5

World War II and the Tavurvur Eruptions of 1941–43

5.1. Monitoring the Volcanoes

Dr Stehn's proposal that a volcanological observatory capable of providing early warnings of volcanic eruptions should be established at Rabaul began to take effect despite the earlier, reasonable criticisms of the idea by his co-investigator, geologist Dr W.G. Woolnough. Funds were made available in 1939 for building the observatory and equipping it with instruments as part of the administration's Department of Lands, Surveys, Mines and Forests (Fisher 1940a; R.W.J. Collection 10). Norm Fisher, geologist, would be in charge of the observatory; he was sent to Java for further training under Dr Stehn in 1939. Fisher informed the world geoscience community of the construction of the 'Vulcanological Observatory' by preparing a short note for the international journal *Bulletin Volcanologique* published in Italy (Fisher 1940a). The observatory was to be built in a commanding position on a south-western spur of Tovanumbatir on the northern rim of the caldera overlooking Rabaul and all the historically active volcanoes of Blanche Bay. In addition, observation posts would be established near Tavurvur and Vulcan by using tunnels driven into the caldera walls near each volcano, fitted with instruments and gas-proof doors, and connected by telephone to the main observatory.

Figure 5.1. First volcanological observatory to be built overlooking Rabaul town.

This was the first building to be erected on Observatory Ridge for the prewar volcanological observatory run by N.H. Fisher. A residence was subsequently built, together with a tennis court. GA negative reference GB1352.

Fisher's plans were quite ambitious and involved construction of several above-ground rooms: an office, laboratory, darkroom, observation room and a small museum. The building consisted initially of a simple fibrocement-sheet construction over an insulated cellar that would contain most of the instruments (Figure 5.1). Fisher wrote in the final paragraph of his note that 'the instruments have been on order for some time, so it is probable that the station will be in operation before the end of the current year' (Fisher 1940a, 187). The hoped-for instruments included a German-designed Wiechert seismograph and Italian tiltmeters, but obtaining them during global wartime conditions proved impractical. Two seismographs, a tiltmeter and an annunciator had to be manufactured locally in Rabaul (Figure 5.2). Completed in June 1940 by Mr W.E. Jackson of the Department of Public Works, the instruments were 'a great job of work', being 'wonderful exhibits of precise workmanship and delicate adjustments', reported the *Rabaul Times* (1940, 5). Tenders for erection of a residence at the observatory were let in May of the same year.

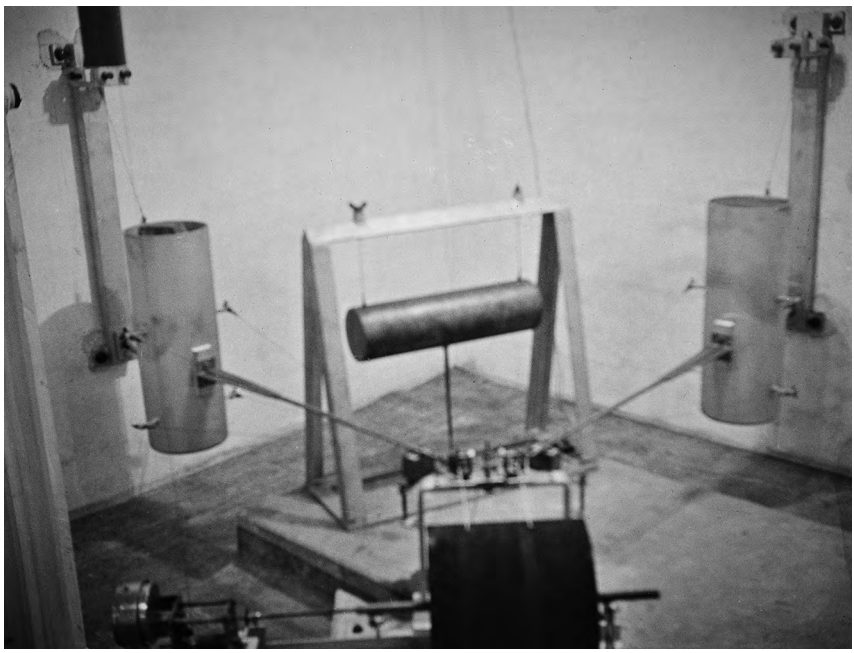

Figure 5.2. Volcano-monitoring equipment in observatory cellar.

Instruments installed in the cellar of the prewar volcanological observatory were designed and built in Rabaul under the direction of N.H. Fisher. Two parts of a seismograph are seen in this photograph (taken by Fisher) hanging on the western and southern walls of the cellar. Arms extend from them to the smoked-drum recorder in the foreground where the earthquake vibrations are traced out. The horizontal cylinder suspended in the trestle-shaped steel frame is an earthquake annunciator made after a design by Dr Stehn. Earthquakes would produce movement of the cylinder that, in turn, would cause a pointer to move across a series of mercury-filled electrical terminals to a point dependent on the size of the earthquake. A bell would ring automatically in the observatory residence, and shutters dropped in a panel in the observatory building, when earthquakes took place. Printed from original negative held by the National Library of Australia. R.W.J. Collection 10, Folder 2, NHF-envelope no. 4. High-resolution digital copy provided by the National Library of Australia.

Staff of the volcanological observatory led by Fisher provided weekly reports of their observations between December 1937 and January 1942. These reports were published in the *Rabaul Times* and were made available to the Australian Government in Canberra, where many were archived officially. Fisher was assisted by L.E. Clout, a draftsman with the Department of Lands; by the end of 1940, the administration had appointed an assistant volcanologist, C.L. 'Clem' Knight. Other contributors to the weekly reports, particularly when Fisher was in Java, were K.L. Spinks, H.J. Badger and L.C. Noakes. These reports and others, including copies of radiograms

between the administration and Canberra, are still held by the Rabaul Volcanological Observatory (RVO) and digital copies of them are provided in the RVO information management system (IMS) (RVO 1937–42). Fisher and Noakes also published on aspects of the geology of New Britain as a whole (Fisher and Noakes 1942).

No further volcanic eruptions took place at either Tavurvur or Vulcan during 1938–40 but, reported Fisher in a memorandum to the government secretary in Rabaul:

> [A] series of small steam explosions occurred at Tavurvur Volcano between 9.30 a.m. and 10.15 a.m. Sunday 3rd March 1940. These were apparently due to the choking up of the principal vents on the crater floor by material washed down by the recent [wet season] rains and by slips within the crater … The explosions were witnessed at close quarters by a party of ten or eleven natives, mostly from the Seventh Day Adventist Mission at Palm Beach, Rabaul, who were gathering sulphur at the foot of the vertical face [just] west of the edge of crater. (Fisher 1940b, 1)

There were no casualties and the emitted dust and rocks barely extended beyond the crater limits. Nevertheless, the event was indicative that Tavurvur was still retaining significant amounts of volcanic heat, unlike Vulcan, which had cooled significantly. Further, rising temperatures at Tavurvur had been recorded by Fisher in his reports by the end of the year and had been noted in newspapers. For example, the headline for a short article published in the *Pacific Islands Monthly* for January 1941 was: 'Eruption? Rabaul's Volcanoes Under Suspicion. From Our Own Correspondent. Rabaul, Jan. 3' (*Pacific Islands Monthly* 1941, 9). The 'correspondent' was presumably Gordon Thomas.

A severe earthquake shook the whole of the Gazelle Peninsula and elsewhere at about 2.28 am on 14 January 1941, particularly in the north-east, causing damage to houses and contents, and concern in Rabaul town (Fisher 1944). The seismograph at the observatory was put out of action by the earthquake so few scientific details were available on the nature of the main earthquake, which was followed by many aftershocks. Fisher, however, undertook field work, examining the different directions in which houses had responded to the main shock. He concluded that the epicentre of the main earthquake was about 20–21 miles (32–34 kilometres) south-west of Rabaul, near the village of Wunga. Fisher even produced an 'isoseismal map' for the whole region encompassing New Ireland and eastern New Britain. He showed

that the areas of maximum earthquake intensity—measured at 8–9 on the Rossi–Forel scale—defined a broad north-north-west trending zone that was evidently related to a major geological fault running from Ataliklikun Bay across the Gazelle Peninsula to beyond the south coast of New Britain. The earthquake was, therefore, of tectonic rather than volcanic origin.

Dr Woolnough in Australia, early in the first week of January, had sent a memorandum to the Department of the Interior, Canberra, expressing his concerns about the volcanic situation in Rabaul (Woolnough 1941a). He was significantly more anxious about the situation than he had been about the local earthquake on 8 January 1938 (Woolnough 1938). After news of the 14 January earthquake reached him, Woolnough completed an article that was published in the *Sydney Morning Herald* (23 January 1941) and *Rabaul Times* (31 January 1941):

> The news of severe earthquakes at Rabaul, following upon reports that both of the recently active volcanoes have again been emitting steam, focuses attention upon the conditions existing at the centre of administration of the Mandated Territory of New Guinea … It is inescapable that the recent increase in seismic activity in so critical a region must give ground for some anxiety as to the ultimate outcome. (Woolnough 1941b, 10)

Woolnough believed that January's seismicity represented 'deep-seated action' that 'must favour the movement towards the surface of masses of molten rock, bringing fresh supplies of heat and energy within the reach of surface waters. This favours explosive activity.' He also expressed his opinion that Vulcan and Tavurvur were connected by a sea floor fracture and that any new opening and eruption along this crack might 'block completely the harbour of Rabaul, and for ever bottle up any ships which might be caught there' (Woolnough 1941b, 10).

Norm Fisher replied to Woolnough's article in the *Rabaul Times* on 7 February, introducing his generally critical remarks thus: 'Dr Woolnough has presented the most pessimistic and unfavourable aspect of the situation in Rabaul' (Fisher 1941, 4). Fisher stressed that the earthquake and its aftershocks had not led to a change in the state of the volcanoes 'apart from subsidences around Vulcan caused by submarine slippage'. He questioned the evidence that Vulcan and Tavurvur were connected by a potentially active submarine fracture. Woolnough had written that the conditions for evacuations during the 1937 eruption 'could scarcely have been luckier'

(Woolnough 1941b, 10). Fisher, however, took the opportunity to point out that circumstances during the 1937 Rabaul evacuation had not been especially favourable (as Stehn and Woolnough had stated in their report), noting that similar eruptions during the north-west season, especially any from Tavurvur, would not have affected Rabaul; that dusk and darkness did interfere with the evacuation; and that families 'were not so reunited but dispersed largely about their various recreations'. Fisher added that another evacuation from Nodup would not be likely to arise as an 'emergency camp has been prepared at Tavui with full facilities for looking after the population of Rabaul' (Fisher 1941, 4).

Figure 5.3. Oblique aerial photograph of Vulcan cone in 1941.

Vulcan was eroded by rains in the few years after the 1937 eruption. Numerous small gullies with rounded headwalls were formed, as seen in this photograph taken by Flying Officer R.J. Love from a Catalina flying boat in May 1941. Not much vegetation has taken hold on the new volcano, but by the end of WWII the cone was shrouded in vegetation and further erosion was thus inhibited. The erosion of Vulcan and of the nearby shorelines (including what was formerly Vulcan Island) resulted in pumice being washed into Blanche Bay. Some of this pumice floated and was driven into Simpson Harbour during the south-east seasons until at least 1945, though not in the large amounts seen shortly after the 1937 eruption. Photograph courtesy of Mrs M. Love. GA negative reference GB2381.

The January earthquake had apparently not affected the volcanoes, although Fisher had been observing some important changes to the state of Tavurvur—but not Vulcan (Figure 5.3)—as far back as late August 1940 when new hot ground was noted in one of the craters. He summarised this and later developments in a valuable paper written 35 years later (Fisher 1976b). Temperatures remained steady in the craters at about 100°C until early November when an 11°C rise was noted, followed by a spectacular rise to 224°C in December prior to the 14 January earthquake (Figure 5.4). A general rise in temperature followed over the next few months until the last recorded temperature reached 392°C on 3 June 1941. New vents vigorously discharging gas had also appeared during the previous August, giving off a strong smell of sulphur dioxide. The discharges increased here and elsewhere on Tavurvur until 27 May when gas and vapour were 'issuing with a "roar like a train" and the steam cloud was visibly larger' (Fisher 1976b, 205).

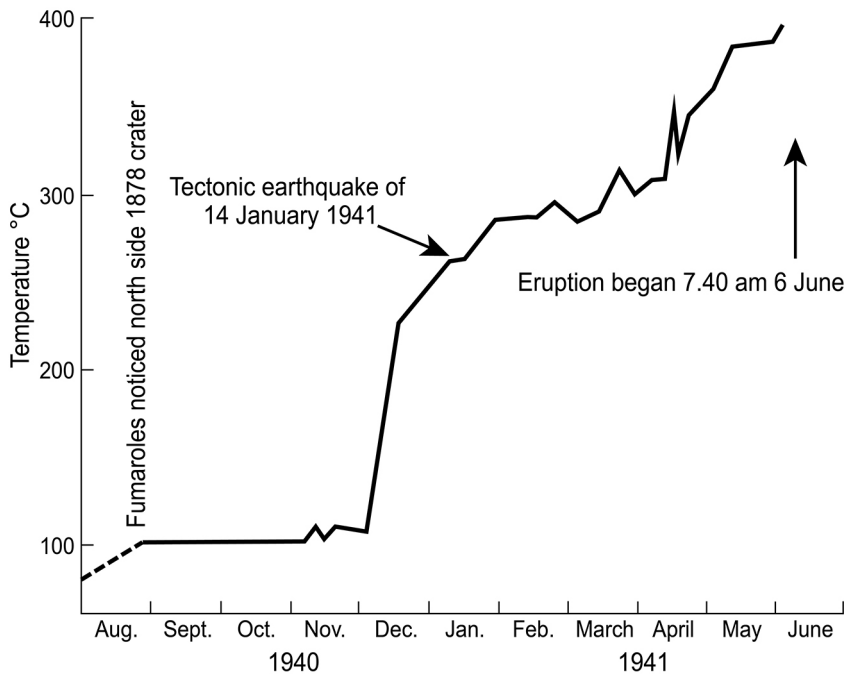

Figure 5.4. Time series graph of Tavurvur temperature measurements, 1940–41.

This rise in temperature of hot ground in the 1878 crater of Tavurvur was detected by N.H. Fisher until a short time before an eruption took place on 6 June 1941 (Fisher 1976b). Adapted from GA drawing, reference 24/B58-2/35.

Sulphur dioxide and hydrogen chloride gases became readily detectable, but no build-up in earthquake activity was recorded on the two seismographs—one at the observatory and the other at a point about 1 kilometre north of Tavurvur—probably because of the low sensitivity of the instruments. The bottom of the main crater of Tavurvur had silted up since 1937, and, in February and March 1940 (the end of the wet season), there had been minor steam explosions caused by the heating of the crater muds—as reported above. Four explosions on 3 March 1940 'hurled mud and small stones up to about the height of the crater rim' and on 12 and 16 March the ejections of 'mud, stones, and later dust were thrown out to a height of a hundred metres or more above the crater rim' (Fisher 1976b, 207).

All these observed changes at Tavurvur were preparatory to the start of a main period of volcanic eruptions that began at 7.40 am on 6 June 1941 and would affect the unfortunate town of Rabaul over the next several months. They would affect not only the usual residents of town, but also, subsequently, the Japanese forces who invaded and occupied Rabaul in January 1942.

5.2. Arrival of 'Lark Force' and Abandoning the Capital

Australia had committed to joining the Allies in the war against Nazi Germany in Europe, but it also had the challenge of guarding its own northern border against possible invasion by the Japanese military, which was expanding resolutely in the Western Pacific. The magnificent deep harbour at Rabaul was an obvious military target for the Japanese; the challenge for Australia was how to defend what was still the capital of a territory mandated to Australia by the League of Nations. More particularly, could enough military resources be assembled to constitute a strong defence of a territory that was, in reality, distant from Australia's continental shores? The fact that the actual military deployments at Rabaul were inadequate and the terrible outcomes that resulted are described in detail in official histories (Wigmore 1957), in many unofficial ones (Hall 1981; Nelson 1992; Lindsay 2010; Threlfall 2012) and in major compilations based on the accounts of individuals and the members of organisations (Aplin 1980; Stone 1995; Downs 1999; PNGAA 2017).

Australian soldiers of the 2/22nd Battalion were among those who saw the 6 June 1941 eruption at Tavurvur. They also saw the succeeding eruptions of what was to be the first phase of volcanic activity that lasted until 29 June. The battalion was part of the 23rd Brigade of the 8th Division, 2nd Australian Imperial Force, and its members were largely young men, in their late teens or early twenties, from Melbourne and rural Victoria. They had volunteered expecting to fight against the Germans in Europe, but had been sent to Rabaul for garrison duty as the defence force for what they discovered was an isolated outpost. An advance party of troops arrived in early March 1941, and, by late April, over 1,000 soldiers had been established in an army camp along Malaguna Road. The battalion was part of a composite force in Rabaul, known as 'Lark Force', that included units of, for example, fortress artillery, anti-aircraft artillery, fortress signals and six women from the Australian Army Nursing Service. Lark Force also had an excellent brass band, some of its members being formerly from the Brunswick Salvation Army Band. They had enlisted as brass bandsmen and stretcher bearers, along with their bandmaster, Sergeant Arthur Gullidge, a talented conductor and composer of band music. Most of the other bandsmen were Salvation Army members from other corps. The Royal Australian Air Force deployed Wirraways a trainer and general-purpose aircraft, in the Rabaul area, but these would prove inadequate in competition with fast 'Zero' fighters of the Japanese Air Force. Members of the already-established New Guinea Volunteer Rifles supplemented the small Australian military force that had been imported to defend Rabaul.

Garrison duties were not especially exciting for the young 2/22nd soldiers, and boredom was a common enemy. However, the Tavurvur eruptions provided some excitement, as few, if any, of the troops had ever before seen a volcano in eruption. Stan Whitty was a member of a fortress signals unit. He recalled:

> One evening, about mid-June 1941, a group of us became aware of some sense of vibrations in the very still air. Then there was this most frightening and terrifying loud explosion. The sensible [people] seemed to be moving out of Rabaul, either in cars or on foot … The ignorant stupid, like us, just stood and looked in awe … The mouth of the volcano was spewing out red hot rocks and ashes. A great cloud was rising high into the sky … The flames belching out of the open mouth were quite plain to see … Though other belchings and eruptions of rock and ashes took place in the following weeks, that first terrifying explosion was never equalled in sound level. The experience made you realise how puny man is compared with

> nature … One chap refused to sleep in his tent … Always slept fully clothed—boots and all—in the back of one of our trucks. Keys always left in ignition switch. (Whitty 1981, 1)

The first eruptive period consisted of irregularly spaced explosions of different intensities, the largest of which took place on 17 June, hurling blocks beyond the foot of the volcano. Dust and rocks were flung out during the first two days of the eruption, but on the evening of the second day, red-hot rocks began to be expelled. The ash during this period was blown towards Rabaul by the south-east winds, and was a considerable nuisance to the townspeople. Mr Hoogerwerff, who was still manager of the Rabaul Printing Works, recorded on 12 June that the 'only inconvenience so far is that the air is full of dust and ashes which make everything very dirty'; two days later he added that he had 'thought it best to go to bed dressed with shoes on … The happenings of the last week do not make one feel too good' (Hoogerwerff 1941).

Many photographs were taken of Tavurvur eruption clouds in 1941 although precise dates are rare (Figures 5.5–5.7). These images, plus descriptions of the eruptions, provide good evidence that most, if not all, of the eruptive activity at these times at Tavurvur, and probably into 1942, was mildly 'vulcanian' in nature. Similar vulcanian eruptions probably took place at Tavurvur in 1878 but were not photographed. Further, the short overnight eruption at Tavurvur in May 1937 also may have been vulcanian in part, although it was not well described.

'Vulcan' is the name not only of the Roman God of Fire but also of a young volcanic island in the Mediterranean that was active in 1888. Volcanic gas and vapour in vulcanian eruptions are exsolved explosively from new, viscous magma beneath craters, producing ash, dust and blocks that are commonly incandescent. Vulcanian explosions can also create atmospheric shock waves. Strong vulcanian eruptions were recorded at the Italian Vulcan in 1888 but, as the Italian volcanologist Mercalli (1907), noted:

> In the less violent explosions large ejecta were lacking and the jet consisted of a dense gray mass of lapilli, sand, and ash that rose slowly, taking the form of a great cauliflower or giant mushroom … [T]he cloud expanded in dense globes and volutes, finally building up to a height of 3 or 4 kilometres. (cited in Macdonald 1972, 223, translated from Italian)

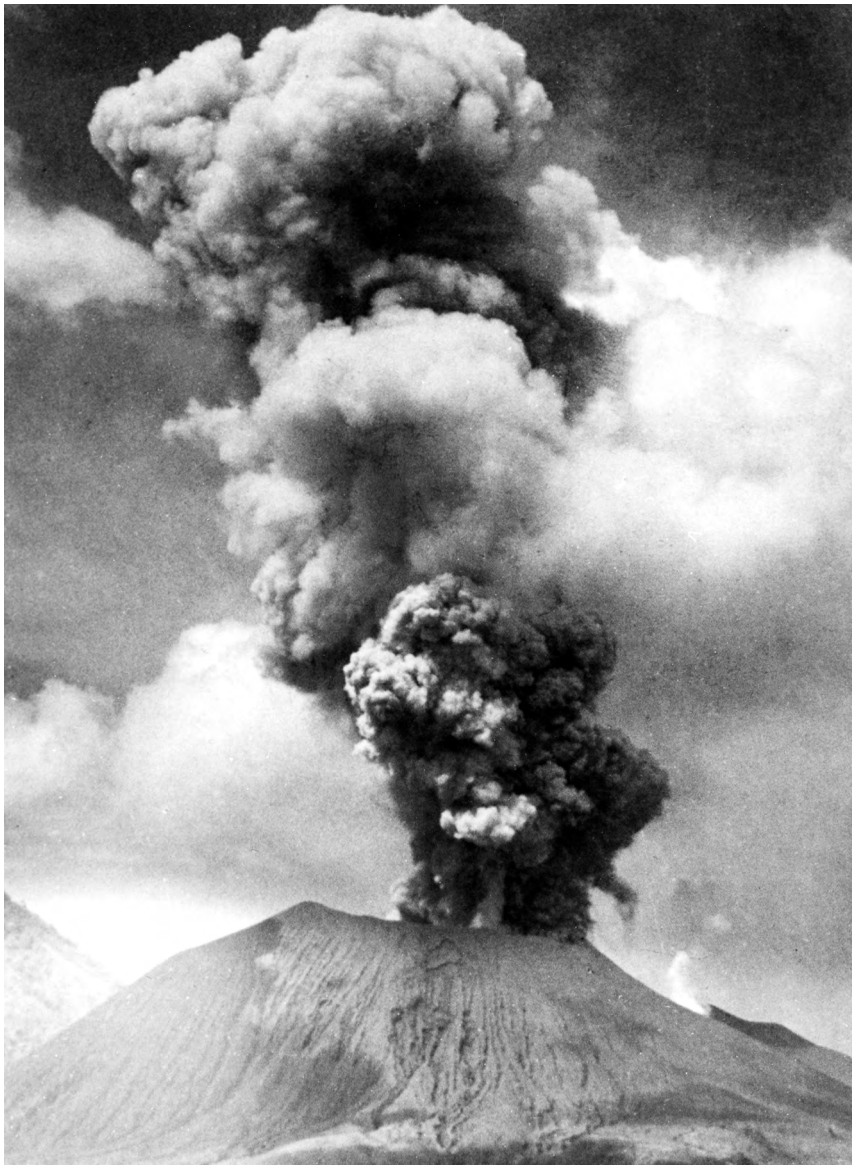

Figure 5.5. Tavurvur in explosive eruption (Hawnt).

E.A. Hawnt took this photograph of Tavurvur in vulcanian eruption in late June 1941. The photograph was supplied by Mr C.N. MacL. Stirling, a former lieutenant in the 2/22nd Battalion. Members of the 2/22nd Battalion and Lark Force Association in Victoria responded most generously to requests for photographs such as this of the 1941–42 volcanic activity at Tavurvur. GA negative reference M2447-11A.

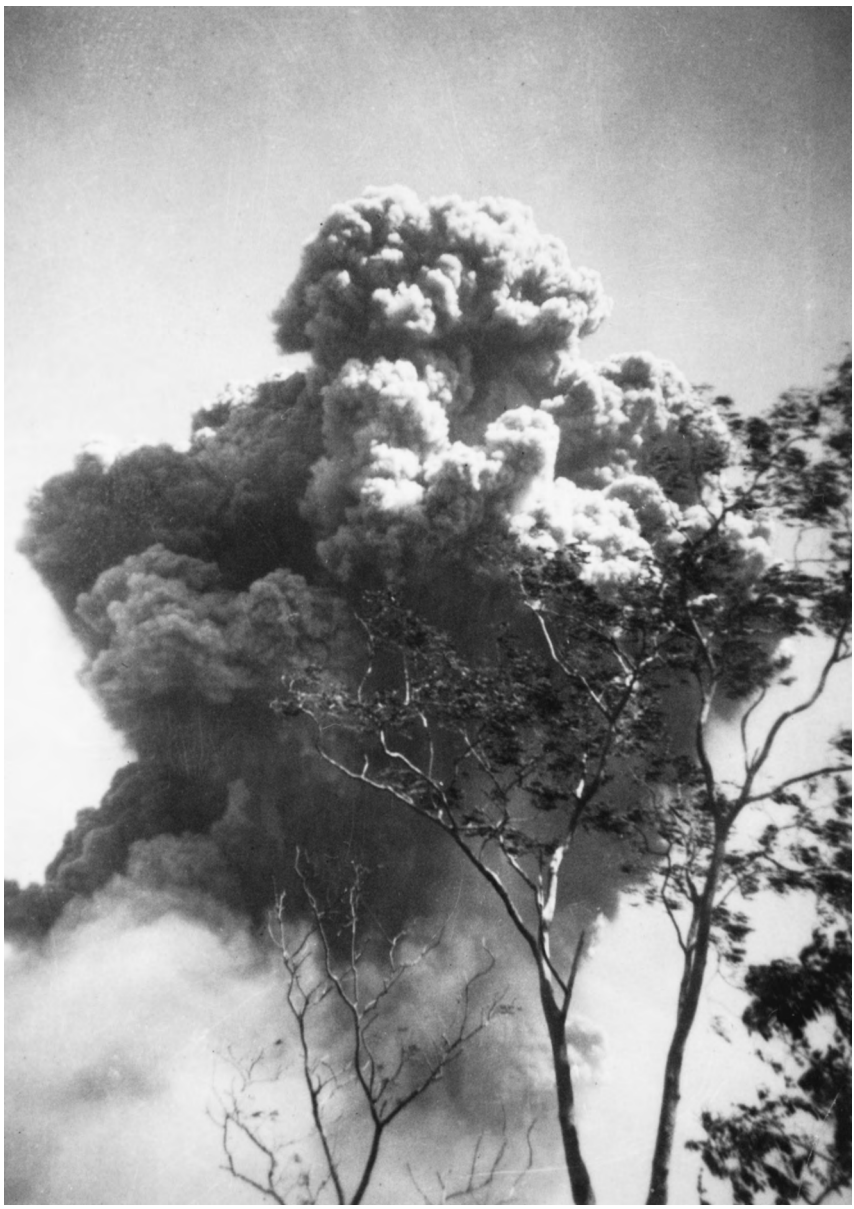

Figure 5.6. Tavurvur in explosive eruption (Hutchinson).

A cauliflower-shaped vulcanian eruption cloud from Tavurvur billows upwards in this 1941 (possibly 1942) photograph supplied by Dr R.C. Hutchinson, a civilian who managed to escape from the Japanese invasion of Rabaul. GA negative reference GB2538.

Figure 5.7. Incandescence in Tavurvur eruption cloud.

Early morning light catches the eastern side of a vulcanian eruption cloud from Tavurvur and is sufficiently dull that incandescence at the rim of the volcano is readily visible. This photograph was supplied to N.H. Fisher courtesy of Mr F. Kollmorgen, a member of the Salvation Army band. Its exact date, other than 1941, is unknown. R.W.J. Collection 30D, Folder 13, Sleeve 13.

Conditions in Rabaul at this time are summarised in a letter dated 20 June 1941 and written by Mrs Mona Anthony to her brother-in-law the Hon. Hubert L. Anthony, a minister in the Australian Government:

> Well, she's still going up with great gusto to a height of 2–3000 feet [600–900 metres], blowing away with great roars and explosions which sound most of the time like a train going over a big overhead bridge. From outside of the town where you can get a good view of it, it presents a wonderful spectacle at night, throwing out great red-

> hot boulders and sparks and glowing away threateningly. No one seems particularly nervous now and there is absolutely no sign of panic, though, naturally, at first it caused a certain amount of alarm, particularly at night. Many people, particularly those with children have gone out of town, and I think that it finally decided those who were hesitating about going South to leave when passages became available. You can't conceive the dust and filth which covers the place … Everyone is going about with handkerchiefs over their noses and mouths and coverings over their hair. We eat it, sleep in it and sit in it, and what a mess! … Nearly half of the children are away from school … If it becomes permanent we will not be able to live here permanently. I should think many people are extremely indignant that the powers that be have missed their opportunity of moving the capital and think that it should have been done after the first [1937] eruption. Of course, there is a war on now as an excuse. Also many of them are extremely irate of the seeming complacency of the Administrator and pray daily that all the dust will blow in his direction. Quite heart breaking to see the homes. We thought this morning that we were going to have some heavenly relief with the wind blowing in the opposite direction but, alas, a strong S.E. has sprung up and … [the ash is] pouring down like rain. (Anthony 1941, 1)

Tavurvur remained inactive for a few days after 29 June, but had resumed its explosive activity by 3 July. However, it lapsed again into quiescence by 18 July. There were more explosions on 27 July, but the succeeding eruptions were mild—at least until 9 August, when activity began to increase at the start of what was to be the longest and most continuous period of activity of the whole eruption. Especially violent explosions took place on 22 and 25 August, and the week of activity ending on 27 August was judged by Norm Fisher to be 'easily the most violent' since the beginning of the activity in June (Fisher 1976b, 208).

Lieutenant David M. Selby was in command of an anti-aircraft battery in Rabaul, and had arrived there in August when Tavurvur was in eruption:

> It was throwing up a tall column of black smoke and pumice dust. From time to time this would die down, then there would be a roar and a huge cloud of swirling black smoke and dust would burst out of the crater, swelling into a mushroom-shaped cloud … The tremendous force of the gas coming from the crater would lift this up until it became the familiar column, rising to a great height until it bent almost at right angle when the wind caught it and carried it over the town of Rabaul. A curtain of dust and pumice stone would

> fall from this over the town. Everything exposed to it would be covered with a layer of black pumice. When rain was expected, it was common to see natives on the roofs of houses sweeping clouds of ash off the roof … At times the [eruption] column would be shot with flames and large rocks would be hurled from the crater. A strong smell of sulphur pervaded the town the whole time I was there … Whatever was in the gas … was powerfully corrosive. Unprotected metal was very soon destroyed and this was particularly noticeable on motor vehicles where any scratched or unpainted parts quickly developed gaping holes. We became quite resigned to the fact that everything exposed to the open air was thickly covered with black grit. (Selby 1981, 1–2)

The metal deterioration mentioned by Selby was probably caused by volcanic gases such as sulphur dioxide, hydrochloric acid, fluorine and hydrofluoric acid:

> [G]alvanised iron, wirenetting, 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. (Fisher 1946a, 2)

Further, Mr Hoogerwerff recorded in early August that:

> The dust seems to be harmful to the vegetation … Only casuarina, mango and a few other strong trees do not suffer but otherwise all the trees and hedges have lost their leaves. (Hoogerwerff 1941, 42)

And, on 28 August, that:

> [Tavurvur has been] ejecting huge quantities of black dust [which is] badly affecting the vegetation, all ironware and textiles. Dust is everywhere, so, our lungs and eyes are sure to suffer someday. If this goes on, Rabaul will no longer be a place to live in. (Hoogerwerff 1941, 42)

The administration, in fact, had already reached the same conclusion as Hoogerwerff. Sir Walter McNicoll—who used his other Christian name after being knighted—called a meeting of the Executive Council for Saturday 23 August, and the decision—delayed for almost four years after the release of the Stehn and Woolnough report—was made to move the seat of government from Rabaul (NAA 1941–46). The decision was announced in an editorial of the *Rabaul Times* the following week (Thomas 1941). Weeks of enduring the effects of Tavurvur's repeated eruptions had finally

removed any remaining doubts about the advisability of leaving Rabaul. Tavurvur ash had even fallen on the administrator's home on Namanula Hill. This was caused by the Tavurvur eruption clouds eddying around Kabiu mountain—no doubt providing satisfaction to those Rabaul people, mentioned in Mona Anthony's letter, who had irreverently hoped for fallout on Government House. Approved by the Australian Government in Canberra, Lae was proclaimed the capital of the Mandated Territory of New Guinea on 9 September 1941, ending Rabaul's 31 years as a colonial capital.

The move of the administration to Lae could not, however, be made immediately. The shift was planned to take place over several months, and the task of crating documents and all the paraphernalia of a bureaucracy took many weeks. McNicoll made several trips between Rabaul and Lae, but, by the end of November 1941, the administrator had transferred his household to Lae and taken up official residence there (*Morobe News* 1941). So ended the line of governors and administrators living on Rabaul's Namanula Hill. The army's hospital was moved into Government House from its tents on Malaguna Road.

Eruptions from Tavurvur continued through September until 7 October. These were generally less severe than those in late August, but, while the south-east season lasted, they nevertheless continued to make life unpleasant for those in Rabaul. The eruptions of Tavurvur helped, however, to alleviate boredom for at least some of the 2/22nd troops. A group of soldiers, wearing masks for protection against volcanic gases, would climb the flanks of Tavurvur while it was active and plant a sign as near as possible to the volcano rim. They would, on their return to camp, then challenge any other group to retrieve the sign, and this game would go on as later groups tried to stick the sign farther up the slopes of the volcano! These daredevil antics were stopped when a commanding officer heard about them. The southern side of the volcano could, in fact, be approached quite closely, with caution, because the eruption point was near the base of a lava plug in the crater formed in 1937, and because the southern wall of this crater was almost vertical. This meant that most projectiles did not fall to the south. Nevertheless, the sign-planting practice could hardly be recommended, especially as, in late October, powerful explosions hurled rocks—that were hot enough to set fire to dry grass—about 1 kilometre from the crater. Visits were also made to the deep gullies on Vulcan (Figure 5.8).

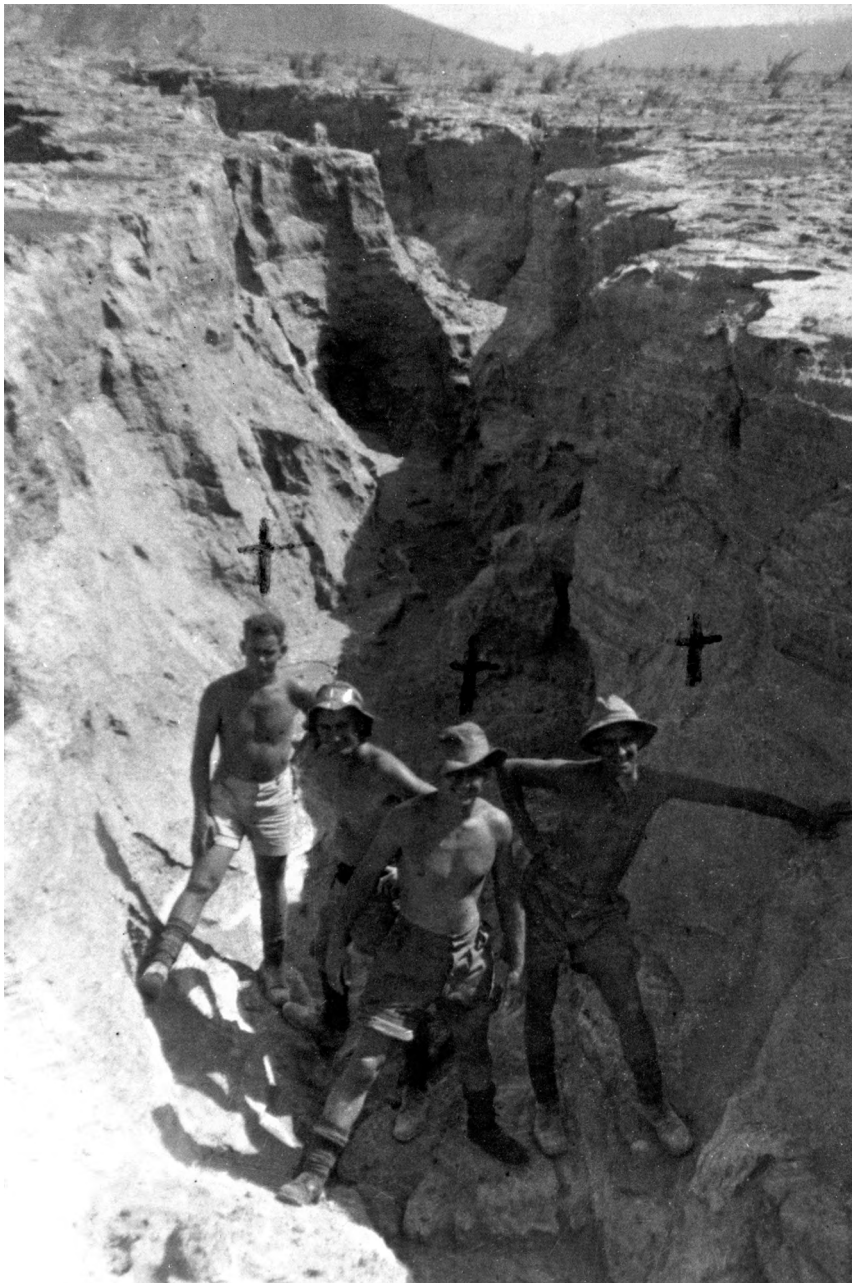

Figure 5.8. Visit to deep erosion gully near Vulcan.

Four soldiers from the 2/22nd Battalion are here on an excursion to the 'Grand Canyon', their name for one of the deep gullies cut into the 1937 pumice near Vulcan (see also Figure 3.62). Mr S.G. Whitty supplied the photograph and marked with crosses those of his mates who died during World War II. GA negative reference GB2675.

A lull in volcanic activity took place from 27 October to 8 November, another from 13 to 15 November, followed by a period of strong activity until 25 November, which was characterised by some exceptionally powerful outbursts. Volcanic bombs were hurled great distances—the farthest yet—on 19 November (Fisher 1976b). However, Tavurvur was quiet for the rest of the year after 25 November, except for short outbursts of activity on 4 December and on 9 January 1942. The north-west season had set in by this time, so ash was not blown over the town. In any case, the people of Rabaul were more concerned with the problems of the war that was about to break over the town. Tavurvur, however, began another eruptive period in the week beginning 19 January (Fisher 1976b).

5.3. Japanese Invasion and the Arrival of Takashi Kizawa

The Japanese Navy had a major base at Truk Lagoon in the Japanese Mandated Territory of Micronesia, which was only about 1,300 kilometres directly north of Rabaul. Rabaul was closer to Truk than it was to Cairns in northern Queensland, where there was no equivalent military base. The Japanese first attacked Pearl Harbor, Hawaii, on 8 December 1941 (Rabaul time), and during the remainder of the month they advanced rapidly on many fronts in the South-East Asian and Western Pacific regions. The attack on Pearl Harbor was the trigger for the US to enter the war as one of the Allies.

Japanese reconnaissance aircraft were seen over Rabaul in December. An attack on the town seemed inevitable (Figure 5.9). There were concerns about the ability of the small force at Rabaul to repel any significant attack, and about the lack of preparation among the soldiers should they have to withdraw from Rabaul; most of the troops had no knowledge of tropical bush craft. The orders from Australia were quite clear. On 12 December, the Australian Chiefs of Staff advised Cabinet in Canberra that there would be no military withdrawal from Rabaul and that the troops should remain there as 'hostages to freedom' (Nelson 1992; Stone 1995). A forward observation line was necessary, they said, but shifting out a large force by sea was dangerous at that time, and there were tasks of higher priority for them to consider. European women and children were compulsorily evacuated to Australia, Chinese stores announced that business would be on a cash-only basis, banks restricted trading hours and the number of social events declined markedly. Christmas was quiet and subdued for many of the all-male households of Rabaul's European community.

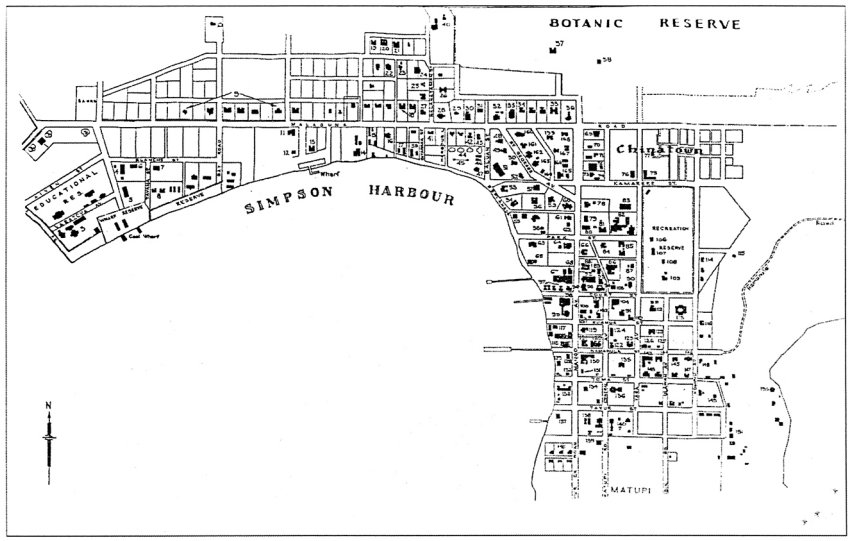

Figure 5.9. Wartime military map of Rabaul.

This is a detail from an original chart of the Rabaul town area that was compiled for Australian military intelligence purposes during WWII (AGS 1944, Map 12; see also Thomas 2012, 9). The original includes an index (not shown here) of 168 placenames compiled by Lieutenant Anthony in April 1943.

Lieutenant David Selby was summoned to headquarters shortly after the news of the Pearl Harbor attack was broadcast on the radio in Rabaul, and was instructed to move his anti-aircraft battery from Malaguna camp to a more strategically advantageous site (Selby [1956] 1971). Selby chose Observatory Ridge:

> Early one Monday morning Dr Norman Fisher, the Government Vulcanologist, was horrified to see two guns lumbering on to his front lawn, accompanied by load after load of ammunition, sandbags and supplies. Slit trenches were dug where he had been patiently coaxing a garden to grow, trees were felled, three times in one day bringing down the electric wires, and troops were quartered in his observatory. Within twenty-four hours a remote and peaceful residence was converted into an important military objective. (Selby [1956] 1971, 11)

Selby's anti-aircraft battery had its first experience of the war on 4 January when Japanese aircraft made a high-level bombing run over the Rabaul airfield. Fifteen New Guineans were killed at the nearby Rapindik Labour Compound. More aerial attacks followed. Tavurvur was active again on 9 January; on 19 January, it began another eruptive period. A major

Japanese invasion force sailed into St Georges Channel on 22 January, and that night—while Tavurvur was in eruption, lighting up the cloud with its glow—Japanese troops were loaded into landing barges and sent into Blanche Bay for a pre-dawn attack on 23 January. Selby ([1956] 1971) was obliged to destroy his anti-aircraft guns on Observatory Ridge in advance of the invasion. He recalled:

> On the night before the invasion the volcano was extremely active with continual flashes and rumbles of explosions. Many of the [Australian] troops were convinced that the invasion fleet, which had been sighted the previous afternoon, had been engaged by an American Fleet and that they were hearing the sounds of a naval battle. (Selby 1981, 2)

However:

> Tomorrow those dim grey ships on the horizon would disgorge their troops by the thousand, the distant warships would blast our positions on the beaches, the aircraft carrier would launch forty or fifty planes to bomb and machine-gun us from the air. (Selby [1956] 1971, 35)

In a tragic case of troops and civilians being sacrificed and abandoned by their military masters for no good reason, the Australian force at Rabaul was routed before 23 January was over. Soldiers and civilians were killed, captured or else escaped into New Britain where many subsequently perished. Others travelled along the northern and southern coasts of New Britain and managed to be rescued or escape back to Australian-held territory and eventually to Australia. Australian soldiers escaping down the eastern side of the Gazelle Peninsula were intercepted by the Japanese at Tol on Wide Bay and approximately 150 of them were slaughtered on about 4 February in what became known, historically and infamously, as the 'Tol Massacre' (Stone 1995).

Norm Fisher, volcanologist, but also a corporal in the New Guinea Volunteer Rifles (NGVR), saw the Japanese landings between Vulcan and Malaguna on 23 January: 'Despite the size of the Australian forces, the Japanese took few early precautions and were laughing, smoking and flashing torches in the darkness of the harbour foreshore' (Stone 1995, 67). This area was later 'subjected to intensive dive bombing. Our mortar received a direct hit and was put out of action' (Downs 1999, 64). Fisher's NGVR party under Lieutenant J.C. Archer retreated to Toma where 'advice was received from commanding officers that further resistance was considered useless'.

Fisher, with others, including assistant volcanologist Clem Knight, retreated from Rabaul rather than surrender to the Japanese. They trudged resolutely southwards along tracks across the central, mountainous part of the Gazelle Peninsula, through Lamingi where there was a mission, avoiding the east coast, but soon reaching Wide Bay—fortunately before the Tol Massacre had taken place. The group there met up with other escapees including Leo McMahon and Bill MacGowan, whose escape stories were later recorded in some detail (Stone 1995; Downs 1999). A small boat was acquired from Kalai Mission on Wide Bay that allowed them to move westwards along the south coast of New Britain, avoiding prowling Japanese ships, to Palmalmal at Jacquinot Bay where they secured another, larger boat. The group of nine, including Fisher and Knight, reached Lindenhafen Plantation, just east of Japanese-held Gasmata, and, after acquiring additional food supplies and gasoline, they escaped at night on 13 February to the relative safety of the Trobriand Islands, then Samarai, then by a Catalina aircraft to Australian-held Port Moresby. Fisher and Knight resumed their careers as civilian geologists on their return to Australia (Wilkinson 1996).

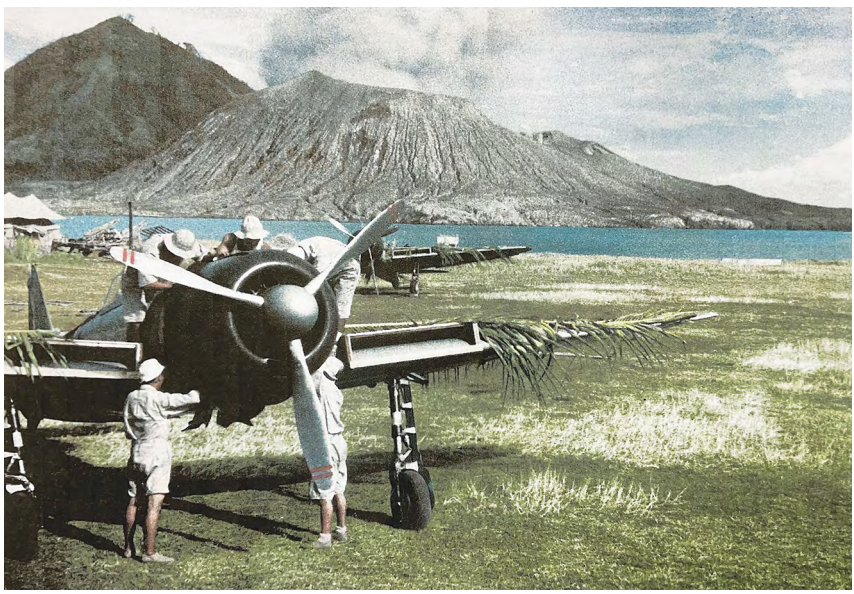

Figure 5.10. Tavurvur in eruption during Japanese occupation.

The volcanic plume being emitted from Tavurvur appears to contain some ash in this colour-enhanced photograph probably taken in early 1942 during the north-west season. Lakunai Airfield and a Japanese aircraft being serviced are seen in the foreground. Photograph supplied courtesy of Dr Yuichi Nishimura.

The Japanese invaders now had to reorganise operations in the Rabaul area to establish the expansive Simpson Harbour as a major centre of mainly naval operations aimed at further military advances southwards against the Australians (*Maru Special* 1984; Figure 5.10). Many prisoners of war (POWs) by now had been incarcerated in Rabaul and they were dealt with by embarkations onto ships for transport to, and eventual imprisonment in, Japan. The *Montevideo Maru* was one of these vessels. Loaded with human cargo at the end of June, it was tragically torpedoed off the Philippines on 1 July 1942 by the US submarine *Sturgeon*. All 1,053 prisoners on board perished (PNGAA 2017; Spurling 2017). Only a few POWs remained in Rabaul for the duration of the war, but they included Gordon Thomas, former editor of the *Rabaul Times* (Thomas 2012). Those who perished on the *Montevideo Maru* included eight of 15 official and non-official members of the Mandated Territory's Legislative Council (Nelson 1995) as well as missionaries such as reverends Laurie Linggood, Howard Pearson and Jack Trevitt (Figure 3.14), and laymen Ron Wayne and Wilfred Pearce (Threlfall 1975), who were mentioned earlier in connection with the 1937 eruption and its aftermath.

The Japanese invaders had inherited from the Australians the problem of how to deal with the volcanoes, especially Tavurvur, which had greeted them in such dramatic fashion. Their commanders were concerned about the effects of the volcanic activity, and especially Tavurvur's ash falls, on the movement of naval vessels and aircraft in and out of Simpson Harbour, and the services of a seismologist were requested from Japan. Takashi Kizawa of the Central Meteorological Observatory in Japan arrived at Rabaul in May 1942 and took charge of a seismological group that monitored the volcanoes for the duration of the Japanese occupation (Kizawa 1961; Kusaka 1976; Nitta 1980; R.W.J. Collection 1 containing correspondence with Takashi Kizawa in 1961–99). Kizawa had not volunteered for the position of Rabaul seismologist; he came as a civilian. A seismological and volcanological observatory was soon built for him by the Japanese Army on the northern edge of Sulphur Creek (Figures 5.11–5.13). The observatory looked across the nearby Lakunai Airfield that was used by Japanese aircraft, towards Tavurvur about 3 kilometres away to the south-east (Figure 5.14). The observatory was equipped with two seismographs—a German-made Weichart and a Japanese Omori—as well as a tromometer for measuring slight shocks. The instruments were housed in an underground shelter (Figure 5.12).

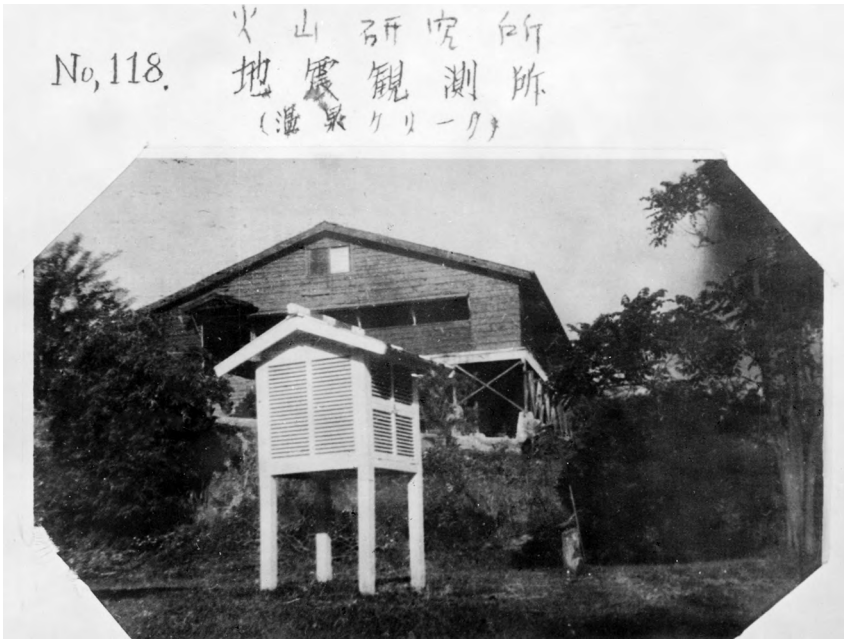

Figure 5.11. Japanese volcanological observatory at Sulphur Creek.

The eastern side of the Japanese seismological/volcanological observatory at Sulphur Creek is seen in this photograph supplied by Takashi Kizawa. Meteorological equipment was housed in the white hutch in front of the main office. GA negative reference GA9988-5.

Takashi Kizawa saw no volcanic activity from Tavurvur during the first 18 months after his arrival. Soldiers told him that the volcano had been active after the invasion, but the date of the last eruption of the 1941–42 period remains unknown. Kizawa recalled soldiers shovelling Tavurvur ash off a tennis court in Rabaul and heaping it into piles. This ash may have fallen at the beginning of the south-east season just before Kizawa arrived in Rabaul, or else was the remains of Tavurvur fallout from the previous season—that is, well before the Japanese invasion. Norm Fisher wrote later that he thought 'the main eruption probably came to an end about March, although there are reports of some small later outbursts of activity' (Fisher 1976b, 209).

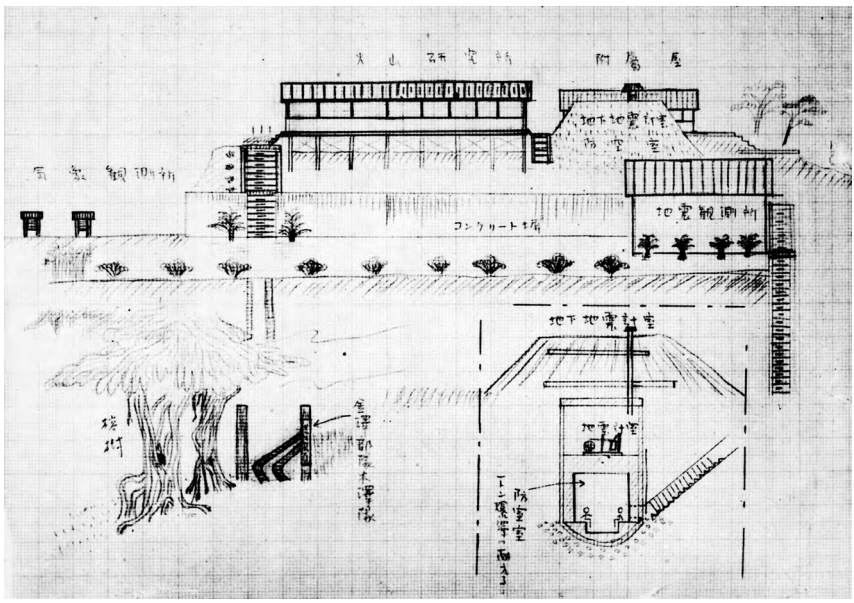

Figure 5.12. Two-part sketch of buildings and bunker at the Japanese observatory.

This sketch of the Sulphur Creek observatory has two parts. The main illustration is of the northern side of the seismological/volcanological observatory, including its entrance in the lower left-hand corner. The inset in the lower right-hand corner is of the air-raid bunker built beneath the room for housing seismological instruments. GA negative reference GA9988-8.

Kizawa made a trip home to Tokyo in the Japanese summer of 1943 for discussions at the Central Meteorological Observatory. Life in Tokyo seemed to be peaceful enough, but Kizawa was troubled by doubts that Japan would eventually win the war. The Allies, led by US General Douglas MacArthur, had been victorious in battles in New Guinea on land and sea, sending Japanese forces into retreat. Kizawa set out his feelings in an emotional article later published under the title 'Death Line' (Kizawa c. 1943). He was concerned in the first place about the prospects of making successful earthquake and eruption predictions in Rabaul, given the extreme conditions of active wartime bombing by the Allies. Another source of anxiety was the task of making choices while in Tokyo about who among his colleagues should return with him to Rabaul. Kizawa made special efforts in Rabaul to have a combined double-basement air-raid/sleeping quarters constructed that was capable of withstanding a direct hit from any large bomb (Kizawa c. 1943; Figure 5.12).

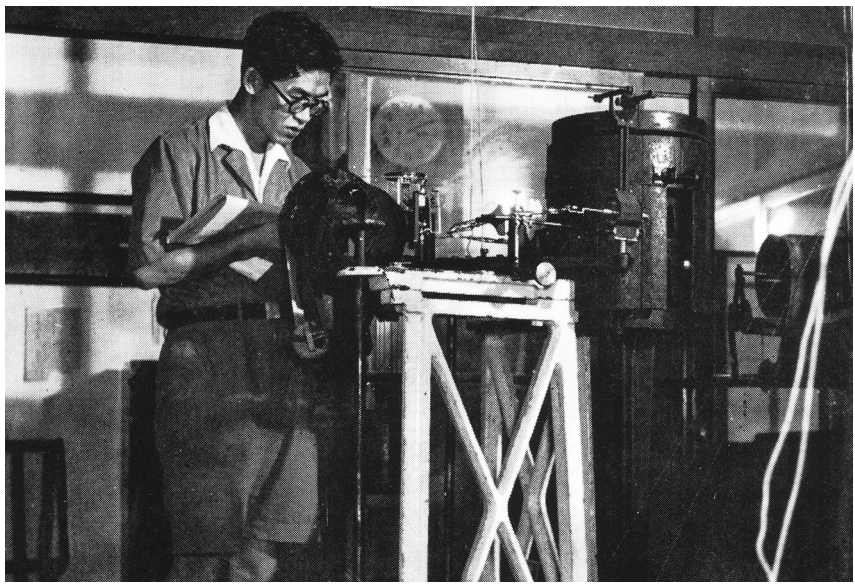

Figure 5.13. Seismograph being used at Sulphur Creek observatory.

Takashi Kizawa is seen here working on seismographic equipment at the Sulphur Creek observatory probably sometime in 1943 (Kusaka 1976; one of several unnumbered photographs between pp. 160 and 161). Digital copy kindly provided by Dr Yuichi Nishimura, Hokkaido University.

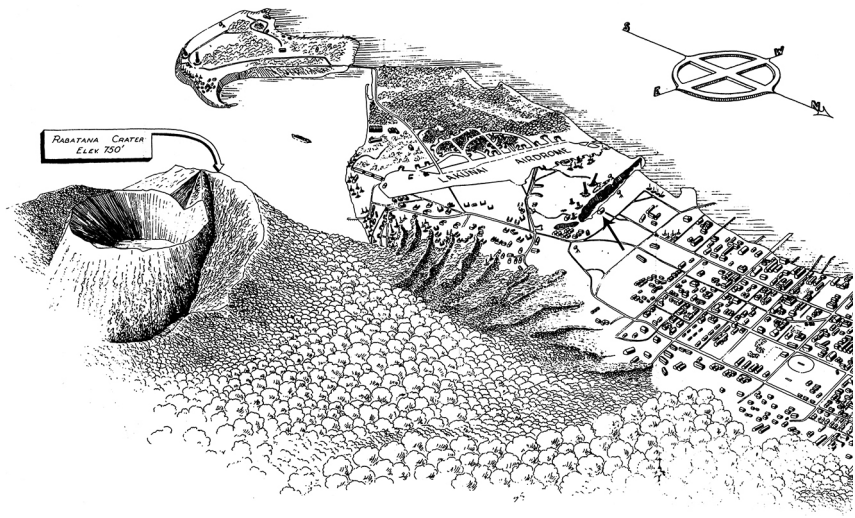

Figure 5.14. Oblique aerial drawing of eastern side of Simpson Harbour.

This is the south-western part of a US military drawing entitled ‘Rabaul Harbor looking south-west 18 Nov ‘43’ (CIU, Directorate of Intelligence, Allied Airforces, SWPA, Litho no. 978). The observatory on Sulphur Creek is shown by the arrow. This detailed drawing was evidently crafted from oblique aerial photographs taken after Allied bombing

runs on Japanese-held Simpson Harbour on 7 and 11 November 1943 (McAulay 1986). Japanese deployments, including the positions of anti-aircraft guns, are shown in detail around Lakunai Airfield and the geothermally active Sulphur Creek down to the right (north). The southern end of Rabaul town is further to the right. Matupit Island is in the upper-left quadrant and a single ship occupies Greet Harbour to the east of the island. 'Rabatana Crater' is actually Palangiangia volcano in the middle of which is the younger and still thermally active volcano Rabalanakaia. Tavurvur volcano is not shown as it is left of the south-western limit of the diagram.

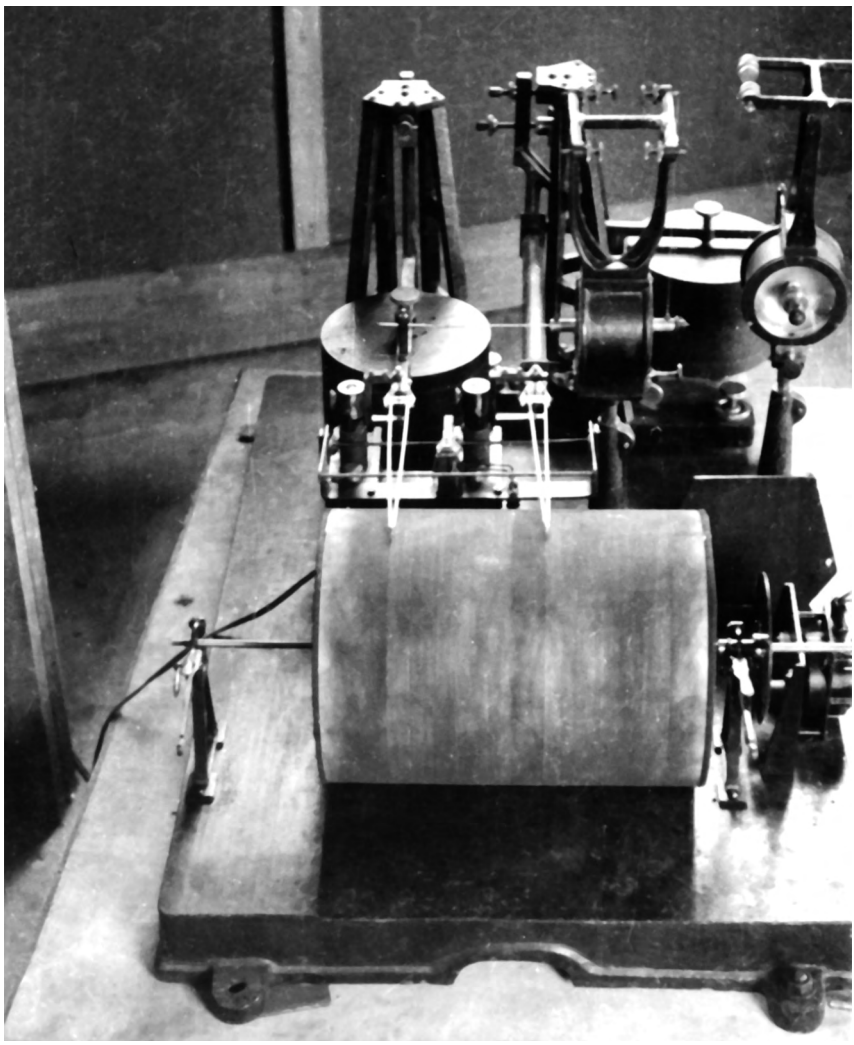

Figure 5.15. Japanese seismograph reinstalled at Rapindik after WWII.

This is the Omori seismograph used by Dr Kizawa at the Sulphur Creek observatory. The instrument was found after the war and is here shown in its reconditioned state and in use at Rapindik, Rabaul, in the early 1950s. The photograph was supplied by Australian volcanologist M.A. Reynolds, who worked at the RVO at that time (Reynolds 2005, 6).

Instrumental records of earthquakes were obtained by Kizawa after the observatory was established at Sulphur Creek, but he was to have increasing problems with the recording because of the Allied bombing raids on Rabaul. These became more and more intense towards the end of 1943 and into 1944. Nevertheless, Kizawa collected some apparently significant data starting on 11 October 1943 when tremors gradually increased, culminating on 16 October when a felt earthquake took place at 9.30 am directly beneath Rabaul (Kizawa 1951). This was followed by earthquake aftershocks. Kizawa had previously adapted his Omori seismograph (Figure 5.15) as a tiltmeter by slowing the rotation speed of the recording drum. Therefore, he had been able to record, earlier on 16 October, first a rising of the ground in the direction of Tavurvur and then, later in the day, after the 9.30 am earthquake, a down-tilt, as measured at the observatory. No eruption took place immediately—at least not until 24 November when Tavurvur started belching out dark ash at the beginning of about one month of activity (Kizawa 1951). A final eruption was photographed on 23 December and the image later reproduced in a Japanese publication (Kusaka 1976). This late-1943 activity at Tavurvur was the last of the 1937–43 period of volcanic eruptions at Rabaul.

Life in Rabaul for the Japanese troops became more and more unbearable as the Allies found ascendancy in their war efforts (Figure 5.16). Buildings in the Simpson Harbour area were smashed, and rebuilding them and living above ground became pointless. Japanese defence measures then diverted to construction of a remarkable network of tunnels and caves that eventually housed several tens of thousands of Japanese troops and their facilities and equipment (Figure 5.17). The tunnels were dug into the soft pumice deposits that form a mantle around much of the Blanche Bay caldera, and they later proved to be successful in withstanding many of the numerous bombing attacks by the Allies. One set of tunnels directly on the St Georges Channel coastline was used by Japanese submarines (Figure 5.18) for supply and delivery and, even today, is known as Submarine Base, or 'Sub-Base'. The Japanese took full advantage of the steep and deep coastal bathymetry, which, decades later, would be recognised as the near-vertical wall of another caldera named Tavui.

Figure 5.16. Aerial photograph of bombing of Sulphur Creek area.

Allied bombing of Japanese-held Rabaul, such as this on 2 November 1943, eventually caused the destruction of the town. Part of the Japanese Navy fleet can be seen in the upper-left corner. Tovanumbatir and the caldera wall dominate the background. Sulphur Creek is seen in the foreground, and the buildings of Dr Kizawa's volcanological observatory can be made out at the top of the far bank of the creek on the right. Phosphorescent bombs have exploded over the defence positions on the near side of the creek. Published courtesy of the Australian War Memorial, Canberra. AWM 100146.

The seismological/volcanological observatory at Sulphur Creek was hit several times and the damage repaired, but by late 1944 attempts to re-establish the buildings were abandoned and Dr Kizawa was obliged to retreat into caves dug into the caldera wall beneath Tovanumbatir. Kizawa established another observatory near Vunakanau and Latlat village, overlooking Vulcan, in December 1944 – January 1945 (Figure 5.19). It was not bombed directly, but the quality of scientific data obtained there was necessarily of a low standard because of poor instrumentation, and, in any case, no more volcanic activity took place, at either Tavurvur or Vulcan.

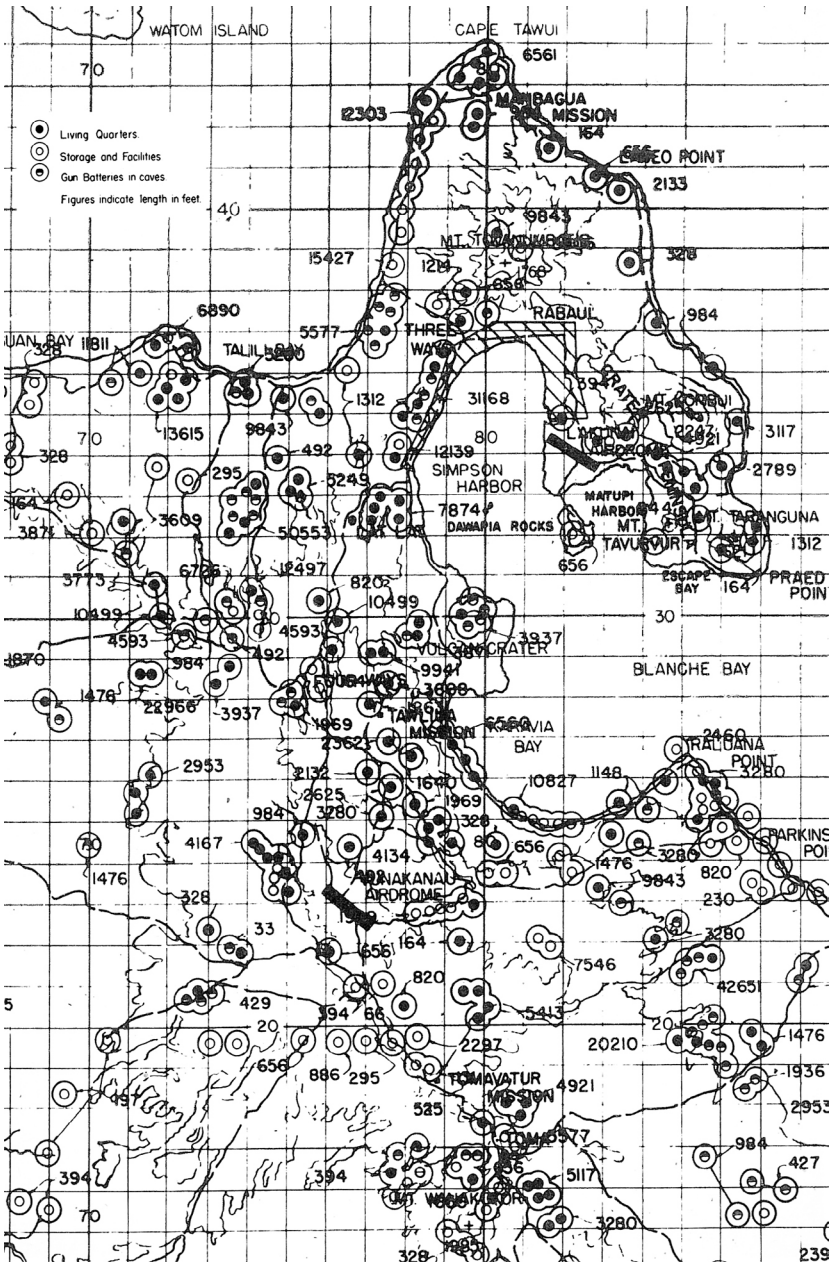

Figure 5.17. Map of Japanese caves and tunnels dug into pumice deposits.

This detail and legend are from a map of Japanese cave and tunnel distribution in the Blanche Bay area (United States Strategic Bombing Survey [Pacific] 1946, Map 19, p. 140). Note that most of the caves have been constructed well away from the seriously targeted bombed site of the former Rabaul town and Lakunai Airfield. Thick pumice deposits are well developed in these areas.

Figure 5.18. Sketch of Kabiu–Tavurvur area plus submarine.

A Japanese submarine and Tavurvur in mild eruption feature in this sketch, looking north-eastwards. Kabiu (the Mother) volcano is in the background. The sketch is part of an advertisement in a Japanese postwar magazine (*Maru Special* 1984).

An unusual story circulated after the war that Allied aircraft attacking Rabaul had dropped bombs into the craters of Tavurvur volcano to trigger an eruption that, hopefully, would be sufficiently large to dislodge the Japanese from their military base. So unusual was the story that many people believed it was probably untrue—a rumour, a myth, a good yarn. But the volcano bombing did take place. Takashi Kizawa told one of us (R.W.J.) of seeing bombers avoiding other targets and circling towards Tavurvur where they released bombs into the craters. The bombing had no effect, and Japanese soldiers considered the event to be a great joke. Kizawa, however, took a different view: that the enemy was inventive and determined enough at least to attempt a new technique. It helped him confirm his view that Japan would lose the war. Norm Fisher also told R.W.J. that he was consulted officially by the Royal Australian Air Force during the war about the use of bombing in triggering an eruption at Rabaul. He dismissed the suggestion outright, but after the war was amused to discover bomb craters within the volcanic craters of Tavurvur.

The thousands of Japanese soldiers in Rabaul were trapped militarily and were almost entirely cut off from military authorities in Japan, as were other Japanese soldiers on islands elsewhere in the Western Pacific (Hiromi 2004). Many of them had agricultural and farming skills that were put to good

use in growing crops, thus adding to the evidence of self-sufficiency of the troops now living mainly in tunnels and caves. They were not troubled by any volcanic eruptions; indeed, the whole period of Japanese occupation does not appear to have been affected significantly by volcanic eruptions, most of which (from Tavurvur) seem to have taken place during north-west seasons when winds blow away from the harbour and town towards the south-east.

The Pacific War ended in August 1945 immediately following the American atomic bombing of Hiroshima and Nagasaki and the formal surrender of Japan on 15 August. Japanese forces in New Guinea surrendered formally after a ceremony on board the British aircraft carrier HMS *Glory* in St Georges Channel on 6 September 1945 (Special Correspondent 1945; Nelson 1995; Hiromi 2004). The arriving flotilla of Allied ships, including the *Glory*, had felt 'violent shudders' that morning—an earthquake had taken place 'as if to mark this important and historical day' (Threlfall 2012, 354). The Australian destroyer HMAS *Vendetta* entered Simpson Harbour that same afternoon, followed on 10 September by escort ships and transports carrying the Australian occupying force. A correspondent on board HMAS *Manoora* described the scene on 10 September:

> The peaks of the Mother and Daughter were veiled with fleecy clouds, and at the base of each could be seen some of the extensive gardens laid out by the Japanese. The scenic beauty of Simpson Harbour unfolded as we made our way slowly to our anchorage. Matupi [Tavurvur] had been active, and wisps of steam were rising from the crater, vents and fissures as we passed. Vulcan looked quite serene. His slopes now are about three quarters covered with vegetation. (Special Correspondent 1945, 59)

Virtually all that had been Rabaul itself was in ruins (Figure 5.20). The skeleton outline of streets, lines of trees and foundations remained, but the months of bombing had been so intense that hardly a wall was left standing. Destruction of the town by war had far exceeded the minimal damage inflicted by the 1937–43 volcanic eruptions:

> The town of Rabaul as the old residents knew it has been completely wiped out. There remains the front wall of Burns Philp's store, battered by shell fire and bomb blast, and the concrete entrance to what appeared to be the Rabaul Club. Concrete foundation posts were a mute reminder of the homes that once stood there, together with broken windmills and water tanks … The whole shore line of

> Simpson Harbour is littered with bombed, gutted and burnt out ships, some half on the beach, others submerged, with only their masts and the tops of funnels showing here and there. A very effective job had been done by our Air Force. (Special Correspondent 1945, 60; Figure 5.20)

Japanese still in Rabaul, including Kizawa, now became POWs of the incoming Australian forces until their repatriation back to Japan in 1946 (Figure 5.21). Kizawa closed, then boarded up, the observatory at Vulcan and left the following message on the entrance: 'For the coming generation these machines have wrought each function to the civilised world and progress of the scientific world during the War' (Kizawa 1961, 2; Figure 5.19). After his repatriation to Japan, Kizawa continued a lifelong career in seismology and volcanology—and an interest in Rabaul (R.W.J. Collection 1).

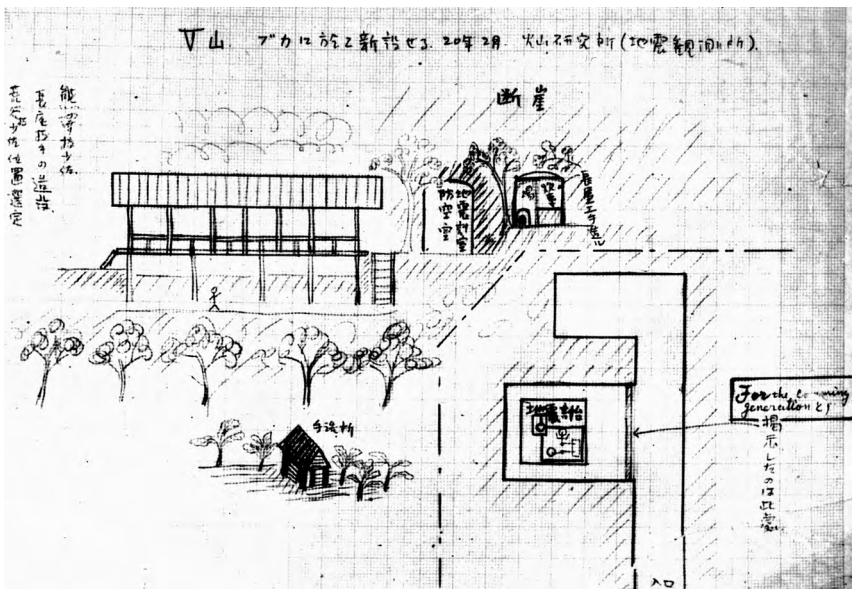

Figure 5.19. Two-part sketch of second Japanese observatory.

This sketch is of the second observatory used by Dr Kizawa in Blanche Bay. He provided the following description: 'This was built in February 1945. Therefore became the last seismograph room. We dug a cave in a cliff at the back of the somma on the west side of Vulcan and set the seismogram. It was in a violent air raid.' The words in the box on the right-hand side of this sketch read: 'For the coming generation these machines have wrought each function to the civilised world and progress of the scientific world during the War.' GA negative reference GA9988-10.

Figure 5.20. Remains of Rabaul town at the end of WWII.

The skeleton of streets in what had been Rabaul is laid out in this photograph taken on 15 September 1945, westwards from Namanula Hill. Published courtesy of the Australian War Memorial, Canberra. AWM 96796.

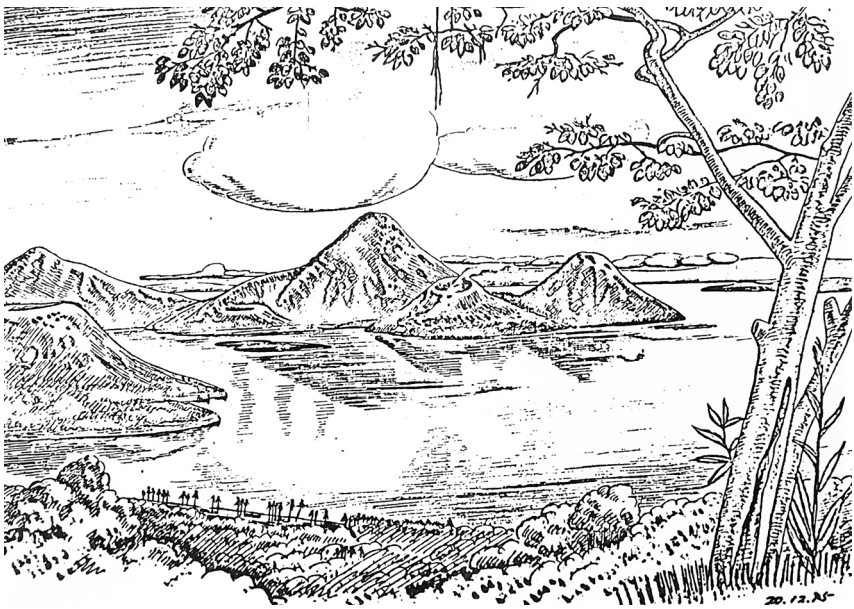

Figure 5.21. Japanese sketch of the volcanoes of Blanche Bay.

A peaceful Blanche Bay is seen in this Japanese drawing, dated 20 December 1945, of the view looking north-eastwards across Karavia Bay from the western caldera rim. A vapour plume drifts off to the south-east from Tavurvur volcano, and part of Vulcan cone is seen on the left-hand margin. The artist was Mr Akira Shigeta, a member of the AA60 Second Company's camp. English translation of the caption is courtesy of Dr Yuichi Nishimura. A copy of the sketch is held in the Lex McAulay Private Records collection at the Australian War Memorial, Canberra.

5.4. Reconsidering the Wartime Eruptions

Some special consideration is required at this stage—before dealing with the postwar period in Chapter 6 of this book—with regard to the Tavurvur eruptions of 1941–43. Perhaps the most notable feature is that Vulcan was not in eruption at the same time as Tavurvur, although it had been in both 1878 and 1937. There was, in other words, no 'twin' or double eruption in 1941–43. Vulcan had cooled to some sort of ambient temperature soon after its relatively short, but powerful sub-plinian eruption at the end of May 1937, and it was covered in trees and grasses by the end of the war (Kizawa 1951). In contrast, Tavurvur had retained its geothermal activity after May 1937, producing some minor hydrothermal outbreaks in March 1940. Temperatures measured by Fisher in the crater of Tavurvur started to climb later the same year. This conclusion will have some merit in considering below how the volcanic system in Blanche Bay actually operates or 'works'.

Another observation is that the Tavurvur eruptions of June 1941 took place four years after those of 1937. This is a significantly long gap—bearing in mind that the definition of a single 'eruption' used in the definitive global database of volcanoes and eruptions is that any eruption preceded by a three-month or greater gap from the previous eruption at the same volcano should be regarded as a *separate* eruption (Siebert, Simkin and Kimberly 2010). However, there are much longer gaps than three months between some of the eruptions at Tavurvur in 1941–43. The three-month definition used in the global database is a convenient one for compiling information in systematic encyclopaedic listings, but it does not correspond with the conclusion, developed in the following pages, that the time range 1937–43 represents a *single* eruptive period.

The 1941–43 eruptions at Tavurvur are not the first occasion for which the term 'vulcanian' can be used for historical eruptions in Blanche Bay. The vivid description given by Wilfred Powell of Tavurvur activity in 1878, for example, corresponds well with vulcanian activity, and the sketch of the eruption cloud in Figure 1.5 may correspond to vulcanian activity in 1791. Similarly, photographs taken of the later stages of the Vulcan eruptions in 1937 are best interpreted as showing vulcanian activity (Figure 3.36), even though these smaller eruptions had been preceded by 'sub-plinian' activity at Vulcan.

Perhaps of even greater interest is the short duration of the Tavurvur eruption in 1937—less than a day—and the question of whether any true vulcanian activity took place then at all. The hydrothermal eruptions that produced the fallout of blue-grey gummy mud on Rabaul town on Sunday 30 May may not have continued into the night, judging by the descriptions left by observers on the *Montoro* on the Sunday evening, including Brett Hilder (Figure 3.27) and George Clarke from Kokopo. Further, Doug Joycey said that the initial eruption of mud lasted only about half an hour, and Dr Cooper had a photograph of Tavurvur in which the eruption appears to be of a more normal vulcanian type (Figure 3.25). Perhaps speculatively much of the fallout that Sunday night into the Monday morning was vulcanian in character, or else was a mixture of fresh magma and mud. If so, the vulcanian phase of the eruption was shorter than in 1941–43 and presumably than in 1878. The implication is that eruptions at Tavurvur in 1937 cut out early but that the volcanic system retained eruption potential that was realised as the vulcanian eruptions of June 1941.

Seismologists working on the subject of forecasting volcanic eruptions have a particular interest in recording any earthquakes that may precede an outbreak and, therefore, that may be related in some way to 'causing' the eruptions. Fisher, Stehn, Woolnough and Kizawa all had such an interest, but they were restricted in their work by the instrumentation available to them in Rabaul and in the Territory of New Guinea as a whole. Regional and local networks of several or, ideally, many seismographs are needed to determine the epicentres and depths of earthquakes and so identify whether they are nearby and 'local' or further away and 'regional'. Fisher (1939a) drew attention to severe earthquakes felt in Rabaul in 1910 and 1916 (and noted by Stanley [1923]) in the context of the 1937 volcanic eruption, and Kizawa (1951) drew attention to a preceding event in 1906. The large earthquake of 14 January 1941 is also of interest in the context of the June 1941 eruption, but Fisher (1944, 11; 1976b) emphasised that temperatures at Tavurvur had begun rising *before* the 14 January event and so concluded that the two events were only 'in a general way related'. Similar seismic/volcanic relationships would be studied internationally in the years ahead as more earthquake stations were installed globally and in specific volcanic areas such as Rabaul. Interpreting the significance of those relationships, however, remains challenging.

This text is taken from *Return to Volcano Town: Reassessing the 1937–1943 Volcanic Eruptions at Rabaul*, by R. Wally Johnson and Neville A. Threlfall, published 2023 by ANU Press, The Australian National University, Canberra, Australia.

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