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AN INVESTIGATION OF VOLCANIC ACTIVITY AT DOMA PEAKS

by

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SUMMARY

Doma Peaks, in the southern Highlands District of Papua New Guinea, is a large volcanic complex which is believed to have a potential for further eruption. Current activity is confined to a hot spring and several cold solfataric areas which are depositing sulphur, and are producing strongly acid springs. Mudlfows and/or pyroclastic flows have descended from the crater to the Tari valley down the Arua river gorge in comparatively recent time. The lavas of the volcano appear to range from basalt to andesite, and some of them have shoshonitic affinities.

AN INVESTIGATION OF VOLCANIC ACTIVITY AT DOMA PEAKS

Introduction

My attention was first drawn to the possibility of recent volcanic activity in the Highlands of Papua New Guinea by an American anthropologist, Robert Glasse (1963), who had just returned from a protracted study of the people of the Tari area (see Appendix 1). These people had legends of an eruption which had occurred a few generations earlier. The event had impressed itself on the tribal memory, not because of loss of life, but because of the marked improvement in the fertility of the land. Rituals were still carried out from time to time in the hope of repeating the event.

Further information was obtained in 1958 from Mr W. Crellan, who was in charge of the government station at Tari for several years. He pointed out that the local people were also aware of the danger of an eruption, and noted that they became nervous when earthquakes occurred (e.g. 1954).

An investigation of Doma Peaks was carried out in May 1968, following a report from D.B. Dow that airline pilots frequently noted the smell of sulphur gases when flying over Doma Peaks.

A party including R.F. Heming, local guides, carriers, and myself left Pangwanda village on 10 May, and began an ascent of the crater along the Arua River. Once beyond the gently sloping country of the Tari valley floor, the party entered the Arua river gorge, and followed an ill defined hunting track which winds back or forth across the river. Five kilometres from the crater area the river divides into tow main tributaries: the southern one drains the crater area, and the other drains an area due north of the crater, from where it descends in a deeply incised gorge (Fig. 1).

A camp was made on the first night in a moss forest about half a kilometre beyond the tributary junction. On the following night a base camp was made on the southern side of the mudflow deposit (Fig. 1) and about 2 km from the crater. Rain was continuous during the afternoon and night.

On the following morning an ascent was made into the crater along the waterlogged valley floor: inspection of the main solfataric areas was completed by the early afternoon, by which time the daily rains had begun, and the party returned to camp. Heavy rains, high humidity, and low temperatures are handicaps to any lightly equipped expedition working at this altitude (ca 2900 m).

Return to Pangwanda village on 13 May involved 8 hours of hard walking.

Doma Peaks

Doma Peaks is the name given to a deeply dissected volcanic complex 19 km east of Tari (Plate 1). The complex is built up on uplifted Miocene sediments which in this area are predominantly limestones (Perry et al.) and it forms the headwater drainage for the Kikori and Purari river systems.

This Pleistocene volcano is an impressive mountain, standing almost 2000 m above the surrounding valleys. Viewed from Tari it bears a resemblance to Mount Lamington in that the crater is breached in the west, and drained by an 'avalanche valley' which descends to the floor of the Tari valley, where an extensive outwash fan is formed (Plate 1). One looks up the valley into a large amphitheatre which gives the effect of a huge crater. This 'crater' appears to be partly of volcanic and partly of erosional origin. The amphitheatre-headed erosional effect of drainage on many of New Guinea's volcanoes seems to be active here. Erosion, in combination with rotational slips and/or slumping, appears to be responsible for the large, ill defined 'crater' forming the headwaters of the southern tributary of the Arua. The northern part of the structure surrounding solfataric areas 1, 2, and 3 has characteristics most suggestive of a volcanic origin, and has been labelled 'crater' ih Figure 2.

Below this crater the floor of the 'avalanche valley', down to the main tributary junction of the Arua river, is covered with a recent deposit of unsorted pyroclastics which, at least in part are hydrothermally altered. The hummocky surface of this deposit is unforested, and has been labelled 'mudflow' in Figure 1. It is covered with shrubs, ferns, and grasses and with swamp vegetation in the numerous waterlogged areas in which peat is probably being formed.

The deposit may be of pyroclastic flow origin, though no firm conclusion could be drawn because of limited exposure. The uneven surface and apparent thickness of the deposit close to the crater suggest mudflows as a more likely origin. I have seen deposits of similar morphology below the crater of Bandai San in Japan, where extensive hydrothermal alteration was taking place before its eruption in the 1880's. This eruption destroyed much of the cone, and poured it over the countryside as mudflows and pyroclastic flows.

The Names of Doma Peaks

Early maps identify the structure under the name of Mount Rentoul (APC, 1961). The latest maps show it as Doma Peaks. The local people from Tari have at least three names for the structure - each called after a spirit. The summit area above the crater (i.e., near the trig station) is known as LEMA, the high scarps north of the Arua river are known as AMBUA, and the rugged hills on the opposite side of the river gorge are known as DOMA.

Solfatario Areas

The location of the solfataric areas near the top of Doma Peaks is shown in Figure 2. It is probable that other areas exist outside crater environs.

The most conspicuous features of the solfatario areas are active deposition of sulphur, a strong foetid sulphuretted odour, and an absence of heat. Dead vegetation and discoloured rock were characteristic of each of the areas closely examined (Fig. 3).

Area 1 is situated at the base of a steep rock wall about 30 metres above the crater floor, and is an irregular tract of several hundred square metres. Trees are dead in the area, and decaying logs and standing trunk remnants testify to establishment of the vent many years age. Fluctuation in activity is suggested by large tufts of a sedge-like grass which appeared to have been killed within a few months of the inspection. The surface of the area is largely covered by a thick mat of moss within which sulphur is apparently being deposited by invisible, unpressurized, gaseous emanations. The sulphur-vegetable mass can be broken off in lumps and microscopic examination shows that the sulphur is partly crystalline and partly massive. The massive sulphur completely enveloping the strands of vegetation seemed to have been precipitated in a colloidal state from solution.

Although the foetid sulphuretted odour pervaded the whole area, the emission rate was such that no discrete vents were apparent.

Many of the rocks in the area were altered to a sugary, white, granular mass in which all the pre-existing minerals have been destroyed (thins sections 244 b & c). It is probable that acid solutions remove most of the mineral constituents and leave a siliceous skeleton pseudomorphing th original rock texture (Zelenov, 1962).

Area 2 is situated higher up the crater wall, west of Area 1. It was similar in appearance to Area 1, and a recent landslide had deposited debris over part of the devegetated area.

Area 3 is situated beside a small lake on the crater floor ½ km west of Area 1. The surface is red-brown (probably owing to iron staining) and unvegetated. Activity here may be moribund or extinct.

Area 4 was identified from a distance by the presence of dead trees. It is situated at the base of a steep part of the 'avalanche valley' wall about 1 km west of Area 3. It was not visited.

Areas 5, 6, and 7 are adjacent and situated at the base of a steep slope about 1 km southwest of Area 3. A small stream joins the valley here, and extensive boggy areas are formed on high ground at the base of the slope. These areas are largely moss-covered and the intervening pools often contain cold springs which produce a vigorous gaseous ebullition, and deposit white colloidal sulphur (Fig. 4). Here also is the strong sulphuretted odour and inhibition of vegetation, particularly of trees. Analyses of the waters (Table 1) indicate that they contain free sulphuric acid and no chlorides.

Area 8 is a small spring situated on the southern side of the Arua river gorge between 6 and 7 km west of the crater (Fig. 1). It emerges from the ground near the access track in an area that is heavily forested. The water is iron-stained and mildly warm, and it seems to have no effect on adjacent vegetation.

Other Areas. Local natives claim that other active areas exist outside the crater area. I gained the impression that one such area exists in the valley north of the crater - that is, in the headwater area of the northern tributary of the Arua.

Petrography

Outside river gorges, outcrop on Doma Peaks is poor because of thick soil and vegetation cover. Twenty-five specimens were collected in the traverse up the Arua River to the crater. Petrographic notes on the rocks, and the names proposed by D.E. McKenzie, are given in Appendix 2.

The rocks are strongly porphyritic, and contain up to 90% phenocrysts. Plagioclase is the most common mineral, and most rocks contain abundant ferromangesian minerals. Listed in order of decreasing abundance, the minerals are:

Plagioclase
Augite
Hypersthene
Olivine
Magnetite
Calcite
Brown hornblende or biotite
Apatite
Analcite

Half the specimens collected were in situ; the remainder were boulders from the Arua river gorge. Although no conclusions can be drawn on eruptive succession, it is interesting to note that the lavas from the crater area all contain hypersthene and rare traces of olivine; the plagioclases are almost entirely in the labradorite range (specimens 68400244-247). On the other hand, lavas from the Doma (specimens 248-249) and Ambua (specimens 250-251) sides of the Arua river gorge rarely contain hypersthene; olivine may be abundant, and plagioclase is more basic, ranging up to bytownite. McKenzie has identified some of these Doma-Ambua rocks as being strongly alkaline (249A, 252). W.B. Dallwitz's determinations of plagioclases indicates a core composition of bytownite or anorthite for all but one of the Doma-Ambua rocks.

Conclusions

The Doma Peaks volcanic centre must be considered as potentially active. The presence of solfataric activity, even without appreciable heat, suggests that little time may have elapsed since the last eruption. Taking into consideration such examples as Vesuvius, Bezymianny, and Mount Lamington, where dormant periods of the order of a thousand years are indicated prior to disastrous eruptions, it would be unwise to classify Doma Peaks as extinct.

Anthropological evidence for a recent eruption from Doma Peaks is at best inconclusive. Estimates of the time for such an event range from 90 to 400 years, and stories similar to those told by the Tari people are widespread throughout the Highlands (Watson, 1963). Until such time as independent evidence for the time of the last eruption becomes available, these estimates should be regarded with reservation. If the valley has ever been devastated by nuées ardentes, carbonized material should be found in the area for accurate dating.

In discussion with A.S. Renwick, Chief Government Geologist, Port Moresby, it has been suggested that this volcanic centre should be placed under permanent surveillance with appropriate instrumentation. It is further suggested that in the event of the first signs of eruption from Doma Peaks, it would be advisable, as a first precaution, to remove people from the area below the Arua gorge shown in plate II.

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APPENDIX 1

Bingi at Tari
by Robert M. Glasse

Krakatoa's echo[1] has also sounded at Tari in the Southern Highlands of Papua. In fact the Huli version of the event is similar to that of the Agarabi and my dating of the account places the occurrence in the 1880s. Huli called the phenomenon Bingi and they believe it has occurred several times in the past, each time foreshadowing a remarkable increase in soil fertility. They hope Bingi will recur and the aim of one of their most complex rituals, Dindi gamu (Earth magic) is to secure a repetition. In 1955 several sharp earth tremors were felt at Tari and Huli thought a recurrence of Bingi might be imminent.

They describe Bingi in the following terms. Thunder, lightning and tremors herald the advent of Bingi. On the first day the sky darkens when it should be morning. For the next three days a white pumiceous silt falls from the sky. It covers the sweet potato mounds (which are two or three feet high), chokes the streams and destroys unprotected crops. Afterwards many trees lose their foliage and birds and animals die. For a time food is short but people quickly replant their crops and these flourish in the enriched soil.

The legend (mana) of Bingi contains practical and ritual precautions for survival. Members of kin groups build communal houses at the first sign of Bingi. They lay in food and vessels of water to last four days and gather their pigs and dogs. They cover some of their gardens with grass. As sexual intercourse is dangerous at this time, all wives return to their natal groups. During the actual fallout no one leaves the communal house except for men who are last surviving sons. If these precautions are not followed, Bingi turns into a holocaust, destroying all life.

Huli do not attribute Bingi to volcanic eruption or to other natural processes. They believe that the deities or gods (dama) are ultimately responsible, but have no concept of a specific causative agent. Today they are rather ambivalent about a possible recurrence for Bingi is outside the range of ordinary experience and no one living has actually lived through it. They are eager for a renewal of soil fertility. On the other hand Bingi is dangerous and if the mana is not faithfully carried out it could end in devastation.

Occasionally today Huli find lumps of white sandy soil while digging in their gardens - they attribute this to Bingi. The specimen I examined was porous and crumbly, like soft pumice. Could it have come from Krakatoa? I suspect highland volcanoes, such as the Doma Peaks, are a more likely source.

[1]Watson, James B. "Krakatoa's Echo?" Journal of the Polynesian Society, Vol. 72, pp. 152-155, 1962.

APPENDIX 2

Petrographic notes on Doma Peaks lavas by D.E. Mackenzie.

68400244a High K biotite-olivine hypersthene-augite basalt

Phenocrysts: plagioclase (some with K feldspar rims), augite, hypersthene, olivine rare (hypersthene rims (partial)), opaques, biotite with opaque rims.

Groundmass: plagioclase laths (felted), pyroxene, opaques.

68400244B Altered acid-intermediate ignimbrite.

68400244C Altered volcanolithic sandstone.

68400245A High K(?)-hornblende-biotite hypersthene-augite basalt

Phenocrysts: plagioclase (some with very narrow K-feldspar rims), augite, hypersthene, biotite (thin opaque rims), hornblende (thin opaque rims), opaques.

Groundmass: plagioclase, augite, opaques, ?hypersthene, ?K-feldspar.

68400265B Hypersthene-augite andesite

Phenocrysts: plagioclase (some broken), augite (euhedral), hypersthene (some mantled with augite).

Groundmass: ferruginized; some fine-grained plagioclase and pyroxene.

68400246A Two-pyroxene andesite

Phenocrysts: plagioclase, augite, hypersthene, opaque mineral (magnetite?).

Groundmass: plagioclase, hypersthene, augite, magnetite, apatite, brown isotropic glass.

68400246B Two-pyroxene andesite

Phenocrysts: plagioclase, hypersthene, (zoned; mantles augite (rarely)), augite, magnetite(?),

Groundmass: plagioclase, pyroxene, opaques.

68400247A Altered andesitic tuff or ash.

68400247B Two-pyroxene andesite

Phenocrysts: plagioclase, augite, hypersthene, magnetite(?), trace of altered olivine.

Groundmass: plagioclase, hypersthene, augite(?), magnetite(?).

68400248A Two-pyroxene andesite

Phenocrysts: plagioclase (riddled with inclusions of altered glass).

Groundmass: plagioclase, augite, hypersthene, opaques, altered glass, calcite.

68400248B High K(?) olivine-augite-basalt, or shoshonite

Phenocrysts: plagioclase (An_{57}, very narrow K feldspar rims; some composite with augite), augite, olivine (20-30% altered).

Groundmass: plagioclase, augite, magnetite, calcite (secondary), K feldspar (trace, interstitial), altered glass (trace).

68400249A High potash(?), olivine-augite basalt, or shoshonite(?)

Phenocrysts: plagioclase (An_{57}), augite, olivine, magnetite.

Groundmass: plagioclase, augite, magnetite, olivine (rare), calcite-secondary, rare; also patches in plagioclase phenocrysts, glass.

68400249B Augite basalt (sheared and altered in narrow zones).

Phenocrysts: plagioclase (An_{57}), augite, magnetite.

Groundmass: plagioclase, augite, magnetite, glass.

68400250 (Lamprobolite -) olivine-two-pyroxene andesite (very fresh - suitable for analysis)

Phenocrysts: plagioclase (An_{45}) - 68%, augite (15-20%), olivine (suggestion of very narrow pyroxene rims) - 5%, hypersthene (some with augite rims) - 10%, magnetite (3%), lamprobolite (largely replaced by fine magnetite and pyroxene) - less than 1%.

Groundmass: plagioclase, augite, magnetite, hypersthene (trace), zeolite (analcite), 68400251 High K(?) olivine-augite basalt

Phenocrysts: plagioclase (An_{55-60}, very narrow alkali feldspar rims) - 65%, augite (20%), olivine (2%), magnetite (10%+), alkali feldspar (1-2).

Groundmass: plagioclase, augite, magnetite and/or ilmenite, alkali feldspar.

68400252 Shoshonite

Phenocrysts: plagioclase (An_{55}; strewn with augite, magnetite, and glass inclusions; alkali feldspar rims) - 65%, augite (25%), olivine (1%), magnetite (2-3%), alkali feldspar (5%).

Groundmass: plagioclase, augite, magnetite, low-relief alkali (feldspar(?), secondary calcite & iddingsite-bowlingite (after olivine); patches of calcite in g'mass.

68400253A Two-pyroxene basalt (calc-alkaline?)

Phenocrysts: plagioclase (An_{70}, sieved with inclusions; some zoning), augite, hypersthene, magnetite, olivine (rare; completely altered; hypersthene rims).

Groundmass: plagioclase, augite, magnetite, secondary calcite, hypersthene.

68400253B Altered augite? basalt

Consists of plagioclase and rare, partly altered augite phenocrysts and magnetite microphenocrysts in a groundmass of plagioclase, fine-grained green chlorite, and magnetite. Chlorite has replaced ferromagnesian crystals and glass. Some plagioclase phenocrysts sieved with inclusions of opaques and altered glass.

68400254 Vesicular olivine-augite basalt with rather high K.

Phenocrysts: plagioclase (An_{52-55}; zoned An_{63} to An_{45}; very narrow rims), alkali feldspar, augite, magnetite, olivine (rare, largely altered to iddingsite).

Groundmass: plagioclase, augite (almost all with "hour-glass structure), magnetite, olivine (rare), "iddingsite", and a trace of alkali feldspar.

68400255A Made up of altered, devitrified glass; mixed texture, possibly ignimbrite.

68400255B Hypersthene-augite basalt or basaltic andesite

Phenocrysts: plagioclase (An_{60}), augite (some composite, some replaced by calcite), hypersthene, opaques.

Groundmass: plagioclase, opaque grains, pyroxene.

68400256 Olivine-augite "shoshonite" (high K basalt)

Phenocrysts: plagioclase (An_{60}; narrow K feldspar rims), augite (commonly composite), olivine (partly replaced by opaques), opaques.

Groundmass: plagioclase, augite (stained yellow), opaques, alkali (K?) feldspar.

68400257 High K-(olivine)-hypersthene-augite basalt.

Phenocrysts: plagioclase (with narrow alkali feldspar rims; secondary sericite), augite, hypersthene (some as cores in augite), opaques, olivine (almost completely replaced by iddingsite and opaques; rim of hypersthene crystals).

Groundmass: plagioclase, augite, opaques, ?hypersthene.

6800258 High K-hypersthene-augite basalt or basaltic andesite

Phenocrysts: plagioclase, augite, hypersthene, opaques.

Groundmass: plagioclase, augite, hypersthene?, opaques, apatite, secondary calcite.

6800259 High K-olivine-hypersthene-augite basalt

Phenocrysts: plagioclase (K-feldspar rims), augite, olivine (almost completely altered), hypersthene, opaques.

Groundmass: plagioclase, augite, opaques (altered) ?K feldspar.

APPENDIX 3

ANALYSIS OF VOLCANIC SPRING WATERS FROM DOMA PEAKS, P.N.G.

by

H.R. Lord

The following results were obtained for the analysis of two spring waters from Doma Peaks, P.N.G. Samples were submitted by G.A.M. Taylor.

	Area No. 5 Cold Spring	Area No. 6 Bubbling Spring
pH	3.1	2.8
Specific cond. at 20°C (micromho/cm)	520	950
T.D.S. at 180°C	865 ppm	1030 ppm

	ppm	Me/l	ppm	Me/l
Ca	29.9	1.45	20.4	1.02
Mg	3.4	0.28	1.9	0.15
Na	3.0	0.13	5.4	0.24
K	2.6	0.07	4.3	0.11
Li	0.1	-	0.1	-
Al	10	1.11	32	3.54
Fe	2.5	0.13	7.8	0.43
Mn	0.5	-	0.3	-
Total cations	52	3.17	72	5.49
Cl	nil	-	nil	-
CO_3	nil	-	nil	-
HCO_3	nil	-	nil	-
SO_4	369	7.68	392	8.16
Total anions	369	7.68	392	8.16
SiO_2	44		56	

Both these samples contain free sulphuric acid.

Fig. 1. Headwater drainage of Arua river showing mudflow deposits extending from the crater to the main tributary junction.

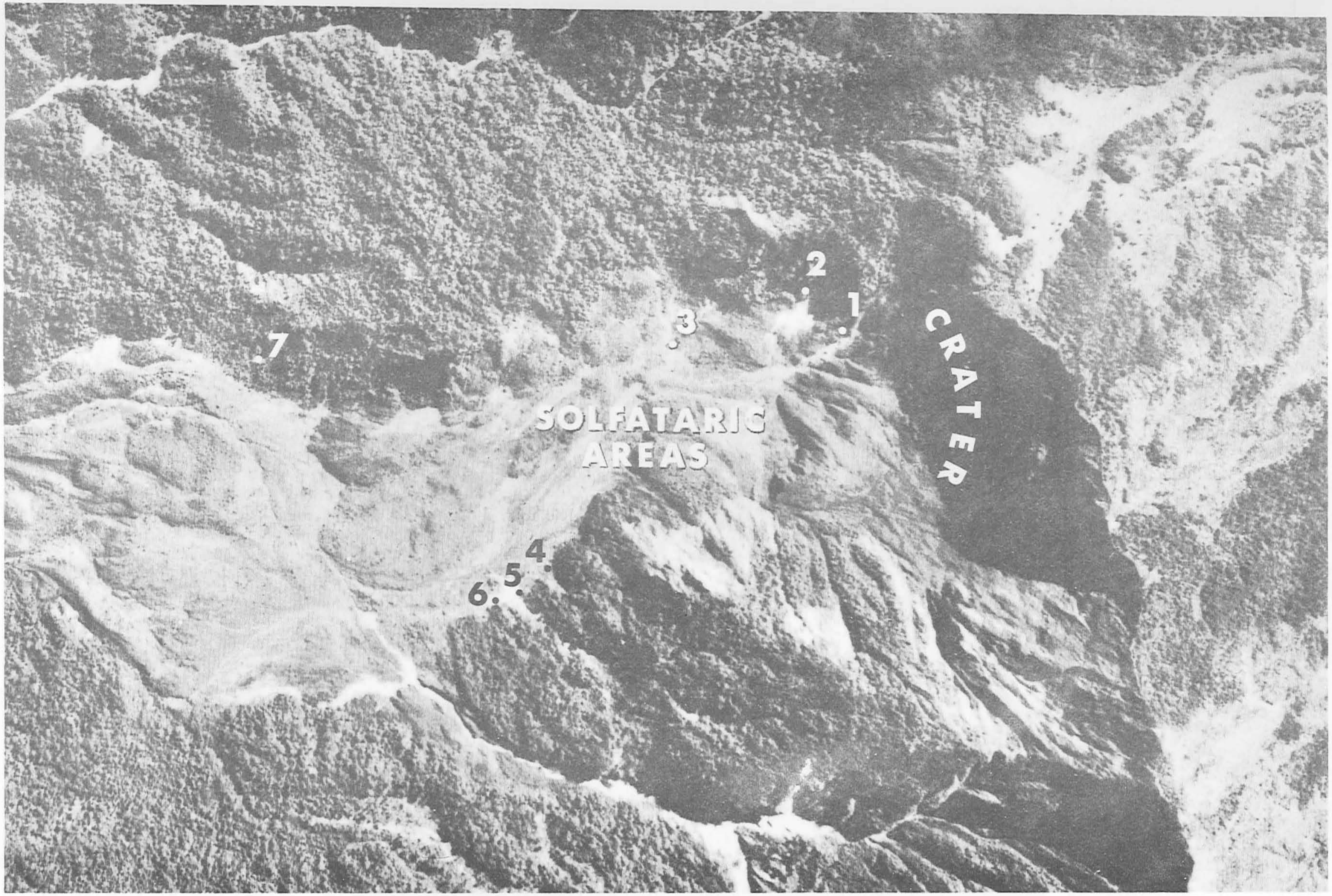

Fig. 2. The crater area of Doma Peaks. Each solfataric area is numbered.

Fig. 3. Dead vegetation and bleached rock at Area 1.

Fig. 4. Gas ebullition in a cold spring, area 6. Tl
white deposit is colloidal sulphur.

PLATE 1

DOMA PEAKS (SPECIAL) PAPUA

Scale 1:50,000

1 0 1 2 3 miles

Contour Interval: 25 metres

Topography of Doma Peaks contour interval 25 metres

To Accompany Record No. 1971/137

B 54/A8/19 (Contours)

PLATE 2

DOMA PEAKS (SPECIAL) PAPUA

Scale 1:50,000

1 0 1 2 3 miles

To Accompany Record No. 1971/137

B 54/A8/19

Relation of settlement to crater and area of high vulnerability in event of eruption