

Dyke intrusion model and crustal deformation

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At eastern off Izu Peninsula, central Japan, earthquake swarms have been intermittently repeated over the 20 years since June 1978. In total, 30 swarm events were recognized in the last 20 years. Synchronized to the occurrences of these swarms, remarkable crustal deformation has also been repeatedly detected by means of tiltmeters, strainmeters, leveling surveys, laser distance measurements, and GPS observations.

In the earlier 10 years, abnormal crustal deformations were mainly observed by repeated surveys and the groundwater observations. However, it was difficult to distinguish whether these abnormal deformations are accumulated continuously or step-wise because of poor time resolution in the survey methods and unstable co-seismic responses in the groundwater observation. Only possible co-swarm signals had been detected by a volumetric strainmeter installed at Higashiizu (HIG) station. But they were not always believed to be true signal because they were reported from only one station and the contamination of rain effects was suspected. Moreover we could not explain the signal amplitudes which were fairly large compared to its epicentral distances. In March 1989, a borehole tiltmeter started operation at Kawana (KWN) station adjacent to the swarm region. It recorded a clear co-swarm tilt signal associated with the event in May 1989, simultaneously with a strainmeter record at HIG. Then they were confirmed to be true signals associated to the swarms. Two months later, another strong swarm started in July 1989 and was accompanied with a submarine eruption at Teishi knoll. A plenty of data obtained from this event enabled us to establish a dyke intrusion model for the swarm activity in this area [Okada and Yamamoto, 1991]. Since then, repeating swarm events and associated crustal deformations could be successfully modeled by the same concept.

In addition to such a co-swarm crustal deformation, it was found that small precursory crustal deformation signals are preceded to the major swarm activities by careful check of the tiltmeter records associated to the repeated swarms [Okada et al., 2000]. Preceding the start of swarm activity the tiltmeter installed at KWN showed a gradual tilt movement having the following characteristics. (1) It clearly appears only for major swarms. (2) Preceding time is several hours to half a day. (3) Signal level is an order of 0.1 micro-radian. (4) Tilt direction is always NE down and smoothly connects to the initial co-swarm movement. From the final point we can consider that the pre-swarm tilt has the same origin as the co-swarm one. Namely, we can assume that the cause of pre-swarm crustal deformation is dyke intrusion at depth. Such pre-swarm crustal deformation signals were also detected by an adjacent tiltmeter and a three-component borehole strainmeter (Ishii, 1997) as well as the volumetric strainmeter at HIG.

Persistent swarm activity seemed to stop after a major event in April 1998. At the same time long lasting abnormal crustal deformation also seemed to stop its movement. However, after a quiescence of 4 years, a minor swarm activity took place again on May 2002 and similar events were also repeated on June 2003 and April 2004. At present we have no definite answers to the following questions. (1) Until when the swarm activity will continue? (2) Will major swarm recur in near future? (3) Will volcanic event like in July 1989 happen to occur?

References

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