[1]Department of Earth Sciences, National Taiwan Normal University, 88, Section 4 Ting-Chou Road, Taipei 116, Taiwan

[2]Department of Geosciences, National Taiwan University, 1, Section 4 Roosevelt Road, Taipei 106, Taiwan

[3]Institute of Earth Sciences, Academia Sinica, 128, Section 2 Academia Road, Taipei 115, Taiwan

[4]Institute of Geophysics, National Central University, 300, Jung-Da Road, Jung-Li 320, Taiwan

The Ailao Shan-Red River (ASRR) fault belt is one of the most profound active strike-slip faults in East Asia. It is generally believed that the Cenozoic India-Eurasia collision caused the southeastward extrusion of Indochina along the ASRR fault belt (left-lateral displacement) in mid Tertiary. However, geomorphologic evidences and earthquake focal mechanism solutions do indicate a present-day right-lateral slip of the ASRR. Structural analyses and field observation along the ASRR in northern Vietnam revealed that the ASRR has undergone multiple phases and styles of deformation (three ductile folding events with a younger brittle deformation) possibly since Triassic to Pliocene. The deformation history, combined with offshore exploration data and igneous activities, enabled us to better constrain the tectonic evolution of the ASRR. A previously unrecognized deformation event (D1) with foliations showing dextral sense of shear possibly formed during the Triassic Indosinian orogeny or during Eocene post India-Eurasia collision. D2 is the strongest deformation event within the ASRR forming large-scale horizontal folds possibly commenced since Eocene-Oligocene as the thickened ductile crust flowed eastwardly away from the Tibetan Plateau under SE Asia, and extended to Early Miocene till termination of sinsitral strike-slip movement of the ASRR. D3 continuously uplifted most of the ASRR and formed current antiformal domes in northern Vietnam with NW-SE subvertical fold axial planes parallel to the trend of ASRR, possibly due to the right-lateral movement of the ASRR during Late Miocene to Pliocene. Continuous denudation uplifted the ASRR crossing the brittle-ductile transition zone forming brittle structures (D4) as the right-lateral movement of the ASRR continued.

T11A-06 0925h

Paleoseimology deduced from the Fengyuan trench on the northern part of the Chelungpu Fault, central Taiwan: an example of very low angle reverse fault

Yoko Ota[1] (+81-3-3728-5317; ota@iceice.com); Masanobu Shishikura[2] (m.shishikura@aist.go.jp); Mitsuhisa Watanabe[3]; Hiroshi Sawa[4]; Masaru Yamaguchi[5]; Makoto Yanagida[6]; Takenobu Tanaka[6]; Kiyoshi Ichikawa[7]; Yuan-Hsi Lee[8]; Shih-Ting Lu[8]; Tung-Sheng Shih[8]

[1]Yokohama National University, 2-11-13-201, Minami-senzoku, Ota-ku 1450068, Japan

[2]Geological Survey of Japan/AIST, Central 7, 1-1-1, Higashi, Tsukuba 3058567, Japan

[3]Toyo University, 5-28-20, Hakusan, Bunkyo-ku 1128606, Japan

[4]Tsuruoka National College of Technology, 104, Ioka, Tsuruoka 9978511, Japan

[5]Japan Broadcasting Corporation, 1-14-22,Obata, Moriyama-ku, Nagoya 4630011, Japan

[6]Hanshin Consultants Co. Ltd, 1-26, Higashiterao, Higashidai, Tsurumi-ku, Yokohama 2300018, Japan

[7]Komazawa University, 1-23-1, Komazawa,, Setagaya-ku 1548523, Japan

[8]Central Geological Survey, MOEA, Taiwan, 2-109, Chunghou 23557, Taiwan

We carried out the trenching and boring at the western margin of the lowest terrace, east of Fengyuan City, in order to know the nature and frequency of the faulting, on the northern part of the Chelungpu fault, central Taiwan. At this trench, we found that in addition to the 1999 earthquake fault which is characterized by the very low angle reverse fault with overturning of the younger strata, the penultimate earthquake event, which occurred between ca. 1400 yr BP and 2000 yr BP. The age of the lower part of the terrace gravel (Bed E) is ca. 4000 yr BP, thus two faulting events occurred during the past ca.4000 years. The amount of horizontal shortening and vertical displacement of the penultimate event are twice of those of the 1999 earthquake, supporting the presence of two events. The age of the penultimate earthquake at the Fengyuan site is the oldest record within the Chelungpu fault so far and suggests this part of the Chelungpu fault represents an independent segment from the central and southern part.

T11B MCC: 3005 Monday 0800h

Observational and Theoretical Insights Into the Structure and Dynamics of Mid-Ocean Ridges I

(joint with V)

Presiding: **W H Smith,** NOAA Laboratory for Satellite Altimetry**; J A Goff,** Institute for Geophysics, University of Texas

T11B-01 0800h

Correlating the textures of altimetric gravity and multibeam bathymetry

Walter H. F. Smith[1] (301-713-2857 x126; Walter.HF.Smith@noaa.gov)

Karen M. Marks[1] (301-713-2857 x124; Karen.Marks@noaa.gov)

John A. Goff[2] (512-471-0476; goff@utig.ig.utexas.edu)

David T. Sandwell[3] (858-534-7109; dsandwell@ucsd.edu)

[1]NOAA Lab for Satellite Altimetry, NOAA code E/RA-31 1335 East West Hwy., room 5408, Silver Spring, MD 20910-3282, United States

[2]UT Institute for Geophysics, University of Texas at Austin 4412 Spicewood Springs Rd., Bldg 600, Austin, TX 78759, United States

[3]Scripps Institution of Oceanography, Univ of Calif San Diego 9500 Gilman Dr., code 0225, La Jolla, CA 92093-0225, United States

We compare the tectonic fabric textures seen in altimetric gravity and multibeam bathymetry at sites on the flanks of slow- and fast-spreading ridges, midplate, and back-arc basin areas. Our aim is to correlate altimetric and bathymetric textures, to determine the limits of resolution of current altimetric data, and to characterize the seafloor texture signals that should be recoverable with a future altimetric mission having a lower noise floor than existing data. Multibeam data we compiled for this analysis are from the RIDGE synthesis, the NGDC coastal and global relief projects and other holdings, and data contributed by other investigators. Altimetric data are gravity version 11.1 (18 km filter) and topography "polish" version 8.2. All our data are available at http://ibis.grdl.noaa.gov/SAT/Bathy.intro.html Areas with dense multibeam swath coverage are necessarily small, and the wavelengths our data sets resolve are mostly in the uncompensated band. Simple forward models of gravity assuming uncompensated seafloor topography agree well with altimetric gravity in amplitude and spectral roll-off, except at the shortest wavelengths where altimetric fields are too smooth. Where abyssal hill amplitudes and wavelengths are large enough, gravity texture shows clear ridge-parallel lineations.

URL: http://ibis.grdl.noaa.gov/SAT/Bathy.intro.html

T11B-02 0815h

The Correspondence of Altimetric Gravity Texture to Abyssal Hill Morphology

John A. Goff[1] (512-471-0476; goff@ig.utexas.edu)

Walter H. F. Smith[2] (301-713-2857, ext. 126; walter@raptor.grdl.noaa.gov)

[1]University of Texas Institute for Geophysics, 4412 Spicewood Springs Rd., Bldg. 600, Austin, TX 78759, United States

[2]NOAA Lab for Satellite Altimetry, code E/RA31, 1335 East-West Highway, room 5408, Silver Spring, MD 20910-3282, United States

We examine the possible relationship between altimetric and abyssal hill textures along the flanks of Southeast Indian Ridge, where previous studies observed a progressive west-to-east increase in abyssal hill roughness and scales. Such a relationship is often considered unlikely because abyssal hills are typically smaller than upward continuation filter scales. Nevertheless our analysis, which carefully avoids inclusion of fracture zones and major propagator psuedofaults, also demonstrates a west-to-east increase in gravity rms roughness and scale. The rms exhibits the most well resolved variations. Characteristic scales and aspect ratios also increase to the east, although less resolvably. At the roughest gravity textures, ~ridge-parallel lineaments can be resolved, suggesting that this texture is directly responding to abyssal hill morphology. We suggest that the westernmost gravity texture samples, adjacent to axial high regions, represent a base noise level. The rms roughness of these data is ~4 mgals with a characteristic scale of ~9 km. We demonstrate, using synthetic realizations, how a filtered product such as altimetric gravity could be responsive to variations in the unfiltered substrate from which it was derived at scales smaller than the length of the filter. We first compare the roughness and characteristic scales from filtered and unfiltered profiles. Filtered profile scales are weakly dependent on unfiltered scale where the latter are smaller than the filter size, but possibly resolvable enough so the lineated fabric of larger abyssal hills could be evident in the altimetry data. The roughness of the filtered profiles is found to be strongly dependent on both the roughness and scale of the unfiltered profiles. Altimetric roughness may thus be very sensitive to gross changes in abyssal hills, even those too small to be directly resolved. A reduction in the noise level by future altimetry missions would greatly enhance this response. Our follow-up investigations will focus on predictions of altimetry texture based on upward continuation of 2-D abyssal hill morphology and realistic renderings of altimetric noise.

T11B-03 0830h

Evidence for Highly Focused Magmatic Accretion Along the Ultra-Slow Southwest Indian Ridge

Jian Lin[1] (508-289-2576; jlin@whoi.edu)

Henry J.B. Dick[1] (508-289-2590; hdick@whoi.edu)

Hans Schouten[1] (508-289-2574; hschouten@whoi.edu)

[1]Woods Hole Oceanographic Institution, Department of Geology and Geophysics, Woods Hole, MA 02543, United States

The Southwest Indian Ridge (SWIR) spreads at effective slow to ultra-slow rates of only 8-15 mm/yr at the 7°-16°E region, depending on its local obliquity. During Dec. 2000-Jan. 2001 and Jan.-Feb. 2003, we carried out an extensive SeaBeam bathymetry, gravity, and magnetic survey, as well as rock dredging, of a 400-km-long section of the SWIR, including the Shaka transform. The results reveal dramatic variations in seafloor morphology, residual gravity anomaly, crustal magnetization, and rock types within the surveyed region. A 50-km-long segment centered on 14°30' E, which we call the "Narrowgate" segment, has a well-defined narrow axial rift valley, a bull-eye-shaped mantle Bouguer gravity low with along-axis amplitude of 25 mGal, and clear off-axis record of magnetic stripes to crustal age of 7 Ma. These ridge-axis features resemble a classic slow-spreading ridge segment in the northern Mid-Atlantic Ridge. However, this ridge segment appears to be less robust prior to 7 Ma. To the west, a 200-km-long stretch of the ridge axis at 11°45'-14°15'E lies obliquely to the spreading direction, resulting in effective ultra-slow full spreading rates of only 8 mm/yr. The relatively deep rift valley, systematically positive mantle Bouguer gravity, and extremely low amplitude of crustal magnetization suggest that while lithosphere is formed there, it has very little magmatic crust. Such interpretation is collaborated by the abundance of ultramafic rocks dredged on this stretch of the ridge. Further westward, an apparently robust ridge segment, called the Joseph Mayes Seamount segment, is found near 11°20'E. This 40-km-long ridge segment is associated with major mantle Bouguer anomaly with along-axis amplitude of 40 mGal as well as strong crustal magnetization. However, this ridge segment appears to have become magmatically robust only 3-4 Ma. Together the above evidence suggests that magma accretion along this stretch of the SWIR axis is highly focused in space and time. We propose a model in which the overall low magma supply rate and dominant lithospheric cooling at a slow/ultra-slow ridge will result in temporal centers of highly focused magma accretion. The extremely heterogeneous thermal and rheological boundaries in the lithosphere should help lateral migration of melts to be pooled towards such temporal centers of magmatic accretion.

T11B-04 0845h

Correlation of Shallow Seismic Structure and Observed Geologic Boundaries of Fast-Spreading Crust Exposed Near Hess Deep

Gail L Christeson[1] (512-471-0463; gail@ig.utexas.edu)

Kirk D McIntosh[1] (kirk@ig.utexas.edu)

[1]Univ. TX Institute for Geophysics, 4412 Spicewood Springs Rd, Bldg 600, Austin, TX 78759, United States

In July 2003 we conducted a seismic survey over fast-spreading crust adjacent to the Hess Deep rift. The program acquired 16 MCS profiles parallel to the scarp

T

edge adjacent to the region where the lithologic boundary between the dikes and overlying extrusive section had been mapped by submersible dives. 2 of these profiles extended across the East Pacific Rise so that the shallow seismic structure could be continouously mapped from zero-age crust to the tectonic window where the shallow stratigraphy is exposed. The program also acquired 7 scarp-perpendicular MCS profiles, one of which extended across the Hess Deep rift onto the plateau adjacent to the south wall of the rift. Initial processing indicates that the layer 2A reflector is imaged on all profiles; additional processing will allow us to map the layer 2A/2B boundary across a 15 km x 25 km region. For all profiles travel times of refractions were picked on every 10th shot gather (every 375 m) and were also used to map the layer 2A/2B boundary along each profile. Patterns in layer 2A thickness are very consistent between adjacent profiles which are located 0.5-2.0 km apart. In at least part of the study region there is a good correlation between depth to the layer 2A/2B boundary and the observed lithologic boundary between dikes and the overlying extrusives; additional analysis will be required to determine if this correlation exists over the entire survey area.

T11B-05 0900h

Axial High Topography and Thermal Structure Along the Plume-Influenced Western Galapagos Spreading Center

Tanya M Blacic[1] (530 753-4482; blacic@geology.ucdavis.edu); Garrett Ito[2] (gito@hawaii.edu); Juan Pablo Canales[4] (jpcanales@whoi.edu); Anji Shah[3] (ashah@qur.nrl.navy.mil); Robert Detrick[4] (rdetrick@whoi.edu); John Sinton[2] (sinton@hawaii.edu); Jian Lin[4] (jlin@whoi.edu)

[1]University of California Davis, Geology Department 1 Shields Avenue, Davis, CA 95616, United States

[2]SOEST, Department of Geology and Geophysics University of Hawaii, Honolulu, HI 96822, United States

[3]Naval Research Laboratory, Marine Physics Branch Code 7420 455 Overlook Ave. SW, Washington, DC 20375, United States

[4]Woods Hole Oceanographic Institute, Department of Geology and Geophysics 360 Woods Hole Rd., Woods Hole, MA 02543, United States

Recent studies propose that the axial high topography observed at intermediate- and fast-spreading mid-ocean ridges (MORs) reflects the thermal structure and stress state of the MOR lithosphere. Hotspot related variations in thermal structure along the western Galapagos Spreading Center (GSC) thus offer an opportunity to test some of the proposed causes for axial high topography. Along the intermediate rate spreading western GSC we observe axial high topography from ~92.5°W to 91°W similar to that seen along portions of the fast-spreading East Pacific Rise. In this region we see large variations in the amplitude of the axial high with the height decreasing dramatically with distance away from the Galapagos hotspot. The decrease in amplitude of the axial high corresponds remarkably well to an increase in the depth of the seismically imaged axial magma lens. Eberle and Forsyth (1998) suggest that dike injections above the magma lens relieve tension in the shallow crust and generate large vertical variations in horizontal stress. The resulting bending moment thus uplifts the ridge axis. Contrary to our observations at the GSC, their model predicts increasing uplift with increasing depth of the magma lens. Alternatively, Shah and Buck (2001) propose that the crust is hot and partially molten directly beneath the ridge axis and that material rapidly cools and accretes to the plate as it moves off axis. As it cools, the crust becomes more dense and tends to sink relative to the level at which it accreted to the plate resulting in a topographic high at the axis. If the axial magma lens is deeper, then the change in temperature with distance from the axis is reduced and the near-axis lithosphere is strengthened, resulting in a smaller axial high. Thus it appears that Shah and Buck's (2001) model is more consistent with our observations of the western GSC than Eberle and Forsyth's (1998) hypothesis. We can constrain the width of the region of rapid cooling off axis using seismic refraction studies, which show a zone of low seismic wave velocity beneath the ridge axis. Using constraints from multichannel seismic imaging of the axial magma lens, seismic refraction data, gravity and bathymetry measurements we will investigate aspects of the thermal structure of the western GSC between 93°W and 91.5°W including width of the hydrothermal cooling region, crustal strength, and percent melt present in the lower crust to further our understanding of the causes of axial high topography at mid-ocean ridges.

T11B-06 0915h

Plume-Ridge Interaction North of Iceland: Constraints from Crustal Thickness.

Emilie E. E. Hooft[1,2] (emilie@newberry.uoregon.edu)

Bryndís Brandsdóttir[3] (bryndis@raunvis.hi.is)

Rolf Mjelde[4] (rolf@ifjf.uib.no)

Hideki Shimamura[5] (shima@eos.hokudai.ac.jp)

[1]University of Oregon, 1272 Geological Sciences, Eugene, OR 97403, United States

[2]Dept. Terrestrial Magnetism,Carnegie Institution, 5241 Broad Branch Rd. N.W., Washington, DC 10015, United States

[3]University of Iceland, Hofsvallagötu 53, Reykjavík IS-107, Iceland

[4]University of Bergen, Allégt 41, Bergen 5007, Norway

[5]Hokkaido University, N-10, W-8, Sapporo 060-0810, Japan

Hotspot-ridge interactions affect the melt production at nearby mid-ocean ridges causing spatial and temporal variations in crustal thickness. We present results from a seismic refraction experiment to measure crustal thickness along and across the Kolbeinsey ridge north of Iceland. We surveyed a 230-km-long along-axis line, situated about 10 km east of the Kolbeinsey Ridge, and two cross-axis lines which are 710 and 140 km long, located 70 and 180 km north of the Icelandic coast, respectively. The ocean bottom seismometer spacing was 15 km along the ridge, 10 km across the ridge, and 30 km east of the Iceland margin. The seismic source was a 4800 cu. in. airgun array with 200 m shot spacing. For each refraction line, we invert *Pg* and *PmP* arrivals using the tomography method of *Korenaga et al.* (*JGR*, 1999). We find that crustal thickness decreases to the north along the Kolbeinsey Ridge; the crust is about 13 km (10 km) thick 200 km (400 km) from the center of the Iceland hotspot. The melt flux at the Kolbeinsey Ridge appears smaller than at similar distances along the Reykjanes Ridge south of Iceland; where crustal thickness is 16.5 km (12.5 km), at 200 km (400 km) from the hotspot center. This observation is consistent with the north-south asymmetry in geochemistry and ridge axis elevation; between 200 and 400 km from the hotspot center the axis of the Reykjanes Ridge is 500 m shallower than the axis of the Kolbeinsey Ridge. Thus the Iceland hotspot enhances melting more substantially at the Reykjanes Ridge than at the Kolbeinsey Ridge; this asymmetry has not yet been explained by geodynamic models. Quantifying crustal thickness will help determine whether the asymmetry in ridge axis depth can be explained isostatically or if dynamic support is required. Our across-axis profiles suggest undulations in crustal thickness similar to those associated with the V-shaped ridges of the Reykjanes Ridge. Thus temporal variability in the influence of the hotspot on spreading-center melt production is observed both north and south of Iceland.

T11B-07 0930h

Heat Flow and Hydrothermal Circulation of the Lucky Strike Segment, Mid Atlantic Ridge

Alain Bonneville[1] (bonnevil@ipgp.jussieu.fr); Javier Escartin[1]; Francis Lucazeau[1]; Mathilde Cannat[1] ; Philippe Gouze[2]; Richard P Von Herzen[3]; Claudia Adam[1]; Michael Le Bars[1]; Eric Monoury[1]; Valérie Vidal[1]

[1]Laboratoire de Géosciences Marines, CNRS-Institut de Physique du Globe, Paris 75252, France

[2]CNRS-Université de Montpellier, place E.Bataillon, Montpellier 34060, France

[3]Woods Hole Oceanographic Institution, Quissett Campus, Woods Hole, MA 02543, United States

In June 2003, expedition Luckyflux aboard the R/V Poseidon conducted a heat flow survey of a zone centred on the Lucky Strike segment of the Mid Atlantic ridge south of the Azores between ~35°N and 39°N. Using a 5 m-long lance with 7 outrigger thermal probes, about 150 successful thermal gradient measurements were obtained, 140 of these with in-situ thermal conductivity. Measurements were made at ~1 mile intervals along several profiles, where adequately sedimented sites were identified using 6-channel and 3.5 kHz seismic data from the previous Sudazores'98 cruise. We conducted heat flow measurements in two areas: a near axis region within the V-shaped ridge of overthickened crust that emanated from the Azores hotspot between ~14 and 4 Ma, and an off-axis region East of the V-shaped ridge. The off-axis region is characterized by an homogeneous sediment cover, 300-400 m thick, and crustal ages varying between ~6 and >10 Ma. Long wavelength (tens of km) low heat flow anomalies can be identified but the mean of 160 mWm-2 is comparable to the conductive heat flow expected for a crust of that age. Along two 80-km profiles perpendicular to the ridge, we observed coherent but different patterns. On the first profile, low heat flow values of 20-50 mWm-2 are observed at the base of the V-shaped ridge. These values are 100 mWm-2 below the profile average, showing that hydrothermal circulations can also affect oceanic crust beneath a thick and relatively impermeable sediment cover. On the other profile, heat flow generally decreases from west to east. On both profiles, higher than average values of heat flow are also present, associated on one of them with a nearly outcropping basement elevation. These contrasting overall heat flow patterns in similar geological context indicate that the likely pattern of hydrothermal circulations is mainly 3D, and not driven only by the presence of basement outcrops. In the near-axis region, where the tectonic structure is more complicated and the sediment cover heterogeneous, heat flow data show no clear spatial variation and their mean value, 60 to 90 mWm-2, is systematically lower than theoretical conductive values for young seafloor. These heat flow differences will be used to estimate the importance of advection in the heat budget. This characterization of the regional thermal state around a slow-spreading segment will provide the basis for future long-term studies on the structure, thermal evolution and the hydrothermal systems within the MOMAR (MOnitoring the Mid Atlantic Ridge) project.

URL: http://www.ipgp.jussieu.fr/rech/lgm/luckyflux

T11B-08 0945h

Ocean-floor Asymmetry and Its Relationship with Transform Faults

Stephen S. Gao (785-532-2243; gao@ksu.edu)

Kansas State University, 108 Thompson Hall, Dept. of Geology, Manhattan, KS 66506

Based on elevation data along 20 profiles across major divergent plate boundaries, a recent study (Doglioni et al., 2003 Tectonics) found that the eastern sides of the major oceanic and some continental rifts are on average 100-300 m higher than the conjugate western sides. The same study proposed that the asymmetry is caused by a global-scale westward shift of the lithosphere relative to the depleted and lighter asthenosphere. To verify the intriguing observation, we extract elevation data at about 473,000 locations along 2130 profiles of 1100 km in length on each side of the Mid-Atlantic Ridge (MAR), from a database of ocean-floor topography, and obtained the elevation difference between the east and west sides of the MAR. Interestingly, we find that the difference at most of the lithospheric blocks confined by the 22 longest transforms faults (TFs) is closely related to the direction and amount of displacement along the faults. Positive difference (e.g., higher on the eastern than the western sides of MAR) is observed on blocks that drifted westward, and negative difference is observed on blocks that drifted eastward, suggesting that westward drift of lithosphere relative to the asthenosphere is not a global feature. On average, the east-west difference has a mean value of 155±7 m along the MAR in the latitude range between 50S and 50N latitudes. In addition, we found that the difference in east-west elevation is positively correlated with the amount of displacement along the TFs. The best-fitting curve suggest that a displacement of 100 km along the TFs leads to an east-west elevation difference of about 200 - 300 m. We propose a model involving movement of the lithosphere along the TFs relative to the location of maximum buoyancy in the asthenosphere to explain the observation.

T11C MCC: Level 1 Monday 0830h

New Views of the Structure and Composition of the Deep Earth I Posters *(joint with GP, S, V, MR, DI)*

Presiding: **D L Farber,** Lawrence Livermore National Laboratory**; J Badro,** University Paris VI - Institut de Physique du Globe

T11C-0397 0830h POSTER

Kinetics of grain-growth in wadsleyite: implications for point defect chemistry

Yu Nishihara[1] (203-432-5791; yu.nishihara@yale.edu)