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Since the collision between Eurasia and India at ca. 45 Ma, there has been 2000-3500 km of convergence between India and Asia. How and where the indentation was accommodated in the region east of the India indenter are still subject to speculation, due to lack of geological investigations carried out in the region. Our field studies show that a significant part of the post-collisional northward indentation of India into Asia has been absorbed by the previously undocumented Gaoligong Shan (GSSZ) and Chong Shan (CSSZ) shear zones, in addition to the left-lateral displacement along the better-known Ailao Shan shear zone that lies farther NE in Yunnan, China. Penetrative ductile deformation marked by steep foliation and subhorizontal lineation affects all rock types within both shear zones and kinematic indicators show right-lateral and left-lateral shear along the GSSZ and CSSZ, respectively. U/Pb ages on several monazite grains and grain fractions from mylonitic to non-mylonitic leucogranites within the shear zone range from ca. 80-18 Ma. The youngest ages come from undeformed leucogranites cross-cutting the foliation, which indicate that right-lateral movement ended before ca. 18 Ma, when right-lateral shear between India-Sibumasu switched to the Sagaing fault zone in Burma. High-temperature sinistral strike-slip shearing along the CSSZ was active at ca. 28 Ma and terminated before ca.17 Ma, based on U/Pb ages of monazite grains from deformed and foliation cross-cutting leucogranites. These new geochronological data suggest that both the GSSZ and CCSSZ are not belts of Precambrian metamorphic rocks as previously suggested, but are important Cenozoic shear zones that are contemporaneous with the left-lateral Ailao Shan shear zone. The documentation of these structures also indicate that crustal fragments in SE Asia did not extrude to the southeast as a single block, but rather extruded as at least two crustal fragments with considerable internal deformation, bounded by three large-scale intra-continental shear zones.

T22C-05 1440h INVITED

GPS Measurements from the Southern Tibetan Plateau: Tests of Plate-like or Continuous Deformation

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Observations of relative motion in a geodetic network in Ladakh, India, and across southern Tibet indicate slow shear on the Karakorum fault, rapid east-west extension across the whole of southern Tibet, and constant arc-normal convergence between India and southern Tibet along the Himalayan arc. Measurements of ten campaign-style and six permanent sites with GPS precise geodesy provide bounds on the style and rate of surface deformation in the Tibet-Himalaya region. Divergence between sites at Leh, Ladakh, India and Shiquanhe, western Tibet as well as slow relative motion among sites within the Ladakh network limit right-lateral slip parallel to the Karakorum fault to only 3-5 mm/yr (1 σ). This low rate concurs with a recent estimate of 3-4 mm/yr for late Holocene time, but disagrees with the much higher rate of 30-35 mm/yr that has been used to argue for plate-like behavior of the Tibetan Plateau. Convergence between the Indian subcontinent and Ladakh at 15.5 $\pm$ 1.7 mm/yr at N42 $^\circ$ E $\pm$ 3° (1 σ) differs little from estimates of convergence across the central segment of the Himalaya. Finally, lengthening of the baseline between Leh, Ladakh and Lhasa (in southeastern Tibet) at 17.8 $\pm$ 1 mm/yr is consistent with an extrapolation of rates of east-west extension of the Tibetan Plateau based both on shorter GPS baselines and on diverging slip vectors of earthquakes in the Himalaya and suggests no significant acceleration associated with the Karakorum fault.

T22C-06 1455h

InSAR observations of conjugate strike-slip faulting in West Central Tibet

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A combination of Landsat7 image interpretation and repeat-pass synthetic aperture radar interferometry (InSAR) characterizes the fault geometry and kinematics of the Bue Co conjugate strike-slip fault system in west central Tibet (33°N, 82°E). The conjugate strike-slip fault system is centered along the E-trending Bangong-Nujiang suture zone, and is comprised of the NE-striking left-slip Bue Co fault to the north and NW-striking right-slip Lamu Co fault to the south. Preliminary interferograms were constructed using radar image pairs spanning 6 to 7 years from descending passes of the ERS European Space Agency satellites. Maps of the surface displacement field along the radar line of sight show a concentration of strain along the Lamu Co fault, consistent with right-lateral slip. These results agree with slip constraints from geologic observations. Within the detection limit of InSAR, we do not observe a significant strain gradient along the opposing Bue Co fault, which is consistent with basic fracture mechanics. This result of a single active fault that comprises a conjugate strike-slip fault system is similar to InSAR observations along the Dong Co conjugate fault system 300 km to the east (32°N, 86°E). We suggest that conjugate strike-slip structures are characteristic of central Tibet, and that they are consistent with a constrictional strain field of regional extent.

T22C-07 1510h

Geodetic slip rates for the major strike-slip faults in the eastern Tibet

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Several active fault systems in the northern and eastern Tibet control, to a large extent, the pattern of active deformation due to the India-Asia collision. Recent GPS geodetic measurements in the region suggest rates of strike-slip motion ranging from several mm/yr to 1 cm/yr on these major faults. Here we report a detailed description of fault slip rates and their variation for the Haiyuan, eastern Kunlun, Xianshuihe-Xiaojiang and Red River faults, using data from hundreds of GPS sites. Many of these sites are part of the Chinese national GPS network, surveyed mostly in 1999 and 2001. The geodetic slip rate estimates for these faults suggest that while active faulting on the major fault systems plays an important role in accommodating eastward crustal movement of Tibetan Plateau, internal deformation and rotation of tectonic blocks bounded by these major faults absorb a significant amount of the eastward lateral extrusion of Tibetan crust.

T22C-08 1525h

Northeastwards decrease in the late Pleistocene-Holocene slip-rate and propagation of the Altyn Tagh fault (China).

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Measured, long-term ($>$ 100 Ka) slip-rates appear to decrease northeastwards along the Altyn Tagh Fault. Our recent results imply that the rate is fastest near Tura, on the central segment of the fault ($85-89^\circ$E). Here, offsets of fluvial terrace risers and abandoned channels ($\approx$ 420 m) and glacial features ($\approx$ 3.5 km) are constrained by both radiocarbon and cosmogenic dating (^{10}Be and ^{26}Al) and yield a slip rate of $\approx$30 mm/yr. Farther East, north of Huatougou, at the transition between a push-up mountain and a pull-apart basin, cosmogenic dating of offset terrace risers on the most active trace of the fault system yields a well-constrained rate of 18 mm/yr. Yet farther East, near Aksay, on the north Altyn Tagh fault (NATF), at three sites where extensive radiocarbon and surface exposure dating were performed, the slip-rate is 20 $\pm$ 3 mm/yr, with a lower bound of 13 $\pm$ 2 mm/yr. At 95°E, eastern of the main Subei junction, the rate found at Lou Zhao Wan on the NATF, is only on order of 15 mm/yr with a minimum of 12.5 mm/yr. Finally, near Shibao Cheng (96°E) the slip rate of 4$\pm$2 mm/yr has been obtained west of the junction with the Qilian Shan Front (Meyer *et al.*, 1996). Thus, long-term morphochronologic measurements over a length of $\approx$ 1000 km indicate a systematic eastward decrease, from 30 mm/yr to 4 mm/yr, of the left-lateral slip-rate along the fault. This behavior is in contrast to that on the Kunlun Fault where the morphochronologic rate over a similar length of the fault appears to have remained constant over the last 45 Ka (Van der Woerd *et al*, 2000). At a more detailed level, the ATF slip rate appears to display a stepwise decrease at the junctions with branching, sub-perpendicular, active thrusts south of the fault. We relate this pattern to the eastward propagation of the fault, still in progress, whose present kinematics remains linked to the formation, in the last 10 Ma, of thrusts that young to the northeast. This propagation process has been a vital element in the building of the NE corner of the Tibet plateau (Meyer *et al*, 1998).

T22D MCC: 3007 Tuesday 1340h

New Views of the Structure and Composition of the Deep Earth IV

(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

T22D-01 1340h

The Effect of Pressure on Diffusion of Au, Pd, and Re in Fe-Ni Alloys

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It is understood that the core of the earth consists predominantly of an iron-nickel alloy. Diffusion is commonly considered to be a rate limiting step in many processes such as crystal growth as well as element partitioning. It follows that understanding the diffusive behaviour of trace siderophile elements in Fe-Ni alloys could help constrain models of core formation, time and length scales of communication between the inner and the outer core of the earth, and crystallization of the inner core. We measured the effect of pressure on the diffusivity of several siderophile elements (Au, Pd, Re) in solid 90:10 iron-nickel alloy using a multi-anvil pressure device. The elements investigated can be considered to be broadly representative of many siderophile elements. Diffusion couple experiments were conducted at pressures ranging from 5 to 25 GPa, and temperatures ranging from 1200° C to 1600° C. Alloys for the diffusion couples were presynthesized by compacting and heating mixtures of pure metal powders in a piston-cylinder device at 1GPa and 1400° C for 60 hours. The diffusion couples were made by juxtaposing a disk of pure 90%Fe 10%Ni alloy with another disk of a similar alloy doped with up to 2% of the diffusant of interest. The duration of the experiments ranged from 12-120 hours. Diffusion profiles in all experimental products were measured by elctrom microprobe analysis. It was found that there is a substantial decrease in diffusivity with the application of pressure for all three elements, and the magnitude of this decrease appears to be similar for all three elements. The relative diffusivities consistently span

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about an order of magnitude at any given set of conditions (Au is always 10x faster than Re, and Pd is intermediate). These are some of the first high pressure data of trace element diffusion in iron nickel alloys, and are part of a broader study with the goal of systematically understanding the general diffusion behaviour of siderophile elements in Fe-Ni alloys at conditions relevant to the earth and other planetary bodies.

T22D-02 1355h

Phase transition of CaCO3 in the lower mantle

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Calcite is the dominant carbon-bearing phase in the Earth's crust, and acts as a buffer for the long-term cycling of CO2 between the atmosphere, oceans, and solid Earth. It is unsurprising, therefore, that the high-pressure stability and behaviour of CaCO3 and related phases has attracted considerable interest. It is generally known that calcite transforms to aragonite, which often occurs in high-pressure metamorphic rocks, at high P-T that correspond to the lower crust and the uppermost upper mantle. It is unknown whether aragonite transforms to new high-pressure phase or dissociates into CaO and CO2. Therefore, the high-pressure stability limit of aragonite was investigated. High-pressure X-ray diffraction experiments were performed using a laser-heated diamond anvil cell. The samples were heated with a YAG laser to overcome potential kinetic effects on possible phase transitions. The samples were probed using an angle-dispersive X-ray diffraction technique at the synchrotron beam lines BL10XU, SPring-8 and BL13A, Photon Factory in Japan. In the first set of experiments, the pressure was increased directly to 70 GPa at room temperature, and an X-ray diffraction pattern of the sample was recorded. It is difficult to identify CaCO3 phases at room temperature before the sample was heated. A strain-broadening of the diffraction peaks occurred, because a large differential stress was induced in the diamond anvil cell experiments as pressure increased. After the desired pressure was achieved, the sample was heated to about 2000 K to relax the differential stress and to overcome potential kinetic effects on possible phase transitions. After the heating, some new peaks appeared in the diffraction pattern. This implies that the starting material transformed to a new high-pressure phase. According to additional experiments, the phase transformation from aragonite to a new calcium carbonate form was observed at pressures higher than about 35 GPa, corresponding to the lower mantle. The new carbonate shows a hexagonal symmetry and was confirmed to remain stable to 70 GPa. This indicates that carbon might to be stored in the new carbonate phase in the deep mantle.

T22D-03 1410h

Ultrahigh pressure deformation of polycrystaline hcp-cobalt

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During the past few years, a novel set of methods has been developed allowing direct measurements on elasticity and rheology under static ultrahigh pressures using synchrotron x-ray diffraction and the diamond anvil cell. In particular, the analysis on the development of texture and uniaxial stress in a polycrystalline sample under ultrahigh pressure and non-hydrostatic conditions yielded to very interesting results on the microscopic deformation mechanisms and strength of MgO, silicate perovskite or ϵ-Fe [eg. Merkel et al. 2002, Merkel et al. 2003]. However, our understanding of the properties of the ϵ phase of iron remains poor. There are considerable uncertainties and disagreement on the results of various experiments or first-principles calculations. In particular, the results of the radial diffraction measurement on ϵ-Fe [Mao et al. 1998] have been highly controversial. In order to address this issue, we performed investigations on polycrystalline hcp-cobalt. Its properties such as the bulk modulus and thermal expansion are very close to those of ϵ-Fe and it is readily available under ambient conditions. Thus, it is a well known material and results from the high pressure radial diffraction experiments can be compared with those from well-established techniques. In the present analysis, we performed a new set a measurements between 0 and 20 GPa under ambient temperature conditions at the ESRF synchrotron source using amorphous boron gasket, monochromatic x-ray beam, and imaging plate techniques. From such an experiment, we are able to extract information on non-hydrostatic stress, elasticity, and preferred orientations of the sample in-situ under high pressure and compare them with results obtained previously on ϵ-Fe. Documenting the evolution of stress, elasticity and texture in hcp metals is of great interest for our understanding of the bulk properties and seismic anisotropy of the Earth's inner core. S. Merkel et al., J. Geophys. Res. 107 (2002) doi: 10.129/2001JB000920.
S. Merkel et al., Earth Planet. Sci. Lett. 209 (2003) 351.
H. Mao et al., Nature 396 (1998), 741

T22D-04 1425h

Al_2O_3 and its influence on oxygen vacancies in the lower mantle

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While commonly accepted mineralogical models of the Earth's lower mantle consist of the three phases: (Mg,Fe)SiO_3 perovskite, (Mg,Fe)O (magnesiowüstite), and $CaSiO_3$ perovskite, little is known about how the minor and rare gas elements fit in. The role of aluminum in $MgSiO_3$ perovskite has received much notice recently. As a trivalent cation, aluminum introduces two likely and interesting substitution mechanisms, one of which involves the formation of oxygen vacancies. Aside from significantly lowering the bulk modulus of $MgSiO_3$ perovskite, these vacancies can provide "comfortable" sites for larger, minor elements or noble gases. Our previous theoretical simulations for the $MgSiO_3$-Al_2O_3-MgO system indicate that as much as one-third of the aluminum enters $MgSiO_3$ via vacancy-forming substitution in the upper part of the lower mantle, and that the number of vacancies is reduced by about a factor of two at lowermost mantle conditions. To better understand the role of aluminum in the lower mantle assemblage, we examine the solubility of aluminum in $CaSiO_3$ perovskite as well. While a small fraction of an already minor element (Al) in a minor phase ($CaSiO_3$) would not significantly affect the elasticity of the lower mantle directly, it could affect its geochemical properties (*e.g.* hosting of rare elements, water solubility, melting temperature, etc.). We find that, in contrast to $MgSiO_3$, vacancy-forming substitution is favored in $CaSiO_3$ throughout most lower mantle conditions. However, we also find that aluminum partitions preferentially into $MgSiO_3$. Although we do not yet have an activity-composition relationship for the case of multi-site mixing, a rough estimate of vacancy abundances can be obtained by assuming that the activity coefficients do not deviate significantly from unity. We thus estimate that adding aluminum into the lower mantle assemblage introduces about one oxygen vacancy per 100 O atoms at standard conditions, a result that is consistent with zero pressure data. Since the number of vacancies is only slightly reduced by lower mantle pressure-temperature conditions, these results strongly suggest that O vacancies play a significant geochemical role in the lower mantle. In addition, vacancy formation decreases the amount of MgO present, which may subtly affect the thermal contribution to lateral seismic velocity variations.

T22D-05 1440h

Experimental Evidence for the Existence of Metallic Fe-Rich Alloy in the Earth's Lower Mantle.

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It is known that aluminous silicate perovskite, the major mineral of Earth's lower mantle, can accommodate significant amounts of ferric Fe. We have performed multianvil experiments to determine the influence of oxygen fugacity and temperature on ferric iron solubility in aluminous perovskite. High-pressure melting and sub-solidus experiments were performed on synthetic perovskite and peridotite compositions between 21-27 GPa. Low oxygen fugacities were imposed by the presence of powdered metallic Fe and adding Re and ReO_2 produced more oxidising conditions. These experiments show that perovskite ferric Fe solubility is positively correlated with the aluminium content but independent of oxygen fugacity. High ferric iron concentrations are present in Al-bearing perovskite even when it is in chemical equilibrium with metallic Fe and at the peridotite solidus. For typical mantle Al-contents we calculate that over 60% of iron in perovskite will be ferric. This requires the bulk ferric iron content of the lower mantle to be over ten times that estimated for the upper mantle. The lower mantle must consequently be either enriched in ferric iron compared to the upper mantle or perovskite must sequester oxygen by the reduction of ferrous iron to metallic iron. If whole mantle convection occurs then the latter is the more likely scenario and the lower mantle must contain approximately 1 weight % of a metallic Fe rich phase. This metallic phase would form as material enters the perovskite stability field and would remain trapped in the lower mantle assemblage. If minor amounts of this metallic Fe have separated to the core since the lower mantle formed this could have raised the oxygen content of the mantle from its early reduced state after core separation, to the level reflected in the present day upper mantle. This amount of metallic iron will not significantly influence the elastic properties of the lower mantle, however, the substitution mechanism of Al and ferric iron is likely to have a strong influence on the elastic properties of perovskite.

T22D-06 1455h

Inverse Problem of Thermal Convection: Numerical Approach and Application to Mantle Plume Restoration

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Modern seismic tomography images of the Earth's interior allow the complex trajectories of the present-day convective flow to be seen at least in the upper mantle. To reconstruct quantitatively both the observed mantle structure and temperature field backwards in time, we need a numerical tool for solving an inverse problem of thermal convection at infinite Prandtl number. In this paper we present a variational approach to three-dimensional numerical restoration of thermoconvective mantle flow with temperature-dependent viscosity. This approach is based on a search for the mantle temperature and flow in the geological past by minimizing differences between present-day mantle temperature derived from seismic velocities (or their anomalies) and that predicted by forward models of mantle flow for an initial temperature guess. The mantle temperatures in the past so obtained could be employed as constraints on forward models of mantle dynamics. To demonstrate the applicability of this technique, we restore numerically a fluid dynamic model of the evolution of upper mantle plumes and show that the initial shape of the plumes can be reconstructed accurately. We model then the evolution of the plumes forward in time (plume upbuilding) starting from the restored state to the state they were before the restoration and demonstrate the high accuracy of the model predictions. We show also that a neglect of the heat diffusion in the backward modeling of thermal plumes (in order to simplify the numerical procedure) results in erroneous restorations of the plumes.

T22D-07 1510h

Chemical Heterogeneities and Layering in the Lowermost Mantle

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An increasing number of geophysical observations, mainly seismological, indicate Earth's lower-mantle is chemically heterogeneous [1]. Recent mineral physics

studies of the two main constituents of the lower mantle (magnesium silicate perovskite and magnesiowüstite) reveal fundamental changes in the chemical affinity of iron at 70 GPa [2], resulting in the depletion of iron in the silicate to the benefit of the oxide. Here, we will correlate the mineralogical and geophysical data, and provide a mineral-physics basis for a chemically heterogeneous and layered lower mantle. We will discuss the geophysical, geochemical, and geodynamical implications of such observations for global-Earth modelling, such as the dynamics of plumes, the chemistry at the core-mantle boundary, and heat conductivity at the basis of the lowermost mantle. [1] R. van der Hilst and S. Kárason, Science 283, 1885 (1999) [2] J. Badro et al., Science 300, 789 (2003)

T22D-08 1525h

In Situ Observation of Anisotropy Development With Pressure to 50 GPa in Olivine, Ringwoodite, Magnesiowuestite and Silicate Perovskite

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Magnesium silicates are the dominant minerals in the earth's mantle. Constraining the development of lattice preferred orientation in these materials is important for understanding anisotropy in the deep earth. Here we report results on deformation of San Carlos olivine in axial compression studied in-situ in the diamond anvil (DAC) using synchrotron radial x-ray diffraction. In order to minimize extraneous diffraction, gaskets of amorphous boron were used. Experiments were performed at room temperature, except for brief periods of in-situ laser heating to induce the phase transformations. At all conditions, high stresses and development of preferred orientation were documented. With increasing pressure (between 9 and 43GPa) olivine [001] axes align perpendicular to the compression direction. Ringwoodite (between 25 and 50GPa), develops moderate preferred orientation with a (111) compression component. After the phase transformation (at 50GPa), perovskite and magnesiowuestite display strong transformation textures. Magnesiowuestite has a [100] maximum parallel to compression, consistent with earlier observations. Patterns in perovskite, due to peak overlaps, have not yet been deconvoluted. These preliminary results indicate that significant anisotropy changes occur during phase transformations, e.g. by topotaxial growth, nucleation under stress, or martensitic mechanisms, and accompanied by deformation. All phases appear to be ductile at the high confining pressures in the DAC, even at room temperature. This is the first evidence for preferred orientation in ringwoodite and perovskite. These results will help in establishing deformation mechanisms of these minerals and are significant for interpreting seismic anisotropy in the transition zone. In the future, to be closer to earth conditions, we plan to conduct similar experiments at temperature and pressure.

T22E MCC: 3005 Tuesday 1600h

Taking the Measure of Deforming Landscapes II *(joint with G, H)*

Presiding: **M A Ellis,** Center for Earthquake Research and Information, University of Memphis**; A L Densmore,** Institute of Geology, ETH Zürich

T22E-01 1600h INVITED

Length Scale and Scaling in Both Topography Shape and Topography Dynamics

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Erosion processes both shapes topography and control topography dynamics so that it should be feasible to constrain the latter from the analysis of the former. During the last ten years, a bunch of studies have been done on analyzing topography in terms of erosion and transport laws. A kind of consensus has emerged around the power-law stream model which assumes that the erosion flux can be adequately described by its dependency on water flow and local topographic slope, and which gives that power laws with threshold are adequate functions to describe these dependencies, and that several processes (i.e. power-law functions) are necessary to cover the complete range of basin areas. But the consequences of these results in terms of dynamics have not been fully appraised yet. Thanks to a numerical surface-process model, we explore the relationship between form and dynamics, and especially the existence of characteristic time scales and their relationship to both structural and erosional parameters. Basically landscape erosion has a two-step evolution: an early phase which corresponds to the onset of drainage network, and a gentle back-to-equilibrium history. The former is very sensitive to initial topographic conditions and its dynamics is intimately related to drainage captures. We are mainly concerned with the latter which gives the long-term response of a continental system to any tectonic or climatic perturbation. Its characteristic time scale τ depends on the system size L in a power-law relationship which defines the nature of the continental-scale diffusion equation. For processes which depends linearly on slope (with or without threshold), this scaling can be written as: $\tau = \tau_H * (L/\sqrt{a_H})^{\alpha}$, where τ_H and a_H are the characteristic time scale and drainage area of hillslope, L the system size, and α the diffusion exponent which only depends on the river process. In all relevant cases, α is smaller than 1 leading to abnormally fast diffusion. In some cases (if erosion flux is highly dependent on river flux and/or if the sediment are efficiently transported in rivers), α is 0 and the system evolution is entirely controlled by hillslope dynamics. An analytical solution of α has been derived with the assumptions described above. We also show that the complete analytical solution of the topography history takes the general form: $h(t) = h_o \exp(-(t/\tau)^{\beta}) + h_\infty$ All parameters will be physically explained and related to system characteristics and erosion transport parameters.

T22E-02 1615h INVITED

Insights into the evolution of tectonically-active glaciated mountain ranges from digital elevation model analyses

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Glaciers have played an important role in the development of most active mountain ranges around the world during the Quaternary, but the interaction between glacial erosion (as modulated by climate change) and tectonic processes is poorly understood. The so-called glacial buzzsaw hypothesis (Brozovic et al., 1997) proposes that glaciers can incise as rapidly as the most rapid rock uplift rates, such that glaciated landscapes experiencing different rock uplift rates but the same snowline elevation will look essentially the same, with mean elevations close to the snowline. Digital elevation model-based analyses of the glaciated landscapes of the Nanga Parbat region, Pakistan, and the Southern Alps, New Zealand, lend some support to this hypothesis, but also reveal considerably more variety to the landscapes of glaciated, tectonically-active mountain ranges. Larger glaciers in the Nanga Parbat region maintain a low downvalley gradient and valley floor elevations close to the snowline, even in the face of extremely rapid rock uplift. However, smaller glaciers steepen in response to rapid uplift, similar to the response of rivers. A strong correlation between the height of hillslopes rising from the cirque floors and rock uplift rates implies that erosion processes on hillslopes cannot initially keep up with more rapid glacial incision rates. It is these staggering hillslopes that permit mountain peaks to rise above 8000m. The glacial buzzsaw hypothesis does not describe the evolution of the Southern Alps as well, because here mean elevations rise in areas of more rapid rock uplift. The buzzsaw hypothesis may work well in the Nanga Parbat region because the zone of rapid rock uplift is structurally confined to a narrow region. Alternatively, the Southern Alps may not have been rising sufficiently rapidly or sufficiently long for the glacial buzzsaw to be imposed outside the most rapidly uplifting region, around Mount Cook. The challenge now is to understand in detail why glaciers exhibit this range of behavior; why large glaciers apparently erode more efficiently than small glaciers, what are the processes that control the development of periglacial hillslopes, and why the rates of erosion on these hillslopes might be limited.

T22E-03 1630h

Topographic Steady State in the Southern Alps of New Zealand

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Steady-states between erosional and tectonic processes occurring in continental collisions are important because these represent the stable states toward which the dynamic tectonic-erosion system evolves. Topographic steady-state has been illustrated by numerical models of landscape evolution but often relies on conditions such as invariant rock uplift rate, climate, lithology, etc. Alternatively, transient surface processes such as glacial erosion may prevent the development of a topographic steady-state. Horizontal tectonic advection may also avert achievement of a topographic steady-state. This concept can be easily understood by considering the following first-order one-dimensional equation governing landscape evolution:

$$\frac{\partial h}{\partial t} = u_u - u_i - v\frac{\partial h}{\partial x} \quad (7)$$

where h is elevation, x horizontal distance, u_u rock uplift rate, u_i is incision rate (including diffusion of hillslope as well as incision of bedrock in fluvial channels) and v horizontal velocity tectonic advection. A numerical solution of this equation is proposed to investigate which major regional mechanisms may or not permit to reach a topographic steady state. This solution is then coupled with a GIS analysis of a 50m DEM of the South Island in New Zealand, where a continental collision is occurring, to extract geomorphologic features across the orogen that can be explained in terms of the solution of the equation described above.

T22E-04 1645h

Using Digital Topography to Differentiate Erosionally Exhumed and Tectonically Active Mountains Fronts

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Mountain ranges in the southern Rocky Mountains have departed on unique landscape evolutionary pathways in the late Cenozoic that are directly dependent upon the degree of post-orogenic tectonic activity they have experienced. The topography of Sierra Nacimiento, a Laramide uplift in west-central New Mexico lacking an active range-front fault, is shaped primarily by erosional exhumation that is continuous, but not steady, being driven by distal base level fall from Rio Grande incision and resultant south to north knickpoint migration. In contrast, the topography of the Taos Range, a rift flank uplift in north-central New Mexico is shaped by contrasting active stream incision and aggradation astride an active range front

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