Self-potential changes on Unzen Volcano 1991-2001

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abstract. Evolution of a hydrothermal system beneath Unzen Volcano has been investigated by self-potential (SP) monitoring for eleven years since 1991. We detected a large and steep rise in SP before the formation of the summit lava dome in 1991. A concentric positive SP anomaly around the dome amounting more than 1000mV was found. Besides the positive anomaly, we have observed the growth of a negative center adjacent to the dome during the early stage. The growth of such bipolar SP change is attributed to the streaming potential associated with shallow hydrothermal circulation, which is driven by the onset of the magmatic eruption (Hashimoto, 1995). Our monitoring has revealed that the concentric positive SP still exists and even shows a gradual growth at some stations after the eruptive period. This fact implies that a hydrothermal circulation will not easily disappear once it is set up. Spatial pattern of SP is basically stable throughout these eleven years.

1. General features of SP anomaly on Unzen

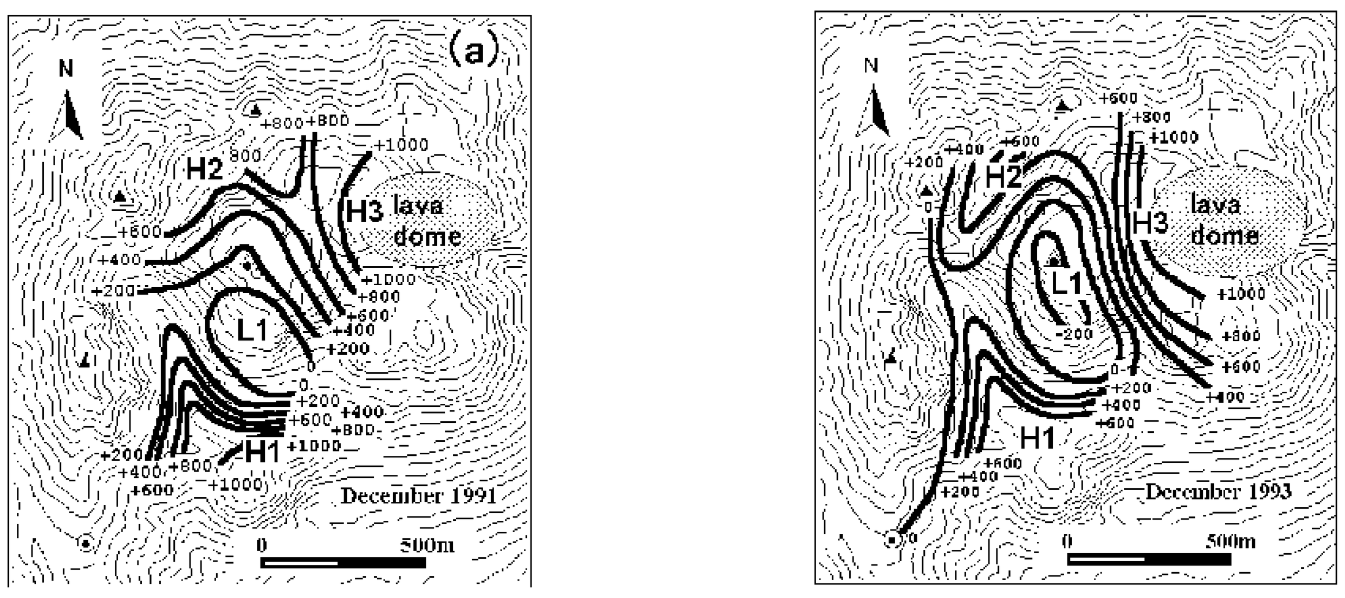


fig. 1: SP mappings on Unzen in 1991 (left) and 1993 (right). A large positive SP anomaly around the newly formed lava dome (H3) is distinct. The H1, H2, and L1 are mainly due to topographic effect. Unit of the contour values is mV. We consider that these SP variations are due to the streaming potential (electro-kinetic effect) associated with subsurface hydrothermal circulation.

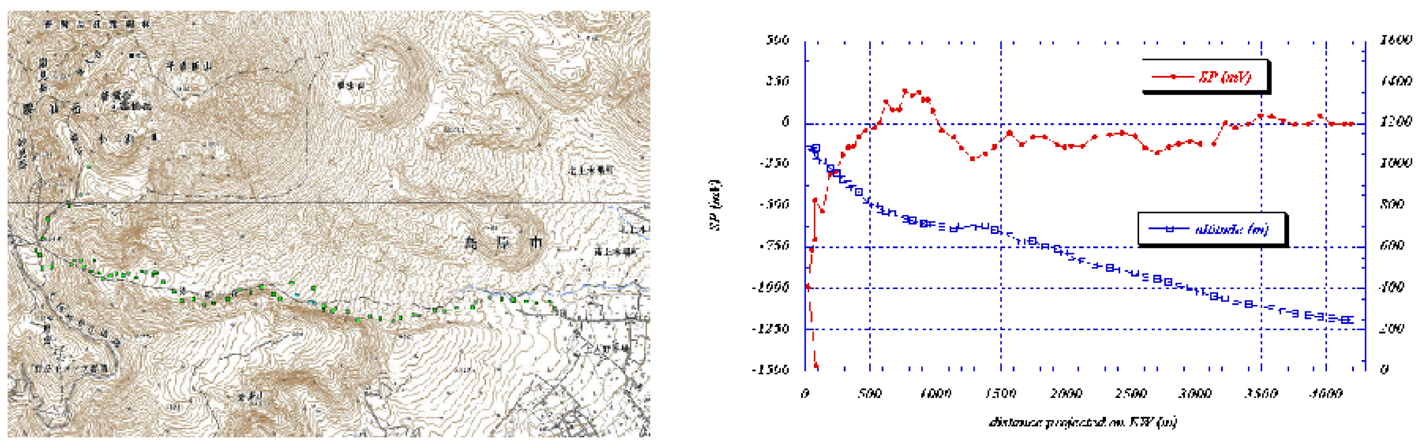


fig. 2: SP profile along eastern flank of Unzen (Akamatsudani valley). We can see a clear negative correlation between SP and topographic altitude, which is explained by normal topographic effect. Accordingly, the positive SP around the new dome as shown in fig.1 is restricted only in the summit area, suggesting the source-depth is shallow (<1km).

2. Evolution of SP anomaly

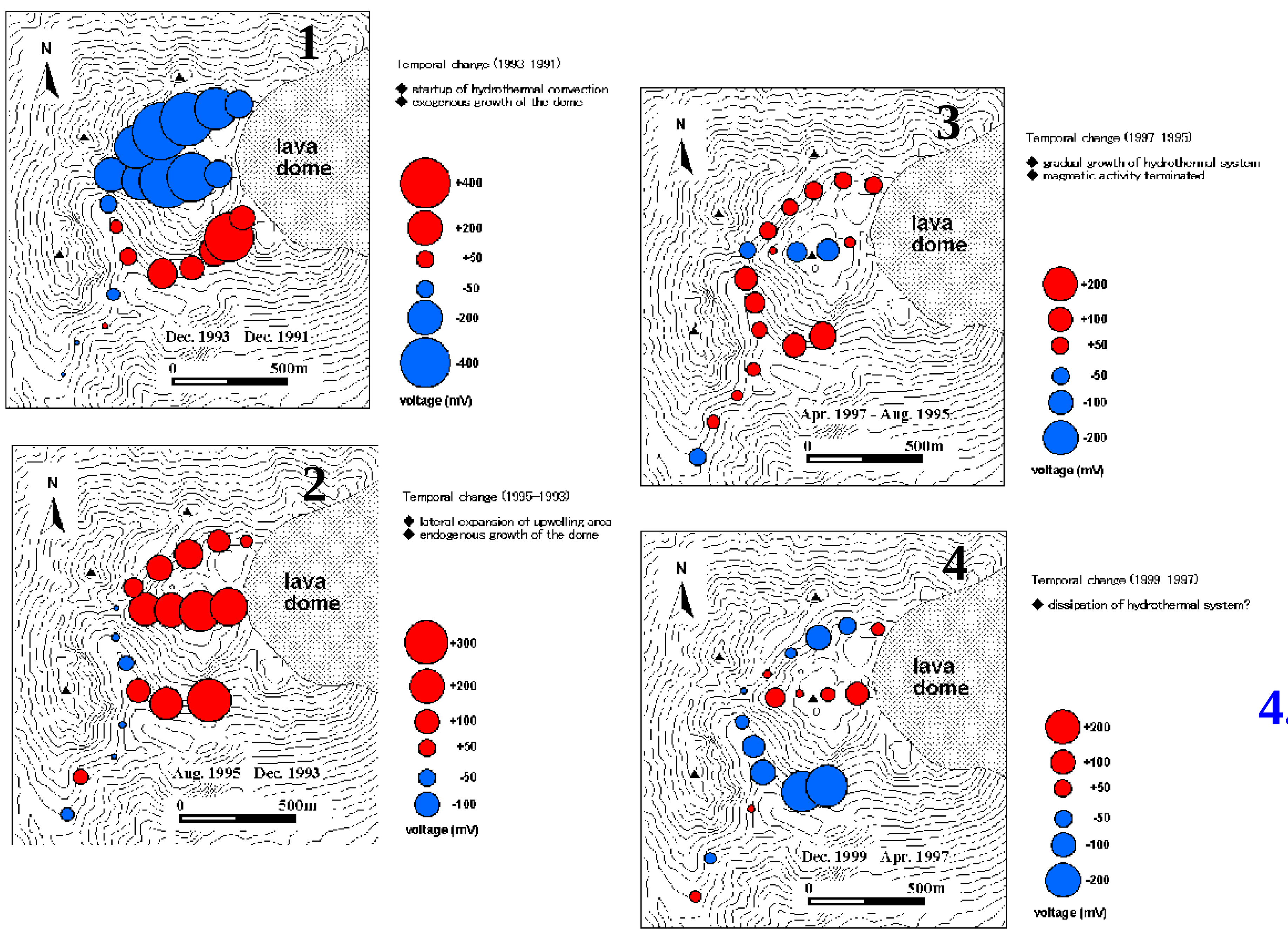
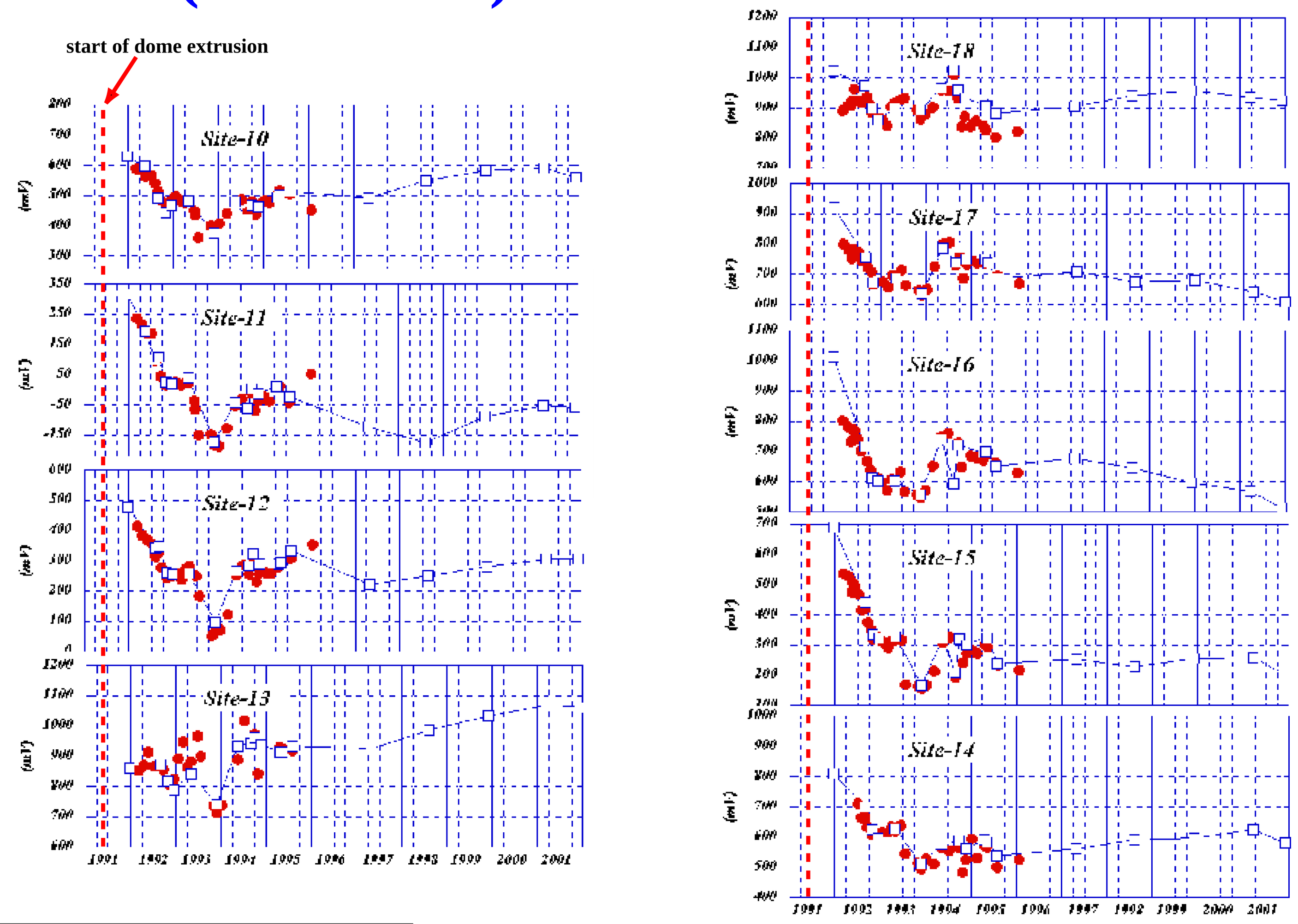
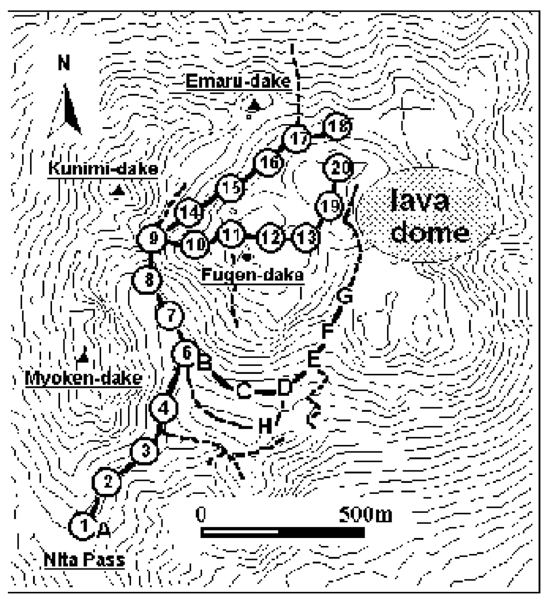


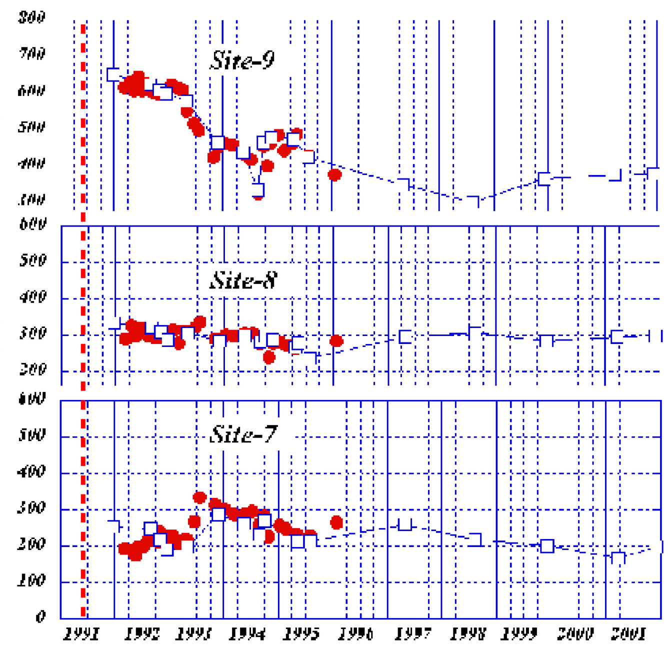
fig. 3: Distribution of temporal changes of SP between the periods, 1991, 1993, 1995, 1997, and 1999. A bipolar change at the first stage is clear, plausibly indicating the start-up of the hydrothermal circulation at shallow part of the summit area. We consider that the changes in negative sense is attributed to the down flow of meteoric water due to a growth of entrainment of circulation. The succeeding growth of positive changes in the second stage is probably due to the lateral expansion of the upward flow around the new dome.

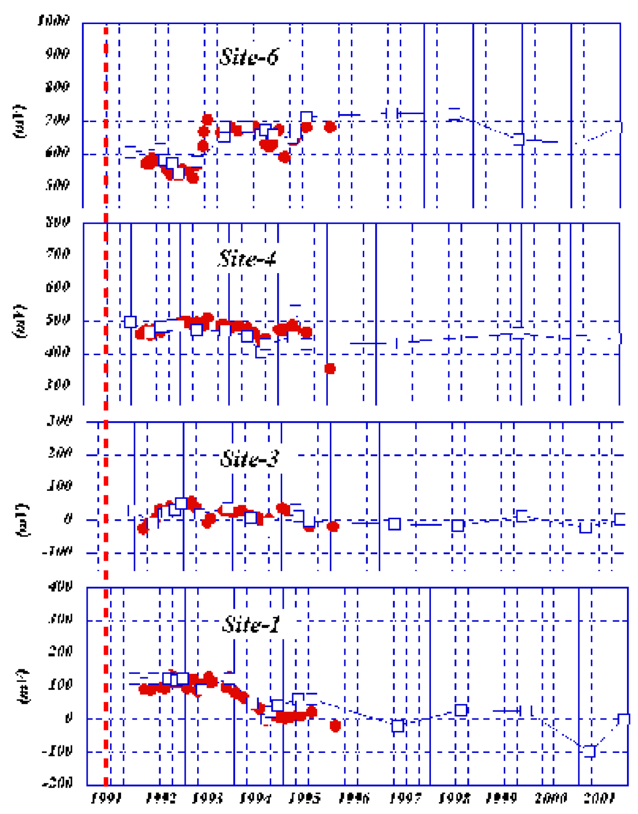
3. Time series (1991-2001)





stations of SP measurements





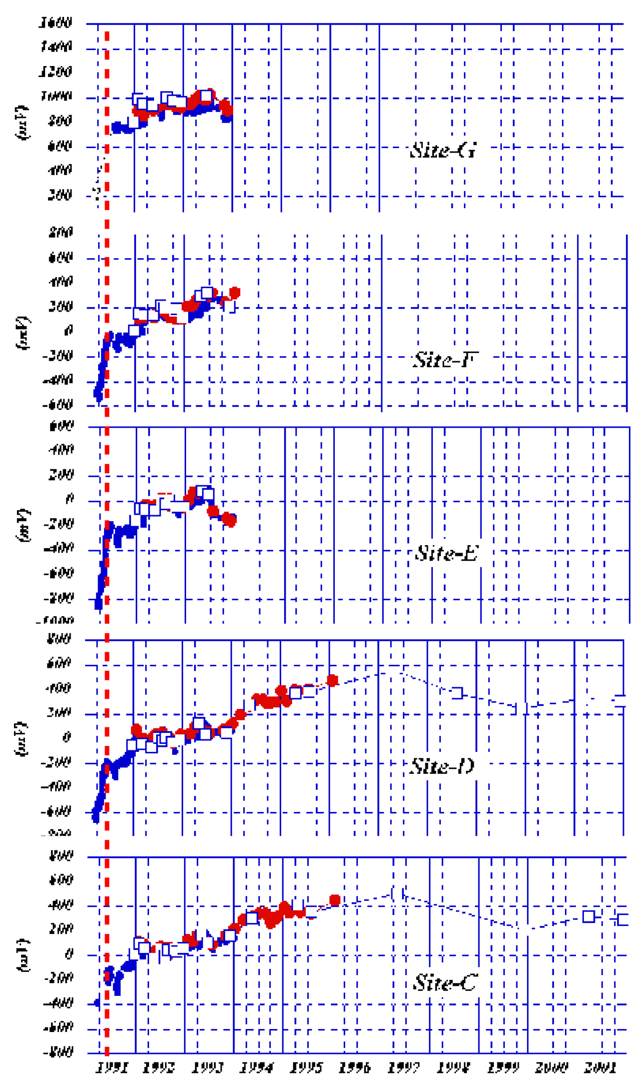


fig. 4: Time series of SP during 1991-2001. Largest and steep increase was observed on southwestern flank of the dome before the extrusion in May, 1991. Changes roughly settled down after 1996. However, the highest SP level at the new dome still persists.

4. Plausible model for subsurface hydrothermal system

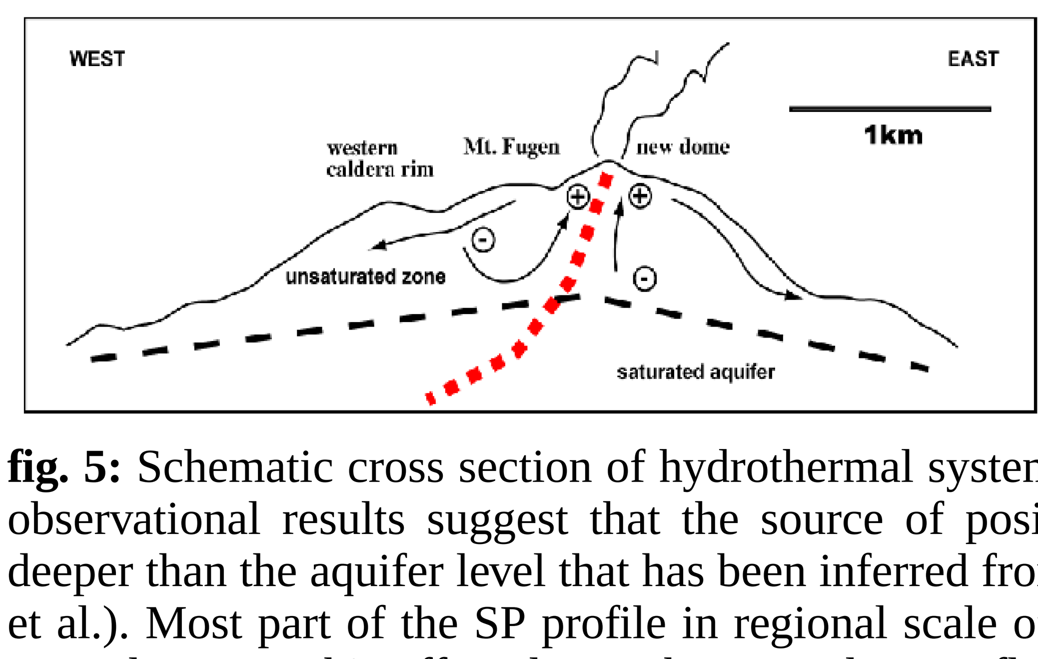


fig. 5: Schematic cross section of hydrothermal system inferred from SP results. Our observational results suggest that the source of positive SP on the summit is not deeper than the aquifer level that has been inferred from resistivity survey (Kagiyama et al.). Most part of the SP profile in regional scale of this area can be explained by normal topographic effect due to the ground-water flow from top to foot. Hence, the SP anomaly and its evolution at the summit is attributed to the upward flow of hydrothermal water along the conduit and its entrainment circulation system of surrounding area in unsaturated zone at shallow part of the volcano.