U.S.Geological Survey Grant No. **01HQGR0017**

EARTHQUAKE POTENTIAL OF MAJOR FAULTS OFFSHORE SOUTHERN CALIFORNIA: COLLABORATIVE RESEARCH WITH OREGON STATE UNIVERSITY AND LEGG GEOPHYSICAL

Mark R. Legg, Legg Geophysical, 16541 Gothard Street, Suite 107, Huntington Beach, CA 92647
Telephone: (714) 842-0404; Fax: (714) 842-5777; E-mail: mrlegg@attglobal.net
Chris Goldfinger, Margin Geology, Active Tectonics Group, Ocean Admin Bldg. 104, Oregon State University, Corvallis, OR 97331 Telephone: (541) 737-5214; E-mail: gold@coas.oregonstate.edu

Program Elements:
I-Products for Earthquake Loss Reduction; **II-**Research on Earthquake Occurrence and Effects
Key Words: Neotectonics, Seismotectonics, Tectonic Geomorphology, Tectonic Structures

Abstract

Major active faults offshore southern California are poorly known with respect to slip-rates and seismic hazards. However, due to their long strike length and apparent recency of motion based on new multibeam bathymetry and submersible observations, these faults may pose a serious threat to coastal populations and structures. Due to the relative paucity of hazard data, they are often not considered in tectonic models and seismic hazard assessments. For example, the seismic hazard mapping prepared by the USGS and CDMG (now CGS) omitted two of the largest and most continuous offshore faults, the San Clemente fault and the San Diego Trough fault, due to lack of data on recency of motion and slip rate. Yet because of the great length of these structures, exceeding 300-500 km, and well-defined character of these faults, they have the potential to generate large magnitude (M>6.5) earthquakes that would be destructive to heavily populated coastal areas including San Diego, Los Angeles, and Orange Counties. Indeed, these faults are closer to the southern California coast than the severely damaged Marina district and collapsed Cypress freeway are to the 1989 Loma Prieta rupture area. Long-period shaking effects due to large offshore earthquakes may be equally destructive to vulnerable coastal structures of southern California. Critical port facilities, such as those at Long Beach and San Pedro, would be easily disrupted by even modest ground movement of the fill on which they are constructed.

We have compiled a comprehensive bathymetric dataset including recent high-resolution multibeam (SeaBeam 2000 and 2100 and Simrad EM 120 and EM 1000) bathymetry, Scripps underway multibeam data back to the early 1980's, and dense NOAA hydrographic soundings offshore southern California and northern Baja California. These data cover the entire Borderland, including major portions of the two largest faults within the Inner Borderland offshore southern California: the San Clemente and the San Diego Trough fault zones, as well as parts of the Palos Verdes - Coronado Bank fault zone. These data provide an accurate delineation of fault geometry and character, illuminate numerous piercing point offsets on a variety of scales, and provide at least qualitative geomorphic evidence of recency of movement and rate of slip. Combined with a dense grid of existing high-resolution single-channel seismic reflection data and observations from the submersible ALVIN, these data are sufficiently detailed to allow a first-order estimate of rates of deformation. In this first year study, we generated new detailed maps of the San Clemente fault zone, and part of the San Diego Trough fault zone (Figure 1), that allow an accurate assessment of fault segmentation and the relationship of fault morphology to seismicity.

Recent observations from the submersible ALVIN provide the first confirmation of large earthquake occurrences on the submarine San Clemente fault, and allow more accurate interpretation of submarine fault earthquake potential than previously possible. The detailed fault mapping allows delineation of the lateral extent of major fault segments that are used to estimate the rupture potential; the ALVIN

observations of fault scarp heights are used to estimate fault displacements for large earthquakes. Preliminary recognition of offset piercing points from the combined seafloor geomorphology and subsurface imaging allowed estimation of the, heretofore elusive, submarine fault slip rates for part of the San Clemente fault zone. Seafloor displacement during large submarine earthquakes represents the added potential for generation of destructive local tsunami, which may come from either fault motion itself, or triggered submarine landslides. Preliminary models from this project suggest that coastal run-up elevations would be comparable to the maximum seafloor uplift at the source. The occurrence frequency of such events remains to be estimated along with the fault uplift and lateral slip rates. Another general finding is that the perception that strike-slip faults do not generate tsunami is incorrect. Strike slip faults generate significant vertical motion at both restraining and releasing bends. Elastic strain accumulation at either of these structures, when released, has a large vertical component. Additionally, the horizontal movement of steep submarine topographic features anelastically during a strike-slip earthquake can generate a tsunami.

Results of the completed work are important for upgrading the seismic hazard models of the southern California region to more accurately assess shaking and related hazards to coastal areas. In particular, the long-period shaking effects and induced ground failure such as liquefaction or sea cliff and coastal slope failures may be assessed. Large coastal structures such as power generating stations, port facilities, bridges and roadways, railroads, refineries, and other important facilities are vulnerable to long-period shaking, and therefore, it is imperative to accurately assess this hazard along the coast. Similarly, efforts to assess inundation hazards from locally generated tsunamis also require accurate assessment of offshore faulting and seafloor deformation from large earthquakes.

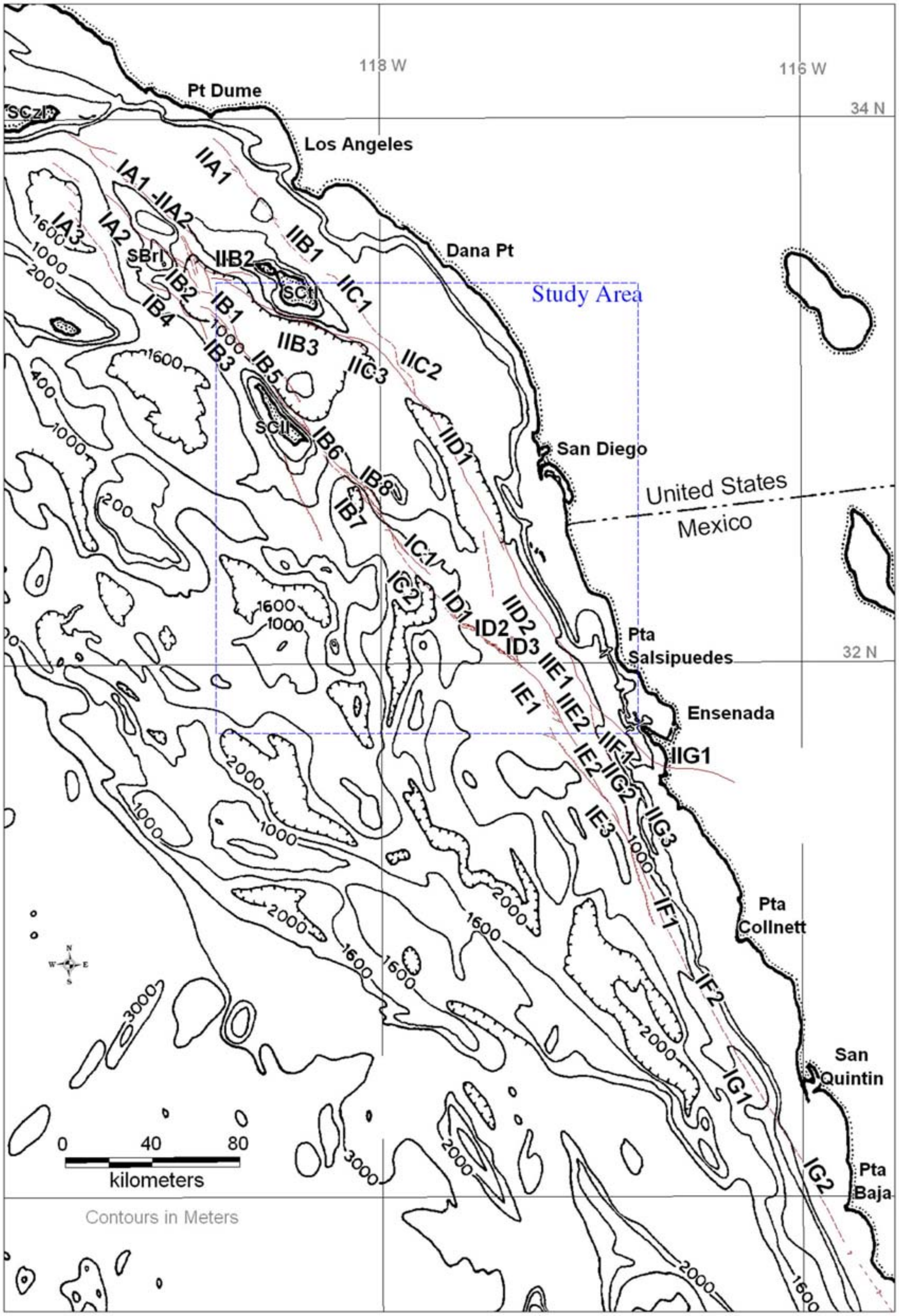

Figure 1. Map showing major sections and segments of the San Clemente and San Diego Trough fault systems (Table I). SCzI = Santa Cruz Island; SCtI Santa Catalina Island; SBrI = Santa Barbara Island; SClI = San Clemente Island.