T21D MCC: Level 1 Tuesday 0830h

Role of Large Strike-Slip Faults in Tectonics of the Tibetan Plateau I Posters *(joint with G)*

Presiding: **Y Yue,** Stanford University; **E R Sobel,** Institut für Geowissenschaften

T21D-0477 0830h POSTER

New age constraints on the evolution of the Karakorum Fault, West Tibet

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Results of detailed mapping and dating of sheared rocks along southern fault-half helps assess the total offset, lifespan, slip-rate and geodynamic importance of the Karakorum Fault (KFZ). South of 33°N, along SW edge of Tashikang-Gar basin, active right-lateral normal faults, belonging to KFZ, exhume metamorphic and magmatic footwall rocks forming the SE termination of Ladakh-Karakorum range. Close to active fault, gneisses and mylonites are affected by strong ductile dextral shear and inter-layered with leucocratic melt veins sheared to various degrees. Several generations of veins are often observed on a same outcrop, with late, weakly deformed veins cutting highly sheared ones. This implies that anatexy and intrusion were coeval with dextral shearing. Direct dating of leucogranites reveals Oligo-Miocene formation ages. U/Pb thermoionization dating on zircons yields concordant ages at 22.7+-0.1Ma. Discordant zircons ages are consistent with a poorly defined lower intercept at 32+-3 Ma, and a Proterozoic (1300+-100 Ma) upper intercept. In situ ion microprobe dating of 17 zircons (24 spots) confirms these results. Four mylonite zircons yield comparable, concordant ages ranging between 20 and 25 Ma in their cores and rims, in good agreement with conventional U/Pb dating. Inherited zircon ages range from Paleozoic to Precambrian (ca.1200 Ma). Some of them recrystallized partially during Tertiary deformation, yielding discordant ages, the youngest being 34+-0.8Ma. Cooling was delayed until 12 to 8Ma, at which time very rapid cooling is recorded by 40Ar/39Ar and fission track data. Purely strike-slip ductile shear was thus already in progress along the fault at 23Ma and possibly earlier (ca.34Ma). A marked kinematic change from purely dextral to dextral-normal motion occurred around or just after 12 Ma. Best offset estimate along this main (northern) branch of KFZ is given by correlation of the ophiolite-bearing melange of Shiquanhe with the Shyok suture zone in Pakistan (minimum offset of 250km). Assuming that this offset accrued in time span of about 23Ma suggests average long-term rates of at least 1 cm/yr. Evidence for strike-slip faulting is also clear within the Ladakh-Karakorum range and along its SW border where mapping shows large-scale boudinage of ophiolite units implying a maximum offset of 400km along a southern branch of KFZ. South of Baer, several active strike-slip branches bound the Kailas-Ponri range to the south and continue eastwards at least up to 82.5E (lake Kunggyu). The southern part of the range is made of steep, fault-bounded slivers with clear field for brittle dextral shear. Our structural study of the area does not support inference that the Karakorum Fault terminates west of Manasarovar lake and merges with the Gurla Mandatha detachment. Instead, both deformation and large-scale geometry concur to show that the Karakorum Fault Zone continues east of 81E as a dextral, transpressive flower structure reactivating the Indus-Tsangpo suture.

T21D-0478 0830h POSTER

Geochronological, Geochemical and Structural Constraints on the Initiation and Evolution of the Karakoram Fault, Ladakh, Northwest India

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The significance and role of major strike-slip faults during continental deformation is a major source of debate among geologists and geophysicists. In the last thirty years two end-member views of deformation have evolved, each offering a profoundly different philosophy of continental tectonics. While one end-member view suggests that regional deformation is distributed through a continuously deforming upper mantle with an overlying brittle carapace (e.g. England and Houseman, 1986), the other interprets deformation as constrained by slip on major discontinuities at the lithospheric scale (e.g. Armijo et al., 1986; Peltzer et al., 1989). A significant factor in this discussion is the role of strike-slip faults in Asia and in particular that of the Karakoram Fault (KF). The KF, a c.800 km dextral strike-slip fault, which bounds the southwestern margin of Tibet, is suggested to be one of the main faults that controls the eastward extrusion of the deforming Asian lithosphere (Molnar & Tapponnier 1975). As each end-member model for continental deformation differs in the significance that it attaches to the extrusion hypothesis, it is vital that an accurate geological offset and a precise age for KF initiation are established because these parameters constrain the extent of the extrusion. The initiation and evolution of the KF can therefore provide important data with which to test models for continental deformation. In this paper, the authors examine the strain history of the KF in detail and compare its evolution to other strike-slip faults in the region. We present new U-Pb ID-TIMS data on 15 samples constrained by 70 mineral ages, coupled with new geochemical data and micro- and macro-structural analysis in the Ladakh region. We will discuss the temporal, spatial and geochemical relationship between Karakoram Batholith (KKB) and the Eastern Karakoram Batholith (EKB) and suggest a mode of initiation for the KF and describe its evolution. End-member models of deformation are then discussed in relation to the initiation and evolution of the KF in light of this new dataset. References cited: Armijo, R., P. Tapponnier, J.L. Mercier & T. Han. Quaternary extension in southern Tibet: Field observations and tectonic implications. J. Geophys. Res., 91, 13,803-13,872, 1986. England, P.C. & G.A. Houseman. Finite strain calculations of continental deformation, 2. Applications to the India-Asia plate collision. J. Geophys. Res., 91, 3664-3676, 1986. Molner, P. & P. Tapponnier. Cenozoic tectonics of Asia, effects of continental collision. Science, 189, 419-426, 1975. Peltzer, G., P. Tapponnier, & R. Armijo. Magnitude of Late Quaternary left-lateral displacements along the north edge of Tibet. Science, 246, 1285-1289, 1989.

T21D-0479 0830h POSTER

Tectono-Metamorphic Events Along the Dangjin Pass Transect of the Altun Shan, Western China: Conditions, Timing and Tectonic Implications

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The Altun Shan range harbors the Altyn fault that shows a cumulative post-Jurassic sinistral offset of ca. 400 km. Aside from this young tectonics, little is known about the evolution of this boundary structure of the Tibetan plateau. We studied the Dangjin pass transect, where two major shear zones can be discerned, a northern brittle fault, which delimits metamorphic rocks of the Altun Shan to alluvial sediments in the north and a southern ductile fault zone characterized by low-grade, retrograde metamorphic rocks. To the south, again medium grade metamorphic rocks crop out. The northern zone displays an increase in metamorphic grade from the biotite zone to staurolite-in. Average PT calculations gave 6 kbar and 550°C (garnet zone) to 615°C. The ductile shear zone displays lower greenschist metamorphic conditions with relics of higher grade minerals. The southern unit shows a two-stage metamorphic evolution, recorded by distinct mineral compositions. PT conditions increase from 550°C/4 kbar to 535°C/7.5 kbar during the first event, and are ca. 620°C/7 kbar for the overprint. Along the transect, four Ar/Ar age groups are evident: (1) ages of ca. 450 Ma between the two shear zones; (2) ages of ca. 165 Ma in rocks bordering the ductile shear zone; (3) ages down to ca. 30 Ma within the latter; and (4) ages of ca. 350 Ma in metamorphic rocks of the southern zone. Muscovite from the southern shear zone gave a total gas age of 32.5 Ma, K-feldspar shows a stair-case pattern with ages from ca. 32 Ma to 137.5 Ma. Hornblende from the southern unit yielded total gas ages of 395 and 425 Ma. These data allow to discern four distinct tectono-metamorphic events. Ordovician (about 450 Ma) metamorphism and cooling, which signifies a major regional event. A second, late Devonian-early Carboniferous (about 350 Ma) regional event occurred south of Dangjin pass, that overprinted parageneses of the first phase. Within the Altun Shan, a restricted mid-Jurassic (ca. 165 Ma) event is observable, and finally strong retrograde metamorphism and shearing at about 30 Ma, which denotes a ductile precursor stage to the active Altyn Tagh fault.

T21D-0480 0830h POSTER

Further Confirmation of a Low Slip Rate on the Altyn Tagh Fault

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Estimates of slip rate inferred from geodetic data on the 2000-km-long Altyn Tagh fault, on the northern edge of the Tibetan Plateau, are 2-3 times lower than those estimated from several investigations of geologic offsets. Geodetic measurements by our group in 1994-8 indicated a slip rate of 94 mm/yr, subsequently confirmed by several other investigators. Recent PRC estimates yield yet lower rates on the eastern half of the fault (5 mm/yr). In 2002, points on a 300-km-long GPS profile between 88?-91? E, previously measured in 1994 and 1998, were occupied for a third time, and a shorter profile at 85?, first measured in 1998, was occupied for the second time. Geodetic rates calculated from the data obtained in 2002 indicate left-lateral strike-slip motion of 57 mm/yr on the eastern profile and 510 mm/yr on the 60 km western profile. Rates of convergence on the two profiles are found to be 3 +/- 1 mm/yr and 2 +/- 1 mm/yr, respectively. Two large strike slip earthquakes occurred during the span of our measurements. When our data are corrected for elastic displacements inferred from these events the 1994-98 rate is changed insignificantly, and the 1998-02 is increased by approximately 2 mm/year. Our preferred rate for the central Altyn Tagh fault is thus approximately 7 mm/year, a number that will undoubtedly have been refined somewhat by the time of the meeting. The eight year record of geodetic data leaves little maneuvering room, and thus the geologic and modern slip rates are not reconciled.

T21D-0481 0830h POSTER

Displacement Gradients on the Eastern Kunlun Fault: Implications for the Kinematics of Deformation in Tibet

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The question of whether large strike-slip fault systems in Asia accommodate eastward extrusion of quasi-rigid Tibetan lithosphere or whether these faults accommodate internal variations in strain between deforming regions of thickened Tibetan crust is central to a more fundamental question - do the rules of plate tectonics govern intracontinental deformation? The Kunlun fault, in north-central Tibet presents a key opportunity to evaluate competing models for the kinematics

of Asian deformation. Although initial remote sensing interpretations of the eastward extent of the fault system suggested that the fault terminated within the Tibetan Plateau, recent regional maps interpret the fault to be linked with structures transecting the plateau margin. Coupled with rapid and uniform slip rate (∼1 cm/yr) along ∼600km of the fault (Van der Woerd, 2002), the fault is argued to accommodate eastward extrusion of much of central Tibet, Here we evaluate this hypothesis with new geomorphic mapping and observations of Holocene fluvial terraces and fault scarps along the easternmost ∼100km of the Kunlun fault. Our mapping suggests that significant displacement is not transmitted beyond the eastern margin of the Tibetan Plateau. Moreover, we exploit the preservation of flights of fluvial terraces as precise markers of displacement along this segment of the fault; coupled with radiocarbon ages of detrital charcoal, offsets of terrace risers at two localities yield preliminary slip rates ranging from ∼6 mm/yr to ∼2 mm/yr. Viewed in concert with previous rate determinations, slip rates appear to decrease toward the eastern end of the fault. We are currently working to assess the degree to which this displacement gradient is absorbed by shortening and crustal thickening within the Anyemaqen Shan and/or reflects distributed shear and rotation of the fault. Regardless, our preliminary results indicate that the Kunlun fault does not control extrusion of Tibetan lithosphere, but rather suggest that fault displacement is intimately tied to regional deformation gradients.

T21D-0482 0830h POSTER

Evolution of Mustang Graven, Tibet Himalayas, due to Eastward Extrusion of Tibet Plateau in and After the Last Glacial Age

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This study clarifies neotectonics and evolution of Mustang Graven due to eastward extrusion of the Tibet plateau in and after the Last Glacial Age. Mustang Graven is a NS trend depression and is located in Tibet Himalayan zone just behind the Higher Nepal Himalayas. Its average height is 4000 meters. Its width and length are less than ten kilometers and more than fifty kilometers respectively. This study depends on interpretation of aerial photographs in scale of 1/50,000 over the Mustang Graven and field survey carried out in Sept. 2002. A distinct topographic contrast occurs along a mount foot line between the graven and the surrounding mountains, the Tibet Himalayas of 5000-7000 meters asl. Fault scarplets on moraines and fan surfaces, which developed as outwash plains in and after the Last Glacial Age, are traceable along the western foot line. Tectonic deformation of the topographic surfaces are cumulative and five to ten meters in relative height . Sense of the faults is normal downthrowing to the east. Valley side fault in a normal sense is also found in the Thakkola formation, the Plio-Pleistocene sediment, near Dhakmar village. Deformation of the Thakkola Formation is more than fifty meters. Such phenomenon indicate that Mustang Graven has been formed by a tensile stress field of EW direction and evolved also in and after the Last Glacial Age. This implies the extrusion of the Tibet Plateau has been continuing throughout the late Pleistocene and to the Holocene.

T21D-0483 0830h POSTER

Investigation on the rupture behavior of the 2001 Kunlun and 1997 Manyi, China, earthquakes

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We examine the rupture processes of the 14 November, 2001(09:26:10 GMT) Kunlun earthquake (Ms=8.1), and 8 November 1997 (Mw=7.6) Manyi earthquake to investigate the temporal and spatial slip distribution along the ruptured faults. The 2001 Kunlun earthquake struck the northern Tibetan plateau, China, near the Kusai Hu segment of the Kunlun Fault. Field investigation shows this earthquake produced a surface ruptured of about 400 km long and a maximum strike-slip motion of 16.3 m. The 1997 Manyi earthquake occurred at a Quaternary fault to the west of the 2001 Kunlun rupture zone. The Manyi earthquake produced a 170-km-long surface rupture zone with a maximum left-lateral strike-slip of 7 m. These large rupture lengths and strike-slip movements, including 1937 M7.5 Tuosho lake earthquake prior 1997 event, show the possible partitions of the Kunlun fault deformation into eastward extrusion of Tibet. To understand the ruptured behavior of the 1997 Manyi and 2001 Kunlun earthquakes, we investigated the teleseismic waveforms accommodated with field observations to obtain the temporal/spatial slip distribution of the ruptured faults. Two components of slip, strike-slip and dip-slip, were inverted, allowing the change of rake angle through rupture. A multiple-time window was introduced to make the source duration close to reality. For the 2001 Kunlun earthquake, we revealed a fault geometry with strike of N100E, and the dip of 82°. The rupture velocity was 3 km/s with source duration of 33 s. The optimum results show that the strike-slip motions took place in the most portion of the fault with a maximum displacement of 7 m at about 240 km east from the epicenter. Three distinct asperities were found with total seismic moment of 8.69e+20Nm (Mw=7.9). The study on the 1997 Manyi earthquake is undergoing. The rupture behavior of these two earthquakes will provide important information not only their possible implication on tectonic involvement of Kunlun fault to eastward extrusion of Tibet, but also the earthquake rupture physics toward possible stress triggering along a fault system.

T21D-0484 0830h POSTER

Viscoelastic Crustal Deformation in the India-Eurasia Collision Zone: Difference in Time Dependence Between the Vertical and Horizontal Components

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The present-day convergence rate between the Indian and the Eurasian plates has been estimated to be about 50 mm/yr. At the collision boundary extending along the Himalayas, about 40 % of the total convergence is consumed by the subduction of the Indian plate beneath the Eurasian plate. The present crustal movement in this region is characterized by rapid uplift along the high Himalayas and large-scale horizontal deformation in and around Tibet. The fundamental causes of these two different types of crustal movement are the same; interaction between the Indian and the Eurasian plates. So far, we have represented the plate interaction by steady increase in tangential displacement discontinuity (dislocation) across the interface that divides an elastic surface layer overlying a viscoelastic half-space into the Indian and the Eurasian plates. With this single plate interaction model, we have consistently explained the present rapid uplift of the high Himalayas and large-scale horizontal deformation in and around Tibet. The former is due to the steady slip along the ramp-shaped plate interface below High Himalayas, and the latter is due to the slip deficits of 30 mm/yr at the collision boundary relative to the surrounding subduction zones. In the present study, we introduced the viscoelasticity of the lithosphere and computed the viscoelastic response to a step slip over the plate interface to examine the time dependence of the viscoelastic crustal deformation. First, using 2-D model we computed vertical component of the viscoelastic response to a step slip over the plate interface with a realistic shape observed in Himalaya. Since the lithosphere-asthenosphere system consists of the high viscosity surface layer and the low viscosity substratum, its response to a step slip is characterized by three different phases; instantaneous elastic deformation of the total system ($0 \leq t \leq 10$ yr), rapid viscoelastic relaxation of the asthenosphere (10^2 yr $\leq t \leq 10^6$ yr), and gradual viscoelastic relaxation of the lithosphere (10^7 yr $\leq t$). The vertical component of the viscoelastic response decreases with time due to viscoelastic relaxation of the tectonic stress supporting the surface load associated with crustal uplift. Second, we computed the horizontal components of the viscoelastic step response with a simple 3-D model. We considered a plate interface with simple geometry and introduced a slip deficit region on it. The slip deficit region corresponds to the Himalayan collision boundary. At $t = 10^7$ yr, the stress relaxation must be completed both in the lithosphere and the asthenosphere. However, we cannot find large difference in the pattern of surface deformation between $t = 10^4$ yr and 10^7 yr. This result indicates that the horizontal components of the viscoelastic response are not largely affected by stress relaxation of the lithosphere, because the gravity does not suppress horizontal deformation unlike the case of vertical deformation. From this result, we can conclude that the horizontal deformation due to steady slip on the plate interface steadily increases at a nearly constant rate up to $t = 10^7$ yr at least.

T21D-0485 0830h POSTER

Discrete Element Simulations of Indentation Tectonics; Insights for Velocity and Stress Distributions

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Discrete Element Method (DEM) approximates the geologic body as an assembly of particles, thus can appropriately simulate the brittle behaviour of the upper crust. We have applied the method to the indentation tectonics of Indian - Eurasian collision to examine the stress and velocity distributions of internal deformation of the Eurasian Plate. Since the method is a forward modelling technique, progressive development of strain and stress can be examined during the collision process. The results show that the velocity distributions and the stress fields of the particles, extracted for every short time interval during deformation, are quite unstable. This may be due to the brittle behaviour of the particle assembly corresponding to the upper crust, in which localisation of stress concentration and its release by faulting are clearly observed. In particular, shear stress is commonly concentrated along a broad shear band and is released by faulting, which causes a pair of large velocity anomaly in two opposite directions. When applied to real geology, the velocity distribution corresponds to GPS which shows overall continuous curvature from the Himalayan Mountains. This suggests that, although the surface deformation is characterised by faulting, such a large-scale tectonics is primarily controlled by ductile deformation of the lower crust and its substrates. The normal stress distribution of the simulation results demonstrated that the simplified tectonic model by Tapponnier (1982) has a strong boundary condition that may affect the experimental results, thus the model needs to be revised.

T21D-0486 0830h POSTER

Localization of Shear Along a Strong Inclusion in a Continuous Deformation Model: An Application to the Altyn Tagh Fault

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Two end-member descriptions are commonly used to describe deformation of the lithosphere in continental collision zones. One assumes that deformation occurs on discrete faults that extend through the crust and into the upper mantle. The second treats the continental lithosphere as a viscous fluid that deforms continuously, with faults occurring only in the brittle upper crust. The first description uses the existence of strike-slip faults with large offsets and rapid slip as an argument that deformation is not continuous on a lithospheric scale. Here we apply the second view to examine the effects of a marked contrast in strength (or viscosity) on the localization of shear strain along the discontinuity using thin viscous sheet calculations with continuous displacement fields. Two parameters are varied to examine a range of lithospheric properties: the stress-strain exponent n, which relates strain rate to a power of stress, and the Argand number Ar, a measure of buoyancy force relative to viscous stress. We find that a shear zone develops in the weaker material just outside the rigid inclusion when the discontinuity is oblique to the principal convergence direction. The width of this zone narrows along the rigid inclusion with increasing strain, increasing n, and increasing

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Ar. When applied to the scale of the Tarim Basin, the results indicate the development of a shear zone approximately 100 km wide, comparable to the width of the Altyn Tagh fault zone. The formation of this shear zone does not require strain-weakening of the material or fault zones that extend through the lithosphere.

T21E MCC: 3005 Tuesday 1020h

Development of Fault Systems Through Time: Process and Rates II

Presiding: **N Dawers,** Tulane University**; D Commins,** Imperial College

T21E-01 1020h INVITED

Constraining Fault Evolution at an Active Extensional Relay: Star Valley, Wyoming

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Relay zones, the sites where faults overlap and become linked, provide important insights into the processes by which fault segments coalesce. Whilst numerous studies have been made of the detailed structural geometry of relay zones, our understanding of the temporal evolution of faulting during relay formation remains limited. We focus on the Grover relay, a 4-km-wide en echelon step in the Star Valley fault located at the eastern margin of the Basin and Range province, Wyoming. Several coeval latest Quaternary ruptures have been documented on both segments by paleoseismological studies suggesting that the north and south segments are well linked. We use sedimentological and geomorphic observations to investigate faulting-landscape interactions and to propose a model of relay evolution. Typically relay zones comprise an en echelon fault overlap of inboard and outboard faults. At the Grover relay, the outboard fault loses displacement northward into a N-plunging fault-related anticline that has deformed early synrift deposits. Early syn-rift and pre-rift rocks are also preserved between the segments of the Star Valley faults and are being exhumed in the footwall of the outboard fault suggesting that the relay is not a newly developing one. Stratigraphic relations at the initial point of fault overlap indicate that approximately 2-my-old syn-rift alluvial fan conglomerates derived from erosion of the inboard footwall onlap and are ponded against the hangingwall dipslope of the outboard segment. This indicates that the Star Valley segments were in overlap position and the outboard fault formed topography during conglomerate deposition. This pinning point provides a minimum age for onset of fault overlap and permits estimation of a propagation rate for the outboard fault tip of approximately 9 mm/yr. This is an order of magnitude greater than Holocene fault displacement rates derived from trenching studies. Analysis of drainage patterns indicates that streams on the outboard footwall have incised headward in response to displacement on the outboard fault and captured drainage that originally flowed down the relay. Captured streams show well-developed concave profiles. Streams on the outboard fault tip by contrast show convex-up profiles indicating that tectonics dominates the streams ability to incise and develop an equilibrium profile. Stream capture has resulted in major denudation of the outboard footwall suggesting that this may be an important process in local footwall erosion. Comparison with numerical landscape evolution models (Densmore et al. 2003) suggests that capture of early formed relay zone drainage occurs in situations where fault segments propagate into overlap position and link rapidly, after which displacement addition on the overlapped segments drives the rapid baselevel fall that leads to capture. We hypothesise that the relative timeframe of fault linkage plays a critical role in landscape evolution and sediment dispersal patterns at evolving relays.

T21E-02 1040h

Normal Fault Growth and Linkage in the Whakatane Graben, New Zealand, During the Last 1.3 Million Years

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Here we show how seismic reflection data of different spatial resolutions can be used to constrain the linkage history and displacement rate variations of a single major fault. Previous work on the determination of fault growth rates and fault network evolution at time-scales from 10^4 - 10^6 years has been hampered by a lack of a well-constrained stratigraphic succession that provides a high-fidelity record of fault development over these time periods. We present data collected in the offshore Whakatane Graben, Bay of Plenty, New Zealand, where intense normal faulting occurs as a result of active back extension. The focus of our study is the Rangitaiki Fault, a linked segmented normal fault which is the dominant active structure in the graben. The total linked fault length is c. 20 km long and has a displacement of up to 830 $\pm$ 130 m in the top 1.5 km of sediments. The fault has been actively growing for the last 1.34 $\pm$ 0.42 Ma and has developed from isolated fault segments to a fully linked fault system. Initially, the dominant process of fault growth was tip propagation, with an average and maximum displacement rates of 0.52 $\pm$ 0.18 mm yr^{-1} and 0.72 $\pm$ 0.23 mm yr^{-1} respectively. Interaction and linkage became more significant as the fault segments grew towards each other, resulting in the fault network becoming fully linked between 300 and 18 ka. Following fault segment linkages, the average displacement rate of the fault network increased by almost three-fold to 1.41 $\pm$ 0.31 mm yr^{-1}, while the maximum displacement rate increased to 2.72 $\pm$ 0.61 mm yr^{-1}.

T21E-03 1055h

The Tectonic Evolution of the Tjörnes Fracture Zone, offshore Northern Iceland - Ridge Jumps and Rift Propagation

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The Tjörnes Fracture Zone (TFZ) links the rift zones in northern Iceland with the Kolbeinsey Ridge north of Iceland. The TFZ was initiated during the Miocene (7-9 Ma), following an eastward jump of the spreading axis in northern Iceland. A roughly 150 km long (EW) and 50 km wide (NS) deformation zone has since developed which includes both right-lateral, strike-slip faults and three N-S trending extensional grabens (from west to east the Eyjafjördur, Skjálfandi and Öxarfj"ordur basins) which are filled with a 0.5-4 km thick sedimentary sequence. There are two WNW-striking bands of seismicity in the TFZ, a northern band known as the Grímsey lineament and a southern band associated with the WNW-trending Húsavík-Flatey fault (HFF). Over the past three field seasons we have mapped a large portion of TFZ utilizing multibeam echo sounders (both EM300 and a Reson 8101 shallow water system), collected high-resolution multichannel seismics and Chirp sonar, and obtained bottom photographs. The HFF can be traced offshore from Húsavík village across Skjálfandi Bay as two WNW-trending, south-facing fault scarps and northwest of Flatey Island into the southern Eyjafjördur basin as a WNW-trending, north-facing scarp. In Skjálfandi Bay several smaller WNW-trending faults are located sub-parallel of the main HFF. Offshore Flateyjarskagi, west of Flatey Island, a zone of intense deformation has been mapped, including clear evidence of right-lateral strike-slip faulting. The sediment-filled basins north of the HFF are bounded by numerous NS-trending faults, some of which extend to the seafloor, suggesting they are actively extending. The very subtle expression of the HFF in eastern Skjálfandi Bay, and the more prominent but simple expression of recent (post-glacial) faulting along the western HFF near Flatey Island are consistent with historical and recent seismicity which is concentrated on the Húsavík fault system on the Tjörnes peninsula, along the western HFF and in the southern Eyjafjördur, basin. A GPS geodetic station on the Tjörnes peninsula, northeast of the HFF, maintained by the Iceland Meteorological Service shows that over the past 2 years the southern TFZ has been moving with the North American plate suggesting that little strain accommodation is currently occurring along the main HFF. These observations are consistent with a model for the tectonic evolution of the TFZ in which the continued northward propagation of the northern rift zone in Iceland has progressively shifted relative motion between the North American and Eurasian plates northward to the series of NNE-SSW trending rift zones along the Grímsey seismic lineation.

T21E-04 1110h

Seismic Reflection Imaging of the Tucson Basin and Subsurface Relations Between the Catalina Detachment System and the Santa Rita Fault, SE Arizona

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Industry seismic reflection data collected in SE Arizona in the 1970's imaged the structure of the Tucson basin, the low-angle Catalina detachment fault, and the Santa Rita fault. Recent reprocessing of these data, including detailed near-surface statics compensation and modern event-migration techniques, have served to better focus the subsurface images. The Tucson basin occupies an area of approximately 2600 km^2 and is bounded to the northeast by the Catalina-Rincon metamorphic core complex and to the south by the Santa Rita Mountains. The basin is characterized by an apparent half-graben structure down dropped along the eastern side and filled with up to 3700 m of Oligocene to recent volcanic and sedimentary rocks. In the northern portion of the basin, the gently-dipping ($\sim$30 degrees) Catalina detachment fault is imaged from the western flank of the core complex dipping to the southwest beneath the Tucson basin. The detachment surface is evident to several seconds two-way-time in the seismic data and is characterized by broad corrugations parallel to extension with wavelengths of tens of kilometers. In the southern portion of the basin, the Santa Rita fault is imaged at the northwest side of the Santa Rita Mountains and dips $\sim$20 degrees to the northwest beneath the Tucson basin. Large, rotated hanging-wall blocks are also imaged above both the Catalina detachment and Santa Rita faults. While the Catalina detachment fault is no longer active, geomorphic analysis of fault scarps along the western flank of the Santa Rita Mountains supports recent (60-100 ka) movement on the Santa Rita fault. Preliminary results indicate that the Santa Rita fault terminates against the Catalina detachment fault beneath the central basin, suggesting that the recent movement observed on this fault may be, in part, a reactivation of the older fault surface.

URL: http://www.geo.arizona.edu/~/fwagner/projects.html

T21E-05 1125h INVITED

Constraining fault interactions and vertical displacement rates in a compressive proto-back-arc environment, South Wanganui Basin, New Zealand

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The Kapiti-Manawatu Fault System (KMFS) is a 25 km-wide network of steep, reverse and normal faults that runs parallel, and 200 km to the west of the Hikurangi subduction margin, New Zealand. The KMFS