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ADMINISTRATIVE CENTRES FOR THE RABAUL DISTRICT

by

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ADMINISTRATIVE CENTRE FOR THE RABAUL DISTRICT.

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INTRODUCTION.

The principal alternative sites which have been considered or suggested are discussed from the points of view with which a geologist and vulcanologist is primarily concerned - namely vulnerability to volcanic action , earthquakes, and tidal waves, foundations, water supply and accessibility of material suitable for road surfacing, aggregate etc.

The areas considered are (1) Rabaul, (2) Nonga-Tavui, (3) Keravat-Kabaira, (4) Vunakanau-Taliligap, (5) Kokopo-Rapopo. At all of these areas an adequate extent of land suitable for building on exists. No consideration is given here to the relative availability of the land i.e. as to whether it is crown land, native owned or occupied by coconut plantations.

The positions of these five centres relative to the volcanoes Vulcan and Matupi (Tavurvur) and to the principal line of weakness along which most of the earthquakes originate are shown in the accompanying plan, which also illustrates the effects likely to be experienced at each in the event of further volcanic outbreaks. The areas indicated as being subject to eruption damage are based on past experience in the 1937 and 1941-42 eruptions. The 1937 eruption is regarded as having exhibited the probable maximum of severity. In the first place it is obvious from the distribution of volcanic products in the Blanche Bay area that it is the most serious eruption that has occurred for hundreds, probably thousands of years. Furthermore, such an eruption is due to a gradual building up of gas pressure over a very long period, the violence of the ultimate eruption being roughly proportional to the pressure built up, and it is unlikely that greater pressures than those developed by 1937 could be built up without forcing an outlet to the surface and consequently precipitating an eruption. There is no evidence that volcanic activity at Matupi has ever reached the violence of the 1937 outbreak at Vulcan and it is assumed that eruptions at Matupi much more severe than those of 1937 and 1941-42 are not probable.

A difference in the shape of the areas affected by the eruptions of each of the volcanoes will be noticed. This is due largely to the greater violence of the Vulcan outburst, the volume of the material thrown out and the number of active vents, so that the products were distributed over a wider area; and also to differences in the character of the ejected materials. That at Vulcan contained a higher proportion of very fine light volcanic dust, whereas that from Matupi was generally coarser and heavier. Further irregularities in the distribution of the ejectaments are caused by the effect of the local topography upon wind direction.

The map illustrates only the condition during the two typical seasons, and does not take into account other possible wind directions. However, although wind observations at Lakunai aerodrome throughout the year showed more variations than are generally realised, experience during eight months of the 1941 eruption - from June 1941 to January 1942 inclusive - showed that the path of the dustcloud from Matupi volcano does not vary greatly from those shown.

The "areas of severe destruction" shown on the map are those in which damage to property is severe or complete and from which all the population would have to be evacuated in time of eruption. In the "Areas of minor destruction" the effects of all but the most catastrophic type of eruption are mainly of "nuisance value" but considerable discomfort could be caused over long periods, as experienced in Rabaul during 1941, in addition to the effect on the morale

of the population, particularly the women, of living in the path of an erupting volcano. It should be understood that the boundaries of the areas shown are only approximate but they are based on the best information available from past experience.

Other factors to be considered in addition to the above are the blanketing of vegetation by continued deposition of volcanic dust, with resultant excessive run-off causing floods, silting up of drainage channels and stoppage of roads - as in Rabaul following the commencement of the wet season after the 1937 eruption - and the corroding effects of volcanic gases. When the volcanoes are dormant the principal gases given off are steam, carbon dioxide and sulphuretted hydrogen. When an eruption is in progress, however, the gases contain sulphur dioxide, hydrochloric acid, fluorine, hydrofluoric acid and other active corrosive agents. During 1941 galvanised iron, wire--netting, gauze, containing zinc or copper, and many other metals were attacked, mainly by the hydrochloric acid in the atmosphere. The result was that extensive replacements became necessary, and drinking water collected in tanks from roofs became fouled with zinc chloride and unusable.

An examination of the craters undertaken during the first week of December 1946 showed that the volcanoes are in a quiescent condition and that a long period without eruption may normally be expected. No temperatures above 100 degrees centigrade were recorded, even in the bottom of Matupi crater, and only sulphuretted hydrogen gas could be detected from the fumaroles, most of which are depositing crystalline sulphur. Conditions around the foreshore at Matupi, at Rabalanakaia and at Sulphur Creek are essentially unchanged and the very gradual diminution of signs of activity in and around Vulcan which has been taking place ever since 1937 has continued.

I have always maintained that while the Administrative establishment existed at Rabaul, the direct danger from volcanic eruptions was not sufficiently great to justify the expense of moving that establishment. Now, however, when it is a matter of starting practically from zero, obviously the sensible thing to do is to re-establish the administrative centre at some place not directly in the path of possible outbursts. Furthermore, climatically Rabaul has little to recommend it, as the flat on which the town was formerly situated is cut off by the surrounding ring of hills from most winds and consequently experiences a heat and humidity considerably in excess of that felt at places in the area outside this confining ridge.

In the following sections the various aspects with which the geologist is concerned are discussed separately and the results are presented at the end in the form of a table.

VOLCANIC.

Rabaul comes within the area of minor damage from both volcanoes, and is uncomfortably close to the danger zone at Matupi. In addition it is adjacent to Rabalanakaia and Sulphur Creek, and though the former is probably extinct, the small craters at the head of Sulphur Creek are known to have erupted about 1850. Probably the worst feature of Rabaul's position however, is the fact that it lies directly in the path of the south-east wind from Matupi volcano, and in the case of a repetition of the 1941-42 eruption, the inhabitants could expect little respite from volcanic dust showers during the greater part of the year.

The Nonga-Tavui area and the Vunakanau-Taliligap area are practically outside the paths of volcanic effects from any of the craters and the Keravat-Kabaira area is entirely free. The Kokopo-Rapopo area is on the fringe of the dust path from both Vulcan and Matupi during the north-west season, and could

receive deposits of volcanic dust from either in the case of an eruption from December to March. However, it is 10 miles distant from the craters, as compared to 3 miles for Rabaul and the effects would be correspondingly lighter, and of shorter duration.

SEISMIC

The main line of weakness along which earthquakes originate runs from Ataliklikun Bay through a low-saddle across the northeastern part of Gazelle Peninsula and continues in a south-easterly direction toward the south-west coast of Bougainville Island. This line has been well established by field mapping and by plotting the epicentres of hundreds of earthquakes determined from the seismograph records taken at Rabaul Observatory during 1940 and 1941. The severe shock of January 1941 originated along this line not far from Malabunga; a heavy earthquake on September 12th 1940 had its epicentre farther to the south-east. Severe eathquakes felt in 1916, 1919, 1923, 1927, 1933, 1937, 1945 and 1946 also undoubtedly originated along this line, and that of 1916, the strongest known prior to 1941, almost certainly had its epicentre in the same area as the 1941 shock. Plotting of the destructive results of these earthquakes shows that the maximum effects were felt about ten miles on either side of the epicentral zone, with an elongation of the area of maximum effect along the direction of the northwest-southeast line of weakness. At greater distances the effects of the shock gradually become less. During the 1941 earthquake practically every house within this area was displaced from its blocks and suffered extensive damage. Bursting of water tanks, and breaking of crockery, glassware and even furniture were common throughout the whole district.

It will be seen from the map that the Keravat-Kabaira area lies entirely within the zone of maximum earthquake damage and hence it should not be considered as a possible site. The Vunakanau-Taliligap area is marginal to it, and Kokopo-Rapopo, Rabaul, and Nonga-Tavui progressively farther away.

Rabaul has the additional advantage that it is to some extent blanketed off from the effects of earthquakes originating along the main line of weakness by the deep trough of Blanche Bay. On the other hand Rabaul is sufficiently close to the volcanic centres to be seriously affected by the preliminary earthquakes of the volcanic type which precede a major eruption such as occurred in 1937. These volcanic shocks are local in character and their intensity dies away rapidly with increased distance from the volcanic centre, in contradistinction to the shocks of tectonic origin, whose effects are felt over very considerable areas.

Closely connected with consideration of earthquake effects is the question of foundations. It is well known that a building erected on a foundation of unconsolidated alluvial material may be many times more susceptible to earthquake damage than one built on solid rock. None of the five centres being discussed is ideally situated in this respect. Most of the coastal flats on the north-eastern portion of Gazelle Peninsula have been built up of pumice washed down off the hills after former eruptions, or eroded from older pumice layers by deeply incised streams. This alluvial material consisting largely of pumice provides an unstable foundation, particularly at Rabaul, Keravat and Kokopo. Vunakanau and Nonga are underlain by rather better consolidated material.

Wherever building is carried out adequate precautions should be taken to render the structures earthquake-resistant. The principal features of construction to be observed are firm foundations, adequate anchoring of the buildings to the foundations, and sufficient reinforcing of structures by cross-bracing to make the whole into a solid non-yielding unit. The principles and practice of earthquake-proof construction are well known to Mr. W.E. McGowan Assistant Director of Works, Territory of Papua-New Guinea.

TIDAL WAVES.

Small tidal disturbances have been recorded in the Blanche Bay area at various times, but the only one of any importance was a wave 10 feet high on 13th March 1888, which was caused by a violent volcanic explosion at Ritter Island, near the western end of New Britain. It is always possible that seismic seawaves might be caused by earthquakes originating at submarine epicentres south or south-east of Rabaul and although the various sites are shielded to some extent from tidal waves approaching from these directions, it is desirable that the administrative centre should be located some little height above sea level if possible. This can be satisfactorily arranged at Kokopo-Rapopo, Nonga-Tavui, and Vunakanau-Taliligap but would be difficult at Rabaul or Keravat.

WATER SUPPLY.

The Keravat-Kabaira and the Kokopo-Rapopo areas are best served in the matter of water supply, the former by Keravat river, the latter by Matanatava Creek.

Owing to the porous and relatively unconsolidated character of the underlying formations construction of dams of any but the smallest dimensions would be difficult and of precarious permanency particularly in view of the prevalance of severe earthquakes in the area. Foundation conditions are especially unstable in the Kokopo-Rapopo areas. Water storage would probably be best effected in reinforced concrete tanks or reservoirs.

Small springs exist in the other three areas, especially around Vunakanau, and army experience at Namanula has shown that such springs can be utilised to provide water for considerable numbers of men. Such supplies could be augmented by catchment of storm waters in small dams.

All five areas are reasonably well served with reserves of underground water, provided more intelligence is shown in its utilisation than has been the rule in the past. At present in Rabaul, for instance, where there is an extremely porous substratum of pumice through which water flows practically unimpeded, water is drawn from several points quite close to the shore line, while the latrines for the Japanese prison camp, the native labour compound, probably most of China-town and other native and semi-native establishments consist of holes or pits feeding into this porous substratum. Movement of fresh ground-water derived from rains and soakage from higher levels is seaward over the upper surface of the heavier seawater which soaks in from the sea to some distance inland. Latrines and wells should be so arranged that the latrines are on the seaward side and no water should be used for domestic purposes which is drawn from wells that could possibly be contaminated.

There is a further advantage in drawing water some distance back from the beach in that the quality of the water improves with distance inland. Near the sea-front the layer of fresh water resting upon the salt is relatively thin and the quality of the water obtained depends upon the care that is used in tapping and drawing off water from this upper layer. If it is pumped heavily salt or brackish water is drawn up from below. Farther inland the ground water is almost entirely fresh.

The porous layers under the surface at all five centres will all carry good supplies of water. Conditions at Keravat-Kabaira, and Rabaul are essentially similar, and at Kopopo-Rapopo and Nonga-Tavui, where harder less porous beds may be of more common occurrence in the substrata. I have no personal knowledge of actual supplies of well or bore water in the Vunakanau area, but there is no doubt that adequate supplies can be obtained. Especial care would have to be given at this centre to the placing of latrine pits and bores, if this method of sanitation were to be employed.

AGGREGATE, ROAD METAL ETC.

Roads in the Rabaul area in the past have been commonly surfaced with puniceous material in various stages of weathering, or with basaltic scoria. The punice makes a reasonably good surface but is very susceptible to washouts and very special attention has to be given to drainage. It also is a prolific producer of very fine dust in dry weather. The weakness in the use of punice is that it contains insufficient natural binding material and to be an effective road surfacing it should be scientifically blended with the right amount of clayey material to produce a firm-setting mixture. Clay binder is not plentiful in the immediate vicinity of Rabaul although supplies could probably be obtained along the North Coast, in the Toma area, near Keravat and south of Kokopo.

Older volcanic materials exposed in some of the deeper cuttings, as on the Nonga road, which are more completely weathered or consist of finer heavier material, would make a more satisfactory surfacing .

The scoria that has been used in Rabaul has practically no bonding content at all, and is useful only as a road covering, unless it is mixed with a considerable proportion of binder, or used with bitumen. Supplies of basaltic materials of various types are obtainable from the old Rabaul Quarry site, or various other locations along the back of the Rabaul flats, from Malaguna to the South Daughter. The R.A.A.F. is at present using fragmentary weathered basaltic material from the side of the most easterly small crater at the head of Sulphur Creek, and fine red scoria from the bottom of the western slopes of the South Daughter. Similar basaltic materials to those previously broken at the Rabaul Quarry could be obtained along the beach road to Kokopo from Keravia to Raluana, and in the Toma area, around Mount Varzin, also, particularly the fragmentary types, near Tavui Point. Good supplies of solid basalt suitable for aggregate, riprap, and bitumen road surfacing are obtainable in the Rabaul area, at Keravia, and probably at Mount Varzin.

The cliffs along the north-eastern side of Kabaira Bay consist of limestone, which could be used for road surfacing, and similar but rather softer material is interbedded with volcanic beds in the neighbourhood of Tavui Point.

ACCESSIBILITY.

Airfields that are in use or have been used exist at Rabaul, Vunakanau, Keravat and Kokopo, so that the only site not directly served is Nonga. Assuming satisfactory wharf facilities could be provided at Kokopo and Kabaira, these two areas and Rabaul are adjacent to wharf areas. Nonga-Tavui is 5 miles from Toboi wharf and 8 miles from Lakunai airfield. Vunakanau is approximately 10 miles from the wharves.

In my opinion, the possibility that future eruptions may close the entrance to Rabaul Harbour is so extremely remote that no practical consideration need be given to it.

CONCLUSION.

Of the five sites discussed, it may be taken that Rabaul has been ruled out on account of its proximity to the volcanoes, and it has been included mainly to provide a standard for comparison. The Keravat-Kabaira area should definitely be excluded from consideration because it is situated so close to the locus of epicentres of severe earthquakes. Of the other three sites, the Nonga-Tavui area has most to commend it on the score of freedom from the effects of volcanoes, earthquakes and tidal waves, followed by Vunakanau-Talilligap and

Kokopo-Rapopo. None of these three areas, however, could be considered untenable on the above grounds.

The five centres are listed on Table 1 and the order of preference shown with regard to susceptibility to the effects of volcanic eruptions, earthquakes and tidal waves, and also with regard to the other factors discussed, viz:- Water Supply, Aggregate and Road Metal, Accessibility, and Climate.

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TABLE 1.

ORDER OF PREFERENCE OF THE FIVE AREAS DISCUSSED

WITH REFERENCE TO THE HEADINGS CONSIDERED IN THE REPORT.

	"Forces of Nature" Freedom from risk of damage from				"U T I L I T I E S" *						GRAND TOTAL
	Volcanoes	Earthquakes	Tidal Waves	Total	Water Supply	Aggregate Road Materials etc	ACCESS Port	ACCESS Airfield	Climate	Total	
RABAUL	5	2	5	12	5	1	1	1	5	13	25
NONGA-TAVUI	2	1	2	5	4	2	4	5	2	17	22
KERAVAT-KABAIRA	1	5	4	10	1	5	3	4	4	17	27
VUNAKANAU-TALILIGAP	3	4	1	8	3	3	5	2	1	14	22
KOKOPO-RAPOPO	4	3	3	10	2	4	2	3	3	14	24

* No reference is made here to cost and availability of land, supplies of building materials, relative suitability from town-planning view-point, etc.

MAP OF RABAUL AREA
GAZELLE PENINSULA
NEW BRITAIN

Showing relation of the suggested alternative sites for the administrative centre to the volcanoes and to earthquake epicentres.

0 4 8 Miles

- Area of severe destruction - Vulcan
- " " " " Matupi
- " " Minor " Vulcan
- " " " " Matupi
- Principal existing roads
- Alternative wharf areas
- Air fields
- Quarry Sites

In each case areas affected during Southeast Season (April - November) are distinguished by heavier lines from those affected during Northwest Season (December - March).

Outlines of areas based on 1937 eruptions of Vulcan & Matupi & 1941-42 eruption of Matupi

- Zone of Maximum earthquake damage, January 1941

Watom Is.

Nonga-Tavui Area
Tavui Pt.

Duke of York Group

Urara Is.

Massava Bay

Talili Bay

Rabaul Area

Matupi (Tavurvur) Crater

Vulcan Crater

Blanche Bay

Kokopo - Rapopo Area
Cape Gazelle

Keravat - Kabaira Area

Ataliklikun Bay

Vunakanau - Talilitap Area

Rapopo

Matanatava Ch.

Tobera

Kabanga Bay

Warangoi R.

APPROXIMATE POSITION OF MAJOR LINE OF WEAKNESS ALONG WHICH MOST EARTHQUAKES ORIGINATE

ZONE OF MAXIMUM EARTHQUAKE DAMAGE

ZONE OF MAXIMUM EARTHQUAKE DAMAGE

Epicentre of Severe Earthquake Jan. 14th 1941.

NOTE: The Oct. 1949 Earthquake indicated that on the whole the line of weakness is north of that shown here.

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