04:45 PM Goldfinger, C.

AN ESTIMATE OF MAXIMUM EARTHQUAKE MAGNITUDE ON THE CASCADIA SUBDUCTION ZONE

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The Cascadia subduction zone lacks interplate seismicity from which to derive estimates of earthquake parameters for future interplate earthquakes. We approach this problem by comparing forearc deformation in Cascadia to that in other subduction zones to estimate Cascadia earthquake magnitude. Interplate slip vectors in oblique subduction settings are commonly rotated toward the arc from the plate convergence vectors. This difference, the slip vector residual (SVR), is attributed to internal deformation of the forearc. The maximum magnitude of earthquakes in these settings is inversely correlated with the SVR, implying that the largest earthquakes occur where forearc deformation absorbs only a small percentage of oblique plate convergence. We invert slip-rate data from our mapped oblique strike-slip faults in Cascadia, and calculate that the SVR for a hypothetical interplate earthquake in Cascadia would be 11°-26°. Comparison with forearc deformation rates (SVR's) from other subduction zones suggests a maximum Mw < 8.2 for an interplate event in Cascadia.

We find that historic subduction earthquakes have a definable range of aspect ratios (1:1-7:1) that may be used to constrain likely rupture scenarios in Cascadia. This data defines a maximum aspect ratio of about 7:1 for historic large events. We estimate that the rupture width in Cascadia is 50-90 km, using the thermal estimates of Hyndman and Wang (1993) for the downdip extent, and an updip limit estimated by analogy with the Nankai subduction zone. These values suggest a maximum rupture length of < 600 km.

SESSION 195, 01:00 PM

Thursday, October 27, 1994

T60. Rheological and Structural Evolution of Contractional Orogenic Belts

WSC 6A

01:00 PM Royden, L.

DEFORMATION OF THE TIBETAN PLATEAU (IN THREE DIMENSIONS)

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A three-dimensional analytical viscous flow model for continental deformation in which crustal deformation is driven by motions imposed at the Moho simulates most of the salient features of the Tibetan plateau; including development of a steep-sided, flat-topped plateau, approximate doubling of crustal thickness beneath the plateau, little shortening internal to the plateau, a surface suture between India and Asia located near the southern margin of the plateau; east-west extension across the plateau, and topographic "tails" on the southeastern and southwestern corners of the plateau. These results are obtained only when a few basic conditions are imposed on the model: (1) crust adjacent the plateau is composed of a strong crust without a weaker lower layer; (2) crust beneath the plateau is composed of a strong upper to mid-crust, but the lower part of the thickened crust is very weak, up to 5 orders of magnitude weaker than the upper crust; (3) for at least the past 20 m.y. the "mantle suture" between Indian and Asian mantle has been approximately fixed with respect to the Indian mantle, suggesting subduction of Asian mantle material. The vergence of subduction is imposed primarily by the need to reproduce the three dimensional morphology of the plateau (with topographic "tails" at the southern corners); a very different plateau shape, unlike the modern plateau geometry, is produced if Indian mantle is subducted. It is this direction of subduction that also causes the India-Asia surface suture to be localized near the southern margin of the plateau and the India-Asia "mantle suture" to be localized near the northern margin of the plateau. These results suggest that a strong, relatively undeformed Indian mantle may underlie most of the southern and central Tibetan plateau, consistent with the fast seismic P-wave velocities observed beneath the plateau. Within the plateau interior, surface deformation is almost completely decoupled from motions of the underlying mantle, and surface deformation is driven by laterally transmitted stresses. Model results also suggest that the initial deformation following continental collision first produced a long, linear east-west trending mountain belt at the India-Asia suture. The current elevation was obtained very quickly and for the past 30 m.y. the plateau has broadened without a significant increase in elevation. East-west extension across the plateau develops naturally during deformation; removal of the mantle lithosphere is not required to produce extension.

01:15 PM Northrup, C. J.

THE INTERACTION OF EXTENSIONAL AND CONTRACTIONAL STRUCTURES DURING COLLISIONAL OROGENY: EXAMPLES FROM THE NORTHERN SCANDINAVIAN CALEDONIDES.

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The Caledonian collision in Scandinavia culminated with the SE-directed thrust emplacement of a far-traveled composite allochthon onto the western margin of the Baltoscandian Shield. In the Lofoten - Rombaken region of northern Scandinavia, late-Caledonian cross-folding and deep erosion produce excellent exposure of the deep levels of the allochthon and its thrust contact with the underlying structural basement. During thrust emplacement, rocks at this structural level in the allochthon experienced constrictional strain, with extension parallel to the transport direction. Extension was accomplished by heterogeneous penetrative strain at the outcrop scale and by movement on several discrete shear zones at larger scales. Low-angle extensional shear zones occur in two orientations. Some dip toward the hinterland (NW) and have apparent transport directions opposite of thrust faults in the region. Normal faults of this orientation are commonly reactivated older thrust fault surfaces. Other extensional faults cut down section toward the foreland (SE) and have transport directions identical to thrusts. Extensional faults of both orientations root into SE-directed thrust faults at or near the base of the allochthon. In the westernmost part of the area, rocks in the footwall of the basal thrust fault experienced amphibolite facies metamorphism during the emplacement of the allochthon. Devolitilization of calc-pelitic schists in the footwall produced syntectonic veins (plagioclase + calcite + quartz + muscovite) that fill boudin necks and form tension gash veins. The fracture-tips of the tension gash veins propogated at a high angle (~78 °) relative to the basal thrust fault, a relationship consistent with a steep orientation of sigma-1 during simultaneous thrust emplacement and transport-parallel extension of the allochthon. Because the extension within the allochthon occurred prior to the end of SE-directed thrusting and late folding, this extension must have occurred during the contractional phase of orogeny and is not a product of post-orogenic "collapse".

01:30 PM Camilleri, Phyllis A.

ON THE RHEOLOGICAL, STRUCTURAL, AND METAMORPHIC EVOLUTION OF FOOTWALLS TO THICK THRUST SHEETS

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Prograde regional metamorphic rocks that record an increase in pressure and temperature are common in internal zones of contractional orogenic belts. These rocks attest to tectonic burial by thrusting and thermal relaxation during/following burial. The presence of widespread ductile features within such metamorphic rocks (e.g., regionally developed foliation) illustrate that burial and consequent heating results in a loss of rock strength and hence ductile flow. The significance of flow during prograde metamorphism, and its contribution to the rheological/structural evolution of internal zones, is poorly understood.

The extensionally exhumed, metamorphosed footwall to the Mesozoic Windermere thrust (WT) in the Pequop Mountains-Wood Hills-East Humboldt Range region, NE Nevada, provides an opportunity to study the nature of flow during prograde metamorphism. Carbonate and clastic rocks in the footwall of the WT underwent Barrovian style metamorphism in response to structural burial. Footwall rocks record substantial P-T increase and are unmetamorphosed at shallow levels and progressively increase in metamorphic grade up to upper amphibolite facies (ky/sill zone) at deep levels. Metamorphism was synchronous with development of S and S-L (S>>L) tectonites. Attenuation of footwall stratigraphic units accompanied tectonite development. The amount of attenuation varies with metamorphic grade from ~ 0 % in lower greenschist facies to ~ 40-50% in upper amphibolite facies rocks. Foliation within tectonites is parallel or nearly parallel to bedding and lineation is defined by porphyroblast or grain shape elongation. S tectonites predominate in weakly metamorphosed to lower amphibolite facies rocks, whereas S-L tectonites are predominant in upper amphibolite facies rocks. Microstructures in metacarbonate and metapelite, and analysis of crystallographic preferred orientations of quartz *c*-axes in metaquartzite, indicate a dominantly coaxial strain path with flattening strain predominating at lower metamorphic grades and plane strain at higher metamorphic grade. This is consistent with the observed variation in the relative abundance of S vs. S-L tectonites with increasing metamorphic grade. The microstructural data indicate that during prograde metamorphism the footwall of the WT underwent bulk pure shear deformation, resulting in stretching of the footwall. Stretching most likely: 1) results from a loss of strength due to relative upward migration of isotherms during/following burial, and 2) acts as a mechanism that in part facilitates isostatic accommodation or sinking of the overlying load resulting in a reduction in topography. Stretching of footwalls to thick thrust sheets may be a natural process once sufficient structural overburden is developed and thermal relaxation or prograde metamorphism ensues.

01:45 PM Jiang, Dazhi

S/C FABRICS IN OROGENIC BELTS: HOW SHOULD THEY BE INTERPRETED ?

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Small-scale structures and fabrics such as folds, stretching lineations, S/C fabrics and rotated porphyroclasts develop throughout orogenic histories at all crustal levels. They contain important information about the rock deformation history and larger-scale tectonic processes. However, a thorough understanding is still lacking of the links between the paths of rock deformation mechanisms, kinematics and, as the "signatures" of such paths, fabrics and structures, although such an understanding is necessary for proper interpretations of structures and fabrics. This is because current interpretations are based on homogeneous and steady flow and deformation theory or similarly constrained experiments while the rock flow and deformation are demonstrably heterogeneous and non-steady.

Using the widely-used shear sense indicators, S/C fabrics and rotated porphyroclasts, as examples, we demonstrate how, when geologically realistic non-steadiness is taken into consideration, they can have complicated relations with the host shear zone.

Two foliations are commonly developed in ductile shear zones, S-foliation defined by shape fabrics and related to the accumulation of finite strain, and shear band cleavages (C and