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Late Quaternary faulting along the western margin of the Poronaysk Lowland in central Sakhalin, Russia

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Abstract

Sakhalin Island straddles an active plate boundary between the Okhotsk and Eurasian plates. South of Sakhalin, this plate boundary is illuminated by a series of M_w 7–8 earthquakes along the eastern margin of the Sea of Japan. Although this plate boundary is considered to extend onshore along the length of Sakhalin, the location and convergence rate of the plate boundary had been poorly constrained. We mapped north-trending active faults along the western margin of the Poronaysk Lowland in central Sakhalin based on aerial photograph interpretation and field observations. The active faults are located east of and parallel to the Tym–Poronaysk fault, a terrane boundary between Upper Cretaceous and Neogene strata; the active faults appear to have reactivated the terrane boundary at depth in Quaternary time. The total length of the active fault zone on land is about 140 km. Tectonic geomorphic features such as east-facing monoclinal and fault scarps, back-tilted fluvial terraces, and numerous secondary faults suggest that the faults are west-dipping reverse faults. Assuming the most widely developed geomorphic surface in the study area formed during the last glacial maximum at about 20 ka based on similarities of geomorphic features with those in Hokkaido Island, we obtain a vertical component of slip rate of 0.9–1.4 mm/year. Using the fault dip of 30–60°W observed at an outcrop and trench walls, a net slip rate of 1.0–2.8 mm/year is obtained. The upper bound of the estimate is close to a convergence rate across the Tym–Poronaysk fault based on GPS measurements. A trenching study across the fault zone dated the most recent faulting event at 3500–4000 years ago. The net slip associated with this event is estimated at about 4.5 m. Since the last faulting event, a minimum of 3.5 m of strain, close to the strain released during the last event, has accumulated along the central portion of the active strand of the Tym–Poronaysk fault.

Keywords: Sakhalin; Tym–Poronaysk fault; Active faulting; Paleoseismology; Slip rate; Plate boundary

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1. Introduction

Sakhalin Island lies on an active plate boundary between the Okhotsk and Eurasian plates (Fig. 1). South of Sakhalin, this plate boundary is located offshore along the eastern side of the Sea of Japan where a series of M_w 7–8 earthquakes occurred in the last century, including the devastating 1983 M_w 7.7 Sea of Japan and 1993 M_w 7.7 Hokkaido Nansei-oki earthquakes. Farther north, this plate boundary is considered to extend onshore along the length of Sakhalin (Seno et al., 1996). However, the location and convergence rate of the plate boundary in Sakhalin has been poorly constrained by geologic data.

A study by a French–Russian group (Fournier et al., 1994) described the major faults of this plate boundary in Sakhalin based on interpretation of satellite images, structural analysis of the faults, and studies of instrumental seismicity. The major faults identified were the Tym–Poronaysk fault that extends northward from the southwest peninsula west of Aniva Bay to the west-central part of the island and the Ekhabi–Pil'tun fault in northeast Sakhalin (Fig. 2). Although these faults were

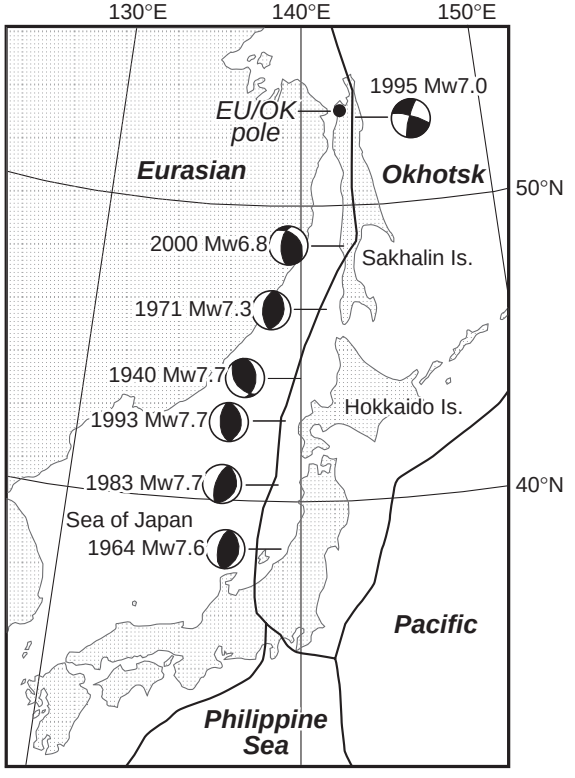

Fig. 1. Plate tectonic framework of the Japanese and Sakhalin Islands showing plate geometry after Seno et al. (1996) and focal mechanism solutions of large earthquakes along the Okhotsk and Eurasian plate boundary since 1940 after Katsumata et al. (2004). The Eurasian/Okhotsk Euler pole is from Seno et al. (1996).

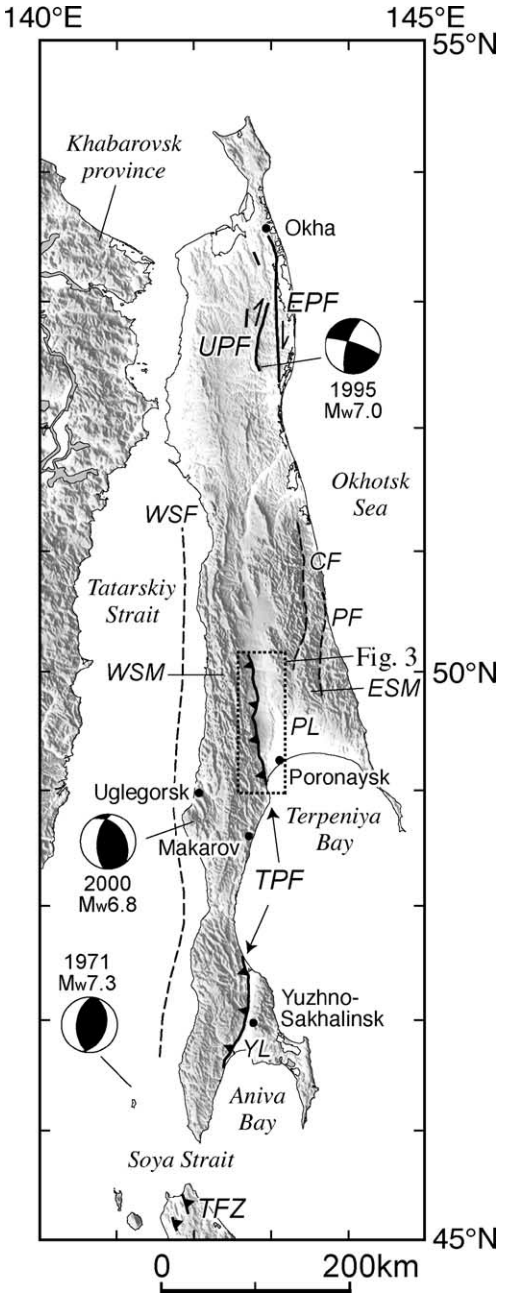

Fig. 2. Distribution of active faults (solid lines) and historical large earthquakes in and around Sakhalin. Active faults in Sakhalin are from Suzuki et al. (2000) and Tsutsumi et al. (2000), and those in Hokkaido south of the Soya Strait are from Ikeda et al. (2002). Focal mechanism solutions for historical earthquakes are from Katsumata et al. (2004). Abbreviations for active faults are EPF, Ekhabi–Pil'tun fault; TFZ, Teshio fault zone; TPF, Tym–Poronaysk fault; UPF, Upper Pil'tun fault. Abbreviations for physiographic features are ESM, East Sakhalin Mountains; PL, Poronaysk Lowland; WSM, West Sakhalin Mountains; YL, Yuzhno–Sakhalinsk Lowland. Dashed lines denote inactive or uncertain faults from Fournier et al. (1994). CF, Central fault; PF, Pribrezhnaya fault; WSF, West Sakhalin fault. Shaded relief map was drawn with the GMT software (Wessel and Smith, 1998).