Stress field in the northwestern part of the South Island, New Zealand, and its relationship with faults of recent earthquakes (3)

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目的

ニュージーランドでは北島から南島北部にかけてオーストラリアプレートに太平洋プレートが沈み、現在の南島北部ではおよそESE-WNW方向の圧縮応力場が分布する（Townend et al., 2012）。南島北西部では、タスマン海の形成とエメラルド海盆の形成に伴う引張応力場により発達した古い正断層が存在し、古い正断層（高傾斜角面）が逆断層として活動する反転テクトニクスが、現在の東北日本と同様に確認されている（例えば Ghisetti et al., 2014）。

我々はこれまでにニュージーランド南島北西部で生じた二つの大規模地震（1929年Buller地震 Mw 7.3、1962年Westport地震 Mw 5.6）を対象に応力場に対する断層のすべりやすさの検討を行った（田上・他, JpGU Meeting, 2022）。その結果、対象地域ではESE-WNW方向の圧縮応力場を確認した。また、60°未満の傾斜角を持つ東傾斜の面がすべりやすい傾向を示した。本研究では引き続き、2つの大規模地震（1968年Inangahua地震、1991年Hawks Crag 地震）を対象に応力場に対するすべりやすさの検討を行なった。

データと手法

まず、対象領域における臨時観測点と定常観測点のデータを用いて応力場を推定した。次に、Anderson et al. (1993)で推定された大規模地震のメカニズム解の節面に対して、Slip Tendency法（Morris et al., 1996）を用いて応力場に対する断層面のすべりやすさを評価した。

結果

1968年Inangahua地震（Mw 7.1）

2つの節面のうち、西傾斜の面が高いST値（>0.7）を示し、応力場に対してすべりやすい傾向であった。Inangahua地震は西傾斜の断層面で活動したことが考えられている（Anderson et al., 1994）ことから、本研究で得られた傾向は実際の地震の断層面と整合的である。

1991年Hawks Crag地震

前震(Mw 5.8)と本震（Mw 6.0）を対象にST値を算出した。結果、前震は低傾斜角の面が高いST値（>0.7）を示したが、本震ではST値に大きな差はなかった。Ghisetti et al.（2014）では、本研究地域において低傾斜角の新しい断層が高傾斜角の断層の深部に発達していると示唆されている。このことから、応力場に対してすべりやすい低角傾斜面で前震のすべりが生じ、その後、本震は高角な面で活動したことが示唆される。

Introduction

In New Zealand, the Pacific plate is currently subducting below the Australian plate in the northern part of the South Island. Stress fields of ESE-WNW oriented compression are widely distributed in the northern part of South Island (Townend et al., 2012). Many old normal faults are widely distributed on the northwestern South Island. These old faults were developed due to the extensional stress fields associated with the formation of the Tasman Sea and the Emerald Basin (Ghisetti et al., 2014). As in northeastern Japan, a tectonic inversion in which old normal faults become reverse fault has been confirmed in this region (Sibson and Ghisetti, 2018).

Our previous studies focused on the two large to moderated-sized earthquakes (1929 Buller earthquake Mw 7.3 and 1962 Westport earthquake Mw 5.6) that occurred in South Island (Tagami et al., JpGU Meeting 2022). We confirmed that the eastward-dipping planes with a dip angle of less than are likely to slip. This study focused on two other large to moderate-sized earthquakes (the 1968 Inangahua earthquake and the 1991 Hawks Crag earthquake). We investigated the relationship between the fault planes of these earthquakes and the stress field.

Data and methods

First, we estimated the stress field using the focal mechanisms obtained by temporary and permanent stations (Okada et al., 2019; Matsuno et al., 2022) and the GeoNet moment tensor solutions. Then, using the Slip Tendency analysis method (Morris et al., 1996) we evaluated the likelihood of slip for both nodal planes of the focal mechanisms estimated by Anderson et al. (1993).

Results

1968 Inangahua earthquake (Mw 7.1)

The westward-dipping plane has a high ST value (>0.7) and is more likely to slip under the current stress field. Inangahua earthquake is considered to have occurred on the westward-dipping plane (Anderson et al., 1994). Our result is consistent with the previous study.

1991 Hawks Crag earthquake

We focused on foreshock (HC1, Mw 5.8) and an aftershock (HC2, Mw 6.0). In the case of HC1, the low dip angle plane has a high ST value (>0.7). In the case of HC2, both nodal planes have a similar ST value. In Ghisetti et al. (2014), new lower dip angle fault planes are developed in the deep part of the higher dip angle fault plane. Therefore, it is suggested that slip first occurred on the lower dip angle fault plane as the foreshock, and then slip with the high dip angle fault plane occurred as the aftershock.

References

Anderson, H., Beanland, S., Buck, G., Darby, D., Downes, G., Haines, J., Jackson, J., Robinson, R., and Webb, T., 1994., New Zealand Journal of Geology and Geophysics, 37, 59-86.
Anderson, H., Webb, T., and Jackson, J., 1993, Geophys. J. Int, 115, 1032-1054.
Ghisetti, F. C., and Sibson, R. H., 2006, Journal of Structural Geology, 28, 1994-2010.
Ghisetti, F.C., Barnes, P. M., and Sibson, R. H., 2014, New Zealand Journal of Geology and Geophysics, 57(3), 271-294.
Okada, T., Y. Iio, S. Matsumoto, et al., 2019, Tectonophysics 765, 172–186.
Matsuno, M., Tagami, A., T. Okada, et al., 2022, Tectonophysics 835, 229390.
Morris, A., Ferril, D. A., and Henderson, D. B., 1996, Geology, 24(3), 275-278.
Sibson, R.H., Ghisetti, F.C., 2018, Bull. Seismol. Soc. Am. 108, 1819–1836.
Townend, J., Sherburn, S., Arnold, B. C., and Woods, L., 2012, Earth Planet. Sci. Lett., 353-354, 47-59.