

Crustal fluids beneath Kyushu forearc region

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In this study we have determined two dimensional (2-D) resistivity and three dimensional (3-D) seismic velocity structure beneath Kyushu subduction zone. 40 magnetotelluric (MT) stations were deployed in the study area. The MT data were collected using five component wide-band MT instruments (Phoenix MTU-5 system). A simultaneous remote reference measurement was carried out at the Sawauchi site (900 km northeast of the study area). The observed apparent resistivity and phase data were inverted simultaneously using the 2-D inversion code of Ogawa and Uchida [1996]. We have applied a tomographic method [Zhao et al., 1994] to P and S arrival times from regional earthquakes and teleseismic events to determine a detailed 3-D P and S wave velocity structure beneath Kyushu. The obtained resistivity and seismic velocity model through the inversions show as follows: (1) In central Kyushu, a prominent conductive anomaly exists in the crust beneath the forearc region. (2) A low-velocity zone corresponding to the conductive anomaly was revealed in the crust. (3) These results indicate that the conductive and low-velocity zone may reflect crustal fluids in the forearc region.

Possible fluid-related earthquakes from seismic spectra analysis: detection and mechanism

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Fluid had been considered as a possible factor in triggering earthquakes, but, the evidence in elucidating the behavior and mechanism is still unresolved. Fracture zone associated with fault zone after an earthquake could be considered as a fluid reservoir, which possibly yields to some observations/detections of phenomena associated with pre-, co- or post-seismic of a larger earthquake. The fluid might behave from high pore-fluid saturation within fractured fault zone from fully to partial saturation as a transient feature after a large earthquake. We suspect this process might yield the migration of fluid flow, and thus, related to the occurrence of some aftershocks. Considering that the fluid flow triggering events might have a mechanism from tensile cracks rather than tensile shear, the S/P spectra ratio would be around 2-0.7 rather than higher values of 6-2 for tensile shear. We investigate the spectra ratio of the selected events from the analysis of the recorded broadband waveforms, we found significant association of the S/P spectra ratio of 2-0.7 in about 10-60 days after the Chi-Chi earthquake. It might give the evidence of the tensile crack events in association to the fluid flow and give the migration of the seismicity. These events are mostly in the negative Coulomb stress regime of the mainshock and are in the depth f about 5-8km. Our assumption on this is that the migration of fluid flow increases the pore-pressure, which reduces the normal stress, and, thus, yield the co-seismic negative Coulomb's stress regime to become positive to trigger these fluid flow associated aftershocks. The migration of this aftershock to the distance of the fault is with a speed of about 220m/day for our Chi-Chi case study in about 10-60 days after the Chi-Chi earthquake. More profiles along the fault will be further examined to assure our understanding on fluid migration within the crust. Moreover, if the zone of the fluid triggered events could be constrained spatially and temporally, we might be able to estimate the possible amount of fluid involved during this process.

Keywords: aftershocks, fluid flow, S/P spectra ratio

Remarkable crustal strain and Groundwater level changes associated with reflood of the underground gallery

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Tono Research Institute of Earthquake Science has been investigating the relationship between the variation of groundwater level and variations of crustal tilt, stress, and strain. We have installed a multi-component borehole instrument (three Ishii-type borehole strainmeters, two borehole tiltmeters and thermometer) at the bottom of boreholes site (BH-1; 50m depth) in the Tono mine (JAEA) in the Tono region, central Japan, as a part of the research. The BH-1 site is located in the Toki granite.

At Tono mine, backfilling of underground galleries were started from March 2012 and completed in March 2015. The drainage pump stopped on December 9, 2014. In this study, we report the crustal strain changes associated with reflood of the underground gallery. As research advances, the following results were obtained: (1) Observed strain change of maximum principal strain, minimum principal strain, and areal strain at the BH-1 site are -1.075×10^{-6} strain, -5.448×10^{-5} strain, -5.556×10^{-5} strain, respectively. (2) Compression of ENE-WSW direction is remarkable at the BH-1 site.

We consider that observed 'compression to excellence in ENE-WSW direction' may be caused by the hydrogeological structure, such as the orientation of the crack in Toki granite neighborhood of borehole strainmeter.

Keywords: reflood of the underground gallery, Strain observation, Groundwater level observation

Estimate of hydraulic properties of the crust - An example from water discharge by Naganoken-Hokubu earthquake

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On November 28, An M 6.7 earthquake occurred at northern part of Nagano Prefecture, Central Japan. The Kamishiro Fault, which has been well known as to be a part of Itoigawa-Shizuoka Tectonic Line, was activated by the earthquake and surface rupture about 9 km in length was appeared along its trace.

Post-seismic fluid discharge was observed from the fracture zone of the Kamishiro Fault. Our team has been observed and monitored the flow amount and chemical characteristics of the fluid for about 5 months from one week after the earthquake.

In this presentation, we describe the occurrence of earthquakes and its relation to the hydraulic properties and discuss about the governing equations of fluid flow in fracture zone of the Kamishiro Fault.

Keywords: Naganoken-Hokubu earthquake, Kamishiro Fault, Fluid discharge, Fracture zone, Hydraulic property

Distribution of slab-derived fluid mixed into groundwater system in NE Japan arc

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The Li/Cl ratio of groundwater is proposed as useful indicator for detecting minor amounts of slab-derived saline fluid mixed into groundwater aquifers (Kazahaya et al., 2014). A weak point of the Li/Cl indicator appears in case that slab-derived fluid is mixed into saline groundwater. An extended indicator for detecting slab-derived fluid using Li and halogens is shown to solve complicated mixing groundwater system. We report here the distribution of upwelling of the slab-derived (and magmatic) fluid into groundwater system in NE Japan arc using an extended chemical indicator for groundwater. The areal distribution feature is explained by upwelling model of slab fluid controlled by subduction system.

Keywords: slab-derived fluid, NE Japan arc, groundwater

The behavior of surface radicals on mechanochemically activated silicates

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High concentration of hydrogen gas has been occasionally observed in soil gas along active faults (Wakita et al., 1980; Sugisaki et al., 1983). Such hydrogen gas is thought to be generated by a chemical reaction (radical reaction) between fluid and active surface of minerals newly created by fault activities (Wakita et al., 1980). Subsequent laboratory experiments have confirmed that hydrogen gas is truly generated during fracturing of silicate minerals in wet condition (e.g., Kita et al., 1982, Kameda et al., 2003). However, the reaction mechanism has not been fully understood.

Delogu (2011) carried out a crushing experiment of quartz in a solvent of ethanol with 2,2-diphenyl-1-picrylhydrazyl, as a radical scavenger, and evaluated directly the amount of hydrogen radicals using UV-vis spectrophotometry. In this study, we applied this method to albite, another common constituent mineral in crustal faults, in an attempt to elucidate the behavior of hydrogen radicals in natural fault zones.

Our experiments revealed that hydrogen radical is generated during grinding of both quartz and albite. The amount of the hydrogen radicals increases as the specific surface area of the ground sample increases. Comparing the amount of the hydrogen radicals generated, those from albite is much smaller than from quartz. These results are reasonable because the density of Si radicals on well-cleaved (010) and (001) planes of albite is estimated to be 1/6 of that on quartz. In addition, Hochstrasser and Antonini (1972) showed that alkali metals interfere the generation of hydrogen radicals. This property may also affect the amount of surface radicals on ground albite.

When we compare the amount of hydrogen radicals with those of hydrogen gas per unit area of newly created surface reported by Kameda et al. (2003), the hydrogen radical is more than one order of magnitude greater than hydrogen gas. This suggests that most of generated hydrogen radicals disappear before combining to be hydrogen molecules.

Keywords: radical reaction, mechanochemistry, hydrogen gas