C105-P003 **Room: Poster Session Hall** **Time: May 18**

Correlation between radionuclide concentrations in the top soils of active faults and earthquake activity

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It is important to clarify heterogeneous structures, displacements, and periodicities of active faults around which many earthquakes have occurred. For this understanding, we adopted radioactive surveying that measures alpha and gamma rays with the decays of radionuclides, and aimed at identifying the origins of radionuclide concentrations in the top soils from the relationship with earthquake activities. The four active faults under different tectonic environments, Hutagawa-Hinagu, Nojima, Atera, and Atotsugawa faults were selected for the radioactive survey executed from Oct. 2004 to Dec. 2008. The Hutagawa-Hinagu fault with 75 km length is ranked B activity: an earthquake of magnitude 5.3 occurred in its middle during June 2000. The activity of the Nojima with 7 km length is also B, but a large earthquake (magnitude 7.3) with occurred during January 1995 in the northern fault and at the 18 km depth, which accompanied the right lateral and reverse displacements of about 2 m on the surface. The 66-km Atera fault (A activity) is a left lateral fault, and the Atostugawa fault (A activity) has partly the creep zones and the concentrated earthquakes zones.

Two methods, alpha scintillation counter (ASC) and gamma ray spectrography (GS) were used. ASC detect 222Radon (Rn) in the U series and 220Radon (Tn) in the Th series. Using the large difference in half lives (Rn: 3.8 days and Tn: 54 seconds) and a calculation method of Rn atoms by considering equilibrium and nonequilibrium conditions (Koike et al., 2000), the concentrations of Rn and Tn were obtained. GS measures gamma ray intensities (Bq/g) of 12 radionuclides using a germanium semiconductor detector for the soil samples taken from the bottom holes (depth 65 cm) at which ASC is carried out. In addition, we adopted uniaxial compressing test using granite samples with different locations (Inada, Oshima, Rokkou, Toki, and Funatsu) to measure Rn emanations with rock fracturing.

The ASC results showed that the Rn concentrations are the highest at Futagawa-Hinagu fault and the lowest at Nojima fault, and the Tn concentrations are high at Futagawa-Hinagu and Nojima fault and lowest at Atotsugawa fault. There were high correlations between the Tn and the other gamma-decayed radionuclides concentrations, and the measurement points with high concentrations of Tn and gamma-decayed were located near the hypocenters of the above two earthquakes. A mechanism can be considered that the radionuclides ascended through the active faults during the earthquakes and were trapped in the top soils. Another interesting feature is that there were several measurement points with high Rn concentrations in the concentrated micro-earthquakes zones during the ten years (1998 to 2008) in spite of low concentrations of gamma-decayed radionuclides. This implies that Rn can be emanated by micro-earthquakes and trapped in the top soils. Therefore, micro-earthquakes probably have strong effect on spatial distributions of Rn concentrations in the top soils. The compression tests clarified that the Rn concentrations begin to increase at the 40 to 60 percent level of the for yield stresses except for the Inada granite samples, which corresponds with the stress level for large increase of microcracks (Scholz, 1968). This result can support the above assumption on the strong effect of micro-earthquakes on the Rn emanation at the active faults by relating microcracks to micro-earthquakes.