The 2011 Kurobe River earthquake of M5.4 with reference to deep crustal structure of the Hida mountain range

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Kurobe River earthquake

The Hida Mts. is located between Toyama and Gifu Prefectures and Nagano Prefecture, in central Japan. Many of mountain peaks rise above 3000 m. The Tateyama-Kurobe area is in the deepest part of the Hida Mts. Kurobe River runs through the eastern margin of Toyama Prefecture from the deepest part of the Hida Mts. down to the Toyama Bay.

The 2011 Tohoku earthquake of Mw9 induced Kurobe River earthquake swarm on March and October. A JMA magnitude of the largest event on October 4 was 5.4, which is call the Kurobe River earthquake in this presentation. Fig.1 shows epicenter distribution of the swarm and relative locations of the Tateyama Mt., the Kurobe River and Kurobe dam.

From scaling law between Mw and lengths of earthquake faults, a fault length of the M5.4 earthquake can be assumed to be 6 km, consistent with the swarm distribution. Assuming left lateral strike slip fault of a length 6 km, a fault width 3 km and a uniform slip 40 cm, we obtain crustal deformation in which amplitude of horizontal component of 3 cm to SE direction and vertical component of 5 mm subsidence.

Tateyama-Midagahara volcano

The Tateyama-Midagahara volcano (36.571N, 13.590E, Elevation 2.6 km) is one of 110 active volcanoes listed in JMA Catalogue for volcanic warnings and volcanic alert. In the past decade, there were volcanic plume activity in 2006, sulfur combustion forming sulfur flows in 2010 and reactivation of plume activity in 2014 (JMA Web for volcanic warning). Research group of Tokyo Institute of Technology conducted audio-frequency magnetotelluric survey in 2013 to find a conductive layer suggesting hydrothermal reservoir a few hundred meters below surface (Seki et al., 2015).

Deep crustal structure below Tateyama-Kurobe area

Analyzing refraction/reflection experiment data along a 180 km long profile between Agatsuma in Gunma and Kanazawa in Ishikawa Prefectures passing through the Tateyama-Kurobe Alpen route, Takeda et al. (2004) obtained the crustal structure below the Hida Mts. At the time of the 1996 Joint Geophysical Research in the Hida District, we operated temporary dense seismic network of seismographs installed every 1 km along the Tateyama-Kurobe Alpen Route. Analyzing two sets of data, Matsubara et al. (2000) successfully obtained beautiful tomographic model Fig.2 of P wave velocity below the Tateyama-Kurobe area. Fig.2 shows a reservoir of partially melted magma at depths from surface down to 15 km, where P and S wave velocities are 5 km/s and 2.5 km/s, respectively.

Above results suggest that a part of fluid rising up from magma reservoir becomes fluid reservoir at depths a few hundred meters below Tateyama-Midagahara and another part infiltrates into a fault to induce earthquake at the point indicated by arrow in Fig.2.

Concluding comments

It seems to be much dynamic and attractive to tackle volcanic activity, earthquake and deep structure of Tateyama-Kurobe Geopark area together with geological history in a single framework.

The rupture area of the 1984 Western Nagano Prefecture earthquake was about 10 km away from Ontake volcano that erupted in 2014. That of the 2011 Kurobe River earthquake was about 5 km away from

Tateyama-Midagahara volcano. These showed that, for the purpose of protection of tourists, volcanic and seismic activities should be investigated simultaneously.

Fig.1 Distribution of epicenters of earthquake swarm on March and October, 2011, plotted on basic map due to GSI Web Site. Data selection by TSEIS of ERI, University of Tokyo with earthquake parameters of JMA.

Fig.2 E-W cross section of P wave velocity below the Tateyama-Kurobe region (Matsubara et al., 2000). A red arrow indicates location of the Kurobe River earthquake.

Keywords: Tateyama-Midagahara Volcano, Kurobe River, induced earthquake, crustal structure, magama reservoir

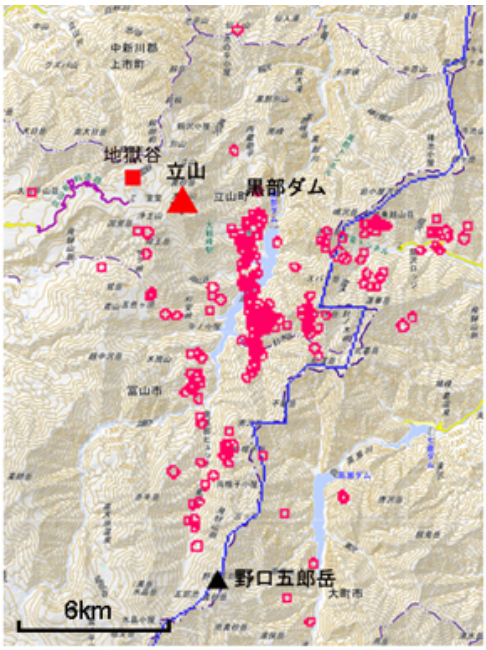

Fig1

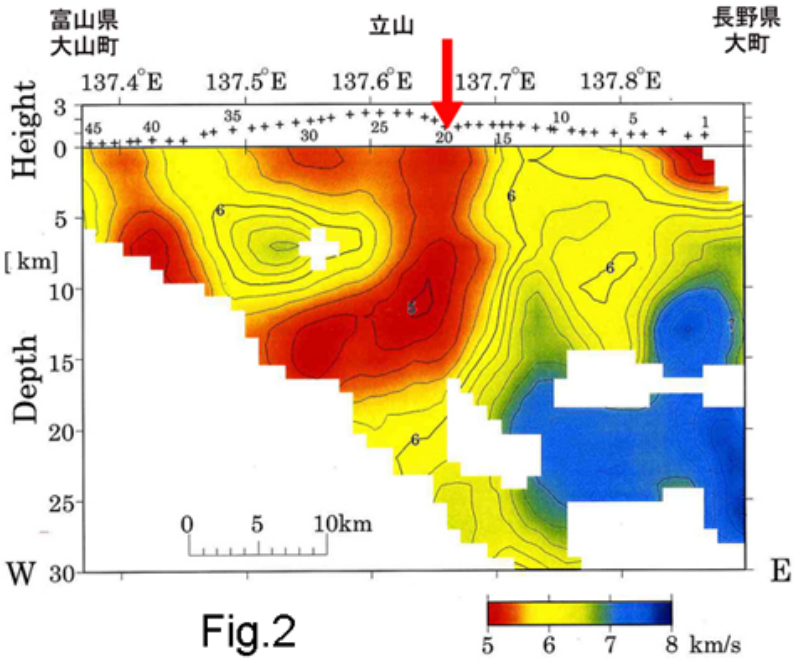

Fig.2

