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ERUPTION OF MANAM VOLCANO, TERRITORY OF NEW GUINEA, DECEMBER 1956 - FEBRUARY 1957

by

M.A. Reynolds

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FIGURE 1

Aerial view of Manam Volcano from south-south-east.

January 14th 1957.

SUMMARY

Manam Volcano became active on 8th December 1956, but was not reported until 5th January 1957. The activity was investigated from 14th January until 5th February, when it was concluded that if the pattern of activity showed no marked change, there was no danger to inhabitants or their gardens.

The active crater is south-east of the top of Manam, which is in the form of a trifurcate ridge. Main features of the eruptions were as follows,

1. Explosive activity predominated.

2. Most fragments of red-hot lava ejected were angular, and accumulated on the rim of the crater; they eventually moved down the slopes as avalanches which resembled typical "aa" lava flows (the 1946-47 "flows" probably occurred in this manner).

3. Subsidiary flows of viscous magma occurred near the rim of the crater.

4. Minor activity resembling steam explosions occurred from sources in the deep valley south of the crater.

5. Dust and gas from eruptions was negligible; there was a strong glow from the crater, sometimes visible in the day.

No significant earth movements were recorded by the tiltmeter or shock recorder that were set up.

INTRODUCTION

The first report that Manam Volcano was active was received by signal from Bogia on 5th January, 1957; the glow from the crater had been seen at night from Bogia during the preceding week. On the night of 10th January a lava flow from the crater was also witnessed from the New Guinea mainland near Bogia, and some detonations were heard. This information was also sent by signal as well as details of an inspection from the workboat "Lakanai" on 11th January. The District Commissioner and District Officer of Madang District conducted an aerial inspection of Manam on 11th, but saw very little because the upper 2,000 feet of the cone was capped by cloud.

The writer departed from Rabaul on 12th January and inspected Manam from the air en route Madang. On this occasion, also, the summit and crater were capped by cloud. Another aerial inspection was conducted, in vain, when travelling to Awar Plantation on 14th (see Figure 1.) The first two nights on Manam Island were spent at Tabelo village on the south coast. On 16th January, the writer moved to Waris village, farther east along the coast, where better observations of the activity could be made Bam Island was visited on 20th to review conditions there and to obtain a tiltmeter and shock recorder for further observations on Manam. These instruments were installed near Waris on 26th January and readings and records were obtained until 4th February. Investigations were completed on 5th February.

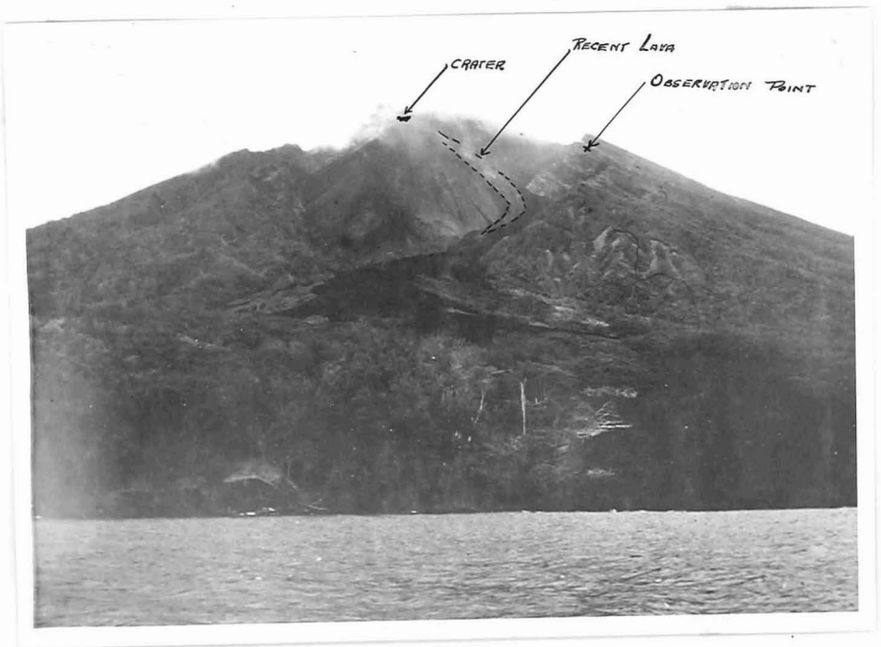

FIGURE 2

Manam Volcano from south-east. Deposits of recent activity, as at January 15th, shown in erosion channel in upper parts of 1946-47 flow. No deposits had formed on the steep slopes of the semi-cone at that time. The observation point of January 31st - February 1st is also shown.

I was assisted during this period by Cadet Patrol Officer R. Focken, and his help and that given by Assistant District Officer W.Johnston of Bogia is acknowledged. The co-operation of the District Commissioner and District Officer, Madang, was also appreciated, and thanks are due to Fathers Boehm and Aerni of the Roman Catholic Mission at Bieng for information and hospitality. Native people of Waris village seemed to have a better knowledge of ways of access to the upper parts of the 1946-47 lava flow and vantage points than those of other villages farther south.

STRUCTURE OF ACTIVE CRATER AND ENVIRONMENT TO SOUTH-EAST

Best (1953) discovered that the crest of Manam consisted "of a trifurcate ridge, the three axes of which are oriented at 70°, 195° and 313° (magnetic) respectively." A large "fumarole" was situated not far below the crest to the north-east; the volume of vapour from here showed no apparent change between November 1954, when Manam was visited by the writer, and January 1957 when this investigation commenced.

The active crater, which showed signs of eruption in 1953, was south-east of and below the crest. It is situated at the summit of a semi-cone [V] built out from the steep western wall of a broad avalanche valley which extends towards the south-eastern coast. The inner walls of the valley are mostly vertical and composed of fragmental material interwoven with numerous small lava sills and some dykes (see Fig.4). The outer slopes enclosing the valley are fairly steep and deeply dissected by stream beds. They represent the outer surface of the old caldera wall referred to by Best. An observation point used on 31st January and 1st February, 1957, was above the northern walls of the avalanche valley; measurements made with an aneroid barometer showed that the summit of the caldera wall here was about 4,000 feet above sea level. Vegetation varies from dense rain-forest on the lower slopes to mainly bracken and fern trees from about 3,000 feet to 3,400 feet above sea level. Small bracken and sedge-like plants were distributed sparsely over the upper 600 feet. The upper parts of the caldera between the avalanche valley and the next large steep-sided valley south to south-west of the crater differ from the above in that they are covered with dense rain forest to the summit (about 4,200 feet above sea level).

The semi-cone below the active crater occupies the greater part of the floor of the avalanche valley. It is separated from the inner walls on the south by a narrow deeply dissected valley, and on the northern side by a broader valley which narrows in the upper parts towards the western end. The relation is shown in Figure 2. The structure of the semi-cone at the western end is not known. Figure 2 also shows the lava deposits from activity in 1946-47. They appear to have accumulated mostly on the northern side of the crater and flowed in an erosion channel around the northern margin of the semi-cone. At the eastern base of the cone they linked with deposits from the south side and spread out over gradual slopes to the coast. The gradient from the eastern base of the semi-cone to the active crater in the northern channel is much steeper. The 1946-47 lava deposits in the photograph are dark compared with the small narrow ribbon of recent material, shown light grey, as at 15th January, 1957. The recent lava occupies an erosion channel within the 1946-47 flows. Subsequently this channel became filled and the lava began to accumulate in other channels until by 26th January most of the 1946-47 deposits had been covered down to the base of the semi-cone. The recent deposits, however, had not proceeded below this level, about 2,500 feet above sea level, before observations were completed on 5th February.

V The term "semi-cone" used in this report represents the half of a cone which has been bisected vertically.

The steep eastern slopes of the semi-cone were covered by small light-coloured scoria fragments when photographed on 15th and 17th January (Figures 2 and 3); these were apparently deposited during the last eruption in 1947. Some small "islands" of older lava flows and deposits protruded through this cover. A grey veneer of recent lava fragments had covered the scoria deposits by the time photographs were taken from the observation point to the north (see Figure 4, 31/1/57; Figure 5, 1/2/57).

Thermal activity, other than that from the second crater to the north, was observed from small vents in steep-sided ridges extending from the crest of the volcano towards the active crater.

ACTIVITY

The native people of Waris village first noticed that activity at the crater had changed from the usual emission of white vapour clouds to an explosive phase on 8th December, 1956. A student who had returned home from Alexishafen on holidays was fairly certain of this date. The initial explosive activity was not heard, but was suggested by the spasmodically ejected lava fragments resembling black puffs of smoke.

Waris village is about 2 miles east of the crater and offers the best view of the activity. Sound effects are also heard clearly because the avalanche/valley walls are open towards the coast just south of here. Observation from Waris between the months of November and March has the added advantage that the wind during this period is generally from the north-west, and sounds are heard better than at other times of the year. A disadvantage of making observations during the "north-west" season, however, is that there is more rain, and cloud caps cover the summit area of Manam, particularly on the south-east side, for most of the time.

Little is known on Manam Island of activity between 8th December, when explosive activity was only mild, and Christmas. This is due to the fact that most of the people congregated at the Biong Mission on the north-west coast and that cloud covered the summit during that period. The Waris people returned to their village at Christmas and observed very strong explosive activity. Fine dust from this activity settled over most of the south-east part of the island. Explosive activity continued from then until at least the first week in February, 1957. Waris people stated that it was most intense in late December, 1956. They seemed quite unperturbed by the noise of detonations and the fact that they were probably nearest to, and because of the physiography, more likely to be affected by the activity than other people.

Other general information on the activity, supplied by Father Aerni of the mission station, officers of the Department of Native Affairs and from my own observations, is listed in chronological order hereunder.

1956:

December, 27, 28 First noticed that activity had commenced

(a) from Biong Mission by dark coloured cloud from crater
(b) from Bogia by glow at night.

December, 29 - 31 Glow from crater seen at Bogia.

FIGURE 3

Manam Island people on the northern rim of the erosion channel in 1946-47 deposits just above the end of recent deposits, as at January 17th 1957; the north-eastern slopes of the semi-cone are shown at upper left rising from behind south bank of erosion channel.

1957:

January 1 - 9	Glow from crater seen from Bieng and Bogia at night. Occasional dust clouds seen during day from Bieng.
January 10	From midnight on 9th, stronger glow than before seen above crater from Bieng, and also heavy dust cloud during day. Bogia reported lava flows, and that detonations were heard between 1900 and 2115 hours.
January 11	Inspection by Assistant District Officer W. Johnston on workboat "Lakanai". He reported that there were detonations every few seconds; that there was a lava flow, about 20 yards wide, which extended for one-third of the way down from crater, and that it was "still trickling"; also that only one vent was erupting.
January 12	From Father Aerni, Bieng Mission - red glow seen 0245 hours and detonations heard by local native people that night.
January 13	Glow from crater at night seen at Bieng.
January 14	Detonations heard at Bieng, Tabele.
January 15, 16	Frequent detonations and strong glow from crater at nights; glows were sometimes seen at times of strong detonations during the day on 16th.
January 17	Base of the recent lava "flow" visited. The photograph, Figure 3, was taken at this time; the following observations were made -

(1) lowest deposits were about 2,500 feet above sea-level;
(2) they were still hot:
  (a) a 0-200°C. maximum recording thermometer was inserted to about 6 inches; mercury rose to over 200°C. in 7 minutes, and thermometer withdrawn;
  (b) a sapling stick inserted about a foot into the deposits had charred andwas glowing by the time it was withdrawn about ½ hour later;
  (c) heat haze was strong above the deposits;
(3) macro-examination of rock types showed that new deposits composed of porphyritic olivine basalt and appeared very similar to the basalts of the 1946-47 lava flow;
(4) new deposits were mostly scoriaceous and grey in colour; the only difference from 1946-47 material was the outside colouring, which had become red brown by deuteric alterations and weathering;
(5) gas was not obvious; it was interesting to note that birds and insects existed in this area (also, later, that parrots were nesting in the upper parts of the valley walls within a mile of the crater);
(6) lack of vegetation in 1946-47 deposits is considered to be due to their unconsolidated and unstable nature.

At 1400 hours while returning to the coast, I heard a loud noise from the crater area. The noise, which frightened native guides, was probably caused by an avalanche of lava fragments built up at the side of the crater.

What appeared to be actual lava flows were witnessed that night; this is discussed in more detail later.

January 18 - 20 — Activity was the same as during the period 15th-17th January.

January 22 — While returning from Bam Island to Bogia I saw a second stream of newer fragmentary deposits in another erosion channel north of the first described. The summit was obscured by cloud. A thin stream of vapour was seen rising from the avalanche valley south of the crater; this phenomenon was also observed by Mr. Johnston during his previous inspection of Manam. It was attributed to either thermal activity or dust and steam rising from the rare bombs which fell in this valley. Subsequent inspection of this valley both from the coast and from on top of the enclosing walls failed to reveal either thermal activity or any recent bombs. It is possible that the latter had disintegrated and were not immediately obvious amongst the scree deposits in the upper slopes.

January 22 - February 5 — The nature of activity was unchanged; there were frequent detonations most of the time and occasional lava flows were seen by night.

January 31 - February 1 — The closest inspection of crater activity was made from an observation point near the summit of the caldera wall on the north side of the avalanche valley in which the active cone was situated. The position is shown in Figure 2. It afforded an excellent view of the activity at times when it was not covered with cloud. The photographs (Figures 4-6) were taken from the observation point.

More detailed descriptions of the activity and other phenomena associated with it are given hereunder:

1. The Explosive Nature of the Activity -

Observations made during the investigation of activity in January, February 1957 suggested that the lava "flows" of the 1946-47 activity were not true "aa" flows as suggested by Best (1953). They were similar in their situation and composition to the deposits of the recent eruption, which were apparently formed in the following manner:

(a) Lava in the red hot condition was ejected by the frequent explosions on to the outer rim of the crater; a slight inclination of the inner walls of the crater or of the conduit is suggested to account for the fact that little material fell on to the eastern flanks of the cone.

FIGURE 4

Crater activity at 1830 hours, January 31st 1957; slopes of semi-cone almost covered by new lava fragments. Vapour streams from lava bombs rolling down slopes are shown (left of centre) and also slow-moving avalanche (right of centre). In bottom right hand corner, a spur composed of interbedded fragmentary material and small sills is shown.

Photo from observation point.

(b) The pyroclastic material was composed mostly of irregularly shaped fragments of lava, some quite large; there was very little dust. The maximum height to which it was ejected appeared to be no more than 1,000 feet above the crater; most of the ejecta therefore fell very close to the crater on its outer slopes.

(c) When conditions for observation were good or detonations could be clearly heard, frequency of explosions was calculated; on the average, six or seven explosions occurred per minute. This meant that accumulation of pyroclastic material was rapid.

(d) Material heaped quickly in this manner would form an unstable mass; angularity of the fragments, however, would enable the mass to become quite large before the force of gravity and frequent jolting from explosions caused it to collapse and slide down the outer slopes of the crater. These slides, or avalanches, which were slow moving (estimated speed about 1 mile per hour) had the characteristics of "aa" flows and could easily be mistaken for them.

(e) As the lava fragments slid down the slopes they occupied the lowest topographic features, such as the erosion channel in which the first series of "flows" was witnessed, and became spread out along them. Subsequent avalanches were superimposed upon these and another accumulation of material similar to that occurring near the rim of the crater, commenced farther down the outer slopes. A further slide of this mass of material commenced, therefore, when it became unstable.

(f) This process was repeated until eventually huge masses of lava fragments were involved in the sliding movements. Such an avalanche occurred when the writer arrived at the observation point on 31st January. As the whole of the summit area was shrouded in cloud, the noise of the movement was not immediately recognised; it sounded like a heavy shower of rain approaching. A photograph (Figure 4) taken later that day shows an avalanche with thin vapour streams blown to the south by the prevailing wind.

(g) If activity in 1946-47 was the same as that described above, the repetition of accumulation of pyroclastic deposits followed by avalanches continued until after the masses of fragmentary material flowed into the sea. Explosive activity, therefore, and not lava extrusion would have been responsible for the extensive "flows".

Other features of explosive activity were as follows:

(1) Irregularity of shape and angularity of lava fragments ejected during explosions, referred to above, was noticed mainly during observations at night. The material examined during the ground inspection on 17th January was mostly scoriaceous and only poorly rounded by sliding; there was no evidence of lava fragments having been fluid when ejected. High viscosity is therefore suggested for the lava in the conduit.

FIGURE 5

Deposits on slopes of semi-cone, as at 0800 hours. February 1st. Base of viscous lava flow just left of and below white vapour in centre of photograph. Photo from observation point (using 90 mm. lens).

FIGURE 6

Minor activity in steep-sided gully below southern slopes of semi-cone.

(a) at 1745 hours, January 31st 1957;

(b) at 1745 plus about 30 seconds.

(2) Some fragments (or bombs) fell beyond the zone of accumulation near the crater rim and occasionally on the eastern side of the semi-cone. Some bombs also apparently fell into the avalanche valleys south and west of the summit of Manam. The larger of these with greater momentum travelled at great speed (estimated up to 40 miles per hour) down the steep slopes; they came to rest in flatter or eroded areas where further progress was impeded by scree or large boulders. Bombs bouncing down the eastern slopes of the semi-cone at night produced a spectacular effect. As they bounced, scores of red hot fragments flaked or broke from their surface, producing a shower of sparks; the noise, sometimes clearly audible from the coast, resembled that of a locomotive engine gathering speed. Lines of small puffs of vapour from this type of activity are shown in Figures 4 and 6a.

(3) Voluminous clouds of dust and vapour such as witnessed during explosive activity at other volcanoes in the Territory of New Guinea since 1953 were markedly absent during the Manam eruption. Fine dust, however, did at times settle over the south-east part of the island.

(4) Based on the sound effects, explosions at the crater would be better described as detonations. At times there were loud sharp cracks as of thunder immediately overhead.

(5) At night when visibility was good, a continuous glow was seen from the crater. The colour and intensity varied from dull red when quiescent to bright orange red at times of explosions. The glow, occasionally also seen by day, suggests that the top of the magma was not far below the rim of the crater; thermodynamic energy was apparently insufficient to force the viscous lava higher in the conduit and gas accumulations caused the frequent explosions. Jets of "flame" sometimes accompanied the explosions; the jets could have been due to either gas or showers of incandescent dust. The crater glow can be seen in Figure 6b, and a jet of flame, in front of the black explosion cloud, in Figure 4.

2. Lava Flows -

The deposits formed from activity in January, February 1957 were composed mostly of ejecta from the crater. Some lava was contributed by what appeared to be small lava flows from the rim down the eastern and south-eastern slopes of the semi-cone. The exact nature of the activity could not be determined during the investigation. Actual flows were spasmodic and best seen by night; they were often obscured by small streams of vapour emitted at the same time. Features which were obvious were as follows:

(1) The lava was extruded from vents and fissures in a small ridge on the eastern side of the semi-cone; it appeared on most occasions to be squeezed out as large blobs by internal pressure, and rolled down the slopes in the same manner as described previously for bombs falling on this side of the crater.

(2) The ridge extended from the rim of the crater to about 500 feet below; it may have been a viscous lava flow whose surface had cooled and solidified (see Figure 5). Main sources of emission were just below the crater rim, in a wide band near the bottom and from points in the periphery.

(3) Flows, continuous for short periods, were observed on the nights of 17th January and 1st February. They originated from the vent or fissure just below the rim and apparently travelled small distances over a shallow zone before the slopes became steep; here the lava broke off and rolled away. The flows left a red trail in their wake.

(4) During observation on the morning of February 1st, two other solidified lava flows were noticed south-east of the/described above; they /one extended only a short distance from the rim of the crater.

(5) Fragments of lava from effusive and explosive activity eventually covered the light-coloured deposits of previous activity on the slopes of the semi-cone.

The mechanism may have been similar to that which formed the caldera wall deposits of fragmentary material interwoven with sills and dykes mentioned on page 2.

3. Other Phenomena -

Unusual activity which resulted in the formation of voluminous dust and vapour clouds occurred between 1745 and 1800 hours on 31st January. The source, as seen from the observation point, appeared to be a series of vents in the deeply dissected valley on the south side of the semi-cone. Figure 6 shows small vapour clouds at the commencement of activity and the large volume of vapour and dust subsequently developed. The size of the cloud formed compared with the small dark cloud from the active crater (upper right hand corner in Figure 6b) suggests that a large volume of steam was produced independently of the main source of activity. No noises were heard at the observation post. The activity may have resulted from slow-moving avalanches of ejected material reaching the top of a steep-sided stream bed and collapsing into pools of water accumulated from previous heavy rains. Examination of the lower parts of such an avalanche on 17th January revealed that the deposits maintain high temperatures for long periods. An inspection of the southern valley was made with binoculars from old lava deposits to the east on 5th February; thermal activity was not observed.

GROUND TILT AND VOLCANIC EARTHQUAKES

A small concrete block used by Best in 1953 for tiltmeter readings was pointed out by native people of Waris village; it is situated just south of that village and west of the path to the landing point. The area had been overgrown, but was quickly cleared and a hut which gave adequate shelter from rain, was constructed over the block. Instruments from Bam Island were installed on 26th January, and readings and records were obtained from then until 4th February.

1. Tiltmeter Readings -

Apart from variations due to atmospheric temperature fluctuations, no significant trend was shown by the overall tiltmeter readings.

2. Shock Recorder -

The pendulum mass was oriented to give maximum displacement for movements in a north-south plane, i.e. for tremors from the crater area, the greater amplitude transverse waves would have been recorded. Owing to the faulty clock drive, records for periods greater than about 15 minutes were rarely obtained. For this reason, the shock recorder was examined frequently. No marks which could be attributed to ground movements were observed on any of the records.

3. Ground Movements Observed -

Father Aerni felt very slight, short period movements in the mission quarters (a two storey building) at the following times -

January 11th 1845 - 1930 hours
12th 1530 hours
13th All day.

He states, however, that very strong winds from the north-west and strong surf pounding the nearby coast may have caused these movements.

Native people of the Tabele, Budua, Waris villages, situated along the coast on the southern to eastern side of the island had felt no earth tremors during the activity. Waris people, however, stated that during the strong activity in late December their houses shook at times of big explosions.

A bubble in the damping liquid of a prismatic compass resting on a rock outcrop at the observation point vibrated slightly at the times of detonations at the crater. The vibrations were possibly due to small ground waves generated by the explosions or by concussion effects against the steep walls beneath the observation point.

CONCLUSIONS

Although detonations at the crater occurred every few seconds, and the frequency did not change during the period of investigation, a number of facts suggested that unless there was a change in the nature of the activity, no danger existed to the inhabitants of the island. These facts are listed below -

1. Ejected material was deposited in erosion channels in the 1946-47 deposits: avalanches followed the same path as that during 1946-47. No danger existed to native villages and gardens if this trend continued.

2. Most ejecta fell in the vicinity of the crater; the danger area for this activity was within a mile radius from the crater.

3. Dust and gas were not emitted in large volumes; gardens on the leeward side of the crater, therefore, were not likely to be damaged.

4. There were no apparent ground movements which suggested development of more intense activity.

The pattern of activity during previous eruptions was well known to older people in the villages. Father Boehm, who was at Bieng Mission on the north-west coast of Manam Island for about 30 years, had also passed on his knowledge of previous eruptions to the Fathers who replaced him. These authorities regarded activity in December 1956 to February 1957 as mild; they expected stronger developments in the coming May or June. The people were warned that any unusual developments such as commencement of earthquakes or obvious ground movement should be reported by radio to the Vulcanologist, Rabaul, immediately.

REFERENCES

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