Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SCG066-01 Room:201A Time:May 22 10:45-11:00

Ubiquitous gas monitoring system observed gases in the Atotsugawa fault

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Attempts of monitoring generated gases due to faulting have been performed by e.g. Sugisaki (1978). 30 years after the study performed, we developed a Quadrupole Mass Spectrometer into a GRowndWater Data Analyzing System (GROWDAS) in order to measure gasses under ground continuously. We started to observe nitrogen, oxygen, argon, carbon dioxide, methane and helium gasses by the GROWDAS at the Atotsugawa fault, Gifu prefecture on December 2010. In this study, we show results of the gas observation.

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SCG066-02 Room:201A Time:May 22 11:00-11:15

Generating process of intraplate earthquakes and roles of crustal fluids

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The generating process intraplate earthquakes has not been fully understood yet. Recently, roles of the weak zone in the lower crust are noted, since aseismic deformation of the weak zone can generate stress concentration on the seismogenic fault above it. The existence of the weak zone is estimated as low velocity and/or low resistivity anomalies in the lower crust detected by tomographic studies. Furthermore, the stress concentration that is thought to be generated by the deformation of the weak zone was detected around the seismogenic faults in Japan. The weak zone is thought to be weakened by water in the lower crust. In fact, low velocity and/or low resistivity anomalies are estimated between the weak zone and the subducting slub beneath it.

Keywords: intraplate earthquake, lower crust, stress accumulation process, Niigata-Kobe tectonic zone, crustal fluid

Japan Geoscience Union Meeting 2011
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SCG066-03 Room:201A Time:May 22 11:15-11:30

Radon and Dischage Water Observations in Wari-ishi Hot Spring, Gifu Prefecture

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The continuation observation of Radon and water flow rate was carried out at the Gifu Hida Kamioka, Wari-ishi hot spring, in Gifu University. The amount of water flow from 850m below ground was measured in the 10 minute interva1 from 1998 to 2004, and at intervals of 1 second from 2004, by using the Radon detector and electromagnetic flux meter with the accuracy of 0.25%.

The observation result of water change is related to the crust distortion accompanying the earth tide or the occurrence of an earthquake through change of the pore pressure of a stagnant water layer.

The purpose of this research is to clarify relation of water change, and seismic waves and crust distortion, and to clarify the relation of the occurrence of groundwater and an earthquake from a viewpoint of earthquake prediction. Analysis of water flow was performed in the following four viewpoints, 1)hypocentral distance of the earthquake and magnitude, 2)earth tide, 3)seismic waves, 4)crust distortion at the time of the occurrence of earthquakes.

Keywords: Radon, Hot Spring, Earth Quake Prediction, Discharge Underground Water, Tidal Response

Japan Geoscience Union Meeting 2011
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SCG066-04 Room:201A Time:May 22 11:30-11:45

A continuous and long term monitoring of hydraulic conductivity at Kamakura

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We will discuss results of a continuous monitoring of the hydraulic conductivity at Kamakura observatory.

The radon concentration anomaly related to earthquakes is governed by both rocks and the structure of an aquifer. The most important parameter of the structure of the aquifer is the porosity, which is directly connected to the hydraulic conductivity. It is therefore essential to establish a monitoring method of the hydraulic conductivity with the radon concentration for understanding such preseismic phenomena.

Groundwater level recovery, which is caused by an intermittent water sampling with 1 hour interval, was recorded automatically every 10 seconds for 1 year. The time constants of the water level recovery were calculated by Wylie's equation. Finally, the apparent hydraulic conductivities were calculated from the recovery constants with the structural parameters of the well.

We will focus attention on the characteristics of the time series of the apparent hydraulic conductivity.

Keywords: Groundwater, Hydraulic Conductivity, Continuous Monitoring

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SCG066-05 Room:201A Time:May 22 11:45-12:00

2000 western Tottori earthquake triggered by latent magmatism: variations in the 3He/4He ratios in the source region

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A magnitude (Mj) 7.3 intraplate earthquake occurred in the western Tottori area, southwest Japan, on 6 October 2000, where there was no apparent prefaulting subsurface indication of the source fault of the 2000 earthquake. Magnetotelluric soundings were taken in and around the aftershocks occurred in order to image three-dimensional electrical resistivity structure at depths of up to 40 km, which could indicate an anomalously conductive body in the middle crust to the upper mantle on the southwest side of the source fault. Free gas and dissolved gases collected from groundwater wells around the seismic source region are characterized by 3He/4He ratios several times higher than the atmospheric value; the highest value of 5.1 RA is similar to those of typical arc-related volcanic gases. Although alkali basalts of early Pleistocene age are sparsely distributed in the western Tottori area, the observed 3He/4He ratios are higher than the calculated 3He/4He ratio derived from the ancient magmatism, considering post-extrusive radiogenic ingrowth of 4He by decay of U and Th included in the magma. Therefore, it is concluded that the geophysical anomaly imaged to the southwest of the source fault is attributed to latent magmatism in the present-day subduction system. Aqueous fluids separated from the cooling crustal magma could cause deep low-frequency earthquakes around the Moho discontinuity and migrate into the brittle upper crust. In addition, the presence of aqueous fluid is expected to weaken the crustal materials. Locally anelastic deformation, implying notable compressive deformation in the E-W direction, was observed in the region where aftershocks were distributed. Under overpressure conditions, the existing fault could serve as a pathway for aqueous fluids expelled from magma with high 3He/4He ratios, so that the upwelling of overpressurized fluids toward the Earth's surface results in the emanation of groundwaters with high 3He/4He ratios along the trace of the source fault segments.

Keywords: 2000 western Tottori earthquake, helium isotope, latent magmatism

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SCG066-06 Room:201A Time:May 22 12:00-12:15

Experimental evidence for pressure solution of quartz aggregate with small effective stress (0.5 MPa) at 25 - 45C

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Dissolution rates of pressure solution (PS) of quartz sand in 0.002 M $NaHCO_3$ solution were experimentally determined at low temperatures (25? to 45?C) and low effective stresses (0.32 to 0.51 MPa) under conditions far from equilibrium. They were 1.5+/-0.4 x 10^{-15} (25?C), 2.1+/-0.3 x 10^{-15} (35?C) and 2.7+/-0.7 x 10^{-15} (45?C) (Si mol/cm^2/sec), respectively. The ratios of the dissolution rates of PS to those of quartz sand at zero effective stress were 4.0+/-1.2 (25?C), 3.0+/-0.6 (35?C) and 2.4+/-0.6 (45?C), respectively. In response to a step-like increase of applied uniaxial loads, the dissolution rates of PS increased definitely at first, but the dissolution rate decreased gradually in the course of keeping the effective stress constant. After the effective stress was removed, there was a tendency that the dissolution rate increases more or less again. The apparent activation energy of our PS experiments was calculated to be approximately 24 kJ/mol, and this value is smaller than that of dissolution reaction of quartz sand at effective stress = 0. Our results clearly show that even at such low temperatures and low effective stresses, Si release into solution as a result of PS can be detected. Actually, when the stress is applied to a cracked granitic medium involving a groundwater flow system, the Si concentration in groundwater may be increased as a result of PS. This is interesting if there are available monitoring data as to dissolved Si in the groundwater for the purpose of earthquake prediction. We suggest that our study would help formulate a new method for the geochemical earthquake prediction study on the basis of pressure solution of SiO_2.

Keywords: pressure solution, quartz dissolution, earthquake prediction

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SCG066-07 Room:201A Time:May 22 12:15-12:30

ESR thermochronological studies on frictional heating events in the Taiwan Chelungpu fault drilling project Hole B cores

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The Taiwan Chelungpu Fault Drilling Project (TCDP) was launched in 2002 after the 1999 Chi-Chi earthquake to elucidate the rupture process caused in a subduction seismogenic zone, and continuous drill cores were collected from two main boreholes (Holes A and B) penetrating through the Chelungpu fault plane at depths [Ma et al, 2006]. In the Hole B cores, there exist three major fault zones at about 1136 m, 1194 m and 1243 m depths [Hirono et al., 2007]. As a result of the close investigations using various analytical methods, the black fault gouge zone distributed at about 1136 m depth (BGZ1136) is considered to have been most likely active in the Chi-Chi earthquake. Some preceding studies reported that high magnetic susceptibility and low inorganic-carbon content detected from the BGZ1136 may have been caused by coseismic frictional heating [Ikehara et al., 2007; Hirono et al., 2007]. On the other hand, X-ray diffraction analytical data clearly indicated that smectites, chlorites and illites exist in the BGZ1136 [Hashimoto et al., 2008; Hirono et al., 2008]. Especially the content of illites has been extremely increased as compared with that in the surrounding fault rocks, implying the occurrence of smectite-illitization in the BGZ1136 [Hirono et al., 2008]. However, since frictional heating is considered to cause an instantaneously dry state, hydrothermal reaction under a state of thermal equilibrium like smectite-illitization cannot occur at the same time as frictional heating. Thus, we carried out thermal analyses of the 1136m major fault zone in the Hole B cores using the electron spin resonance (ESR) technique. As a result, we obtained no evidence of the striking generation of frictional heat such as the anomaly of ferrimagnetic resonance (FMR) signal from the BGZ1136. Instead, we detected small FMR signal of maghemite from it. Magnetic analyses indicated that the black gouge has much higher coercive force than the surrounding fault rocks, suggesting the transformation of maghemite produced by ancient frictional heating into hematite due to hydrothermal reaction.

We have newly carried out thermochronological studies using the E_1' center, which is a paramagnetic signal associated with unpaired electrons trapped at vacancies in quartz [Fukuchi & Imai, 2001]. According to our step-by-step (5 minutes) heating experiments, the E_1' center commonly grows at 200-300 degree C, is saturated at 300-350 degree C and is almost annihilated at 450 degree C. The E_1' center in the BGZ1136 has been strikingly decreased, compared with those in the surrounding fault rocks, so that the black gouge may have been subjected to heat over 400 degree C. The only heat source is most probably frictional heating, because no igneous or metamorphic rock exists around the 1136m major fault zone. On the other hand, the E_1' center in the black gouge strikingly increases by heating at 250 degree C or more and has a maximum intensity at about 350 degree C. This means that the BGZ1136 was not subjected to heat over the heating for 5 minutes at 250 degree C in the Chi-Chi earthquake. This conclusion from the E_1' center is consistent with that from the FMR signal of maghemite. The E_1' center exactly suggests that frictional heat over 400 degree C detected from the BGZ1136 may have been generated earlier than the Chi-Chi earthquake. Moreover, thermochronological analyses using the E_1' center reveal that the black gouge may have been produced by ancient frictional heating older than 50 ka. The ESR thermochronology may allow us to identify coseismic frictional heating events of ˜1 ka in deep drill cores.

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Keywords: electron spin resonance, E' center, Chelungpu fault, fault gouge, frictional heat, thermochronology

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SCG066-P01 Room:Convention Hall Time:May 22 14:00-16:30

Mass transport in a fault zone: effects of fracturing and host rock lithology

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Fault zone development has the potential to impact regional groundwater flow (e.g. Caine et al., 1996, Geology). Groundwater flow plays an important role in mass transport and nuclide migration. Thus understanding mass transport along fault zones is one of the major subjects for topical issues such as geological disposal of radioactive waste. Here we analyzed whole-rock chemical composition of fault rocks from well-studied outcrops of the Atera Fault in central Japan, using XRF and ICP-MS, to elucidate chemical composition changes associated with fault activities.

The fault zone studied includes a smectite-rich fault core between two clearly distinguishable damage zones of cataclasite of the Naegi-Agematsu Granite and fault breccia of the Nohi Rhyolite on opposite sides of the fault core (Niwa et al., 2009, Island Arc). Black fragments of mafic volcanic rocks are included in the fault core. The fragments, derived from the Ueno Basalts of 1.5 Ma, are characteristically coated with carbonates.

On the basis of the whole-rock chemical composition analyses, we identified the concentration of heavy rare earth elements (HREE) and U in the fault core. Intense brecciation and subsequent fragment size reduction due to fault fracturing increase surface area and enhance potential for water-rock interaction and clay mineral formation (e.g. Wintsch et al., 1995, JGR). In addition, the radical reaction on new fracture surfaces during brecciation of silicate minerals generates hydrogen ions, which may facilitate further chemical reaction of fluids with silicate minerals to form clay minerals (Kameda et al., 2003, GRL). Assuming that the concentration of HREE and U in the fault core was caused by fault activities, sorption on clay minerals could be one of the dominant concentration mechanisms. The sorption reaction is mainly controlled by ion-exchange and/or complexation on mineral surfaces. In the case of ion-exchange reaction, light REEs (LREE) are more selectively-sorbed in 2:1 clay mineral such as smectite than HREE, because LREE have smaller hydrated radii than HREE (Otani et al., 2005, Resour. Geol.). On the other hand, REE tends to form complexes with carbonates, hydroxides or organic matters. These complexes are more stable for HREE than LREE (Shikazono et al., 2006, Resour. Geol.). It is possible for HREE to concentrate in the fault core together with the carbonate coated with the black fragments. Although REE and U is also concentrated by the sorption on iron oxide or iron hydroxide (Akagawa et al., 2004, J. Geol. Soc. Jpn.), these elements in the studied outcrop seems to be less correlated with composition changes of Fe.

The REE and U concentrations is also influenced by the dissolution and/or precipitation of minerals including these elements. The Naegi-Agematsu Granite is rich in radioactive minerals such as zircon and monazite (Ishihara and Wu, 2001, Bull. Geol. Surv. Jpn.), however, compositions of HREE and U in the fault rocks are less correlated with those of Zr and P. Thus their concentration could not be caused by the distribution of radioactive minerals. Moreover, there has a low likelihood of simple HREE precipitation in the fault core, because they are precipitated only in lower pH than LREE except tetravalent cerium. Th/U-Ce/U plots show that the fault core is under a reductive environment (poor in Ce and rich in U). The fault core shows sulfur concentration, as well as carbonate concentration in the fragments of mafic volcanic rocks. It is possible that uranium dissolved in groundwater could be migrated as complex ions binding to carbonate or sulfate ions, and precipitated in the reductive fault core (Kobayashi, 1989, Mining Geol.).

As discussed above, heterogeneity of host rock lithology presented as mixing of fragments of mafic volcanic rocks in the fault core has a great influence on the concentrations of specific elements, through surface complexation of HREE and uranium precipitation in the reductive environment.

Keywords: fault zone, mass transport, rare earth element, clay mineral, carbonate

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SCG066-P02 Room:Convention Hall Time:May 22 14:00-16:30

Zircon thermochronology of fault zones:Case study of the Mozumi-Sukenobu fault, central Japan

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Quantitatively understanding of heat generation and transformation associated with faulting is a key to understand not only dynamics of faults but also heat budget, temperature structure and range records. To understand thermal history along faults, geologic thermometers such as thermochronometers, homogenization temperatures of fluid inclusions and vitrinite reflectances have been used. Zircon fission-track thermochronology has been one of the most powerful tools to reveal thermal history along faults (e.g., Murakami et al., 2004; Tagami and Murakami, 2007). Zircon fission-track thermochronology has advantages as below: (1) fission tracks are annealed only by heating, (2) zircon is physically robust and chemically stable and can occurs along fracture zones, and (3) short-term annealing kinetics of zircon fission tracks is well understood based on laboratory experiments.

In the Mozumi-Sukenobu fault, the strongest thermal anomalies were detected between two fracture zones identified in the tunnel by using zircon fission track methods. This secondary heating is attributed to ore deposit water probably sourced from the Kamioka mine on the basis of spatial distribution of ZFTand ZHe ages, numerical calculations using the 1-D thermal diffusion equation, geological observations and ZFT inversion calculations.

Keywords: thermochronology, fault, Atotsugawa fault group

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Temporal change and factor analysis of radon concentrations in discharged gas of an active volcano

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Clarifying geologic structure and property is important to resource exploration, utilization of underground space and disaster prevention against earthquake. In this study, we adapted radioactive surveying, which has been widely for investigations of active fault, surface geology, groundwater, and geothermal to identify predominant factors on radionuclide concentration in the top soils in tectonically active areas. Possible factors are earthquake, tide, groundwater, temperature and pressure at deep parts, and fault. These factors are contained in active volcano areas and therefore, a fumaroles site at the western side of Mt. Aso was selected. Target nuclide was Radon (^{222}Rn), which is inactive chemically and can exist in only gas condition among all radioactive nuclides. Ionization chamber method was used to detect alpha rays accompanying the decay of Rn: electric charge and current are detected as output signal of electric voltage by ionization effect. Rn gas was pumped up from 1 m depth and Rn concentrations had been measured continuously at 10 minute interval from 11 September 2001 to 15 January 2004.

Rn concentrations showed large and periodical change with time and had strong correlation with daily average temperature. The effect of temperature was removed from the original data and the residual components were assumed to be determined by tectonic factors. By comparing the residual components with the main nine components of earth tide calculated using GOTIC2 (Matsumoto *et al*., 2001), the tidal force was clarified to have strong effect on Rn concentration because the residual components became large generally with the increase of the tidal force. In addition, a relationship between the volcanic earthquakes and the rise of residual components was found.

To confirm the effect of tidal force on Rn concentration, a laboratory experiment was conducted using granitic soils filled in a box and a granite sample as a Rn source in the soils. Rn concentrations on surface were measured and confirmed to have a relationship with the earth tide. Consequently, control factors on Rn concentration were identified as earthquake activity and earth tide in deep depths, and the temperature was considered to change Rn concentration near the surface by affecting the velocity of gas rise.

Keywords: radon, temperature, volcanic earthquake, earth tide, Mt. Aso

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Introduction of a new groundwater and gas monitoring system

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We developed a Quadrupole Mass Spectrometer into a groundwater and gas monitoring system in order to measure gasses under ground continuously. Advantages of the system are following, 1) Gases can be measured anywhere the system can stand in an area of 1 m x 1 m because the size of the system was reduced, 2) The operation is unattended during observations by a working of an automatic gas collecting and dehydrating unit. Here, we introduce a new groundwater and gas monitoring system (Groundwater data analyzing system; GROWDAS).