Microearthquake activity near a 'characteristic earthquake' sequence off Kamaishi, NE Japan

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1. Introduction

Microearthquake activity in the earthquake cluster that includes the M4.8+/-0.1 interplate 'characteristic earthquake' off Kamaishi, Japan [Matsuzawa et al., 2002; Okada et al., 2003; Uchida et al., 2005] was investigated by using double-difference (DD) method [Waldhauser and Ellsworth, 2000]. Besides the regular recurrence interval (5.52+/-0.68 year) and constant magnitude (M4.8+/-0.1) of the repeating events, the earthquake cluster has a unique attribute that microearthquake activity in the cluster becomes more active before the occurrences of the M4.8+/-0.1 earthquakes. Here, we investigated a space-time evolution of the seismic activity in the cluster based on the DD technique.

2. Data and Method

We have relocated 21 earthquakes of M2.0 to 4.8 for the period from 1995 to 2003. We calculated waveform cross-spectra of P and S waves for event pairs to estimate precise travel time differences. The time window investigated was set to be 3.5 seconds starting 1 second before the onset of each phase and delay times were estimated from the phase differences in a frequency band of 1 to 10 Hz. We successfully obtained 8001 and 4289 travel-time differences for P and S phases respectively and applied the DD algorithm to these data. Note that the 'hypocenter' determined using this procedure corresponds to the centroid of the slip distribution.

3. Results

All the earthquakes are relocated close to each other (within 1.5 km) and formed three clusters (western, middle, and eastern). The three clusters are aligned east-west direction and the depths of the earthquakes seem to delineate the westwardly dipping plate boundary, although the apparent dip is about 10 degrees steeper than the dip angle of the plate boundary in this region (around 30 degrees). The western (deepest) cluster which consists of relatively large earthquakes (M2.9-3.8) seems to be near to the edge of the M4.8 event if we assume circular fault and 380 bar stress drop [Matsuzawa et al., 2002] for the event. The earthquakes in this cluster seem to be co-located (located within 100m of each other). The middle cluster was estimated as close as 100m to the centroid of the 2001 M4.8 event and consistently occurred within 1 month after earthquakes occurred in the western cluster. The eastern (shallowest) cluster was also close to the M4.8 event although it seems to be outside of the source area of the M4.8 event.

4. Discussion

All the events analyzed here were located within 1km from the centroid of the M4.8 event. Since the rupture dimension of the M4.8 event is thought to be around 1 km [Okada et al., 2003], these earthquakes and the M4.8 event are expected to interact with each other.

The result that some events occurred very close to the centroid of the M4.8 event indicates that the asperity of the M4.8 event undergoes slip in the interseismic period (i.e., the asperity is not 100% coupled) or that the seismic area for the M4.8 event consists of several asperities that slip at the same time.

The locally steeper dip angle of the plate boundary inferred from the alignment of the clusters suggests a possibility that the asperity of the M4.8+/-0.1 events is generated by small geometrical irregularity of the plate interface.

5. Conclusions

The microearthquake clusters which became active before the 2001 M4.8 interplate earthquake off Kamaishi are located along the plate boundary very close to the M4.8 event. The temporal change in the microearthquake activity is probably due to the temporal evolution of slip and stress in or around the asperity for the M4.8 event.

Acknowledgments

We would like to thank S. Kirby, K. Imanishi and T. Igarashi for the valuable discussions. This work was partly supported by the 21st Century Center of Excellence program, 'Advanced Science and Technology Center for the Dynamic Earth' at Tohoku University.