

Seismology

Continental Earthquakes and Tectonics

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SLIA-01

Crustal Transect of Accreted Tectonostratigraphic Terranes in the Chugach Mountains and Copper River Basin, Alaska: Initial Results of TACT

R.A. PAGE, C.S. FUIS, W.D. MOONEY, W.J. NOKLEBERG and C. PLAFKER (all: USGS, 345 Middlefield Rd., MS-977 Menlo Park, CA 94025)
D.L. CAMPBELL (USGS, P.O. Box 25046, Denver Federal Center, Denver, CO 80225)

During 1984, the U.S. Geological Survey initiated the Trans-Alaska Crustal Transect (TACT) project an integrated geologic/geophysical investigation of the continental crust and its evolution along the Trans-Alaska Pipeline corridor. Preliminary results are available from studies in the Chugach Mountains and the Copper River Basin. (1) The north-dipping Border Ranges fault system juxtaposes interfolded blueschist and greenschist of the accretionary Chugach (CH) terrane against mafic and ultramafic rocks of the composite Peninsular (PN)/Wrangellia (WR) terrane to the north, and bounds extensive thin sheets of PN/WR-terrane rocks that have been thrust relatively southward at least 40 km over the north margin of the CH terrane. This fault system is interpreted to be a late Mesozoic subduction zone along which oceanic rocks and flysch of the CH terrane were accreted against and beneath the PN/WR terrane. The exposed mafic and ultramafic rocks along the south margin of the PN/WR terrane are inferred to be the uplifted root of a Jurassic magmatic arc. (2) Basement beneath most of the PN terrane contains a thick section of magmatic rocks that is uplifted along both its north and south margins by folding or faulting. (3) Within the CH terrane, the crust beneath the central Chugach Mountains along lat. 61°N between Valdez and the Copper River is characterized by a complex stack of alternating high (6.8-7.6 km/s) and low-velocity layers. (4) To the north, within the northern CH and southern PN/WR terranes, a prominent north-dipping (60-90°) reflector (7.2-7.6 km/s) underlies the northern Chugach Mountains and the southern Copper River Basin and extends downdip at least to a depth of 20-25 km beneath Copper Center.

This paper will also be presented as poster S12C-05

SLIA-02

Seismic Reflection Profiling through the Long Valley Caldera

DEMPER, S., HUMPHREYS, M.C., JOHNSON, R.A., and SMITHSON, S.B. (Department of Geology and Geophysics, Program for Crustal Studies, University of Wyoming, Laramie, WY 82071)
ELLSWORTH, W.L., HILL, D.P. (U.S. Geological Survey, Menlo Park, CA 94025)

In cooperation with the U.S. Geological Survey, the University of Wyoming seismograph crew conducted a series of reflection experiments across the Long Valley caldera using a 96-channel recording system and 4 vibrators in order to image the deep structure of the caldera. The goals of the experiment were to study wave propagation in this volcanic setting and to image a postulated magma chamber at about 6 km depth. Tests consisted of 8 wave tests in different surface materials including rhyolite and basalt, wide-angle CDP recording, 3-wave recording, and vertical-incidence CDP profiling. Wave tests showed that the amount of energy was highly variable and depended on surface materials; organized noise consisted of low-velocity surface waves and reverberating first breaks. A wide-angle profile was set up to duplicate a previous U.S.G.S. refraction profile in which an event was interpreted as a possible wide-angle reflection. A strong event was recorded at 3-4 s at a range of 17 km, even on individual sweeps, and this event was "walked in" to zero offset. Other events arrive at 4.4 and 4.6 s. The vertical-incidence CDP profile was located across the resurgent dome in order to image a magma chamber, and clear events were also recorded in this data between 1.0 and 2.5 s. Ringing is a problem on some records. In spite of unfavorable conditions caused by loose surface material, seismic reflection recording holds great promise to study the volcanic environment.

This paper will also be presented as poster S12C-06

SLIA-03

Crustal Reflection Profiling in the Metamorphic Core Complex of the Ruby Range, Nevada

HURICH, C.A., HUMPHREYS, M.C., SNOKE, A.W., JOHNSON, R.A., FOUNTAIN, D.M., and SMITHSON, S.B.
(Department of Geology and Geophysics, Program for Crustal Studies, University of Wyoming, Laramie, WY 82071)

The University of Wyoming seismograph crew carried out 5 different recording experiments in the crystalline core of the Ruby Range using a 96-channel recording system with explosives and 4 vibrators. These experiments included a wave test, two high-resolution profiles with both explosive and vibrator sources, an upper-crustal CDP profile, and wide-angle recording out to a range of 22 km. The seismic profiles were located down-plunge from structures cropping out in the northern Ruby Range and East Humboldt Range. The high-resolution profiles were intended to image the detachment faults and mylonite zone which mark the transition between infrastructure and suprastructure of the core complex. Both high-resolution profiles were recorded with point sources and receivers to optimize resolution. Shallow reflections are abundant on both data sets and reflections were recorded out to 3 s with 0.5 kg charges at 1 s depth. The upper-crustal CDP profile exhibits numerous multicyclic events between 2 and 5.5 s. Other events occur between 5.5 and 7.5 s but are less common. CDP profile confirms the high resolution profiles. These data provide another demonstration of the efficacy of mylonites as reflectors. We conclude that mylonite zones probably represent some of the best crustal reflectors due to their layered and relatively planar geometry. Comparisons are made between the mylonite reflectors and events deeper in the crust. Most of the crust appears to be sub-horizontally layered. This layering could be caused by nappes, several mylonite zones or both.

This paper will also be presented as poster S12C-07

SLIA-04

Reflection profiling of the lower crust in the Basin and Range: Dixie Valley, Nevada

DAVID A. OKAYA (Geophysics Dept., Stanford University, Stanford, CA 94305)

Seismic profiling of the lower crust has primarily been achieved by deep seismic programs such as COCORP. However, given certain source conditions, shallow industry data may be converted to image the lower crust. Recorrelation of unstacked field records to longer travel-times is possible provided 1) a Vibroseis source was used; 2) the sweep was composed from low to high frequencies (up-sweep); and 3) the original uncorrelated field records are available for reprocessing. Recorrelation may be performed using a sweep of fixed frequency bandwidth or a "self-truncating" sweep whose frequency content diminishes with time.

Twenty-two km of seismic data in Dixie Valley, Nevada were collected using a linear 12 s, 12-65 Hz Vibroseis up-sweep and a 16 s recording period, resulting in profiles of 4 s duration. Recorrelation to 12 s is accomplished using a "self-truncating" sweep. The upper bandwidth frequency ranges from 5 Hz at 4 s to 30 Hz at 12 s.

Conventional CDP stacking of the recorrelated data reveals many short, sub-horizontal reflections present in the intermediate to deep crust. Presence of reflected energy in the field records suggests the stacked reflections are real. The presence and orientation of the sub-horizontal reflections may be explained by lower crustal compositional layering, laminar plastering, igneous intrusion, in conjunction with lower crustal stretching.

Strong Moho reflections are not visible, but an abrupt termination of the sub-horizontal reflections occurs at approximately 10 s, suggestive of the transition from the base of the crust to the upper mantle. Strong laterally continuous reflections indicative of low-angle detachment zones are not present in the intermediate crust. Structural models for Dixie Valley based on the seismic profiles and other geophysical information require detachment zones, if present, to be located below the seismogenic crust.

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This paper will also be presented as poster S12C-08

SLIA-05

Late Cenozoic fault patterns and magma migration in Death Valley from COCORP seismic profiles

L. Serpa (University of Kansas, Lawrence, KS 66045), S. de Voort, J. Williams, J. Oliver, S. Kaufman, L. Brown, E. Hauser (Cornell University), L. Wright (Penn. State), and B. Troxel (UC Davis)

COCORP deep seismic reflection profiles in Death Valley indicate two styles of brittle deformation in the upper crust of that region. The sedimentary cover is commonly cut by listric normal faults which join along the contact between the sedimentary rocks and the underlying crystalline basement. The basement rocks are tilting and extending along a series of widely spaced, moderately dipping faults. Faults can be traced to a maximum depth of 15 km where they appear to be truncated by, or sole into, a region of

detachment. A partially molten sill is interpreted to lie at mid-crustal depths beneath the center of Death Valley and a previously unidentified fault zone appears to connect the buried sill to a 600,000 year old cinder cone at the surface. Thus this fault zone which forms the southern boundary of the Death Valley pull-apart basin is inferred to have acted as a conduit for magmas traveling to the surface from the magma sill. A similar fault zone near the center of the valley is interpreted as the buried expression of the Mormon point turtleback fault. Relatively continuous reflections are recorded near 10 s which may correspond with the crust-mantle boundary and may be a continuation of similar events observed in COCORP profiles from the Mojave desert. The Mojave survey lies 50 km southwest of Death Valley across the Garlock fault zone. Two events can be traced in the Mojave data beneath the surface location of the Garlock toward Death Valley. Either, or both, of these events may be a continuation of the mid-crustal detachment or some other reflecting horizon in Death Valley. Comparison of the Death Valley - Mojave profiles with COCORP data from the northern Basin and Range suggest that extensional deformation may be modifying or overprinting many of the lower-crustal pre-extensional structures in the western United States.

This paper will also be presented as poster S12C-09

SLIA-06

Upper Crustal Structure of the Lassen Peak Area, Northern California, from Seismicity and Refraction Data

BERGE, P.A., WALTER, STEPHEN R. (both at: U.S. Geological Survey, 345 Middlefield Road, MS-977, Menlo Park, CA 94025)

In September, 1982 the U.S. Geological Survey recorded a 120-km-long refraction profile across Lassen Peak, between the Klamath Mountains and the Sierra Nevada foothills. Additionally, nearly one thousand earthquakes (M 3) have been located in the vicinity of Lassen Peak since early 1981. We use the refraction and the seismicity data to determine the nature of the upper crust in this volcanic region. The two data sets were used independently to develop two strikingly similar crustal models. One model was created by standard refraction interpretation using ray-plottings, and the other by linear inversion of the earthquake travel times.

INVERSION MODEL		REFRACTION MODEL	
Depth(km)	Velocity(km/s)	Depth(km)	Velocity(km/s)
0.0	4.3	0	1.5-4.6
2.0	5.5	1	4.4-5.6
4.5	6.0	3	5.9-6.1
6.0	6.17	4	5.7-6.1
9.0	6.35	6	6.3
24.5	7.2		

Differences in the two models reflect differences in the methods used to construct them, rather than structural differences inherent in the data. The inversion model produced laterally homogeneous, horizontal velocity layers, while layer dip and velocity were allowed to vary laterally along the refraction line model. Thus a range of velocity values for each depth in the refraction model is presented in the table above. The low-velocity zone present at 4 to 6 km depth in the refraction model does not extend along the entire lateral distance of the model and therefore cannot be resolved by the seismicity data.

The distribution of seismicity and the velocity structure correlate well with the Lassen geothermal system. Nearly 25% of all the thousand earthquakes locate in the geothermal area immediately south of Lassen Peak, few deeper than 6 km. The refraction model similarly distinguished the geothermal area from surrounding areas, showing high velocities of 5.6 km/s between depths of 1-3 km beneath Devil's Kitchen Hot Springs and the Terminal Geyser, as opposed to velocities around 4.4 km/s at the same depth in non-geothermal areas. A lack of seismicity at depth and high velocities suggest an intrusion related to the heat source below the geothermal area.

Another feature present in both models is that both the seismicity data and the refraction model seem to indicate that Sierran basement continues under the Cascade volcanics toward the Klamath Mountains, at least as far NW as Lassen Peak.

This paper will also be presented as poster S12C-10

SLIA-07

Structures of the Lower Crust and Mantle As Imaged in SIRPS Migrations

SUSAN MCCREARY

BERNARD RAYNAUD (Both at: SIRPS, Bullard Labs, Dept. of Earth Science, Cambridge CB3 0EZ, UK)
DAVID K. SMYTHE (British Geological Survey, 19 Grange Terrace, Edinburgh EH9 2LP, UK)

SIRPS (British Institutions Reflection Profiling Syndicate) has collected over 3000 km of deep seismic reflection data from the continental shelf surrounding Britain. The reflection profiles, collected to 15 s TWT, sample at least the top 40 km of the continental lithosphere and show 1) major low-angle structural reflectors which seem to cut through the entire upper crust and possibly the lower crust, 2) a highly reflective lower crust, 3) a strong band of reflections, interpreted to be the Moho, which can be seen fairly continuously at 10 s TWT and striking of all

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