Central California Coast Earthquake Hazards
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12. GPS Measurement of Crustal Deformation in the Central California Coast Region

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The central coast region of California, west of the San Andreas fault from ~35.7N southward to ~34.6N, is a zone of right-lateral transpression, and examination of seismicity, focal mechanisms, and geologic data suggest that this region is comprised of several rotating crustal blocks. Relatively little geodetic data have been collected in the coastal region, particularly prior to the 2003 M6.5 San Simeon earthquake. Existing studies of regional deformation rates have produced conflicting results. We are compiling a spatially-dense and well-constrained Global Positioning System (GPS) velocity field to be used in combination with other data to develop a 3D kinematic deformation model for the region. The GPS data will help to identify actively deforming structures and elucidate how strain is partitioned between shear parallel to the San Andreas fault and contraction perpendicular to other regional faults, as well as provide constraints for testing thick-skinned and thin-skinned crustal models.The preliminary velocity field leverages existing observations from continuous GPS sites and campaign data available in online archives. We have reoccupied campaign GPS sites with 1-2 past surveys in order to extend their time series and obtain better-constrained rate estimates. Since April 2008 we have undertaken to densify the network employing “semi-permanent” GPS, which involves deploying a pool of receivers at a subset of sites, collecting data for several weeks, and rotating the receivers to another subset of sites. This is repeated so that each site is occupied several times a year and is a cost-effective way to obtain velocity estimates with low uncertainties in a short period of time (*e.g.*, two years). As a guide in site selection we have used InSAR data to identify areas of nontectonic (*e.g.*, hydrologic) motion that could contaminate GPS observations.

13. Pre-Stack Depth-Migrated Reflection Images of the Central California Coast Ranges: Profile SJ-6

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Following the 1983 M 6.5 Coalinga earthquake, the U.S. Geological Survey licensed data from an industry seismic reflection profile that extends northeastward from Morro Bay to the Great Valley, known as W-SJ-006 (SJ-6). These data provide one of the best regional images of the geologic structure across the central California Coast Ranges. The processed, stacked section that came with the license extended to about 6 s (15- to 18-km depth), but the data were subsequently recorrelated to 12 s (~36 km depth) and interpreted by several authors (Trehu and Wheeler, 1987; Wentworth and Zoback, 1989; Bloch *et al.*, 1993). Prominent features in the seismic images west of the San Andreas fault (SAF) include a sedimentary basin deformed by reverse faults and a gently east-dipping, middle- to lower-crustal reflective zone. East of the SAF, folding and reverse faulting are seen beneath Kettleman Hills Dome and Reef Ridge. In most places, reflection images east of the SAF are better developed

than west of the SAF, probably because of more uniform sedimentary layering and more smoothly varying velocity distribution. To better image the structures west of the SAF, we are applying more modern processing methods, such as Kirchhoff pre-stack depth migration. Because pre-stack depth migration requires a good velocity model, we are developing multiple velocity models by 1) examining refraction profiles (Walter and Mooney, 1987) that were coincident with the SJ-6 reflection profile, 2) conducting conventional velocity analysis on the original data, and 3) developing a tomographic velocity model from the original data. Preliminary results suggest that a high-quality velocity model is critical to improving migrated images.

14. Structure and Behavior of the San Gregorio Fault Offshore of Half Moon Bay, California

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The San Gregorio Fault is a double-stranded fault that lies predominantly offshore in the coastal zone of the San Francisco Peninsula, California. With a possible slip rate of 7 mm/year and paleoseismic evidence for two magnitude 7 events in the last 1400 years on the eastern strand, this fault poses significant seismic hazard to the San Francisco Bay area. Geologic evidence from the eastern strand suggests a slip rate of about 4 mm/year over the past 80,000 to 85,000 years, leaving about 3 mm/year to be taken up by the western strand; because the western strand is offshore, this rate has not been verified. These slip rates have been used in earthquake rupture forecast (ERF) models.The eastern strand, which extends offshore along the trend of the onshore Seal Cove fault, has a continuous and extremely linear scarp for at least 15 km, as imaged in swath bathymetric data. The western strand of the fault zone is not well imaged in the bathymetry but appears in high-resolution seismic-reflection data as the edge of a zone of deformation. Deep-penetration multi-channel seismic data suggests that the zone of deformation is part of a flower structure. The western fault strand is buried at least 8 m below the seafloor. Based on sedimentation rates of about 1-3 mm/year (Lewis *et al.*, Marine Geology, 2002) and the rate of earthquakes in the paleoseismic record, there have been multiple M7 events on the San Gregorio Fault while the 8 m of sediment accumulated. Unless the faulting is not expressed in the geophysical data, the western strand may not have been active during these events. If only the eastern strand, with its sharp surface expression, is presently active, then 3 mm/year of slip may be misplaced in the ERF models, which are calculated over shorter time periods than the temporal scales over which the fault behavior varies.

15. Finding Fault Facts—The Monterey Bay Area Quaternary Fault Database

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Although the nature of Quaternary faults is well documented for most of the San Francisco Bay area and the Los Angeles area, much less is known about the faults of the Monterey Bay area. In a collaborative effort with the USGS and NEHRP, a seamless map database was compiled that includes the San Gregorio, Monterey Bay/Tularcitos, Reliz, Zayante, San Andreas, southern Sargent, and southern Calaveras Faults within Santa Cruz County, northern Monterey County, and northern San Benito County.To create the database, published and unpublished geologic maps of the study area were complied and converted into digital format. Unpublished

paleoseismic trench logs, mainly from consultant reports, were obtained from local planning departments and geotechnical consultants.Several new findings became apparent from the compilation, such as the discovery of enigmatic vertical clay-filled fractures exposed in fault trenches along the southern Calaveras Fault Zone, finding that the recency of movement along the Zayante Fault Zone decreases from north to south, and evidence of probable Holocene activity on the Navy and Tularcitos Faults in Carmel Valley.For technical users, the database is provided in ESRI ArcGIS format and includes attributes such as name, location certainty, dip, and age of offset for each fault strand. In addition, geomorphic features indicative of fault recency or location is included for many of the faults. Paleoseismic trench locations are shown and linked to images of their trench logs. For non-technical users, the database is available in Google Earth format, allowing them to view and download the same information in the GIS database in a more user-friendly manner.Thus, the different database formats address the varying needs of users, but share the common element of providing information to allow users to understand fault hazards of the Monterey Bay area.

16. An Educational Video to Promote Tsunami Preparedness in California

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Tsunami hazards have recently captured the world's attention in large part due to the devastating Indian Ocean tsunami of December 16, 2004. This tragedy resulted in a renewed sense of urgency in the field of tsunami warnings and hazard mitigation. Although tsunamis are infrequent along the California coast, it is important to provide education and training to prepare local communities. Video is a powerful means for supporting community awareness programs, because visual stimulus is one of the most effective ways of reaching a broad audience. Seeing the potential hazard in a video is an incentive for many people to be better prepared for a future incident. We have created a video about tsunami preparedness along the coast of California that distinguishes between a local tsunami and a distant event. Our video addresses the specific needs of northern, central and southern California. The video presents recommended guidelines for tsunami response and community preparedness from responsible officials. These officials include local emergency managers, first-responders, and leading experts on tsunami hazards and warnings. The primary goal of our video is to make information about tsunami hazards and preparedness more easily accessible to the broad public. Our tsunami video, which will be available online, will help communities to prepare for tsunamis.

17. Seismicity Rate Changes along the Central California Coast Due to Stress Changes from the 2003 M6.5 San Simeon and 2004 M6.0 Parkfield Earthquakes

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We investigate the relationship between seismicity rate changes and modeled Coulomb static stress changes from the 2003 M6.5 San Simeon and 2004 M6.0 Parkfield earthquakes in central California. Coulomb stress computed from mainshock slip models is projected onto the orientations of major faults. The San Simeon mainshock loaded parts of the Rinconada, Hosgri and San Andreas strike-slip faults, along with the reverse faults of the southern Los Osos domain. All of these loaded faults, except for the San Andreas, experienced a seismicity rate increase at the time of the San Simeon mainshock. The Parkfield earthquake occurred 9 months later on the Parkfield segment of the San Andreas Fault, which

was unclamped by San Simeon. The Parkfield earthquake unloaded the Hosgri fault and the reverse faults of the southern Los Osos domain, which both experienced seismicity rate decreases at the time of Parkfield, although the decreases may be related to the decay of San Simeon-triggered seismicity. Coulomb stress unloading from the Parkfield earthquake appears to have altered the aftershock decay rate of the southern cluster of San Simeon aftershocks, which is deficient compared to the expected number of aftershocks from the Omori decay parameters based on the pre-Parkfield aftershocks. Dynamic stress changes cannot explain the deficiency of aftershocks, providing evidence that static stress changes affect earthquake occurrence. However, a burst of seismicity following the Parkfield earthquake at Ragged Point, where the static stress was decreased, provides evidence for dynamic stress triggering. It therefore appears that both Coulomb static stress changes and dynamic stress changes affect the seismicity rate. A delayed triggering mechanism is also required if San Simeon triggered Parkfield.