

The anomalously low b-values within the subducting slab prior to the 2003 Tokachi-oki Earthquake, Japan

Shinji Nakaya[1]

[1] Civil Eng., Shinshu Univ.

<http://www.weng.cs.shinshu-u.ac.jp/CIVIL/ARCH/nakaya/nakaya.html>

Lithospheric plates are subjected to high stresses during subduction, and many of the world's largest earthquakes occur within the Wadati-Benioff Zone in the subducting slab. The M 8.0 2003 Tokachi-oki Earthquake (TOE) occurred on September 26 in the southern Kuril Trench southeast of Hokkaido, Japan, close to the epicentre of another very large earthquake in 1952 (M 8.1). The coseismic rupture processes of these two earthquakes have been analysed, based on seismic and geodetic data for the 2003 event [e.g., Yamanaka and Kikuchi, 2003; Koketsu et al., 2004; Yagi, 2004], and based on tsunami data for the 1952 event [e.g., Hirata et al., 2003]. The spatial distribution of asperities within the subduction zone has also been estimated.

The b-value of an earthquake catalogue is related to the ratio of large to small earthquakes, and is defined as the slope of the Gutenberg-Richter frequency-magnitude relationship, that is, $\log N = a - bM$, where N is the number of earthquakes equal to or larger than magnitude M, and a is a constant term representing the total number of earthquakes. In a variety of tectonic settings, b is approximately unity [Utsu, 1971], but several factors appear to influence b locally. In particular, previous researchers have observed that higher material heterogeneity [Mogi, 1962] or thermal gradients [Warren and Latham, 1970] result in higher b-values, whereas an increase in shear stress [Scholz, 1968; Urbancic et al., 1992] or effective stress [Wyss, 1973] reduces the b-value. Anomalously low b-values appear to be correlated with the locations of asperities [Wiemer and Wyss, 1997], and regions with relatively low b-values are considered to sustain higher applied shear stresses following a large mainshock [Enescu and Ito, 2002]. Thus, observations of relatively low b-values may reflect locally elevated shear or effective stress.

Our analysis of seismicity data from the subducting slab along the Kuril Trench reveals a zone of anomalously low b-values near the hypocenter of the 2003 Tokachi-oki Earthquake (M 8.0). The zone of low b-values (0.50-0.65) at depths of less than 80 km in the subducting slab moved toward the hypocenter of the 2003 earthquake in the period 1990-2003. In our understanding, this transient low b-value zone corresponds roughly with the location of an asperity inferred from waveform inversion by recent research. The occurrence of the 2003 earthquake, a large thrust event on the subducting plate interface, in this zone of anomalously low b-values suggests that low b-values in the subducting slab prior to the mainshock and during the aftershock series is concordant with high stress concentrations associated with interseismic strain accumulation and redistribution in the vicinity of the rupture.