

Concentration of Carbon at the Central Plane in the Nojima Fault Zone

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Introduction

The Nojima fault appeared on the surface in the northern part of Awaji Island, central Japan as a result of the Hyogoken-Nanbu earthquake (1995.1, M=7.2). An active fault drilling was performed by the National Research Institute for Earth Science and Disaster Prevention (NIED) near the fault at Nojima-Hirabayashi, and core specimens were retrieved from depths of 1001 to 1810m were retrieved simultaneously. This borehole penetrated three fracture zones around the depths of 1140m, 1300m, and 1800m, respectively. We analyzed carbon and oxygen isotope ratios of calcites, carbonate and graphite (C) contents to reveal the characteristic of fluids which precipitated the calcite in the active fault zone and the phenomenon associated with fault movements.

Methods

Calcite samples were obtained from the drilling cores in fracture and non-fracture zones. Each of samples was powdered and analyzed by X-ray diffraction method to ascertain the abundance of calcite. Powder samples were reacted with 100% phosphoric acid at 25degrees Celsius in vacuum (McCrea, 1950), and calcite converted into carbon dioxide. These isotopic compositions were measured with a mass spectrometer (MAT250). Graphite contents were analyzed by CHN analysis after reacted with hydrochloric acid (8%) to remove carbonate rocks.

Results

Carbonate contents

Carbon contents were 0.5 to 3.5 wt. % in the hanging wall, 0.2 to 0.8wt. % in the foot wall and about 0.2 wt. % in non-fractured rock. Therefore, fault fluids migrated mainly through the hanging wall.

Graphite (C) contents in the 1140m fracture zone

Graphite was concentrated at the central plane.

Carbon and oxygen isotope ratios of calcite

The analyzed values of the carbon and oxygen isotope ratios are -13.2 to 0.1per-mil and 8.6 to 21.6 permil, respectively. The carbon and oxygen isotope ratio of calcite in the fracture zone at a depth of 1140m, 1300m, 1800m is enriched in ^{13}C and ^{18}O compared to the non-fracture zone. These results indicated fluids enriched ^{13}C and ^{18}O migrated along the fracture zone.

Discussion

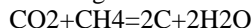
Carbon isotope ratio of CO_2 and oxygen isotope ratio of fluid in the fracture zone

At the other borehole (DPRI1800m borehole), the carbon isotope ratios of CO_2 were equilibrium with those of CaCO_3 at the temperatures where the cores were retrieved; 40 to 50degrees Celsius (Arai et al., 2001).

If the fluids have migrated through the fracture zone and precipitated calcite at the depths where the core specimens were retrieved (29 to 58degrees Celsius), the isotope ratios of fluids in equilibrium with these carbonates are calculated to be $\delta^{13}\text{C}$: -22 to -8per-mil and $\delta^{18}\text{O}$: -18 to 4per-mil. In general, geothermal fluids is enriched in ^{13}C and ^{18}O (Sano and Marty, 1995, Matsubaya et al., 1973). For example, $\delta^{13}\text{C}[\text{CO}_2]$ values of geothermal fluids range from -10 to 0per-mil. As mentioned above, the carbon and oxygen isotope ratio of calcite in the fracture zone at is enriched in ^{13}C and ^{18}O compared to the non-fracture zone. Therefore, calcite may be formed from geothermal fluids in the fracture zone.

Graphite (C) contents in the 1140m fracture zone

Graphite was concentrated at the central plane. A number of theories for the hydrothermal origin of graphite have been published. For example, when geothermal fluids associated with CO_2 and CH_4 upwelled the fracture zone with decreasing pressure, graphite was generated as the following reaction (Rumble and Hoering, 1986).



On the other hand, Salotti et al.(1971) assumed extraction of C from calcite as CH_4 by the reaction $\text{CaCO}_3 + 4\text{H}_2 = \text{CH}_4 + \text{H}_2\text{O} + \text{Ca}(\text{OH})_2$, and precipitation by $\text{CH}_4 = \text{C} + 2\text{H}_2$.

In general, graphite is formed in a reduced environment. Therefore, it may be formed by a hydrothermal fluids migrated from depths or by a high pressure and frictional heat associated with fault movements.

We will characterize the state of graphite with laser Raman microprobe.