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Subsurface gas monitoring for seismo-geochemical studies in Haruno borehole

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The results of subsurface gas monitoring are reported by application of gas chromatography (GC) to the gas composition of bubbles associated with groundwater for seismo-geochemical studies. An automated gas monitoring system was used to determine gas compositions in a 500 m borehole at the Haruno Crustal Movement Observation Site (HOS), central Japan during the period (1) from December 1999 to December 2000. The average compositions of gases and fluctuations (2SD) in this period were He = 82 ppmV, H_2= 170 ppmV, Ar = 0.05%, N_2= 50% and CH_4= 45%. A new automated gas monitoring system equipped with a micro-GC was installed in the borehole at the HOS, and gas bubbles from the borehole were monitored during the period (2) from December 20 06 to March 2007. The average compositions of gases and fluctuations (2SD) in this period were He = 8 ppmV, H_2= 13 ppmV, Ar = 0.6%, N_2= 66% and CH_4= 14%. The gas concentration ratios (He/Ar, H_2/Ar, N_2/Ar, and CH_4/Ar) fluctuated significantly over time and repeatedly showed abrupt spike-like increases during the period (2). The gas compositions obtained in the period (1) and (2) were markedly different. Over the period from 2000 to 2007, the gas bubbles have been depleted in He, H_2, and $CH_4$of subsurface origin, but enriched in Ar and $N_2$of atmospheric origin. The difference can be interpreted as being due to an irreversible change of the aquifer/gas system. The present subsurface gas composition at HOS is estimated to be He = 63 ppmV, H_2= 37 ppmV, Ar = 0.17%, N_2= 63%, and CH_4= 37%. The new monitoring system is able to analyze the gas composition with a smaller volume of sample gas and with higher precision than the previous system. During the three month monitoring period (2), the separation capacity of the capillary column of the micro-GC was sufficiently maintained to determine gas chromatographic peak areas for the five gaseous species examined. This study verifies that the new monitoring system with micro-GC is promising for continual subsurface gas monitoring for earthquake prediction studies.

Keywords: earthquake prediciton, groundwater, gas monitoring, spike-like increase, subsurface gas