A geophysical insight into the relationship between magma migration and faulting activity at seismogenic depths

Shinji Nakaya[1]; Kiminori Nakamura[2]

[1] Civil Eng., Shinshu Univ.; [2] Department of Civil Engineering, Shinshu Univ

To realistically model such a fluid flow we must adequately represent the geometry of individual fractures, and then evaluate the connectivity of the network as a whole. A benefit of being able to accurately evaluate fracture network connectivity may be geophysical insight into the relationship between magma migration and faulting activity at seismogenic depths [e.g., Tsuneishi and Nakamura, 1970; Byerlee, 1993; Tsunogai and Wakita, 1995; Miller et al., 1996; Yamashita, 1997].

Many researchers have reported that natural fracture network patterns exhibit partial fractality in terms of fracture size (length) distribution, spatial distribution and aperture distribution [e.g., Okubo and Aki, 1987; Hirata et al., 1987b; Hirata, 1989; Ohno and Kojima, 1992; Marrett and Allmendinger, 1992; Gillespie et al., 1993; Bloomfield, 1996; Cladouhos and Marrett, 1996; Balberg et al., 1991; Bour and Davy, 1997; Van Dijk et al., 2000; Gillespie et al., 2001; Wilson, 2001], and that the spatial distributions of earthquake hypocenters are partially multifractal [e.g., Kagan and Knopoff, 1980; Kagan, 1981a, b; Geilikman et al., 1990; Hirata and Imoto, 1991; Hirabayashi et al., 1992; De Rubeis et al., 1993; Godano and Caruso, 1995; Legrand et al., 1996; Godano et al., 1997; Godano et al., 1999; Nakaya and Hashimoto, 2002]. Moreover, seismogenic fault lengths are also found to follow a power law (fractal) distribution, as revealed by two empirical relationships: the Gutenberg-Richter frequency-magnitude relationship [e.g., Turcotte, 1997] and the relationship between magnitude M and faulting area S, log S = M-4.07 [Sato, 1979]. A number of researchers have recently described these natural fracture network patterns and the connectivity properties using binary fractal fracture network models or models based on fractality [e.g., Darcel et al., 2003; Nakaya et al., 2003]. The growth of fault fracture networks in the seismogenic layer before and after major seismic events can therefore be expected to be related to the temporal variation of fractal parameters during seismicity [Nakaya, 2005].

In this study, the relationship between percolation probability and fractal parameters has been investigated using a random three-dimensional network model with the Monte Carlo method, in order to understand fluid migration through a binary fractal fracture network [Nakaya et al., 2003]. The numerical results indicate that applying the percolation probability to dynamic fracture networks in earthquake swarm at the region of Miyakejima and Niijima- Kozushima Islands, 2000 substantiates the hypothesis that the three fractal geometric parameters control the fracture connectivity and hence the migration of magmas through seismogenic faults. Our numerical approach may be equally applicable to studies of earthquake-fluid interaction based on seismicity catalogs.