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SEISMIC ACTIVITY OF MOUNT EREBUS, ANTARCTICA IN 1989

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Abstract: Seismic observations of Mount Erebus (77°37′S, 167°09′E, 3794 m) on Ross Island, Antarctica have been operated by international cooperative programs since December 1980.

The annual mean number of earthquakes per day counted at the summit station E1 of Mount Erebus was 47 in 1989. This value indicates that the low seismic activity after the 1984 volcanic event still continued until 1989. However, the seismic activity in 1989 can be divided into two phases in the periods of January-August and September-December. The average daily count of earthquakes for the former phase was 61 and that for the latter one was 15. The seismic activity in the former phase was higher than that in the latter one.

The hypocenters of only 12 earthquakes were determined in 1989 by using the *P* arrival time readings at five stations. The distribution of the earthquakes in 1989 is similar to those in the previous years after the 1984 volcanic event.

The average daily number of earthquakes in 1988 was 15 and the surface of the lava lake of Mount Erebus solidified in December 1988. On the other hand, the average daily number of earthquakes in 1989 was 47 and the surface of the lava lake was melted again in December 1989. It seems that the seismic activity of Mount Erebus in 1989 was slightly higher than that in 1988.

1. Introduction

Mount Erebus (77°37′S, 167°09′E, 3794 m) located in Ross Island is the only volcano in the erupting activity at present in the Antarctic. There has been a lava lake in the crater at the summit of Mount Erebus since December 1972 (KYLE *et al.*, 1982; TAKANAMI *et al.*, 1983). The seismic observations around this volcano were started in December 1980 by an international cooperative program named International Mount Erebus Seismic Study (IMESS) among Japan, New Zealand and the United States, and were continued until 1986. The seismic network of IMESS has been used by IMEEMS (International Mount Erebus Eruption Mechanism Study) between Japan and New Zealand to study the eruption mechanism and the seismic activity of Mount Erebus since 1987 (*e.g.*, KAMINUMA and MURAKAMI, 1989).

A new volcanic episode of Mount Erebus occurred on 13 September 1984 and lasted until December (KAMINUMA *et al.*, 1987). Remarkable changes of the seismic activity were recognized before and after the 1984 volcanic activity. The average daily count of earthquakes increased until the 1984 volcanic activity since 1980 when IMESS was started. However, the daily count of earthaquakes decreased quickly after the

1984 volcanic activity and the seismic activity became low. The low seismic activity continued until 1988. Although the earthquakes were located not only in the Erebus mountain area but also throughout Ross Island before the 1984 volcanic activity, the earthquakes clustered in the summit area of Mount Erebus after the 1984 volcanic activity (KAMINUMA *et al.*, 1987; KAMINUMA and MURAKAMI, 1989; KAMINUMA, 1989; KAMINUMA and DIBBLE, 1990).

The seismic activity of Mount Erebus in 1989 is mainly reported in this paper.

2. Observation Network

Five seismic stations were operated in 1989 as shown in Fig. 1. Two stations (E1 and TRC) are located in the summit area of Mount Erebus and the other three stations (HOO, BOM and ABB) are on the flanks. All stations have a vertical-component seismometer with 1-Hz natural frequency (KAMINUMA *et al.*, 1986). In 1989, another station (E1LH), which is about 800 m from the E1 station, was also operated. E1LH has a horizontal-component seismometer with 0.2-Hz natural frequency.

The seismic signals from each station are continuously transmitted to Scott Base of New Zealand about 38 km south of the Erebus summit, and are recorded on a 14-channel FM data recorder and a one-channel chart recorder for monitoring (KAMINUMA and MURAKAMI, 1989).

The video camera for monitoring explosions from the lave lake in the summit crater was installed at the crater rim of Mount Erebus in December 1986. The video signals are also transmitted to Scott Base by radio-telemetry and recorded with the

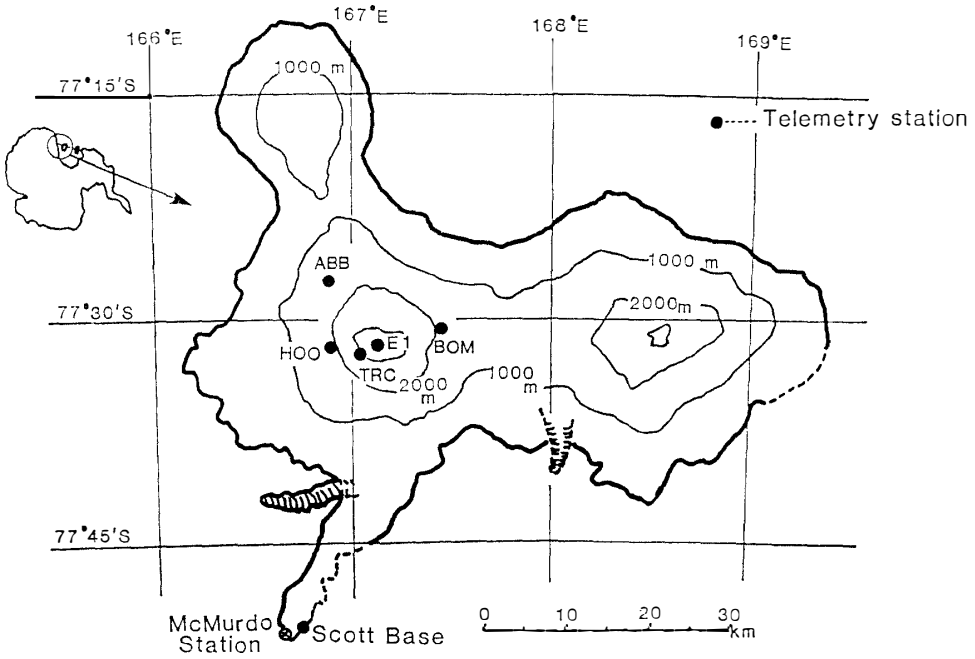


Fig. 1. The 1989 seismic network of Mount Erebus. ABB (Abbott Peak), HOO (Hoopers Shoulder), BOM (Bomb), E1 (the summit of Mount Erebus), TRC (Truncated Cone), SAB (Scott Base).

same time signal as that used for the seismic network (DIBBLE *et al.*, 1988; KAMINUMA *et al.*, 1988).

3. Seismic Activity in 1989

Figure 2 shows the daily number of earthquakes counted at E1 mostly. The total number of earthquakes in 1989 was 15427 and the average daily number of earthquakes

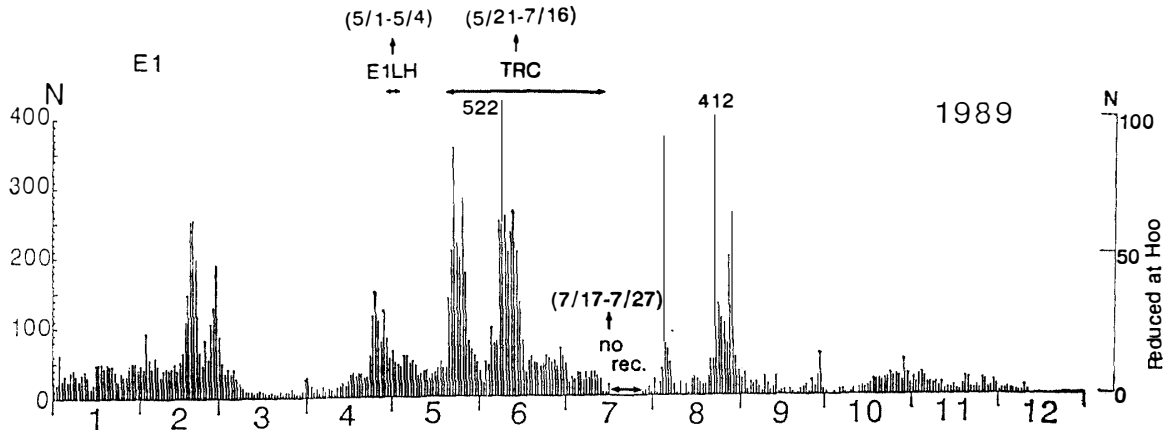
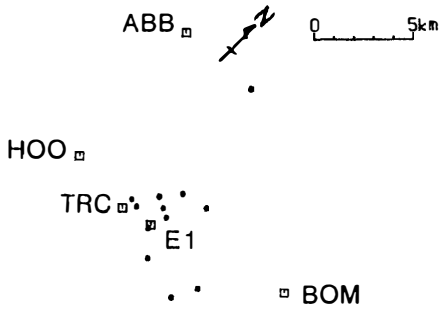


Fig. 2. Daily number of earthquakes in and around Mount Erubus counted at E1.



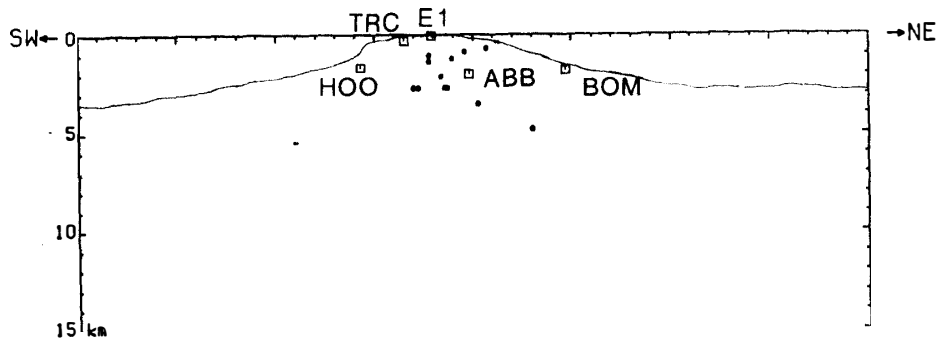


Fig. 3. Hypocenter distribution in 1989.

was 47. The seismic activity in 1989 can be divided into two phases in the periods of January–August and September–December, as is obvious from Fig. 2. The average daily number of events was 61 and there were a few swarm-like activities for the former phase, and that for the latter one was 15 without any swarm-like activity. The activity in the former phase was higher than that in the latter one.

Hypocenters of 12 earthquakes in 1989 were determined by using the *P* arrival time readings at five stations, as shown in Fig. 3. The upper part of Fig. 3 shows the epicenter distribution and the lower part shows the hypocenter distribution projected onto the SW-NE cross section. The hypocenters have horizontal and vertical location errors within 3 km. The earthquakes are concentrated in the summit area of Mount Erebus. The focal depth distribution ranges 0–5 km beneath the summit of Mount Erebus.

4. Discussion

The daily numbers of earthquakes during 1980–1986 were counted at HOO which had been a reference station for monitoring the seismic activities through IMESS study (KAMINUMA *et al.*, 1988). Because the seismic activity around Mount Erebus became low and very few earthquakes were recorded at HOO, the daily number of earthquakes has been counted at TRC which is located near the crater since 1987. KAMINUMA and MURAKAMI (1989) reported that the number of earthquakes recorded at TRC was about

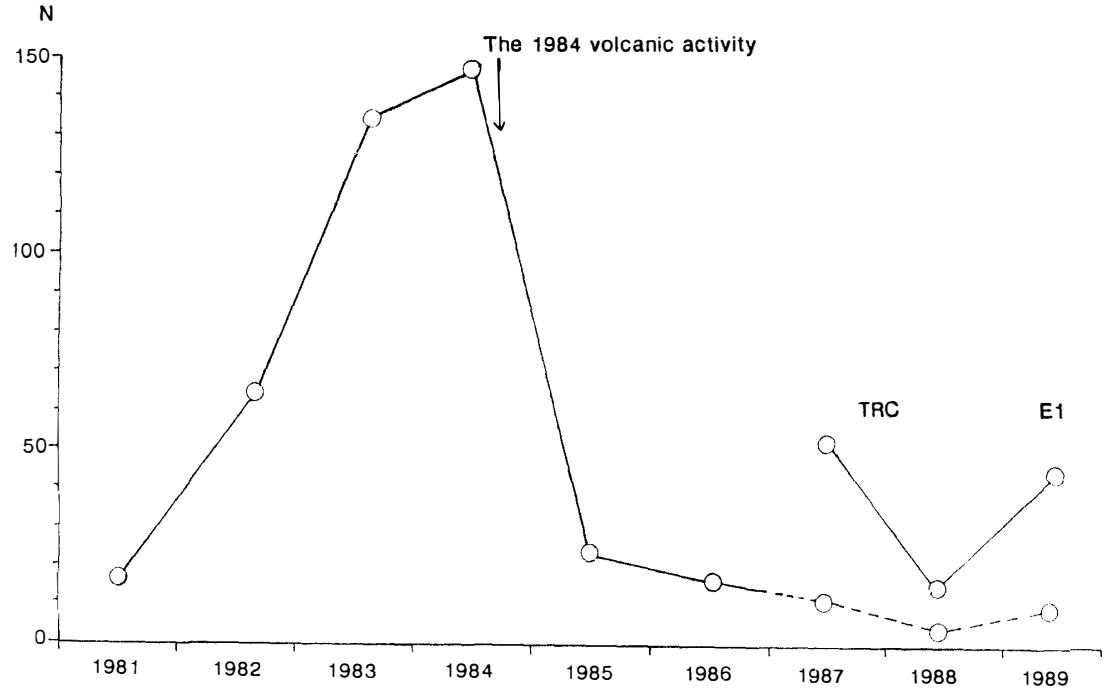


Fig. 4. The annual average number of earthquakes. The numbers from 1981–1986 were counted at HOO and those from 1987 to 1989 were at TRC/E1. Dotted line shows the numbers reduced to HOO. The number in 1984 was counted during only seven months between January and July.

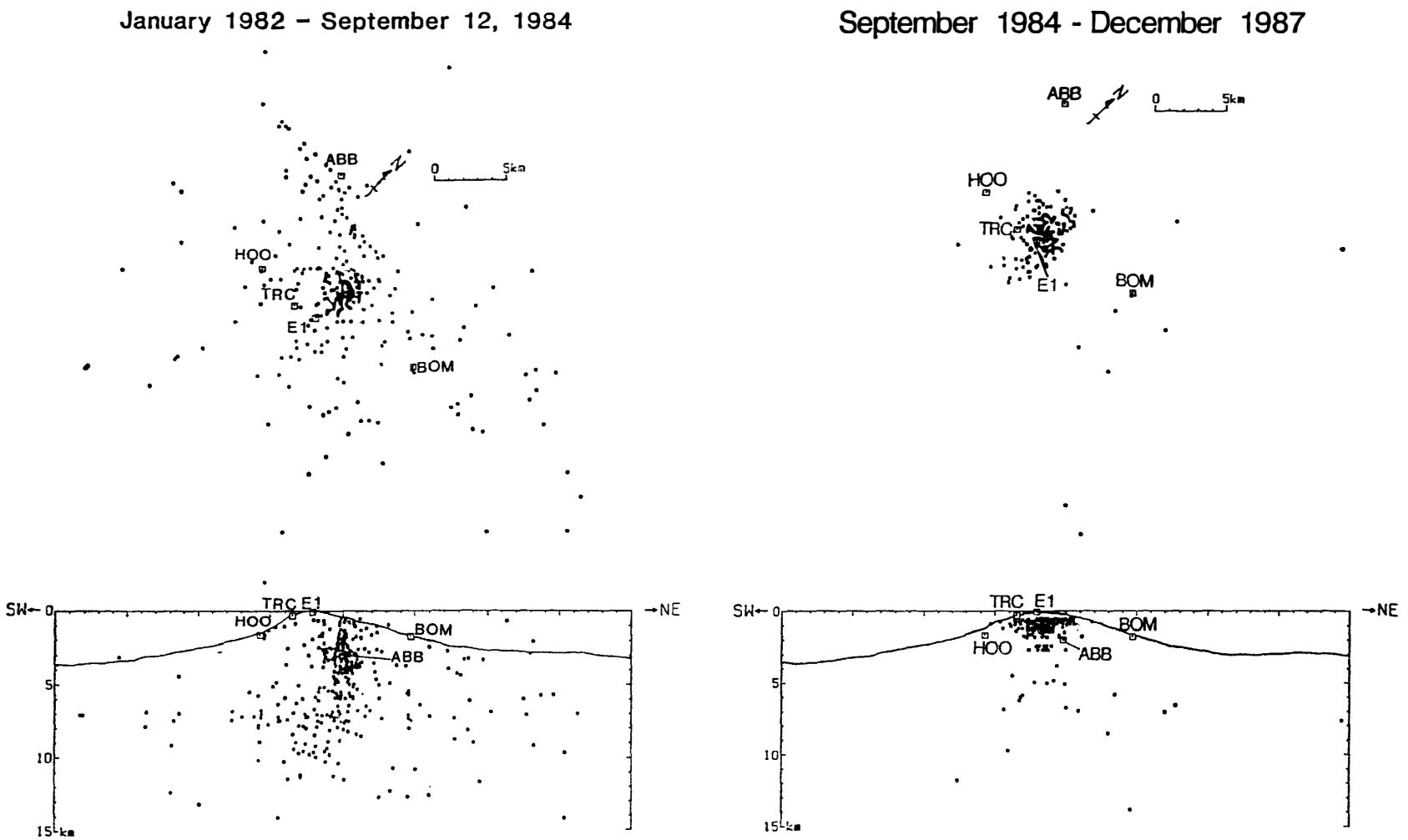


Fig. 5. Hypocenter distribution before and after the 1984 activity. The left part is the hypocenter distribution before the 1984 activity, and the right part is that after the 1984 activity.

four times larger than that at HOO from the critical comparison of daily number of earthquakes counted at HOO and TRC. The number of earthquakes in 1989 was counted at E1. As E1 is located in the summit area near TRC, the number of earthquakes recorded at E1 can be assumed to be almost the same as that at TRC. From this assumption, the annual mean number of events counted at HOO was estimated to be 12 per day in 1989.

Figure 4 shows the annual mean number of earthquakes per day at HOO for the period from 1981 to 1986 and at TRC or E1 for the period from 1987 to 1989. The estimated numbers at HOO are also shown by dotted line.

As shown in Fig. 4, the daily count of earthquakes gradually increased until the 1984 volcanic activity since 1981. However, after the volcanic activity, the daily count decreased quickly and the seismic activity of Mount Erebus became very low (KAMINUMA and DIBBLE, 1990). This low seismic activity has continued in 1989. However, there is a slight increase in the daily count of earthquakes in 1989 as compared with that in 1988.

Hypocenter distributions before and after the 1984 volcanic activity are given in Fig. 5. The hypocenters have horizontal and vertical location errors within 3 km. Though the number of determined hypocenters in 1989 was not so many as those obtained by the previous works (*e.g.*, KAMINUMA and MURAKAMI, 1989), the hypocenter distribution in 1989 is similar to that after the 1984 volcanic activity. No clear change in the earthquake distribution is recognized since the 1984 volcanic activity.

Although the lava lake in the main crater disappeared soon after the volcanic activity started in September 1984, it appeared again in December 1985. In December 1988, it was confirmed by the scientists who stayed at the summit that eruption occurred from four vents on the solidified surface of the lava lake. In December 1989 the lava lake reappeared, and Stronbolian eruptions occurred repeatedly from it. The change of seismicity seems to be related with the change of the lava lake activity.

5. Conclusion

The seismic activity of Mount Erebus in 1989 is summarized as follows:

1) The total number of earthquakes counted at E1 was 15427 and the average daily number of earthquakes was 47 in 1989. The low seismic activity around Mount Erebus still continued after the 1984 volcanic activity.

2) The seismic activity can be divided into two phases in the periods of January–August and September–December. In the former phase, the average daily number of earthquakes was 61 and there were a few swarm-like activities. The average daily number of earthquakes was 15 and no swarm-like activity for the latter phase. The seismic activity in the former phase was higher than that in the latter one.

3) The hypocenters clustered in the summit area within 5 km depth from the Erebus summit. The hypocenter distribution of earthquakes in 1989 is similar to those in the previous years after the 1984 volcanic activity.

The average daily number of earthquakes in 1988 was 15 and the surface of the lava lake of Mount Erebus solidified in December 1988. However, the average daily number of earthquakes in 1989 was 47 and the surface of the lava lake melted again in

December 1989. The above facts suggest that the volcanic activity in 1989 became slightly higher than that in 1988.

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