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REPORT ON BAM ISLAND VOLCANO

AND AN INSPECTION OF KADOVAR AND BLUP BLUP

by

G. A. Taylor.

Records No. 1955/73.

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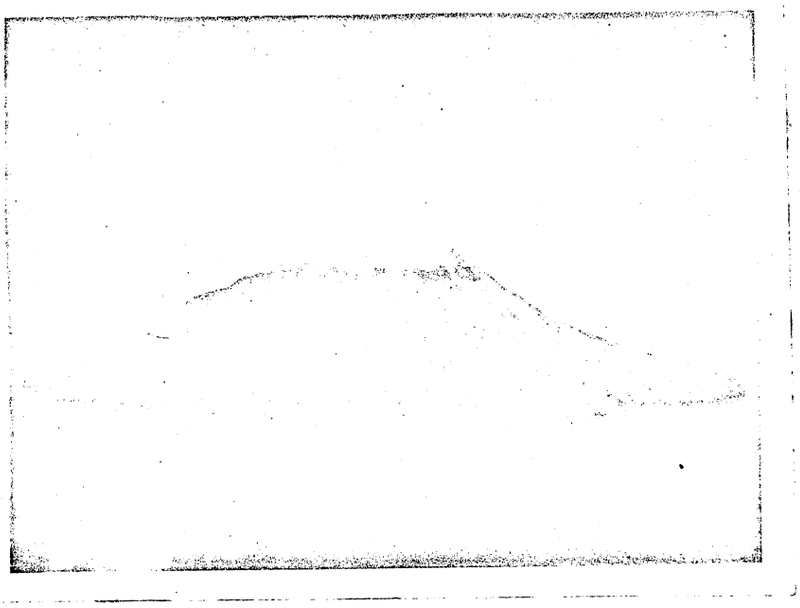

Fig. 1. Approaching Bam Island from the south east.

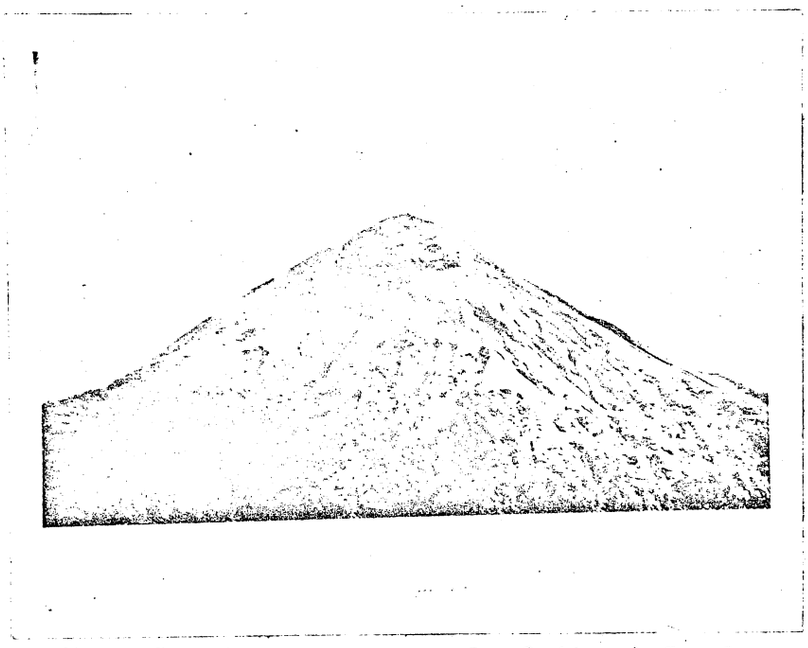

Fig. 2. The eastern end of the island showing marginal vegetation and bare summit area.

Fig. 3. Bam village on the northern coast. 1600 yards from the crater.

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INTRODUCTION

Bam Island is situated about 30 miles off the north coast of New Guinea, Latitude 3°30'S, Longitude 144°35'E. The island is very roughly oval in shape with a maximum diameter of about 1½ miles. It rises steeply from the sea to a height of about 2000 feet. Its total area would be little more than 1000 acres of which less than 60% would be suitable for native agriculture.

Normally it supports a native population of about 400 people, who live in a village on the northern side of the island where a shelf made by old lava flows forms a narrow area of comparatively flat ground. Coconuts are the main source of the considerable wealth of these people and one of their most important foods. The trees are planted mainly on the north and north eastern sides of the island, where most of the available agricultural land is situated. Taro, kau kau and fish are the other chief foods. The fact that the island lies in the off-shore "stream" of the flood waters from the Ramu and Sepik Rivers probably accounts for the extraordinary abundance of fish in these waters and the unusual importance of this item in their diet.

Movement to the Mainland.

After the explosive activity of August, October and November, 1954, the Bam people were moved on to the New Guinea mainland near Bogia in December. For a number of reasons the people did not settle down in their new environment. They found it difficult to adapt themselves to a new diet; they had no immunity to malaria; their religious and psychological ties to their island homeland were so strong that the prospect of permanently remaining on the mainland engendered a hopelessness and loss of morale which seemed to destroy their will to live and no doubt accounted for many of the deaths which occurred.

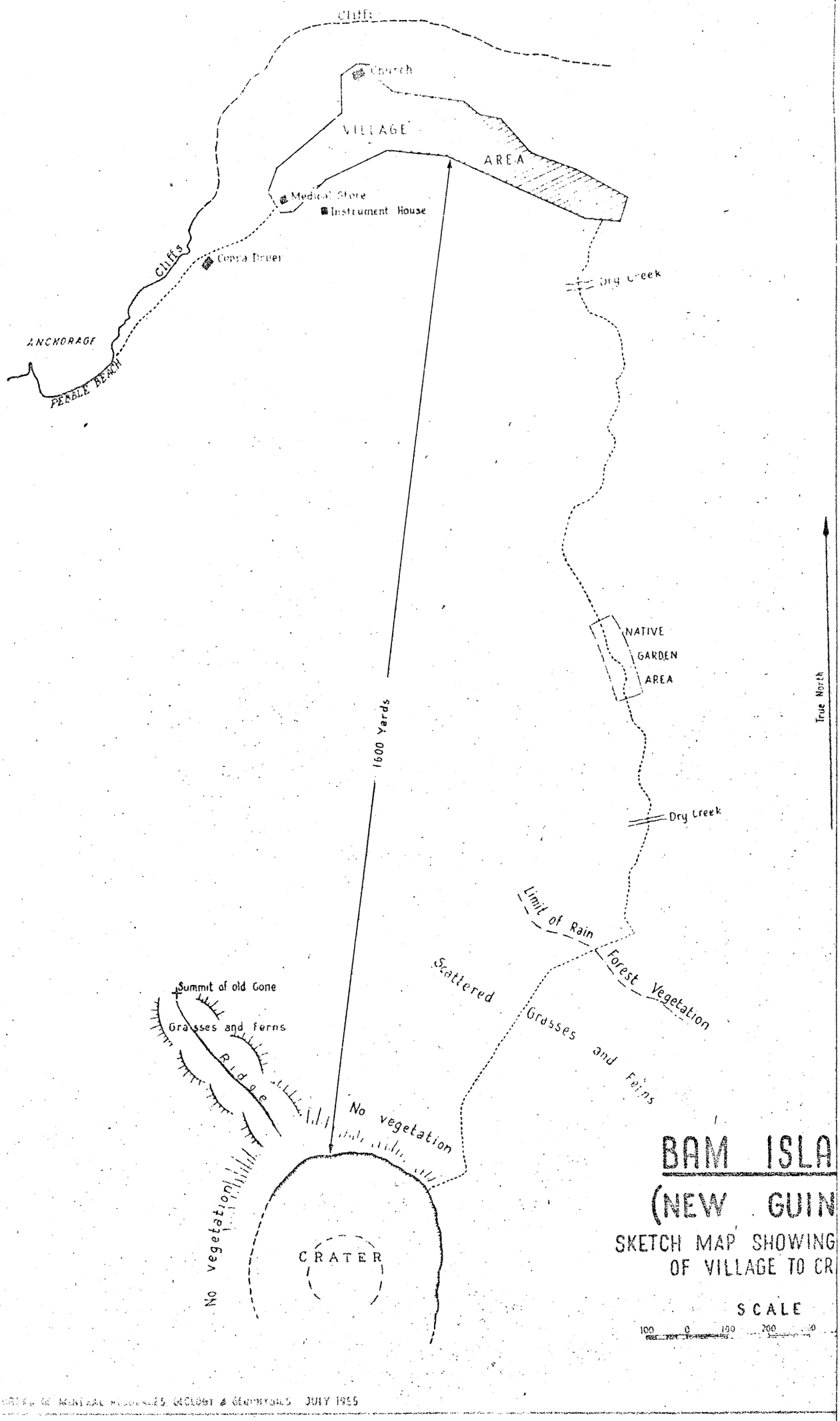
Approval of the request of the Bam Islanders to return to their home was given by the Administrator early in May. A plan was drown up for the rehabilitation of the people and an advance party proceeded to the island towards the end of May. The writer arrived at Bam on 27th May with instruments for vulcanological observations.

Investigations of the Area.

First attention was given to the installation of the instruments. As a foundation for the instruments a 3'x2'x3' cement block was constructed at a site selected south of the western end of the village. Over this block a rough bush house was built. The block had set and reliable recording from the tiltmeter and earthquake recorder began by the 1st June. In addition, instruments were installed to obtain data on atmospheric temperature and pressure, and rainfall. Arrangements were made for the daily transmission of this instrumental data and any observed variation of crater activity by short coded signals to the vulcanologist at Rabaul. Mr. C. Smythe was instructed in the operation of the instruments.

Inspections of Bam crater were carried out on 29th May, 1st June and on 4th June. A tape and compass traverse from the

Fig. 4



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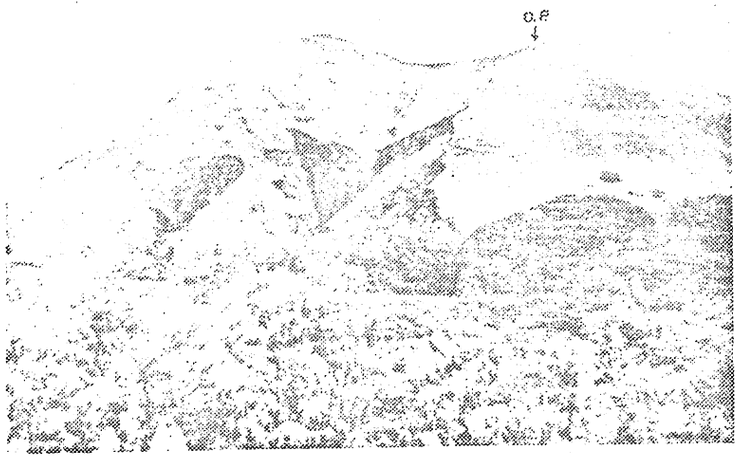

Fig. 5. North east slopes of Bom showing recent erosion of cone and observation point.

Fig. 6. Observation point on north east rim.

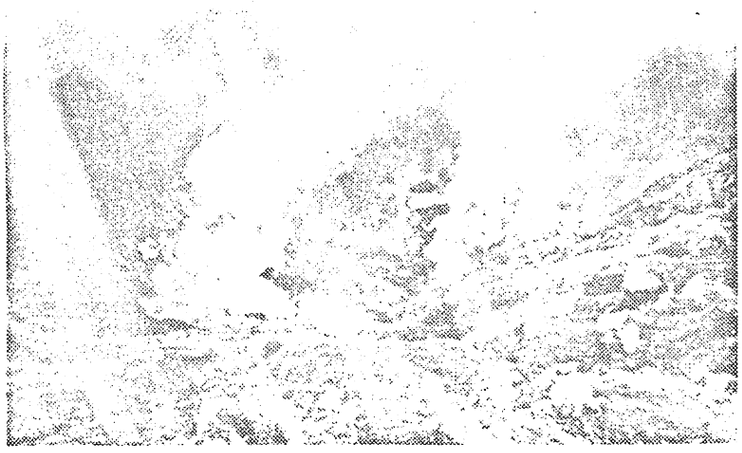

Fig. 7. The floor of the crater as seen beneath the vapour cloud. Observed from north-east rim.

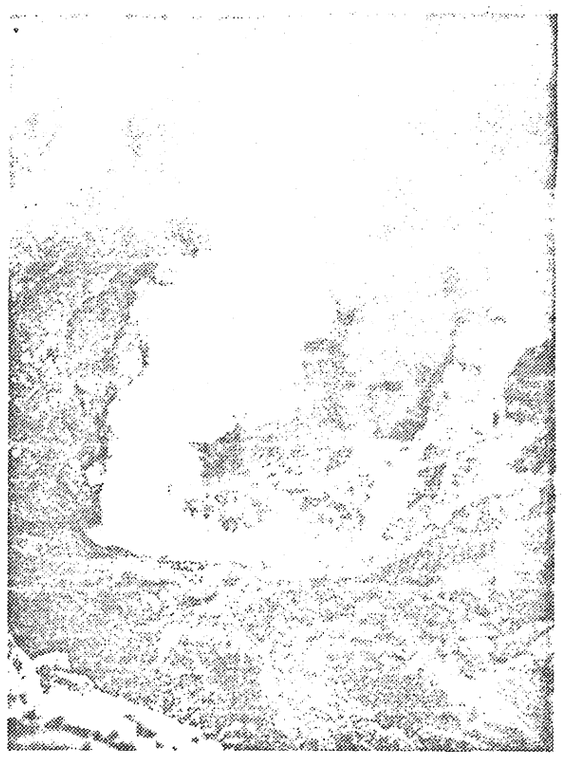

Fig. 8. The floor of Bam crater from the north-eastern rim.

Fig. 9. The explosion from Bam crater 3rd June 1705 hours as seen from village.

anchorage to the summit of the volcano was carried out to ascertain a reasonably accurate figure for the distance from the crater to the village. On 2nd and 3rd June respectively the neighbouring islands of Rodover and Blup Blup were visited. On 5th June thermal areas around the base of Bom were inspected. The writer departed for Lanam at 1430 hrs 7th June.

Structure and Ejecta

Bam Island appears to be the top of a submarine volcano which projects about 2000 feet above sea level. It is a strato volcano made up of alternating lava-flow sheets and fragmental material. The more massive lava flows appear to have originated from an older crater of which the western side of the island is the remaining crater wall. The present crater seems to be a south easterly migration from the old centre. In the limited section of the new cone available for inspection it is apparent that in recent times explosive activity has been far more common than lava emission. Most of the fragmental material consists of a solid non-vesicular lava ranging in size from angular blocks a foot or more in diameter to a black sand and dust. A few bread-crust bombs were observed around the crater, but on the whole there was little evidence of high temperatures in connextion with recent activity. The material around the crater rim appeared to be typical of low temperature vulcanian activity.

Near the village the section in the pit excavated for the concrete block was found to consist essentially of 3 feet of fine black sand overlying larger boulders which may have originated from an underlying lava flow. On the surface, however, was a thin layer of scoriaceous lapilli which could only have been produced from a fluid, high-temperature lava. The date of ejection of this material is unknown but it seems highly improbable that it was deposited more than 80 years ago, and it may be of much more recent origin.

Crater Conditions

Crater inspections were made from a rocky outcrop on the north eastern rim. This vantage point was reached by a climb of approximately 2½ hours from the village. The prevailing north west or south east winds keep this rim comparatively free of gas.

The crater is sheer sided for the first two or three hundred feet, until it reaches an inner ledge which slopes steeply down towards the centre to form the wall of a comparatively small concentric crater at the bottom. The diameter of the crater is about 1000 feet and its depth about 600 feet.

On the rare occasions when the vapour cloud in the crater temporarily lifts, it is possible to see the floor. The gas emission originates mainly from a number of vents on the floor and walls of the concentric crater. The largest vent lies on the eastern side of the floor where it emerges from a mass of large boulders. The boulders are covered with a whitish sublimation product, and sulphur deposition was not obvious. The only vents observed in the outer crater ring were a few mildly active gas seepage points near the top of the northern rim. Temperatures were of the order of 70°C.

The noise of gas escaping from the floor vents is just audible during normal windy conditions, but during rare atmospheric calms it is quite clearly audible. On the morning following the explosion of June 3rd, while moving around the western rim with Mr. Johnson, the writer heard two small explosions, not unlike gunshot. A very slight darkening of the vapour cloud on one of these occasions indicated dust emission. No large debris was ejected.

The vapour cloud from the crater contained quite strong concentrations of sulphur dioxide. Respiration in this cloud was possible for a short time provided one was not standing too close to

the crater margin, but the effects were very unpleasant. The tape and compass traverse of the western rim had to be abandoned because of the severe attacks of coughing caused by the sulphur dioxide. One component of the gas also affected the eyes. It was not the lachrymose effect of HCl but rather a stinging as if some irritating granule had entered the eye.

It is difficult to compare the concentration of acid gases at Bam with those prevailing at Langila in 1952 because the crater at Bam is so very much bigger and thus opportunity for dilution of the gas by turbulent air currents is far greater than at Langila. Taking the dilution factor into account it seems probable that the concentration of acid gases at Bam is lower than that at Langila in 1952.

Temperatures

The inaccessibility of the crater prevented any direct measurement of the important active points on the floor. It was necessary to fall back on the unsatisfactory assumed temperatures from observed physical effects. The pressures indicated by the sound effects suggested the possibility of abnormal temperatures, but transparent zones above the emission points, to confirm this view, were not apparent. Observation conditions were far from ideal.

To check the upper limit of this probable temperature abnormality observations were continued at the crater rim after nightfall on the 1st June.

No luminous effects were observed. Admittedly conditions were not good, for the crater, during this period of observation, was continuously full of vapour. Even so, it is considered that any marked luminosity would have penetrated the cloud, and it was concluded that temperatures were lower than 500° Centigrade.

The debris thrown out by the explosion of 3rd June gave no indication of high temperature conditions.

Marginal Thermal Areas.

On 4th June, when standing on the summit of the remnant of the old cone, the writer noticed a discoloured area in the sea on the south western side of the island. It was a yellowish patch of water extending out from the shore about 100 yards and being carried towards the west by the prevailing current.

Enquiry among local natives revealed that this discoloration originated from hotsprings along the shoreline in this neighbourhood. Examination of this locality revealed a quite extensive hotspring zone along the shore. The springs emerged from numerous points in a boulder bed of dark grey lava which had originally been a flow. Entering the sea a few inches above the prevailing water level, the springs coated the surrounding rocks with bright orange and yellowish coloured compounds and discoloured the sea for a distance of about 300 yards along the coast. The highest temperature recorded was 52° Centigrade.

A circuit of the island revealed three other thermal areas along the coast. All were smaller than the south west area. One lay south-south-west of the crater, one south, and the last, on the north-north-eastern side, was not very far from the village.

The natives had made no previous mention of the existence of these hot springs, although their existence is inferred in the legend of how the volcanic fires got from Manam to Bam.

The Explosions

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Relatively strong explosions occurred at 1705 hours on 3rd June and at 0024 hours on 7th June. Each was accompanied by a low rumble and an aerial concussion effect which vibrated buildings

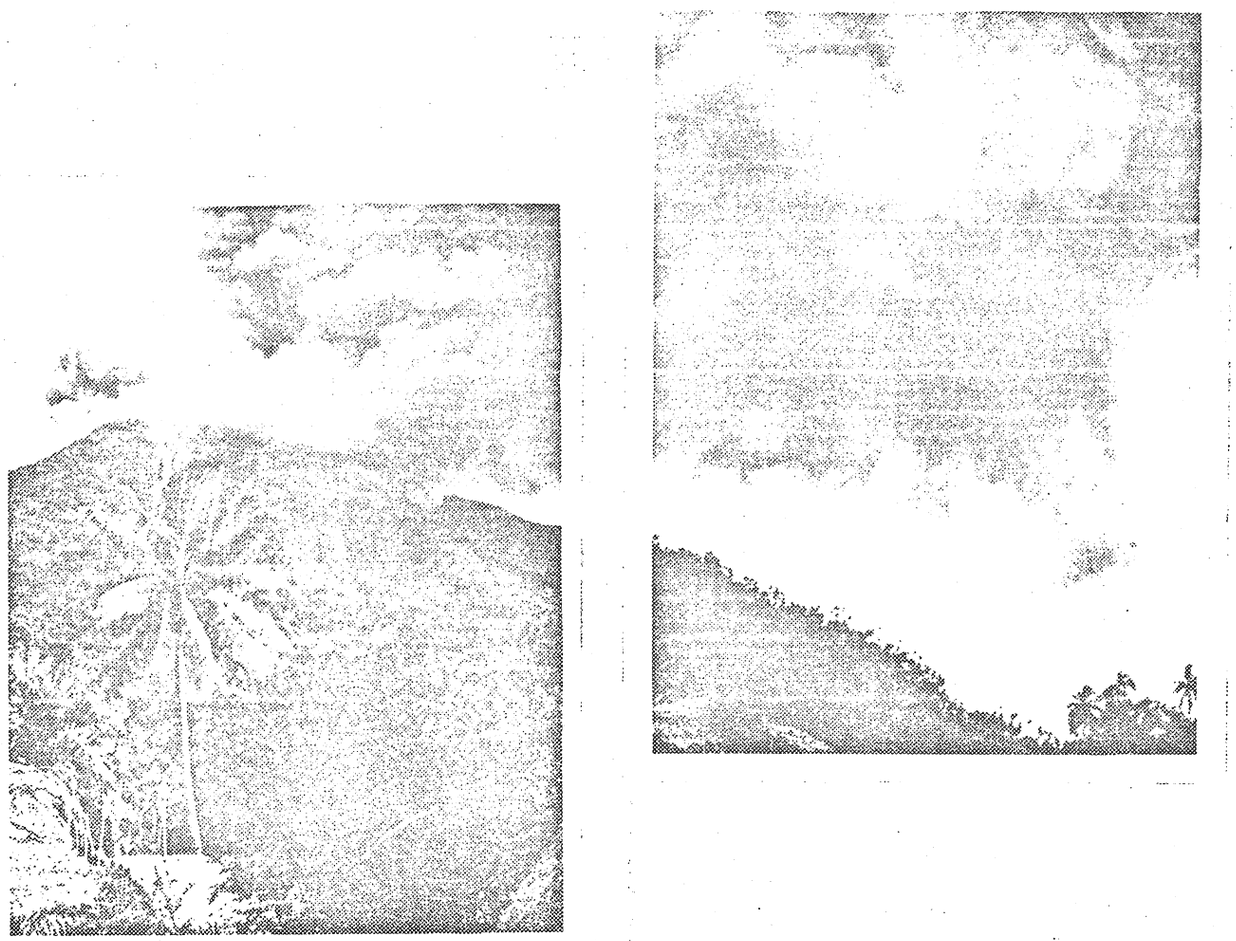

Fig. 10. The fall-out of dust on the north western side of Bam. 3rd June.

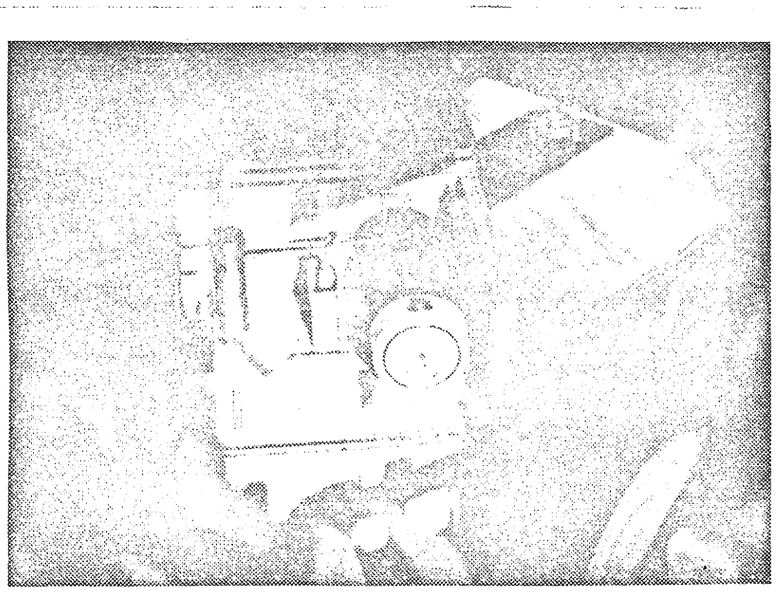

Fig. 11. The earthquake recorder and tiltmeter installed on Bam.

in the village area. Both produced dust clouds of the tightly convoluted cauliflower type characteristic of vulcanian activity. No luminous effects were visible in the clouds.

The explosion of the 3rd June appeared to be the larger of the two. An observer on the administration vessel from Newak which was standing six or seven miles off the island reported that the dust cloud ascended to several thousand feet. At the village the steep angle of view made it difficult to assess a height. A notable feature of the emission, as seen from the village, was the fact that the dust cloud appeared to well or billow out of the crater rather than project vertically as it would have done if high pressures from a source relatively deep in the conduit had been responsible for the outburst. The accompanying photographs show some characteristics of the explosion of the 3rd June and the effect of the strong prevailing winds at the summit level carrying the ejecta towards the western side of the island. No material fell close to the village.

The duration of dust emission was no longer than five minutes for either of these explosions.

Ground Movement

Associated with any change in the activity of a dormant volcano it is usual to find evidence of movement of the magma at depth in the occurrence of small local earthquakes and slow ground movement or tilting of the volcanic edifice.

Unfortunately the installation of the earthquake recorder and tiltmeter was not completed early enough to obtain a complete record of the conditions preceding the explosive activity of early June. It may be significant, however, that since the last explosion on the 7th June there has been a progressive variation in tilt throughout the remainder of the month.

The tiltmeter is orientated through the centre of the crater. As is apparent from the graph, the daily readings are closely related to atmospheric temperatures. But superimposed on the temperature fluctuations is an accumulated variation of about 30 seconds of arc for the month of June. Taken at its face value this trend indicates a fall of the crater area and could be related to a withdrawal of the magma from beneath the volcano. There are, however, too many possible variable factors influencing the readings of a single component tiltmeter to draw such a conclusion with any degree of assurance. The volcanic edifice may be made up of a number of independently moving blocks so that we may be measuring the movement of a single block rather than the movement of the cone as whole. In addition there is nearly always a seasonal variation which for Bam is at present unknown. The order of the variation for June suggests that it is too great to be accounted for by seasonal variatio alone.

The tiltmeter has also revealed the presence of a long period groundwave which is not picked up by the earthquake recorder. These groundwaves produced an oscillation of the tiltmeter bubble, particularly during the days following the explosive activity. Some of these oscillations appeared to have a period of about five minutes, but most of them were very much shorter fluctuations. It is the sort of movement one would associate with slow surging of magma body at depth.

Similar movement was very common at Langila in 1952; but on that occasion the movement was attributed to earthquakes which were occurring in the region. No such explanation is valid at Bam.

Since the installation of the earthquake recorder there has only been one definite shock for the month of June. It occurred at 0342 hours on 15th June, and was of small amplitude and probably

of local origin.

A much longer period of recording is necessary before the full significance of the instrumental data on ground movement for the month of June can be appreciated. There seems little doubt that some movement of volcanic material is taking place at depth and it is possible that the explosive activity of early June was preceded by a build-up of subterranean pressures which caused the summit area of the volcano to rise.

Lunar-Solar Influences.

It has been found with recent volcanic activity in the Territory that the disposition of the sun and/or moon may be an important factor in initiating a new phase of activity or determining the time of more violent activity. Apparently the gravitational force of these two planetary bodies can have a triggering effect on a ripe volcanic system by affecting the conditions of regional tension or compression.

It is of special interest to find that the explosive activity of Bam occurred at the time of an unusual tensional maximum. On the 5th June the sun and moon were occupying zenith positions close to the tropics and cancer and capricorn respectively and they were in opposition. These conditions produce a maximum tensional pull on structures close to equatorial latitudes. Bam, Long Island and Tuluman appear to have responded to these unusual conditions by increased activity.

The rather mild response of Bam may indicate that the prevailing potential for explosive activity is low. If conditions at depth are slowly building up to produce more powerful activity, it is probable that the solar movement back across these latitudes in September-October will produce a more powerful response about this time. When the sun reaches its zenith position for a given latitude the solar harmonic of the equilibrium tide is at a maximum.

History and Tectonic Earthquakes.

The scanty knowledge of the history of activity at Bam handicaps an assessment of the nature of its future activity. All we know with any degree of certainty, aside from last year's activity, is that the volcano was in violent eruption in 1877. There are also persistent rumours that Bam becomes active whenever Manam erupts. Some support to this rumour is given by the fact that this did actually happen in 1877, and the people's legend of the fire at Bam having originated from Manam may be further evidence of a sympathetic activity between the two volcanoes.

Although very much more comprehensive than for Bam, the data available on previous activity of Manam is for the most part too sketchy to give a reliable picture of the scope and intensity of early eruptions. There is however, a strong suggestion that the more violent outbursts of Manam volcano have been associated with conditions of abnormal regional seismic unrest. This was certainly the case in 1877, for this eruption was preceded by several years of extraordinary regional earthquake activity. Nor does it appear coincidental that the unusually severe activity of 1936-7 was preceded by powerful earthquakes in the Aitape district, and the 1925 eruption appears to have been accompanied by shocks occurring from an almost identical epicentre.

Without losing sight of the fact that these observations are not sufficient to draw a firm conclusion as to the reliability of this relationship, it is at least reassuring to find that over the last five years there has been no increase in seismic activity of an order that would suggest an especially violent outburst from Manam or Bam. Since 1950 seven large earthquakes have occurred within 100 miles of Manam. Although this is about the same number as for the five earlier years their intensity appears a little higher. One earthquake, in November 1952, had the comparatively high magnitude of 7½. The United States Coast and Geodetic Seismological Stations fixed

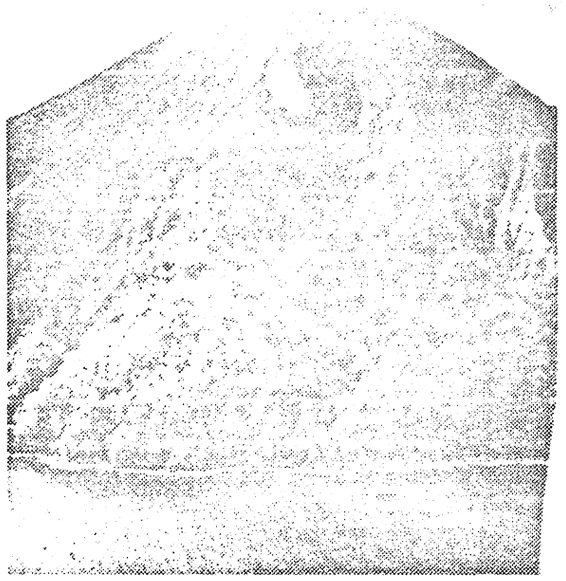

Fig. 13. The steep slopes on the western side of Bam.

Fig. 14. Remnants of the old cone near the western summit.

Fig. 15. The village from the old cone summit.

the provisional epicentre as Lat 5°S Long 145½°E or about 30 miles north west of Madang. The Japanese stations fixed the epicentre as Lat 3°South Long 145°E or about 35 miles north east of Bam.

The absence of any reports of a major disturbance near Madang for this period suggests the latter to be the more likely determination.

In view of the above observations it seems of particular importance to our knowledge of the seismicity of this region that we should have the completest possible information on all earthquakes felt in the Madang, Wewak and Highland districts. Greater attention could be paid to the reporting of these events in the monthly Vulcanological Reports.

Summary and Conclusions

Although the crater conditions at Bam cannot be considered normal, there was little in the recent observations to suggest that vent temperatures, pressures and gas compositions were indicative of a rapidly increasing explosive potential. The gas pressures appear to have declined to a marked degree since Best's inspection of the crater in November, 1954, and little change in the composition of gases is evident over the same period.

The absence of preliminary local earthquakes and the limited vertical range of the June explosions suggest a relatively superficial origin for the gas accumulations. Evidence was found around the crater rim to indicate that other small explosions had occurred during the period the island was unoccupied. There is a puzzling lack of evidence to indicate that the summit area has been covered with heavy vegetation at any time in the immediate past. This could be due to drainage characteristics induced either by impermeable surface crusts or underlying lava flows. The consistent emission of sulphur dioxide would also produce a similar inhibitory effect on vegetation, but Best did not observe any appreciable quantity of sulphur dioxide in the gases in 1953. This brings one to the very tentative view that the normal pattern of the volcanoes activity may be of mild intermittent explosions at intervals more frequent than for neighbouring Manam.

The progressive variation of about 30 seconds of tilt during the month of June suggests that some deepseated movement in the volcanic system has taken place since the explosive activity in the first week. On first appearances this indicates a decline of pressures at depth, but the number of variable factors influencing the readings of a single instrument of this type makes a much longer period of recording essential to any reliable appreciation of the significance of this movement.

Associated with the marked increase in volcanic activity in the Territory in recent years there has been a corresponding increase in regional seismic activity. The most complete figures at present available on earthquake occurrence throughout the Territory are as follows:-

Year	No. of Shocks.	Year	No. of Shocks.
1930	12	1942	12
1931	15	1943	14
1932	14	1944	13
1933	7	1945	18
1934	25	1946	14
1935	21	1947	10
1936	19	1948	10
1937	13	1949	22
1938	14	1950	22
1939	21	1951	28
1940	14	1952	27
1941	10	1953	28
		1954	22

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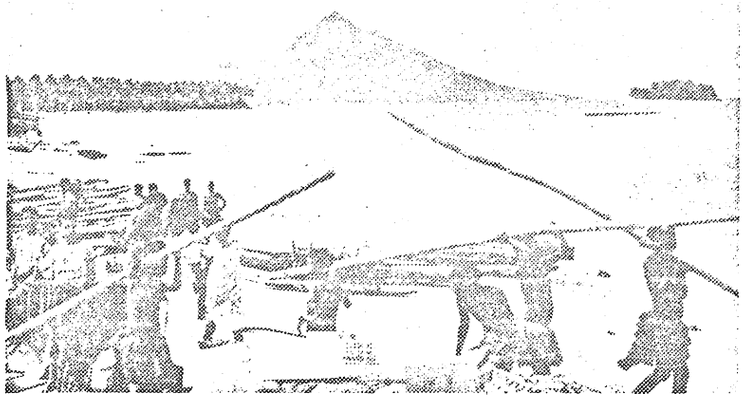

Fig. 16. Loading stores and timber for Bem at Bogia. Manam in the background.

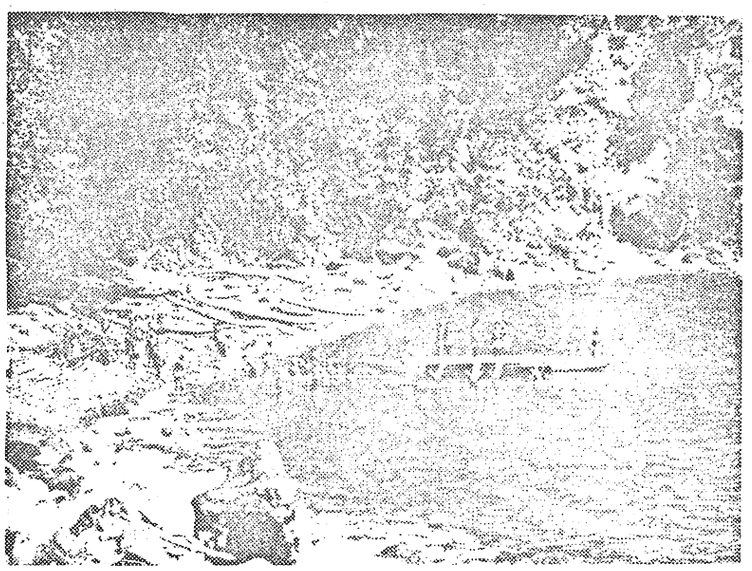

Fig. 17. Unloading stores at the anchorage on the North Eastern side of Bem.

Fig. 18. The eastern side of Kadovar Island.

Allowing for the fact that these figures tend to overemphasise an increase in recent years because of improved instrumentation throughout the world, there does appear to be a general increase in total seismicity coincident with and preceding the recent volcanic reactivation of old centres.

It was at first puzzling that no response developed from the traditionally active Lamam, until detailed examination of the distribution of recent earthquakes showed that the epicentres tended to be specific. This was particularly evident in the shocks preliminary to the activity of Long Island and Langila.

As far as the western end of the volcanic arc is concerned there has been an increase in seismic activity but not a marked one. The most important shock in recent years, relative to Bam, seems to be the problematic occurrence on 6 Nov 1952. If the northern epicentre is the correct one it could have quite conceivably triggered the volcano into its present state of unrest.

Should seismic activity about this western end of the volcanic arc increase further, it is probable that Bam will produce more powerful explosions.

RECOMMENDATIONS

Earlier recommendations regarding the establishment of a European observer on the island, the supply of boats to the Bam people to enable them to move in the event of an emergency, and the building of shelters to protect them from falling debris, have been or are being put into effect.

It is suggested that question of maintaining an observation post on the island be reviewed at the end of the twelve months.

KADOVAR.

The small volcanic island of Kadovar lies about 16 miles almost due west of Bam and fourteen miles from the nearest part of the New Guinea coast, where the Sepik River enters the sea. The island is roughly oval in shape with its maximum length of 1½ miles orientated in west south west-east north east direction. The width is no more than ½ mile.

The steep cone rises sharply out of the sea to a height of nearly one thousand feet (984 ft.). It is a strato type volcano made up of fragmental and effusive products of a fairly light coloured andesite resting on basal flows of a dark grey, sometimes vesicular lava which seems to be of a much more basic composition.

The most recent activity of this volcano produced a steeply sloping dome-shaped mass of rocks which rose three or four hundred feet above the old crater floor and engulfed the south western walls of the crater.

The shape of the mass and the texture of the rock fragments covering the surface of this structure suggest that it is a true volcanic dome. The absence of a terminal depression suggests a dome rather than a cone and the summit area is made up of large boulders of a type one associates with disintegrating spines rather than ejected material.

One or two generations ago a thermal area existed on the top of the dome. The natives are very specific about the location of this area although at the present time there is no visible evidence of its existence. The place is completely overgrown with dense secondary growth and the surrounding rocks and soils show no trace of sublimation products. It lies north east of, and less than a hundred yards from, the highest point on the dome and is reached

by a path ascending the steep dome face at the rear of the church which is built on the south eastern end of the crater floor.

The natives say there are no other thermal areas on the island.

Population and Settlement

The population of the island at the last census was 246. Most of the natives live on the northern side of the island. Groups of houses are scattered around the crater rim and on the floor of the crater. The largest settlement appears to be on the northern slope of the island just above the anchorage facing Blup Blup.

The soil of the island appears to be immature and very fertile. The manner in which the steep stony slopes of the dome were being cultivated and the prevalence of secondary growth over the whole of the dome summit suggested that these people had very little surplus land. In addition to taro and kau kau, coconuts and galip nuts probably form an important part of their diet and, like the Bams, fish is their main source of protein.

Past Activity

The absence of legend, the soil condition and general physiography of the volcano suggest that it has not erupted for several hundred years. Nevertheless the existence of summit thermal areas until very recent time places it in the dormant rather than the extinct category.

BLUP BLUP (Lat $5^{\circ}30\frac{1}{2}$'S Long $144^{\circ}37$'E.)

8 miles almost due north of Kadovar, the larger island of Blup Blup rises to a height of about 800 feet. It is roughly circular in shape and about 2 miles in diameter.

It is also volcanic, and the natives say there is a crater lake at the summit which is overgrown with sago palms and swamp vegetation. The slopes are covered with dense rain forest vegetation and the interspersed garden areas are very much more limited than on either Kadovar or Bam. The soil is of the hard clayey variety and appears to be very much older than on the neighbouring islands. Similar dark coloured basaltic-looking andesites form the basal rocks on this island.

Along the western coast of the island, behind the fringing reef, cliffs alternate with white sand beaches. The cliff sections are composed of dark coloured Aa flow rocks and well bedded tuffs. In the centre of a beach on the northern side of the island near the garden village of Angon is a thermal area which stretches about 60 yards along the shore. The hot springs emerge from the sand just below high tide level so that the temperature tends to fluctuate with the tide. At low tide a temperature of 67°C was recorded. The hot water discolours the sand to light grey and gives off a strong hydrosulphide odour. No other thermal areas exist on the island according to the natives. It was not possible to check this report by a complete examination of the island. A point about two miles along the coast east of the thermal area was reached before returning back along the west coast to the anchorage on the south western side.

Blup Blup appears to have been inactive for a very much longer period than Kadovar. This is reflected in the maturity and lower fertility of the soils.

It now supports a population of 242 people and could undoubtedly support a much larger population for a short time. But, as Mr. Skinner has pointed out in his report, it could not be considered as a permanent place to resettle the Bam's. The prevalence of malaria and tuberculosis would present difficulties even as a temporary refuge.

The islands lying west of Blup Blup are undoubtedly an

extension of the volcanic chain. Thermal areas are reported to exist on Kei, Nokeo and Kairiru islands.

ACKNOWLEDGEMENTS.

The assistance of all Administrative Officers connected with the investigation is gratefully acknowledged. I am particularly indebted to Mr. Beanteod and Mr. Skinner for the co-operation received in Madang, and to Mr. Ellis, Mr. Johnson and Mr. Smythe for their help on Bam Island.

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Assistant Administrator
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Senior Geologist,
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Port Moresby.

Chief Geologist,
Bureau of Mineral Resources,
CANBERRA.