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REPORT ON VOLCANIC ACTIVITY ON AMBRIM ISLAND

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INTRODUCTION

Ambrim Island lies in the centre of the New Hebrides group which is situated approximately 1500 nautical miles north-east of Sydney.

Benbow crater is the main residual active centre of the large ancient volcano which has formed Ambrim Island. For the eleven months preceding December 1951 it has been the source of extraordinarily intense and prolonged explosive activity. The volume of ash and scoria ejected during this period exceeds 800,000,000 cubic metres.

Evidence has been found during the recent inspection of this volcano that suggests that the current phase of explosive activity has ended.

Ambrim volcano is of the open conduit type as distinct from the closed conduit volcano which may have such unpleasant characteristics as catastrophic eruptions following long periods of dormancy and, in some instances, the highly lethal type of glowing cloud eruption. There is no liklihood of this type of eruption occurring at Ambrim. The Ambrim lavas are basic in chemical composition and resemble those of Kilauea crater of Hawaii Island.

Kilawea is an example of one type of open conduit volcano.

Open conduit conditions involve the presence in the crater of liquid lava in free contact with the atmosphere. The lava is kept in circulation and is maintained at a high temperature by the escape of gas and its interaction with the atmosphere. A condition of equilibrium is reached towards the top of the lava column where the rate of gas ebullition reaches such a fine state of balance that it is influenced by variations in the atmosphere pressure. In the lower layers of the lava column, however, the pressure of the head or upper column produces conditions which are similar to those existing in closed conduits where the lavas under pressure become saturated with gas. Thus gas retention in the column is proportional to depth from the surface and gradually over a period of time the gas tension builds up in the lower layers until the system tends towards instability, conditions are then ripe for eruption.

At this stage any change in conditions capable of reducing the pressure on the lava column is likely to become the trigger mechanism which sets off a new eruptive cycle. The most usual event is a reduction of pressure on the highly gas-charged lower layers by fracture or assimilation of the retaining crater wall and consequent drainage of the upper part of the column by rapid lateral lava flows. This seems to be the normal mechanism of Ambrim eruptions. The eruptions of 1894, 1913, 1929 and 1937 were each initiated by lateral lava flows with subsequent explosive activity. The flows appeared to have originated low on the slopes of Ambrim and in some instances at submarine levels.

The 1950-1951 Eruption

The current eruption seems to be exceptional in the absence of initial lava flows. It also appears exceptional in the duration and intensity of the explosive activity. This raises the question: what is the mechanism of the recent eruption?

Perhaps some indications can be found in the pattern of events which followed the previous eruptions, for all volcanoes appear to have in their eruptive habit a basic pattern of gas accumulation, resistance and release.

Following the exhaustion of the volcanic energy with the 1937 eruption it is evident that the slow rise of lava in the conduit began again. In 1942 the presence of lava in the crater made itself known by a terminal flow which had its origin high up on the cone. One flow crossed the high caldera plateau north-east of Benbow and reached the sea two or three miles west of Rannau. This flow showed some characteristics of viscous Pahoehoe lava and was less gaseous than the Aa blocky flows which Benbow commonly produces. As this flow undoubtedly originated from the upper lava column layer which is freely exposed to the air, a lower gas content and a higher temperature is to be expected. Terminal flows, being a drainage from the top of the column, rarely affect the distribution of pressure within the lava column system, so that the absence of explosive activity in 1942 is not unexpected.

A classical precedent for this form of effusive activity are the terminal lava flows of Vesuvius during the period 1881 to 1905.

After 1942 Benbow remained quiet and it can be assumed that during this period the accumulation of volcanic energy was taking place, with increasing gas tension in the lava column layers beneath the surface "plug" of relatively gas free lava.

The next event of significance appears to be the report of earthquakes prior to the 1950-1951 eruption. An observer on the island of Paama reports that the first severe earth tremor occurred on 22nd July 1950 and tremors became particularly severe prior to the initial eruption of 6th December. These tremors were undoubtedly of tectonic origin associated with regional crustal adjustments, for an Australian observatory reports very numerous shocks originating from the New Hebrides during this period. Volcanic tremors are usually of low intensity, short range, and rarely perceptible beyond a 20 mile radius from a volcano. There is then the suggestion of a seismic crisis which calls to mind the dynamism of the Lesser Antilles group in the West Indies, where seismic crises have sometimes heralded an eruptive cycle. The Paama observer reports more than seventy severe earth tremors over the eighteen months ending November 1951. These tremors are considered to be of an intensity of two or greater and, in the main, of tectonic origin, as they were observed to be quite distinct from the innumerable low intensity volcanic tremors which accompanied the eruptions.

The characteristics of this seismic pattern suggest that here we may find the key to both the mechanism which initiated the eruption and the future condition of the volcano.

After a period of accumulation it is probable that the magmatic reservoir underlying the volcano contains a number of delicately balanced energy or pressure systems. The disrupting influence of an earthquake may disturb the equilibrium of these systems. This, in turn, effects the balance of forces in the lava column and a new eruptive phase is begun. There is a further suggestion in the pattern of earthquake occurrences that the eruption was frequently assisted by seismic disturbances of regional origin during the current period of activity.

If this assumption is correct the virtual cessation of seismic activity since mid November, when the present eruption ceased, is a good indication that the current eruptive period has ended.

Other arguments supporting this conclusion are deduced from information supplied by local observers and observations made during the investigation.

The present absence of luminous effects in the crater is indicative of the absence of incandescent lava. Without liquid lava in the crater the eruption potential is low. Flames and crater glow, typical of Strombolian activity, were a feature of the early and most intensely active phases of the eruption. No luminous effects have been observed since June.

Changes in the character of sound effects during the eruption are indicative of phase changes which accompany exhaustion of the lava column and final choking of the vent. After June the explosions and detonations, which had been such a feature of the early activity, were replaced by rumblings and prolonged roaring effects. The rumblings were indicative of a deep seated origin and a lowered lava column.

The roaring which sometimes attained the pulsating effect of a high pressure steam jet, has previously been observed as characteristic of the secondary gaseous phase in eruptions of this type. So tremendously powerful was the gaseous release during this period that the volcano was described as a vibrating shell about to disintegrate. This phase of rapid gas emission usually reams out the throat of the volcano enlarging the crater and ejecting dust and ash, consisting of much comminuted cone material. With the waning of power of the emission, material from the collapsing cone eventually blocks the vent. The blockage may be removed several times with explosive violence, but finally the reserves of gas are insufficient to remove the plug and the eruption ends. This appears to be the sequence of events with Ambrim.

Unfortunately bad weather conditions prevented confirmation of some of these points during inspection of the crater. However the complete absence of sound effects was indicative enough of the absence of liquid lava in the crater and the compact lava bombs and blocks of old cone material found on the rim of the crater, are phenomena which are usually characteristic of the final phases of an eruptive cycle.

Possible future activity

Regarding future activity of Ambrim, if the conclusions drawn from the above observations are correct and the present eruptive cycle is ended, it is probable that previous patterns of activity will be repeated. The lava column will rise again slowly assimilating the cone material blocking the crater and its arrival in the crater, in 2 to 5 years, will be heralded by a mild explosive activity of short duration or a terminal lava flow without explosive activity. A period of mild Strombolian activity will ensue until such times as gas accumulation stores sufficient energy for a further major eruption. The average period between major eruptions over the last 60 years has been roughly 12 years.

Effects of the Eruption

The distribution of ejected material is an important factor in decisions governing relief and resettlement of native peoples. The accompanying map roughly outlines the areas of major ash deposition. Outside the immediate crater area the distribution is largely influenced by prevailing winds. An apparent anomaly exists in south-east Ambrim which received heavy deposits of materia during the south-east season. The explanation lies in the existence of a contrary wind at higher levels. Material ejected penetrates the upper atmospheric layer in which air currents are waning to the south-east and a major distribution of ejectaments occurs south-east of the volcano.

Secondary distribution of material may also effect settlement in low lying areas. Ash and scoria deposits in the immediate vicinity of Benbow crater exceeds nine metres in thickness. Re-establishment of the drainage channels will probably remove large quantities of this material in the form of mudflows. Mudflows usually move with considerable force and velocity leaving a trail of destruction in their wake. Villages and gardens in low lying areas adjacent to drainage channels from the caldera plateau are practically certain to be destroyed. The most critical area likely to suffer from mudflows appears to be on the south coast between Beaulap and Lalinda. A more restricted area on the coast west of Rannon may also be affected.

RECOMMENDATIONS

A long history of secondary crater outbursts and lava flows clearly indicates that settlement in the Dip Point - Craig Cove area is foolhardy. Submarine lava flows have also been a feature of this western sector of the island and consequently coastal subsidence would not be unexpected.

The appointment of local observers in all potentially active volcanic areas of the New Hebrides is also strongly recommended. During the recent investigation the writer was greatly assisted by the record of the eruption made by Mrs. Chiles of Paama Mission.

The following note may be of assistance to such observers:-

a. The violence of an eruption is usually proportional to the length of the period the volcano has been dormant.

b. Distribution of ejected material from volcanic eruptions is largely controlled by the direction of the prevailing winds. (Meteorological Service can probably supply wind roses for upper and lower atmospheric layers).

c. Four kilometres (approx. 2½ miles) has been determined at the usual danger limit for serious injury from falling material in other volcanic areas. The same limits can fairly safely be applied to New Hebrides Volcanoes for "normal" eruptions. Should an eruption occur in an area with no previous history of eruption this limit would have to be considerably extended.

d. Volcanic earth tremors are usually the most reliable indicators of an impending eruption. Volcanic tremors may be distinguished from tectonic, or regional tremors by the following characteristics -

   i. Character of Movement and intensity

   The motion is rapid and the intensity low, and is generally only perceptible under favourable conditions.

   ii. Duration.

   Seldom longer than a few seconds.

   iii. Frequency.

   The frequency of occurrence usually increases, as the beginning of the eruption approaches, the tremors becoming very numerous prior to critical conditions.

   iv. Range

   The range is short. For the trĕmors to be felt at a distance of 20 miles from a possible eruption centre is exceptional.

e. It has been observed that the current eruption of Ambrim was associated with tectonic tremors. Although a definite relation is suggested in this eruption, it must be recognised that all tectonic earth tremors do not indicate imminence of a volcanic eruption. The New Hebrides belt is a region of crustal instability and consequently earthquakes are of common occurrence. It is only when critical pressure conditions are developed within a volcano that this relationship will be applicable. Hence earthquake reports as warning data should be regarded with caution unless supported by other phenomena indicating an increase of volcanic activity.

Following is a list of the phenomena that are usually associated with increased volcanic activity:

1. Numerous volcanic tremors
2. Increase in gas exhalation from craters (other than normal fluctuations due to variation in atmospheric conditions).
3. Increase in temperature and extension of fumarole or hot ground areas - sometimes manifested by dying of vegetation and drying up of hot springs.
4. Increase in temperature and rate of gas ebullition in hot spring areas or the appearance of hot springs in new areas.
5. Large quantities of dead fish in the sea.
6. Underground rumblings.
7. Cracks in the ground.

The above phenomena must be interpreted with common sense without jumping to conclusions on the basis of observations of isolated phenomena. Some normal explanation should be sought before reaching conclusions regarding its volcanic significance.

For example a new hot spring was reported from the Quion Hill area of northern Efate. The spring lies on the northern side of the airstrip opposite Quion Hill. Enquiry revealed that this was the site of an old spring which had died away some years ago. In absence of any supporting symptoms its reappearance was attributed to some change in ground water channels. Such a change could be brought about by unusual falls of rain or exceptional tidal conditions.

With regard to definition of volcanic areas having an eruption potential the brevity of the investigation hardly qualifies the writer to enumerate such areas. Generally speaking any volcano having a well preserved cone and crater structure has some potential.

The following are suggested as some of the potential areas:-

Vanua Lava, Aoba, Ambrim, Lopevi, Tongoa, Undine Bay crater group, Yasour on Tanna.

It is hoped that at some future date an opportunity will arise for a much more comprehensive survey of this very interesting volcanic region.

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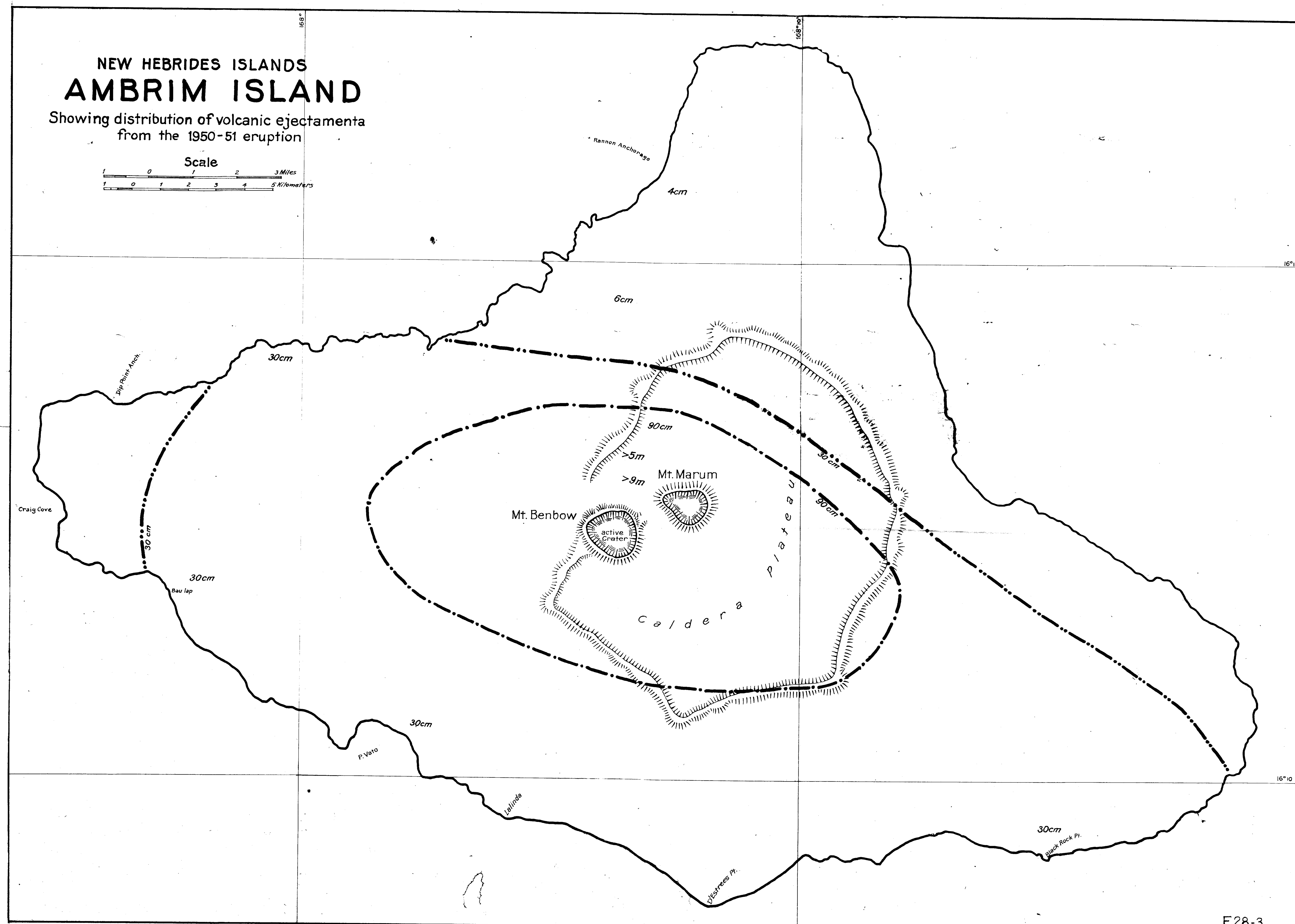
NEW HEBRIDES ISLANDS
AMBRIM ISLAND
Showing distribution of volcanic ejectamenta from the 1950-51 eruption
Scale
1 0 1 2 3 Miles
1 0 1 2 3 4 5 Kilometers
168°
168°10'
16°10'
16°10
Rannon Anchorage
4cm
6cm
30cm
Dip Point Anch.
90cm
>5m
>9m
Mt. Marum
Mt. Benbow
active Crater
Caldera plateau
Craig Cove
30 cm
30cm
Bau lap
P. Vato
30cm
Lalinda
D'Estrees Pt.
30cm
Black Rock Pt.
30 cm
90cm
F28-3