Path of hydrogen gas in fault zones

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Significantly high concentrations of hydrogen gas have been observed at active faults (e.g. Wakita et al., 1980; Sugisaki et al., 1983). Experimental studies have suggested that such hydrogen gas is generated by a radical reaction due to rock fracturing caused by fault activity (e.g., Kita et al., 1982; Kameda et al., 2003). Although many studies of hydrogen gas observation have been reported with the view to fault activity assessment or earthquake prediction (Notsu, 2005), path of hydrogen gas derived from fault activity is poorly understood. Shimada et al. (2005) suggested that hydrogen gas produced by rock fracturing in deep underground faults was dissolved by groundwater, and transferred by advective flow to land surface, on the basis of the measurement of gas extracted from boring cores penetrated to fault zones. If the hydrogen gas is transferred by advective flow with groundwater, high concentrations of hydrogen gas can be observed in the crack-rich damage zone of high permeability, rather than in the clay-rich fault core of low permeability. Here, we tried multipoint hydrogen gas measurements along a fault zone crosscutting an active fault. The method of hydrogen gas measurement conforms to that through the use of a portable gas monitor and a hand drill shown by Shimada (2006, 2007).

The studied exposure includes the Atera Fault which is one of the active faults located in Gifu Prefecture. The fault plane in the study area trends northwest and separates welded tuff in the western side and granite in the eastern side (Niwa et al., 2005, 2006). The fault zone consists of, from west to east, fault breccia derived from welded tuff (14 m in width), smectite-rich fault gouge (1.2 m in width), and fault breccia and cataclasite of granite (5 m in width). We monitored hydrogen gas concentration for 3 hours in multipoint of the fault zone, as well as cracks in protolith outside the fault zone.

The hydrogen gas monitoring show that hydrogen gas more than 60 ppm/min is releasing from the fault breccia and cataclasite, whereas that less than only several ppm/min is releasing from the fault gouge as well as from the cracks in protolith outside the fault zone. Specifically, higher concentration of hydrogen gas than 300 ppm/min is monitored at the breccia and cataclasite in the granite. This result indicates that the hydrogen gas is transferred in the breccia and cataclasite of relatively-high permeability rather than in the smectite-rich fault gouge of low permeability, and strongly supports the suggestion by Shimada et al. (2005) that a path of the hydrogen gas derived from fault activity is controlled by advective flow with groundwater.

References: Arai et al. 2001, Island Arc 10, 430; Kameda et al. 2003, GRL 30,10.1029/2003GL018252; Kita et al. 1980, Geochemical Journal 14, 317; Kita et al. 1982, JGR 87, 10789; Notsu 2005, Chikyu Monthly 27, 461; Niwa et al. 2006, Japan Geoscience Union Meeting 2006; Shimada et al. 2005, 2005 Japan Earth and Planetary Science Joint Meeting; Shimada et al. 2006, Japan Geoscience Union Meeting 2006; Shimada et al. 2007, Japan Geoscience Union Meeting 2007; Sugisaki et al. 1983, Journal of Geology 91, 239; Wakita et al. 1980, Science 210, 188.