Stress field in the northwestern part of the South Island, New Zealand, and its relationship with faults of recent earthquakes

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Introduction

In New Zealand, the Pacific plate is subducting below the Australian plate in the northern part of the South Island. Currently, compressional stress fields in the ESE-WNW direction are distributed in the northern part of the South Island (Townend et al., 2012). Many old rifts and normal faults are distributed on the northwest side of the Alpine Fault. These features developed due to the extensional stress fields associated with the formation of the Tasman Sea and the Emerald Basin (Ghisetti et al., 2014). Currently, a tectonic inversion has been confirmed in this region (e.g., Ghisetti and Sibson, 2006) in which old normal faults act as reverse faults.

In northeastern Japan, compressional stress fields in the E-W direction are currently distributed (e.g., Terakawa and Matsu'ura, 2010), and tectonic inversion has been confirmed (Okamura, 2010). Thus, Northeastern Japan and the northern part of the South Island have a similar tectonic setting. In inversion tectonics, reverse faults originating from old normal faults and newly formed reverse faults coexist, making it difficult to understand how and on which faults earthquakes are generated.

In our previous studies, we focused on the large to moderated-sized earthquakes that occurred in northeastern Japan (Tagami et al, JpGU Meeting 2021; Tagami et al, SSJ meeting 2021). We confirmed that along the eastern margin of the Japan Sea the eastward-dipping nodal planes with a low dip angle are more likely to slip than the westward-dipping planes with a high dip angle. This is consistent with the actual fault planes shown in previous studies.

In this study, we focused on two large to moderate-sized earthquakes (the 1929 Buller earthquake and the 1962 Westport earthquake) that occurred in the northwestern part of the South Island. We investigated the relationship between the stress fields and the fault planes.

Data and methods

We use moment tensor data from GNS Science and focal mechanisms estimated from P-wave first motions at temporary stations (Okada et al., 2019) and routinely operated stations (GeoNet). For estimating the regional stress field, we employ the stress tensor inversion method developed by Michael (1984, 1987). For estimating the likelihood of slip, we use the Slip Tendency (ST) analysis (Morris et al., 1996).

Result 1. Stress Fields

On the northwestern side of the Alpine Fault, the focal mechanisms are dominated by reverse fault and strike-slip fault types. The estimated stress field is found to be an intermediate between reverse fault type and strike-slip fault type. The stress field around the two earthquakes shows a reverse fault type. The maximum horizontal compressional direction seems to rotate from E-W to ENE-WSW direction from south to north, but the differences are not statistically significant.

Result 2. Slip Tendency

・The 1929 Buller earthquake (M_w 7.3)

The eastward-dipping plane has a higher ST value (>0.7) and is more likely to slip under the stress field. The Buller earthquake is thought to have occurred on the White Creek fault (Doser et al., 1999). The White Creek fault dips to the east (Ghisetti and Sibson, 2006). Therefore, our results are consistent with previous studies.

・The 1962 Westport earthquake (M_w 5.6)

The eastward-dipping plane has a higher ST value (>0.7) and is more likely to slip. The Westport earthquake is thought to have occurred on a fault located about 3 km offshore from the Cape Foulwind fault with a similar strike angle (Doser et al., 1999). The Cape Foulwind fault dips to the east (Ghisetti and Sibson, 2006). Therefore, our results are consistent with previous studies.

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