretable in terms of the state of stress in the vicinity of the earthquake source. For all earthquakes, except very shallow ones, focal mechanism studies provide the only possible measurement of the state of stress in the vicinity of the focal region.

Focal mechanism solutions might suggest the nature of the northeastern termination of the Aleutian Wadati-Benioff zone--whether the subducted slab is torn at that point or merely becomes seismically quiet. For shallow earthquake concentrations along the transect route, focal mechanism studies in combination with precise hypocentral determinations could resolve the orientation and sense of motion of buried active faults.

Surface wave analysis

Measurement of phase- and group-velocity dispersion of Rayleigh waves provides a simple method to determine regional shear-wave velocity structure from earthquake-generated waves recorded at a few stations. The theory of interpretation relies upon simple plane-layered earth structures in which the layer thicknesses and compressional velocities are known. For this reason, the method is most powerful when applied to a region for which seismic-refraction data are available.

Relying upon natural sources, the experiment requires a relatively long period of continuous recording (6 months to 1 year) to obtain an adequate data set. The dimensions of the larger Alaskan terranes, approximately 200 km, are adequate for measurements of waves with periods of 15 to 200 seconds using a 5- to 10-station array. Generally speaking, this bandwidth is suitable for determining shear velocity structure from the mid-crust to the low-velocity channel of the asthenosphere. A large number of stations reduces error in the dispersion measurements and thus improves confidence in the interpretations. A reasonable TALI objective would be to employ five or more instruments with bandwidth from 1 to 100 seconds for 6 to 12 months across each large terrane. This would allow determination of the average elastic properties for each terrane, properties that are not available from methods based on active seismic sources.

Geophysical (nonseismic)

Other geophysical studies will play an important role in support of the TALI seismological studies. These include potential-field methods, such as gravity and magnetic modeling; geoelectrical methods, such as magnetotelluric soundings; borehole-based methods, such as heat-flow measurements and in situ stress measurements; paleomagnetic methods to determine paleolatitude of major portions of the Alaskan crust; and aircraft- and satellite-based methods, such as remote sensing to help delineate structural and geological blocks, and satellite-based geodetic measurements to detect present-day relative motions between these blocks.

Potential-field geophysics

Gravity analysis

Local variations (anomalies) in the earth's gravity field can be used to discriminate geologic bodies that differ in density from their neighbors and to infer their geometries and contrasts in density. Thus, gravity is useful in studying such features as igneous intrusions, sedimentary basins, faults, geological contacts, and crustal roots associated with foldbelts or subduction zones. Gravity data are also critical for assessing whether

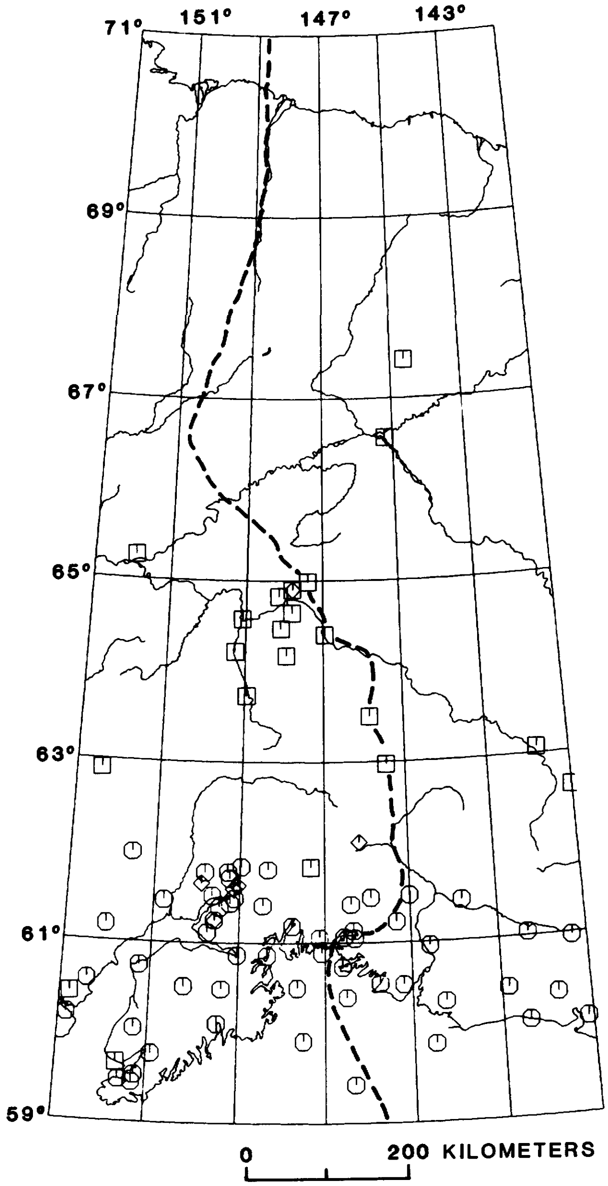


Figure 8.--Location of seismograph stations in vicinity of TALI transect, 1984-1985. USGS stations are represented by hexagons, UAF stations by squares, and NOAA stations by diamonds. Note paucity of stations north of 65° N. latitude.

the topography along the transect is isostatically or dynamically supported. The USGS is compiling existing gravity data in digital form to facilitate production of complete Bouguer gravity anomaly maps along the transect route, and for use in interpreting the geologic and other complementary geophysical data. Limited additional gravity data are being collected in conjunction with the ongoing USGS seismic profiling and in conjunction with several State, Federal, and university field projects. It is hoped that industry data will also become available. In general, additional gravity coverage is needed within the TALI corridor; it may be obtainable with recently developed airborne gravity techniques.

Opportunities exist for modeling not only the geometries and density of geologic bodies and the configuration of geologic boundaries within the TALI corridor, but also the rheologic response of the lithosphere to tectonic processes, including subduction, obduction, formation of batholiths and volcanic fields, and oroclinal bending. An important data base for large-scale rheological modeling is that derived from satellite altimetry.

Magnetic analysis

Although magnetic data are available for most of the State and all of the TALI corridor, they are commonly in various formats and have been collected in various ways. The USGS and the ADGGS have compiled the available data, but the data still need refining and gaps need to be filled.

Opportunities exist for analysis of existing magnetic field data along the TALI corridor and also for the collection and analysis of new data in certain areas. These opportunities include modeling of magnetic structures via semi-inverse and filtering techniques, estimation of Curie-temperature depths, and synthesis of magnetic results with those from geologic, seismic, and other geophysical methods.

Deep geoelectrical studies

Deep geoelectrical studies include magnetotellurics, active-source time-domain sounding, and direct-current resistivity sounding. These methods are capable of determining electrical resistivity at depths ranging from a few meters to several hundred kilometers. Resistivity of crustal and mantle rocks is related to rock type, temperature, and water content; it thus may help to identify geological features that are hard to detect otherwise, such as deep crustal conductors that may characterize mylonitized zones or tectonically mobilized zones. As is common with geophysical observations, the properties determined by geoelectrical methods seldom have a unique interpretation, but they can be used to constrain, or their interpretation can be constrained by, the results of other geophysical techniques.

Magnetotelluric soundings are especially useful when done in conjunction with seismic-reflection and -refraction profiles, as they can penetrate to similar depths. Geoelectrical data can in places indicate major faults and depths of sedimentary basins, differentiate between sediments of different geologic ages, and resolve spatial variations in the physical properties of the crust; thus they are useful in constraining and augmenting seismic interpretations. Opportunities exist to conduct geoelectric sounding along the TALI corridor and to apply appropriate interpretative techniques.

Paleomagnetic studies

Paleomagnetism uses remanent magnetism, acquired as the rocks were laid down or cooled from a molten state, to reconstruct paleogeography. Available data indicate that several major terranes of southern Alaska originated at equatorial paleolatitudes. There is not yet enough information available to resolve the rates or style of northward motion, or its timing, although as more data accumulate, the constraints on possible models get tighter. Paleomagnetic measurements can also aid in determining whether terranes identified on geologic grounds were ever significantly displaced from one another. For Arctic Alaska, however, a pervasive overprint has masked the paleomagnetic record and made this determination difficult. Nevertheless, studies of this overprint itself, in the Brooks Range and elsewhere, may give valuable information relating to the thermal and tectonic history of the terranes of the TALI corridor.

Borehole geophysical studies

A number of boreholes may become available for research purposes during TALI, such as petroleum or mining exploration holes, seismic shot holes, holes drilled in connection with other scientific programs (for example, permafrost studies), or holes dedicated for specific TALI objectives. These boreholes will provide opportunities for heat-flow measurements, which would permit preparation of a heat-flow map for the TALI corridor and nearby portions of Alaska and Canada; in situ stress measurements via hydrofracturing techniques or emplacement of strain gauge arrays; and measurement of geoelectric, density, seismic, and other geophysical properties, and lithologic descriptions of the rock masses penetrated by the borehole.

Satellite-based studies

Remote sensing

Airborne and satellite remote sensing techniques use electromagnetic radiation in the visible, near-visible, and gamma-ray bands collected from airborne or satellite sensors. The data are processed to produce images which reflect tectonic elements (for example, faults), geochemical signatures (for example, alteration patterns), and physical properties (for example, the thermal inertia of the rocks). Opportunities exist to produce remote sensing images of the TALI corridor and to integrate them with geologic and other types of data.

Geodesy

New developments in space and satellite geodesy allow relative distance measurements at the earth's surface at the decimeter level at present, and perhaps at the centimeter level within the lifetime of TALI (5-6 years). These techniques are being applied to Alaskan geodynamic problems initially near the active plate boundary along the Pacific margin, with emphasis on seismic gaps. In the future, the techniques will be used to investigate internal plate deformations. Starting in 1984, six sites in Alaska were occupied by very long baseline interferometry (VLBI) stations, three of which focused on the Pacific-North American plate margin. Simultaneous measurements in Japan, Kwajalein, Hawaii, California and Canada were made to establish the first baseline data for the relative motion between the Pacific and North American plates and for stability within the North American plate. These measurements will bear on subjects of central interest to TALI: (1) plate boundary processes in southern Alaska; (2) relative motion between terranes bounded by active faults in the interior of Alaska; (3) isostatic equilibrium and vertical crustal deformation; (4) strains associated with ongoing flexure of the lithosphere; and (5) delineation of stress provinces through combination of space geodetic measurements with geologic and volcanic stress indicators and with other direct and indirect stress measurement methods.

Rock properties

Information on the properties of rocks from the TALI corridor is needed for use in modeling and interpreting geophysical data along the corridor. Rock properties measured by the geophysical teams involved in TALI should be incorporated into a widely accessible data base. Important parameters to include are rock type and mineralogy, porosity, pore fluids, chemistry, density, magnetic susceptibility, electrical resistivity, and P- and S-wave seismic velocities and velocity anisotropies. Many measurements of these various rock properties exist, but they are scattered throughout industry, State and Federal agencies, and universities. Existing information needs to be compiled in an accessible data base to which new data could be added.

Geological

TALI presents many geological research opportunities for advancing the knowledge of the stratigraphy, structure, tectonics, and geologic history of Alaska. Geological studies will provide the framework for deciphering the deep crustal structure of Alaska and will elucidate the nature and history of accretionary tectonic processes that have shaped the Alaskan lithosphere. Geological data and interpretations are essential for providing the foundation for interpreting data obtained from seismic and potential-field geophysical methods, and from other geophysical and geochemical techniques that will be incorporated in TALI.

Deciphering the complex geologic history of the TALI corridor demands application of a broad suite of geological and geochemical methods. Maximum progress requires coordination and integration of various types of geological and geochemical studies, many of which should proceed in parallel. For example, structural and fabric studies of metamorphic rocks should be integrated with petrologic and isotopic studies to determine the temperatures, pressures or depths, and ages of simultaneous periods of metamorphism and deformation.

Geologic mapping

Geological mapping is the most basic ingredient of the TALI program in the sense that all other earth-science disciplines and techniques require knowledge about the nature and distribution of the various bedrock units that occur along the transect route. The principal components of geological mapping should include: (1) compilation of existing mapping within 50 to 100 km of the TALI route at scales of 1:250,000 or larger; (2) systematic mapping along the TALI route at a scale of 1:63,360; (3) larger scale mapping of geologically complex or critical areas, such as major sutures; (4) collection and compilation of data for topical maps, such as metamorphic isograd and facies maps, structural maps, and maps of active faults and Quaternary tectonic deformation; and (5) regional maps along the route with emphasis on synthesis.

Stratigraphic, basin analysis, and paleontological studies

Several types of basic information are needed to elucidate the nature, origin, and geologic history of sedimentary rocks exposed along or near the TALI route. This knowledge will further understanding of the timing of amalgamation of accreted terranes and the long-term history of vertical tectonic movements in and near sedimentary basins. The types of information needed include: (1) sedimentary facies distribution; (2) sedimentary petrology; (3) diagenetic and thermal history, and organic maturation data; (4) biostratigraphy, paleoecology, and paleontologic province data; (5) structural framework of sedimentary basins; and (6) paleocurrent and provenance data.

Petrologic, geochemical, and isotopic tracer studies

These three disciplines will provide significant information on the temperature-pressure histories of the various exposed crystalline terranes. They can provide information on the existence of ancient magmatic arcs in Alaska, on the distribution of accreted oceanic crust, and on plutonism associated with accretion of allochthonous terranes onto nuclear Alaska. Petrologic, geochemical, and isotopic investigations will focus on the various igneous and metamorphosed igneous rocks to determine the mineral phases, the abundances of major, minor, and trace elements, and the isotopic composition of selected elements, such as strontium and lead. The most important goals of such investigations will be: (1) to infer the original plate-tectonic environment of the volcanic rocks, such as mid-ocean ridge, intraoceanic arc, or intraplate platform; (2) to determine the pressure-temperature conditions of generation of various plutonic rocks; and (3) to determine the nature and origin of compositionally distinctive mafic or intermediate rock suites, such as the mafic complex of the Border Ranges and associated intermediate intrusive rocks of the Chugach Range. Together, such results may place constraints on the nature of the lower and intermediate crust that are not obtainable by other means.

Petrologic studies of metamorphic rocks

Petrologic studies will address the pressure-temperature and deformational history of metamorphosed crystalline rocks exposed along the TALI route. Amalgamation and accretion of terranes should leave a weak to strong metamorphic imprint on deep crustal rocks. Recently developed techniques can yield relatively precise information on the temperature, total pressure or depth, and fluid pressures that occurred in each event; and isotope geochronology can commonly date these events. Petrologic studies of metamorphic rocks, including determination of prograde and retrograde mineral assemblages, microprobe analyses of mineral phases, and studies of fluid inclusions and vein fillings will elucidate the pressure-temperature conditions of metamorphism. In conjunction with age-annealing and temperature studies by fission-track and ^{40}Ar-^{39}Ar methods, the various petrologic results may be used to construct the pressure-temperature paths, temperature gradients, and histories of uplift of metamorphic rocks.

Structural and fabric studies

Structural and fabric studies will yield important information on the deformational history of rock sequences. Such studies can provide constraints on timing and geometry in the amalgamation of allochthonous terranes and in their accretion to the margin of nuclear Alaska. Important topics for investigation include: (1) the structural history of individual terranes or geologic regions; (2) the geometry of the deformation(s) exhibited by various rock sequences or masses in each terrane or geologic region; (3) the kinematics or movements of each terrane or geologic region during migration and accretion; and (4) the movements of individual minerals and correlation of these movements with those deduced from geometric analyses of structures.

Age studies

Dating of rocks is requisite to deciphering the complex geologic record. Dating studies will provide information on (1) the ages of igneous, metamorphic, and some sedimentary rocks encountered along the transect; (2) the plate tectonic origins and modifications of igneous rocks; and (3) the timings of metamorphisms and deformations that occurred during discrete tectonic events, such as terrane accretion. Essential dating techniques include K-Ar, U-Pb zircon, Nd-Sm whole rock, Rb-Sr whole rock and mineral isochron, and fission track analyses.

Metallogenesis studies

Currently an extensive study is being completed by the U.S. Geological Survey and the Alaska Division of Geological and Geophysical Surveys on the genesis of metallic mineral deposits and their relation to accreted terranes of Alaska. This study is being done for the Alaskan volume of the Decade of North American Geology under the sponsorship of the Geological Society of America. The ADGGS, USGS, and U.S. Bureau of Mines are also studying the metallogenesis of mineral deposits in the Dalton Highway corridor in the southern Brooks Range. TALI will present a unique opportunity to conduct additional detailed studies of mineral deposits in each metallogenic province exposed along the transect route, and to relate the formation and modification of mineral deposits to the origin, migration and accretion, and metamorphism of the enclosing terranes. Detailed studies of deformed and metamorphosed mineral deposits should also be integrated with metamorphic petrologic and structural studies to help determine temperatures, pressures, and timings of tectonic events. These studies will provide valuable information on the mineral resource potential of Alaska.

Neotectonic studies

Alaska is the most tectonically active area of the United States, and studies of neotectonics will provide valuable clues about ongoing geologic and tectonic processes. Three major areas of neotectonic studies could contribute significantly to TALI. First, rates and styles of Holocene tectonic deformation could be determined in a variety of geologic domains along the TALI route. Current strain is being monitored by periodic observations of a geodetic network across the strike-slip Denali fault. In southern coastal Alaska, studies of displaced shorelines and geodetic surveys have documented horizontal and vertical deformation associated with the thrusting during the great (M_w 9.2) Prince William Sound earthquake of 1964.

Information on the earlier Holocene vertical displacement history of the Prince William Sound area has come from studies of radiocarbon-dated uplifted terraces and drowned shorelines. Little is known about Holocene deformation elsewhere along the corridor. Second, late Tertiary and early Quaternary tectonic deformation could be documented by studies of erosional surfaces that could include determination of: (1) the existence of single or multiple surfaces; (2) relative heights of erosional surfaces above mean sea level; (3) warping, rotation, or faulting of erosional surfaces during the Holocene; or (4) deposition of alluvial fans, rock glaciers, fluvial sediments, or marine sediments on erosional surfaces. Third, more extensive local seismograph networks, augmented by geodetic strain and tilt instrumentation, could be established along active faults, as now exist along various major faults in parts of central and southern California. The data from such networks could document current rates of seismic slip and senses of offset along the faults. Additionally, geologic studies of trenches dug across major, known or suspected active faults, such as the Denali fault, could provide information on their paleoseismic history.

Deep Drilling

The spectacular results of the Soviet deep drilling program at the Kola research well are an ample demonstration of the value of deep continental drilling. It is essential that a few deep wells be drilled to investigate geologic processes and in situ physical properties and, secondarily, to provide some "ground truth" tie points for geophysical interpretations of critical deep geologic sections. Continental scientific drilling is a major element of the NSF's Continental Lithosphere Program, and appears on its way to being established as a major program in its own right, much in the same mold as the ocean drilling program under JOIDES. A consortium of universities--DOSECC (Deep Observation and Sampling of the Earth's Continental Crust, Inc.)--was formed in 1984 to design and manage the NSF continental scientific drilling program.

One obvious target in southern Alaska is a deep hole at the south end of the transect to examine geologic processes and physical conditions within an active subduction zone. A candidate site for a hole is on Middleton Island, near the eastern end of the Aleutian arc (fig. 9).

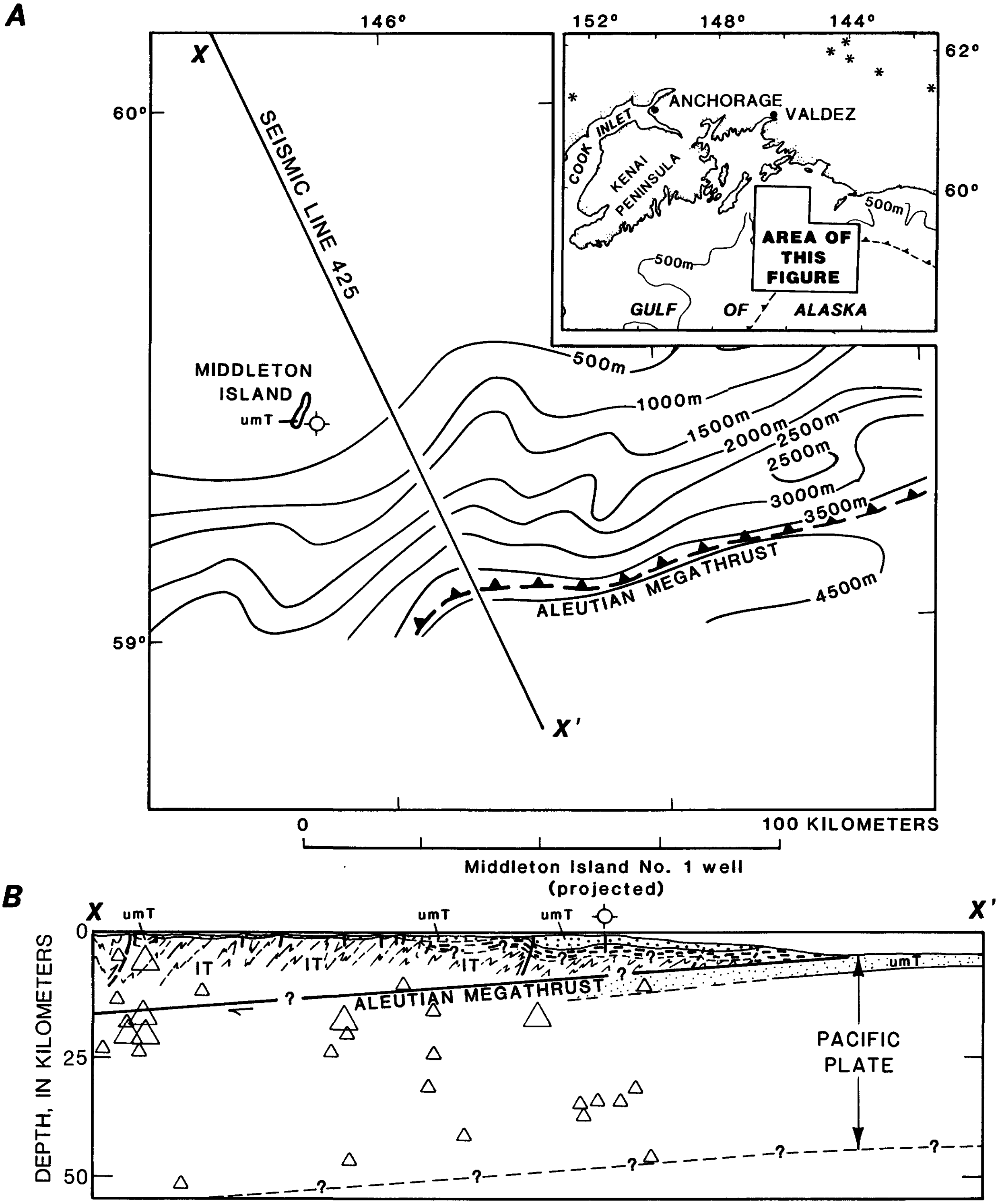
Middleton Island sits on the upper plate of the Aleutian megathrust, at the edge of the continental shelf, 50 km landward of the Aleutian trench. A petroleum well, drilled 3 km southeast of the island to a depth of nearly 4 km, indicates a normally stacked sequence that bottoms in early or middle Eocene strata. Elevated wave-cut terraces on the island record a sequence of at least six major episodes of tectonic uplift in the past 4,200 years, the most recent of which accompanied the magnitude 9.2 (M_W) earthquake of 1964. This uplift is the consequence of near-orthogonal plate convergence at a rate of 5.8 cm/yr.

A single 24-fold seismic-reflection profile across the continental margin, passing 15 km northeast of Middleton Island, shows late Tertiary and Quaternary marine sedimentary deposits subducted subhorizontally, with no apparent disturbance, beneath the Tertiary rocks of the continental slope. Based on extrapolations from the seismic-reflection profile and from regional earthquake data, the top of the subducted plate may be shallower than 10 km below Middleton Island. If so, this may be the only onshore location in the world where it is feasible to drill into an active zone of subduction.

A broad range of problems could be addressed with a deep hole beneath Middleton Island, among which are the pressure of pore fluid in the subduction zone and its role in faulting and subduction, the state of stress in the vicinity of the megathrust and in the overlying plate, and the physical properties of materials in the megathrust. Sampling within the subduction zone would document the physical and chemical alteration of marine sedimentary deposits subducted about 1 million years ago. A deep hole would also provide a quiet observatory for monitoring seismicity and acoustic emissions in the vicinity of the megathrust as well as changes of pore pressure, strain, fluid chemistry and temperature associated with the accumulation and release of strain during the earthquake process.

Additional marine seismic data in the vicinity of Middleton Island are needed to provide more detailed information on the structure and stratigraphy of the overriding and subducting plates in the vicinity of the island.

Figure 9.—Possible site for deep scientific hole at Middleton Island in Gulf of Alaska (modified from George Plafker and others, 1982, Geological Society of America Map MC-28P). Proposed well would pierce upper plate of Aleutian megathrust and penetrate subduction zone beneath upper plate. A, Locations of Tenneco Middleton Island No. 1 well and U.S. Geological Survey multichannel seismic-reflection line 425. B, Structure section with hypocenters from U.S. Geological Survey Preliminary Determination of Hypocenters, 1967-1977. Large triangles are earthquakes located with 50 or more stations; small, with fewer than 50 stations. Geologic units: umT--upper and middle Tertiary rocks (siltstone, sandstone organic shale, locally abundant submarine volcanic rocks and sandy mudstone); lT--lower Tertiary rocks (marine and continental clastic rocks).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INVESTIGATIONS IN PROGRESS

There are many investigations already in progress along the TALI corridor. Most of the large investigations are promoted by one or more of the following groups: U.S. Geological Survey (USGS), Alaska Division of Geological and Geophysical Surveys (ADGGS), University of Alaska (UAF), and Rice University (RU). Numerous scientists from academia, industry, and government are cooperating in these studies. The following paragraphs describe major ongoing projects related to TALI; a complete summary describing every ongoing project is beyond the scope of the present effort.

U.S. Geological Survey

A major component of TALI is the Trans-Alaska Crustal Transect (TACT), a multiyear project being conducted by the U.S. Geological Survey. TACT is an integrated geologic and geophysical investigation of the structure, composition, and evolution of the Alaskan crust along the pipeline corridor and its seaward extensions across the continental margins. The investigation features coordinated application of complementary disciplines and methods, and multidisciplinary interpretation and synthesis of geologic and geophysical data.

TACT is planned as a phased project, in which a broad range of geologic and geophysical studies will be focused sequentially on segments of the transect. As proposed, the project would include extensive seismic-refraction and seismic-reflection profiling, both onshore and offshore; geologic mapping and topical geologic studies; gravity and magnetics studies; magnetotelluric sounding; heat flow studies; and seismic imaging of the crust and upper mantle primarily using earthquake sources.

TACT was initiated during 1984 in southern Alaska. Field studies focused on the northern Chugach Mountains and the Copper River Basin, between Valdez and the Alaska Range. Seismic-refraction/wide-angle seismic-reflection profiling was completed along 260 km of the transect route from a point about 60 km east of Valdez northward to the Denali fault in the Alaska Range. In addition, two cross profiles were obtained, a 130-km line along the axis of the Chugach Mountains east of Valdez and a 155-km profile extending southwestward from Gulkana across the southwest sector of the Copper River Basin. Geologic studies, in cooperation with other groups, were concentrated in the Chugach Mountains and western Wrangell Mountains. Bedrock mapping at a scale of 1:63,360 or larger was completed for a strip at least 20 km wide and roughly 100 km long centered on the transect route from east of Valdez to the Copper River Basin and along the western margin of the Wrangell Mountains, and for four critical 15-minute quadrangles (Valdez B-3, B-4, C-3, and C-4) spanning the suture zone between the Chugach and Peninsular-Wrangellia (composite) terranes. Topical geologic studies conducted in the vicinity of the transect and the auxiliary Chugach refraction profile included the pressure-temperature history of regionally metamorphosed rocks; the petrology and petrogenesis of ultramafic, mafic, and volcanic rocks; isotopic studies; fission-track analyses; local stratigraphic and paleontologic studies; structural analysis; and detailed mapping along sutures and major faults. An aeromagnetic survey was flown at 1-mile (1.6 km) spacing over the western Wrangell Mountains to fill a hole in the existing aeromagnetic data base. In addition to the field investigations, existing gravity measurements in the Gulkana and Valdez 1-degree quadrangles have been terrain-corrected, and complete Bouger gravity maps for these quadrangles are being prepared.

The types of geologic, seismic, and geophysical studies initiated in 1984 were continued in 1985 with the focus shifted to Prince William Sound and the Alaska Range. The seismic refraction/wide-angle reflection profile along the transect was extended 65 km southward to the Copper River delta. Two additional transverse lines were shot: a 135-km line along Montague, Hinchinbrook, and Hawkins Islands in the Prince William terrane and a 110-km line from Gulkana to Mentasta Pass across the Copper River Basin and the inferred boundary between the Peninsular and Wrangellia terranes. Geologic mapping and detailed topical studies were conducted in the vicinity of the transect route in the Chugach Mountains and the Alaska Range. In subsequent years, these studies will progress northward with the goal of completing the land investigations by the end of the decade.

The scope of TACT has been expanded in 1986 to include deep seismic-reflection profiling and reconnaissance magnetotelluric sounding. The initial reflection targets were an 80-km profile across the suture zone between the Chugach and Peninsular-Wrangellia (composite) terranes and a 50-km profile across the Denali fault in the Alaska Range. Marine investigations, heat flow measurements, and seismic imaging of the crust and upper mantle from earthquake sources are dependent upon future funding.

More than 20 scientists from academia, industry, and other governmental agencies (both State and Federal) are cooperating with or participating in the TACT geological and seismological studies under a variety of arrangements.

Numerous USGS projects are complementing the TACT studies and contributing to the transect effort. Examples include the monitoring and investigation of earthquakes in southern coastal Alaska, petrologic and geochemical studies of the origin and age of the Wrangell Lavas, geologic mapping and mineral resource appraisal of the eastern Alaska Range and the Livengood quadrangle, a geologic transect across the Koyokuk basin, and the statewide study of tectonostratigraphic terranes.

Rice University—University of Alaska Cooperative Studies

Rice University and the University of Alaska (Fairbanks) have been cooperating on studies in the Brooks Range area as part of an Alaskan transect program. The project has been funded by industry as an industrial associate program with considerable additional support provided by the ADGGS.

To date, Rice University has concentrated on investigating the detailed structural history of an area known as the Doonerak window area and the structure of the schist belt.

The University of Alaska efforts have concentrated on interpreting the available gravity and earthquake data for Arctic Alaska. The gravity data are mainly for the Dalton Highway (obtained from the USGS) and for several long traverses along roughly parallel north-south river valleys (ADGGS data). These gravity data are being modeled using ADGGS geologic cross-sections and maps, and aeromagnetic and rock physical property data. Earthquakes for Arctic Alaska have been relocated using different velocity models. An apparent belt of low-level seismicity stretches from interior Alaska to the Mackenzie delta area. The northeasterly trend may be a function of station distribution, and the events may be more widespread throughout the Brooks Range; however, the existence of shallow seismic activity in this area presumably represents crustal deformation or readjustment. It is hoped that at least a minimal network of seismometers can be permanently installed in Arctic Alaska so that these small events can be better located and their significance established.

University of Alaska

The University of Alaska is also working on a number of TALI-related projects. Among these are the operation of a seismic network (in cooperation with ADGGS and the USGS); paleomagnetic studies of the travel histories of terranes, particularly the Wrangellia terrane and other southern terranes; goethermal potential studies in the Copper River Basin; and various mapping projects (both by faculty and for student thesis research) along portions of the whole TALI route. The K-Ar geochronology laboratory (currently operated cooperatively with ADGGS) is also involved in dating and thermal history studies in cooperation with many of the individual projects.

Alaska Division of Geological and Geophysical Surveys

The Alaska Division of Geological and Geophysical Surveys has a number of cooperative projects with the USGS, UAF, and RU located in and near the TALI corridor that will contribute to the geophysical and geological data base on which TALI can draw. Each of these ADGGS projects is generally directed at assessing the petroleum, mineral, or hydrological resources of Alaska. Some of these projects are regional or statewide in geographical extent.

Three active ADGGS projects will provide both regional and detailed local structural and stratigraphic information that can be projected into the geophysical profiles. A major ADGGS mapping project in the south central Brooks Range is run in cooperation with the USGS, UAF, RU, and the U.S. Bureau of Mines (USBM). Nineteen 1:63,360-scale quadrangles have already been studied as part of this project. The studies include bedrock and surficial mapping, gravity and magnetic modeling, structural and lithostratigraphic terrane analysis, stratigraphy, paleontology, geochronology (U-Pb, Rb-Sr, Sm-Nd, and K-Ar), whole rock and exploration geochemistry, metallogeny, and resource evaluation. Results of these studies are already producing new interpretations of the regional tectonics and crustal evolution of the Brooks Range that will be important considerations in any syntheses of TALI results. ADGGS has also supported a small but separate UAF study of skarns in this area. A second ADGGS 1:63,360-scale mapping project is focused in the Killik River, Chandler Lake, and Philip Smith quadrangles, which transect the haul road in the north central Brooks Range. The project includes several UAF thesis studies. This project is generating information on the timing of Brooks Range thrusting and subsequent uplift as well as structural, biostratigraphic, and lithostratigraphic data. Basin analyses of these data are improving our understanding of the evolution of the North Slope petroleum province. A third major ADGGS project that is contributing to that understanding and to the geologic data base for TALI is focused on the eastern North Slope where petroleum potential evaluations are required for possible oil lease sales. This project, which is run in cooperation with the USGS, UAF, USBM, and the U.S. Bureau of Land Management, involves bedrock mapping and structural and stratigraphic studies. The results of surface studies are to be correlated with subsurface geology and structure in order to analyze oil basins in the eastern North Slope. Closely coordinated with this project is a regional study of the surficial geology.

Completed projects in the Fairbanks and Livengood areas provide bedrock mapping, geochemical and mineral analyses, and interpretation of the structural geology. Long-term mapping and structural geology and petrology projects in the Chugach Mountains are contributing to an understanding of the regional tectonics and crustal evolution in the southern part of the TALI transect, including ideas on the significance of the boundary between the Peninsular and Wrangellian terranes. Finally, some mapping and interpertation has been carried out by DGGS geologists in the Valdez quadrangle.

In addition to the various geological mapping projects outlined above, ADGGS has several geophysicists who are working nearly full-time in interpreting North Slope seismic, gravity, and magnetic data. Their expertise, particularly in permafrost areas, will be invaluable in interpreting the seismic data acquired by the TALI and TACT groups.

APPENDIX

List of Participants
TALI Workshop
Anchorage, Alaska
May 29, 1984

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Lynn A. Yehle

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UNIVERSITY OF ALASKA

U.S. GEOLOGICAL SURVEY

ALASKA DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

NATIONAL SCIENCE FOUNDATION