Highlights of Research Activities

Crustal Structure and Tectonics

Personnel: T. Atwater, N. Brown, C. Busby-Spera, S. Cisowski, R. Crippen, J. Crowell, J. Elliot, D. Imperato, E. Keller, D. Kimbrough, J-L. Lin, **B. Luyendyk***, R. Morris, C. Nicholson, B. Patrick, S. Richard, R. Sibson, C. Smith, C. Sorlien, W. Stuart, A. Sylvester (* Agenda coordinator)

Projects in this area span the globe from Canada to Antarctica. In the Yellowknife mining district in Canada Dr. Richard Sibson and graduate student Norm Brown are conducting an ICS project relating faulting, fluid movements, and fault zone mineralization. A similar project is underway in the Mother Lode of The Sierra Nevada by Dr. Sibson's graduate student James Elliot. In the southern Brooks Range, Alaska, the history of high-grade metamorphic rock is under study by Dr. Brian Patrick. At Mt. St. Helens Dr. Jonathan Less began an investigation of the structure of the volcano using high resolution seismic tomography. During and extended visit to Japan, Dr. Lees researched the velocity structure beneath the Kanto-Tokai volcanic district.

In the Grand Tetons, Wyoming, ICS leveling surveys by Dr. Art Sylvester and his students are measuring the uplift of this range. Using seismic and well data, ICS researchers John Crowell and Peter Malin and graduate student Doug Imperato are studying the origin of folds in the subsurface strata of the California Central Valley which are often traps for petroleum. Drs. Crowell, Malin, and J-L. Lin completed a study of the Sargent Oil field subsurface structure, which is near the Loma Prieta earthquake hypocenter. In the area of southern California and the Mojave Desert, the tectonic history of Pacific-North American plate interaction is being studied on several fronts. These include studies of the San Andreas fault (Dr. T. Atwater), the Ridge Basin (Dr. J. Crowell), tectonic geomorphology of the Los Angeles Basin (Dr. E. Keller), and crustal rotations in the northeast Mojave (Dr. Bruce Luyendyk). Seismic reflection data in the offshore Santa Maria Basin and southern California Borderland are being studied by Dr. Craig Nicholson, Bruce Luyendyk, and graduate student Chris Sorlien who are mapping deep crustal structure and determining tectonic history in these regions. Fault movements and seismicity are being monitored on the southern San Andreas fault by Drs. Nicholson and Sylvester. Several projects are focused in southeast California and southwest Arizona. Researchers involved include Atwater, Crowell, Dr. Steve Richard, Rebecca Morris, Dr. Robert Crippen and Dr. William Stuart. These projects mostly concern Miocene tectonics here, including crustal rotations, extension, and link-up of faults in this area with the Eastern California shear zone in the central Mojave Desert. In addition, Jurassic island arc rock sequences are being mapped in southern Arizona by Dr. C. Busby-Spera in order to understand the ancient western North America continental margin.

In Antarctica, ICS researchers B. Luyendyk, D. Kimbrough, S. Richard and graduate student Christine Smith have spent two field seasons in Marie Byrd Land, West Antarctica, to study the fit of this piece in the Gondwana supercontinent, and to study the uplift of deep crustal rocks here. Paleomagnetic study of rock samples obtained on the expeditions is being done by Luyendyk and Dr. Stan Cisowski.

Crustal Materials

Personnel: A. Proussevitch, **F. Spera***, D. Stein, G. Tilton, A. Trial, A. Tumarkina (* Agenda coordinator)

Research in this area by Dr. Frank Spera and his group is concerned with the origin of magmas (molten rock), behavior of volcanoes, and the minerals and rocks which comprise the earth's crust and mantle. Laboratory studies are concerned with the rheology of magmatic emulsions (crystals, vapor, melt) under varying physical conditions, such as shear rate. These studies are aimed at understanding volcanic phenomena such as caldera subsidence and collapse. Just completed is a finite element code to simulate convection in silicate melts taking into account phase changes. This is a first approach relevant to Mid-Ocean Ridge processes, and to the development of geothermal resources. Another theoretical effort is aimed at modelling the behavior of silicate melts using the analog of molten germania (GeO_2). This research incorporates molecular dynamic simulations at the atomic level.

In another research effort, Dr. George Tilton is studying the isotopic systematics of carbonatites, rocks derived from the earth's mantle. The aim is to describe heterogeneity in the mantle, and to understand its evolution.

Earthquakes

Personnel **R. Archuleta***, R. Harris, J. Lees, G. Lindley, P. Malin, A. Martin, C. Nicholson, W. Prothero, P. Rodgers, S. Seale, L. Steck, J. Stiedl, S. Swain (* Agenda coordinator)

The most important development affecting seismological studies at ICS was the initiation of the Southern California Earthquake Center (SCEC), a National Science Foundation Science and Technology Center. The National Science Board recommended that the SCEC be funded for five years with a total budget of $13.6 million. UCSB is one of eight core institutions in the SCEC which is headquartered at USC. Ralph Archuleta, ICS Associate Director, represents UCSB on the SCEC Board of Directors. ICS/UCSB serves as the SCEC's principal institution for the acquisition, deployment

and development of portable, broadband seismic recorders that will serve all the institutions in the SCEC.

Although the SCEC dominated the 90-91 fiscal year, other projects that are continuing at ICS include Archuleta's downhole seismometer array studies at Garner Valley sponsored by the Office of Research, U. S. Nuclear Regulatory Commission. Mr. Scott Swain, BS and MS from UCSB, was hired as the project engineer, replacing Mr. Peter Sangas who resigned from the position. This project received funding from the Electrical Power Research Institute to add surface accelerometers and one more borehole accelerometer to the existing downhole array. Dr. Sandra Seale has spent most of her efforts examining the data from the array to determine the transfer function for the soil. A paper on the Garner Valley instrumentation and preliminary data analysis is under review at the Bulletin of the Seismological Society of America.

Dr. Craig Nicholson received funding from the U.S. Geological Society for his work on fault interation, segmentation, and geometry along the southern San Andreas fault. With his Petroleum Research Fund he continues to examine the structure off the coast of central California. This work is in collaboration with Dr. Bruce Luyendyk and a graduate student, Chris Sorlien. Dr. Ruth Harris earned her PhD in December working with Archuleta on the effects of en echelon fault features on the dynamics of propagating fractures (earthquakes). She received a National Research Council Fellowship to continue her research at the U.S. Geological Survey, Menlo Park, CA.

Graduate students Grant Lindley and Jamison Steidl completed two studies that were initiated with USGS funds following the October, 1989, Loma Prieta, earthquake. Lindley has produced maps of the stress drops of the aftershocks of the mainshock. These stress patterns correlate strongly with the regions of high slip during the mainshock. The regions of high slip were determined by Steidl by inverting the strong motion accelerograms to determine the evolution of faulting during the earthquake. Both works have resulted in papers that are in press or under review.

Drs. Archuleta and Peter Malin continued study of data from the Loma Prieta aftershock sequence. Malin and Dr. Jonathon Lees worked on the Parkfield earthquake prediction experiment. These projects included seismic monitoring using a downhole seismic array and the study of high frequency seismic wave attenuation in the San Andreas fault zone. Malin and Lees have since departed ICS for faculty positions at Duke and Yale universities, respectively.

Dr. William Prothero is continuing his research on the Kaokiki fault zone on the big island of Hawaii. This project is concerned with the origin of large earthquakes on this zone which are hypothesized to occurr on a deeply buried sediment layer beneath the volcanic pile. Dr. Prothero's graduate student, Lee Steck, has recently completed his dissertation on the

velocity structure beneath Long Valley caldera, California, using teleseismic ray paths and velocity anomalies.

Hazardous Waste Disposal

Personnel: S. Cullen, **L. Everett***, J. Kramer, M. Leipnik, H. Loaciaga, T. Robinson, D. Springer, J. Wells, I. Zekster
(* Agenda coordinator)

Hazardous waste disposal in the earth's crust is being studied in the Vadose Zone Monitoring Laboratory (VZML) of the ICS. This laboratory has as it's mission research and educational activities on the subject of ground water protection by contaminant detection and the monitoring of contaminant movement above the principal water table, in the vadose zone. Through the efforts of the director Dr. Lorne G. Everett and Co-Principal Investigator Stephen J. Cullen, the VZML has emerged as the research backbone for the U.S. Environmental Protection Agency's newly-defined vadose zone monitoring strategy. National regulations are currently being promulgated which will require vadose zone monitoring at all hazardous waste land disposal units. Dr. Everett and Stephen Cullen have been invited to write the guidance document to support this effort.

In addition to presentations at professional meetings and publication in scientific journals, VZML has conducted numerous short courses and workshops on vadose zone monitoring strategies and techniques around the country. Primary audiences included the U.S. Navy, U.S. Air Force, Department of Energy, and various professional organizations.

Cooperative working agreements have been initiated with the Water Problems Institute, Russian National Academy of Sciences, Moscow and the Weizman Institute of Israel.

Efforts directed via Dr. Everett's chairmanship of the American Society of Testing and Materials Committee on Vadose Zone Monitoring have coordinated thinking and developments of both public agencies and private enterprise to formalize standards for investigative protocols in subsurface environmental studies.

VZML is developing new research initiatives and has been successful in obtaining funding from private, state, and federal sources to develop solutions to emerging environmental management issues. VZML recently initiated a project using a Geographic Information System workstation to develop a fundamental understanding of subsurface contaminant migration at Vandenburg Air Force Base. The U.S. Bureau of Reclamation has funded this research effort.