2004 Annual Report

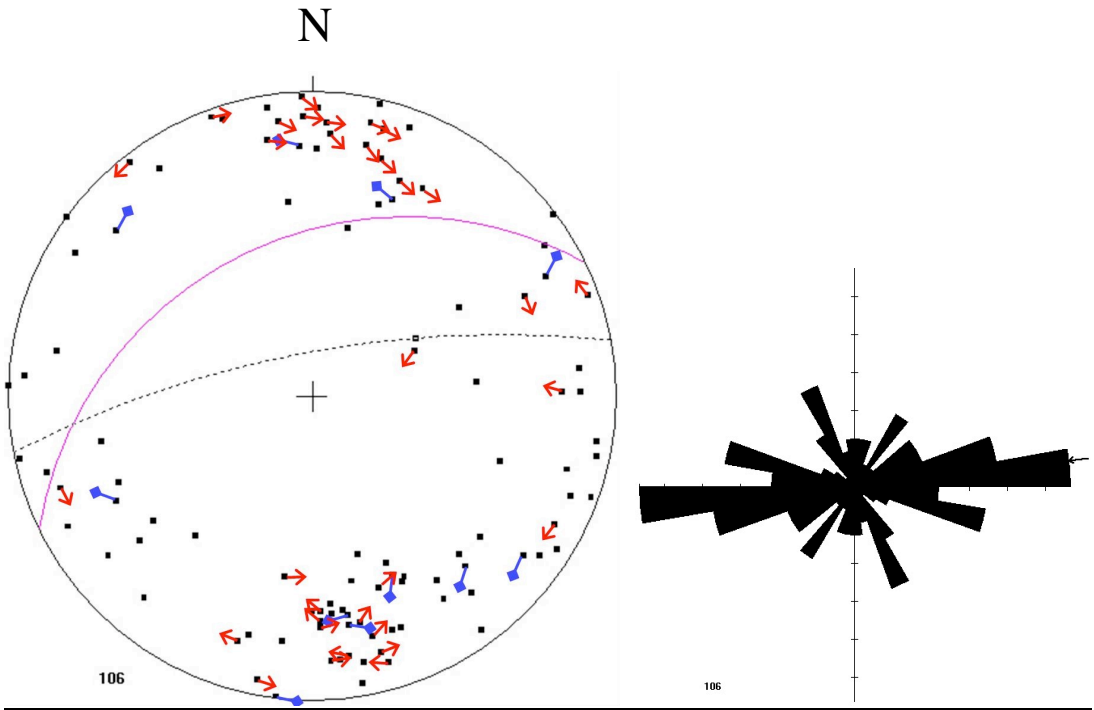
*Summary*

During the past year, progress has been made on three fronts:

1) Graduate student Ory Dor has mapped slip surfaces in the gouge at the JPL exposure of the Sierra Madre fault zone.
2) Ron Biegel, who joined my group as a Research Assistant Professor, has been mapping fault zone structures along the San Gabriel Fault. He and I wrote a paper on relating fault zone structure to fault mechanics.
3) I have completed a theoretical manuscript on the generation of secondary seismic radiation by the dynamic generation of off-fault fracture damage.

*Ory Dor's Mapping of Slip Surfaces in Gouge*

To date, graduate student Ory Dor has mapped the orientation of over 100 slip surfaces in the gouge layer of the Sierra Madre fault zone where it outcrops in a stream cut to the east of JPL. The figure below left shows the orientation of the normals to these surfaces. The arrows show the orientation of those slickensides which indicated normal slip, the lines with squares at their tips indicate those slicks showing reverse slip. The rose diagram below right shows the strikes of the slip surfaces indicating that most are nearly parallel to the strike of the fault plane.




The first order net effect of the slip surfaces is to thin the gouge layer. We are currently working to interpret these orientations in terms of a self-consistent stress field, or

alternatively, in terms of the expected slip directions in the dynamic stress field of a propagating rupture using recent results from Rice et al. (2004).

*Ron Biegel's Field Studies of Fault Zone Structures*

1. We completed a major review article, titled "Relating Fault Mechanics to Fault Zone Structure", accepted for publication in Vol. 47 of *Advances in Geophysics*. The article reviewed recent works that described exhumed fault zones and demonstrated that many of the fault structures could be explained by recently proposed theories in fault mechanics. In particular it was shown that the damage zone of faults could be explained as products of off-fault damage from earthquakes modeled as elastodynamic slip pulses as recently proposed by Rice et al.(2004).

2. One way to test the slip pulse model of Rice et al. is to characterize the damage zones of exhumed faults such as the San Gabriel and Punchbowl faults and compare them with predictions from the model. We have begun to map the damage zones of faults using a non-destructive instrument called the Schmidt Hammer. This is an ideal instrument for testing rock damaged during faulting since it measures a rebound value that has been correlated with Young's modulus and other elastic parameters. Ron Biegel has tested the instrument in the field by measuring rebound values on rock within the damage zones of the San Gabriel and Punchbowl faults.

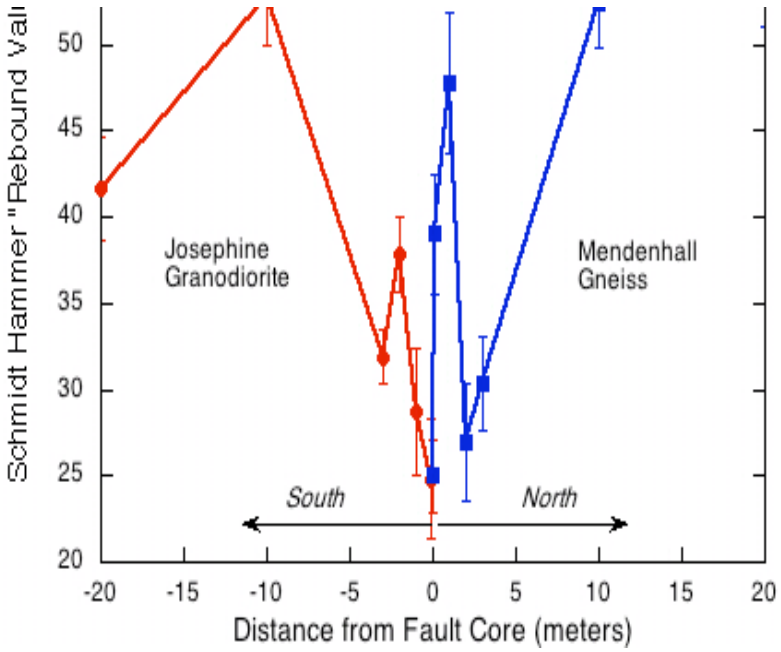



*Figure 6. Schmidt hammer rebound value as a function of distance from the core of the San Gabriel fault zone in Little Tejunga Canyon.*

3. We also plan to use the Schmidt hammer to obtain rebound values from the damaged wall rock of the Punchbowl fault. Jennifer Wilson measured the crack

density in samples taken during traverses within the damage zone of the Punchbowl. We intend to correlate rebound values of the Schmidt hammer with crack density by measured rebounds at the same locations that Wilson et al. Obtained her samples. Thus far Ron Biegel has made about 6 to 8 preliminary trip to the Punchbowl fault to become familiar with the terrain. Geological maps and history have been researched and other preparations taken for sampling. In order to be certain that measurements were made at the correct sites, consultation with Judy Chester (Wilson's advisor) is now taking place to confirm the site locations.

4. We have also been doing preliminary investigation of the San Gabriel fault as another site for mapping the damage zone with the Schmidt hammer. Numerous exploratory trips have been made to find the best sites to test with the sites. Geological maps and history have also been researched. At this time several sites have been tested and the technique for using the Schmidt hammer have proven very promising.

*High-Frequency Secondary Seismic Radiation Generated in the Process Zone of an Earthquake Rupture.*

I have completed the first draft of a manuscript in which I use methods developed in collaboration with Lane Johnson (Johnson and Sammis, 2001) to calculate the seismic radiation generated by the off-fault damage during the propagation of an earthquake rupture. These calculations use stress field near the tip of a dynamic slip pulse calculated by Rice et al. (2004) to drive the micromechanical damage mechanics developed by Ashby and Sammis (1990).