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Cumulative energy changes of the Kii Peninsula southeast offshore earthquake

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1. Introduction

The hypocenter distribution of the Kii Peninsula southeast offshore earthquake is investigated.
The hypocenter structure is a dichotomized form consisting of two hypocenter areas, a deep part, and a shallow part. Earthquakes in the shallow hypocenter are directly related to the Kii Peninsula southeast offshore earthquake. On the other hand, deep source earthquakes are associated with oceanic plate movement. As a result, earthquakes in the shallow source area are associated with oceanic plate movement.

2. Kii Peninsula southeast offshore earthquake

2.1 Hypocenter distribution

Figure 1 shows the time distribution of the hypocenter depth of the earthquake that occurred off the southeastern coast of the Kii Peninsula in 2004. The horizontal axis is the elapsed time based on January 1, 2004. The vertical axis is the depth of the hypocenter that occurred. As is clear from the figure, the hypocenter area is clearly separated into a group of earthquakes shallower than 50 km and a group of earthquakes deeper than 300 km. It has been observed that this separation form is not limited to 2004, but continues from 2003 to today. Therefore, it is considered that this distribution structure is clearly due to the geological structure peculiar to the region.

2.2 Seismic model

The Kii Peninsula is composed of three types of geological bodies, one of which is an accretionary prism [3]. This accretionary prism was formed in the deep sea near trenches and troughs at the boundary between the oceanic plate and the ocean. Then, the subduction of the oceanic plate curved the accretionary prism located above it, and further subduction gradually changed to a vertical distribution. **Figure 2** shows the relationship between the accretionary prism and the hypocenter position. The lowermost part is an ocean plate and the middle part is a vertical accretionary prism, and the surface layer is located above it. The movement of the oceanic plate causes an earthquake at the contact surface between the accretionary prism and the oceanic crust. This is the deep hypocenter area. The strain of the accretionary prism generated in this region also transmits the strain to the upper part of the accretionary prism, and an earthquake occurs at

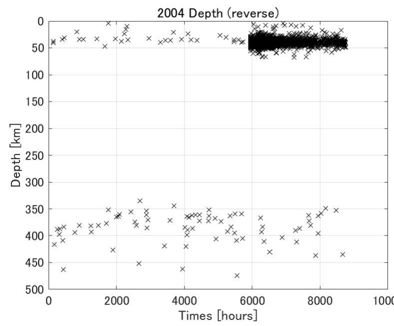

Fig.1 Hypocenter depth distribution of the Kii Peninsula southeast offshore earthquake in 2004.

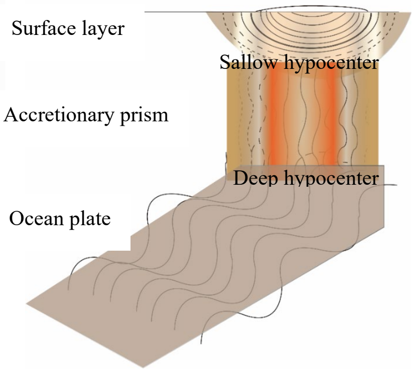

Fig.2 Hypocenter location in the model of the Kii Peninsula southeast offshore earthquake.

the contact surface between the upper part of the accretionary prism and the lower part of the surface layer. This is the shallow hypocenter area. In this way, the occurrence of deep and shallow

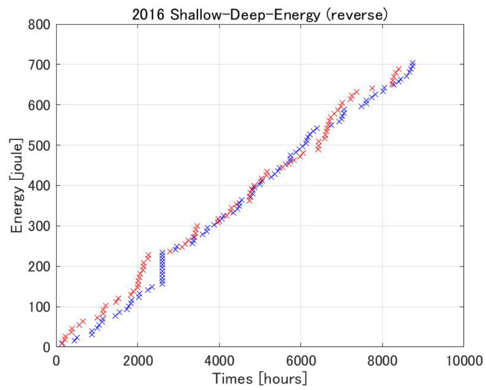

Fig.3 Time transition of cumulative energy in 2016.
x Deep earthquake, x Shallow earthquake

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earthquakes are related to each other because they share the accretionary prism.

The strain of the accretionary prism generated in the lower part also transmits the strain to the upper part of the accretionary prism, and an earthquake occurs at the contact surface between the upper part of the accretionary prism and the lower part of the surface layer. This is the shallow hypocenter area. In this way, the occurrence of deep and shallow earthquakes is related to each other because they share the accretionary prism.

2.3 Energy transition

Since an earthquake is a release phenomenon of strain energy accumulated in the crust, the energy of a new earthquake starts to accumulate after the occurrence of similar earthquakes in the same area in the past [4]. Off the southeastern part of the Kii Peninsula, the hypocenter area is deeply divided into two as shown in Section 2.2. Therefore, the accumulated strain energy is also divided into two. Therefore, we examine their energies to investigate the relationship between deep and shallow earthquakes. The energy E (Jule) of an earthquake is expressed by the following equation [5].

$$\mathrm{Log}_{10}E = 4.8 + .5\,M, \qquad (1)$$

M is magnitude. **Figure 3** shows the cumulative energy of the Kii Peninsula southeast offshore earthquake in 2016. The horizontal axis is the time when New Year's Day is 0. The vertical axis is the cumulative energy of earthquakes that occurred from New Year's Day. That is, it is a cumulative value obtained by adding the energy ($\log_{10}E$) calculated from the magnitude of the earthquake that occurred, with the New Year's Day as 0. The cumulative energies of 76 earthquakes from M 1.5 to 3.7 that occurred in the deep region are indicated by x marks. In addition, the cumulative energy of 86 earthquakes from M 1.5 to 3.1 that occurred in the shallow area is indicated by x mark. As is clear from the figure, although the number of earthquakes occurring in both regions and the range of their magnitudes are different, not only the rate of increase in cumulative energy of both earthquakes but also the detailed fluctuations are the same. For example, the fluctuation curve from 2000 hours to 2600 hours is parallel to deep and shallow earthquakes. The shallow earthquake occurred about 450 hours after the deep earthquake. Such changes cannot be observed at two hypocenters with different hypocenters. Therefore, it was shown that the vibration model shown in Fig. 2 is highly effective. Next, **Fig. 4** shows the energy transition of the Kii Peninsula southeast offshore earthquake that occurred in 2020. Comparing Fig. 4 and Fig. 3, the upward trends of cumulative energy are the same, but the rate of increase is significantly different. The final cumulative value of the shallow earthquake in Fig.4 is 100 (J) smaller than that of Fig. 3, but the final cumulative value of the deep earthquake is 250 (J) larger than that of Fig. 3. Therefore, 350 (J) of energy is stored in the accretionary prism and the like. It is important to continuously observe this stored energy because it is the source of larger earthquakes.

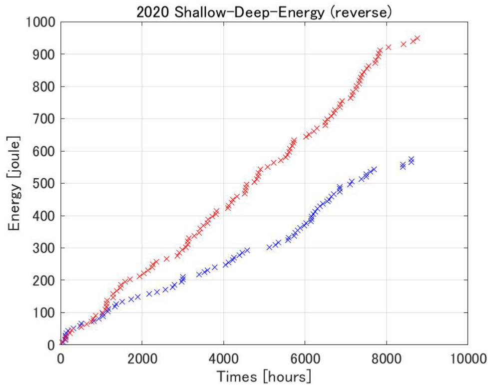

Fig.4 Time transition of cumulative energy in 2020.
x Deep earthquake, x Shallow earthquake

Summery

It was confirmed from the source area of the occurrence earthquake that the source structure off the southeastern part of the Kii Peninsula is divided and distributed in two depth areas. The hypocenter structure was modeled and their energy transitions were investigated. As a result, it was shown that the energies of deep and shallow earthquakes are related, and that the difference between them is important for future earthquake occurrence. Moreover, since earthquakes in the deep region are caused by plate movement, the relationship between them and stored energy is an important predictive factor.

References

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