Frequent occurrence of “rapid” aseismic slip events at the Izu-Bonin Trench

*Yoshio Fukao[1], Tatsuya Kubota[2], Hiroko Sugioka[3], Ryo Furue[1]

1. JAMSTEC, 2. NIED, 3. Kobe Univ

Introduction

We deployed an array of absolute pressure gauges on the seafloor at depths around 5000 m near the Izu-Bonin Trench through one year period from May 2015, where we detected “rapid” aseismic slip events (1,2). Their durations were not so short as those of ordinary earthquakes of comparable sizes but not so long as those of slow slip events. We proposed that these were the events amid the transitional regime connecting the stable plate-sliding and unstable seismic-slip regimes. Here, we report additional evidence for the occurrence of such “rapid” aseismic slip events.

Methodology of signal retrieval

Detection of a “rapid” aseismic slip event by using seafloor pressure gauges is challenging partly because the signal can easily be masked by ocean tide. Oscillatory motion of ocean tide has a peak-to-trough amplitude of 100 hPa at the representative period of 50000 s with a typical rate of pressure change of 0.2 Pa/s. The target signal, on the other hand, is characterized by a ramp-type pressure change of about 5 hPa with a rise time on the order of about 5000 s, corresponding to the rise rate of about 0.1 Pa/s. The intensity of the target signal is thus only 1/10 to 1/20 of the ocean tide while its increasing rate is at most comparable, making the signal detection from raw records often infeasible. In an attempt for an easier detection, we employed the tide-incorporated ocean circulation model (JCOPE_T) (3) to reduce the tidal contribution to a level comparable to the signal level (Fig.1).

The events detected

Besides the already reported two “rapid” aseismic events (15/09/01 and 15/09/05) (1), we here add the two similar events (15/08/30 and 15/09/08). Fig.1 shows the differential (Observed-JCOPE_T) record containing a target event in the central 20000s section. Note that by subtracting the JCOPE_T from the observed record, the tidal amplitudes were reduced to about 1/10 of the original one so that the targeted signal could be visually identifiable. We searched for the ramp function that best explains the targeted signal. Fig.1 shows the ramp function so estimated at each observational site, indicating a seafloor subsidence of 3~4 cm with a rise time on the order of 5000 s for the 08/30 event (Top, t=0 at 02:43:20, Aug.29) and a seafloor uplift of 4~5 cm with a rise time on the order of 10000 s for the 09/08 event (Bottom, t=0 at 03:23:20, Sep.07).

Discussion and conclusions

The series of the events may be summarized as follows.

(1) The 08/30 “rapid” aseismic event causing depression at all the sites,
(2) The 09/01 M6.0 seismic event causing depression at some sites and uplift at other sites,
(3) The 09/01 “rapid” aseismic event causing uplift at almost all the sites,
(4) The 09/05 “rapid” aseismic event causing seafloor uplift at all the sites.
(5) The 09/08 “rapid” aseismic event causing seafloor uplift at all the sites.

Thus, this 10 days-activity consisted of multiple events of seafloor depression and/or uplifting and its net result was an excess of seafloor uplifting. The individual events were in part seismic but mostly aseismic, yet they were still much faster than ordinary slow slip events. “Rapid” aseismic slip events may not be so rare as has ever been thought. We interpret these events as those amid the transitional regime that connects the unstable seismic regime and the stable sliding regime.

References

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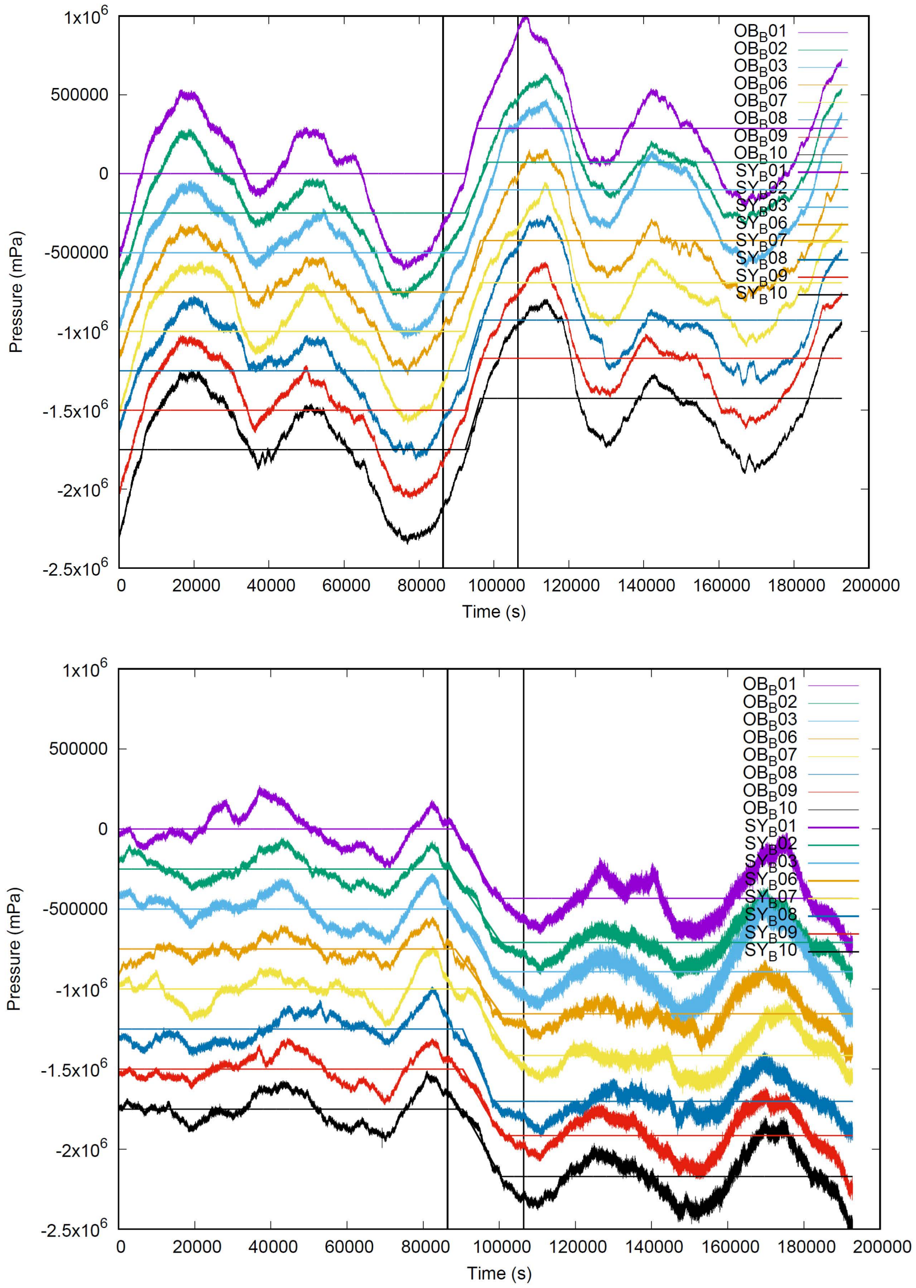
Figure 1. Detection of “rapid” aseismic events with the aid of JCOPE-T



The ramp-type pressure change maximizing the variance reduction is searched in the targeted 20000-s time window.

