as the result of the redistribution process of the remnant concentrated stress due to the faulting of the mainshock. The periodic strong aftershocks seem to be the result of the concentrated accumulation of stress related to the repeated smaller shocks.

S32B-05

Induced Rocking and Torsional Vibrations of a Long Structure in the Nearfield of the 1979 Imperial Valley Earthquake

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Digitally recorded acceleration time histories of the 1979 Imperial Valley earthquake by the elements of the El Centro Differential Array are used for the estimation of the induced torsional and rocking vibrations of long structures in the nearfield of strong earthquakes. The underlying assumption in these estimates is high rigidity of the foundation relative to the surrounding soil. Based on these estimates, the amplitude of vibration of a 55 meter long foundation within 5 km of the fault exceeds 2×10^{-4} radians, or nearly 0.01 degrees for either mode. The strongest impulses of rocking and transverse rotations coincide with arrival of S phases. However, the latter mode of oscillation maintains a longer duration of excitation. The sensitivity of amplitude and spectral shape to the foundation dimension is discussed.

S32B-06

Seismic Response of Massive Embedded Foundations Relative to Adjacent Ground Surface

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An experiment using explosion sources was conducted at a power plant in whose vicinity shallow, reservoir-induced earthquakes had been recorded by a strong-motion accelerograph. The experiment was to assess the differences between foundation and ground surface motions for such RIS events. The power plant foundations are deeply embedded with the major structures founded on rock; soil depths are typically 20 m. Seismic signals generated by explosions were detected by seismometers located within the power plant foundations and at an array of ground surface sites. Thirty channels of data for each of 26 explosions were digitally recorded from stations as distant as 2 km. The explosion-generated signals, like those for the shallow reservoir-induced earthquakes, are dominated by S and higher mode surface wave groups, and exhibit complex particle motions due to near-receiver effects and heterogeneities along the propagation path. Spectral amplitudes for all wave groups recorded in the foundation were typically less than half those at ground surface sites in the band 5-40 Hz.

A second significant set of foundation and ground surface records was obtained from strong-motion accelerographs at the Pleasant Valley pumping plant, situated 9 km from the Coalinga, California, earthquake of May 2, 1983 (Maley et al, in EERI Special Report, in press). The foundation of the plant is embedded 6 m in alluvium. The foundation/ground surface spectral modulus ratio resembles a low-pass filter with corner near 1 Hz.

S32B-07

Aftershocks and Afterslip

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Observations of aftershocks and afterslip following moderate earthquakes in California support a conceptual model of an active fault in which significant earthquakes represent the breaking of lock points or asperities; in contrast, afterslip represents continuing and spreading slip controlled by the time-dependent rheology of the surrounding fault zone. Aftershocks are caused by the breakage or slippage of minor asperities. The afterslip process controls the rate of occurrence of aftershocks and the growth of aftershock zones. The presence within the surrounding fault zone of additional significant lock points limits or retards the growth of aftershock zones and retards development of afterslip. Lock points may represent the ends of individual fault segments, other geometric irregularities, or areas of high effective strength. Distant from, or in the absence of lock points, the growth of aftershock zones and afterslip proceed at an initially high rate which decays with time. Numerical simulations of these phenomena, based on dislocation theory and assuming a distribution of lock points surrounded by a fault zone characterized by a quasi-plastic or other time-dependent relaxation rheology, are in good agreement with observations. Aftershock sequences studied include those of the 1966 Parkfield, 1968-1969 Borrego Mountain-Coyote Mountain, 1971 San Fernando, 1971-1973 Bear Valley-San Juan Bautista, 1974 Bush fault, 1975 Oroville, 1979 Coyote Lake, 1979 Imperial Valley and 1980 Livermore earthquakes.

S32B-08

On Combining the Das-Hamano Numerical Method with a Generalized Frictional Sliding Law

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The numerical boundary integral method used by Hamano and Das for calculating dynamic brittle crack growth can be adapted for use with any frictional sliding law on a plane interface in an elastic medium. Two unknown functions on the fault plane, slip u and traction T, are determined by two relations between them, (1) the response of the elastic half spaces on each side of the fault plane and (2) the frictional constitutive law of the fault plane. In each element of the fault plane at each time step the Das-Hamano method provides a linear relation between slip and traction,

$$u + F\,T = L$$

where the "local compliance" F is the discretized Green function at the source point, and the "load" L is the convolution of the discretized Green function with past values of traction. Any constitutive relation between slip and traction can complete the solution.

For each element of the fault plane the logic for starting and stopping slip is handled by analogy to plastic yielding. Implementation of this logic requires that slip be saved from the immediately preceding time step. A trial value of traction is found assuming no increment in slip in the current time step, and this is the solution if the frictional traction is not exceeded. Otherwise slip is incremented so that traction equals the frictional traction. Frictional traction may be a function of slip, slip rate, or slip history, as in Ruina's friction law with memory. Calculations with slip-weakening friction in plane strain confirm results I found previously by a finite difference method. Calculating spatial convolutions via Fourier transforms reduces computer time by a large factor.

S32B-09

Seismicity simulation using a mass-spring model characterized by the displacement hardening-softening friction law

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Dietrich (1972) simulated aftershocks using a 1-D, mass-spring numerical model with a time-dependent friction law. But an important precursory phenomenon called "quiescence" (Kanamori, 1981) cannot be produced by this model unless, as Mikumo and Miyatake (1983) showed using a 3-D model, one assumes a somewhat arbitrarily bimodal distribution of frictional strength. Here we used the friction law proposed by Stuart (1979), which is a displacement hardening-softening model, and reproduced the quiescence. When we specified different parameters of the friction law to the blocks in our mass-spring model, we found a variety of seismicity patterns. If we choose the pre-seismic slip, or breaking slip, much larger than those estimated by Papageorgiou and Aki (1983) from strong motion data for California earthquakes, we get the recurrent sequence of creep followed by mainshock without small earthquakes. But when we choose a pre-seismic slip in the same order as the results of Papageorgiou and Aki, we get normal seismicity and quiescence before large events. This simple model points to a promising approach for the interpretation of the recurrence phenomenon and the rupture process during an earthquake by the same physical model.

S32B-10

An Elliptical Asperity: Fracture Process and Seismic Radiation

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The fracture process and resulting seismic radiation due to the breaking of a single elliptical asperity on an infinite fault plane are studied. The formulation of the problem and the method of solution are the same as that discussed by Das and Kostrov (1983, JGR) for a circular asperity. The initial static solution, which is discretized for input into the numerical boundary-integral technique, shows that the stress concentration is always stronger at the end of the major axis (unlike elliptic cracks where this is not necessarily true). Elliptical asperities of aspect ratios 1:3 and 1:5 are studied. It is found for aspect ratios of 1:3, that when the initial stress is along the major or minor axis, the dynamic fracture process can only be initiated by relaxing a point at the asperity edge close to the major axis and the fracture front propagates almost as a straight line across the asperity at a velocity of about $\alpha/2$. When the initial stress is at 45° to the axes, the dynamic fracture process can be initiated anywhere along the asperity edge. When a point at the end of the minor axis is relaxed, the fracture front is V-shaped with the point of the V at the end of the minor axis. For asperities of aspect ratio 1:5, it is found that the dynamic fracture may be confined to the region near the end of the major axis, with the rest of the asperity remaining unbroken (a foreshock?). Displacement pulses for these cases will be shown.

S32B-11

Two-point correlation function of seismic moment tensor, isotropic case

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Due to random orientation of elementary double-couple and compensated linear vector dipole sources, an extended source region of an earthquake will almost always contain both of these elementary sources, although it is to be expected that the size of the CLVD terms will be a few orders of magnitude smaller than that of the double-couple component. To study the geometry of faulting of an extended source region we construct the two-point correlation function of the seismic moment tensor, which is itself a fourth rank tensor. If the medium and the prestress are isotropic, the fourth-order correlation tensor has three scalar invariants. We have estimated these invariants for the earthquakes in several catalogs of fault plane solutions. Although the accuracy of these catalogs is rather poor, nevertheless we can conclude that individual earthquake sources have a more-or-less planar geometry in the early stages of rupture, and during the later phases of rupture the degree of non-planarity increases.

S32B-12

Fractal Geometry in the San Andreas Fault System

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It has been noted that the spatial distribution of earthquakes and the mode of strain release in the San Andreas Fault system is related to the complexity of fault geometry. Because of their rough appearance over many length scales, faults can be regarded as fractal surfaces. Direct estimates of fractal dimension D of portions of the San Andreas Fault system between the northern Gabilan Range and the Salton Sea, including the postulated extent of the great 1857 Fort Tejon earthquake, are obtained from measured fault lengths, analogous to the lengths of coastlines as discussed in Mandelbrot [1977 and 1983]. Regions characterized by complicated fault geometry are associated with larger values of D. Based on fault traces mapped at a scale of 1:750 000, D is 1.0 for that reach of the San Andreas Fault between Mustang Ridge (36° 5'N, 120°40'W) and Cholame which could be associated with the nucleation of the 1857 earthquake. At this same scale, D is 1.3 for the San Andreas and related faults near San Bernardino where the 1857 rupture stopped, compared to D of 1.2 for the San Andreas-San Juan fault segments near the point of arrest of the 1966 Parkfield earthquake. Recently active fault breaks mapped at a scale of 1:24 000 are characterized by a jump in measured D from 1.0 to 1.3 where fault slip estimated by Sieh along the San Andreas Fault associated with the great 1857 earthquake drops from 9 to 6-1/2 m. If this fractal geometry persists through the seismic cycle, it may be possible to use a quantitative measure of complexity to explain the occurrence of great and characteristic earthquakes along a given reach of the fault and to refine predictions of ground displacements produced by earthquakes.

S32B-13

Stress Transfer and Non-linear Stress Accumulation at the Aleutians

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When a tectonic scale rupture occurs at a plate boundary, immediate elastic loading is imposed on the adjacent plate segments. Part of the stress drop also loads the asthenosphere which relaxes over time. Asthenosphere relaxation causes further loading of the adjacent segments as well as stress recovery in the ruptured zone. We use the modified Elsasser Model of elastic lithosphere/ viscoelastic asthenosphere coupling of Lehner, Li and Rice (1981) to study the stress transfer and stress accumulation processes at the Aleutians. It is found that the 1965 Rat Island Earthquake and the 1948 earthquake in Central Aleutian are likely to have been triggered by adjacent ruptures, in the sense that their occurence would have come at a later time had their neighboring segments not been ruptured. Stresses in the Unalaska