tain, M_L=6.2), major aftershocks and preshocks. The events are located using the crustal velocity structure of Hadley and Kanamori (1978) and seismic stations at Riverside, Palomar, Barrett and La Jolla (Δ=60-140 km). Station corrections are determined from station residuals for well constrained recent earthquakes in the study areas. The 1937 earthquake is relocated to 33°26.0'N, 116°25.5'W, between the SE end of the Buck Ridge fault and the Clark fault. Initial aftershocks ruptured unilaterally ~6 km to the NW. The earthquake of 2/25/80 (M_L=5.5) occurred at the NW end of this rupture zone with aftershocks extending a few km NW into the SE end of the Anza Seismic gap defined in Sanders and Kanamori (1984). A significant increase of earthquake activity occurred 1½ years before the 1937 event, about 35 km west in the Cahuilla Valley area. The 1954 earthquake is relocated to 33°17.5'N, 116°10.6'W, at the SE end of the mapped Clark fault. Aftershocks form a linear pattern on strike with the fault extending SE for ~12 km. The 1954 event was preceded by two years of relative quiescence, broken by a group of five preshocks (M_L=3-4.2) ten weeks prior to the main shock. These occurred during an eight hour span and are located in the aftershock zone of the main event. The rupture zones of the 1937 and the 1954 events thus relocated together with the rupture zones of the 1968 (Borrego Mountain, M_L=6.8), 1969 (Coyote Mountain, M_L=5.8) and the 1980 earthquakes are used to delineate the spatial rupture patterns of the south central San Jacinto Fault Zone for the past 50 years.

S21A-05

7.7mm/a of Displacement Across a 3Km Wide Shear Zone on the San Andreas Fault Near the Salton Sea

P. WILLIAMS*
R. BILHAM**
Lamont Doherty Geological Observatory, Palisades, NY 10964, *also Dept. Geol. Sci., Columbia Univ., New York, **also CIRES, University of Colorado, Boulder, CO 80309.

Wasteway No. I is a normally dry drain that extends due south from the Coachella Canal across the San Andreas fault to the northernmost shore of the Salton Sea. Deformation of steel reinforcing bars exposed in compressional cracks with a 3Km section of the wasteway shows it to have been shortened by 20±1cm since 1948. A subsurface radar profile adjacent to the normally dry drain shows evidence for ground disturbance close to ruptures in the concrete. The San Andreas fault zone at this point appears to be much wider than thought hitherto, and the creep rate (7.7mm/a) more than three times higher than that determined with short (<50m long) alignment arrays in the Coachella Valley. Segments 5Km to the NW and SE were activated in 1968 and 1979 after the Borrego Mtn. and Imperial Valley earthquakes which may account for at least 1cm of the observed movement. 30Km baseline geodetic measurements across this part of the Coachella Valley for the period 1973-1981 indicate right lateral displacement amounting to 12mm/a, a shear strain rate of 0.4μrad/a. If we assume that all the observed creep extends to depths of 30Km and that a 47μrad strain change will be associated with fault rupture, a repeat time of 300 years appears possible. Additional shear may have occurred over a wider zone than that indicated by the damaged wasteway which would further extend the estimated repeat time.

S21A-06

Stressing of Locked Zones Along a Creeping Fault

RENATA DMOWSKA
SIMON T. TSE
JAMES R. RICE (All at: Division of Applied Sciences, Harvard University, Cambridge, MA 02138)

We analyze the stressing of locked regions along a vertical strike-slip fault zone, which creeps elsewhere, at the boundary of elastic lithospheric plates. Calculations are done by the 2D "line spring" method which reduces computer time from 3D calculations but cannot resolve details of the deformation field at short spatial wavelengths along strike. Stress variations and concentrations are shown due to non-uniformities along strike of the boundaries of locked zones or of their previous dislocations. The procedure is applied to constrain stressing rates and crustal parameters for the creeping portion of the San Andreas Fault between San Juan Bautista and Parkfield. We find that in order to fit both near fault trace creep and broadscale (10 km) geodetic data near Parkfield, a very localized locked zone must be assumed and if this is to extend to depths compatible with the 1966 nucleation depth at 9 km and with recent low level seismicity, the zone cannot have the form of a long locked strip along the 1966 rupture path but is probably localized near Parkfield in a manner assumed by Aki (1968) and Stuart et al. (1984).

S21A-07

Crustal Deformation in Great California Earthquakes Cycles

VICTOR C. LI (Department of Civil Engineering, MIT, Cambridge, MA 02139)
JAMES R. RICE (Division of Applied Sciences, Harvard University, Cambridge, MA 02138)

Periodic crustal deformation associated with repeated strike slip earthquakes is computed for the following model: A depth ℓ ($\leqslant H$) extending downward from the Earth's surface at a transform boundary between elastic lithospheric plates of thickness H is locked between earthquakes, but slips an amount consistent with remote plate velocity V after each lapse of earthquake cycle time T. Lower portions of the plate boundary slip continuously under constant stress throughout the cycle, and the plates are coupled to a Maxwellian viscoelastic asthenosphere. Parameters of the model are chosen to fit the apparent time-dependence, throughout the earthquake cycle, of surface strain rates along presently locked traces of the 1857 and 1906 San Andreas ruptures (Thatcher, 1983). We also fit data assembles by King et al. on variations of contemporary strain rates as a function of distance from the 1857 trace, and by Prescott et al. (1979) for the 1906 trace. Using $V = 56$ mm yr, $T = 150$ yr, for a generalized Elsasser foundation model, reasonable but not yet optimized fits are given with a 10 yr relaxation time for that model and with $\ell = 8$ to 10 km in a lithosphere with $H = 75$ km. Fitting contemporary strain rates from King et al. suggests some upward penetration of slip into the locked zone near Carrizo Plain.

S21A-08

Stick-Slip Confinement to Upper Crust by Temperature Dependent Frictional Constitutive Response

SIMON T. TSE
JAMES R. RICE (Both at: Division of Applied Sciences, Harvard University, Cambridge, MA 02138)

The temperature dependence of laboratory-based frictional slip parameters for Westerly granite and a Lachenbruch-Sass San Andreas Fault geotherm are used to develop a depth-variable description of a strike-slip fault surface. Temperature dependence of the instantaneous dependence of strength τ on slip velocity V and of steady state strength, $\tau = \tau_{ss}(V)$, is based on data by Stesky for temperatures above 300°C and room temperature data of Dieterich, Tullis and Weeks. Results suggests a stabilizing transition from $d\tau_{ss}/dV < 0$ to $d\tau_{ss}/dV > 0$ around 10 km depth. Calculations of depth and time variable slip for earthquake cycles in the manner of Mavko, based on a Dieterich-Ruina constitutive model with one evolving state variable, suggest that stick-slip behavior is limited to the upper 11 km or so of crust. Rapid post-seismic creep occurs over another 3 to 4 km depth, whereas at greater depths the steady imposed plate slip rate seems to be only modestly perturbed by the earthquakes occurring above.

S21A-09

Geodetic measurement of deformation in the Central Mojave Desert, California

J. Sauber (Department of Earth, Atmospheric, and Planetary Sciences, M.I.T., Cambridge, MA 02139)
W. Thatcher (U.S.G.S., Menlo Park, CA 94025)

Data from triangulation and trilateration surveys have been used to calculate shear strain rates in the Central Mojave since ~ 1934. The geodetic network extends 110 km E-W and spans the NW-striking, right-lateral strike-slip faults of the Central Mojave. Strain rates decrease from west to east across the net, a trend which is also reflected in the level of 1932/83 seismicity. Between the Helendale and Camp Rock faults, the shear strain rate is 0.15 ± 0.03 μstrain/yr across a plane roughly parallel (N41W ± 6) to the strike of the faults. Assuming that this deformation is due to right-lateral displacement on the local faults, the average (1934/82) shear straining corresponds to a relative displacement of ~ 7 mm/yr aross the net. Farther east, between the Calico and Ludlow faults, no significant strain accumulation was measured. P-wave first motion data were used to determine focal mechanisms of ten earthquakes to compare with the recent fault patterns and the geodetic results. Preliminary results show predominantly strike-slip motion on planes that differ in orientation from the NW striking faults. The P axes for these events are NNE-NE. The orientation of maximum compression predicted from the strain data is, however, ~ due North.

S21A-10

Strain and Gravity Changes Observed at Pearblossom, California, and Strain Changes Observed at Palmdale, California; Evidence for Correlation

J.O. LANGBEIN, M.F. LINKER, W.H. PRESCOTT, R. JACHENS (U.S. Geological Survey, Menlo Park, CA 94025)
L.E. SLATER (University of Colorado, Boulder, CO 80302)

Data from two trilateration networks that straddle the San Andreas fault and are located near Pearblossom and Palmdale, California, indicate that the accumulation of shear strain is correlated over this 35 km section of the fault and has a correlation coefficient of 0.97. Data from both networks indicate that the shear strain accumulates at 0.2 ppm/yr within a zone of 5 km of the fault trace. Furthermore, gravity measurements at Pearblossom correlate ($r = 0.95$) with the dilatational strain inferred from the data from the Pearblossom geodetic network. To date, however, a low signal to noise ratio from the Palmdale network does not permit comparison of the orthogonal components of extensional strain from one network to the next even though the data from the Pearblossom network shows substantial fluctuations about its secular rate.

The geodetic data from Pearblossom consist of very frequent observations of line-length changes for 11 baselines using a two-color geodimeter which has a precision of 0.14 ppm for a 5 km baseline. These measurements were initiated in October, 1980, and were made weekly. Beginning in April 1984 the schedule was reduced to monthly reoccupations. The data from the Palmdale network consist of line-length measurements made with a single-color geodimeter using aircraft instrumentation to measure the refractive index. The precision for this technique is 0.36 ppm for a 10 km baseline. During the same interval covered by the Pearblossom data, only 5 measurements have been made at Palmdale. Since late 1982, there have been 5 gravity measurements at the central monument in Pearblossom which have been referenced to Riverside, California. The precision of the gravity data is 6 μgal.

S21A-11

Fault model for geodetic data in the Transverse Ranges, California

ABE CHENG (IGPP, UCLA, Los Angeles, CA)
DAVID D. JACKSON (same)

We have used line lengths of USGS trilateration measurements between monuments in the Los Padres, the Tehachapi, the San Gabriel, the Palmdale and the San Fernando networks. These networks cover the San Andreas, the White Wolf, the Garlock, the San Gabriel, the Santa Susana, the Pleito and many other faults around the Transverse Ranges. In modeling, we have applied rectangular dislocation and horizontal block motions to describe the fault behavior and tectonic motion. Geological fault slips estimated by Bird et al (1984) over several million years are the initial values and prior data of our nonlinear regression model. The resolution values show that some faults are well resolved by the line length data, while others are resolved only by the prior estimates.

The block slip (or the deep fault slip) along the San Andreas fault is about 31 ± 5 mm/yr north of the Transverse Ranges and about 22 ± 4 mm/yr at Palmdale.. The central San Gabriel fault converges faster than the northern and southern section.

Since the Pleito fault separates two converging blocks, it appears to be a thrust.

S21A-12

A Geodetic Case for a Low Stress San Andreas Fault in a Rigid (Non-Lithostatic) Crust

LEARY, P. C., Department of Geological Sciences, University of Southern California, Los Angeles, California 90089-0741

Shear stress $\tau_{xy}(x,y,z)$ on a major strike-slip fault in a uniform crust of rigidity G can be shown via a Taylor series expansion to have a linear depth dependence given by

$$\tau_{xy}(x,y,z) \cong G(\gamma_{xy}(x,y,o) - 2\partial_{xy}W_o(x,y)\cdot z), \quad (1)$$

where γ_{xy} is the surface shear strain on a fault whose trace lies on the y-axis, $W_o(x,y)$ is the surface deformation, and $z < L_x \sim 25$ km, with L_x denoting the characteristic length of horizontal deformation transverse to the fault. Thus surface uplift is diagnostic of shear stress with depth.

Vertical geodesy puts limits on the shear stress gradient. If it is supposed that the crust near the San Andreas fault (density $\rho \sim 2.7$) is not rigid and has lapsed into a near lithostatic stress state (Poisson ratio $\nu \sim 1/2$), then for an ordinary (Byerlee) frictional coefficient $.6 < \mu < .85$ in the presence of hydrostatic pore fluids, (1) requires for a fault near rupture that

$$2G\partial_{xy}\,W_o(x,y) \sim \mu[(\nu/1-\nu)\,\rho-1]g \sim 100 \text{ bars/km}. \quad (2)$$

Since lithostatic stress conditions along the fault are likely to be uniform, gradients along the fault are likely to be small. It follows from (2) that shear induced deformation $W_o(x,y)$ be on the order of tens of meters. The implied large magnitude doming may be absent (1) if strong stress variations exist along the fault; (2) if an exceptionally low value of μ obtains in the fault zone; or (3) if the crust is non-lithostatic. Fault zone geodetic observations and laboratory friction laws combine to favor the last option.