Partial Breaking of a Mature Seismic Gap: The 1987 Earthquakes in New Britain

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Abstract — To better understand the mechanics of subduction and the process of breaking a mature seismic gap, we study seismic activity along the western New Britain subduction segment (147°E–151°E, 4°S–8°S) through earthquakes with \( m_b \geq 5.0 \) in the outer-rise, the upper area of subducting slab and at intermediate depths to 250 km, from January 1964 to December 1990. The segment last broke fully in large earthquakes of December 28, 1945 (\( M_s = 7.9 \)) and May 6, 1947 (\( M_s = 7.7 \)), and its higher seismic potential has been recognized by McCann et al. (1979). Recently the segment broke partially in two smaller events of February 8, 1987 (\( M_s = 7.4 \)) and October 16, 1987 (\( M_s = 7.4 \)), leaving still unbroken areas.

We observe from focal mechanisms that the outer-rise along the whole segment was under pronounced compression from the late 60's to at least October 1987 (with exception of the tensional earthquake of December 11, 1985), signifying the mature stage of the earthquake cycle. Simultaneously the slab at intermediate depths below 40 km was under tension before the earthquake of October 16, 1987. That event, with a smooth rupture lasting 32 sec, rupture velocity of 2.0 km/sec, extent of approximately 70 km and moment of \( 1.2 \times 10^{27} \) dyne-cm, did not change significantly the compressive state of stress in the outer-rise of that segment. The earthquake did not fill the gap completely and this segment is still capable of rupturing either in an earthquake which would fill the gap between the 1987 and 1971 events, or in a larger magnitude event (\( M_s = 7.7–7.9 \)), comparable to earthquakes observed in that segment in 1906, 1945 and 1947.

Key words: Subduction zone, New Britain earthquakes, mature seismic gap, earthquake prediction.

Introduction

Recent observational and theoretical work on earthquake cycles in subduction zones (Christensen and Ruff, 1983, 1988; Astiz and Kanamori, 1986; Dmowska et al., 1988; Dmowska and Lovison, 1988; Astiz et al., 1988; Lay et al., 1989) has explained certain seismic phenomena in relation to stress accumulation and release associated with great underthrust events. It has been realized that temporal variations of stress, associated with earthquake cycles, occur in the subducting slab and, as well, in the area of the outer-rise, oceanward from the main zones of subduction earthquakes. In the outer-rise, the bending stresses present

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become overprinted with tensional stresses in the beginning of the cycle, caused by the slip in the main subduction event. By the latter part of the cycle that has changed to a compressional overprint, occurring because the main thrust zone remains locked while converging motion of the remote ocean floor continues. These factors result in typical tensional outer-rise earthquakes following large subduction events, as well as sporadic compressional ones preceding large subduction events, as documented in the works cited above.

At intermediate depths, in the down-going subducting slab, the tensional stresses caused by slab pull receive a superposed compressional component in the beginning of the cycle, caused by the slip in the main thrust subduction event. In the latter part of the cycle the continuing slab pull and the locking of main thrust zone result in higher tensional stresses at intermediate depths.

We have utilized these new insights when analyzing the mechanics of partial breaking of a mature seismic gap along the western New Britain subduction segment (147°E-152°E, 4°S-8°S). In particular, we have used seismic mechanisms to infer the temporal and spatial changes in stress patterns in the outer-rise and in the downgoing slab caused by the recent partial breaking of the segment in the October 16, 1987 (mL = 5.9, Ms = 7.4) earthquake. We have complemented our study by the analysis of the source process of that earthquake.

**Tectonic Setting and Seismic History of the New Britain Subduction Segment**

The New Britain-Solomon Islands area, east of New Guinea (Figure 1), is characterized by complex interactions between several microplates and high seismicity levels both at the plate interfaces and at intermediate and great depths in the subducted slabs.

The Solomon plate subducts towards NNW under the Bismarck plate along the New Britain trench and towards the northeast under the Pacific plate along the Solomon trench, with a contortion around the junction of the Solomon and New Britain trenches.

In the north, backarc spreading operates along the Bismarck Sea seismic zone, with left-lateral strike-slip movements. This seismic lineation arches from around 2°S, 147°E and enters the Solomon Sea tangentially to the Solomon trench at the convergent region of the Solomon and New Britain trenches, creating in that region a triple junction. Seismic activity in the Bismarck Sea seismic zone is high, and earthquakes with magnitudes larger than 7.0 have occurred there during the past 60 years.

In the south another spreading center is operational along the Woodlark ridge, with weak, shallow seismicity (PASCAL, 1979; LAY and KANAMORI, 1980; COOPER and TAYLOR, 1987).

The Wadati-Benioff zone to the west of the junction between the New Britain and Solomon trenches trends southwest and dips to the northwest at about 70°-75°