FINAL TECHNICAL REPORT

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Theodolite and total station measurements of creep rates on San Francisco Bay Region faults

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TITLE: THEODOLITE AND TOTAL STATION MEASURMENTS OF CREEP RATES ON SAN FRANCISCO BAY REGION FAULTS

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TECHNICAL ABSTRACT

The primary objective of our investigations is to measure fault slip and creep rates on San Francisco Bay Region faults to continue a detailed monitoring program that has been funded by the USGS (NEHRP) since 1979. We have continued to make measurements across San Francisco Bay Region faults to determine the rates of present fault movement and to discover any changes in these rates that might occur. Our results can be applied to reducing losses from earthquake in the United States because any changes in the rate of fault creep, including the onset of creep on a previously "locked" fault or the cessation of creep on a previously creeping fault, could be an indication of a forthcoming earthquake.

We continue to use the triangulation method for site measurements employed by the project since 1979. During the past year we have upgraded the surveying equipment to a state-of-the-art T002 total station and have also upgraded ancillary equipment. We continued to use both surveying instruments until we demonstrated that data were comparable. We are maintaining precision that is sufficient to detect movement of more than a millimeter or two since the previous measurement. The accuracy is such that in most cases measurements have detected the actual horizontal fault movement that is occurring at the surface.

We measured the amount of horizontal fault movement within a width of about 55-280 m at 32 sites on the San Andreas, Hayward, Calaveras, Concord-Green Valley, Antioch, Seal Cove-San Gregorio, Rodgers Creek, West Napa, and Maacama faults. We have established 2 new sites on the Rogers Creek fault, in response to observed increases in seismicity, and we have established 2 new sites on the central San Andreas fault to better understand the transition between the creeping and non-creeping sections. We measure creeping fault segments about six times each year, and non-creeping segments at least twice each year. Once a year we measure 23 after-slip sites that were established on the Hayward fault and 3 sites that were established on the Calaveras fault in 2002, in conjunction with J. Lienkaemper of the USGS.

During the past two years, there have been no significant changes in the creep rates on Bay Area active faults. The San Andreas fault remains locked throughout most of its length, and continues to creep at a high rate (average 11.6 mm/yr) at our San Juan Bautista site, the northern end of the central creeping section. The Hayward fault continues to creep at a moderate rate (4.7-6.3 mm/yr), although there has been a recent increase on some of the southern Hayward fault sites and a slowdown in creep that were are monitoring carefully near the segment boundary between the northern and southern parts. The Calaveras fault continues to show consistent measurements at each site, but highly variable measurements between sites (1.7-16.1 mm/yr). We observed no unusual behavior in association with the earthquake swarm in February 2003. Measurements on the Concord-Green Valley faults are somewhat noisier than other sites, but continue to show consistent creep rates of 3.0-4.1 mm/yr. Sites on the Maacama fault have shown creep rates of 4.7-6.7 mm/yr, but we are watching these sites carefully because there appears to be a recent increase in those rates. We have no data suggesting creep on the Rogers Creek fault, but we have established two new sites from which we will be able to report results in future years. Sites on the San Gregorio-Seal Cove fault continue to show no discernable creep.

We have continued to monitor effects of the Loma Prieta earthquake on Bay Region faults and to develop new analytical and interpretative phases of the project. We have begun to involve undergraduate and graduate students in research projects using the creep data; for example, analyzing how the details of the creep signal for the different faults compare to temporal variations in microseismicity along the faults and perhaps to seasonal rainfall variations. We have also begun to create fault rupture and stress models for various earthquake scenarios within our measurement area using stress-triggering software. When any sites show noteworthy or unusual behavior, we measure them more frequently, apply other analytical tools, and notify cognizant USGS personnel.