zones in mantle wedges may be attributable to "superplastic" flow under low stresses within the ultra-fine-grained dehydration products in dehydration-induced fault zones. Abers, G. A. Earth Planet. Sci. Lett., 176, 323-330 (2000). Fujie, G. et al., Geophys. Res. Lett., 29, 7 (2002). Brocher, T. M. et al., Geology, 31, 267-270 (2003).

T42D-06 1455h

HIGH TEMPERATURE DEFORMATION OF OMPHACITE IN ECLOGITE: IMPLICATIONS FOR SUBDUCTED LITHOSPHERE

Junfeng Zhang[1,2] (1-909-787-5516; jezhang@citrus.ucr.edu)

Harry W. Green[1,2] (1-909-787-4505; hgreen@mail.ucr.edu)

Haemyeong Jung[1] (1-909-827-7035; hjung@citrus.ucr.edu)

[1]Inst. Geophys. Planet. Phys., University of California, Riverside, CA 92521, United States

[2]Dept. of Earth Sciences, University of California, Riverside, CA 92521, United States

Omphacite is a major component mineral in subducted oceanic crust at depth. It often develops strong lattice preferred orientation and dominates the flow properties and seismic anisotropy in eclogite. Investigation on the rheology of omphacite is important for a better understanding of geodynamic problems associated with eclogite in subduction zones. The high temperature deformation behavior of polycrystalline omphacite ($Di_{58}Jd_{42}$) is being studied at temperatures of 1300-1500 K, a confining pressure of 3 GPa, and strain rates of 10^{-4}/s to 10^{-5}/s. We obtained a power-law creep for the high temperature deformation of omphacite with n=3.1, Q=289 KJ/mol, and a preexponential factor of $10^{-1.2}$MPa^{-n}s^{-1}. These results show that the creep strength of omphacite falls between its two end members of solid solution (diopside and jadeite), which supports the previous arguments that sodic pyroxene could be significantly weaker than other pyroxenes (enstatite and diopside). A steady increase of flow strength is also observed after adding garnet. Eclogite reconstituted from powders of 50% garnet ($Pry_{21}Alm_{18}Gro_{61}$), 40% omphacite ($Di_{58}Jd_{42}$), 10% quartz shows strength about 3 times that of polycrystalline omphacite. These data are consistent with observations of extensive deformation of omphacite in eclogite at low peak metamorphism temperatures during deep subduction and exhumation. These preliminary results also suggest that strain will concentrate into omphacite-rich domains within the subducting zones.

T42D-07 1510h

Nanoindentation Creep of Quartz, Olivine, and Calcite, with Implications for Rate and State Friction Laws

David L. Goldsby[1] (401 863-1922; David_Goldsby@brown.edu)

Andrei Rar[2] (865 974-8202; 2ut@email.cind.ornl.gov)

George M. Pharr[2] (865 974-8202; pharr@utk.edu)

Terry E. Tullis[1] (401 863-3829; Terry_Tullis@brown.edu)

[1]Department of Geological Sciences, Brown University, 324 Brook Street, Providence, RI 02912, United States

[2]Department of Materials Science, University of Tennessee, and Metals and Ceramics Division, Oak Ridge National Laboratory, 434 Dougherty Engineering Building, Knoxville, TN 37996-2200, United States

A hallmark observation from friction experiments on rocks is that the coefficient of friction increases linearly with the log of time of quasi-stationary contact. This increase in friction, or *state* in the rate- and state-variable friction laws, is usually attributed to an increase in real area of contact between rough surfaces caused by deformation of highly stressed contacts. This behavior is typically explored in slide-hold-slide (SHS) friction experiments at ambient temperature. Despite the importance of the evolution of the state variable for determining conditions for which earthquakes may nucleate, contact-scale deformation mechanisms in rocks remain unknown. In an effort to identify these deformation mechanisms, nanoindentation creep experiments were conducted on single crystals of quartz, olivine and calcite at room temperature and constant loads of 50 to 250 mN. The amount of creep in a typical nanoindentation creep test is indicated by the increase in indentation area with time, determined from the measured displacement of indenter into the specimen and the well-characterized geometry of the indenter tip. A major limitation of such tests, that displacements are difficult to discern from thermal noise, was eliminated by employing *continuous stiffness* techniques. A 45-Hz oscillation in displacement of 2 nm amplitude was imposed on a diamond Berkovich indenter held at otherwise constant load for times comparable to those in SHS tests, up to $5{\times}10^4$ s. By analyzing the resulting specimen response with a frequency-specific analyzer, a nearly continuous measure of the contact stiffness, proportional to contact area, was obtained. Thus, contact area is determined over times too short for significant thermal drift. Changes in area with time from indentation tests were compared with those inferred from complementary SHS tests on quartz, olivine and calcite rocks conducted in a high pressure rotary-shear apparatus. The contact area between indenter and specimen increased linearly with log time for each mineral, in qualitative agreement with the linear increase in area with log time inferred from SHS tests. However, the rate of fractional area increase from nanoindentation tests is much larger than inferred from SHS tests, by factors of 2, 5, and 10 for quartz, olivine, and calcite, respectively. This discrepancy may indicate that contact stresses in the two tests are the same, but that area formed during the hold in SHS tests is partially destroyed during reloading after the holds, as demonstrated for acrylic plastic and glass (*Dieterich and Kilgore*, 1994). Alternatively, the difference may indicate that contact stresses in rock friction experiments are significantly less than determined from indentation tests.

T42D-08 1525h

Nature and Origin of Cataclastic Bands in Well Cemented Quartz Arenite

John R Farver[1] (419-372-7203; jfarver@bgnet.bgsu.edu)

Charles M Onasch[1]

[1]Bowling Green State University, Department of Geology, Bowling Green, OH 43403-0218, United States

Cataclastic bands are a common structure in well-cemented quartz arenites deformed at low temperatures (<250°C). These structures have been interpreted to originate by cataclasis with or without recrystallization. However, recent studies of samples from the Tuscarora and Oriskany sandstones from the Appalachian Valley and Ridge province suggest dilation was more important than shear in the formation of these bands. The cataclastic bands consist of sharply to diffusely-bounded tabular bodies ranging in thickness from 50 μm to a few cm filled with quartz having a uniform 5 μm grain size. In some cases, wall-parallel displacement can be demonstrated, but in others, the displacement is purely dilational. Two-phase, aqueous fluid inclusions in vuggy cores found in some bands yield homogenization temperatures of 140-170°C. FTIR data from traverses across cataclastic bands show a marked decrease in water content within the bands compared to nearby wall rock grains, and also suggest the presence of submicroscopic sheet silicates (mica or clays). In cathodoluminescence the bands are uniformly dark in contrast to brighter luminescing wall rock grains indicating either complete reconstitution of original wall rock or introduction of new phases. Rather than cataclasis, the fine grained texture in the bands is believed to result from rapid crystal growth in a dilating fracture with variable, but small amounts of shear. Despite the fine grained texture, the presence of sheet silicates suggests that these bands may have acted as a fluid conduit, not a permeability barrier.

T42E MCC: 2002-2004 Thursday 1700h

Birch Lecture

Presiding: **P Segall,** Stanford University

T42E-01 1710h INVITED

Splitting, Stretching and Spreading of Lithosphere

W. Roger Buck (845-365-8592; buck@ldeo.columbia.edu)

Lamont-Doherty Earth Obs, Columbia University, Palisades, NY 10964, United States

That lithospheric plates diverge across relatively narrow zones has been accepted since the late nineteen sixties. Thus, in surprise many that several basic features of continental rifts and oceanic spreading centers were first observed in the last few years. Several of these new findings concern the distribution of molten or frozen magma along segments of present or past divergence. One view that the observations reinforce is that tectonic processes often cannot be understood without accounting for magmatism. This talk highlights the impact of new observations on how we think about the processes of faulting and magmatism from the plate tectonic scale to the scale of individual faults and magma chambers.

T51A MCC: 3007 Friday 0800h

Analysis of Plate Boundary Deformation Using Stress and Strain Rate Data in Tandem I *(joint with G, S)*

Presiding: **S Miyazaki,** Stanford University**; K Wang,** Geological Survey of Canada

T51A-01 0800h INVITED

A Thermo-Mechanical Model of the San Andreas Fault System in Central and Northern California

Stephan V. Sobolev[1] (stephan@gfz-potsdam.de)

Mark D. Zoback[2] (zoback@pangea.stanford.edu)

Andrey Yu. Babeyko[1] (babeyko@gfz-potsdam.de)

[1]GeoForschungsZentrum-Potsdam, Telegrafenberg, Potsdam 14473, Germany

[2]Stanford University, Mitchell Building, room 359, Stanford, CA 94305-2215, United States

The San Andreas Fault System (SAFS) in central and northern California is a family of sub-parallel strike-slip faults that accommodate the transform motion between the Pacific and the North America plates. We present here a fully coupled numerical thermo-mechanical model of the SAFS as it evolved over the past 20 Myr following the northward migration of the Mendocino triple junction. The strike-slip displacements and fault perpendicular compression (over the last 5 Myr) are implemented as side boundary conditions in the upper 20 km of the 100 km deep model box, other parts of the side boundaries and bottom boundary being free for material flow. The model employs realistic visco-elasto-plastic rheology and allows for spontaneous generation of faults. The modeling replicates the evolution of multiple strike-slip faults, the overall eastern migration of the San Andreas fault itself from the western edge of the Coast Ranges near Cape Mendocino to the eastern edge in central California, the variation of heat flow in the Coast ranges along and across the SAFS as well as high angle (60-80°) between the direction of the maximum horizontal stress and the local fault orientation in the upper crust. The modeling shows that the key conditions for such behavior are the cooling (and strengthening) of the lithosphere following passage of the triple junction which causes ductile deformation at depth to migrate eastward with time and the drop of frictional strength at high strain in the upper crust which results in a small number of major transform faults to develop, rather than a broad distribution of such faults. Our modeling suggests that the major faults in the SAFS in Central and Northern California must have been weak during most of the 20 Myr period over which it evolved.

T51A-02 0820h

Seismic Versus Aseismic Deformation in Iran Inferred from GPS and Seismicity Data

Frederic Masson[1] (33 4 67 14 48 92; fmasson@dstu.univ-montp2.fr); Jean Chery[1]; Joseph Martinod[2]; Denis Hatzfeld[3]; Philippe Vernant[1]; Farokh Tavakoli[4]; Moshen Ashtiany[5]

[1]LDL -UMR CNRS 5573, Universite Montpellier, Pl. E. Bataillon, Montpellier 34095, France

[2]LMTG - UMR CNRS 5563, Universite Paul Sabatier, 38, rue des 36-Ponts, Toulouse 31400, France

[3]LGIT - UMR CNRS 5559, Universite Joseph Fourier, BP 53, Grenoble 38041, France

[4]Geodynamic Department, National Cartographic Center, Po. BOX 13185-1684, Meraj Ave, Tehran 19531, Iran (Islamic Republic of)

[5]International Institute of Earthquake Engineering and Seismology, Farmanieh, Dibaji, Arghavan St., N 27, Tehran 19531, Iran (Islamic Republic of)

The present tectonic of Iran results from the north-south convergence between the undeformed shield areas