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# July 1980 MT. HOOD

# EARTHQUAKE SWARM

by

Alan Rite
H.M. Iyer

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## ABSTRACT

During the month of July 1980, an unsual amount of seismic activity was recorded in the vicinity of Mt. Hood, Oregon by the USGS Cascades seismic network. Hypocentral parameters for this earthquake swarm are presented as well as a brief review of historical seismicity in the Mt. Hood region.

## INTRODUCTION

Mt. Hood, the northern most of the Oregon Cascade volcanoes, is situated approximately in the middle of the Cascade range which extends from Lassen Peak in northern California to Mt. Garibaldi in British Columbia. This thousand kilometer long range forms a major tectonic feature of the western United States, yet, has had relatively few geophysical studies. The Cascades are relatively young and are characterized by active volcanism which is presumed to have been caused by the interaction of the Pacific, North American, Gordo, and Juan de Fuca plates during mid-Tertiary times and the subsequent underthrusting of the Juan de Fuca plate beneath the American plate (Atwater, 1970; Davis, 1971; Dickenson, 1970). No trace of a coastal trench is currently present off the coast of Oregon and there is a lack of seismic activity associated with the underthrusting. This could be explained by a reduced rate of underthrusting plus the fact that the plate is perhaps above normal temperatures because of its proximity to the Juan de Fuca ridge (Atwater, 1970).

For the Oregon cascades in general and Mt. Hood in particular, assessment of the background seismicity is difficult due to the incompleteness of historical records and the sparse distribution of seismographic stations until the recent installation of the USGS Cascades network; the network was first fully operational in late April 1980. This network records from 2-10 microearthquakes in the Oregon Cascades per day and detected a substantial microearthquake swarm in the vicinity of Mt. Hood beginning July 6, 1980 (Decker et. al., 1980). This seismic activity cautions against using the term "aseismic" to describe the Oregon Cascades.

This report will detail the circumstances of the July 1980 Mt. Hood earthquake swarm and will attempt to present a brief summary of historical seismicity in Oregon with particular reference to earthquakes which have been reported for the area near Mt. Hood.

## HISTORICAL SEISMICITY OF OREGON

There are three recent articles which are concerned with the earthquake history of Oregon (Berg & Baker, 1963; Couch & Lowell, 1971; von Hake, 1976) and an older descriptive account (Townley & Allen, 1939). These records have been supplemented with a computer search through the earthquake records of the National Geophysical and Solar Terrestrial Data Center of NOAA to determine Oregon seismicity levels from 1841 onward. Unfortunately, earlier records of seismic activity in Oregon are based solely on felt effects of earthquakes and are strongly dependent on the size and distribution of population in the state. For example, the population of Oregon approximately tripled between 1920 and 1970 and during these 50 years roughly twice as many earthquakes were reported as during the preceeding 50 years (Couch & Lowell, 1971). It is particularly important to remember this bias for the Cascades and the eastern portion of the state which are sparsely inhabited.

Berg and Baker's 1963 paper lists 240 events for the state of Oregon from December 1841 through December 1961. In addition, Couch and Lowell (1971) published a supplemental listing of 40 earthquakes which occurred between 1959 and 1970.

For comparison, the NOAA listing (ending December 10, 1979) contains approximately 450 events in the search area between 116.00W and 125.00W longitude and 42.00N and 47.00N latitude with 28 events occurring after the last listing in Couch and Lowell's paper. During the period 1841-1961, 34 earthquakes of intensity V or greater (Modified Mercalli Scale) were centered within Oregon or near its borders although only 13 of these events had an intensity greater than V (von Hake, 1976).

From the available literature, it seems reasonably certain that no earthquakes of magnitude 5 or greater passed unnoticed in the state of Oregon between 1841 and 1963. After 1963, earthquakes in the state were located principally with the 5 seismographic stations in Corvallis (OSU), Portland (OMSI), Klamath Falls (OTI), Blue Mountain (NOS), and Pine Mountain (UO-NASA). Couch and Lowell (1971) indicate that after the operation of these 5 stations, no earthquakes greater than magnitude 3.5 have gone unnoticed in the state. With the installation of the USGS Cascades Network, the threshold limit for location of earthquakes within the Oregon Cascades is at least magnitude 2.5.

## HISTORICAL SEISMICITY OF MT. HOOD

Seismically, the Cascades in Oregon have been characterized as relatively quiescent (Couch & Lowell, 1971) as indicated by Table 1. With reference to this table, it should be noted that the seismicity level for the Cascades is very strongly affected by an earthquake of intensity VIII which occurred on October 12, 1877 in the vicinity of Cascade Locks; this is equivalent to a body wave magnitude of about 6.1 (Couch & Lowell, 1971; Richter, 1958). This event was followed about 5 hours later by another large earthquake (intensity VII) and both of these events caused chimneys to be overthrown in Portland (Townley & Allen, 1939). Since the location of these events is highly questionable, the energy release rate in the Cascades given by Table 1 could be much too high. Although there is insufficient data to calculate a meaningful seismic activity level, the figures of Table 1 would indicate a Cascades yearly seismic level of about one magnitude 4.2 event per year (Richter, 1958).

Table 2 gives a listing of those events which occurred in the general vicinity of Mt. Hood (summit latitude 45.36N, longitude 121.68W) in the search area between 45.00N and 45.80N latitude and 121.00W and 122.00W longitude from the NOAA listing, Berg and Baker (1963), and Townley and Allen (1939). This table indicates only one locatable earthquake on December 13, 1974 which is in close proximity to the volcano.

Westhusing (1973) conducted a reconnaissance survey of near event seismic activity in the vicinity of Mt. Hood. He employed a tripartite array of ultrasensitive high frequency (peak frequency response of 25 Hz) seismometers deployed about 7.5 km to the north of the summit of Mt. Hood. During 16 days of recording, 53 events were recorded in the magnitude range between -1.7 and +1.8. Approximately 80% of these events were located to the south of the array and appear to have been shallow shocks between 5 and 10 kilometers depth. Many of the epicenters appear to be concentrated near the center of the volcano rather than along the flanks and use of the Gutenberg-Richter relation for b-values indicates that these events were probably tectonic in origin.

In November 1977, Green et. al. (1979) deployed a seismic network of 16 stations around Mt. Hood for a period of 13 months. During that time, 10 local and 25 regional events were recorded. All the local earthquakes occurred beneath Mt. Hood at shallow depths and very roughly define a zone striking north-northwest beneath the mountain. Table 3 and Figure 1 show the locations of the local events. It is interesting to note that Green et. al. (1979) suggest a rate of seismic activity for Mt. Hood which is approximately two orders of magnitude less than the work done by Westhusing (1973).

## CASCADES SEISMIC NETWORK AND DATA ANALYSIS

The Cascades seismic network consists of 32 stations deployed along the length of the Oregon Cascades (Figure 2). Average station spacing is about 50 kilometers and the entire network first became operational in late April 1980. Station location information is summarized in Table 4.

The Cascades network follows the standard pattern of USGS telemetered seismographic networks (McHugh & Lester, 1978). Vertical seismometers with a natural frequency of 1 Hz are used at each site and the data is telemetered from the remote station sites to 4 central receiver sites by VHF radio telemetry. The signals are then multiplexed at the receiver sites and transmitted to USGS headquarters at Menlo Park, California via commercial telephone lines. At Menlo Park, the data is recorded continuously in analog form on 16 mm film as well as 2.54 cm magnetic tape. Each day the film records are scanned and local, regional, and teleseismic events are cataloged. Events selected from the film scanning catalog for more detailed analysis are played back on a high speed (100 mm/sec.) ink-jet oscillograph and manually selected for first-motions, P arrival times, and if clear, S times. Magnitudes are determined from the film records using the coda-magnitude relation given by Lee et. al. (1972) for central California. Crosson (1972) has determined an empirical coda-magnitude relation for the Pacific Northwest but the differences between it and Lee's relation are small in the magnitude ranges considered for the Mt. Hood swarm of July 1980. After selection of the appropriate phase information, the HYPOELLIPSE (Lahr, 1980) computer program is run on a PDP 11/70 minicomputer and the output is analyzed for residuals, weights, and quality. The crustal model of Kohler et. al. (1978) was used for locations since it provides the most detailed velocity model for the area near Mt. Hood. Use of an infinite half-space model was also compared with Kohler's model and agreement for selected events was generally $\pm$ 3 km. As an additional check on hypocenter parameters, some July events were also run on the Eclipse (Data General) s/200 minicomputer using the interactive seismic display system available and the HYP079 (Willie Lee, unpublished) earthquake location program. A complete listing of hypocenter parameters for the July 1980 Mt. Hood earthquake sequence and 2 later locatable events is given in Table 5. Figure 3 shows the locations of the events.

## JULY 1980 MT. HOOD SWARM

Beginning July 6, 1980 at 6:17 pm PDT, a significant increase in seismic activity in the vicinity of Mt. Hood was recorded by the Cascades seismic network. Prior to this earthquake swarm, Mt. Hood had shown only

very infrequent activity. For example, in the month of June 1980 only 2 events with multiple station arrivals and with VHE (Mt. Hood East) as the first station were recorded; prior to the July 6 sequence the last recorded activity at Mt. Hood had been on June 19 at 2:06 pm PDT when 7 stations recorded an event with a magnitude of approximately 2.3. Since the end of the July swarm, 2 locatable events have been recorded in the vicinity of Mt. Hood and these events are listed in Table 5. Both of these latter events have been small and one of them was located very close to the central area of swarm activity while the other event on September 18 was located about 10 kilometers to the southwest of the main area of swarm activity.

From Table 5 it is observed that within one-half hour of the initial 2.80 body wave magnitude shock, 7 more events were recorded in the immediate area of the first shock with magnitudes varying between 1.6 and 2.8. At least one of these events was felt by some personnel at Timberline Lodge, a ski resort situated on the southeast flank of Mt. Hood, as a very slight shaking of some small objects; Timerline Lodge is approximately 4 kilometers to the southwest of the main area of swarm activity. Locations of the earthquakes in the swarm seems to indicate a tight clustering of the events in the depth range of 4 to 7 kilometers (Figure 4) which is consistent with the depths reported by Westhusing (1973). The frequency of activity remained anomalously high for about 48 hours following the initial shock with 40 events recording on 3 to 9 stations within the first 24 hours. A histogram of activity in the region for the first several days is shown in Figure 5.

In addition to the multiple station events, a number of very small tremors were recorded by VHE. It was subsequently learned from the Hood Forestry service that there had been some tree-stump blasting in the vicinity of Hood Meadows, within approximately one kilometer of the VHE station. During the time from July 6, 1980 up to and including July 16, 143 such small single station events were recorded. Through correspondance with the construction firm, approximate times when blasting occurred were obtained and it was found that no more than 50 of the small events could be possible correlated with blasting. Playbacks of a number of the small events and their comparison with two known blasts revealed that the blasts had either no discernable S-phase or a very poorly developed one. By comparison, a large number of the single station events showed very clear S-phases. Owing to the possibility of significant P to S conversion of blast events however (Kisslinger et. al., 1961), it is impossible to discriminate between the blasts and the micro-tremors other than on a temporal basis. By this criterion, roughly 90 very small events occurred somewhere in the vicinity of VHE during the 10 days from July 6-16. All of these events had coda magnitudes of less than 1.1 and most had magnitudes less than 0.5.

Comparing Figures 1 and 2 it is seen that the general location of swarm activity is similar to the area of reported local events by Green et. al. (1979). From the list of 10 local events reported by these author, 3 were located within 3 kilometers south of Mt. Hood and the remaining 7 were on the mountain itself; the largest event was in this latter group and had a magnitude of 3.4. No exposed faults are known to exist on Mt. Hood itself although a known fault exists along the Hood

River Valley northeast of the mountain (Westhusing, 1973). A group of fumaroles is located near Steel Cliff and Crater Rock (Figure 3) covering an area of 9700 $m^2$ which Friedman and Frank (1977) attribute to a fracture system and brecciated zone peripheral to the hornblende-dacite plug dome of Crater Rock. These authors also suggest that a concentric fracture system may be associated with the present crater. The fumarole field is located approximately 4 kilometers to the northwest of the swarm region but association of the earthquake swarm with geothermal phenomenon is not clear at this time.

## CONCLUSION

While the July 1980 Mt. Hood earthquake swarm was mild in terms of its total seismic energy release (approximately 8 x $10^{15}$ ergs), it was unusual for the frequency of activity in comparison with previous studies conducted at the volcano (Westhusing, 1973; Green et. al., 1979). Subsequent to the swarm events, Mt. Hood has returned to a relatively quiescent state with roughly one locatable earthquake per month. Further monitoring of seismic activity at Mt. Hood will continue and will be critical in determining whether the sequence of swarm activity was anomalous or an expression of episodic seismic activity at the volcano.

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Table 1

| Physiographic Area | Maximum Intensity+ | Maximum Acceleration ($cm/sec^2$) | Years of Maximum Intensity | Average E/yr (E=erg) 1870-1970 | Average $E/yr/km^2$ 1870-1970 | Estimated Seismic Activity Level |
|---|---|---|---|---|---|---|
| Cascade Range | VIII | 147.0 | 1877 | $2.7 \times 10^{17}$ | $9.6 \times 10^{12}$ | Insufficient Data |

+ Modified Mercalli Scale (1956 edition)

(excerpted from Couch and Lowell, 1971)

Earthquake Characteristics of Cascade Range, Oregon

Table 2

| # | Year | Mon. | Day | Hr. | Latitude | Longitude | Magnitude | Intensity | NOAA | Berg | Townley |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1866 | 11 | 24 | 06 | 45.6N | 121.1W | | IV | x | x | x |
| 2 | 1866 | 12 | 24 | 06 | 45.6N | 121.1W | | III | x | x | x |
| 3 | 1877 | 10 | 12 | 17 | 45.6N | 121.6W | | VIII | x | x | x |
| 4 | 1892 | 02 | 29 | 10 | 45.6N | 121.1W | | IV | x | x | |
| 5 | 1893 | 07 | 07 | 01 | 45.6N | 121.1W | | III | x | x | |
| 6 | 1896 | 08 | 26 | 06 | 45.4N | 121.7W | | IV | x | x | x |
| 7 | 1902 | 12 | 04 | 8-9 | 45.4N | 121.1W | | | | x | x |
| 8 | 1902 | 12 | 05 | 04 | 45.7N | 121.5W | | III | x | x | |
| 9 | 1919 | 12 | 26 | 06 | 45N | 122W | | IV | x | | x |
| 10 | 1936 | 07 | 16 | 04 | 45.8N | 121.5W | | | x | | |
| 11 | 1974 | 12 | 13 | 03 | 45.265N | 121.599W | 4.10 | IV | x | | |

Earthquakes occurring in the vicinity of Mt. Hood (summit latitude 45.7N, longitude 121.68W) in the search area between 45.00N and 45.80N latitude and 121.00W and 122.00W longitude. Search references are NOAA computer search (Wil Rinehart, personal communication), Berg and Baker (1963), and Townley and Allen (1939).

Table 3: Local earthquakes with solutions computed by the hypoellipse computer program (from Green et. al., 1979)

| Date | Origin Time (G.M.T.) | Latitude deg. min. | Longitude deg. min. | Depth (km below sea level) | Magnitude ($M_L$) | RMS | GAP |
|---|---|---|---|---|---|---|---|
| 11/18/77 | 00:01:43.33 | 45N23.15 | 8121W41.86 | 0.40 | 2.0 | .14 | 261 |
| 11/23/77 | 23:48:22.80 | 45N19.18 | 121W40.28 | 6.59 | 2.0 | .19 | 64 |
| 03/30/78 | 13:35:58.92 | 45N20.37 | 121W41.42 | 7.73 | 2.0 | .14 | 68 |
| 03/30/78 | 13:36:26.56 | 45N19.38 | 121W41.87 | 11.98 | 2.0 | .12 | 87 |
| 07/14/78 | 17:25:22.31 | 45N23.24 | 121W41.74 | 15.12 | 2.0 | .46 | 63 |
| 09/06/78 | 00:07:44.84 | 45N22.32 | 121W42.21 | 0.91 | 2.0 | .12 | 87 |
| 09/06/78 | 04:47:54.20 | 45N22.26 | 121W42.53 | 2.08 | 3.4 | .13 | 63 |
| 09/06/78 | 04:49:09.03 | 45N22.45 | 121W42.11 | 9.70 | 2.0 | .28 | 99 |
| 09/06/78 | 04:49:43.79 | 45N22.278 | 121W41.60 | 4.38 | 2.0 | .16 | 118 |
| 09/06/78 | 04:50:40.97 | 45N21.86 | 121W42.17 | 2.01 | 2.0 | .05 | 170 |

Table 4

| # | Station | Location | Elev. (m) | Longitude | Latitude |
|---|---|---|---|---|---|
| 1 | VHO | Mount Hebo | 951 | 123W43.52 | 45N13.15 |
| 2 | VHH | High Heaven | 533 | 123W18.57 | 45N15.88 |
| 3 | VLM | Little Larch Mtn. | 1158 | 122W02.35 | 45N32.31 |
| 4 | VGT | Goat Mtn. | 993 | 122W15.92 | 45N08.99 |
| 5 | VLO | Lookout Mtn. | 1351 | 122W23.58 | 44N52.77 |
| 6 | VCP | Cooper's Ridge | 1161 | 122W05.37 | 44N40.27 |
| 7 | VHE | Mount Hood East | 1739 | 121W40.46 | 45N19.72 |
| 8 | VSM | Salem | 290 | 123W07.65 | 44N57.62 |
| 9 | VGB | Gordon Butte | 729 | 120W46.65 | 45N30.94 |
| 10 | VMN | Maupin | 555 | 121W03.18 | 45N11.21 |
| 11 | VTH | The Trough | 773 | 120W33.63 | 45N10.87 |
| 12 | VJY | Jersey | 951 | 120W58.45 | 44N54.13 |
| 13 | VBE | Beaver Butte | 1544 | 121W35.21 | 45N03.62 |
| 14 | VBP | Bald Peter | 1876 | 121W41.34 | 44N39.66 |
| 15 | VIP | Ingram Point | 1731 | 120W37.13 | 44N30.49 |
| 16 | VTD | The Dalles | 305 | 121W18.69 | 45N32.72 |
| 17 | VGP | Green Peter | 1212 | 122W34.89 | 44N29.00 |
| 18 | VMH | Mount Hagan | 902 | 122W24.44 | 44N08.26 |
| 19 | VGM | Grass Mtn. | 1561 | 122W32.76 | 43N35.54 |
| 20 | VSC | Scott Mtn. | 1295 | 123W03.79 | 43N22.35 |
| 21 | VTC | Trout Creek Butte | 1690 | 121W39.95 | 44N14.45 |
| 22 | VRB | Round Butte | 743 | 121W16.21 | 44N36.05 |
| 23 | VFB | Fredrick Butte | 1369 | 120W14.25 | 43N39.51 |
| 24 | VPM | Patrick Mtn. | 1387 | 120W39.98 | 43N11.60 |
| 25 | VSB | Spring Butte | 1664 | 121W20.84 | 43N31.42 |
| 26 | VWM | Walker Mtn. | 2158 | 121W42.95 | 43N18.30 |
| 27 | VWB | Wanoga Butte | 1736 | 121W33.27 | 43N54.82 |
| 28 | VPE | Pine Mtn. | 1932 | 120W56.68 | 43N47.45 |
| 29 | VCL | Crater Lake | 2048 | 122W07.21 | 42N52.71 |
| 30 | VHB | Hamelton Butte | 1957 | 121W21.00 | 42N47.12 |
| 31 | VHY | Horsefly Butte | 1932 | 121W02.95 | 42N15.87 |
| 32 | VCM | Chase Mtn. | 1889 | 121W59.33 | 42N05.73 |

Station locations and abbreviations for
the USGS Cascades Seismic Network.

Table 5

| No. | Calendar Date | Origin Time (PDT) Hr | Min | Sec | Latitude | Longitude | Depth (Km) | Magnitude | RMS Error (Sec) | No. of Stations |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | July 6, 1980 | 18 | 17 | 8.54 | 45 N 20.68 | 121 W 40.48 | 6.22 | 2.80 | 0.10 | 8 |
| 2 | " | 18 | 20 | 1.23 | 45 N 20.62 | 121 W 40.97 | 5.83 | 2.43 | 0.08 | 7 |
| 3 | " | 18 | 26 | 0.81 | 45 N 18.77 | 121 W 40.00 | 4.87 | 2.56 | 0.25 | 5 |
| 4 | " | 18 | 31 | 27.07 | 45 N 18.43 | 121 W 37.07 | 0.66 | 2.55 | 0.99 | 7 |
| 5 | " | 18 | 33 | 20.35 | 45 N 20.15 | 121 W 40.51 | 6.32 | 2.24 | 0.11 | 7 |
| 6 | " | 18 | 34 | 51.12 | 45 N 20.74 | 121 W 41.14 | 5.26 | 1.79 | 0.00 | 4 |
| 7 | " | 18 | 42 | 41.17 | 45 N 20.88 | 121 W 40.47 | 5.89 | 2.00 | 0.13 | 8 |
| 8 | " | 18 | 49 | 22.40 | 45 N 17.93 | 121 W 38.28 | 1.98 | 2.56 | 1.01 | 7 |
| 9 | " | 18 | 53 | 39.24 | 45 N 20.26 | 121 W 40.13 | 6.11 | 2.24 | 0.14 | 7 |
| 10 | " | 18 | 59 | 32.85 | 45 N 20.62 | 121 W 42.13 | 5.00 | 1.98 | 0.29 | 4 |
| 11 | " | 19 | 02 | 34.73 | 45 N 21.08 | 121 W 41.27 | 5.82 | 2.24 | 0.05 | 6 |
| 12 | " | 19 | 09 | 56.16 | 45 N 20.84 | 121 W 41.27 | 5.24 | 2.21 | 0.00 | 6 |
| 13 | " | 19 | 10 | 38.14 | 45 N 27.63 | 121 W 41.66 | 3.29 | 1.98 | 1.08 | 4 |
| 14 | " | 19 | 12 | 59.74 | 45 N 20.31 | 121 W 40.54 | 5.65 | 2.25 | 0.09 | 8 |
| 15 | " | 19 | 16 | 46.36 | 45 N 21.25 | 121 W 40.37 | 5.77 | 1.97 | 0.00 | 4 |
| 16 | " | 19 | 18 | 6.70 | 45 N 21.00 | 121 W 41.45 | 5.00 | 1.94 | 0.44 | 3 |
| 17 | " | 19 | 29 | 47.13 | 45 N 20.79 | 121 W 40.38 | 5.37 | 2.26 | 0.14 | 7 |
| 18 | " | 19 | 55 | 11.11 | 45 N 22.40 | 121 W 41.38 | 3.86 | 1.94 | 0.14 | 5 |
| 19 | " | 20 | 06 | 44.57 | 45 N 20.76 | 121 W 40.40 | 6.37 | 2.24 | 0.09 | 6 |
| 20 | " | 20 | 50 | 49.52 | 45 N 21.05 | 121 W 40.70 | 5.00 | 1.94 | 0.00 | 3 |
| 21 | " | 21 | 15 | 47.50 | 45 N 20.30 | 121 W 40.59 | 6.53 | 2.43 | 0.09 | 6 |
| 22 | " | 21 | 21 | 24.07 | 45 N 20.27 | 121 W 41.56 | 5.00 | 1.94 | 0.00 | 3 |
| 23 | " | 21 | 32 | 32.97 | 45 N 20.38 | 121 W 42.15 | 5.00 | 1.85 | 0.00 | 3 |
| 24 | " | 21 | 36 | 26.49 | 45 N 19.27 | 121 W 42.21 | 3.77 | 1.96 | 0.19 | 4 |
| 25 | " | 21 | 53 | 12.68 | 45 N 21.71 | 121 W 43.41 | 5.00 | 1.94 | 0.00 | 3 |
| 26 | " | 22 | 36 | 6.20 | 45 N 21.02 | 121 W 40.62 | 5.05 | 2.20 | 0.01 | 4 |
| 27 | " | 22 | 53 | 34.17 | 45 N 20.53 | 121 W 41.21 | 4.11 | 2.25 | 0.02 | 6 |
| 28 | " | 22 | 54 | 10.83 | 45 N 21.00 | 121 W 40.74 | 4.98 | 2.20 | 0.00 | 4 |
| 29 | " | 23 | 10 | 38.59 | 45 N 20.59 | 121 W 41.20 | 5.91 | 1.95 | 0.00 | 4 |

Listing of hypocenter parameters for all locatable earthquakes of the July 1980 Mt Hood earthquake swarm. Also included are all successive locatable earthquakes at Mt. Hood until October 7, 1980.

| No. | Calendar Date | Origin Time (PDT) Hr | Min | Sec | Latitude | Longitude | Depth (Km) | Magnitude | RMS Error (Sec) | No. of Stations |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | July 7, 1980 | 00 | 19 | 12.59 | 45 N 20.73 | 121 W 40.91 | 5.00 | 1.78 | 0.00 | 3 |
| 31 | " | 01 | 05 | 50.42 | 45 N 20.71 | 121 W 40.39 | 6.13 | 1.81 | 0.10 | 7 |
| 32 | " | 01 | 53 | 22.54 | 45 N 22.26 | 121 W 41.99 | 2.89 | 1.94 | 0.00 | 4 |
| 33 | " | 02 | 03 | 42.65 | 45 N 21.43 | 121 W 42.00 | 4.97 | 2.23 | 0.07 | 5 |
| 34 | " | 02 | 59 | 1.88 | 45 N 20.65 | 121 W 40.61 | 5.89 | 2.44 | 0.12 | 7 |
| 35 | " | 03 | 31 | 23.02 | 45 N 20.76 | 121 W 40.30 | 5.69 | 2.60 | 0.11 | 7 |
| 36 | " | 05 | 55 | 17.57 | 45 N 21.54 | 121 W 41.20 | 4.98 | 1.98 | 0.02 | 5 |
| 37 | " | 05 | 55 | 51.77 | 45 N 21.52 | 121 W 40.90 | 4.98 | 1.95 | 0.00 | 4 |
| 38 | " | 06 | 16 | 59.89 | 45 N 22.18 | 121 W 44.25 | 5.00 | 1.95 | 0.00 | 3 |
| 39 | " | 12 | 18 | 45.21 | 45 N 20.30 | 121 W 41.70 | 3.67 | 1.94 | 0.00 | 4 |
| 40 | " | 13 | 15 | 17.48 | 45 N 20.68 | 121 W 40.57 | 5.26 | 2.25 | 0.12 | 7 |
| 41 | July 8, 1980 | 03 | 27 | 29.46 | 45 N 20.18 | 121 W 41.02 | 5.73 | 2.25 | 0.13 | 7 |
| 42 | " | 03 | 44 | 30.68 | 45 N 20.94 | 121 W 40.33 | 5.45 | 2.23 | 0.14 | 6 |
| 43 | " | 05 | 54 | 45.28 | 45 N 20.36 | 121 W 41.19 | 4.67 | 2.25 | 0.10 | 5 |
| 44 | " | 08 | 44 | 32.62 | 45 N 20.73 | 121 W 40.29 | 6.32 | 2.43 | 0.11 | 6 |
| 45 | " | 11 | 39 | 47.03 | 45 N 20.73 | 121 W 40.52 | 6.36 | 2.46 | 0.09 | 8 |
| 46 | " | 11 | 40 | 37.66 | 45 N 20.82 | 121 W 40.47 | 6.00 | 2.03 | 0.11 | 7 |
| 47 | " | 11 | 45 | 10.48 | 45 N 20.68 | 121 W 40.66 | 5.19 | 2.43 | 0.14 | 8 |
| 48 | " | 17 | 47 | 53.94 | 45 N 21.27 | 121 W 41.30 | 5.41 | 2.20 | 0.00 | 4 |
| 49 | " | 19 | 49 | 28.72 | 45 N 20.49 | 121 W 40.61 | 4.75 | 2.61 | 0.11 | 8 |
| 50 | " | 21 | 23 | 41.02 | 45 N 21.25 | 121 W 40.82 | 4.76 | 2.11 | 0.09 | 5 |
| 51 | July 9, 1980 | 00 | 19 | 54.20 | 45 N 20.46 | 121 W 42.43 | 4.02 | 2.54 | 0.02 | 5 |
| 52 | " | 10 | 48 | 33.75 | 45 n 20.86 | 121 W 40.68 | 4.88 | 2.25 | 0.13 | 7 |
| 53 | " | 20 | 26 | 5.99 | 45 N 34.19 | 121 W 42.61 | 1.55 | 2.71 | 0.21 | 12 |
| 54 | July 11, 1980 | 05 | 27 | 38.35 | 45 N 21.04 | 121 W 41.13 | 4.90 | 1.95 | 0.00 | 4 |
| 55 | " | 22 | 51 | 46.66 | 45 N 18.43 | 121 W 37.19 | 1.10 | 1.56 | 1.28 | 6 |
| 56 | July 17, 1980 | 02 | 03 | 1.43 | 45 N 20.48 | 121 W 41.04 | 5.32 | 0.83 | 0.03 | 5 |
| 57 | July 19, 1980 | 05 | 39 | 24.19 | 45 N 20.47 | 121 W 40.98 | 0.36 | 1.15 | 0.12 | 6 |
| 58 | Aug. 14, 1980 | 22 | 27 | 24.75 | 45 N 21.08 | 121 W 41.71 | 6.15 | 1.55 | 0.08 | 7 |
| 59 | Sept 18, 1980 | 16 | 46 | 02.11 | 45 N 16.12 | 121 W 44.75 | 4.37 | 2.10 | 0.21 | 8 |

## Figure Captions

Figure 1 Locations of 9 local earthquakes recorded by the Mt Hood network from November 20, 1977 to December 1978. The dark star indicates the mainshock of September 6, 1978, the open star is the foreshock of the September 6 earthquake and the open circles are the aftershocks. Dark circles indicate other earthquakes. (From Green et. al., 1979)

Figure 2 Station location map for the USGS Cascades seismic network. Three letter station abbreviations are explained in table 4.

Figure 3 Epicenter locations events from the July 1980 Mt. Hood earthquake swarm. Size of crosses is proportional to the magnitude of the event.

Figure 4 Histogram of the number of earthquakes versus depth for the July 1980 Mt. Hood earthquake swarm.

Figure 5 Histogram of seismic activity at Mt. Hood. The times are PDT (GMT - 7 hours).

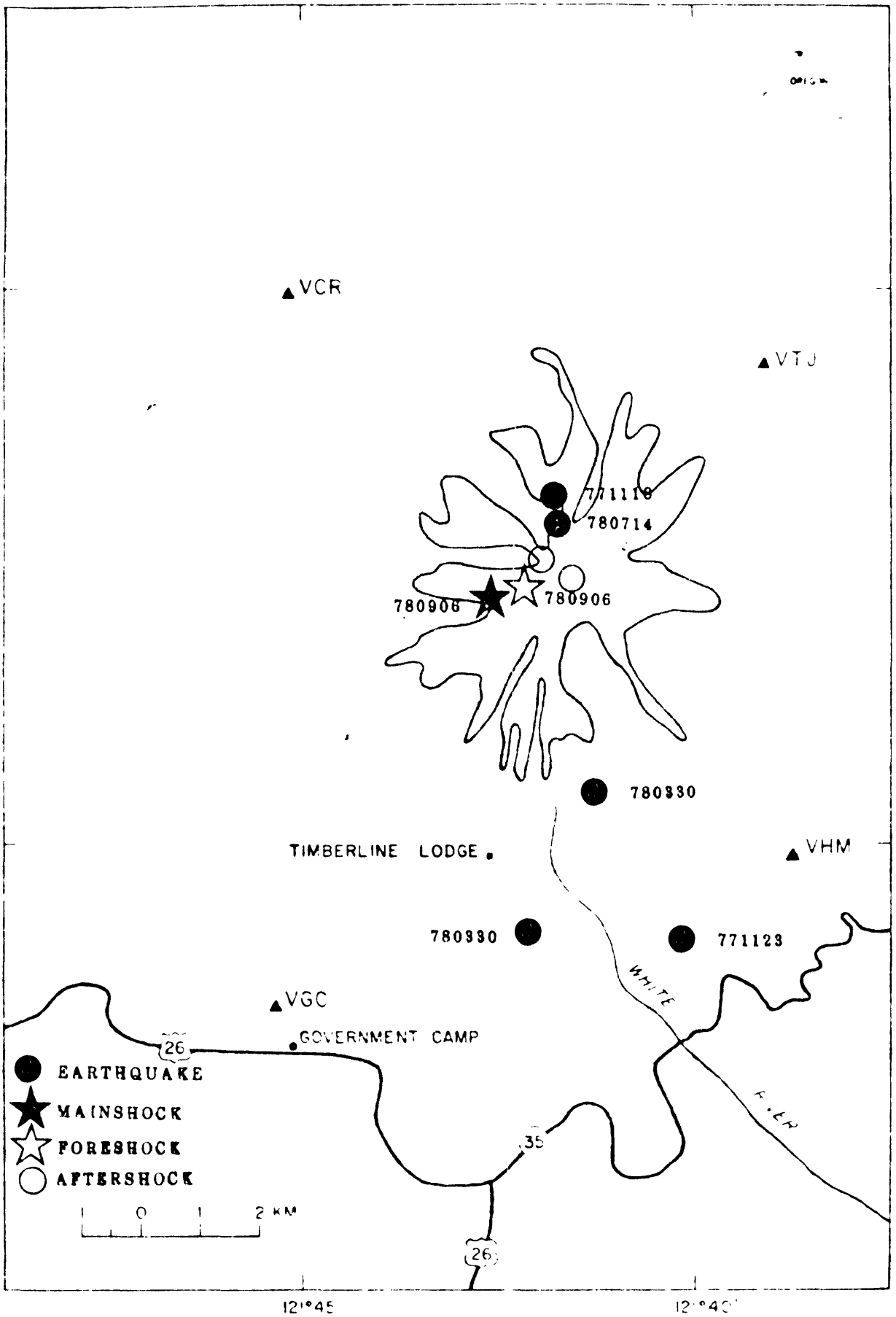
VCR
45°25
VTJ
771110
780714
780906
780906
780830
TIMBERLINE LODGE
VHM
45°20
780830
771123
WHITE
VGC
GOVERNMENT CAMP
26
EARTHQUAKE
MAINSHOCK
FORESHOCK
AFTERSHOCK
0
1
2 KM
35
26
121°45
121°40

Figure 1

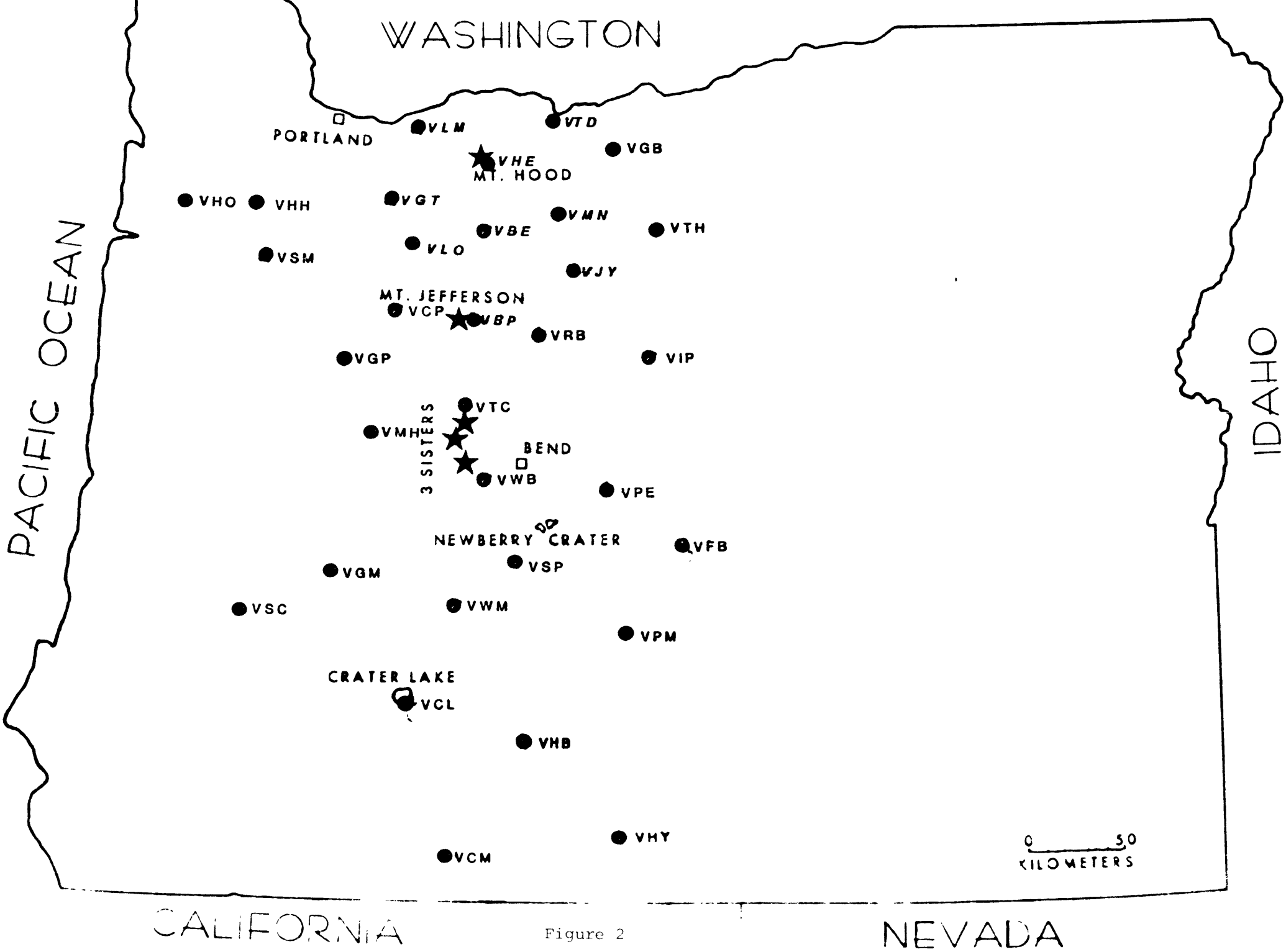
WASHINGTON
PACIFIC OCEAN
IDAHO
CALIFORNIA
NEVADA
PORTLAND
VLM
VTD
VGB
VHE
MT. HOOD
VHO
VHH
VGT
VMN
VTH
VBE
VSM
VLO
VJY
MT. JEFFERSON
VCP
VBP
VRB
VGP
VIP
VTC
3 SISTERS
VMH
BEND
VWB
VPE
NEWBERRY CRATER
VFB
VSP
VGM
VSC
VWM
VPM
CRATER LAKE
VCL
VHB
VHY
VCM
0
50
KILOMETERS

Figure 2

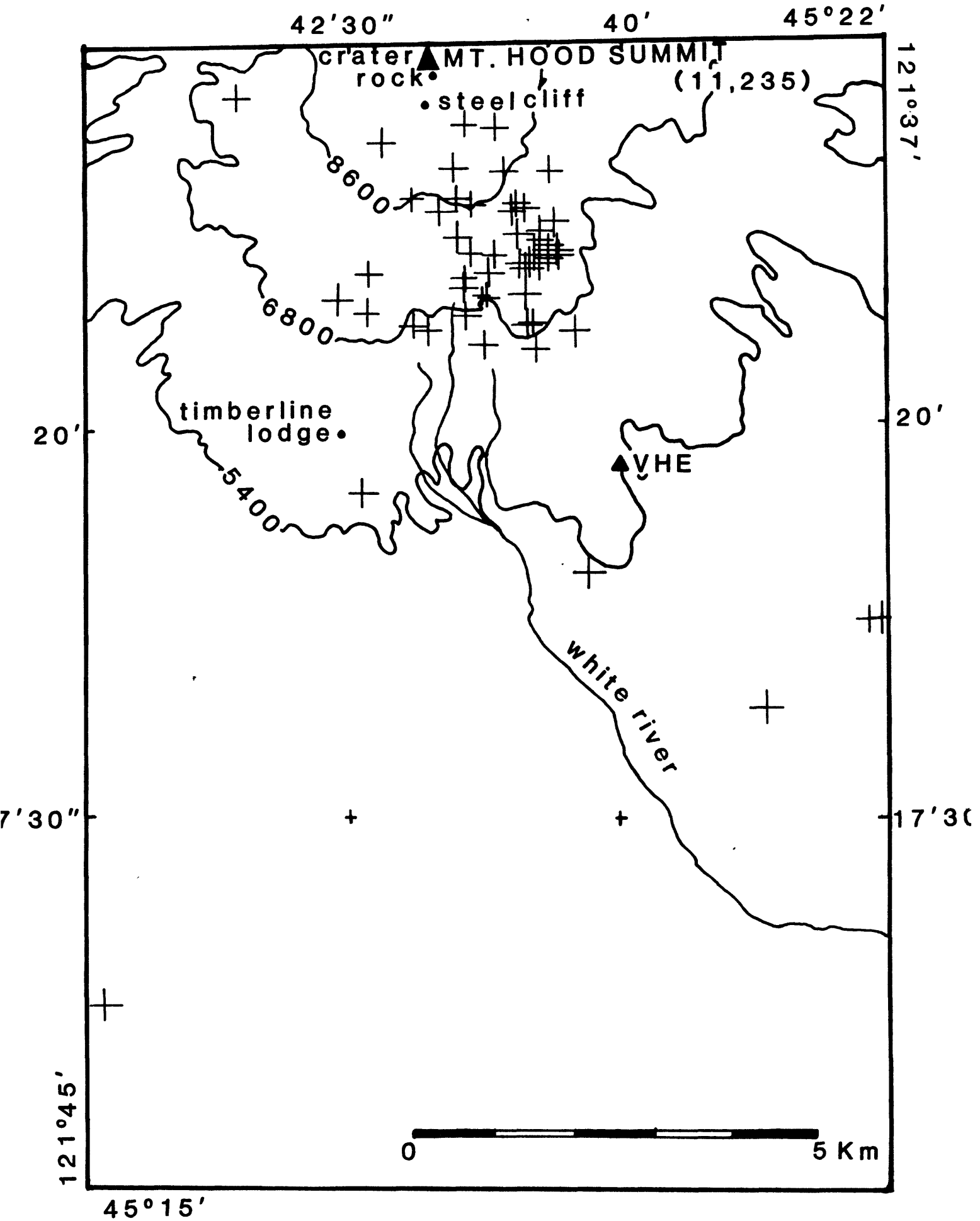
42'30"
40'
45°22'
crater rock
MT. HOOD SUMMIT
(11,235)
steel cliff
8600
6800
5400
timberline lodge
VHE
white river
121°37'
20'
17'30"
121°45'
45°15'
0
5 Km

Figure 3

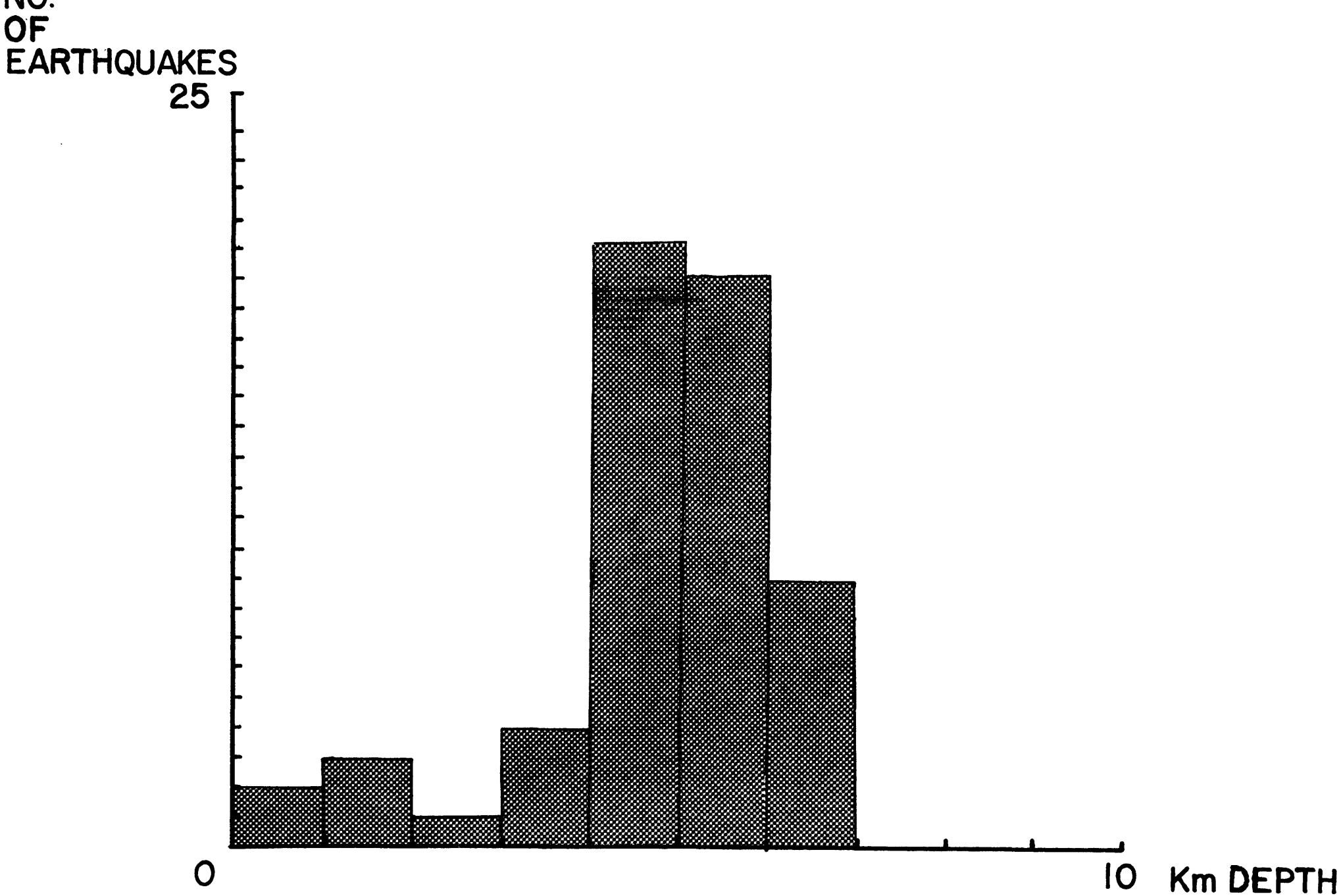


FIGURE 4

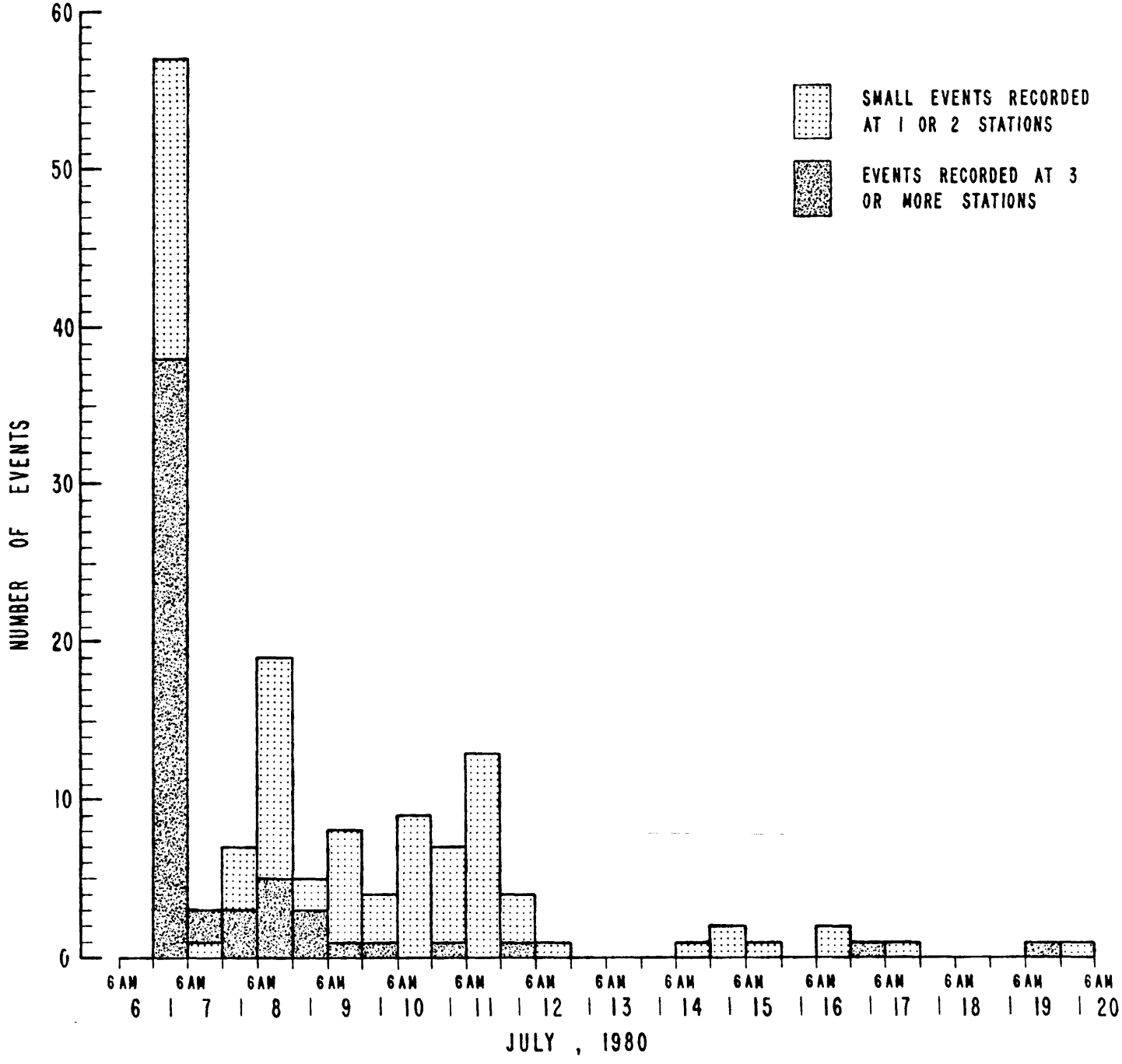
60
50
40
30
20
10
0
NUMBER OF EVENTS
SMALL EVENTS RECORDED AT 1 OR 2 STATIONS
EVENTS RECORDED AT 3 OR MORE STATIONS
6 AM 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20
JULY , 1980

Figure 5