

Slip distribution of the 1952 Tokachi-Oki earthquake (M 8.1) along the Kuril trench deduced from tsunami waveform inversion

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The March 4, 1952 Tokachi-oki earthquake (MJ 8.1, magnitude determined by Japan Meteorological Agency(JMA)) was an important event in terms of seismic gap hypothesis. Utsu [1972] identified a seismic gap next to the 1952 source region along the Kuril trench, where the June 17, 1973 Nemuro-Oki earthquake (MJ7.4) occurred. Although the 1973 event was smaller than predicted, a re-determination of 1952 aftershocks [Sekiya et al., 1974] showed that the 1973 event completely ruptured the seismic gap.

On the other hand, Hatori [1975] suggested the possibility of another large earthquake in the tsunami source gap between the 1952 and 1973 events. These two hypotheses conflict because the proposed aftershock and tsunami source areas of the 1952 event do not coincide.

The maximum tsunami height following the 1952 event reached 3 to 4 meters on the Pacific coast of eastern Hokkaido. The tsunami and the preceding earthquake caused 28 deaths, injured 287, and destroyed 8534 houses. Tsunami heights at other places were 1 to 2 meters.

Hatori [1973] (HT73) estimated that the tsunami source area was $8.8 \times 10^3 \text{ km}^2$ by using tsunami travel-times. However, the southeast boundary is not constrained and the fault area may possibly extend to trenchward. Kasahara's [1975] and Aida's [1978] fault models use their minimum depths, 0 km and 1 km, respectively, and are too shallow compared with depth of the plate interface.

We performed a linear least squares inversion using tsunami waveforms recorded at 13 tide gauge stations. We prescribed 10 subfaults on the upper boundary of the subducting Pacific plate, to cover the tsunami source area and most of the aftershock area.

Inverted slip distribution is shown in Figure. The solution shows that the total seismic moment is $1.87 \times 10^{21} \text{ Nm}$, which is consistent with estimates of $1.7 \times 10^{21} \text{ Nm}$ by Kanamori and Anderson [1975] from seismic waves.

Visual observations of tsunamis at Tokotan, Kiritappu, and Hanasaki, all east of Kushiro, poorly bound the northeastern end of the tsunami source area estimated by HT73. We recomputed the wave fronts from these points and compared with coseismic vertical displacement calculated from the slip distribution. The visually observed tsunami travel-times may indicate the onset of tsunami generated by subfault J rather than at the northeastern edge of the HT73's tsunami source area. The tsunami source area is estimated to be $25.2 \times 10^3 \text{ km}^2$ if we define it to be the area with coseismic vertical displacement larger than 0.1 m.

Large amounts of slip (more than 4.0 m) were estimated on the trenchward subfaults located on the shallow part of the seismogenic interface. Tsunami earthquakes have slip concentrated near trench axis [Satake and Tanioka, 1999], but the 1952 event was not a tsunami earthquake.

Most of the aftershocks occurred on subfaults where the stress drop was smaller than 4 MPa. Very few aftershocks occurred where the stress drop was the largest (19 MPa). Regions with large stress drop during the mainshock seem to be correlated with regions with lack of aftershocks.

Large earthquakes (MJ ~7) occurred on Aug. 12, 1961, Nov. 15, 1961, and Aug. 2, 1971 on the margins of relatively small coseismic slip. These events may be caused by a post-seismic stress concentration at the edges of the 1952 fault plane.

A subducting seamount has been inferred mainly from magnetic data near the southern Kuril trench [Yamazaki and Okamura, 1989]. The seamount is located at the southwest corner of fault plane where the 1952 coseismic slip was relatively small, indicating that the subducted seamount acted as a barrier.

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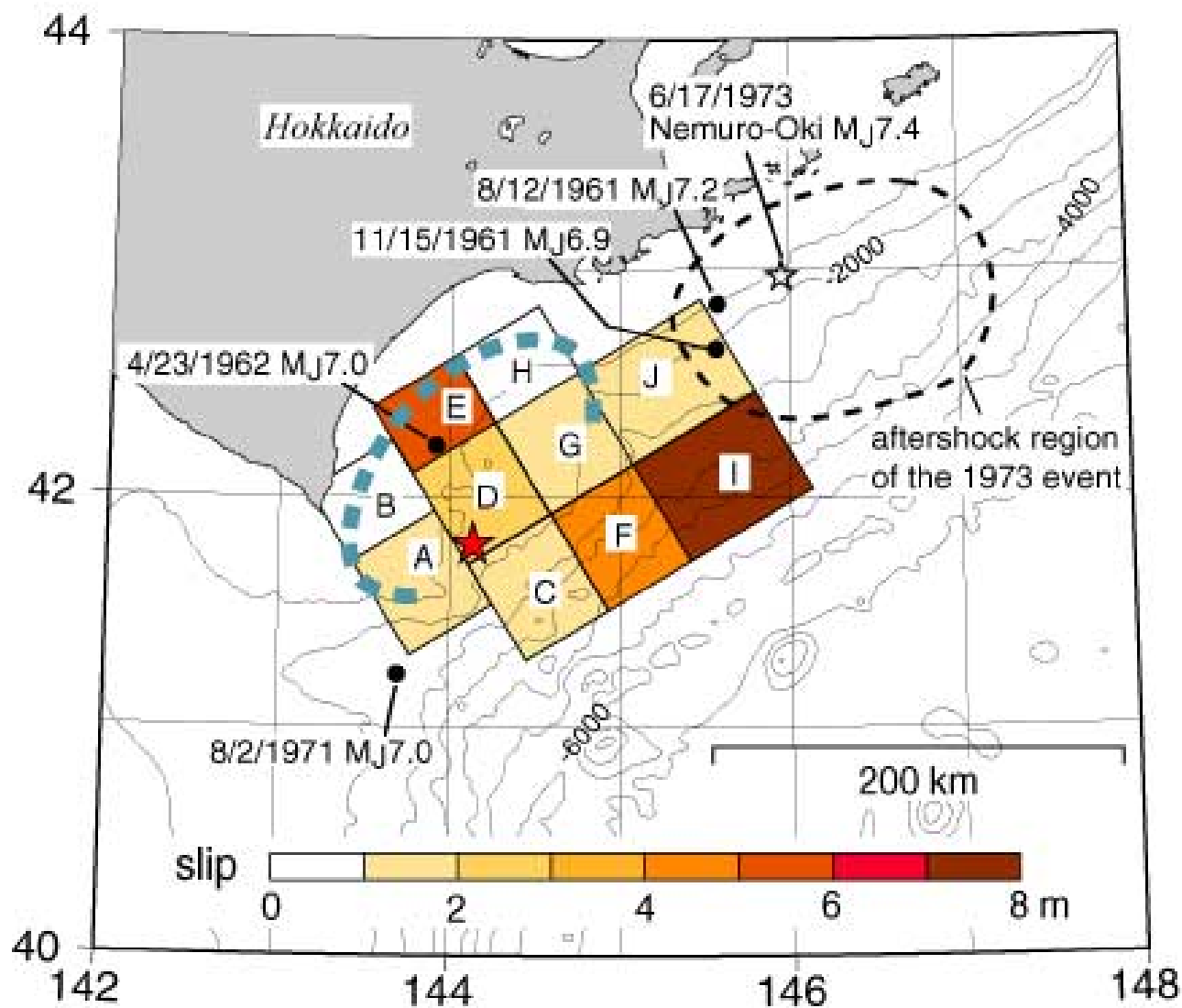


Figure. Slip distribution of the 1952 Tokachi-Oki earthquake determined from the inversion. Large earthquakes (solid circles) from 1952 through 1973 with $M_J > 6.8$ that occurred in and around the rupture area of the 1952 event are also shown. Aftershock region of the 1973 event is shown by the dashed curve. Red and open stars indicate the epicenters for the 1952 and 1973 events, respectively, determined by JMA. Hatori's [1973] tsunami source area is enclosed by blue dashed curve.