PAGEOPH, Vol. 140, No. 2 (1993) 0033–4553/93/020179–03$1.50 + 0.20/0


# Introduction

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The generation of large earthquakes in subduction zones presents a broad spectrum of challenging scientific problems in the Earth Sciences. From plate tectonics we know that subduction zones are locations where the oceanic lithosphere deforms and sinks into the mantle beneath the neighboring plate, and that they are a primary manifestation of mantle convection and dynamics. At shallow depths, the subduction processes give rise to volcanism and to most of the world's seismicity, including the largest earthquakes. In addition, from a geological perspective, the shallow parts of subduction zones are also the areas of intense orogenesis and crustal deformation.

In many regions subduction produces large amounts of seismicity, reflecting the rapid strains that occur both in the interplate contact zone, and within the colliding plates themselves; in other areas, the subduction process appears to proceed without any significant seismic activity or visible evidence of strain accumulation. This difference in behavior, which can be seen when comparing different subduction zones or different segments within a subduction zone, is controlled by the mechanics of almost rigid plates, a viscous substrate, and of the contact zones between the plates.

Progress in observational as well as theoretical investigations of subduction zones over the last decade or two has increased our fundamental knowledge of tectonic processes in these regions, but has also revealed complex and poorly understood behavior which suggests that no simple laws will soon be found that can satisfactorily explain every aspect of the subduction process. An understanding of the complex physics governing the observed diversity of interplate behavior in subduction zones is the common goal of the studies presented in this special issue, and each provides a different approach which contributes to our understanding and ability to predict the seismicity, or lack thereof, in different subduction zones.

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In the first volume of this topical issue, YU *et al.* show how large scale relative plate motion is partitioned between the interplate contact and within the overriding plate, and how this is a common phenomenon that can be observed in most subduction zones. However, there are systematic geographical differences, and the study provides some observational constraints on what may govern the coupling between subducting and overriding plates. LIU and MCNALLY apply new modeling techniques to address the question of what the stress level might be within the colliding plates and across the interplate contact. Their focus is on earthquakes near the outer rise, where a correlation exists between the phase of the seismic cycle, and the depth of faulting and type of focal mechanism that is observed. With a given rheological model of the oceanic lithosphere, constraints can be placed on the variations in compressive stresses transmitted in the plate.

In the third paper of this volume KISSLINGER reviews the wealth of observations of seismicity in subduction zones that has been collected by local and regional networks in these areas. Data from these networks have been essential for determining the seismic velocity structure in subduction zones, as well as for obtaining accurate locations of hypocenters. Also, the data have allowed detailed geographical mapping of seismic activity down to the microearthquakes size, and these seismicity patterns have been used for earthquake prediction and the identification of asperities on the fault plane.

The next three papers attempt to evaluate the seismic potential of different subduction segments. ZÚÑIGA *et al.* analyze the aftershock sequence of an $M_s = 6.9$ earthquake in the Acapulco–San Marcos segment of the Mexican subduction zone and discuss the implications of their observations for the seismic potential of that area. PAPADIMITRIOU evaluates the validity of the time-predictable model for strong, shallow earthquakes along the western coast of South and Central America, and then estimates the seismic potential of particular segments within the time window of 1992–2002. COMTE and SUÁREZ analyze the complex spatio-temporal behavior of seismicity of two well recognized seismic gaps in southern Peru and northern Chile in an attempt to infer their current seismic potential. Even if observed complexities and the available database of only $\sim 30$ years do not allow for a firm estimate of the seismic potential in these areas, this is the most comprehensive study of its kind of these zones and will be invaluable in future studies.

The final two papers in this volume represent case studies. HOUSTON *et al.* analyze the anomalous (unusual focal mechanism, relatively high stress drop and short duration) and thus controversial $M_w = 7.7$ earthquake that occurred on October 20, 1986 in the Kermadec segment, with the epicenter approximately 200 km south of the intersection of the Louisville Ridge and the Tonga-Kermadec trench. To evaluate the tectonic significance of that earthquake the authors perform a comprehensive analysis of source parameters using surface- and body waves and relocated aftershocks. They conclude that this event represents an intraplate fault-

ing within the downgoing plate, and appears to be associated with segmentation of the subducting plate produced by forces related to the subduction of the Louisville Ridge.

To analyze fault plane heterogeneities in the northern Solomon Islands subduction segment and their association with rupture characteristics in general and the existence of earthquake doublets in particular, XU and SCHWARTZ study in detail two sets of doublets, from 1974 and 1975, and then relocate 85 underthrusting events in the area. The authors find that few smaller magnitude events overlap asperity regions, and that the majority of small magnitude underthrusting earthquakes occupy a segment that has never experienced a magnitude greater than 7.0 earthquake in the historic times.

It will be of great value to society when seismologists and geophysicists are able to monitor and predict the pattern of geophysical phenomena associated with subduction; this issue presents a modest step towards this goal.