High-resolution acoustic analysis of an active fault recorded in delta sediments

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Abstract

Two local earthquakes with strong vertical motion occurred on the 14th (Mw6.5) and 16th (Mw7.3) of April 2016 in the central part of Kumamoto Prefecture. Damage in the city of Kumamoto near the seismic center was huge.

Many large local earthquakes (>M5) have occurred since A.D. 1500 in the coastal region of the eastern Ariake Sea around Kumamoto, and historic records document the damage. The trace of the active fault is clearly shown by acoustic survey, but the information is restricted to the western part of the Ariake Sea. Unfortunately though, the stratigraphic record is incomplete here because the past 10,000 years are not present. Similarly, the acoustic survey in the eastern part has not been utilized extensively due to acoustic scattering.

However, if the scattering is excluded, these acoustic data lead to the discovery of an unknown active fault for which an age can be determined. In this study, the 5cm-resolution sections below 10m from the sea bottom were not used to avoid the scattering deformation, and the fault movement is recorded in the delta sediments which are composed of alternating sands and muds that reflect the sound with varying intensity due to the changes in sedimentology.

Three strong reflection layers exist in the acoustic record. From top to bottom, they are L1 to L3. Two normal faults were also found, both 7 km in length and trending east to west. The 2016 earthquake uplifted the delta sediment up to 30 cm. Thus, the fault moved three times in the geological past based on the vertical deformation of the layers.

The activity history of the fault is estimated based on the 14C age of an acoustic reflection layer (L3) and the sedimentation rate. Based on the 3410 ± 40yr BP age of L3 (Tsukawaki, et al., 2002), the sedimentation rate is 0.2cm/y. This rate leads to L1 being active ~500 years ago (about A.D. 1520), and L2 ~2000 ago (about A.D. 20). The age of the shifted sediments of L1 almost coincides with the destruction of Kumamoto Castle by the July 21, 1625 earthquake (M5.0-6.0). The results of this study suggest that high-resolution acoustic analysis is useful for the interpretation of paleo-seismic activity.