IRIS

18th Annual Workshop

Westward Look • Tucson, AZ • June 8–10, 2006

Thursday, June 8

USArray Today

7:00	Continental Breakfast	Sonoran Terrace
8:00 – 8:30	**Welcome – *Susan Beck, Karen Fischer, Arthur Goldstein, David Lambert, David Simpson***	**Quail/Javalina Rooms**

8:30 – 10:30 **USArray Plenary: Overviews – *Gene Humphreys, Thorne Lay*** **Quail/Javalina Rooms**

- 8:30 – 8:45 "Introduction to USArray Today"
  – **Gene Humphreys** *(University of Oregon)*
- 8:45 – 9:15 "USArray and Active Tectonics in the Western US"
  – **Wayne Thatcher** *(US Geological Survey)*
- 9:15 – 9:45 "Thermal Structure of the Lithosphere from Shear Wave Velocities"
  – **Keith Priestley** *(Bullard Laboratory)*
- 9:45 – 10:15 "Deep Earth Under North America"
  – **Ed Garnero** *(Arizona State University)*
- 10:15 – 10:45 Discussion

10:45 – 12:15	Poster Session: USArray	Santa Catalina Ballroom
12:15	Lunch	

1:30 – 3:20 **USArray Plenary: EarthScope-Funded Research Projects – *Gene Humphreys, Thorne Lay*** **Quail/Javalina Rooms**

- 1:30 – 1:45 "USArray Science"
  – **Thorne Lay** *(University of California, San Diego)*, **Kaye Shedlock** *(NSF)*, **Greg van der Vink** *(EarthScope Facility Office)*
- 1:45 – 2:05 "The EarthScope Automated Receiver Survey: A Community Resource"
  – **Tom Owens** *(University of South Carolina)*
- 2:05 – 2:25 "New Observations on Lithospheric Foundering from the Sierra Nevada Earthscope Project (SNEP)"
  – **George Zandt** *(University of Arizona)*
- 2:25 – 2:45 "Cascadia"
  – **Ken Creager** *(University of Washington)*
- 2:45 – 3:05 "Integrated Flex-Array Survey of the Northwestern Basin and Range Transition Zone"
  – **Derek Lerch** *(Stanford University)*
- 3:05 – 3:25 Six USArray SIG Announcements

3:25 – 3:45	Break	Sonoran Terrace
3:45 – 6:15	**USArray Special Interest Group Meetings**	
3:45 – 4:45	Transportable Array (*A. Trehu, R. Busby*)	Quail/Javalina Rooms
4:15 – 5:15	GeoFrame: An Integrated Geologic Framework for USArray (*B. van der Pluijm, B. Tikoff*)	Palm Room
4:45 – 5:45	Backbone (*B. Romanowicz, K. Anderson*)	Canyon Room
5:15 – 6:15	Flexible Array (*A. Levander, J. Fowler*)	Quail/Javalina Rooms
6:30	Dinner	Sonoran Rooftop
7:30	Coffee & Ice Cream – Jon Spencer, "Metamorphic Core Complexes"	Quail/Javalina Rooms

Saturday, June 10 — International Day

7:00	**Continental Breakfast**	**Sonoran Terrace**
8:00 – 10:15	**International Development Agencies and Geophysics – *Art Lerner-Lam***	**Quail/Javalina Rooms**
8:00– 8:15	Introduction to International Day and Update on IRIS International Activities	
8:15– 8:45	Swiss Seismological Service and FDSN – **Domenico Giardini**	
8:45– 9:15	US A.I.D. Office of Foreign Disaster Assistance – **Gari Mayberry**	
9:15– 9:45	Regional Disaster Center for Latin America & Caribbean – **Maria Teresa Casas**	
9:45–10:15	Discussion	
10:15 – 11:45	Poster Sessions Western Pacific North, Central, and South America Asia, Antarctica, Africa, and the Middle East	Santa Catalina Ballroom
12:00 – 1:00	**Lunch**	
1:00 – 3:00	**International Geophysical Activities – *Susan Beck***	**Quail/Javalina Rooms**
1:00– 1:30	"AfricaArray: Imaging the African Superplume" – **Andy Nyblade** *(Pennsylvania State University)*	
1:30– 2:00	"Collaboration on Seismic Experiments in Central Europe Creates a Scientific Snowball" – **Randy Keller** *(University of Texas at El Paso)*	
2:00– 2:30	"Disaster Preparedness in Asia" – **Roger Bilham** *(University of Colorado, Boulder)*	
2:30– 3:00	"Lithospheric Thickening and Foundering: Mountain and Capacity Building in the Andes" – **Susan Beck** *(University of Arizona)*	
3:00 – 3:15	**Break**	
3:15 – 5:15	**International Activities Special Interest Group Meetings**	
3:15 – 4:15	International Funding Opportunities (*A. Lerner-Lam*)	Quail/Javalina Rooms
3:45 – 4:45	Refurbished Instrument Usage (*A. Nyblade, G. R. Keller, R. Willemann, J. Fowler*)	Palm Room
4:15 – 5:15	Building Collaborations in Latin America (*S. Beck, K. Fischer*)	Quail/Javalina Rooms
Evening	**Barbeque**	**Barbeque Grounds**

Friday, June 9

7:00	**Continental Breakfast**	**Sonoran Terrace**
7:00 – 12:00	Fieldtrip to Santa Catalina metamorphic core complex Other recreational activities Business meetings	Meet at front entrance
11:45	**Lunch**	

1:00 – 3:00 **Interpreting Seismic Velocity and Attenuation Plenary Session – *Karin Fischer*** **Quail/Javalina Rooms**

1:00– 1:30	"Rheological and EM Constraints on Interpretation of Upper Mantle Seismic Properties" – **Greg Hirth** *(Woods Hole Oceanographic Institution)*
1:30– 2:00	"Upper Mantle Composition and Variability: Implications for Seismic Velocity Experiments" – **Cin-Ty Lee** *(Rice University)*
2:00– 2:30	"What Can We Learn from Images of Seismic Wave Attenuation?" – **Colleen Dalton** *(Harvard University)*
2:30– 3:00	Discussion

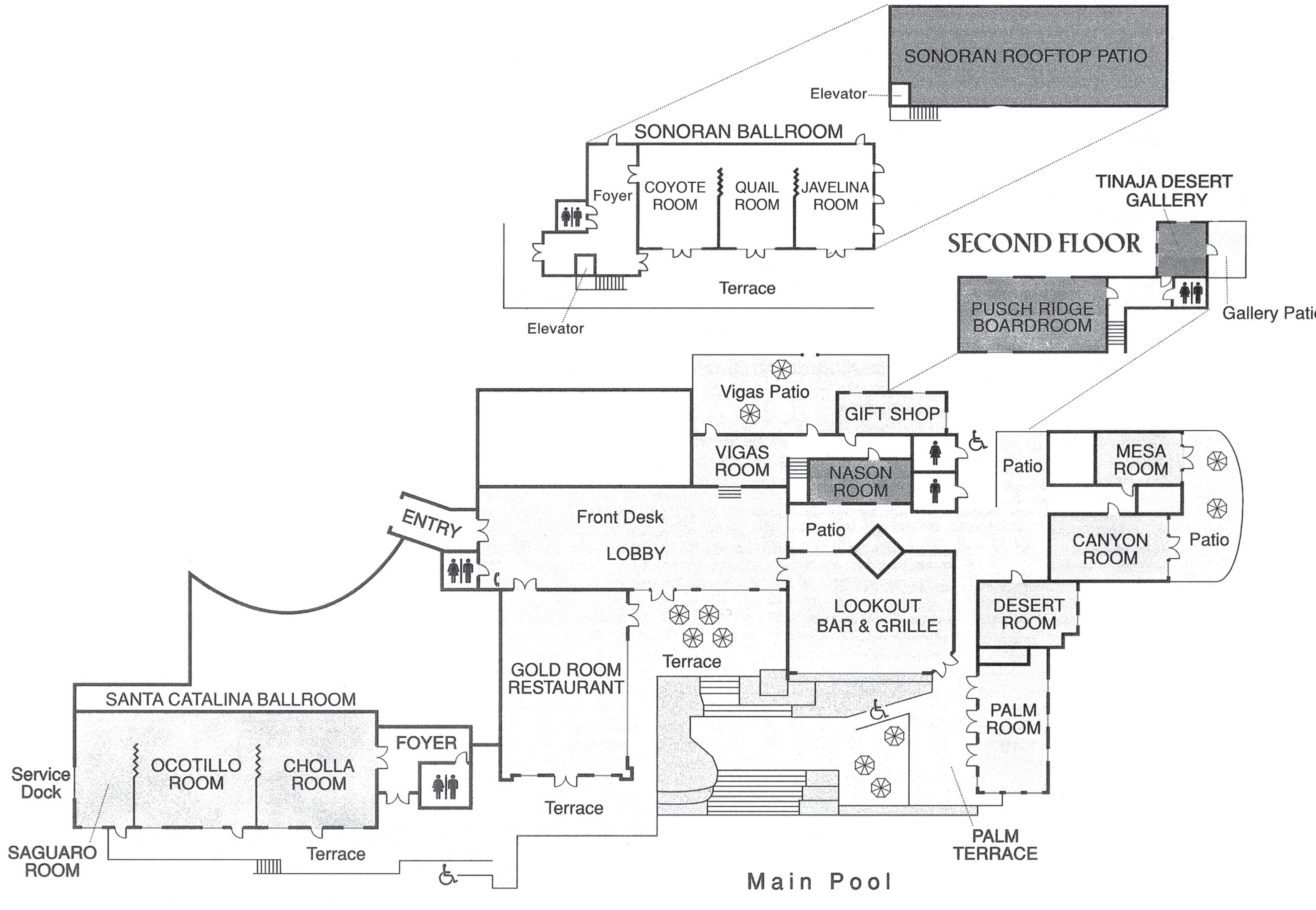
3:00 – 4:30 Poster Sessions — Santa Catalina Ballroom

- Comparing and interpreting velocity, attenuation, and anistropy from regional to continental scales
- Core structure
- Advances in active source instrumentation and shot design
- Advances in waveform analysis methods and software and data interfaces

4:00 – 5:30 **USArray Special Interest Group Meetings**

4:00 – 5:00	Pacific Northwest Experiments (*M. Fouch, K. Creager, G. Humphreys*)	Quail/Javalina Rooms
4:30 – 5:30	Magnetotellurics (*S. Park, S. Ingate*)	Palm Room

6:00 **Dinner – Speaker: *Mary Vaughn*, "World Bank Development Activities"** **Sonoran Rooftop**


SONORAN ROOFTOP PATIO
Elevator
SONORAN BALLROOM
Foyer
COYOTE ROOM
QUAIL ROOM
JAVELINA ROOM
Terrace
Elevator
TINAJA DESERT GALLERY
SECOND FLOOR
PUSCH RIDGE BOARDROOM
Gallery Patio
Vigas Patio
GIFT SHOP
VIGAS ROOM
NASON ROOM
Patio
MESA ROOM
Patio
CANYON ROOM
ENTRY
Front Desk
LOBBY
Patio
LOOKOUT BAR & GRILLE
DESERT ROOM
Terrace
GOLD ROOM RESTAURANT
PALM ROOM
SANTA CATALINA BALLROOM
FOYER
Service Dock
OCOTILLO ROOM
CHOLLA ROOM
Terrace
SAGUARO ROOM
Terrace
PALM TERRACE
Main Pool

IRIS Annual Workshop

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Posters

Thursday, June 8th

USARRAY

Rainer Kind	LITHOSPHERIC STRUCTURE IN THE WESTERN US FROM S RECEIVER FUNCTIONS
John Jasbinsek	EVIDENCE OF LOW VELOCITY ZONES ATOP THE 410-KM DISCONTINUITY BENEATH THREE WESTERN US PASSCAL ARRAYS
Don Helmberger	LOW VELOCITY ZONE ATOP THE TRANSITION ZONE IN THE WESTERN US FROM S WAVEFORM TRIPLICATION
Philip Crotwell	EARTHSCOPE AUTOMATED RECEIVER SURVEY: RESULTS FROM THE TRANSPORTABLE ARRAY
Ben A. van der Pluijm	GEOFRAME: AN INTEGRATED GEOLOGIC FRAMEWORK FOR EARTHSCOPE'S USARRAY
Craig Jones	SIERRA NEVADA EARTHSCOPE PROJECT (SNEP): BACKGROUND AND EARLY RESULTS BEARING ON FOUNDERING OF CONTI
Hersh Gilbert	ROOT REMOVAL AND DEEP CRUSTAL EARTHQUAKES IN THE WESTERN FOOTHILLS OF THE SIERRA NEVADA
William Stephenson	TOWARDS RESOLVING AN EARTHQUAKE GROUND MOTION MYSTERY IN WEST SEATTLE, WASHINGTON STATE
Jeffrey Roth	SEISMIC VELOCITY STRUCTURE OF THE SOUTHERN CASCADIA SUBDUCTION ZONE
Julien Chaput	FEASIBILITY OF BODY WAVE GREEN'S FUNCTION RECOVERY FROM THE CROSS-CORRELATION OF CASCADIA TREMORS
Shaji Nair	CONSTRAINTS ON CRUSTAL THICKNESS AND VP/VS RATIO IN THE SOUTHERN CASCADES USING RECEIVER FUNCTIONS
Ken Dueker	PRELIMINARY RESULTS FROM THE BATHOLITH PASSIVE SOURCE PROJECT
Robert Nowack	DECONVOLUTION OF 3-COMPONENT TELESEISMIC P-WAVES USING THE AUTOCORRELATION OF THE P TO SV SCATTERED
Kevin Eagar	DECEMBER, 2003 MICROEARTHQUAKE SWARM IN EASTERN ARIZONA
Andy Frassetto	THICKNESS AND DEEP CRUSTAL COMPOSITION OF METAMORPHIC CORE COMPLEXES IN SOUTHERN ARIZONA
Alan Levander	SEISMIC STRUCTURE OF THE SOUTHERN ROCKIES AND COLORADO PLATEAU AND ITS TECTONIC SIGNIFICANCE
Ken Dueker	IMBRICATION OF THE LOWER CRUST BENEATH THE ARCHEAN-PROTEROZOIC CHEYENNE BELT SUTURE
Huaiyu Yuan	TESTING UPPER MANTLE ANISOTROPIC VELOCITY PARAMETERIZATIONS
Tae-Kyung Hong	TOMOGRAPHIC INVESTIGATION OF THE CHARLEVOIX SEISMIC ZONE AND ITS METEOR IMPACT STRUCTURE
Hawman Robert	COMBINED WIDE-ANGLE REFLECTION AND RECEIVER FUNCTION STUDIES OF THE CRUST AND UPPER MANTLE BENEATH THE CAROLINA TERRANE AND BLUE RIDGE PROVINCES, SOUTHERN APPALACHIANS
Meredith Nettles	TWO UNUSUAL SEISMIC EVENTS IN THE GULF OF MEXICO IN 2006
Daniel McNamara	RESULTS FROM A SIDE BY SIDE SEISMIC VAULT COMPARISON EXPERIMENT
Harold Bolton	QUALITY CONTROL WITHIN THE USGS GSN AND ANSS NETWORKS
Matthew Mercurio	OPTIMAL SITING OF USARRAY GEOPHYSICAL INSTRUMENTS USING GIS-BASED SUITABILITY ANALYSIS
Jennifer Eakins	THE EARTHSCOPE USARRAY ARRAY NETWORK FACILITY (ANF) THROUGH TWO AND A HALF YEARS OF OPERATION
Robert Newman	USARRAY APPLICATIONS OF ANTELOPE PHP WEB TECHNOLOGIES: ANF.UCSD.EDU
Peggy Johnson	USARRAY AT THE IRIS DMC: QUALITY CONTROL
Christian Guillemot	THE EARTHSCOPE INFORMATION SYSTEM
Charna Meth	EARTHSCOPE COMMUNICATIONS: ENGAGING THE BROAD SCIENTIFIC COMMUNITY

John DeLaughter	EARTHSCOPE EDUCATION AND OUTREACH
Charna Meth	THE FIRST EARTHSCOPE NATIONAL MEETING
Christel Hennet	EARTHSCOPE DATA GENERATION AND DATA FLOW
William Schultz	FACILITATING THE MANAGEMENT OF EARTHSCOPE WITH GEOSPATIAL TECHNOLOGY
Greg Anderson	THE PLATE BOUNDARY OBSERVATORY: DATA MANAGEMENT PROGRESS AND HIGHLIGHTS
Kathleen Hodgkinson	THE PLATE BOUNDARY OBSERVATORY STRAINMETER PROGRAM; PROGRESS AND FIRST OBSERVATIONS.
Steven Semken	NATIVE AMERICAN PERSPECTIVES AND PREFERENCES BEARING ON EARTHSCOPE DEPLOYMENTS IN THE SOUTHWEST
Russell Welti	WEB-BASED, REAL-TIME DATA FOR MUSEUMS AND VISITOR CENTERS
Christopher Loos	USING WEB-BASED TOOLS FOR COMMUNITY INTERACTION – THE IRIS SUMMER INTERNSHIP PROGRAM

Friday, June 9th

COMPARING AND INTERPRETING VELOCITY, ATTENUATION, AND ANISTROPY FROM REGIONAL TO CONTINENTAL SCALES

Teh-Ru Song	PROBING CONTINENTLA LITHOSPHERE NEAR RIO-GRANDE RIFT, SOUTHWESTERN UNITED STATES USING P AND S WAVE
Egill Hauksson	QP AND QS MODELS IN THREE-DIMENSIONS OF THE SOUTHERN CALIFORNIA CRUST: INFERRED FLUID-SATURATION AT
Derek Schutt	TAKING THE TEMPERATURE OF THE YELLOWSTONE HOTSPOT
Ken Dueker	CONSTRAINING YELLOWSTONE MAGMATIC PROCESSES BENEATH THE EASTERN SNAKE RIVER PLAIN
Huaiyu Yuan	MOHO AND LITHOSPHERE-ASTHENOSPHERE BOUNDARY OBSERVATIONS ALONG THE YELLOWSTONE HOTSPOT TRACK
Catherine Rychert	CONFIRMATION OF A SHARP LITHOSPHERE-ASTHENOSPHERE BOUNDARY BENEATH EASTERN NORTH AMERICA USING S-TO-P SCATTERED WAVES
Jesse Lawrence	FAST AND EFFICENT ATTENUATION MEASUREMENT USING WAVEFORM CROSS-CORRELATION AND CLUSTER ANALYSIS
Federica Marone	RADIAL AND AZIMUTHAL ANISOTROPIC STRUCTURE OF THE NORTH AMERICAN UPPER MANTLE
Matthew Fouch	SHEAR WAVE SPLITTING ACROSS THE WESTERN U.S.: APPLICATION OF HIGH DATA VOLUME PROCESSING TOOLS
Simon Lloyd	INFLUENCE OF OBSERVED MANTLE ANISOTROPY ON ISOTROPIC TOMOGRAPHIC MODELS

CORE STRUCTURE

Satoru Tanaka	SMKS WAVES OBSERVED BY DENSE MOBILE BROADBAND SEISMIC ARRAYS
Wen-che Yu	COMPLEX SEISMIC ANISOTROPY IN THE EARTH'S INNER CORE BENEATH AFRICA
Keith Koper	DECORRELATION OF CODA WAVES FROM EARTHQUAKE DOUBLETS RECORDED AT YKA: INNER CORE SUPER-ROTATION ?

ADVANCES IN ACTIVE SOURCE INSTRUMENTATION AND SHOT DESIGN

Eiji Kurashimo	A NEW SINGLE CHANNEL DATA LOGGER FOR SEISMIC PROFILING
Marvin Speece	USE OF IRIS'S NEW SNOW STREAMER DURING AN INNOVATIVE OVER-SEA-ICE SEISMIC REFLECTION SURVEY IN SOUTH
Steven Harder	LARGE SHOTS, SMALL SHOTS, AND THE IMPORTANCE OF COUPLING

ADVANCES IN WAVEFORM ANALYSIS METHODS AND SOFTWARE AND DATA INTERFACES

Shayesteh Mehrabian	DISCRIMINATION BETWEEN EARTHQUAKE AND EXPLOSION SEISMOGRAM USING WAVELET TRANSFORMATION
Pascal Audet	MODELLING WAVEFORM DISTORTION DUE TO ELASTIC HETEROGENEITY WITH A WIDE-ANGLE, ONE-WAY WAVE EQUATION
David Okaya	IMPRINT OF CRUSTAL SEISMIC ANISOTROPY ONTO MANTLE SHEAR-WAVE SPLITS: CALIBRATED NUMERICAL TESTS

Gary Pavlis	OBJECT-ORIENTED SOFTWARE: IT'S THE INTERFACE, NOT THE IMPLEMENTATION
Igor Morozov	COMPREHENSIVE OPEN-SOURCE SYSTEM FOR GEOPHYSICAL DATA ACQUISITION, PROCESSING, AND VISUALIZATION
David Okaya	ON-DEMAND ACROSS-INTERNET CALCULATION OF SYNTHETIC SEISMOGRAMS: THE SCEC EARTHWORKS SCIENCE GATEWAY

Saturday, June 10th

WESTERN PACIFIC

Cliff Frohlich	A SEISMOGRAPH AND GPS NETWORK TO EVALUATE SUBDUCTION DYNAMICS IN NORTH-CENTRAL VANUATU
Eiji Kurashimo	CRUSTAL STRUCTURE OF THE MARIANA VOLCANIC ARC, INFERRED FROM SEISMIC EXPERIMENTS
Linda Warren	EARTHQUAKE MECHANICS AND DYNAMICS IN THE TONGA-KERMADEC SUBDUCTION ZONE FROM FAULT-PLANE ORIENTATION
Lorraine Wolf	NUMERICAL MODELING OF POROELASTIC RESPONSES TO THE CHI-CHI EARTHQUAKE, TAIWAN

NORTH, CENTRAL, AND SOUTH AMERICA

Jean-Philippe Mercier	PROTEROZOIC SHALLOW SUBDUCTION IN NORTHWESTERN CANADA
Gary Fuis	A COMPARISON BETWEEN THE ALPINE AND SAN ANDREAS FAULTS, NEW ZEALAND AND CALIFORNIA
Gerry Simila	SEISMIC STRONG MOTION ARRAY PROJECT (SSMAP) FOR THE NICOYA PENINSULA, COSTA RICA
Gerry Simila	INVESTIGATION ALONG THE COSTA RICA-PANAMA BORDER: DECEMBER 25, 2003 (M6.5) AND MAY 01, 2006 (M5.9)
Laura Auger	RECEIVER FUNCTION IMAGING OF THE CENTRAL AMERICAN VOLCANIC ARC
Catherine Rychert	SEISMIC ATTENUATION IN THE CENTRAL AMERICAN SUBDUCTION ZONE
Jack Odum	NEAR-SURFACE SHEAR-WAVE VELOCITY, VS30, AND NEHRP SITE CLASSIFICATIONS IN PUERTO RICO
Alan Levander	BOLIVAR & GEODINOS: INVESTIGATING ISLAND ARC ACCRETION ALONG THE SOUTHERN CARIBBEAN PLATE BOUNDARY
Fenglin Niu	CRUSTAL VARIATIONS IN THE SE CARIBBEAN AND VENEZUELA AND THEIR IMPLICATIONS FOR CONTINENTAL GROWTH
Ellen Syracuse	PRELIMINARY TOMOGRAPHIC RESULTS AND EARTHQUAKE LOCATIONS FROM THE TUCAN EXPERIMENT
Neil McGlashan	QUADRAT ANALYSIS OF THE ANDEAN MARGIN SEISMIC GAP
Stephanie Devlin	ACCURATE FOCAL PARAMETERS OF CENTRAL ANDEAN CRUSTAL EARTHQUAKES
Simon Lloyd	CRUSTAL THICKNESS AND STRUCTURE OF PRECAMBRIAN SOUTH AMERICA FROM RECEIVER FUNCTION ANALYSIS
Patricia Alvarado	USING HISTORIC AND BROADBAND SEISMIC DATA TO CHARACTERIZE THE ANDEAN CRUST BETWEEN 30°S AND 36°S

ASIA, ANTARCTICA, AFRICA, AND THE MIDDLE EAST

Michael Martin	SEISMIC ANISOTROPY BENEATH THE TIBETAN PLATEAU: NEW RESULTS FROM THE HI-CLIMB SEISMIC ARRAY
Risheng Chu	UPPER MANTLE STRUCTURE BENEATH THE TIBETAN PLATEAU
Kathleen Keranen	AN INTEGRATED STUDY OF 3-D CRUSTAL STRUCTURE IN THE MAIN ETHIOPIAN RIFT
Masaki Kanao	ANTARCTIC ARRAYS DEPLOYMENTS: CONTRIBUTION BY THE JAPANESE EXPEDITION AT INTERNATIONAL POLAR YEAR
Florian Haslinger	THE CTBTO INTERNATIONAL MONITORING SYSTEM, DEVELOPING COUNTRIES, AND THE GSN
Megan Flanagan	JOINT INVERSION FOR THREE-DIMENSIONAL VELOCITY STRUCTURE OF NORTH AFRICA AND THE MIDDLE EAST
Megan Flanagan	REGIONAL TRAVEL-TIME UNCERTAINTY AND SEISMIC LOCATION IMPROVEMENT USING A 3-DIMENSIONAL A PRIORI VELOCITY MODEL
Tom Hearn	Q VARIATIONS WITHIN THE CRUST OF CHINA

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Abstracts

USING HISTORIC AND BROADBAND SEISMIC DATA TO CHARACTERIZE THE ANDEAN CRUST BETWEEN 30°S AND 36°S

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The Andean crust between 30°S and 36°S is seismically active at both slab (~100 - 200 km) and crustal (< 35 km) depths. The most damaging events, however, are the crustal earthquakes associated with the thin-skinned Precordillera and the thick-skinned Western Sierras Pampeanas (WSP) of the Andean backarc. This region is characterized by an elongated flat subduction geometry at about 31°S, which correlates with a shut off of the active arc at 8 to 6 Ma. South of 32°S, crustal earthquakes of magnitudes over 6.0 occur within the South American upper plate along the active arc and backarc region, overriding a steep subduction zone. The Andean backarc is also characterized by several accreted Paleozoic terranes later reactivated by Mesozoic extensional processes. We have combined historical and modern seismic data to study the crustal seismicity and crustal structure in this region. Our approach involves 1) the study of the seismic source using paper seismograms for the largest magnitude earthquakes in the past century, 2) the characterization of the moderate seismicity recorded by the passive IRIS-PASSCAL broadband deployment of the CHile Argentina Geophysical Experiment (CHARGE) during 2000 and 2002, 3) the study of the most recent larger earthquakes in the WSP using broadband data from permanent stations operating in the region, and 4) the study of the crustal structure using CHARGE broadband data. The study of the 1944 and 1952 San Juan earthquakes consisted of collecting, digitizing and deconvolving teleseimic P-waveforms. We constrained a thrust focal mechanism with Mw 7.0 for the 1944 event and a major left-lateral strike-slip component in the 1952 (Mw 6.8) solution. We determined point source focal depths < 12 km for both events and short durations (10 and 8s, respectively) of their source time function. We constrained the seismic moment tensor and focal depth for 27 moderate (3.5 < Mw < 5.2) earthquakes modeling regional broadband CHARGE waveforms between 15 and 50 s. Our results indicate predominantly reverse focal mechanisms with depths between 14 and 26 km in the Precordillera and WSP. The Eastern Sierras Pampeanas (ESP) and active arc show strike-slip focal mechanisms with shallower depths (< 7km). We performed a seismic moment tensor inversion of regional broadband waveforms, recorded by global network stations located at distances between 400 and 1100 km, for the larger magnitude most recent WSP earthquakes. The 2002 (La Rioja) and 2004 (Catamarca) damaging earthquakes had Mw ~6.0 thrust focal mechanisms and focal depths < 10 km. Our investigation of the crustal structure using multiple waveform inversions and forward modeling of single station-earthquake paths indicates different crustal structures in the region. The Precordillera and WSP have high P-wave velocity, low S-wave velocity and total thickness of 55 km, with a complex layered structure. The ESP and active arc show low P-wave velocity, low S-wave velocity and a thickness of 35 km and 45 km, respectively. These results indicate a high contrast of the different seismic properties between the WSP and ESP crusts which correlates with the presence of different terranes. The western terranes, that generated larger numbers of earthquakes of higher magnitudes from historic to modern times, might have more structures to reactivate, based on the complex history of accretion, rifting and re-accretion of Paleozoic terranes. The integrated study of the Andean active crust is important for the assessment of the seismic hazard in the central-western part of Argentina.

THE PLATE BOUNDARY OBSERVATORY: DATA MANAGEMENT PROGRESS AND HIGH-LIGHTS

Greg Anderson, UNAVCO PBO Data Management/IT Group, UNAVCO Mike Jackson, UNAVCO Will Prescott, UN-AVCO

The Plate Boundary Observatory (PBO), part of the NSF-funded EarthScope project, is designed to study the three-dimensional strain field resulting from deformation across the active boundary zone between the Pacific and North American plates in the western United States. To meet these goals, PBO will install 852 continuous GPS stations, 103 borehole strainmeter stations, and five laser strainmeters, over the next five years. In addition, 209 previously existing continuous GPS stations will be incorporated into PBO through the PBO Nucleus project, and there will be a pool of 100 portable GPS receivers available for survey-mode observations. PBO will also operate 16 continuous GPS stations installed by the USArray component of EarthScope in the eastern United States. As of 30 April 2006, 334 PBO GPS stations had been installed, of which 326 had returned data to Boulder. In addition, PBO was responsible for data flow from 94 PBO Nucleus stations. Most of these stations return data to the PBO data center in Boulder on a daily basis. These data are then processed by the PBO GPS Analysis Centers, at Central Washington University and the New Mexico Institute of Mining and Technology, and the PBO GPS Analysis Center Coordinator at MIT. These groups create a range of GPS products, including station position time series, GPS velocity vectors, and related information. At present, these centers are processing data on a daily basis from about 500 stations; typical position uncertainties are approximately 1.0-1.3 mm horizontally and better than 4 mm vertically. All PBO GPS data products are archived at the UNAVCO Facility and the IRIS Data Management Center, and are available from the PBO web site at http://pboweb.unavco.org/?pageid=88. As of 30 April 2005, PBO had 14 borehole strainmeters and one laser strainmeter installed, with data returned at least once per day from 14 of these 15 stations. PBO handles data flow for a previously installed laser strainmeter as well. These data are analyzed on a daily basis by the Borehole Strainmeter Data Analysis Center in Socorro, New Mexico, and the Laser Strainmeter Data Analysis Center at the University of California, San Diego. These groups transform the raw strainmeter observations into cleaned individual strain gauge components; time series of shear, areal, and linear strain; and related products. All strainmeter data products are archived at and available from the Northern California Earthquake Data Center and the IRIS DMC, and are also available from the PBO web site at http://pboweb.unavco.org/?pageid=89. As of 30 April 2005, PBO also had 13 borehole seismic stations in operation at the borehole strainmeter stations. All stations have VSAT satellite telemetry and real-time data flow (latencies are typically a few seconds) via the Antelope Real-Time System from BRTT. Data from eight stations flow to the PBO Boulder Data Center, while the remaining five flow to the USArray Array Network Facility (ANF) at UC San Diego. All seismic data flow to the IRIS Data Management Center (DMC) for long-term storage and archiving, and are available to the community from the DMC in standard SEED format.

MODELLING WAVEFORM DISTORTION DUE TO ELASTIC HETEROGENEITY WITH A WIDE-ANGLE, ONE-WAY WAVE EQUATION

Pascal Audet, Michael G. Bostock, University of British Columbia,

There is growing evidence that elastic properties of the continental lithosphere and the underlying mantle are both anisotropic and laterally heterogeneous at a range of scales. To fully exploit modern three-component broadband array data sets (e.g. USArray) will require the use of comprehensive modelling tools. Unfortunately, full three dimensional numerical techniques (e.g. Finite-Difference, Spectral-Element, Pseudo-Spectral) are still impractical for forward modeling on standard desktop computers and afford limited physical insight. Ray tracing methods are intuitively and computationally appealing but may neglect important wave effects. We have begun investigating the use of the wide-angle one-way wave equation to model variations in teleseismic waveforms due to elastic heterogeneity. The one-way operators are found from a high-frequency approximation of the square-root operator. The one-way operators include the effects of wave propagation and scattering. Computational cost is reduced through a number of physically motivated approximations. We present initial results involving simple 1D (layer over a halfspace) and 2D (subduction zone) modelling that are compared with reference solutions.

RECEIVER FUNCTION IMAGING OF THE CENTRAL AMERICAN VOLCANIC ARC

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Seismic data recorded on the eighteen month PASSCAL deployment of the TUCAN (Tomography Under Costa Rica and Nicaragua) network have been used to develop receiver function images of the crust and upper mantle. Sixty-two P and PP teleseismic arrivals are deconvolved using a single event joint station method to produce 1177 receiver functions. Stacking each station yields robust features across the network that are seen in various back azimuths and reflected phases. With the exception of stations directly below the volcanic arc, a strong Moho conversion is seen in all azimuth ranges and most phase stacks. The most notable feature is a strong reflection from a dipping interface between the Moho and the subducting slab in the Nicaragua. An active source study indicates the presence of a fast wedge just above the present subducting slab (Walther et al., 2000) that represents a portion of the oceanic lithosphere subducted prior to collision of an oceanic plateau. The depth of the fast wedge in the active source study is within reasonable approximation of the dipping interface seen in receiver function images. It is therefore assumed that this is a continuation of the subducting slab. The presence of a continuous feature within the mantle wedge is likely to affect the thermal structure and fluid pathways, and may be linked to changes in geochemistry along the arc.

LITHOSPHERIC THICKENING AND FOUNDERING: MOUNTAIN AND CAPACITY BUILDING IN THE ANDES

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The western margin of South America has formed in a convergent margin setting similar to western North America prior to 30 Ma. Many of the same tectonic lithospheric-scale processes are happening today in the Andes that presumably happened during the Mesozoic in western North America. Studying both regions will give us insight to processes such as arc magmatism, crustal shortening, lithospheric removal and surface uplift that operate in mountain belts. Many of these similarities as well as the earthquake hazards associated with an active plate boundary provide added incentive to collaborate with Latin American colleagues to understand convergent margins and mountain building. However, these collaborations are sometimes challenging due to different styles of operating, expertise, and expectations. We compare the central Andes with the south-central Andes using seismic results based on two PASSCAL seismic deployments across the Andes at16-20°S and 30-36°S respectively done with collaborators at Universities and government institutions in Bolivia, Chile, and Argentina. The central Andes have an active volcanic arc, high elevations with a central plateau, thick crust and a large amount of shortening in the backarc. The seismic velocities indicate an overall felsic quartz-rich crust with a heterogeneous upper mantle consistent with piecemeal removal of parts of the lithosphere. The northern part of the Altiplano and the Eastern Cordillera show low seismic velocities beneath the crust consistent with lithospheric removal. In contrast, seismic velocities beneath the central Altiplano are consistent with lithospheric mantle still attached to the crust. Oxygen isotope studies in the northern Altiplano suggest rapid surface uplift between 10 and 6.8 Ma that would require lithospheric removal (Garzione et al., 2006). This locality occurs above a transition between fast and slow P-wave velocities in the upper mantle beneath the northern Altiplano. Overall, the large amount of shortening and the lack of a high velocity lower crust suggests that lithospheric material has been recycled into the mantle as the Brazilian craton has subducted beneath the Eastern Cordillera. In the south central Andes the subducting Nazca slab has a subhorizontal geometry and extends inland over 300 km beneath the Sierras Pampeanas (SP) near 31°S but returns to a normal dip to the south at 32°S. Seismic studies indicate that the eastern SP have a crustal thickness of 35 km while the western SP crustal thickness increases to 55 km. The western SP have a high velocity lower crust that may be a higher density material that has not yet been removed. Seismic tomography shows the mantle lithosphere is also very heterogeneous with low seismic velocities beneath the volcanic arc region, high velocities directly below the Moho in the backarc, and anomalous mantle (low Vp/Vs ratio) directly above the flat slab. The along strike variations of the lithosphere are indications of different stages in the process of lithospheric removal and "felsification" of the crust. In country collaboration is essential in any South America PASSCAL experiment but there are different challenges in working in the central and south-central Andes in terms of infrastructure and expertise. One of the challenges is to involve in country collaborators and students in both the fieldwork and the resulting science once the fieldwork is over. Another challenge is merging the goals of local seismic network operations with broader science goals of most PASSCAL projects. There are many opportunities to use PASSCAL projects for improving seismology education and to recruit outstanding graduate students (or encourage student exchanges) from South American countries.

QUALITY CONTROL WITHIN THE USGS GSN AND ANSS NETWORKS

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Over the last two years, quality control (QC) methods that are similar to those applied to IU GSN data have been implemented on the broadband data of the ANSS backbone stations. This higher standard is consistent with the requirements of the USGS Earthquake Hazards Program (EHP) and the commitment the USGS has made to provide a high quality data product from the ANSS. This QC implementation precedes integration efforts of the GSN and ANSS data processing. This poster summarizes the current quality control methods that are applied and provides data flow diagrams for both GSN and ANSS backbone broadband QC'd data and metadata from the station to the IRIS DMC. The status of the QC effort is reported and the symbiotic relationship between the two data centers is discussed.
A summary of current data issues is also presented. The future directions of the Integrated Data Collection Center (IDCC) and the QC processes are also discussed.

FEASIBILITY OF BODY WAVE GREEN'S FUNCTION RECOVERY FROM THE CROSS-CORRELATION OF CASCADIA TREMORS

Julien Chaput, University of British Columbia Dr. Michael Bostock, University of British Columbia

The Green's function for a source and receiver located on the Earth's surface over a heterogeneous medium can be recovered by cross-correlating and integrating the transmission response of noise fields recorded at the two surface locations. This assertion relies on the assumption that the noise field is generated by random, independant sources distributed over a surface underlying the heterogeneity. Moreover, the true arrivals and main contributions to the integral over source locations occur at the stationary points of the integrand for a given structure. In the majority of applications to date, ambient noise is used as a source, and thus only the surface wave contribution to the Green's tensor has been confidently extracted. The lack of attention to the body wave portion of the wavefield is in part due to the general absence of deep, high-frequency noise sources. In this study, we investigate the possibility of using the recently documented non-volcanic tremor on the Cascadia subduction zone, which extends to depths of up to 45 km, as noise sources that, at least partially, satisfy the requirements of the theory. We documented all tremors in 2004 and 2005 that occurred within the vicinity of the POLARIS-BC array on southern Vancouver island. We filtered the data recorded at stations LZB, TWKB and MGCB to isolate the tremor signature, and cross-correlated the results for all components between station pairs. The densest overlap of tremor episodes in 2004-2005 occurs just to the east of stations TWKB and MGCB. We have stacked the cross-correlations from these events for all components and pairs, and have noted that the same station auto- and cross-component correlations are generally highly reproducible, with combinations RZ and TZ on TWKB and MGCB showing a large arrival around 4.5 s lag. For cross-station results, ZZ and RZ cross-correlations are also highly reproducible, though other combinations of components are less so. The largest arrivals occur between 4-5 seconds for TWKB-MGCB, and 3.5 seconds for TWKB-LZB. We are evaluating the origin of the arrivals in terms of structure observed on the 1987 Lithoprobe reflection line, and the possibility of non-stationary contributions arising from incomplete spatial sampling.

UPPER MANTLE STRUCTURE BENEATH THE TIBETAN PLATEAU

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To understand the tectonic evolution of the Tibetan Plateau which was generated by the Indo-Asian convergence over past 70-50 Ma, various collision models have been proposed, but each of the models has a significant different upper mantle structure. In the meantime, current 3-D tomographic studies either have resolutions too low (300-500 km) or cover only small portions of the plateau. So refining the upper mantle seismic structure beneath the whole Tibetan Plateau is necessary. In this study, we use the upper mantle triplication waveforms, which are very sensitive to upper mantle velocity structure. Large amount of broadband seismograms recorded by more than 300 stations in and around Tibet from earthquakes with distance ranging between 12 and 30 degree are analyzed. Preliminary result indicates that the current TIP model is not adequate to fit the observations. The mantle lithosphere under the southern Tibet is faster than under central and northern Tibet.

CASCADIA

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The CAscadia Flexible array Earthscope experiment (CAFE) is designed to elucidate the relationship between water transport, and intraslab earthquakes, arc magmatism, episodic tremor, and aseismic slip. The ultimate goal is to explore H2O processes in this relatively warm subduction zone using the tools of seismology, geodesy, mineral physics and petrology, and to integrate these results with complementary constraints from geodynamics and geochemistry. Seismic imaging will illuminate (i) the descending oceanic plate where it metamorphoses, and (ii) the mantle wedge where fluids may be producing hydrous phases such as serpentine or, beneath the volcanic arc, primary magmas. The experiment traverses the part of the Cascadia system containing three large (M 6.5 to 7.1) intraslab earthquakes as well as the deepest (100 km) earthquakes, thus permitting an investigation of the relationship between the release of fluids and the generation of Wadati-Benioff-zone earthquakes. The transport of fluids may be also a primary driver for episodic tremor and slip (ETS), a phenomenon observed in Cascadia perhaps better than anywhere else on the planet. Accurate source locations and mechanisms of tremor will be explored through integrated analyses of small-aperture seismic arrays, broadband stations, GPS data and long-baseline tiltmeters. The basic experiment has four components: a broadband imaging array of flexible-array instruments integrated with Bigfoot, three small-aperture seismic arrays, analysis of existing PBO and PANGA GPS data sets to define the details of episodic slip events, and integrative modeling. The broadband array features a dense transect from the coast to the Cascades just south of the Olympic Mountains in a staggered configuration to allow along-strike effects to be tested. This is complemented by 2 cross lines, one crossing the slab where the crust appears to be dehydrating, and one in the Cascades foothills to sample the roots of the arc. The short-period tremor arrays are collocated with the dense regions of the broadband array. These data are subject to the gamut of analyses appropriate to such data, including array analysis for wave-front orientation of tremor waves, polarization analysis, migration of teleseismic scattered waves, tomographic images of Vp, Vs and Q, shear-wave splitting, earthquake relocation, investigation of high-frequency phases interacting with the slab, and specialized tiltmeter and GPS processing designed for the detection and quantification of transient events. The results will be interpreted in conjunction with detailed petrological–thermal models of the Cascadia subduction system and used to constrain the dehydration pathways within the down-going plate, the relationship between structure and seismicity at intermediate depths, the relationship between transient strain events and structure, the temperature, melt and volatile content of the mantle wedge, and the growth of continental crust.

EARTHSCOPE AUTOMATED RECEIVER SURVEY: RESULTS FROM THE TRANSPORTABLE ARRAY

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The first stations within the USArray Transportable Array (TA) component of EarthScope have been deployed for over 2 years, with more stations coming online almost daily, yielding sufficient data for preliminary analysis. We have calculated receiver functions for all earthquakes recorded by USArray to date using the iterative deconvolution technique of Ligorria and Ammon in an automated fashion using SOD, the Standing Order for Data, http://www.seis.sc.edu/SOD. We have then used these receiver functions to create crustal thickness and Vp/Vs estimates for each station with sufficient numbers of well recorded earthquakes using the HK stacking technique of Zhu and Kanamori (2000) to form a “Receiver Reference Model” (RRM) at each station. All results are available on the EARS web site at http://www.seis.sc.edu/ears. We present the crustal thickness and Vp/Vs results for all TA stations to date, as well as all other stations in the westernmost US with data present in the POND at the IRIS DMC. We also analyze the distribution and characteristics of the earthquakes and stations that did not produce useful results. Analysis of the efficiency of producing usable receiver functions for stations can give a quantitative measure of station quality, although many factors, such as complex crustal structure, distance from seismogenic regions, local noise levels and station down time, can contribute. For Transportable Array stations, rates of usable receiver functions vary from a high of one every 11 days for TA.S05C to a low of one every 161 days for TA.I05C. Transportable Array stations are compared to global temporary and permanent stations. Results for the rest of the world are also available on the EARS web site. EARS, Earthscope Automated Receiver Survey, http://www.seis.sc.edu/ears SOD, the Standing Order for Data, http://www.seis.sc.edu/SOD

WHAT CAN WE LEARN FROM IMAGES OF SEISMIC-WAVE ATTENUATION?

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Seismic-wave attenuation (1/Q) is highly sensitive to variations in temperature, and joint interpretation of attenuation and velocity models should aid in distinguishing between thermal and chemical heterogeneity in the mantle. Additionally, attenuation may be valuable for detecting the presence of melt and water. However, global attenuation tomography has to date contributed far less than velocity tomography to our understanding of Earth structure, and the existing 3-D global Q models show only limited qualitative agreement. Measurement and interpretation of the wave amplitude, which is the datum in most Q studies, is not straightforward, because factors other than attenuation influence amplitude. Principally, amplitudes are affected by focusing and defocusing due to lateral velocity variations, but uncertainties in the calculation of source excitation and in the instrument response can also obscure the attenuation signal in the data. We have developed a method to remove these extraneous effects and isolate the signal due to attenuation. We invert a large data set of fundamental-mode Rayleigh wave amplitudes in the period range 50--250 seconds simultaneously for maps of attenuation, maps of phase velocity (to correct for the focusing effects), and amplitude correction factors for each source and receiver in the data set. The attenuation models obtained by simultaneous inversion for elastic and anelastic models contain important features that are not robustly imaged when focusing, source, and receiver effects are ignored. The shallow mantle (~50-200 km) is characterized by high attenuation along western North America and along the East Pacific Rise and other ridge systems, and low attenuation within stable continental interiors. Lateral variations in attenuation are 60-80% at these depths, with differences most pronounced between the high-Q old continental regions and low-Q mid-ocean ridges. Such large variations require the presence of areas of very low Q, and correspondingly low velocity, in the asthenosphere and underscore the importance of lateral variability in the physical dispersion of velocities. Our global 3-D model of shear attenuation exhibits a strong correlation with models of shear-wave velocity, particularly for depths < 200 km. The correlation suggests that the variability in both Q and velocity in the shallow upper mantle has a common origin, which is most likely thermal. At the greatest depths sampled by our data (400-500 km) a different pattern, consisting of high attenuation in the southeastern Pacific and Red Sea regions and low attenuation along several subduction zones in the Pacific, dominates.

EARTHSCOPE EDUCATION AND OUTREACH

John DeLaughter, EarthScope

In the past eighteen months, the EarthScope Education and Outreach program has made significant strides. Highlights and plans for the future will be described in this presentation, along with a brief description of how EarthScope and IRIS are pursuing a beneficial partnership.

ACCURATE FOCAL PARAMETERS OF CENTRAL ANDEAN CRUSTAL EARTHQUAKES

Stephanie Devlin, Bryan L. Isacks, Cornell University

We investigate the depth distribution of earthquakes within the South American continental lithosphere to better understand crustal deformation throughout the Central Andes. Intracontinental event depths have direct implications on large-scale deformational and rheological properties of the crust and lithosphere. Focal mechanisms for over 120 crustal events above the subducted Nazca plate were assembled from the Harvard CMT catalog and published studies covering over 40 years of seismicity. The study area includes the Andes crust above three major segments of the subducted plate, the Peruvian and Argentinean flat-slab segments and the intervening segment where the subducted Nazca plate dips more steeply. The most seismically active regions continue to be the thick-skinned foreland thrust belts in the eastern Andes of Peru and the Sierras Pampeanas of Argentina. This seismicity is distributed in the crust from 4 to 36 km, while crustal thickness in these regions is as large as 50 km. Dramatic topographic expression of regional-scale geologic structures in the Andean foreland, where uplifted, tilted blocks and sharp fault scarp features are apparent, is clearly associated with the seismicity. Thrust mechanism events dominate these areas, but a minority of strike-slip orientations also occur. Despite the changes in focal mechanism, the P axes orientations remain consistent, predominantly E to NE trending P axes in Peru and E to SE throughout the Sierras Pampeanas. These directions of maximum compression seem consistent with the direction of convergence of the Nazca and South American plates. The thin-skinned thrust belts east of the central Andean Plateau show significant activity only near Santa Cruz, Bolivia and northern Argentina; most of the Sub-Andean thrust belt of Bolivia and southern Peru remains aseismic. The central Andean plateau itself also remains aseismic except for the region of southern Peru and two earthquakes in the Puna. The crustal seismicity in southern Peru is largely concentrated on the western side of the plateau. The focal mechanisms show a strong grouping of T axes in a horizontal, north-south orientation. Both normal and strike-slip mechanisms occur in this region, with no obvious correlation with elevation or surface structures. Remarkably, with the exception of one normal fault type mechanism near the Cuzco basin, the earthquakes occur in regions of the western parts of the Altiplano that do not exhibit topographic evidence of substantial crustal deformation. To expand the literature-based earthquake dataset, synthetic seismograms of P and SH body waveforms on teleseismic seismograms are inverted to obtain accurate strike, dip, rake, focal depth, and source time function. Continued integration of accurate earthquake locations and associated topographic signatures enables us to closely study seismicity's influence on landscape evolution and its relationship to deeper crustal structures.

PRELIMINARY RESULTS FROM THE BATHOLITH PASSIVE SOURCE PROJECT

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The primary goal of the Continental Dynamics ‘Batholith’ project is to constrain the petrogenesis of the Eocene Coast Mountain Batholith and determine the fate of the residual mass complementary to the massive Eocene granitic melt distillation event. The passive source component of this project was mobilized in June of 2005 and will be demobilized in October of 2006. Currently, 45 broadband seismic sites are being operated along two 250 km long lines that straddle the Coast Mountain Batholith. The northern line is aligned approximately NE-SW and starts in Douglas Channel, runs through Kitimat, and north to Hazelton. The southern line is approximately E-W, starts in Burke Channel, runs through Bella Coola and eastward to Anahim Lake. The two lines are separated by 200-300 km in the Coast Mountains Batholith. These high station density (14 km station spacing) line arrays will permit well resolved imaging beneath the lines. In addition, surface wave-fronts traversing between the lines will provide excellent data to image along strike of the Coast Mountain Batholith. Over the long, foggy winter, we found that 120 watts of solar panels and 200 amp-hrs of battery capacity were able to keep 95% of the Quanterra dataloggers fully operational. Preliminary results from eight months of available data will be presented including receiver function images, teleseismic body wave travel-time maps and noise correlation functions of the planetary ‘hum’.

IMBRICATION OF THE LOWER CRUST BENEATH THE ARCHEAN-PROTEROZOIC CHEYENNE BELT SUTURE

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The Laramie array consisted of the ten month deployment of 30 broad-band seismometers at a two km station spacing across the Archean-Proterozoic Cheyenne belt suture. The 60 km long line array straddled the Cheyenne suture in the Laramie basin of south-west Wyoming. Previous common-conversion point imaging using water-level deconvolved receiver functions revealed a potential imbrication of the Proterozoic Colorado province crust beneath the Archean Wyoming province crust. This polarity of crustal imbrication is inconsistent with simple kinematic models of the Cheyenne suture collison. To improve the quality of our migrations, two significant new processing techniques are applied to the Laramie array dataset: the minimum-phase Green's function (MPGF) deconvolution technique (Baig et al., 2005; Mercier et al., 2006) and wave-equation based shot-profile migration (Shragg et al., 2005). Typical P-wave receiver functions ignore P-P scattering by assuming that the P-component contains no P-P scattered energy (i.e., only source wavelet). However, the MPGF technique explicitly includes both P-S and P-P scattering. The MPGF approach exploits the observations that the P-component Green's function is well approximated as minimum phase (Bostock, 2003). The first step in the MPGF approach is to approximately separate the low-amplitude statistically white Green's function spectrum from the high-amplitude 'red' source spectrum. This frequency separation is accomplished by spectrally shaping the P, SV, and SH component spectra using a Gaussian low-pass frequency filter. The second step improves this frequency separation by performing a least-squares inversion at each frequency for all stations recording a closely spaced 'nest' of earthquakes. This provides the refined amplitude spectra of the three component Green's functions. Finally, the Green's functions phase spectrums are estimated via construction of a quasi-all-pass filters derived from stacking the source wavelet corrected phase of the SV and SH components. Application of these quasi all-pass filters produces the SV and SH Green's functions. The primary benefit of using wave equation based migration is that a 2-dimensional velocity model can be used. This will permit use of a well-resolved 2-D tomogram produced by inversion of teleseismic P-wave travel-times recorded by the Laramie array. Our S-wave velocity model will initially be a scaled version of our P-wave model. A newer version of the migration code permits post-migration velocity analysis (J. Shragg, pers. com.) that could prove useful for constraining lateral and vertical variations in Vp/Vs. The new migrated images will be compared to our previous common-conversion point receiver function image. Our ultimate goal is to confirm or deny the previous observation of the Proterozoic Colorado crust underthrust beneath the Archean Wyoming crust.

CONSTRAINING YELLOWSTONE MAGMATIC PROCESSES BENEATH THE EASTERN SNAKE RIVER PLAIN

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The most distinguishing feature of the Yellowstone hotspot track is the time-transgressive sequence of Rhyolitic calderas that fill the 80 km wide structural downwarp associated with the eastern Snake River Plain (ESRP). The caldera eruptive products are estimated to be 2-3 km thick with a thin <1 km carapace of late stage basalts. Three parameters are often used to explain the ESRP downwarp: 1) Densification of the mid-crust due to emplacement of mantle derived basalts; 2) Differential extension between the ESRP and its margins; 3) Outward directed flow of the ESRP lower crust forced by the load associated with mid-crustal densification. It is noteworthy that the mid-crustal densification process is complicated due to the requirement that the basalt differentiates into granitic liquids. Upon breaching the surface, these granitic liquids create the Rhyolitic caldera eruptions. The result of this hotspot distillation process is that the ESRP mid-crust should comprise a zone of basalt intrusions and fractionated granitic stocks (underlain by cumulates) embedded in the original Archean crust. The previous literature refers to this mid-crustal densification zone as the 'mid-crustal sill', however a more precise moniker for this complex zone would be the MC-MASH (Mid-crustal Melting-Assimilation-Storage-Homogenization) zone. Several lines of evidence support the existence of a densified MC-MASH zone. 1) Petrologic analysis suggests that the caldera eruption magmas are fractionated from mid-crustal basalt intrusions with modest amounts of crustal melting and assimilation. Given the estimated extrusive volcanic volumes, petrologic constraints suggest that a 17-37 km thick layer of mantle derived basalt has been added to the ESRP crust (McCurry and Rodgers, 2005). 2) Flexural modeling to match the observed downwarp of the fold axes about the ESRP suggests that a 10-20 km wide layer with a 3-4% density increase is required (McQuarie and Rodgers, 1998). This density increase is broadly consistent with density estimates of the fractionated basalt intrusions from petrologic modeling. 3) Two seismic refraction lines from 1978 suggest that an approximately 10 km thick high velocity body resides in the ESRP mid-crust (Sparlin et al., 1982; Chiang and Braile, 1984). Receiver function analysis from the 1993 PASSCAL transect is consistent with these refraction models, although free-surface reverberations from the base of the Rhyolite pile complicate the analysis (Peng and Humphreys, 1997). It is noteworthy that a new Rayleigh wave shear velocity image was unable to resolve a mid-crustal high velocity zone as vertical spatial resolution was insufficient (Schutt and Dueker, this meeting). Remarkable is that a new regional scale crustal thickness map shows that no significant crustal thickness variation between the ESRP and its margins (Yuan and Dueker, this meeting). Assuming uniform pre-hotspot crustal thickness and uniform syn-post hotspot extension between the ESRP and its margins, the uniform crustal thickness observation requires that for every km of magmatic addition to the crust, a km of lower crust has been expelled from beneath the ESRP (ignoring a km of crust ejected into the atmosphere). To provide new constraints on the geometry and shear velocity anomaly of the MC-MASH zone beneath the ESRP, 320 days of data from the 47 station Yellowstone Array is analyzed. Our analysis consists of measuring group velocity arrival times from vertical component noise correlation functions (NCF). Preliminary results shows that fundamental mode Rayleigh wave group dispersion curves can be isolated by stacking >50 days of data. Remarkable is that the NCF vary between one- and two-sided with respect to wave-period and differing station correlation pairs. Variations in the directionality of the 'hum' are expected given seasonal variations of ocean swell and internal wave amplitudes. Our ultimate seismic imaging goal is a joint inversion of Rayleigh wave ballistic-wave phase times and hum-wave group velocity times to constrain the fascinating distillation processes occurring along the Yellowstone hotspot track.

DECEMBER, 2003 MICROEARTHQUAKE SWARM IN EASTERN ARIZONA

Kevin C. Eagar, Arizona State University Matthew J. Fouch, Arizona State University George Zandt, Susan Beck, Hersch Gilbert, University of Arizona

The goal of this study is to characterize a swarm of earthquakes detected in central-eastern Arizona in December 2003 and determine their relationship to the regional tectonic system. Data from this study come from the COARSE array, a 9-station temporary broadband seismic network installed by Arizona State University and the University of Arizona (see http://asuarray.asu.edu/coarse for details). We detected a swarm of microearthquakes (ml < 4) and computed preliminary locations. The epicenters are approximately 80 km south of the Springerville volcanic field. The events occurred within a period of 18 hours on December 21 and 22, 2003, with the first seven within a 25 minute period. Epicentral depths range from 0-14 km, but are not well constrained. No apparent spatial or temporal patterns are evident within the swarm from our solutions. However, waveforms for all 12 events are nearly identical in character. We therefore applied a matched-filter algorithm to the data to search for additional similar events through January 2006 but did not find additional similar events. We are currently evaluating first-motion focal mechanisms and performing moment tensor inversions to better characterize the swarm source. Historically, seismicity in Arizona has been sparse, despite major tectonic and volcanic activity from the Late-Tertiary to the Quaternary. Several earthquake zones in regional proximity to the swarm, including the Socorro seismic anomaly, the western Grand Canyon and Flagstaff areas, and Sonora, Mexico, site of the 1887 M7.4 earthquake, suggests active regional tectonism. The discovery of this swarm near an area of Quaternary faulting and young Quaternary volcanics further corroborates this suggestion. In particular, it is in a region previously thought to be seismically quiescent and therefore has important implications regarding present-day tectonic processes of the southern Arizona Transition Zone. We suggest that this swarm is indicative of a significantly higher seismicity level than previously thought for the region in general. The installation of USArray stations and potential FlexArray deployments in the region will provide much better characterization of local and regional seismicity and provide new insights regarding the currently active tectonic state of the region.

THE EARTHSCOPE USARRAY ARRAY NETWORK FACILITY (ANF) THROUGH TWO AND A HALF YEARS OF OPERATION

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The Array Network Facility (ANF) for the Earthscope USArray Transportable Array seismic network is responsible for: the delivery of all Transportable Array stations (400 at full deployment) and telemetered Flexible Array stations (up to 200) to the IRIS Data Management Center; station command and control; verification and distribution of metadata; providing useful interfaces for personnel at the Array Operations Facility (AOF) to access state of health information; and quality control for all data. To meet these goals, we use the Antelope software package to facilitate data collection and transfer, generation and merging of the metadata, monitoring of dataloggers, generation of noise spectra, and analyst review of individual events. Metadata transfers of dataless SEED and Virtual Network Definitions (VNDs) have been simplified by the use of orb transfer technologies at the ANF and receiver end points. Currently four regional networks (Anza, BDSN, SCSN, and UNR) contribute data to the Transportable Array with additional contributors expected. As part of the quality control process, automatic processing and daily analyst review associates arrivals against all regional network bulletins. Through the end of April 2006, there have been 10,047 events recorded with 350,752 P, S, and Lg arrivals reviewed. Despite multiple analyst reviews, there are currently 764 events which have no regional network bulletin association. For 2005, there are only 16 possibly missed events with ml > 3.0 for the regional network bulletins we are collecting. Visit http://anf.ucsd.edu for more information on the project and current status.

REGIONAL TRAVEL-TIME UNCERTAINTY AND SEISMIC LOCATION IMPROVEMENT USING A 3-DIMENSIONAL A PRIORI VELOCITY MODEL

Megan P. Flanagan, Lawrence Livermore National Laboratory Stephen C. Myers, Lawrence Livermore National Laboratory Keith D. Koper, St. Louis University

We investigate our ability to improve regional travel-time prediction and seismic event location using an a priori three-dimensional velocity model of Western Eurasia and North Africa (WENA1.0). The objective is to improve seismic event locations by reducing both bias and uncertainty by providing model-based calibrations for stations throughout these regions. The a priori approach makes use of ancillary geophysical information to estimate the velocity structure (e.g., Pasyanos et al., 2004). We assess WENA1.0 relative to the iasp91 model by using measures of performance based on travel-time residuals and event relocation accuracy. Appraisal of travel-time prediction is based on residual analysis of approximately 6,000 Pg, Pn, and P arrivals recorded at 39 stations throughout the model region. Ray paths range in length between 0° and 40° (local, regional, and near teleseismic) providing depth sounding that spans the crust and upper mantle. The data set also provides representative geographic sampling across Eurasia and North Africa including aseismic areas. The effect of the model on travel-time residuals is effectively isolated by choosing seismic sources with epicenter accuracy between 1 km and 25 km (GT1 to GT25) at a confidence of 95% and by accounting for the effect of arrival-time measurement error. The WENA1.0 model markedly improves travel-time predictions for most stations with an average variance reduction of 29% for all ray paths. We find that improvement is station dependent, with some stations benefiting greatly from WENA1.0 predictions (41% at APA, 35% at NUR, and 27% at NIL), some stations showing moderate improvement (21% at KAD, 20% at SVE, and 17% at SHI), some stations benefiting only slightly (8% at TCF, and 7% at KBS), and some are degraded (–18% at QUE). For location tests we use 196 geographically distributed events with epicenter accuracy between 1 km and 5 km (GT1-GT5). In 134 cases (68% of the events), locations are improved, and average mislocation is reduced from 24.9 km to 17.7 km. Our uncertainty model produces location coverage ellipses that are smaller than those from iasp91 by 37% and are representative of true epicenter accuracy. We conclude that a priori models have the most utility in aseismic areas where data coverage limits the applicability of tomographic and empirical approaches, the development of the uncertainty model may allow the merger of a priori and data driven approaches to model development with use of Bayesian techniques.
This work was performed under the auspices of the U.S. Department of Energy by the University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48, Contribution UCRL-JRNL-220179.

JOINT INVERSION FOR THREE-DIMENSIONAL VELOCITY STRUCTURE OF NORTH AFRICA AND THE MIDDLE EAST

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We report on progress towards a new, comprehensive three-dimensional model of seismic velocity in a broad region extending from the western Mediterranean Sea to the Hindu Kush and encompassing northern Africa, the Arabian peninsula, and the Middle East. Our model will be an integration of regional waveform constraints, surface wave group velocity measurements, teleseismic P and S arrival times, and crustal thickness constraints. These measurements are made from a combination of datasets from MIDSEA, PASSCAL, GeoScope, Geofon, GSN, MedNet, and local deployments throughout the region. The data offer complementary sensitivity to crust and mantle structures and are jointly inverted to image the complexity of this tectonically diverse part of the world. In this phase of the project we focus on computing group velocity measurements and fitting of regional fundamental and higher mode Rayleigh waveforms using the PWI (partitioned waveform inversion) technique. To date we have measured Love and Rayleigh wave group velocities for hundreds of new paths recorded at the MIDSEA stations and combined them with thousands of existing paths transecting the region. The new paths have better defined the distribution of anomalies particularly with respect to the boundaries of sedimentary basins at short periods. In addition we have inverted over 2500 waveforms traversing the Arabian peninsula, Iran, and Afghanistan which extends our original coverage significantly to the east. We also demonstrate the proposed new data-inversion methodology and discuss results from combining these new measurements in a preliminary joint inversion. The combined data coverage will ensure that our three-dimensional model comprises the crust, the upper mantle, including the transition zone, and the top of the lower mantle, with spatially varying, but useful resolution that will allow better calibration of both travel times and waveforms for monitoring throughout the Middle East and North Africa. This work was performed under the auspices of the U.S. Department of Energy by the University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48, Contribution UCRL-ABS-218122.

SHEAR WAVE SPLITTING ACROSS THE WESTERN U.S.: APPLICATION OF HIGH DATA VOLUME PROCESSING TOOLS

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In this study, I provide new constraints on upper mantle anisotropy via shear wave splitting analysis of broadband stations in the western United States. The enormous volume of seismic waveform data currently being collected in this region, in part due to the installation of EarthScope/USArray stations, precludes conventional methods of data analysis and requires robust automated methods for data processing procedures. The western United States is a particularly important region for shear wave splitting analysis as it represents a complex range of tectonic settings, including the convergent margin of the Cascadia subduction zone, the transform plate boundary of the San Andreas and surrounding faults, the highly extended Basin and Range, the essentially undeformed Colorado Plateau, and the actively deforming Rocky Mountains. A uniform dataset with identical data analysis criteria is essential to appropriately compare and contrast these highly different tectonic regimes. I evaluate all 3-component broadband data available from the IRIS Data Management Center beginning in May 2004, which corresponds with the first USArray data available. I retrieve and preprocess seismograms using the Standing Order for Data (SOD) package developed by U. South Carolina. In this preliminary test, I evaluated events with body wave magnitude >= 6.5 and with epicentral distances between 85 and 130 degrees, the appropriate distance window for robust SKS splitting analysis). This initial search yielded 71 events and a total of 5,959 seismograms available for shear wave splitting analysis. In these preliminary examinations, I select a 20-second shear wave splitting analysis window centered an automated estimate of the middle of the SKS phase. Waveforms are bandpass filtered between 8 and 50 s and are evaluated for shear wave splitting using both the particle motion linearization and transverse energy minimization approaches of Silver and Chan [1991]. A total of 150 robust shear wave splitting measurements have been documented thus far. Preliminary results indicate highly variable fast polarization directions near the region of the San Andreas and nearby faults. Away from this major plate boundary, however, fast polarization directions for most stations are very similar to regional absolute plate motion (~WSW for much of the region). Splitting times range from ~0.5 s to ~2.5 s and are peaked near 1.5 s, larger than the global average of ~1.0 s. These results suggest that sublithospheric mantle flow likely dominates the seismic anisotropy signal across the entire western U.S. These preliminary results will be further supplemented with data from USArray and other stations as they become available at the IRIS DMC. Future analysis efforts will utilize other methodologies, including the error surface stacking method of Wolfe et al. [1998], the cross convolution method of Menke and Levin [2003], and the cluster analysis method of Evans et al. [2006]. All results of this study will be included as part of the new global shear wave splitting database in development at Arizona State University (http://geophysics.asu.edu/anisotropy/upper).

THICKNESS AND DEEP CRUSTAL COMPOSITION OF METAMORPHIC CORE COMPLEXES IN SOUTHERN ARIZONA

Andy Frassetto, University of Arizona Hersh Gilbert, George Zandt, Susan Beck, University of Arizona Matthew Fouch, Arizona State University

The Consortium for Arizona Reconnaissance Seismic Experiment (COARSE) is an array of 9 broadband seismometers deployed across eastern Arizona. High quality teleseismic receiver functions generated from these data provide constraints on crustal properties in the southern Basin and Range. Most receiver functions in the COARSE dataset exhibit well-defined moveout of the primary P-S converted phase from the Moho and its reverberation. By using a parameter space search we can confidently estimate crustal Vp/Vs and thickness from these arrivals with minimal tradeoff. Our findings show that the high elevation metamorphic core complexes in the southern Basin and Range exhibit anomalously large Vp/Vs (1.83) and equal or lesser crustal thickness (29-30 km) when compared to lower elevations in the region. At station TUC an extensive set of receiver function data sample both the Catalina-Rincon metamorphic core complex and the adjacent Tucson basin. There exists a distinct, well-constrained trend towards high Vp/Vs (1.85) beneath the core complex and low Vp/Vs (1.71) beneath the basin. Crustal thickness is similar for both settings. Geophysical studies have long shown that generalized composition (e.g. mafic vs. felsic) strongly influences Vp/Vs, wavespeed, and density. We show that Vp/Vs varies substantially in association with the compositional trends between distinct plutons that occur within the Catalina-Rincon core complex. In particular the observed high Vp/Vs may result from substantial amounts of a high density plagioclase-rich, quartz-poor rock intrusive series from 75-65 Ma. These plutons contain higher density and Vp/Vs than both the Precambrian basement and younger Tertiary plutons. Paradoxically, density modeling suggests that the crust is ~85 kg/m3 lighter than the surrounding Basin and Range in order to compensate its high elevation. These results support a model for core complex uplift that requires the crust to be broken by high angle faulting, but with no isostatic crustal root. Instead, a localized zone of low density mantle is required to provide isostatic support. These results also argue that substantial compositional heterogeneity of the crust can occur over a short distance and provide a clue as to how areas that underwent significant Tertiary extension may have been preconditioned for orogenic collapse.

A SEISMOGRAPH AND GPS NETWORK TO EVALUATE SUBDUCTION DYNAMICS IN NORTH-CENTRAL VANUATU

Cliff Frohlich, Frederick Taylor, Luc Lavier, University of Texas at Austin Michael Bevis, Ohio State University

The seismological and tectonic effects of subducting seamounts and ridges are a focus of current scientific interest because these features are common on downgoing plates. Generally, most of the area overlying the interplate seismic zone lies under water, and thus measurements from seismograph and GPS networks sample dynamics over only a limited portion of this region. However, there are a few places where the forearc emerges within 30 km of the trench and measurements can be taken over the entire interplate coupled zone. To study the structure and dynamics of the interplate seismic zone, we propose to install a network of 15 GPS stations and 15 broadband, 3-component seismographs in Vanuatu, focusing primarily on the islands of Santo and northern Malekula. Here large earthquakes occurred in 1965, 1971 and 1974 and the subducting D'Entrecasteaux Ridge and Bougainville Seamount exert a profound influence on arc morphology and seismic activity. The Santo-Malekula region is remarkable because instead of the bathymetric trench, island elevations up to 2000 meters occur along the physiographic extension of the New Hebrides Trench, because seamount chains appear to affect island geomorphology, and because there are anecdotal reports of 'slow' episodes of uplift and subsidence accompanying past large earthquakes. Data from the proposed seismograph/GPS network will permit analysis of regional structural variations using tomographic and receiver-function methods on sites straddling the subducting d'Entrecasteaux Ridge as close as 30 km from the surface trace of the thrust zone and less than 10 km above it. We will also search the data for episodes of slow earthquakes and/or seismic tremor. This structural information and the locations and types of seismic activity observed will be combined with our previous knowledge of episodic tectonic motions derived from analysis of corals to constrain finite element models of the subducting plate. Our objective is to understand mechanically how subducting bathymetric features influence regional geomorphology and large-earthquake activity. Several Vanuatu citizens including a seismologist have been involved repeatedly in previous geophysical research efforts here and will participate in the proposed project. We are currently striving to find funding sources that will allow us to leave 5 of the seismograph stations in Vanuatu permanently, operated by Vanuatu government personnel and contributing data to the global seismic network. Vanuatu government officials understand earthquake and tsunami risk and are supportive of our efforts.

A COMPARISON BETWEEN THE ALPINE AND SAN ANDREAS FAULTS, NEW ZEALAND AND CALIFORNIA

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There are clear similarities in structure and tectonics between the Alpine Fault (AF) system of New Zealand's South Island and the San Andreas Fault (SAF) system of southern California, USA. Both systems are transpressional, with similar right slip and convergence rates, similar onset ages (for the current traces), and similar total offsets. There are also notable differences, including the dips of the faults and their plate-tectonic histories. We investigated crustal structure surrounding the AF and SAF with active and passive sources along transects known as South Island Geophysical Transect (SIGHT) and Los Angeles Region Seismic Experiment (LARSE), respectively. On the South Island, a mid-crustal decollement originating at the AF and extending southeastward into the Pacific plate (PAC) is observed on at least one transect and is required beneath much of the South Island in order to explain both uplift of rocks in the Southern Alps from limited (mid-crustal) depths and an active fold and thrust belt on the PAC. In southern California, a similar mid-crustal decollement is observed on two transects as highly reflective zones within the PAC. Here, the decollement underlies the central Transverse Ranges and the fold-and-thrust belt of the northern Los Angeles basin. On the South Island and in southern California, crustal roots of comparable width and relief are associated with convergence of the plates across the faults. On the South Island, the crustal root reaches a maximum depth of 44 km; in southern California, 37 km. The AF appears to dip moderately southeastward (~50 degrees), toward the PAC, along the SIGHT transects based on surface outcrops; however, it may dip more steeply in the southwest part of the South Island. The SAF dips vertically to steeply northeastward toward the North American plate along the LARSE transects; however, to the northwest, its dip reverses to steeply southwestward, toward the PAC. On the South Island, the AF appears associated with a relatively wide (40-50 km) upper-crustal low-velocity zone (LVZ), but in southern California, the SAF is not associated with a significant upper-crustal LVZ. On the South Island and in southern California, upper-mantle bodies of high P velocity are observed extending from near the Moho to more than 200 km depth. In both locations, they appear attached to, or part of, the PAC, although this relationship is less clear on the South Island. These bodies may arise from thermal, compositional, or anisotropic differences with surrounding mantle. Currently, it is not possible to eliminate any of these three possibilities with certainty.

ROOT REMOVAL AND DEEP CRUSTAL EARTHQUAKES IN THE WESTERN FOOTHILLS OF THE SIERRA NEVADA

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The deployment of the Sierra Nevada EarthScope Project (SNEP) array in central California was designed to investigate the extent and effects of lithospheric removal from the base of the Sierran batholith. The design of this array focused on unraveling the extent to which the batholith lost its garnet-rich root, as has been proposed for the southern portion of the range, and may be continuing further north. Just as previous deployments in this region, the SNEP array is detecting deep crustal earthquakes in the lower crust of the western Sierra foothills. Earthquakes within the lower portions of continental crust are rare as this is a region that is generally though to undergo ductile deformation. Past investigators have proposed that the deep seismicity in the western foothills relates to ancient shear zones that accommodated extension resulting from batholith intrusion (Miller and Mooney, 1994, JGR). The currently deployed SNEP array, which consists of over 45 broadband seismometers and spans the central Sierra Nevada is ideally situated to study local and regional seismicity of the region as well as crustal and mantle structure. Dynamics related to root removal may be responsible for disturbing the base of the crust and producing the observed earthquakes. We have located several deep crustal earthquakes in the western foothills of the Sierra Nevada within the SNEP array from first 8 months of data. Locations of the earthquakes are focused north of Fresno, California, which is coincident with the northern extent of the high-wavespeed anomaly that is thought to relate to the foundered batholithic root. The locations of these earthquakes have depths near 30 km and occur within a region where receiver functions possess very little converted energy off of the Moho and crustal thicknesses reach 40 km. The lack of Moho signal has been interpreted to result from a cusp of crustal material that has been entrained into the mantle by downward flow induced by the foundering root. Stresses induced by this same foundering material may also be responsible for producing earthquakes in the lower crust. An additional curious aspect of these events is that a number of them repeat in time; earthquakes occurring between days and months apart exhibit nearly identical waveforms.

THE EARTHSCOPE INFORMATION SYSTEM

Christian Guillemot, EarthScope

As part of EarthScope commitment to provide timely information on the progress of instrumentation deployment through the construction phase of the facilities, a web-based application has been developed to facilitate the reporting and updating of station meta data and data latency status. New station information is uploaded automatically as the information becomes available while transmission latency is monitored hourly and daily for seismic and geodetic data respectively. The intuitive, easy-to-navigate tool features geospatial, operational, and pictorial information for each of the installed seismic, geodetic, strainmeter, and drilling facilities, and also serves as an entry point to the raw data (level 0) for each station. New maps are added regularly to reduce clustering and preserve mouse-over functionality as the cursor is moved over each station. In order to promote cross-browser compatibility, well-established scripting technologies are used, with no additional requirement on the part of the user to import or download additional software. Meta data information for each station is pre-loaded by the client browser and is available for viewing after a single page refresh.

LARGE SHOTS, SMALL SHOTS, AND THE IMPORTANCE OF COUPLING

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In controlled source seismology, in addition to having an adequate number of receivers, one must have an adequate number of effective and economical sources. Examining the energy-amplitude relationship between large shots (~1000 kg) and small shots (~0.45 kg), the energy of large shot is ~2200 times greater, however the amplitude of the large shot is only ~47 times greater assuming both explosions use the same type of explosive and are equally well coupled. Therefore, one could assume that if you fired 47 small shots in parallel that the amplitude of a large shot could be obtained. The fallacy in this assumption is that the earth responds to large shots with lower frequencies than it does to small shots. However, if one could get an array of small shots to interact in such a way as to produce a composite force on the earth over a large enough area that the earth would respond at the lower frequencies of large shots, then large shots could be simulated with arrays of small shots. To test the above hypothesis, we conducted an experiment at the site of a previous 1000 kg shot from the Potrillo Volcanic Field (PVF) experiment that was conducted in 2003. We designed a hexagonal shot array, which consisted of 91 small shots 0.45 kg each. Each small shot was 2 m from its six nearest neighbors. The width of the array from point to point was 20 m. Each shot hole in the array was drilled to a depth of 3.3 m with great care to insure the drill was oriented vertically and located precisely. After placing the charge in the hole, ~8 liters of viscous water was pumped into the hole to saturate the earth surrounding the charge and improve coupling. Holes were then tamped with cutting to the surface. The charges in the array were connected with carefully measured lengths of detonating cord to insure simultaneous detonation. The array was initiated from a central point with a single detonator. In addition, a seven-element array and a single shot of the same design were detonated for comparison. Texans recorders were deployed in the same locations as in the PVF experiment, although not over the large spread used in PVF. The results of this experiment were disappointing for two reasons. First, the 91-element array showed no evidence of shot interaction needed to generate a lower frequency earth response. We consider this lack of interaction due to poor coupling and possibly shot spacing that was too large. Second, the amplitude of the Pg arrival is many times less than expected, again we consider this due to poor coupling. Coupling in the experiment area is generally difficult. The surface is covered with wind blown sand and the subsurface consists of poorly consolidated silt and sand. Highly porous unsaturated materials couple the explosive energy to the earth extremely poorly because they are inelastically compressed (crushed) rather than elastically moved by the force of the explosion. To increase the bulk modulus, make them less susceptible to crushing, water can be added to fill the pore spaces, this greatly improves coupling. During drilling of the 1000 kg shot more than 10,000 liters of water were lost in the hole. This resulted in the saturation of a considerable volume surrounding the borehole. By contrast in this experiment only about 800 liters of water were used for saturating 100 boreholes. These results stress the importance of water in enhancing coupling of seismic sources. We are reevaluating the design of our array and are considering another test in a wetter environment.

THE CTBTO INTERNATIONAL MONITORING SYSTEM, DEVELOPING COUNTRIES, AND THE GSN

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The IMS will in it's final configuration form a global network of 321 monitoring facilities, an International Data Centre (IDC) in Vienna collecting and distribution data and products, and a communications infrastructure providing connectivity between the stations, the IDC, station operators, and National Data Centers of treaty signatory states. Of the 321 facilities, 241 are 'waveform' (acoustic) technology stations: 11 hydroacoustic (HA, 5 T-phase & 6 hydrophone), 60 infrasound (IS), and 170 seismic (50 primary,PS, and 120 auxiliary, AS), and 38 of those are located in countries classified as Least Developed Country (LDC), Landlocked Developing Country (LLDC), or Small Island Developing State (SIDS). A significant proportion of these stations either share infrastructure with a GSN or other international network facility (in the case of PS, HA, and IS stations), or are themselves also GSN or other international parent network stations (in the AS network). One major difference between the IMS and other parent networks is that an IMS station and all its equipment belongs to the host country, ahd the host country institution is responsible for the upkeep, maintenance, and operations. For the primary network stations this effort is fully funded by the PTS, but for AS stations the host country is expected to provide the funding. Only the communications system will be operated and funded by the PTS for all stations. While the establishment of an IMS station and a National Data Center provides the opportunities for developing countries to join the international scientific networks with a facility of their own, and to further develop their local capabilities, the requirements on the host institutions are quite demanding, and the establishment and maintenance to specifications of these facilities faces serious challenges. Collaboration between the PTS and the international parent networks has proven crucial for the successful establishment and upkeep of many IMS stations, but also offers direct and hidden benefits for the international community. This presentation will highlight some of the achievments of the last 5 years of collaboration between CTBTO and IRIS, and also provide an outlook towards potential future adventures.

QP AND QS MODELS IN THREE-DIMENSIONS OF THE SOUTHERN CALIFORNIA CRUST: INFERRED FLUID-SATURATION AT

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We analyze high-dynamic range waveform spectra to determine t* values for both P- and S-waves from earthquakes in southern California. We invert the t* values for three-dimensional (3D) frequency-independent Qp and Qs regional models of the crust. In general, Qp and Qs increase rapidly with depth, consistent with crustal densities and velocities. The 3D Qp and Qs models image the major tectonic structures and to a much lesser extent the thermal structure of the southern California crust. The near-surface low Qp and Qs zones coincide with major sedimentary basins. In contrast, at shallow depths beneath the Peninsular Ranges, southern Mojave Desert and southern Sierras, we image high Qp and Qs zones, which correspond to the dense and high velocity rocks of the mountain ranges. Several clear transition zones of rapidly varying Qp and Qs coincide with major late Quaternary faults and connect regions of high and low Qp and Qs. At mid-crustal depths, the Qp and Qs exhibit modest variation in slightly higher and lower Qp or Qs zones, which is consistent with reported crustal reflectivity. In general, for the southern California crust, Qs/Qp is greater than 1.0, suggesting partially fluid-saturated crust. A few limited regions of Qs/Qp less than 1.0 correspond to areas mostly outside the major sedimentary basins, including areas around the San Jacinto fault, suggesting a larger reduction in the shear modulus compared to the bulk modulus or almost complete fluid-saturation.

Q VARIATIONS WITHIN THE CRUST OF CHINA

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We use network amplitude data from the Annual Bulletin of Chinese Earthquakes to map regional attenuation beneath China. These data were collected for the ML and MS magnitude estimates. These amplitudes are from the horizontal components of short-period and long-period instruments and generally correspond to surface waves which interrogate the upper crust. Data are corrected for event size, spreading, and observed period but not for radiation pattern. Classical two-dimensional travel-time tomography methods are adapted to find regional attenuation variations, site gain effects, and source size corrections. We find the resolution of crustal features to be superior to that achievable by travel-time tomography. The attenuation Q values for these data averages around 360 for the ML data and 300 for the MS data. Station gain estimates and source size corrections are also derived but are generally small. Reso Features larger than 2 degrees in most parts of China are well resolved and map directly to geologic provinces. Regions with the lowest attenuation (high Q0 values) are beneath the South China Block, Sichuan Basin, Ordos Platform, and the Changbai Shan. These tend to be tectonically inactive regions that are generally dominated by intrusive and cratonic rocks in the upper crust. Regions with the highest attenuation (low Q0 values) are beneath Bohai Basin, Yunnan, eastern Songpan-Ganzi Terrain, and the Qilian Shan. These are predominantly active basins and fold belts. The continental margin also highly attenuates waves.

LOW VELOCITY ZONE ATOP THE TRANSITION ZONE IN THE WESTERN US FROM S WAVEFORM TRIPLICATION

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Song et al. (2004, nature) modeled regional S wave triplications in the northwestern US and found a low velocity zone atop the 410 seismic discontinuity. Here we present detailed modeling of waveforms traveling along the Pacific-North America plate boundary recorded by the TriNet broadband seismic array in southern California. We adopt regional tomographic models to constrain the shallow upper mantle structure down to 200 km and a hybrid 2-D finite difference-Kirchhoff diffraction operator to generate 3D simulations (DiFD), which accounts for responses off the great circle path. Strong azimuthal variations in the interferences of S wave triplications are clearly observed over less than 100 km. To reconcile such rapid change in waveform interferences, we model this array data with DiFD and find that a low velocity zone with a sharp western edge atop the 410 can explain the whole dataset quite well. Current model suggests a low velocity zone 3-5% slower than the ambient mantle with a sharp edge scale of less than 100 km. Though the geometry of the LVZ is not unique due to limited data analyzed, the sharp edge of the LVZ is robustly constrained with the array data.

EARTHSCOPE DATA GENERATION AND DATA FLOW

Christel Hennet, EarthScope Tim Ahern, USArray/IRIS Greg Anderson, PBO/Unavco John deLaughter, EarthScope William Ellsworth, SAFOD/USGS Susan Eriksson, PBO/Unavco Christian Guillemot, EarthScope Fred Pieper, IAGT John Taber, USArray/IRIS Charles Weiland, SAFOD/Stanford University

Over it’s five year construction phase EarthScope will install approximately 1,500 stations across the country. EarthScope stations will include permanent GPS stations, borehole strainmeter stations, long-baseline strainmeter stations, ANSS Backbone seismic stations, Transportable Array seismic stations, and an observatory 3.2 km beneath the surface in the San Andreas Fault. In addition, there will be 2,500 campaign GPS and seismic instruments available for temporary deployments and individual research experiments. Seismic and geodetic data are being produced by all EarthScope components, often with identical instrumentation and shared know-how. All data is openly available through our data centers and through single-point access at www.earthscope.org.

THE PLATE BOUNDARY OBSERVATORY STRAINMETER PROGRAM; PROGRESS AND FIRST OBSERVATIONS.

Kathleen Hodgkinson, UNAVCO Greg Anderson, Tim Dittman, Mike Hasting, Wade Johnson, Dave Mencin, Bob Mueller, James Stair, Joshua Stanley, Sarah Venator, Jim Wright, UNAVCO.

Borehole strainmeters, installed at depths 200 m, measure change in strain with a precision of 1 ppb over periods of hours to months. Strainmeters therefore have the capability of capturing plate boundary transient deformation that is not measurable by GPS or seismometers. PBO has installed ten Gladwin Tensor Strainmeters (GTSMs) in Washington and Oregon, and four on Vancouver Island, Canada. Six strainmeters were installed before the onset of the 2005 Cascadia Episodic Tremor and Slip event and strain data are available from five of these strainmeters beginning several weeks before the first detection of tremor. Another thirty-one installations are planned for Year 3 of Earthscope; the targeted regions include Parkfield, Anza, Yellowstone, Mt. St. Helens. A first analysis of data from 12 strainmeters indicates an accumulation of strain, a first order indication that the strainmeter are operating as expected. A tidal signal, caused by the earth tides and ocean loading, is evident in data from all the strainmeters. All strainmeters have relatively high atmospheric pressure response in the order of 2 to 8 nanostrain per millibar. In addition to strain data, rainfall, atmospheric pressure, temperature and seismic data are measured at all strainmeter sites. Pore pressure will also be measured at most sites. PBO strain data are archived at the IRIS Data Management Center (DMC) and the Northern California Earthquake Data Center (NCEDC). The strain and environmental data flow at hourly intervals to UNAVCO's Boulder Data Center (BDC) where it is converted to miniSEED and sent to the DMC and NCEDC via SEEDLink. Under normal operation the archives receive raw SEED data within 2 hours of it being collected at the strainmeter. Currently, raw data from nine strainmeters are available from the archives and can be retrieved via web interfaces provided by NCEDC and IRIS DMC. The strain data are processed at UNAVCO's Borehole Strainmeter Analysis Center (BSMAC), located at the PASSCAL Instrument Center, New Mexico Tech, Socorro. On arrival at the BSMAC the 1-sps data are inspected. Spurious data and signals known to be introduced by non-tectonic activity are identified. The 1-sps strain data are then reduced to 300-second interval in a multi-stage decimation process using minimum-phase decimate by 2, 3 and 5 causal filters. The BSMAC calculates the tidal signal, atmospheric pressure effects and a borehole relaxation trends for each strainmeter. The processed data are stored in XML files, which contain the strain data, and all the processing parameters needed to regenerate the time series corrections. For every 5-minute observation point the XML file contains the strain measurement, tide, atmospheric, borehole correction and a flag that describes the data quality. The processed data are available from the IRIS DMC and NCEDC and are updated at least every 14 days.

TOMOGRAPHIC INVESTIGATION OF THE CHARLEVOIX SEISMIC ZONE AND ITS METEOR IMPACT STRUCTURE

Tae-Kyung Hong, Lamont-Doherty Earth Observatory of Columbia University Won-Young Kim, Lamont-Doherty Earth Observatory of Columbia University

The Charlevoix Seismic Zone (CSZ) at Quebec, Canada is one of most active seismic zones in eastern North America. A Devonian meteor crater is placed in the middle of CSZ. Meteor impact structures at depth have been rarely identified in the field despite numerous evidences from numerical modelings and laboratory experiments due to their complex geometry. In addition, the influence of meteor impact on local seismicity is veiled, and the understanding on structure of CSZ remains primitive. We present the shear-wave velocity structure of CSZ using a waveform cross-correlation tomography technique. A massive perturbation of medium caused by meteor impact is observed down to mid-crustal depth. The revealed subsurface structure suggests a near vertical angle of meteor impact. The decrease of shear resistance by meteor impact caused an increase of shallow seismicity in the impacted area. Joint interpretation of shear-wave velocity structures and hypocentral distribution indicates that two inactive Iapetan rifting faults with strike of NE-SW are present at depth of 8-18 km beneath the shores of the Saint Lawrence River, and active small-scale faults with strikes of NW-SE and WNW-ESE develop from these rifting faults.

EVIDENCE OF LOW VELOCITY ZONES ATOP THE 410-KM DISCONTINUITY BENEATH THREE WESTERN US PASSCAL ARRAYS

John Jasbinsek, University of Wyoming Ken Dueker, University of Wyoming

The “410-water-filter” hypothesis suggests that the difference between MORB and OIB geochemical signatures may result from hydrated wadsleyite upwelling across a water solubility contrast associated with the phase transition of wadsleyite to olivine at the 410-km discontinuity [Bercovici and Karato, 2003]. The primary dynamical agent in this model is the supposition that upwelling hydrated wadsleyite crosses the hydrous solidus to produce dense melt that perches atop the 410-km discontinuity density contrast. We note that dissenting viewpoints exist [Hirschmann et al., 2005]. A rigorous test of this model is to detect a seismic low velocity layer atop the 410 associated with a melt layer. We call this layer the “410 Low Velocity Zone” (410–LVZ). This study seeks to provide improved constraints with respect to the 410–LVZ width and shear wave velocity reduction using data from three high density broadband seismic arrays. Previous studies have found a 410-LVZ with poorly constrained velocity reductions of 4–6% and rather large layer thicknesses of 25–90 km [Song et al., 2004; Vinnik and Farra, 2002; Vinnik et al., 2003]. To detect and constrain possible 410-LVZ arrivals, we analyze broadband teleseismic data from three 30 station PASSCAL arrays deployed in NW Colorado, SE Wyoming and SW Montana using P-wave receiver functions. Each array provided several hundred high quality receiver functions for the NW, SE and SW back-azimuth quadrants. Move-out corrected stacks for the quadrant data clearly reveal the 410 and 660-km discontinuities with amplitudes near global predictions. Most relevant to this study, however, is the finding of negative polarity P-to-S arrivals atop the 410 in 8 out of the 9 back-azimuth quadrant stacks. All these P-to-S arrivals display the correct move-out characteristics. Modeling the negative polarity 410-LVZ arrival consists of fitting a simple velocity model to the quadrant stacks. The simplest model that can fit the data is a “double gradient slab” (DGS) model. The DGS model is characterized by five parameters: (1) a depth interval over which the shear wave velocity decreases (top gradient); (2) a constant velocity slab interval width; (3) a depth interval over which the shear wave velocity increases (bottom gradient); (4) the velocity decrease for the top gradient; (5) the velocity increase for the bottom gradient. The DGS models assume horizontal-velocity layering and isotropic velocity models. Tangential energy associated with the 410-LVZ arrival is observed, albeit it is small and generally not in phase with the radial 410-LVZ arrival. This suggests that the tangential energy is not from dipping velocity boundaries. Anisotropic velocities within the DGS could also produce tangential energy. However, we believe that an anisotropic layer atop the 410 is not a plausible explanation for the 410–LVZ arrivals. To characterize the DGS models required by our 410-LVZ arrivals, a grid search of 12,800 DGS models is performed. A reflectivity code is used to calculate synthetic seismogram responses. Data misfit with respect to models is assessed using chi-square values. Inspection of posterior one and two-dimensional marginal probability distributions constrains model parameter correlations and probability bounds. The one-dimensional posterior probability distribution bound the shear wave velocity reduction between 4.3% and 7.1% at 70% probability. The DGS slab thickness is bounded between 4 km and 9.2 km with 70% probability. The 1-dimensional marginal probability distributions show that the most probable DGS model has a top gradient velocity reduction of 6.7%, top-gradient thickness of 9 km, a bottom gradient thickness of 6 km, and a 6 km slab thickness. Including half the gradient layer thicknesses, our best estimate of the total thickness of the 410-LVZ layer is 13.5 km. In conclusion, our new constraints for the 410-LVZ reveal a thickness and shear wave velocity reduction consistent with the predictions of Karato and Bercovici (2004). We note that the luxury of stacking 30 closely spaced broad-band stations in each array gives robust modeling results by permitting a significant reduction of signal generated noise in the quadrant stacks.

USARRAY AT THE IRIS DMC: QUALITY CONTROL

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The IRIS Data Management Center (DMC) collects, archives, and distributes seismic data. We are the primary archive and distribution point for all the raw USArray data, the seismic component of EarthScope. We also manage data from PBO and SAFOD, the other two components of EarthScope. This poster addresses USArray data management at the IRIS DMC and describes our quality control procedures that ensure the data is of the highest quality. Currently 246 USArray stations are deployed generating approximately 1500 seismic channels, distributed throughout six western states. In the year 2007, the footprint of USArray's Transportable Array will reach its peak of 400 stations (2400 channels). Prior to and during archiving at the DMC, the data undergo extensive quality control. Our approach to quality control is two-pronged: automatic/algorithmic and manual (human eyes). Automatic QC. As the data flows in real-time to the IRIS DMC it is processed by the QUality Assurance Control Kit, known as QUACK. QUACK examines the data, running various time series and frequency domain analyses and making routine measurements. All of the results are available for viewing through QUACK's web interface, http://www.iris.edu/servlet/quackquery/welcome.do. Here one can view results such as signal RMS and mean, data availability, gaps/overlaps, STA/LTA, and PDFs. In addition to QUACK, we perform automatic data monitoring using SeisNetWatch for rapid notification of signal problems such as clock quality, mass position, and signal anomalies. Manual QC. Data analysts at the IRIS DMC provide the touchstone of our quality control. We have multiple data analysts devoted to quality control of USArray data. We analyze the results of QUACK, study the PDFs and their temporal changes, and analyze the seismic waveforms, imposing human rationale on both the automated QC results and on data issues not caught by the automated algorithms. We continue to develop new quality control methods and add them to our routine processing. Our poster will feature a laptop overview and demonstration of our QC, particularly the QUACK system. Come see how you can use QUACK to get your science done!

SIERRA NEVADA EARTHSCOPE PROJECT (SNEP): BACKGROUND AND EARLY RESULTS BEARING ON FOUNDERING OF CONTI

Craig H. Jones, University of Colorado at Boulder Hersh Gilbert, Purdue University George Zandt, University of Arizona Tom Owens, University of South Carolina Ian Bastow, University of South Carolina Jordi Juliá, University of South Carolina Amanda Thomas, IRIS intern, Georgia Inst. Technology SNEP field team

Petrologic, geochemical, geological and geophysical studies in the southern Sierra have led many workers to conclude that material geophysically described as mantle lithosphere has detached from under the southern Sierra sometime between about 8 and 3 Ma, most likely towards the younger age. This material has been presumed to be in a P-wave high-wavespeed body about 100-200 km under the southwestern Sierra and southern San Joaquin Valley (the "Isabella anomaly" or "Southern Great Valley anomaly"). This conclusion has led to two speculations on the role of this event in the geological history of California: (1) foundering of lithosphere has occurred under nearly the whole of the Sierran crest, leading to uplift in excess of 1 km, extension, and an inboard shift in Pacific-North American plate motion (Jones et al, 2004) or (2) foundering occurred in an approximately 200-km-diameter region centered around the Long Valley caldera and led to localized potassic volcanism and uplift of that region (Zandt 2003). This variation in defensible interpretations suggests that the importance of lithospheric foundering can be examined in the Sierra Nevada by testing these ideas by learning the extent, history, and mechanism(s) of foundering along the entire Sierra. These tests are the focus of SNEP and an associated Continental Dynamics Project. Early results from SNEP include receiver function sections (discussed by Zandt et al., elsewhere at this meeting), surface wave studies, SKS anisotropy, earthquake locations and mechanisms, and travel-time tomography. These results have already suggested refinements to previous ideas about the Sierra. Body-wave travel times reveal a southeasterly plunge to the Isabella anomaly, with its uppermost end apparently reaching the crust in the foothills east of Fresno. Farther east, little variation is noted in the body wave travel times in the High Sierra and westernmost Great Basin. SKS fast directions are relatively uniformly ENE but split magnitudes vary from about 0.5 to almost 2 s in the region. High wavespeeds in the foothills to the north might be more variable than previously inferred. The region lacking a good Moho Ps conversion is mostly restricted to the south of Fresno, but the sharp Moho that may signify root removal continues to the north. Such observations may require adjustment or abandonment of some aspects of the models described previously. As the seismometers move into the northern Sierra, refined models contrast evolution of the process moving south to north in association with a decrease in time since passage of the south edge of the Gorda slab with geological variations in the crustal structure of the Sierra moving from the coincident Jurassic, early Cretaceous, and late Cretaceous arcs in the southern Sierra with a broader overall Mesozoic arc to the north. These ideas suggest variations in seismic structure to be tested in the remainder of the experiment.

ANTARCTIC ARRAYS DEPLOYMENTS: CONTRIBUTION BY THE JAPANESE EXPEDITION AT INTERNATIONAL POLAR YEAR

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Existing seismic stations allows resolution of the structure beneath Antarctic continent at a horizontal scale of 1000 km, which is sufficient to detect fundamental differences in the lithosphere beneath East-West Antarctica, but not to clearly define the structure within each sector. In addition, seismicity around the Antarctic is limited by the sparse station distribution and the detection level for earthquakes remains inadequate for full evaluation of tectonic activity.Antarctic Arrays is an ambitious program to improve seismic instrumentation on and around the Antarctica. This Antarctic Arrays strategy has several components, including 1) process-oriented experiments such as 3D-arrays at SPA; 2) evolving regional arrays; and 3) permanent backbone network. The temporary broadband seismic stations deployed at several outcrops and continental ice sheet around the Lutzow-Holm Bay region can contribute to the Antarctic Arrays program, as one of the the Japanese contributed stations in the marginal part of East Antarctica. In the situation when some array deployments shall be carried out on Eastern Dronning Maud Land by using air-boneplatform from SPA, we can make an effort to offer the ground support for the installation of additional stations. The obtained data targeted at the IPY 2007-2008 period will be initially stored and published for all the related cooperatives and geo-scientists from the data library server of the National Institute of Polar Research (POLARIS system). Then immediately offered to the world data centres of seismology, such as IRIS/DMS, FDSN/GSN, PACIFIC21 centres.These webpages can be opened in general and combined to the JCADM,SCAR/ANTEC, etc.

THERMAL STRUCTURE OF THE LITHOSPHERE FROM SHEAR WAVE VELOCITIES

Keith Priestley, Dan McKenzie, Bullard Laboratories, University of Cambridge

Lithosphere is a geodynamical concept which denotes that part of the mantle which forms the rigid plates and within which heat is transported by conduction. The thickness of the lithosphere controls the Earth's heat loss and the tectonics of the oceans and continents. We combine thermal models of the Pacific lithosphere and pressure and temperature estimates from mantle nodules brought up by kimberlites with 3-D models of Vs from surface wave tomography to obtain an empirical relation for Vs as a function of pressure and temperature. We use this relation to convert regional variations of Vs as a function of depth to lithospheric thickness. The accuracy of the resulting maps is tested by comparison with the location of diamond-bearing kimberlites, which are in most places restricted to regions where the lithosphere is in the diamond stability field. Our parameterization of the shear velocity as a function of pressure and temperature can be separated into two parts: Vs(elastic) that is independent of frequency and Vs(anelastic) that is frequency-dependent. If the attenuation (q) is to be independent of frequency, then the Kramers-Kronig relationships require q = B Vs(anelastic)/Vs(elastic), where B is a constant that is independent of temperature, depth and frequency. This relationship, therefore, provides a simple method of calculating q if the value of B can be obtained from the attenuation observations.

AN INTEGRATED STUDY OF 3-D CRUSTAL STRUCTURE IN THE MAIN ETHIOPIAN RIFT

Katie M. Keranen, Stanford University Simon L. Klemperer, Stanford University The EAGLE Working Group

The Main Ethiopian Rift (MER), situated south of seafloor spreading in the Red Sea and the Gulf of Aden, and north of continental rifting in the Eastern and Western branches of the East African Rift System, is an excellent location to study how continental rifts develop into seafloor spreading ridges. An international, interdisciplinary geoscience project in the MER, EAGLE (the Ethiopia-Afar Geoscientific Lithospheric Experiment), was undertaken between 2001 and 2003. EAGLE was comprised of passive and controlled source seismology, gravity, magnetotellurics, structural analyses, and geochemistry. Phase III of EAGLE in January of 2003 consisted of 23 shots and 1003 Texan single-component seismic recorders distributed along two ~400-km-long cross-rift and axial lines and a 2-D array centered on the Boset magmatic segment in the center of the rift. From these data, along-axis and cross-rift 2-D crustal velocity models and a 3-D upper-crustal velocity model have been published. These models show high-velocity bodies beneath magmatic segments in the MER interpreted to be zones of pervasive dike intrusion, a high-velocity lower-crustal underplate beneath the NW rift shoulder, and crustal thinning along the rift axis from southwest to northeast. From the other phases of EAGLE and from the Ethiopian Broadband Seismic Experiment (Nyblade and Langston, 2002, Eos Trans. AGU, 83, 405– 410) models of crustal density, crustal thickness, crustal resistivity, seismic anisotropy, and mantle velocity structure have been published, along with analyses of structural and geochemical data. Here we present the results of 3-D forward and inverse modeling of seismic refraction/wide-angle reflection data for lower-crustal velocity and Moho structure, we compare our results with the previously published models, and we integrate the diverse datasets to create a comprehensive 3-D model of crustal structure and tectonic processes in the Main Ethiopian Rift. Preliminary results suggest a conflict between published estimates of crustal-thickness variations from the Ethiopian Plateau into the rift and a simple pattern of extension across the rift.

LITHOSPHERIC STRUCTURE IN THE WESTERN US FROM S RECEIVER FUNCTIONS

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The technique of S receiver functions is briefly described. Typical observations are the Moho, a signal called LAB, and the 410 and 660 upper mantle discontinuities. The LAB signal has the opposite sign of the Moho, indicating a reduction of velocity downward. Such a signal is observed in many parts of the Globe. We have interpreted the LAB signal as seismic indication of the Lithosphere-Asthenosphere Boundary. We have also identified the LAB signal at 67 broadband stations in the western US near in average 8 sec precursor time of S and SKS, which correspondes to 70 km depth in average. We show a maps and cross sections of the LAB.

DECORRELATION OF CODA WAVES FROM EARTHQUAKE DOUBLETS RECORDED AT YKA: INNER CORE SUPER-ROTATION ?

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Seismic estimates of inner core super-rotation are converging to the range of 0.1-0.3 deg/yr, however a non-zero rate is not universally accepted. A crucial issue is whether the apparent seismic signals are created from earthquake mislocation rather than time dependent inner core structure. Here we contribute to the debate by addressing the simpler question of whether any change in inner core structure can be deduced over short time scales. To carry out the experiment we developed an array based algorithm that quantifies the degree of waveform similarity between earthquake doublets as a function of time. We applied this technique to data from 5 South Sandwich Islands earthquake waveform doublets that were recently discovered by Zhang et al. [2005] and were recorded at the 18-element, small-aperture seismic array in Yellowknife, Canada. The source-receiver distances for the five doublets are 136-139 degrees, providing a suite of inner core sensitive waves (PKIKP, PKiKP,SKIKP, SKiKP) and a corresponding suite of waves insensitive to the inner core (PP, SKP(AB), SKP(BC), and PKP precursors). By comparing the degree of similarity between the inner core phases and non-inner core phases, we could infer whether any differences were due to time dependent inner core structure, as opposed to differences in source location. For the doublet with the longest time separation (9.6 yrs) we found strong evidence for time dependent inner core structure. However, we found negative results for a doublet with a slightly shorter time separation (7 yrs) that sampled the same geographical area. This may imply that the rate of inner core differential rotation is highly variable or “jerky” on the time scale of ten years, however a more detailed understanding of the generation of inner core coda waves is needed.

CRUSTAL STRUCTURE OF THE MARIANA VOLCANIC ARC, INFERRED FROM SEISMIC EXPERIMENTS

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The Izu-Bonin-Mariana region is the classic example of an intra-oceanic arc-trench-back-arc system. Investigating structural variation along the arc provides fundamental knowledge about crustal formation. In 2002, a seismic refraction/wide-angle reflection survey was conducted over the Mariana volcanic arc between 14.5 and 18.5 degrees N using ocean bottom seismographs (OBS) and the R/V Maurice Ewing airgun source. Fifty-three OBSs were deployed in 3 arc-parallel lines along the active Mariana arc, the Eocene arc which is no longer active, and forearc. The airgun shot interval was 200m, except along the deep-water forearc line, which had a 250m shot interval. OBSs were most densely deployed along the active arc line with 10km spacing because we anticipated rapid velocity variation between the active volcanoes. OBSs on the Eocene arc line were spaced about 15km apart and the forearc OBSs were spaced about 20km apart. Two-dimensional velocity structures along each survey line were derived by 2-D ray tracing method using first arrivals and later phases. The velocity model along the forearc line indicates lateral variation of the forearc crust: the thickness of the forearc basement decreases from 11km in the north to 7 km in the south. This dramatic change in crustal thickness appears to trend approximately parallel to the subduction direction. A middle crust (Vp=6.0-6.5km/s) and a high-velocity lower crust (Vp>7.2 km/s) exists beneath the forearc. A layer with a velocity of 6.7km/s-6.8km/s only exists beneath the northern part of the survey line. A 22-25 km thick crust characterizes the Eocene arc. The middle crust (Vp=6.0-6.5km/s) of the Eocene arc is thicker than that of forearc crust. The velocity of the lower crust of the Eocene arc is 6.7km/s-7.2 km/s. No high-velocity lower crust (Vp>7.2) exists beneath the Eocene arc. The velocity gradient of the middle crust of the Eocene arc is smaller than that of the middle crust of the forearc. Comparing velocity models within the Mariana arc, we will discuss the crustal evolution process of the Mariana arc.

A NEW SINGLE CHANNEL DATA LOGGER FOR SEISMIC PROFILING

Eiji Kurashimo, University of Tokyo and Stanford University Naoshi Hirata, University of Tokyo Yuichi Morita, University of Tokyo Noboru Yuki, Hakusan Corporation

We developed a small-size, light weight, and high-performance data logger which can be used for crustal scale refraction/reflection experiments, in which hundreds of instruments are deployed over several hundred kilometers. Our new data logger has a single-channel 24-bit analog-to-digital converter. The timing is corrected automatically by a built-in GPS receiver, and its accuracy is always within an error of 1 ms. The waveform data are stored in a NAND-type flash memory with capacity of 128 MB. Recordings are performed based on a programmable schedule. The maximum continuous recording period is about 96 hours at a sampling rate of 125 Hz. The maximum sampling rate is 1000 Hz. The logger has a dimension of 200 mm×120 mm×75 mm, and it weighs 1.5 kg including four 1.5V D-size dry cells. The small size and light-weight body enhance portability and manageability. Parameters for recording such as sampling rate and schedule of observation are easily set through a Universal Serial Bus (USB) cable by a laptop computer. In order to easily operate hundreds of loggers, we have developed a special container for transportation, storage, and controlling of the logger. The container stores and controls up to 10 loggers, which are simultaneously operated by the computer. During deployment of the logger, its status including GPS clock, and geophone connection and orientation is automatically checked and displayed by a Light Emitting Diode (LED). After the observation, the loggers are returned to the container and the data are downloaded to the computer. We conducted a seismic reflection experiment on the eastern side of Mt. Fuji, in central Japan. Eight people deployed 148 data loggers in a day and recorded seismic signals from explosive sources using a standard 4.5Hz geophone. We obtained data with well-calibrated time information and high signal-to-noise ratio. The newly developed data logger is confirmed to be useful to obtain spatially dense seismic data with only a small number of crews.

FAST AND EFFICENT ATTENUATION MEASUREMENT USING WAVEFORM CROSS-CORRELATION AND CLUSTER ANALYSIS

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We present a new method of measuring seismic attenuation using waveform cross-correlation and cluster analysis. Cluster analysis improves attenuation measurements by systematically comparing only highly similar waveforms, which reduces bias from scattering, directional differences in source functions, and source-side structure. This semi-automated method is fast and effective, capable of measuring hundreds of relative attenuation measurements in only a few seconds. The reliability and efficiency of this technique will be useful for obtaining large numbers of attenuation measurements with sizeable networks like USArray. Anther advantage is that precise travel times are produced as a byproduct of the waveform cross-correlation, which can be used to directly compare with the attenuation results. Thus far we have applied the waveform cluster analysis method of attenuation to 112 events for all available 1 Hz sampled data from 1995 to 2003. The station spacing is currently uneven, making high-resolution results impossible, but USArray will soon improve resolution beneath North America. Even with the current uneven station spacing, the P- and S-wave results are correlated (R2 3 0.5) in both travel time and attenuation. Much weaker correlations are observed between travel-time and attenuation measurements. Similarities and differences between attenuation and travel times may be used to infer the source of the observed anomalies. The observed anelastic structure has a long-wavelength pattern crudely similar to that of seismic velocity, which likely reflects higher temperatures beneath western North America than in the east. Shorter-wavelength structure suggests complex variations requiring alternate explanations such as variable water content.

MAJOR-ELEMENT COMPOSITIONAL HETEROGENEITY IN THE UPPER MANTLE: IMPLICATIONS FOR SEISMIC VELOCITIES

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Unlike the continental crust, which is known to be structurally and compositionally heterogeneous, the Earth's upper mantle is often treated as being relatively homogeneous. The perception of a homogeneous mantle arises from its general inaccessibility and from the assumption that convection in the mantle probably erases large-scale chemical heterogeneities. However, it is in the uppermost mantle where chemical differentiation occurs. Melting beneath mid-ocean ridges generates oceanic crust and complementary harzburgitic residues from a lherzolitic mantle. These lithologies are then transported to subduction zones and re-introduced into the upper mantle. Subduction zones are also the regions where the mantle wedge melts and where delamination of lithospheric mantle or lower crust has been hypothesized to occur. If these recycled lithologies are not physically re-mixed back together again, considerable major-element heterogeneity should exist in the mantle. For example, it is well-known from mantle xenoliths that lithospheric mantle beneath cratons is depleted in Fe, Ca and Al compared to what is believed to be the source of modern mid-ocean ridge basalts. These lithologies have remained isolated from the rest of the mantle for billion year timescales because cratonic mantle appears to be too strong to be efficiently remixed back into the rest of the mantle. Persistence of major-element heterogeneities may not be confined to just lithospheric heterogeneities. It is possible that residual oceanic lithospheric mantle, eclogitized oceanic crust, or delaminated arc lower crust, might be strong enough to persist as coherent blobs within the convecting mantle. If so, mapping out these major-element compositional heterogeneities and correlating their distribution with temperature, density and isotope geochemistry will go far in linking geodynamics, geophysics and geochemistry. In this study, I will review the types of major-element variations expected in the upper mantle. This will be followed by a discussion about the influence of major-element composition and mineralogy on seismic velocities. Can seismology distinguish variations in peridotite composition from variations in temperature? To what extent are Vp/Vs ratios diagnostic of composition? What types of eclogites can be seen seismically? Recent seismic studies involving constraints on Vp/Vs ratios will be examined in the context of this talk.

INTEGRATED FLEX-ARRAY SURVEY OF THE NORTHWESTERN BASIN AND RANGE TRANSITION ZONE

Derek Lerch, Stanford University Simon Klemperer, Stanford University Ewenet Gashawbeza, Stanford University Jonathan Glen, USGS David Ponce, USGS Elizabeth Miller, Stanford University Joseph Colgan, USGS

In September 2004, Stanford University completed a multi - component seismic survey to collect information on the crustal thickness, velocity structure, and crustal - scale reflectivity of the northwestern Basin and Range transition zone. The experiment consisted of 4 parts: 1) A ~300 km crustal refraction profile, with six in - line shots and two off - line fan shots, with ~1100 receivers spaced 100 - 300 m apart. 2) During the deployment for the refraction experiment, we collected reflection data from both P- and S-wave vibrations with the tri-axial "T - Rex" vibrator truck operated by the Network for Earthquake Engineering Simulation (NEES) and the University of Texas at Austin. This experiment assessed the capability of T - Rex to collect useful crustal - scale reflection data. 3) Twenty - nine short period 3 - component instruments were deployed for seven months following the active - source experiment, using teleseismic events to determine crustal thickness and Vp /Vs ratios. 4) A ~20 km vibrator - source (T - Rex) reflection profile across Surprise Valley, CA, tying high-resolution (40 m receiver spacing, 40 m source arrays) seismic data to recent geologic mapping, geochronology, and drill core data. Our data span the change in tectonic setting from low-magnitude (~20-25%) Basin and Range extension in northwestern Nevada to the relatively unextended volcanic plateaus in northeastern California, filling the gap in geophysical data between previous surveys from these two regions. By completing this geophysical transect, we provide newfound control on the Mesozoic - present tectonic evolution of this poorly understood portion of the U.S. Cordillera. Beginning with the most recent tectonic activity, we document significant crustal thinning associated with Basin and Range extension. The degree of crustal thinning (~20%) is consistent with the amount of extension recorded in the upper crust in northwestern Nevada, suggesting the crustal response to extension was homogeneous over the entire crustal column. In addition to crustal thinning due to Basin and Range extension, our modeling includes low upper crustal velocities (~5.9 - 6.1 km/s) that coincide with the surface location of Cretaceous granites, marking the trend of the elusive northern extension of the Sierra Nevada batholith through northwestern Nevada. Combining geological and geophysical data, we reconstruct the late Cretaceous - present crustal evolution across this region, documenting an interplay between crustal magmatic addition, exhumation, sedimentation, and extension that has strongly changed the crustal character through time. Principal funding for explosive-source profiling was provided by NSF - Earthscope grant 0346245 and by the Petroleum Research Fund of the American Chemical Society; support for vibroseis profiling was received from NSF - Geoenvironmental Engineering and Geohazard Mitigation grant 0444696; and funding for passive-source deployments came from Stanford University. Field support and instruments were provided to all parts of the experiment by the PASSCAL Instrument Center.

BOLIVAR & GEODINOS: INVESTIGATING ISLAND ARC ACCRETION ALONG THE SOUTHERN CARIBBEAN PLATE BOUNDARY

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Post-Archean continental growth is presumed to result from accretion of island arcs to older continental masses. Along the Caribbean-South American (CAR-SA) plate boundary zone the Antilles Arc has collided obliquely with the northern SA margin since the Late Cretaceous. Neogene motions combine right-lateral strike-slip faulting along the coastal faults (El Pilar-San Sebastian-Oca), underthrusting of CAR plate beneath SA, and folding and thrusting and foredeep sedimentation at the southern edge of the plate boundary. We provide a progress report on the components of the U.S. BOLIVAR and Venezuelan GEODINOS projects. The goals of these projects are understanding the mechanisms for accretion of arc-related terranes to the northern SA continent, and assessing earthquake hazard in the SE Caribbean. The project includes geological, geochemical, and geophysical investigations involving ~30 scientists at 9 institutions in the U.S. and Venezuela. The study area extends from the Atlantic Ocean to the 71oW meridian, and from the Guyana Shield (60°N) into the eastern Caribbean basin (14oN). This immense area (>0.7M km2) is comparable in size to California and its continental margin, and rivals the San Andreas plate boundary zone in geologic complexity. Geologic studies have included mapping and age dating of igneous rocks of the Leeward Antilles from Aruba to Los Testigos, mapping of brittle deformation structures on the ABC islands, and mapping in the Villa de Cura blueschist belt in Venezuela, basin analysis and analysis of uplift and subsidence patterns in the onshore and offshore region, and 3-D reconstruction of palegeographic evolution. The BOLIVAR passive seismology group has completed two years of recording with 84 land and OBS broadband instruments. The BOLIVAR active seismology group acquired marine reflection, land refraction, and wide-angle onshore-offshore/OBS profiles along 5 principal reflection/wide-angle profiles. Four of these are along meridians (64°W, 65°W, 67°W, 70°W), extending from the Caribbean basin to the front of the fold-thrust belts onland in Venezuela. The fifth profile was oriented NW and extended from the Venezuela Basin to the Atlantic Ocean, crossing the Lesser Antilles arc and Aves Ridge. We also recorded reflection profiles and wide-angle data along the length of the Leeward Antilles arc.

SEISMIC STRUCTURE OF THE SOUTHERN ROCKIES AND COLORADO PLATEAU AND ITS TECTONIC SIGNIFICANCE

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The tectonic history of the southwestern United States dates to formation of this part of North America in the Proterozoic, ~1.9-1.6 Ga, when a succession of island arcs accreted to the southern margin of the Archean Wyoming province, leaving a pronounced NE-SW structural grain in the entire lithosphere. Phanerozoic tectonism has largely occurred along a N-S axis, paralleling the western margin of the continent, and has included formation of the Paleozoic ancestral Rocky Mountains, the Mesozoic Sevier fold and thrust belt, and the Cenozoic thick-skinned Laramide uplifts, Basin and Range and Rio Grande Rift extension, and episodes of voluminous volcanism. The mid-Mesozoic through modern history is largely attributed to processes associated with subduction of the Farallon plate beneath North America, with the Laramide uplifts resulting from flat slab subduction, and the vast regions of extension due to subsequent Farallon slab removal and development of the San Andreas transform system. Seismic investigations are beginning to unravel a complicated crust and upper mantle structure that is a composite of Archean, Proterozoic, and Phanerozoic influences. The structure of the lithosphere and upper mantle of the Southern Rockies and Colorado Plateau, as determined by recent experiments and regional and global tomography, is highly heterogeneous as a result of ancient and modern tectonism: The Colorado Plateau, which escaped most of the Mesozoic-Cenozoic mountain building around it, has a Proterozoic lithosphere at least 120 km thick. Its ~2 km uplift is attributed to asthenospheric replacement of the sinking Farallon slab, and is therefore thermally driven. Seismic measurements from DeepProbe, PACE, and La RISTRA suggest that the modern lithosphere is being invaded vertically and laterally by asthenosphere. CDROM data show that the Rocky Mountain upper mantle velocity anomalies along NE-SW trends represent a combination of ancient chemically buoyant slab fragments and upwelling Cenozoic upper mantle, with isostatic support of the Rockies thus provided in the upper mantle both thermally and chemically. DeepProbe shows that the Wyoming craton has a shallow, to ~100km depth, lithosphere that is tectospheric in nature, with its elevations supported by upper mantle chemical buoyancy. Surface wave data (van der Lee and Frederiksen, 2005) suggest that the deeper structure is not tectospheric, implying decratonization processes whose age is uncertain. Long term lithospheric heterogeneity as well as Cenozoic plate behavior appear to control the location of much Cenozoic volcanism.

INFLUENCE OF OBSERVED MANTLE ANISOTROPY ON ISOTROPIC TOMOGRAPHIC MODELS

Simon Lloyd, Northwestern University Suzan van der Lee, Northwestern University

We investigate the possible bias in isotropic 3D upper mantle S-velocity models due to observed anisotropy. For a perfectly uniform data coverage, anisotropic effects would be cancelled out of tomographic images. Conversely, if anisotropic regions are sampled by unevenly distributed wave paths, some anisotropy may be erroneously mapped into artificial isotropic velocity anomalies. We quantify these effects on two recent tomographic models derived from fundamental and higher-mode Rayleigh waves. These models are EAV03 for the Mediterranean (Marone et al., 2004) and NA04 for North America (Van der Lee and Frederiksen, 2005). For both regions we compile azimuthal anisotropy mainly from observed SKS splitting, and compute the resulting perturbations on Rayleigh waves used for the models (i.e. same wave paths). We use these data twofold: first we invert only the anisotropic perturbations for an isotropic model, to locate regions where bias may occur in the actual models, then we correct the actual data for the inferred contribution from anisotropy, and invert these in order to highlight potential artifacts in EAV03 and NA04. The depth of the anisotropy is not constrained by SKS waves. Therefore, we hypothesise different depth regions where the anisotropy occurs. Our tests show that the effect of observed anisotropy on isotropic tomographic models is generally small, and depends on the depth of the anisotropy. The potential bias is higher for EAV03 and increases if the anisotropy is concentrated in a shallow layer. However, even for a shallow and thin layered anisotropy the bias introduced is small compared to the isotropic velocity perturbations. This means that EAV03 and NA04, which were both obtained assuming the Earth is isotropic, are not significantly influenced by observed anisotropy.

CRUSTAL THICKNESS AND STRUCTURE OF PRECAMBRIAN SOUTH AMERICA FROM RECEIVER FUNCTION ANALYSIS

Simon Lloyd, Northwestern University Suzan van der Lee, Northwestern University Marcelo Assumpção, University of São Paulo, Brazil

We perform receiver function analysis with data from 10 temporary broadband seismic stations, deployed in different tectonic regions in eastern Brazil. The smallest epicentral distance of events used for the analysis is less than 30 degrees, as, due to the geographic setting, many of the events recorded lie within this distance range. We first obtain crustal thickness and bulk Poisson's ratio beneath each station location by applying two gridsearch methods (Zhu and Kanamori, 2000; Van der Meijde et al., 2003). The two methods yield similar results, with differences generally smaller then the calculated uncertainties. We find a relatively uniform crustal thickness of about 37 km and a Poisson's ratio averaging at 0.26 in both Archean and Proterozoic provinces. Two locations have a thicker crust of 40 and 42 km, respectively. The 40 km crust lies beneath a station in the Mantiqueira orogenic province and the 42 km are found in the Parana basin, which contains flood basalts forming one of the Earth's major igneous provinces. Using the crustal thickness obtained, we invert the receiver functions for a more detailed model of the crust beneath the stations. We compute the best fitting model composed of three layers within the crust over a halfspace. For all stations we find a relatively thin sedimentary layer of approximately 1 km thickness, and for most stations there is a discontinuity at an intermediate depth of about 20 km. While there are small differences in the depth and strength of this intermediate discontinuity, the overall features (including the depth of the Moho) are quite similar at the different locations analysed in this study.

USING WEB-BASED TOOLS FOR COMMUNITY INTERACTION – THE IRIS SUMMER INTERNSHIP PROGRAM

Michael Hubenthal, Chris Loos, and John Taber, IRIS Consortium

Web sites are being increasingly used as a means to create a virtual workplace and facilitate community interaction. To meet this demand within the IRIS community new tools are being added to the IRIS web site. Such functionality will be piloted this summer with the IRIS undergraduate internship program via funding received from the National Science Foundations, Research Experiences for Undergraduates program. To promote a more collaborative, supportive learning environment while in their summer placements, IRIS summer interns begin their summer research this year with a 1-week group orientation at New Mexico Tech hosted by Rick Aster. The purpose is to provide a short introduction to seismology and to give the interns an opportunity to meet and work with other interns before traveling to their individual IRIS institutions. One of the goals of the internship program is to provide the means for the students to continue to interact with each other while they are working on their research in different locations. To foster this goal, IRIS has developed internship research web pages structured to facilitate student interactions and to foster student learning with respect to independent research. Through the site, interns will be required to describe their projects in their own words, identify and structure overarching and periodic goals, monitor and evaluate progress, as well as to discuss the broader reaches of their work. To increase user friendliness, the site will leverage established blogger technology. At the beginning of the internship, interns' will be asked to answer specific questions in their blog focusing on identifying goals and developing a plan to reach the goals they identified with their hosts. During the internship the questions will focus interns' thinking on monitoring and adjusting of the plan and finally to evaluating the internship at its conclusion. Hosts will be encouraged to regularly review interns' blogs, using them as tools to gain insights into interns' current thinking and development. Discussion boards open to the students but not the hosts will also allow students to quickly and easily post topics of interest or reply to posts from their peers. While it is desirable that most online discussions are initiated and responded to by the interns, a discussion board monitor who is an internship alumnus will help stimulate conversations, offer advice, or direct interns to additional resources. The discussion boards will continue to be available to the students throughout the fall semester to help encourage interaction between the students when they meet again at the fall AGU meeting.

RADIAL AND AZIMUTHAL ANISOTROPIC STRUCTURE OF THE NORTH AMERICAN UPPER MANTLE

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Seismic anisotropy provides insight into paleo and recent deformation processes and therefore mantle dynamics. Currently our knowledge of the North American anisotropic structure arises mainly from global tomographic models or SKS splitting studies which lack horizontal and vertical resolution respectively, and are limited to either radial or azimuthal anisotropy. It is most probably due to these limitations that to date continental anisotropic models derived from surface and body wave data are not in agreement and cannot be reconciled. Our goal is a high resolution model for the North American upper mantle incorporating both radial and azimuthal anisotropy. We inverted long period waveform data in the framework of normal mode asymptotic coupling theory (NACT), using 2D broad band sensitivity kernels which allow us to exploit the information contained in long period seismograms for body, fundamental and higher mode surface waves at the same time. We followed an iterative inversion approach. In a first step, we inverted waveform data simultaneously for perturbations in the isotropic S-velocity structure and the anisotropic parameter $\chi=v_{SH}^2/v_{SV}^2$. While keeping this obtained radial anisotropic model fixed, in a second step we inverted for two additional parameters related to the dominant 2Ψ azimuthal dependence of the propagation velocity of surface waves. The inverted dataset consists of more than 40,000 high quality 3 component fundamental and overtone surface waveforms, recorded at broad band seismic stations in North America from teleseismic events and provides a fairly homogeneous path and azimuthal coverage. Our 3D radial anisotropic model shares the large scale features of previous regional studies for North America. We confirm the pronounced difference in the isotropic velocity structure between the western active tectonic region and the central/eastern stable shield, as well as the presence of subducted material (Juan de Fuca and Farallon plate) at transition zone depths. Concerning the radial anisotropic signature, we observe a positive χ anomaly in correspondence of the cratonic areas down to 300 km depth, while a negative χ anomaly beneath the Basin and Range province suggests possible mantle upwelling. Our 3D azimuthal anisotropic model indicates the presence of two layers of anisotropy with distinct fast axis directions under the stable part of the North American continent: a deeper layer with the fast axis direction aligned with the absolute plate motion direction suggesting lattice preferred orientation of anisotropic minerals in a present day ashenospheric flow and a shallower lithospheric layer likely showing records of past tectonic events. Under the tectonically active western US, where the lithosphere is thin, the direction of tomographically inferred anisotropy is stable with depth and compatible with both absolute plate motion direction and the dominant direction obtained from SKS splitting measurements. The combined radial and azimuthal anisotropic 3D structure retrieved in our model, resolved throughout the upper mantle, represents the advancement of this study with respect to previous works. These new results seem to suggest a possible reconciliation between anisotropic models derived from surface and body wave data.

SEISMIC ANISOTROPY BENEATH THE TIBETAN PLATEAU: NEW RESULTS FROM THE HI-CLIMB SEISMIC ARRAY

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The centrepiece of Project Hi-CLIMB (An Integrated Study of the Himalayan-Tibetan Continental Lithosphere during Mountain Building) is a broadband seismic array of over 800 kilometers in length across the Himalayan-Tibetan collision zone. Along a north-south trending corridor between 84 deg E and 86 deg E meridians, the array extended from the southern edge of the Ganga foreland basin, over both Lesser and Higher Himalayas, crossing the Indus-Yarlung Suture (IYS) and the Bangong-Nujiang Suture (BNS), then reaching into the heartland of the Tibetan plateau. In three phases between 2002 and 2005, over 300 seismic stations were deployed at an average spacing of 3-8 km. In this study, we report new results of polarization anisotropy based on birefringence of SKS and SKKS phases recorded by the Hi-CLIMB array. Consistent with previous results elsewhere in Tibet, the Himalayas and the Indian shield, no birefringence is observed south of the IYS. Significant splitting starts about 80 km north of the IYS. Further northward, orientation of the fast splitting axes fi gradually changes from NE-SW to E-W while dt decreases from about 1.3 s to 0.6 s. Near the surface trace of the BNS, dt increases rapidly to 1.5 s or so, suggesting a localized region of significant changes in anisotropic properties. North of the BNS, dt levels off to between 0.5 s and 1.0 s whereas fi remains approximately E-W. In general our new results are consistent with those obtained along the Yadong-Gulmod profile except for the obvious difference that there is a ten-fold improvement in spatial resolution along the Hi-CLIMB profile. As such, any change associated with the BNS was not detected along the Yadong-Gulmod profile. An exceptionally abrupt jump in dt was also reported about 40 km south of the BNS along the INDEPTH-III profile that is consistent with our results. However a detailed comparison of shear-wave splitting between Hi-CLIMB and INDEPTH-III profiles shows two observations that are worth noting. First, while the region of null splitting is consistent between Hi-CLIMB and Yadong-Gulmod profiles, null splitting extends farther north along the INDEPTH profile, suggesting a lateral change in the northern limit of intact Indian mantle lithosphere. Second, part of uncertainties near the BNS in fi and dt result from discordant estimates from SKS and SKKS phases which are typically from distinct events with different back-azimuths and thus support a model with more complex anisotropic properties near the BNS. Acknowledgements This work is supported by the Continental Dynamics Program of the US National Science Foundation under Grant No. EAR9909362. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the National Science Foundation. We also thank the IRIS PASSCAL Instrument Center for unwavering support throughout the long duration of Hi-CLIMB.

QUADRAT ANALYSIS OF THE ANDEAN MARGIN SEISMIC GAP

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Seismic gap theory contends that, because strain accumulation along tectonic boundaries is continuous, areas of seismic quiessence indicate the likelihood of an earthquake in the near-future. Regions between the trench and continent off the South American coastline were examined for earthquake distribution. Quadrat analysis on events from the Andean seismogenic zone was used to reveal notable regions of seismic paucity. However, the non-linear Richter magnitude scale allows for the rupture one large event to release an energy equivalent to many smaller events. Due to this, a lack of seismicity may not indicate large volumes of accumulated strain and therefore a imminent rupture. This study, therefore, focusses not purely on earthquake distribution but also weights individual events based on the calculated total energy released by that particular event. Quadrat analysis allows the individual events to be grouped into zones of accumulated energy which are a better indication of the seismic gap as low energy release equates to higher residual strains acting on the fault. ArcGIS was used to Krige the data into contours indicative of the total energy released by the seismogenic zone for the duration of the period of the study (1973 - present). A distinct seismic gap (zone of low energy/high strain) is identified directly under the city of Iquique, Chile. This is especially prominent as it is bounded to the north and south by areas showing the release of significant volumes of energy which would imply an increased strain on the locked fault plane surrounding Iquique. All available events (~14,000) from the NEIC catalogue occurring between 10S and 40S were used in this study.

RESULTS FROM A SIDE BY SIDE SEISMIC VAULT COMPARISON EXPERIMENT

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We tested six different vault designs at the USGS Albuquerque Seismological Lab. (ASL) in order to determine the performance characteristics over a range of conditions and seismic frequencies. ASL is ideal for such a test due to its low seismic background and the co-location of ANMO and meteorological sensors for comparison. Vaults were instrumented with a mixture of standard gain and high gain STS-2 seismometers and Q330 and RT130 digitizers for a period of several months. The vault designs tested were 1) ANSS backbone McMillan style vault (ALQM), 2) Earthscope transportable array vault with rubber membrane (ALTA), 3) Earthscope transportable array vault without rubber membrane (ALQT), 4) CERI vault (ALCE), 5) USGS portable station with an isolated concrete pad (ALQI), and 5) USGS portable station without an isolated concrete pad (ALQO). Data analysis consisted of computing power spectral density as a function of time and comparing to both temperature and wind measurements. We found that the vault designs performed differently at short and long periods. All vaults performed well. However, clear differences in long period noise levels were observed.

DISCRIMINATION BETWEEN EARTHQUAKE AND EXPLOSION SEISMOGRAM USING WAVELET TRANSFORMATION

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The seismic data obtained from seismograms are an object of careful analysis for numerous purposes, especially for the prediction of large earthquakes. Many approaches based on nonlinear dynamics methods have been applied, but there are some limitations, which narrow down the applicability of the obtained results. By analyzing only seismograms recorded for transverse seismic waves, a sufficient amount of information can be obtained for the definite differentiation of weak earthquakes from explosions. In this study for discrimination between earthquakes and explosions the important factors such as discreteness, long-range memory, local time behavior and also properties of frequency-time dependency are considered. The method is used, based on considering seismograms in the form of a discrete non-Markov random statistical process along with analysis of corresponding phase portraits, memory functions, and non-Markovity parameters. They contain a great amount of the qualitative and quantitative information about seismic activity. With respect to this matter that, the fluctuations of a random variable of a complex system can be represented as a component state vector, a finite discretization time, fluctuations and mean value are defined by conventional relationships. By solving the chain of equations, under the assumptions, the recurrence formulas for memory functions of arbitrary order are obtained. It should be noted that the quantitative description of long-range memory effects in the system have been considered together with memory functions. The set of new parameters describes the discrete structure of the system and allows extracting additional information related to non-Markov properties of the complex systems. By this method some features of different states of the Earth's crust: before and during earthquakes and explosions have been found. These features can be used to view optimistically the solution of the problem of predicting large earthquakes.

PROTEROZOIC SHALLOW SUBDUCTION IN NORTHWESTERN CANADA

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Northwestern Canada is a unique collage of different geologic domains that accreted together at different stages in the planet's history. In this region the rock record spans circa 4.0 Ga, from Early Archean to the present day, over three thousand kilometers. It represents the most nearly complete and continuous sampling of geological time on the surface of the Earth. Throughout the last decade, several geological and geophysical experiments have been carried out in the region leading to important new insights into continental evolution. Amongst them, an extensive layering in the cratonic mantle beneath Yellowknife has been documented and interpreted as the remnants of shallow subduction that occurred during the Archean and Proterozoic Eras. Near-vertical seismic reflection surveys have also shown the presence of fossil subduction west of the Slave craton in the Wopmay orogen. However, the relation between this structure and lithospheric stratigraphy below the Slave craton is not fully understood. In this poster we will present receiver functions images of the subsurface beneath the Wopmay orogen complex using a subset of 20 seismic stations deployed as part of the CANOE array which serve to clarify the relation between structure observed in previous active and passive source seismic studies. On the radial component receiver function image, our results show a clear and continuous Moho along the array with one significant, 75~km long interruption near the suture of the Fort Simpson and Hottah terranes where the relic of Proterozoic subduction has been inferred. The geometry of subduction is better defined, however, on the transverse component image where the former crustal underplated material is identified as a 10~km thick layer exhibiting strong anisotropy. The subducted crustal layer extends from depths of 30~km at the suture to 80~km, over a distance of 150~km further beneath the Hottah terrane, whereupon it becomes hard to trace. The top of this layer corresponds to the continental Moho as inferred from the radial component providing compelling evidence for a Moho (i.e. major jump in S-velocity) defined by an eclogitization phase front. The images also suggest that this feature and a layer at 125~km depth observed below Yellowknife form a single continuous structure.

OPTIMAL SITING OF USARRAY GEOPHYSICAL INSTRUMENTS USING GIS-BASED SUITABILITY ANALYSIS

Matt Mercurio, IAGT

As part of its contribution to the EarthScope project, IAGT has developed a site suitability analysis technique to aid in the selection of candidate sites for the USArray seismic geophysical instrument construction. This technique utilizes geospatial data and geographic information system (GIS) software to make the siting process more productive. In general, suitability analysis refers to a spatial information overlay technique that helps identify the most appropriate locations for specific land uses. As applied to the work of USArray, this technique allows field personnel to quickly focus their initial site reconnaissance efforts on much smaller areas within the larger target siting buffer zones. This approach is applicable for any instrument siting activity where explicit site characteristics can be identified. The goal of the USArray analysis is to narrow and rank potential field investigation locations from within a 15 km area around initial target sites. The first step in the suitability analysis for seismic stations is to exclude all areas in the siting tolerance buffer that are not viable for seismic station siting due to their high levels of background noise, including criteria for varying distances from roads depending on their size and distance from water features. These excluded areas are then subtracted from the initial buffer to leave available areas for siting. The available areas are then ranked by classifying the quality of the site using three preferred characteristics: private land ownership, cellular coverage and location on bedrock geology. The resultant suitability maps are then distributed to USArray siting teams. Along with these hard copy maps, IAGT provides a library of supporting GIS data, and a customized ArcMap GIS mapbook file so the teams can construct custom maps for each site before going into the field. These GIS-based site suitability analysis techniques have proven to be extremely valuable to the EarthScope engineers, but the same concepts and approach are directly applicable to any geophysical instrumentation planning, siting, and installation activities.

EARTHSCOPE COMMUNICATIONS: ENGAGING THE BROAD SCIENTIFIC COMMUNITY

Charna Meth, EarthScope

The success of the EarthScope Project requires strong interaction with the broad scientific community. We achieve this through open communications to keep all audiences updated on EarthScope's status, news, and achievements. Mechanisms for such communications include: presentations at professional meetings, national meetings, workshops, an exhibit booth, electronic and print publications, press, and an extensive website that provides accurate operational status and seamless single-point access to all EarthScope data. EarthScope has participated in dozens of scientific and educational meetings and conferences. At large meetings, the EarthScope Exhibit Booth serves as a nexus for information about the project's status, progress, and activities, and as a centralized venue for discussions. Professional meetings also provide a forum for direct interaction between the project and the users of EarthScope data and data products. Now that the installation is underway, EarthScope is leveraging the meetings to receive direct feedback from the community, maintaining the grassroots atmosphere under which the project was developed. Publications and reports are an important means of interaction with the scientific community. The EarthScope Project Office produces general publications aimed at the scientific community, one-pagers focusing on current news items emerging from the project, and reports on EarthScope's current status and progress. These publications are available to the scientific community at the EarthScope Exhibit Booth, through the EarthScope website, and by directly contacting the EarthScope Project Office. The EarthScope Project's interaction with the press is conducted through the National Science Foundation's office of Public and Legislative Affairs and focused on furthering EarthScope Project's scientific and educational goals. EarthScope's involvement with the press has resulted in articles published in newspapers, news magazines, and science magazines. Local, national, and international television programs have also produced segments featuring EarthScope. The EarthScope Project works to enfranchise the scientific community, support the public's investment in basic research, and communicate its status and results to a diverse audience. Different means of communication are used to accomplish each task, but each method is based on coupling the desired results with the correct tools for delivering the message. As EarthScope continues, outreach to, and interaction with, the broad scientific community will become increasingly important in achieving our scientific goals.

THE FIRST EARTHSCOPE NATIONAL MEETING

Charna Meth, EarthScope Gregory van der Vink, EarthScope Karl Karlstrom, University of New Mexico Rick Carlson, Carnegie Institution of Washington Rick Aster, New Mexico Tech Patricia Raymond, EarthScope

In March 2005, over 300 scientists convened on the Santa Ana Pueblo in New Mexico for the first EarthScope National Meeting. With the goal of furthering interdisciplinary research and identifying cross-cutting strategies for advancing EarthScope activities, the meeting surpassed expectations – both in the number of participants and the breadth of disciplinary representation. The combination of tutorials, plenary science sessions, summaries of previous workshops, and informal discussion groups created an environment of inclusiveness and cross-disciplinary awareness that will help foster the transformative research we expect the EarthScope Project data will support. Organized by Karl Karlstrom, Rick Carlson, and Rick Aster, a key goal of the National Meeting was to provide a community-wide forum to summarize and integrate the diverse workshops initiated by the community. Brief summary reports from a total of 17 workshop groups were presented during the first day. The second day was devoted to a host of plenary presentations on current EarthScope research and educational activities including SAFOD drilling, fault zone structure, earthquake geology, EarthScope and the National Park Service, strength and strain in the Earth, the intersection of geology, geochemistry, and geophysics in studies of the lithosphere and asthenosphere. In the interest of advancing multidisciplinary literacy, an evening session was devoted to four “Earth Science Mini-courses”. The final day featured a panel plenary discussion focusing on the future of the EarthScope program. A wide variety of topics were discussed, ranging from visions of the ultimate legacy of EarthScope and its potential to advance Earth science education on a national scale, to detailed suggestions for the evolution of future meetings. A recurring message was that future EarthScope meetings and other activities must continue to strive for broad inclusiveness, and can offer a uniquely multi- and inter-disciplinary niche for Earth science research, education and outreach. Already, plans are well underway for the 2007 EarthScope National Meeting. The 2007 chairs – Jonathan Price, Wayne Thatcher, and Roland Bürgmann – envision a natural progression from the previous meeting’s emphasis on broad discussion, community interaction, workshops, and programmatic reporting, towards increasingly multidisciplinary presentations and discussions that transcend the traditional programmatic boundaries in geology and geophysics. The 2007 EarthScope National Meeting is scheduled for March 27-30, 2007 in Monterey, California. We hope to see you there.

COMPREHENSIVE OPEN-SOURCE SYSTEM FOR GEOPHYSICAL DATA ACQUISITION, PROCESSING, AND VISUALIZATION

Igor Morozov and Glenn Chubak, University of Saskatchewan

Owing to its affordability and flexibility, open-source software offers substantial benefits yet it is often limited in scope and lacks user interfaces. For a number of years, we have been developing an open-source package (called SIA, (http://seisweb.usask.ca/SIA/) which serves as a tool for the processing and analysis of several types of geophysical data and also as highly integrated framework for developing geophysical applications software. Currently, the package consists of a processing core extending the capabilities of a seismic processing system, graphical user interface (GUI), and customizable interactive 2D/3D OpenGL visualization tool similar to those used in commercial seismic interpretation systems. The GUI has built-in capabilities for cluster and grid management, and both flow processing and some tools (such as 1D and 3D finite-difference modeling) are enabled for parallel execution. The following new features of the system might be of particular interest to IRIS users: 1) Ability to handle controlled-source and earthquake waveforms, travel-times, potential-field datasets (2D and 3-D), and metadata, with high throughput and integration of the tools; 2) Fully customizable, paralelized visualization protocol based on OpenGL, allowing building complex, 3D interactive tools without the need to write any code in OpenGL. 3) Capability for full web-service operation allowing performing custom processing at a remote location. A library of processing examples was created using this approach.(http://seisweb.usask.ca/temp/examples). 4) Tools for real-time data acquisition and management of a seismic network; 5) Extensive C++ code libraries, maintenance utilities, and automated documentation support; 6) Automatic distributed software updates through the Internet.

CONSTRAINTS ON CRUSTAL THICKNESS AND VP/VS RATIO IN THE SOUTHERN CASCADES USING RECEIVER FUNCTIONS

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The goal of this study is to provide new constraints on variations in crustal thickness and composition across the southern Cascadia subduction zone. We utilized waveform data from the CASC broadband array deployed in a linear ~300 km E-W transect across the southern Cascades in 1993 and 1994 with station spacing ranging from 4-8 km. We examine in tandem both crustal thickness (H) and Vp/Vs ratio (R) values using radial receiver functions from multiple events and incorporating converted and reflected phases at the Moho. We use the waterlevel deconvolution method to compute individual receiver functions. We then stack individual receiver functions at each station assuming moveouts based on candidate H and R values and perform a grid search over H values from 30 to 75 km at an interval of 0.1 km, and candidate R values from 1.65 to 1.85 at an interval of 0.0025. We define the optimal pair of H and R values as those that produce the maximum stacking amplitude on PmS. This method is more reliable than conventional receiver function stacking techniques, as it does not depend as heavily upon assumptions of local crustal velocity models. We estimate errors associated with these measurements using the bootstrap method, results from which are expected to be normally distributed around the true values of H and R. We are in the process of evaluating the effects of slab structure on the predicted timing of crustal reverberation arrivals. Preliminary results suggest higher than average crustal thickness values over the entire array, ranging between 40 and 60 km, consistent with the results of some previous workers. The thickness of crust beneath the accreted Coast Ranges averages between 40 to 45 km, while those beneath the Willamette Valley basin are estimated at ~55 km. Crustal thickness values beneath the Cascade Range are ~60 km and perhaps thicker, and are the largest recorded across the study area. Average crustal Vp/Vs across the array is ~1.78 and ranges from 1.75 to 1.8, but these variations are not significant at 95% confidence. We are currently in the process of improving constraints on Vp/Vs over the entire array using multiple station stacking for stations within each geologic terrane. These efforts will improve our understanding of the evolutionary processes that have contributed to the assemblage of potentially compositionally contrasting crustal blocks in the region.

TWO UNUSUAL SEISMIC EVENTS IN THE GULF OF MEXICO IN 2006

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Two highly unusual seismic events occurred in the Gulf of Mexico during the first few months of 2006. Both events were located in regions of active oil and gas production, making an understanding of their source mechanisms important from an environmental hazards perspective, as well as for evaluation of tsunami potential along the Gulf Coast. The structural setting of the earthquakes also resembles that of other offshore environments, where the mechanics of deformation are likely to be similar. The first event, of MS = 5.3, occurred on February 10, 2006, off the coast of Louisiana, approximately 240 km south of New Orleans. The event was detected and located both by traditional means using P-wave arrivals (USGS/NEIC) and by analysis of long-period surface waves (see Ekstrom, 2006, for a description of the method). The second event, which occurred less than 100 km offshore of the tip of Louisiana's Birdfoot Delta, was not detected or located by the USGS, but generated surface waves of an amplitude typical for a shallow event of MW ~ 4.6. In addition to the size of the earthquakes, which are large for this region of low seismic activity, the events are notable for the unusual characteristics of the seismic waveforms they generated. The seismograms are depleted in high-frequency energy, and are best explained by a model of sliding on a shallow, sub-horizontal surface within the thick layer of low-velocity sediments that blankets the off-shore region. These characteristics suggest a landslide- or slump-type, gravity-driven source, rather than a tectonic-earthquake source. Current deformation in this region is the result of gravitational tectonics, modified by the behavior of extensive evaporite deposits. Loading by terrigenous sediments results in extension in the shoreward end of the thick sediment wedge, with this extension accommodated by compression and shortening in the wedge toe. I hypothesize that the displacement associated with the 2006/02/10 and 2006/04/18 earthquakes occurred on a low-angle detachment surface within the sedimentary wedge as a result of gravitational loading. The occurrence of the two events may have been hastened by the redistribution of seafloor sediments that resulted from Hurricanes Katrina and Rita.

USARRAY APPLICATIONS OF ANTELOPE PHP WEB TECHNOLOGIES: ANF.UCSD.EDU

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The Array Network Facility website (http://anf.ucsd.edu) displays a variety of diverse meta-data associated with the USArray Transportable and Flexible Arrays. A suite of online tools has been developed to allow visual and interactive exploration of the data and meta-data from the array stations. The website is partitioned into public and administrative areas. The public area provides dynamic maps of station locations, along with network affiliations, communication providers, hardware configurations, associated latencies and event maps. The public pages also show waveform data returned for the last 1, 2 and 24 hours. This allows rapid assessment of array health from anywhere with internet access. Graphical representations of state-of-health parameters are generated nightly for each station, creating a searchable archive. The station maps and metadata details are fully dynamic, updating immediately based on changes in the underlying databases and streaming data returned. The password-protected administrative area provides access to a searchable database of station-maintenance email from field personnel, filed by station, as well as upload and search facilities for digital photos of field sites integrated with the Flickr photo-sharing facility at http://www.flickr.com. The underlying architecture of this dynamic environment is the Datascope RDBMS, part of the Antelope Environmental Monitoring System (http://www.brtt.com), in combination with the PHP Hypertext Processing (PHP) scripting language. This configuration provides an easily extensible platform for real time environmental monitoring, with many re-usable components. We present the various types of data available from the ANF website, in addition to simple descriptions of how these data were collected and displayed. We also outline upcoming tools that we are currently developing to improve monitoring as this already large array continues to grow.

CRUSTAL VARIATIONS IN THE SE CARIBBEAN AND VENEZUELA AND THEIR IMPLICATIONS FOR CONTINENTAL GROWTH

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Both active and passive, land and marine seismic data were acquired by the U.S. BOLIVAR and Venezuelan GEODINOS projects to understand accretion processes and mechanisms for continental growth. The passive component includes an 18-month deployment of 27 PASSCAL broadband seismographs, a 12-month deployment of 15 OBSIP broadband instruments and an ongoing deployment of 8 Rice broadband seismometers. Combining these data with recordings from the 34 BB stations of the national seismic network of Venezuela and the GSN SDV station, gives a seismic dataset from 84 stations covering an area of ~750,000 km2. Receiver function studies using both the primary P-to-S conversion and crustal reverberations have yielded crustal thickness and average crustal Vp/Vs ratio over a broad region across various geological terranes. Very large variations in crustal structure are observed in the study region. The crustal thickness obtained from land stations varies from ~ 20 km to about 55 km and shows a good correlation with geologic terranes. First, it seems that there are significant differences in the nature of the crust and the crust-mantle boundary between Archean and post-Archean geological terrenes. The crust beneath the Archean Guyana Shield south to the Orinoco River is about 38 km thick. Large amplitude P to S conversions and crustal reverberation phases are observed at stations in the region, suggesting a sharp and flat Moho-discontinuity with a large velocity and density contrast. This suggests the lack of a high-velocity mafic layer in the lowermost crust. In contrast, the crust beneath sedimentary basins north to the Orinoco River tends to be thick (~50 km) with a diffuse Moho. Second, we observe relatively thin (~25-30 km) crust in the eastern and western coastal mountains but a relatively thick crust (~40 km) beneath the coast and the offshore Cariaco Basin, suggesting a significant portion of the high topography of the costal mountain ranges has a dynamic origin. The best illustration of the observed features of the crustal structure in the study regions is probably the profile from a densely instrumented line at along 64 degree west. At its northern end, we estimated a crustal thickness of ~10 km at an OBS station in the Venezuela Basin and an island station (La Blanquilla). It gradually increases to a moderate thickness (~30 km) within ~100 km between La Blanquilla and Margarita. We see this moderately thick crust consistently across the coast mountain region (Serrania del Interior fold and thrust belt) with a southern termination roughly corresponding to the Urica Fault. There is a very abrupt change in crustal thickness across this fault. A thick crust (~50 km) is observed to extend to near the Orinoco River where the crust thins to cratonic values beneath the Guyana Shield. We interpret the crustal variations seen in this profile as a suggestive evidence for obduction of oceanic and island arc rocks onto the South America continent. The overthrust creates the high coastal mountains and depresses the South America plate adjacent to the plate boundary.

DECONVOLUTION OF 3-COMPONENT TELESEISMIC P-WAVES USING THE AUTOCORRELATION OF THE P TO SV SCATTERED

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The deconvolution of 3-component teleseismic P-waves is investigated using the autocorrelation of the P to SV scattered waves which is important for improved imaging of crustal and upper mantle structure. The SV component of the P waveform is first estimated by transforming the 3-component seismic data to the P-SV-SH frame of Kennett (1991) and also taking into account the free surface. This removes the direct P-wave from the SV component leaving only the scattered P to SV waves. Assuming that the P to SV scattering coefficients are random and white, then the autocorrelation of the SV component provides an estimate of the autocorrelation of the source wavelet. This is analogous to the use of the autocorrelation of a reflection seismogram in exploration seismology to estimate the source pulse where the P-wave reflectivity is assumed to be random and white. A minimum phase source wavelet estimated from the autocorrelation of the SV component can be used to deconvolve the unrotated radial and Z components that have been processed to be minimum phase. A minimum phase source pulse is not required, but the direct P-wave must be larger than the scattered waves on the unrotated components. To enhance the direct wave, we use rotated coordinates about the direct P arrival direction. This procedure is first tested on synthetic data and then applied to observed data from the 1993 Cascadia experiment where both P and SV scattered waves are estimated from the data which have been deconvolved using the autocorrelation of the SV component.

NEAR-SURFACE SHEAR-WAVE VELOCITY, VS30, AND NEHRP SITE CLASSIFICATIONS IN PUERTO RICO

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In 2004 and 2005 the Puerto Rico Seismic Network (PRSN) and Geology Department at the University of Puerto-Rico-Mayagüez (UPRM) collaborated with the U.S. Geological Survey to study near-surface shear-wave (Vs) and compressional-wave (Vp) velocities in and around major urban areas of Puerto Rico. Using noninvasive seismic refraction-reflection profiling techniques, we acquired velocities at 24 locations. Surveyed sites were selected on the premise that they were generally representative of near-surface materials associated with the primary geologic units located in and around the urbanized areas of Puerto Rico. Geologic units surveyed included Cretaceous intrusive and volcaniclastic bedrock, Tertiary sedimentary units, and Quaternary unconsolidated fluvial, beach, and lagoon deposits. From the data we developed Vs and Vp depth-versus velocity columns, calculated average Vs to 30-m depth (Vs30), and derived NEHRP site classifications for the 24 sites. The distribution of estimated NEHRP classes is as follows: two class “E” (Vs30 below 180 m/s), ten class ”D” (Vs30 between 180 and 360 m/s), nine class “C” (Vs30 between 360 and 760 m/s), and three class “B” (Vs30 greater than 760 m/s). Results are being used to calibrate site response at seismograph stations and in the development of regional and local shake map models for Puerto Rico.

ON-DEMAND ACROSS-INTERNET CALCULATION OF SYNTHETIC SEISMOGRAMS: THE SCEC EARTHWORKS SCIENCE GATEWAY

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Recent advances in computational performance allow numerical wave propagation simulations to be run with higher source frequencies, larger earth volumes, finer spatial resolution, and wider ranges of earth media properties. These expanded parameter specifications demand increases in computing speed, memory usage, and storage access so that often the wave propagation code is limited to being run on a specific computing platform. Because such platforms usually exist at remote sites, the use of across-the-Internet computational technologies allow for access of distributed computing resources which may not be locally available. Within the Southern California Earthquake Center's Community Modeling Environment IT project, the SCEC Earthworks Science Gateway is a portal-based system designed to perform sophisticated, computationally-intensive numerical wave propagation simulations using remote computational resources. This system allows users to configure and execute simulations using well validated earth models and high performance simulation software. Users have choices in the types of earth velocity models and source descriptions to use, a selection of three different wave propagation codes, and choices in output products (seismograms, wavefront volumes, intensity measure maps). The SCEC Earthworks system uses a scientific workflow approach to prepare all needed inputs for the selected wave propagation code, transfer to a remote computational site (e.g., on the TeraGrid or SCECgrid), perform the simulation, retrieve the results and perform post-processing to prepare output products, digitally archive the products, and notify the user as to where to find these products. The scientific workflow is performed using a more over-arching scripting language based on the Virtual Data System, the Pegasus job scheduler which regulates the execution of tasks, the Globus toolkit which not only transfers files between computers but deals with issues associated with permissible access. Codes need to be pre-compiled on remote hosts. Data archive uses the Storage Resource Broker at the San Diego Supercomputer Center. The user front-end is built using the GridSphere Portlets engine. Because we emphasize the availability of user choices, numerous translator utilities are required to go from one workflow step to another. In addition, seismological metadata are necessary in order to communicate from one application code to another. We illustrate how the Earthworks system uses a workflow to perform a wave propagation simulation. In addition, we offer live demos of this system depending on the quality of poster-hall Internet access.

IMPRINT OF CRUSTAL SEISMIC ANISOTROPY ONTO MANTLE SHEAR-WAVE SPLITS: CALIBRATED NUMERICAL TESTS

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Numerous field experiments using (PASSCAL) land and OBS marine instrumentation are able to observe mantle shear wave splitting. In regions of large-scale mantle flow or intense lithospheric-scale deformation, the shear wave splitting can be on the order of 2 or more seconds with large-scale regional alignment. Closer examination of individual station-event splitting results often reveal local fluctuations, which can be attributed to local station conditions, installation sensor alignment, analysis method uncertainties. The objective of our study is to quantify the amount of fluctuation which may be contributed by crustal anisotropy. We construct numerical simulations of crust-mantle seismic wave propagations wherein we can turn on and off the presence of anisotropy in either the mantle or in the upper crust. In doing so, we control the causes of splitting in order to better understand the results of splitting analysis. We also test the effects of changes in the thickness or intensity (%S) of anisotropic upper crust and of the effects of back-azimuth wave direction. The earth model consists of a 15 km upper crust, a 15 km isotropic lower crust, and a 300 km mantle of which the upper 200 km can be anisotropic. The mantle anisotropy is produced by elliptical TI anisotropy with 4% VS. This produces nearly 2 sec of splitting. The upper crust uses an elliptical TI anisotropy of 16% VS which is defined from seismic velocities from actual petrophysically measured schists. The seismic modeling is performed using a 3-8 second wave within 3D anisotropic finite difference wave propagation code. A 2D grid of stations are used in order to examine spatial patterns of shear wave splitting. Split times and fast direction (?t - ?) are obtained by passing the anisotropic synthetic seismograms through the splitting code of Menke and Levin. For calibration, we run two tests: isotropic crust and mantle, and isotropic crust with anisotropic mantle. In the first test, the seismograms exhibit no splitting and the splitting parameters are null. In the second test, uniform mantle splitting is produced. When crustal anisotropy is activated with an isotropic mantle, local splitting is produced of up to 0.6 sec (for our optimally oriented schist anisotropy). Splitting fast directions correlate with orientations of the crustal fabric. When the mantle anisotropy is added in, the waveforms become altered and the splitting parameters show modification in delta-t and deflections in orientation. The crustal contribution produces second-order alteration to the mantle splitting values. While these might be confused with other explanations, coherence across a spatially high resolution array may provide confidence that the results are due to crustal causes.

THE EARTHSCOPE AUTOMATED RECEIVER SURVEY: A COMMUNITY RESOURCE

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The preparation and distribution of standardized “products” from USArray data is a critical element of the EarthScope initiative. The challenge in preparing these products is twofold. First, the “customers” for these products span a wide spectrum of needs and experiences, ranging from research seismologists to research geologists to K-12 educators and students. Second, processing the large volume of USArray data must be automated if the preparation of products is to be efficient and cost-effective. We have developed a prototype system for automated production for USArray products using, as an example, teleseismic receiver function analysis. The product, which we have dubbed “EARS” (EarthScope Automated Receiver Survey), provides a searchable web interface that allows seismologists to download bulk crustal properties (thickness and Vp/Vs ratio) at any Transportable Array station as well as the calculated receiver functions used to derive the crustal parameters and even the P-waveforms used to generate the receiver functions. In the background, EARS is driven by SOD (Standing Order for Data) supplemented by an automated processing framework and external processing modules that apply a variety of criteria to cull out low quality data in an attempt to produce a robust and reliable product with minimal human intervention. In this talk, we describe the EARS processing scheme and the results to date. In addition, we will outline the products available to the community through the EARS system. These products are intended to streamline the necessary processing steps for researchers interested in analysis of USArray data. The EARS database is an important source of information for researchers to identify features of the waveforms or the models that they find interesting and worthy of further analysis. As a community resource, EARS will provide the end result for some users and the starting point for others.

OBJECT-ORIENTED SOFTWARE: IT'S THE INTERFACE, NOT THE IMPLEMENTATION

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For the past three years I have been building an object-oriented library for some general purpose problems in seismology. The applications are all written in C++ with hypertext documentation that can be found at http://seismo.geology.indiana.edu/~pavlis/software.html. I have attempted to build a set of general-purpose, library routines that can be of use to the broader community. Some data objects of interest include: a general time series object; a three-component seismogram object; ensembles of time series and three-component seismograms; a hypocenter object; a general object to compute a stack; a generalized multichannel, cross-correlation object; and a set of 2D and 3D grid objects that are geographically referenced. In the process of development of these libraries I have repeatedly learned the lesson that the design of the interface is ultimately more important than the details of the implementation. In this paper I will review a common theme of modern software engineering: the interface should insulate the user from the details of the implementation. That is, a well designed interface simplifies the task of using the library to the central concepts that define the algorithm. For instance, I have a Metadata object that I have used extensively. A Metadata object encapsulates the concept familiar to most seismologists as header variables, but has no restrictions on the number or names of the actual parameters it stores. The interface has constructors to build a Metadata object and methods to put parameters into the object or retrieve them by name. How they are stored is hidden in the interface, which I would argue is the proper design for the general concept this encapsulates. I will present other examples from this library as a starting point that I hope could ultimately lead to a standardized interface to common seismological concepts. This can benefit the community in the long term by improving reusability of software.

COMBINED WIDE-ANGLE REFLECTION AND RECEIVER FUNCTION STUDIES OF THE CRUST AND UPPER MANTLE BENEATH THE CAROLINA TERRANE AND BLUE RIDGE PROVINCES, SOUTHERN APPALACHIANS

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We use velocity models derived from analysis of refraction/wide-angle reflection data to constrain the range of average crustal models compatible with receiver functions for two broadband stations in the southern Appalachians. The wide-angle reflection experiments were conducted using over 110 timed quarry blasts and a portable array of three-component seismographs with 4.5-Hz sensors. The blasts were recorded over distances of 6 to 200 km with receiver spacings of 100 to 400 m. The reversed, overlapping raypaths cover portions of the Carolina Terrane, Inner Piedmont, and Blue Ridge provinces in north Georgia and western North Carolina. Shot gathers contain coherent energy at frequencies as high as 45 Hz. Estimates of source wavelets generated by ripple firing are extracted from slant stacks of the gathers. Migration of deconvolved wide-angle reflections shows a thickening of the crust from about 38 km for the Carolina Terrane/Appalachian gravity high to about 50 km along the southeast flank of the Blue Ridge Mountains/ Appalachian gravity low in South Carolina. Blasts recorded within the Blue Ridge province show reflections from the lower crust and Moho at near-vertical to postcritical angles of incidence. Migrated sections show a clustering of reflections at depths between 45 and 55 km, suggesting a layered transition zone at the base of the crust similar to models proposed for the Cumberland Plateau and Adirondacks. Zhu-Kanamori analysis of receiver functions computed for USNSN broadband stations GOGA along the boundary between the Carolina Terrane and Inner Piedmont and MYNC in the Blue Ridge shows a similar trend in crustal thickness. Using a value for average crustal Vp derived from the wide-angle data, the crustal thickness beneath GOGA is roughly 39-42 km. Average crustal Vp/Vs is 1.74-1.75, compared with estimates of 1.72-1.75 derived from travel-time ratios of SmS/PmP arrivals. The results for station MYNC suggest a crustal thickness of roughly 48-52 km with a slightly greater average Vp/Vs of 1.75-1.77. In contrast with station GOGA, the results for station MYNC vary significantly with azimuth. This could be a result of scattering due to mountain topography as well as local relief on the Moho.

SEISMIC VELOCITY STRUCTURE OF THE SOUTHERN CASCADIA SUBDUCTION ZONE

Jeffrey B. Roth, Arizona State University Matthew J. Fouch, Arizona State University

We are examining seismic velocity variations across the southern Cascadia Subduction Zone (CSZ). The goal of this study is to place constraints on the compositional, mechanical and thermal structure of the CSZ, and to consider the implications that this structure has for the tectonic evolution of the region. The data used for this study were recorded by the Cascadia Array (CASC), a dense linear array of broadband seismometers with 4-8 km spacing that spanned from the western coast of central Oregon ~300 km inland. We used a multi-channel cross correlation technique to accurately determine relative delay times for 98 regional and teleseismic P wave events, resulting in 2311 individual measurements. The raw relative delay times are corrected for elevation and for moveout assuming the IASP91 velocity model. The E-W orientation of this linear array is oblique to most sources and therefore precludes tomographic inversion of the delay time measurements. Therefore, we instead evaluate suites of forward models of seismic velocity perturbations to attempt to explain the patterns in our data. Forward models which reproduce the relative delay time data well are generally ones in which the slab dips shallowly (~10 degrees) from the trench to a depth of ~100 km, approximately beneath the High Cascades, and is consistent with the results of previous workers. Below this region, the slab dips more steeply at ~70 degrees to a depth of ~250 km beneath the Columbia Plateau, also consistent with previous work. In general, models where the steeply dipping portion of the slab is detached and extends to greater depths do not fit the data as well as models of a continuous, but kinked, slab. However, we cannot completely rule out the possibility of a detached slab based on our current dataset. In addition, we are currently evaluating the effect of 3D ray propagation through our models on the synthetic delay times. We anticipate that this will provide improved fits between our data and forward models. The necessity of a steeply dipping end of the Juan de Fuca slab in our models provides an important constraint on the tectonic history of the region. For instance, a steepening slab may be the result of slab rollback and foundering after detachment from the Farallon slab at ~45 Ma. This model is also consistent with studies that suggest that the slab is shallower to the north and becomes steeper towards the south near the Mendocino transform. Other models, such as those where the kink in the slab is the result of heterogeneity or zones of weakness within the Juan de Fuca slab, are also viable.

SEISMIC ATTENUATION IN THE CENTRAL AMERICAN SUBDUCTION ZONE

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The goal of this study is to image attenuation structure in the Central American subduction zone using local event waveforms recorded by the TUCAN Broadband Seismometer Experiment. The 48 seismometer TUCAN array (funded by the MARGINs program) spanned fore-arc, arc, and back-arc regions of Nicaragua and Costa Rica from July, 2004 until March, 2006. This subduction zone is characterized by strong along-arc variations in magma geochemistry, slab dip, and arc geometry. Thus, imaging attenuation and velocity structure beneath this region has a particular potential to highlight the mechanisms that dominate subduction zone melting processes. We invert waveforms for the corner frequency and moment of each event and for the t* value of each event station pair, assuming attenuation is slightly frequency dependent (□=.27). Path-averaged attenuation values indicate order of magnitude variations in shear-wave attenuation. We detect high Q (1/attenuation) from paths that primarily sample the slab (Q>300), more attenuation (Q<150) from event-station pairs with longer paths through the wedge, and the hint of a zone with high attenuation (Q<75) from paths directly beneath the arc. These attenuation values are broadly consistent with those observed in other subduction zone environments. Based on our preliminary path-averaged attenuation results, we expect high resolution imaging of significant attenuation anomalies once tomographic inversions are performed. Such imaging should help to constrain the thermal structure of the wedge and locate anomalous regions that are associated with melt or hydration.

CONFIRMATION OF A SHARP LITHOSPHERE-ASTHENOSPHERE BOUNDARY BENEATH EASTERN NORTH AMERICA USING S-TO-P SCATTERED WAVES

Catherine A. Rychert, Karen M. Fischer, Brown University Stéphane Rondenay, Massachusetts Institute of Technology

S-to-P (Sp) scattered energy independently confirms the existence of a seismic velocity discontinuity at the lithosphere-asthenosphere boundary that was previously imaged using P-to-S (Ps) scattered energy in eastern North America. Exploration of the different sensitivities of Ps and Sp scattered energy suggests that the phases contain unique yet complementary information regarding velocity contrasts. Therefore, combined inversions of Ps and Sp energy have the potential to tightly constrain associated velocity gradients. In eastern North America, inverting Sp and Ps data requires a strong, 5-10% velocity contrast that is also sharp, occurring over less than 11 km at 88-104 km depth. Thermal gradients alone are insufficient to define such a sharp boundary, and therefore another mechanism is required. A boundary in composition and hydration could create a sharp enough velocity gradient. However, the magnitude of the observed velocity drop suggests it is more likely that a small amount of melt in the asthenosphere is required. The tight constraints on velocity gradients achieved by combined modeling of Ps and Sp energy offer promise for defining the character of the lithosphere-asthenosphere boundary globally, with implications for regional to global plate-tectonics.

FACILITATING THE MANAGEMENT OF EARTHSCOPE WITH GEOSPATIAL TECHNOLOGY

Bill Schultz, Institute for the Application of Geospatial Technology (IAGT) Fred Pieper, Institute for the Application of Geospatial Technology (IAGT)

With support from NASA, the Institute for the Application of Geospatial Technology (IAGT) has been helping the EarthScope Office with the management of EarthScope by providing a range of map-based applications, products, and services using GIS technology. This activity includes providing application design, map production, and programming support for the EarthScope Information System (EIS), the map-based on-line resource for interactively viewing the current status of the EarthScope facility as it is being constructed. In addition, IAGT staff work closely with the ES Office to create custom map graphics and animations that depict the station installation status and future plans. These products are incorporated into presentation materials in both print and digital form that are used to communicate EarthScope resources to the broad scientific and educational communities. Similar support is provided directly to the individual PBO and USArray components of EarthScope as well. Collectively, the application of GIS and related mapping technologies has proven to be of extremely high value to EarthScope in many aspects including general program management, siting and permitting, operational status monitoring, and education and outreach.

TAKING THE TEMPERATURE OF THE YELLOWSTONE HOTSPOT

Derek L. Schutt, Ken Dueker, University of Wyoming

The passage of the Yellowstone hotspot under the North America plate has caused a dramatic sequence of rhyolite calderas and basalt flows, the geothermal activity in Yellowstone National Park, and the distinct topography of the eastern Snake River Plain valley. Recently, body wave analysis has shown a sub-vertical plume-like low velocity pipe extending from a thinned transition zone to around the lithosphere-asthenosphere boundary. At about 100 km depth, this material is advected to the southwest by North America Plate motion. In this study, we forward model Rayleigh wave phase velocities to estimate the excess temperature of the advected hotspot material. Using both grain size sensitive and non-grain size sensitive velocity-temperature relations, we find the advected material has an excess temperature of 70-200oC. Combined with the body wave results, Yellowstone seems conclusively to be a mantle plume.

NATIVE AMERICAN PERSPECTIVES AND PREFERENCES BEARING ON EARTHSCOPE DEPLOYMENTS IN THE SOUTHWEST

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Peterson Zah, Jaynie Parrish, Office of the President, Arizona State University

EarthScope has begun to take up residence in Arizona and surrounding Southwestern states. In Arizona alone, planned deployments place USArray and Plate Boundary Observatory stations on or near the lands of seven different Native American nations. Some shorter-term projects will also seek access to Native American lands. In addition, the EarthScope education and outreach plan calls for direct affiliations with Native stakeholders and school systems in concert with the research. To facilitate these activities in a culturally-appropriate way, we convened a workshop at ASU for decision-makers and experts in cultural resources and education from the Arizona Native nations that would be affected by EarthScope. The national education and outreach managers of EarthScope and its affiliates were also in attendance. While EarthScope researchers provided Tribal representatives with a thorough introduction to the scientific and educational aspects of the project, including physical demonstrations, the workshop participants shared critical information on relevant cultural and jurisdictional issues, including sacredness of lands, the significance of ancestral homelands, and community-based outreach. This information is now guiding siting and outreach activities underway in Arizona, and will be disseminated to the greater EarthScope community by various means.

SEISMIC STRONG MOTION ARRAY PROJECT (SSMAP) FOR THE NICOYA PENINSULA, COSTA RICA

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The seismic strong motion array project (SSMAP) for the Nicoya Peninsula in northwestern Costa Rica is composed of 10 – 13 sites including Geotech A900/A800 accelerographs (three-component), Ref-Teks (three-component velocity), and Kinemetric Episensors. The main objectives of the array are to: 1) record and locate strong subduction zone mainshocks [and foreshocks, “early aftershocks”, and preshocks] in Nicoya Peninsula, at the entrance of the Nicoya Gulf, and in the Papagayo Gulf regions of Costa Rica, and 2) record and locate any moderate to strong upper plate earthquakes triggered by a large subduction zone earthquake in the above regions. Our digital accelerograph array has been deployed as part of our ongoing research on large earthquakes in conjunction with the Earthquake and Volcano Observatory (OVSICORI) at the Universidad Nacional in Costa Rica. The country wide seismographic network has been operating continuously since the 1980’s, with the first earthquake bulletin published more than 20 years ago, in 1984. The recording of seismicity and strong motion data for large earthquakes along the Middle America Trench (MAT) has been a major research project priority over these years, and this network spans nearly half the time of a “repeat cycle” (~ 50 years) for large (Ms ~ 7.5 - 7 3⁄4) earthquakes beneath the Nicoya Peninsula with the last event in 1950. Our long time co-collaborators include the seismology group OVSICORI, with coordination for this project by Dr. Ronnie Quintero and Mr. Juan Segura. Numerous international investigators are also studying this region with GPS and seismic stations (US, Japan, Germany, Switzerland, etc.). Also, there are various strong motion instruments operated by local engineers, for building purposes and mainly concentrated in the population centers of the Central Valley. The major goal of our project is to contribute unique scientific information pertaining to a large subduction zone earthquake and its related seismic activity when the next large earthquake occurs in Nicoya.

INVESTIGATION ALONG THE COSTA RICA-PANAMA BORDER: DECEMBER 25, 2003 (M6.5) AND MAY 01, 2006 (M5.9)

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The Costa Rica seismic network OVSICORI (Observatorio Sismológico y Vulcanológico de Costa Rica) at the National University located the December 25, 2003 Mw=6.5 in the southern Pacific region of Costa Rica. The event was felt through all the country with the Modified Mercalli scale (MM) felt reports of (VII) at Puerto Armuelles, Panama, (VI) at Naranjo, Laurel, and Ciudad Nielly, and (V) at Golfito and the Osa Peninsula. The majority of the damage was located at Puerto Armuelles, Panama, and Naranjo, Laurel, and Ciudad Nielly, and the event caused local liquefaction and small surface cracking. The main event and aftershocks were located using merged data from Costa Rica and Panama stations. These events are associated with the Panama Fracture Zone (PFZ), which is a N-S dextral strike slip fault along the Cocos-Nazca plate boundary. The Harvard moment tensor solution showed strike slip motion along a north trending fault. During the following 15 days, 109 aftershocks were located at depths of 20-40 km with the depth of the mainshock at 40m. The recent May 01, 2006 (M5.9) event and aftershocks also occurred in the same region, but the Harvard moment tensor solution showed thrust faulting along a NW-SE strike. During the following five days, 53 aftershocks have been located at depths of 5-35 km. The focal mechanisms show the complexity of this zone. Other events for the region support the existence of a compressive tectonic regime associated with the subduction of the Cocos plate beneath the Panama Block (PB), strike slip along the Cocos-Nazca plate boundary, and unsolved motion of the Nazca–Panama Block.

PROBING CONTINENTLA LITHOSPHERE NEAR RIO-GRANDE RIFT, SOUTHWESTERN UNITED STATES USING P AND S WAVE

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Tomographic travel-time models of the La-Rista transect produce excellent waveform fits if we sharpen the blurred images into distinct structures. We observe systematic waveform distortions across the western edge of the Great plain from south American events, starting about 300 km east of the center of Rio Grande Rift zone. The amplitude decreases by more than 50% within array stations spanning less than 200 km while the pulse width increases by more than factor of 2. This feature is not observed for the data arriving from the northwest. While tomographic image shows a fast slab-like feature dipping to the southeast beneath the western edge of the Great Plain, synthetics generated from this model do not reproduce the waveform observations. However, once we enhance the tomographic image and sharpen the velocity contrast between the slab and ambient mantle by a factor of 3, the synthetics also produce observed amplitude decay and pulse broadening. In addition to the travel time delay, amplitude variation due to wave phenonema such as slab diffraction, focusing and defocusing provide much tighter constraints on the geometry of the slab and its velocity perturbation and sharpness as demostrated by grid-search and snapshots of the seismic field. Our preferred model locates the slab 200 km east of the Rio Grande Rift dipping 70-75 degrees to the southeast, extending to a depth of 600 km with a thickness of 120 km and enhanced velocity of over 4% fast. In short, adding a waveform component to regional tomographic studies can help validate and establish structural sharpness. Following the success of modeling S waveform record section, we use the preferred enhanced S tomography model derived from S waveform modeling, scale it to a P model and examine its synthetics. With a scaling factor $dlnVs/dlnVp$ of less than 1.3, the syntheics start to produce waveform distortion similar to the observation. When examining travel time delays and amplitude ratios of these stations, we find a scaling factor $dlnVs/dlnVp$ of 1.25 explain both travel time anomalies and amplitude ratio reasonably well. Gao [2004] has shown the average travel time perturbation t_s and t_p is about 2.9 beneath La Ristra Transect. We can estimate the average scaling factor $\partial lnV_s/\partial lnV_p$ of about 1.67 if we assume V_p/V_s of 1.73. Goes [2000] has shown that the scaling factor $\partial lnVs/\partial lnVp$ due to temperature effect is around 1.8. This support the idea that upper mantle structure imaged beneath La Ristra Transect is primarily due to temperature. However, the preferred scaling factor $\partial lnV_s/\partial lnV_p$ of 1.25 for the fast slab-like anomaly near the western edge of the Great Plains is much lower than the aveage. If we interpret the S wave velocity anomaly of 4% just due to temperature, the slab-like structure is 300K lower than the ambient mantle. However, such interpretation would suggest a scaling factor $\partial lnV_s/\partial lnV_p$ of 1.8 or higher. Such a inconsistency suggests compositional origin of the slab-like structure.

USE OF IRIS'S NEW SNOW STREAMER DURING AN INNOVATIVE OVER-SEA-ICE SEISMIC REFLECTION SURVEY IN SOUTH

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During the austral spring of 2005, we recorded approximately 27 km of high-quality over-sea-ice seismic reflection data over Southern McMurdo Sound (SMS), Antarctica, in support of the ANtarctic Geological DRILLing (ANDRILL) Program. The ANDRILL SMS seismic survey incorporated several new survey techniques that improved both the quality and quantity of over-sea-ice seismic data. For instance, we used a newly acquired snow streamer to aid rapid data collection across sea-ice. The streamer is available through the Incorporated Research Institutions for Seismology (IRIS) PASSCAL instrument pool. This 60-channel snow streamer has vertically oriented gimbaled geophones with 25-m takeout spacing. A Kevlar center strength member allows the streamer to be pulled between shotpoints. This eliminates the need for time-consuming hand placement of conventional spiked geophones. Moreover, previous over-sea-ice seismic experiments have had limited success because of (1) poor source coupling caused by thin sea-ice, or (2) source bubble-pulse effects caused by seismic sources placed in the water column. To mitigate these problems, we used a Generator-Injector (GI) air gun as the seismic source. We lowered the GI gun into the water column through holes drilled into the sea-ice. The GI gun minimized the source bubble effects that had plagued previous over-sea-ice experiments. In addition, the GI gun allowed us to stack data at each shot location and thereby increase the signal-to-noise ratio. Two processing steps were essential to improving image quality of these data: (1) a frequency-wavenumber (FK) filter to remove guided waves from the data, and (2) tau-p deconvolution to suppress the ocean-bottom multiple. Additional surveys that will employ and build upon our current knowledge of these new methods are planned for Granite Harbor and offshore New Harbor in McMurdo Sound.

TOWARDS RESOLVING AN EARTHQUAKE GROUND MOTION MYSTERY IN WEST SEATTLE, WASHINGTON STATE

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A shallow bedrock fold imaged by a 1.3-km long high-resolution shear-wave seismic reflection profile in West Seattle focuses seismic waves arriving from the south. This focusing may cause a pocket of amplified ground shaking and the anomalous chimney damage observed in earthquakes of 1949, 1965 and 2001. The 200-m bedrock fold at ~300-m depth is caused by deformation across an inferred fault within the Seattle fault zone. Ground motion simulations, using the imaged geologic structure and northward-propagating north-dipping plane wave sources, predict a peak horizontal acceleration pattern that matches that observed in strong motion records of the 2001 Nisqually event. Additionally, a pocket of chimney damage reported for both the 1965 and the 2001 earthquakes generally coincides with a zone of simulated amplification caused by focusing. This study further demonstrates the significant impact shallow (<1km) crustal structures can have on earthquake ground-motion variability.

PRELIMINARY TOMOGRAPHIC RESULTS AND EARTHQUAKE LOCATIONS FROM THE TUCAN EXPERIMENT

Ellen Syracuse, Boston University Geoffrey Abers, Boston University Karen Fischer, Brown University Marino Protti, OVSICORI-UNA Victor González, OVSICORI-UNA Wilfried Strauch, INETER Laura Auger, Boston University

Velocity tomography and earthquake location using approximately 13000 P travel times and 10000 S travel times from the TUCAN (Tomography Under Costa Rica and Nicaragua) PASSCAL experiment (2004 – 2006) gives insight into the geometry and structure of the Central American subduction zone. The present-day slab geometry is highlighted by contrasts in dip beneath the two countries: a near-vertical slab dip beneath the volcanic front in Nicaragua and a 30° slab dip beneath central Costa Rica. In both regions, the seismic zone appears as a single ~10 km thick layer of seismicity. The preliminary images of the mantle wedge beneath Nicaragua show a dipping high-velocity region in the mantle wedge beneath Nicaragua, consistent with results from receiver function analysis and offshore active source tomography. This high-velocity region may serve as an impediment to mantle flow and fluid migration, causing the shift in the volcanic front in Nicaragua. Additionally, the effects of introducing a fast slab into the initial velocity model are analyzed.

SMKS WAVES OBSERVED BY DENSE MOBILE BROADBAND SEISMIC ARRAYS

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Recent large-scale mobile arrays provide good opportunity to investigate the deep Earth structure. Here I show examples of African array data for SmKS waves that are propagated in the mantle as S-waves, in the core as P-waves denoted by K, and reflected (m-1) times underside the core-mantle boundary. The Kaapvaal and Tanzanian arrays are suitable for SmKS observation from deep earthquakes in southwestern Pacific. In limited observation periods (1994-1995 for Tanzainian array, 1997-1999 for Kaapvaal array), there are not so many good record-sections in that clearly SmKS wave are appeared. Although approximately 80 events are checked, only 8 events are picked out. Phase weighted stack is applied to the array records to obtain the characteristics of SmKS phases. The vespagrams for all the event-array combination clearly shows SKKS and S3KS, but S4KS is detected only one event-array pair that has the best S/N ratio among all the records. The vespagrams from full-wave synthetic waveforms with PREM or a high velocity layer in the outermost core do not reproduce the S4KS, whereas that with a low velocity layer can explain the observation.

USARRAY AND ACTIVE TECTONIC DEFORMATION IN THE WESTERN UNITED STATES

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Geologic studies and space geodetic measurements are quantifying the tectonic deformation of the western United States at the Earth's surface but cannot constrain its downward extension into the lower crust and lithospheric mantle. Observations of seismic velocity structure and seismic anisotropy can ameliorate this shortcoming and provide constraints on the deformation of the deeper lithosphere and asthenospheric mantle and its possible relation to surface motions. Large GPS datasets from the western U. S. and elsewhere are rapidly mapping continental deformation on scales from 10s to 1000s of km at high precision. Current deformation is concentrated in narrow zones that include major faults or lie in regions with the highest densities of active Holocene faulting. Large intervening regions are characterized by low or undetectable rates of present-day deformation, even in areas of demonstrable late Quaternary or Holocene faulting and minor seismic activity. Using the locations of major faults to define block boundaries, the GPS data are fit well to first order using the same rules of rigid plate kinematics that have been so successfully applied on a global scale. However, small departures from perfect rigidity are evident in the data and indicate regions of internal deformation or smaller blocks unresolved by current data. Seismological data complement space geodetic observations by providing images of deep crust and mantle velocity structure that may mimic rheological layering and flow of the lithosphere beneath crustal blocks. Conventional body-wave tomography, receiver function methods for determining crust and upper mantle structure, and new methods of surface wave tomography are providing increasingly focused images that can be related to active deformation. S-wave splitting observed from SKS body phases map anisotropy related to current or fossil flow fabric in the crust, mantle lithosphere, and asthenosphere. Patterns crust/upper mantle structure and S-wave anisotropy in the western U. S. are only beginning to emerge from studies using existing data and suggest intriguing links between surface tectonics and crust/mantle processes. USArray will provide unprecedented opportunities to refine images of crust/mantle structure and constrain connections between surface tectonics and deformation at depth.

SPECULATIONS ON THE RELATIONSHIP BETWEEN PRESENT-DAY SURFACE DEFORMATION AND DUCTILE FLOW AT DEPTH BENEATH THE CONTINENTS

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Space geodetic measurements made worldwide suggest that present-day surface deformation of continental lithosphere is block-like and follows the rules of plate kinematics. However, GPS data alone provide only very limited constraints on the depth to which inferred block structure extends and how deformation beneath the blocks is accommodated. With several well-known caveats, seismic shear-wave (SKS) splitting observations may provide better constraints on flow at depth related to present-day surface deformation.

Patterns of S-wave anisotropy in the western U. S. are complex and have been variously attributed to 'absolute' motion of the lithosphere over asthenospheric mantle, shearing across major active faults, and driving flow in the asthenosphere. However, an exceptionally high quality mapping of SKS splitting in California and Nevada obtained by Polet & Kanamori [2002 GJI] shows a very simple pattern. Although it has been taken as evidence for driving flow in the asthenosphere, it is also readily explainable as a result of 'absolute' motion of lithospheric blocks over asthenospheric mantle except in southern California, where the ~E-W orientation of fast directions seem to be related to Transverse Ranges tectonics.

Previous studies have suggested correlations between orientation of fast S-wave speed ('fast S orientations') in central and northern Tibet and strain axis orientations determined from present-day surface deformation or integrated deformation calculated from dynamic models for Tibet. These studies, based on continuum model assumptions, have concluded that fast S and strain axis orientations agree, suggesting coherent, coupled deformation through most of the thickness of the lithosphere. Comparison of fast S orientations and relative motions derived from a GPS-based microplate model suggest another interpretation. First, fast S orientations within identified microplates are nearly parallel to predicted block motions relative to Eurasia. Furthermore, fast S orientations across major strike-slip faults (Jiali, Kunlun) are parallel to predicted relative motions across block boundaries. Together these correlations suggest present-day microplate motions may drive or resist more continuous ductile flow at depth.

GEOFRAME: AN INTEGRATED GEOLOGIC FRAMEWORK FOR EARTHSCOPE'S USARRAY

Basil Tikoff (University of Wisconsin) Ben van der Pluijm (University of Michigan)

GeoFrame is a geologic initiative that aims to offer a multi-dimensional view of the construction, stabilization and modification of the North American continent through time (“Building a Continent”). The initiative's goal can be achieved by integration of geologic knowledge with the constraints from geologic time and the results from unprecedented geophysical imaging from the USArray program of the EarthScope Project. The GeoFrame Initiative will address key geologic questions and problems in an integrative fashion. It encourages a cooperative community approach to collecting and sharing data and will offer a coast-to-coast, synoptic perspective of the continent, focusing on the linkages of crustal provinces with the mantle as well as on the lateral boundaries between these provinces. Based on discussions at recent workshops, we outlined 7 focus regions across the conterminous U.S. and an eighth focus topic as part of GeoFrame. These areas specifically address fundamental aspects of the growth, evolution and modification of the North American continent through time with further focus on some of the major continent scale transitions between geological provinces. Study of these regions would proceed in an intensified fashion, in concert with planned USArray steps (“BigFoot” array). Specifically, this stage of investigation would entail map-scale “densified” arrays of passive source seismic receivers (“LittleFoot” array) and associated active source seismic studies and complementary geophysics in conjunction with geologic-based synthesis and targeted studies. It is anticipated that these investigations will pave the way for future continent-scale studies that build on this initial integration. Detailed planning is now urgently needed to outline studies needed in each area. This planning should be done at open workshops where geologists who are familiar with the major questions presented by the geology of the region collaborate with and geophysicists cognizant of USArray collection parameters and capabilities, and seismologists familiar with the capabilities of active source techniques. This integrated working group would then determine how this data set is best used to address problems related to the evolution of continental crust and underlying mantle. While there is general recognition that important geological areas will be omitted by any selection, there was consensus that focus areas linked by questions posed at the continental scale is compelling at a national scale for both scientific rigor and outreach to a broad community. Studies within each target area will address fundamental geologic questions about the assembly and evolution of the continental lithosphere through time. The areas represent all types of tectonic boundaries (collisional, transpressional, strike-slip, transtensional, extensional) at different times in Earth History (Archean, Proterozoic, Paleozoic, Mesozoic, Present). We focus on the fundamental tectonic processes related to the building of North America that are best studied within each target area, related to lithospheric and whole-earth plate tectonic processes. Collectively, the areas constitute a near-seamless continent-scale experiment that offers a coast-to-coast 4D geologic traverse (a GeoTraverse) through the conterminous U.S. The GeoFrame initiative provides three major scientific avenues to the geoscience community in connection with the EarthScope project. First, it provides cohesion and focus by addressing key scientific questions and problems in an integrative and synoptic fashion across the Earth Sciences and across the country. Second, it encourages a cooperative, community approach to collecting and sharing data at an unprecedented scale. Third, GeoFrame provides a geologically-based, science-driven national approach to Education and Outreach in the Earth Sciences.

EARTHQUAKE MECHANICS AND DYNAMICS IN THE TONGA-KERMADEC SUBDUCTION ZONE FROM FAULT-PLANE ORIENTATION

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By identifying the fault-plane orientations of 25 earthquakes >100 km depth in the Tonga-Kermadec subduction zone, we have determined new constraints on the physical mechanism of intermediate- and deep-focus earthquakes and deformation in the subducting slab. After identifying the fault planes with rupture directivity, we compare the fault-plane orientations with the orientations expected for the reactivation of outer-rise normal faults and the creation of new faults in response to the ambient stress field. Earthquakes >300 km depth match the patterns expected for the creation of a new system of faults: we observe both subhorizontal and near-vertical fault planes, and the ruptures show no systematic patterns in the directions of rupture propagation. In contrast, at intermediate depths (100-300 km), ruptures tend to propagate subhorizontally away from the slab surface and all identified fault planes, in both the upper and lower seismic zones, are subhorizontal. After accounting for the angle of subduction, this orientation is inconsistent with the orientation of outer rise normal faults, allowing us to rule out mechanisms, such as dehydration embrittlement, that require the reactivation of these surface faults. Subhorizontal faults are consistent with only one of the two failure planes expected from the slab stress field, suggesting that the ambient stress field is not the only factor controlling fault-plane orientations. Pre-existing weak zones of other orientations or isobaric rupture processes may be important. If all deformation takes place on these subhorizontal faults, it would cause the slab to thin, indicating that slab pull rather than unbending is the primary force controlling slab seismicity at intermediate depths.

WEB-BASED, REAL-TIME DATA FOR MUSEUMS AND VISITOR CENTERS

Russ Welti, John Taber, Gayle Levy, Chris Loos, IRIS Consortium Rick Aster, New Mexico Tech

The Museum Lite display is a simple-to-implement, low cost way to provide high-quality, real-time seismology and other information to a wide audience. It can be easily customized for regional and local audiences in numerous ways. A new user-configurable version entered a beta test period in mid March with 6 sites across the U.S and will be publicly available this summer. The project evolved out of the online Seismic Monitor and the successful IRIS/USGS large-scale earthquake displays installed in several major museums around the US. The major museum displays are too expensive, take too much maintenance to be practical for small museums, schools, visitor centers, etc and firewalls can make access to them difficult. Museum Lite bypasses firewalls, and offers various customizations, such as logos, colors, and the inclusion of any other content the local site desires such as web cams and other real-time information. The system functions as a kind of "portal", a customizable set of web pages that can be viewed either via an interactive touch screen or an automatically cycling display. Each individual venue can select from a menu that currently includes various maps of current seismicity at different scales (global, regional, local), online helicorder displays of nearby seismic (e.g., USArray) stations, static maps of long-term seismicity and seismic hazard and other local information or graphics as desired by the client. These choices will be expanded to include a range of EarthScope data products in collaboration with UNAVCO and EarthScope E&O.

NUMERICAL MODELING OF POROELASTIC RESPONSES TO THE CHI-CHI EARTHQUAKE, TAIWAN

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We use numerical modeling of the 1999 Chi-Chi, Taiwan, earthquake to study coupled deformation and hydrologic processes operating in the earth's crust and shallow alluvial strata. Comparison of modeling results with observed water level and streamflow changes resulting from the Mw = 7.5 earthquake reveals the pattern and magnitude of seismically induced hydrologic responses. We quantify volumetric strain and transient pore pressure changes produced by slip along the main thrust fault in central Taiwan. The coseismic strain model explains observed groundwater level drops, streamflow decreases, and downward migration of isotopically light surface water into the unconfined aquifers in the dilatational zone near the rupture front. We use numerical simulations of compaction and faulting-enhanced gravity flow to explore different mechanisms that likely characterize hydrologic observations in several areas. The compaction models demonstrate how the thickness and permeability of confining sediments, or their sealing efficiency, affect the development of overpressure in the unconsolidated confined aquifers. The gravity-flow model indicates that faulting could enhance groundwater discharge to the surface east of the thrust fault, leading to short-lived, coseismic streamflow increases and the development of pressure anomalies in some discharge areas. The results of this study indicate that faulting-enhanced permeabilities have a transient effect on gravity flow and overpressures in sedimentary basins, with the recovery period of alluvial aquifers related to aquifer permeability and confining conditions.

COMPLEX SEISMIC ANISOTROPY IN THE EARTH'S INNER CORE BENEATH AFRICA

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Seismic anisotropy in the top of the inner core is important to the understanding of the growth and dynamics of the Earth's inner core. The anisotropic structures beneath Africa in the top 80 km of the inner core were not well constrained, due to limited sampling coverage. Here, we analyze a large data-set of the PKiKP-PKIKP phases sampling the top 80 km of the inner core beneath Africa along various sampling directions. The differential travel times of the PKiKP-PKIKP phases sampling Africa reveal polar-equatorial differences. The differential travel times along polar paths are about 0–1.4 s larger than those along equatorial paths, suggesting the presence of anisotropy in velocity in the top 80 km of the inner core beneath Africa. The PKiKP-PKIKP phases along polar paths exhibit a complex lateral gradient from the East to the Middle Africa and a correlation of large (small) differential travel time with small (large) amplitude ratio. Largest differential travel times and smallest amplitude ratios are observed beneath the East Africa (Kenya, Tanzania, Mozambique), while small differential travel times and large amplitude ratios are observed beneath the Middle Africa (Democratic Republic of Congo, Congo, Gabon, Angola). The polar PKiKP-PKIKP waveforms are grouped based on the geographic sampling regions. We perform waveform modeling and iteratively search for the anisotropic velocity and attenuation models that explain the polar PKiKP-PKIKP waveforms in various groups. Most complexities observed in the PKiKP-PKIKP waveforms can be explained by the presence of uniform anisotropy, but with onset of the anisotropy occurring at various depths. The region beneath the East Africa can be explained by a uniform anisotropy model with a magnitude of about 1.6% and an average Q value of 300 present at the inner core boundary (ICB), while the Middle Africa can be explained by a model with an isotropic layer in the top and a uniform anisotropy with a magnitude of about 1.6% and an average Q value of 400 present at a depth of 40 km below the ICB. The region between the East and the Middle Africa can be explained by a model with an isotropic layer in the top and a uniform anisotropy with a magnitude of about 1.6% and Q values of about 200-400 present at a depth 10-20 km below the ICB.

TESTING UPPER MANTLE ANISOTROPIC VELOCITY PARAMETERIZATIONS

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Testing upper mantle anisotropic velocity parameterizations using Billings array teleseismic S and SKS The five simplest model parameterizations of upper mantle anisotropy are tested and ranked using broad-band array data from the Billings array in Montana. The five simplest anisotropy models (hexagonal symmetry) are: single layer with a horizontal fast velocity axis (FVA), single layer with a dipping FVA, two layers with horizontal FVA, two layers with one dipping and one flat FVA, and two layers with dipping FVA. The dataset is provided by the 30 broad-band station Billings array that operated for ten months. The array provided five high quality direct S and ten SKS signals that are stacked (30 to 1) with measured time shifts to provide high-quality stack waveforms with accurate error bars. The S and SKS stack waveforms are modeled for our five increasing complex anisotropic velocity model parameterizations. The Neighborhood algorithm is used to map the posteriori model probability density (PPD) volume. Careful time windowing of the primary S and SKS signals is preformed to remove all converted and free-surface reflected signals except the free surface Spms Moho reflection. Source normalization is accomplished using the cross-convolution technique (Menke and Levin, 2003). The 2-D marginal PPD for most of our models are compact and show little model parameter correlation. The F-test finds that the best anisotropic velocity models demand a dipping FVA. The two models which do not allow dipping FVA can be rejected at >98% confidence. The best model is a two layer dipping FVA model, albeit the two layer model with one flat and one dipping FVA can only be rejected at 82% confidence. The best model has an upper layer with a N13°W FVA strike and a 50° FVA dip and a lower layer with a N65°E FVA strike and a 10° dip down to the southwest. The bottom (asthenospheric) FVA strike is parallel to North American absolute plate motion and the dip is opposite of that predicted for a passive asthenosphere. The steeply dipping FVA in the upper (lithospheric) layer may manifest ancient deformation along a tectonic boundary. Comparison of PPD using an SKS-only dataset to the full-dataset shows that the direct S waves greatly improve resolution of FVA dip. To test for robustness of our conclusions, the dataset was divided into a northern and southern half and PPD constructed. The results from the two sub-arrays are very similar.

MOHO AND LITHOSPHERE-ASTHENOSPHERE BOUNDARY OBSERVATIONS ALONG THE YELLOWSTONE HOTSPOT TRACK

Huaiyu Yuan, Ken Dueker and Derek Schutt, University of Wyoming

Recent teleseismic results from the PASSCAL Yellowstone array have been interpreted as consistent with a small upper mantle plume rising beneath Yellowstone Park [Fee and Dueker, 2004; Yuan and Dueker, 2005, Waite et al., 2006]. However, fundamental scientific questions not addressed by these previous results are: how much magma has been added to the eastern Snake River Plain (ESRP) crust; how much lower crustal flow has this magmatic addition to the ESRP produced; and, how much has the plume disturbed the lithosphere-asthenosphere (LAB) boundary. To address the above questions, we present radial receiver function (RF) common-conversion-point images along the Yellowstone hotspot track. The seismic data was recorded by two PASSCAL arrays - the 2000-2001 YISA and the 1999-2000 Billing array - along with a few NSN stations. The RFs are computed using the modified frequency domain multi-taper spectral correlation (MTC) method that uses pre-event noise for frequency-dependent damping [Park and Levin, 2000]. This extended-time [Helffrich, 2006] method preserves the superior spectral estimation properties of the MTC without the amplitude and polarity loss at time lags beyond 20% of the time-window length. To constrain the tradeoff between crustal thickness and velocity structure, P-S Moho times from the receiver functions are incorporated into Rayleigh wave phase velocity inversion. This produces a crustal thickness map. A second crustal thickness map is constructed by common-conversion points stacking of the RF mapped to depth using the 3-D shear velocity model and a crust and mantle Vp/Vs of 1.75 and 1.80 respectively. The resulting crustal thickness map is consistent with previous sparse refraction results: 42 km crust is found beneath the ESRP with no significant change across the ESRP margins; 54 km thick crust is found beneath the Wyoming province; and, a thin 36 km crust is found beneath the Montana Basin and Range province. A negative velocity contrast arrival with half of the mean Moho arrival amplitude is found at about 65-75 km depth beneath the eastern Snake River Plain and the Montana basin and range province. We consider this arrival to be consistent with a sharp thermal gradient predicted for a plume layer impinging upon the lithosphere. We note that this shallow LAB depth beneath the ESRP is consistent with the depth of the sharp vertical velocity gradients found by the Rayleigh wave imaging. The occurrence of the LAB beneath the Montana Basin and Range province would suggest that plume material has flowed beneath this actively extending region. Implications of the crustal thickness and LAB variations with respect to crustal flow and plume-lithosphere interactions will be presented.

NEW OBSERVATIONS ON LITHOSPHERIC FOUNDERING FROM THE SIERRA NEVADA EARTHSCOPE PROJECT (SNEP)

George Zandt, University of Arizona Hersh Gilbert, University of Arizona and Purdue University Tom Owens, University of South Carolina Craig Jones, University of Colorado SNEP Field Team, see list below

Previous interdisciplinary studies in the southern Sierra Nevada and adjacent Great Valley have documented an ongoing removal of the dense residual root from beneath the southern Sierra Nevada batholith. However, many questions remain concerning the timing, areal extent, mechanism, and consequences of this lithospheric foundering event. The Sierra Nevada Earthscope Project (SNEP) is a scientific experiment designed to investigate these questions with a 2-year seismic deployment of 46 broadband Flex-Array stations embedded in the existing 19 stations of the USArray Transportable Array (TA) in the region. During the summer of 2005, the 46-station array was deployed with ~25 km spacing, from the northern edge of the 1997 Sierra Paradox Experiment (SPE) (approximately a line between Fresno and Bishop, California) to near the southern end of Lake Tahoe (approximately along Highway 4 between Angels Camp and Monitor Pass, California). This ~250 km by ~200 km area encompasses Yosemite National Park, Long Valley and adjacent volcanic fields, and the high country of the central Sierra Nevada and adjacent Walker Lane of the Basin and Range. Analyses have begun on the first 7-8 months of data from most of the new stations (some of the high elevation sites are still inaccessible). Initial studies include receiver functions, teleseismic P-wave traveltimes, SKS-splitting, surface wave dispersion, and an investigation of lower crustal earthquakes in the western foothills. In this presentation, we will focus on the most recent common-conversion-point (CCP) stacks of the receiver functions. Combining data from 24 SPE, 42 SNEP, and 19 TA stations (total of 85 sites) we used over 1300 receiver functions to generate a 3D image of lithospheric layering beneath the southern and central Sierra Nevada. Examining sequential cross-sections reveals distinctive lithospheric “reflectivity” patterns that characterize the region. The westernmost Basin and Range exhibits strong layering with multiple low-velocity zones in the crust and uppermost mantle and a relatively flat and strong Moho varying slowly in depth between 30 and 35 km. In the south this Basin and Range character terminates on the eastern edge of the Sierra Nevada; however, north of Big Pine the Basin and Range character intrudes progressively farther into the range and ends up more than 50 km west of the eastern edge of the range. The lithosphere beneath the southern High Sierra Nevada is characterized by a relatively transparent (homogeneous) crust and sharp Moho that disappears westward beneath the adjacent foothills. The crustal thickness in this area is mostly between 30-35 km with two localized welts of thicker crust. The northwest corner of the study area has a distinctive layered crust that corresponds closely with the surface exposure of the Foothills Metamorphic Belt. These new observations imply that the removal process appears to be actively affecting the northern extent of our study area. The next phase of the SNEP deployment will continue to the northern limit of the Sierra Nevada to determine the extent of the affected region and the character of the batholith where root removal may not have occurred.
SNEP Field Team: Ian Bastow, Scott Burdick (IRIS intern), Katrina Byerly (undergraduate), Josh Calkins, Thomas de la Torre, Jordi Julia, Gaspar Monsalve, Arda Ozacar, Heidi Reeg, Joya Tetreault, Amanda Thomas (IRIS intern), Christina Viviano (IRIS intern)