BEHAVIOUR OF FISSURE ERUPTION OF 1986 IN IZU-OSHIMA AS A GEOTHERMAL HEAT SOURCE

HAYAKAWA, M., Fac. of Marine Sci. and Tech., Tokai Univ.,
Orido 3-20, Shimizu 424, Japan

Izu-Oshima is one of the active basaltic volcano in Japan. This island is located roughly 100 km south of Tokyo. It is well known that in the time of the recent activity of November,1986, not only the eruption of central cone, Miharayama, but also there occurred fissure eruptions trending NNW direction crossing the caldera rim.

The last big eruption prior to the present one was taken place in 1950 and 1951. In that periods, the author with his colleagues made gravity surveys there several times, and by the recent re-examination of these data, it became clear that some changes of gravity with time in that periods were already appeared also in the very place of fissure eruptions of 1986's recent activity. This fissure eruption is seemed to be something similar related to the Middle East Rift Zone on the eastern flank of Kilauea volcano, Hawaii, where is famous of production of approximately 3 megawatts of electric power from the geothermal well HGP-A.

In the following, the author explains the outline of the studies mentioned above.

On the mid-July 1950, a sudden eruption initiated a period of activity lasting for about 70 days until the last part of September 1950; after remaining dormancy for five months, another active period of about seventy days occurred from the beginning of February to mid-April 1951.

During these two periods of activity many eruptions occurred, and lava and other ejectamenta were continually thrown out. The greater part of the atrio was covered with lava.

This activity provided an opportunity to investigate whether any significant local changes in gravity take place during the periods of volcanic activity, and to clarify this problem, the gravity surveys were conducted on Oshima island at four different times between September 1950 and April 1951, and the gravity measurements were done at more than 50 widely distributed stations.

For this surveys the authors used a North American gravimeter imported in August 1949 from the United States. Paralleling with these gravity measurements, levelling survey was also performed at each station, using a Wild universal theodolite (Fig.1, Iida et al., 1952).

Regarding the results, as seen in Figs. 2-5 there appeared remarkable changes in the gravity values, by taking the levelling results into considerations. By the levelling survey, it was clear that the maximum changes in level were only +20 cm mostly in the summit areas. These elevation changes, corresponding to 0.07 milligals in gravity effect, are neglegible in relation to the observed changes in gravity. Briefly speaking, the gravity values increased during the dormant phase and this was particularly noticeable within the somma.

To explain the changes in gravity, authors assumed the presence of a spherical magma beneath the crater which gradually filling with magma in preparation for the next eruption, and being drained, or partially drained by the eruption. The sphere was calculated to be 200 meters in diameter at a depth of deeper than 2 km.

Besides these, recently, by the re-examination

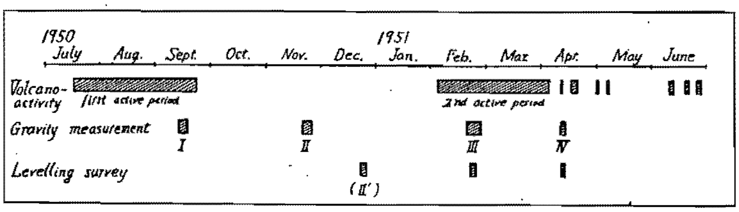

Fig. 1 Volcanic activity, gravity measurement and levelling survey duting 1950 and 1951's volcanic active periods at Oshima volcano.

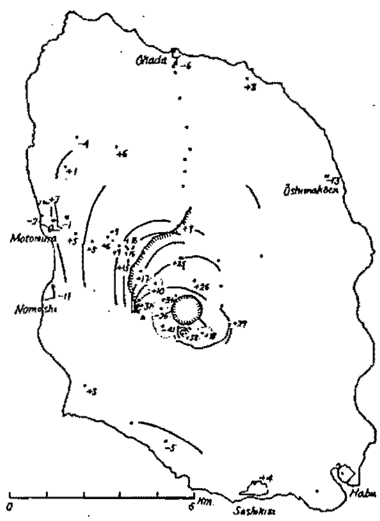

Fig. 2 Change in gravity between September and November, 1950.(Unit 0.01 mgal)

of these data, synthesizing all the changes of gravity with time, it became clear that some changes of gravity with time in that periods were already appeared in the very places of fissure eruptions of 1986's recent activity.

In this case, of course, the effect by levelling changes was taken into considerations, although the amount was very small of several centimeters.

For example, Fig. 6 shows the case obtained by combining the result of Fig.2 with that of Fig.5.

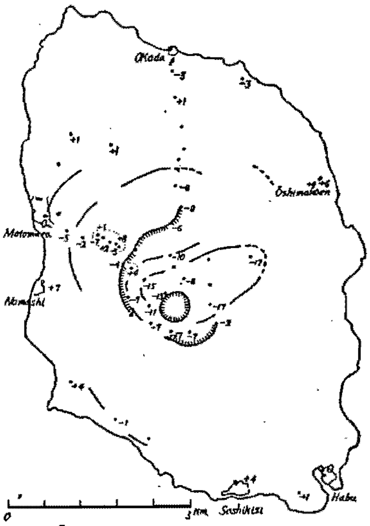

Fig. 3 Change in gravity between November 1950 and February 1951. (Unit 0.01 mgal)

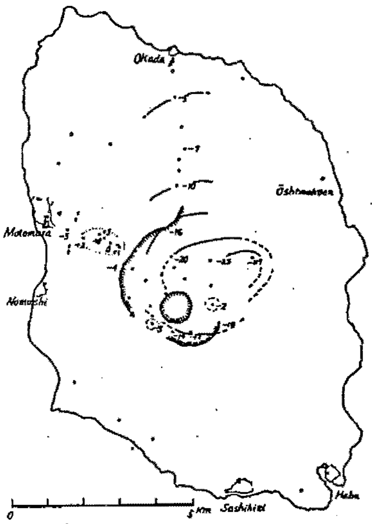

Fig. 4 Change in gravity between February and April, 1951. (Unit 0.01 mgal)

In Fig.6, the changes in gravity within the period of Fig.2 are shown by the lines of ∿∿∿, while those within the period of Fig.5 are shown by the lines of —‿--- , respectively. Looking carefully these results, the average direction of changes in gravity with time shows the trend of NNW-SSE direction crossing the caldera rim, although there are slight fluctuations of the pattern of gravity changes (this average direction is shown by the straight line ——).

By the way, in this connection, it is also very interesting to see the seismicity before and after the fissure eruptions in the time of the recent 1986's activity, which is seen in Fig.7 (Yamaoka et al., 1988).

In the leftmost figure, you see the seismicity of Nov.15-20, 1986, and in the middle, the seismicity of the fissure eruptions' time, Nov.21, 0-16 hr and, the rightmost one shows the seismicity after the fissure eruptions, Nov. 21, 16 hr - Nov.31, 1986.

There seem some fluctuations between the directions of seismicity with time, although the average trend shows NNW direction. Comparing these with Fig.6 of gravity change of 1950-1951, it is very interesting to see the similarity between them.

Let us consider here on the gravity change with time along the NNW direction crossing the caldera rim in the time of 1950-1951's activity in Fig.6.

This matter is very interesting because these gravity changes in this area may suggest the upward crypto-magmatic activity, although the energy might not enough to make fissure eruptions in those days.

But, it is important to see that the preparations for making fissure eruptions might already have been made more than 35 years ago.

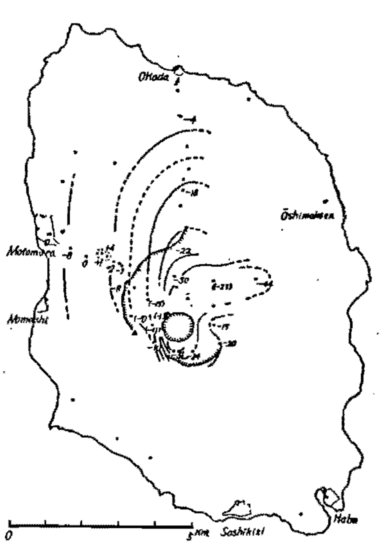

Fig. 5 Change in gravity between November 1950 and April 1951. (Unit 0.01 mgal)

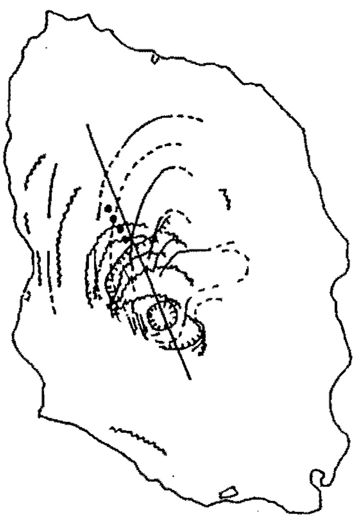

Fig. 6 Change in gravity (1950~1951) & Fissure eruptions (•) (1986)

On the other hand, regarding the recent activity of Nov.,1986, from the geochemical and petrological standpoints, it is interesting to see that the ejecta from the central crater of Miharayama are different from those erupted from the fissures on the caldera floor and on the outer slope of the main volcano, namely, the amount of main chemical composition SiO is quite different in the central crater and the areas of fissure eruptions, that is, for the former SiO_2 51-53%, while for the latter, SiO_2 54-55%, using the ejecta of scoria. This matter might suggest the difference of conduits and heat supply sources for these eruptions (Aramaki and Fujii, 1988).

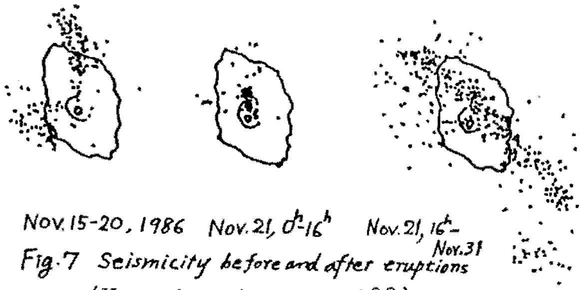

Fig.7 Seismicity before and after eruptions (Yamaoka et al., 1988)

These phenomena remind the author the similarity with the case of the Middle East Rift Zone on the eastern flank of Kilauea volcano, Hawaii (Thomas, 1986).

Of course, there are differences between the case of Oshima and Hawaii, from the size of length of the Rift zone and fissure, and also from the consolidation of the basement.

At the eastmost of the Middle East Rift Zone of Kilauea, it is famous of the geothermal well HGP-A. The well was completed in 1976 to a depth of 1968 meters and has a bottom temperature of approximately 358°c. This well has a production capacity of about 50,000 kg/hr of a mixed phase fluid (50% liquid and 50 % steam). A geothermal generating facility is presently installed on this well and is producing approximately 3 megawatts of electric power (Fig.8) (Kroopnick et al., 1978, Thomas, 1980).

Around this well, already the subterranean structures were made clear by geological, geophysical and geochemical studies. One of them is shown in Fig.9 (Furumoto, 1978a.).

There seem to be suitable reservoir and basement from this figure. In the case, of Oshima, there are still under the unconsolidated situation, however considering from the success and similarity to the Kilauea's case, even at Oshima, it is full of hope for the natural work to make the background of geothermal structure in the near future.

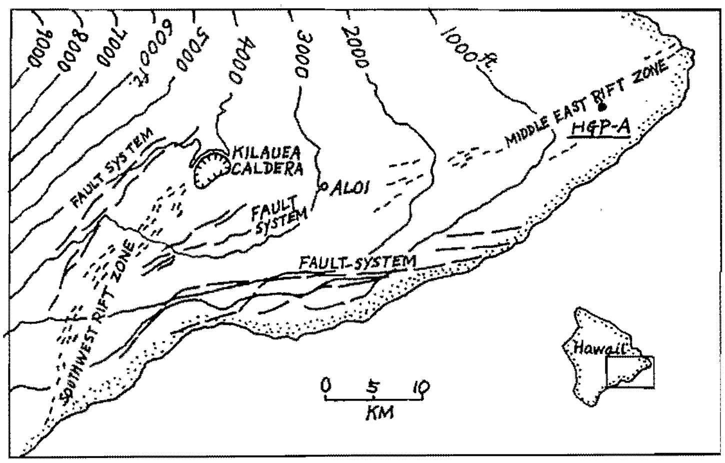

Fig.8 Eastern flank of Kilauea volcano (Thomas,1986)

Regarding this matter, some considerations will be seen in the following.

In the place of the recent fissure eruptions, where the gravity changes were founed in the time of 1950-1951's activity, aeromagnetic surveys were conducted by the Hydrographic Department of Maritime Safety Agency after the volcanic eruption of Nov. 1986 (Ueda et al., 1988).

In this case, some magnetic anomaly caused by thermal demagnetization has been discovered just over the southmost fissure (starting point),

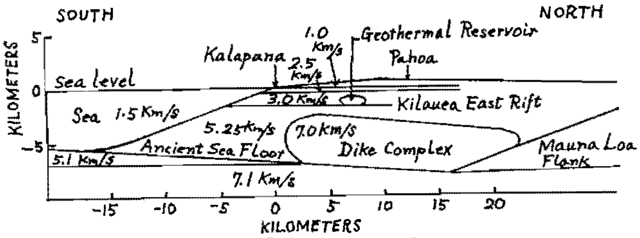

Fig.9 Structure of Kilauea East Rift Zone by seismic data (Furumoto, 1978a)

created by eruption on Nov.21, 1986. Amplitude of anomaly caused by thermal demagnetization amounts to 300 nT and the width of demagnetized part, which is running N60°W from the vicinity of the southmost fissure, is ranging from 300 m to 400 m in horizontal distance. This matter may suggest the intrusion of dike.

On the other hand, at the northmost area of the caldera wall, where is about 3 km NNE of the central cone, Miharayama, there are some wells belong to the Oshima Onsen Hotel. At one of them, No.3 steam well, temporal variations in temperature have been monitored since October, 1986 (Fig.10, Wakita et al., 1988).

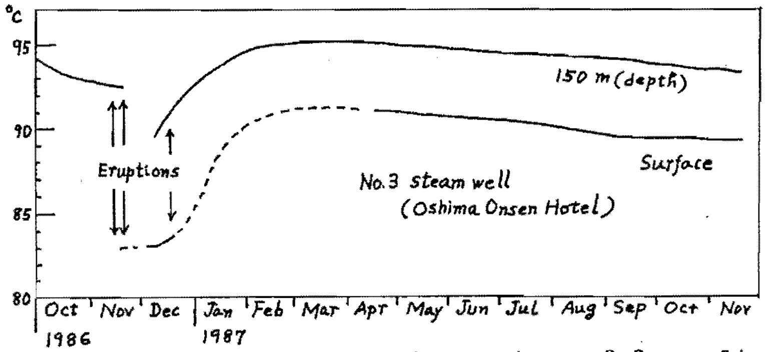

Fig.10 Temporal variation in temperature of fumarolic gas from No.3 well of Oshima Onsen Hotel (Wakita et al., 1988)

Temperature of gas increased 5-6°c after the eruption of November, 1986, reached the maximum value in February-March in 1987 and then decreased gradually. It can be seen that the gas temperatures at both surface and the depth of 150 m (this depth is thought to be corresponding to one of the basement of caldera) show the decrease to the base before the eruption, within one year.

Probably, this matter may suggest that the circulation of subterranean gas or steam including thermal water, could be occurred.

Considering the above matters, there will be the possibilities of forming the subterranean hydrothermal system, provided suitable basement is established, with the lapse of time in the future.

References

Aramaki,S. and T.Fujii, 1988; Petrological and Geological Model of the 1986-1987 Eruption of Izu-Oshima Volcano (in Japanese with English abstract) Bull. Volc. Soc. Japan, Vol.33, 297-306.

Furumoto,A.S., 1978a; Thermal processes of Kilauea East Rift inferred from seismic data. In Seismic Studies on Kilauea Volcano, Hawaii Island (Suyenaga,W. et al.), Hawaii Inst. Geophys. Tech. Rept. HIG-78-8, 123-137.

Iida,K., Hayakawa,M. and K.Katayose, 1952; Gravity Survey of Mihara Volcano, Oshima island, and Changes in Gravity caused by eruption (in Japanese with English abstract), Rept. No.152, Geol. Surv. Japan, 1-24.

Kroopnick,P.M., Buddemeier,R.W., Thomas,D.M., Lau,L.S., and Bills David, 1978; Hydrology and Geochemistry of a Hawaiian geothermal system, HGP-A Hawaii Inst. Geophys. Tech. Rept. HIG-78-6, 64p.

Thomas,D.M., 1980; Water and gas chemistry from HGP-A geothermal well: January 1980 flow test: Geothermal Resources Council Transactions, Vol. 4, 181-184.

Thomas,D.M., 1986; Geothermal Resources Assessment in Hawaii, GEOTHERMICS, Vol.15, No.4, 435-514.

Ueda,Y., Nakagawa,H., and K.Kumagawa, 1988, Aeromagnetic Surveys on Izu Oshima Island after Volcanic Eruption in Nov. 1986 and Their Geomagnetic Considerations; With Special Reference to Inferred Thermal Demagnetization Structure on/around B-Crater (in Japanese with English abstract), Bull. Volc. Soc. Japan, Vol.33, 202-216.

Wakita,H., Notsu,K., Nakamura,Y., and Y.Sano, 1988; Temporal Variation in Geochemical Parameters of Gas from Steam Well and Hot Spring Water Associated with the 1986 Eruption of Izu-Oshima Volcano (in Japanese with English abstract), Bull. Volc. Soc. Japan, Vol.33, 285-289.

Yamaoka,K., Watanabe,H., and S.Sakashita, 1988; Seismicity during the 1986 Eruption of Izu-Oshima Volcano (in Japanese with English abstract), Bull. Volc. Soc. Japan, Vol.33, 91-101.