

Evidence for the hypothesis of upwelling fluid from deep underground

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Stress changes associated with crustal deformations may induce migration of fluid within the crust. It is hypothetically expected that a volume of pore water or fluid, being suddenly pressured in response to an elevated stress level in some seismogenic zone, will tend to intrude up into a crack network, and incidentally emerge at the ground surface or in the aquifer near ground surface. That hypothesis was presented in around 2005. The evidence at that time were as follows:

1) Frequent rises in well water temperature were observed at Iwakuni, Yamaguchi Prefecture, southwest Japan; 2) Gushing of groundwater at the sea bottom was considered to have occurred at the Akashi Strait 2 days before the 1995 Kobe earthquake of M7.3, based on an interpretation of the appearance of brownish-black seawater found by the captain of a passenger boat; 3) Upwelling of deep hot groundwater was occurred at Inagawa Town, Hyogo Prefecture, southwest Japan, which was associated with the 1995 Kobe earthquake. The well water temperature rose 3-4 °C at the time of the shock, and decayed with a time constant of 1-2 years; 4) Heating of ground rocks by upwelling hot water intruding into the fracture zone of an active fault, which is considered to be a precursor for the April 1, 1995 Niigata-ken Hokubu earthquake of M5.5, was confirmed by a LANDSAT infrared image in the northern Niigata area, central Japan, on a summer night in 1994. All of the above transient phenomena can be reasonably understood in the light of the hypothesis of pressured hot water upwelling from deep underground in response to crustal movements around seismically active regions.

The amount of the upwelling fluids will change according to the pressure changes due to deformation of the crust. Shallow groundwater temperature will also change according to the change of the amount of the intruded hot water from deep underground. It should be noted that the 2009 Suruga-bay earthquake of M6.5 in Tokai area, central Japan, was accompanied by precursory and after-effect changes of groundwater temperature. That kind of changes were not detected by the strain meters installed by JMA around the Tokai region. Precursory and after-effect temperature changes were found for other earthquake events such as the 2011 Tohoku earthquake of M9.0.

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