THE PROBLEM OF "THOMPSON ISLAND": VOLCANIC ERUPTIONS AND METEOROLOGICAL EVIDENCE

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THE reasonableness of Dr. P. E. Baker's (1967, p. 73) suggestion that "Thompson Island" (*c.* lat. 54°S., long. 5°E.) may have been destroyed by an undetected volcanic eruption between 1893 and 1898 can be seen against evidence in my possession, which adds background but falls short of conclusive proof that this is what happened.

A recently completed world survey of known eruptions since A.D. 1500 (Lamb, unpublished), including about 50 that produced widely observed dust veils which appear to have affected the strength of the direct radiation reaching the Earth from the Sun, indicates that dust injected into the atmosphere by eruptions in middle and higher latitudes travels with the meandering course of the westerly winds in the upper troposphere and lower stratosphere, but it is never seen nearer the Equator than the latitudes swept by the troughs in the westerlies. This statement of course rests upon Northern Hemisphere evidence. The volcanic dust observations support the indications of other tracer substances in the atmosphere that, superimposed on the main more or less zonal wind streams, there is a slow net poleward drift of the air in the lower stratosphere. Since the amplitude (latitude range) of the troughs and ridges in the upper westerlies over the middle latitudes of the Southern Hemisphere is generally less than over the Northern Hemisphere, it is likely that volcanic eruptions at lat. 50–55°S. almost never produce dust veils that are seen north of lat. 35–40°S. and, because of bad weather and cloudy skies in the upper cold troughs, probably only briefly and occasionally as far north as that. In the 1890's there were few people living in latitudes where a dust veil from "Thompson Island" could have been observed.

It is not surprising therefore that there is no known report of volcanic dust skies in the years concerned which could be connected with "Thompson Island".

It is a curious coincidence, however, that prevailing air temperatures at the southernmost observing stations, in Chile and New Zealand, dipped abnormally low for a long time between about 1896 and 1907. Though the effect does not appear north of lat. 45°S., average temperatures for the year (1896 to 1898) at Dunedin (lat. 45·9°S., long. 170·5°E.) and Punta Arenas (lat. 53·2°S., long. 70·9°W.) were about 0·5° C below those prevailing between 1890 and 1895, and between then and 1907 both places had four or five of the coldest years in their entire record (since 1864 and 1888, respectively). There was a run of extraordinarily cold winters at Punta Arenas unparalleled in the record before or since. July 1900, the coldest month there, returned a monthly mean temperature of −2·0° C, a value only reached in England in the severest continental-type winters and surely only possible in Chile in the presence of extensive sea ice lying abnormally near. This suggestion is consistent with the exceptionally low latitude of the main depression tracks in July 1900, i.e. with lowest monthly mean pressure crossing Chile at lat. 48°S. Moreover, a few accounts have been reported of ships just at the turn of the century finding only 100 miles (160 km.) of sailing room between Cape Horn and the ice.

The impact of the phenomenon on 10-yr. mean July temperatures at Punta Arenas is seen in Fig. 1, which also indicates that Hobart, Tasmania, at lat. 43°S. was not affected.

Temperatures over most of the world appear to follow a similar course to this after great volcanic eruptions in low latitudes, which spread their dust veils over the whole world. The dust normally takes 1 to 4 months to spread into a more or less uniform veil over the latitude zone into which it was injected, and 6 to 12 months to reach its greatest extent over the Earth. Though the average temperature over the Earth probably never shows a significant deficit for more than 5 to 7 (and more characteristically 3 to 4) yr. after a great dust-producing eruption, there is evidence that the effect lasts longer over the higher latitudes. This is probably partly attributable to poleward drift of the stratospheric dust and partly to the production of more floating ice on the polar seas, which may survive one or more summers after the dust has gone.

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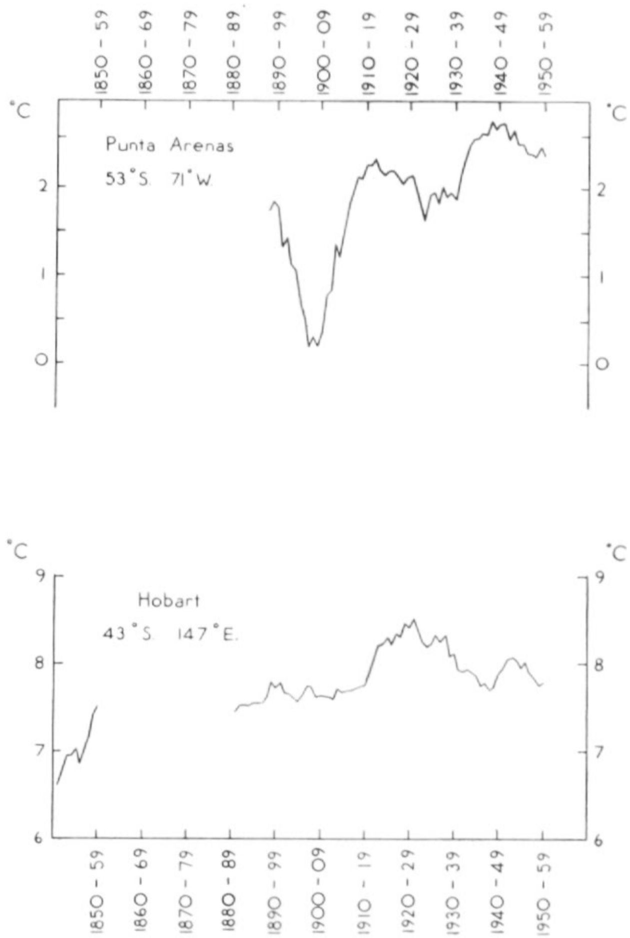

Fig. 1. 10-yr. mean July temperatures for Punta Arenas, southern Chile (lat. 53°S., long. 71°W.), and Hobart, Tasmania (lat. 43°S., long. 147°E.) for the period 1840–1959.

After the great explosion of Coseguina (approx. lat. 13°N., long. 87·5°W.) in 1835 average temperatures dipped by over 0·5° C over the tropical zone and took 6–7 yr. to recover their former level; over the Northern Hemisphere temperate zone the average temperature appears to have dropped 1° C and taken 10 yr. to recover. After the eruption of Katmai in Alaska (lat. 58°N., long. 155°W.) in 1912 no temperature change was noted south of lat. 50°N., though average temperatures were 0·5° C lower for a few years afterwards between lat. 50° and 70°N. and there was a drop of 0·9° C over the polar region, which produced a notable increase of the Arctic sea ice that affected the amount of ice near Iceland until 1918–19.

The dip of the prevailing temperatures observed south of lat. 45°S. between 1896 and 1907 slightly exceeded that observed in similar northern latitudes after the 1912 Katmai eruption, but it was of the same order of magnitude, was similar also in not affecting lower latitudes, but apparently lasted twice as long as in the Katmai case. The temperature dip at Dunedin (1896–1906) also exceeded any effect noticeable there after the famous eruption of Krakatao (lat. 8°S., long. 105·5°E. approx.) in 1883.

For the purposes of meteorological research, which is concerned with the effects of volcanic dust on radiation intake and the energy of the atmospheric circulation, I have devised formulae for assessing volcanic dust veils in terms of the magnitude of the greatest observed deficits of monthly values of direct radiation ($R_{D\ max.}$) reaching the Earth's surface from the Sun, and of prevailing temperatures ($T_{D\ max.}$) at the Earth's surface, as well as in terms of the estimated volume of solid matter blown up into the atmosphere or found in measured dust deposits (q), together with the latitude of origin of the dust and the duration in months ($t_{mo.}$) of the observable dust veil over middle latitudes. The latitude of origin effectively determines $E_{max.}$, the greatest extent of the veil (as a fraction of the Earth's total surface area).

The dust-veil index (*DVI*) values derived by the different formulae, using the alternative types of data mentioned, generally agree within a factor of 1·5, occasionally 2. Values for the eruptions here mentioned were as follows:

Eruption and year	*DVI*	*DVI without account of how much of the world was covered by the veil*
Coseguina (lat. 13°N); 1835	4,000	4,000
Krakatao (lat. 8°S.); 1883	1,000	1,000
Katmai (lat. 58°N.); 1912	150	500

We may attempt similar assessment of the supposed "Thompson Island" eruption in 1895 or 1896 using (a) the temperature deficit about lat. 50°S., and (b) an estimate of the quantity of matter dispersed. The relevant formulae are

$$(DVI) = 52{\cdot}5 \times T_{D\ max.} \times t_{mo.} \times E_{max.}, \qquad (1)$$
$$(DVI) = 4{\cdot}4 \times q \times t_{mo.} \times E_{max.} \qquad (2)$$

In formula (2) q is measured in km.^{3}.

If we estimate $T_{D\ max.}$ for middle latitudes of the Southern Hemisphere (lat. 30–60°S.) as 0·2° C, to represent an average covering the higher latitudes that were affected and the lower latitudes that were not, and 10 yr. ($t_{mo.}$ = 120 months) for the duration of the effect, formula (1) gives *DVI* = 380. (Without taking account of the small fraction of the world's surface likely to have been covered by the dust veil, the figure would be 1,260.)

We may estimate q from the reported size of the island and of the underwater seamount which also seems to have disappeared. If we take the whole as of approximately conical shape, 1 km. radius at sea-level with its peak perhaps 500 m. above sea-level but extending from a true base about 1·5 km. below sea-level, calculation gives the quantity of material dispersed as about 35 km.^{3}. Comparison with other eruptions suggests that one-tenth to possibly as much as one-fifth of this could have been dispersed as fine dust. Corresponding values of q would be 3·5 to 7·0 km.^{3}, and formula (2) would indicate *DVI* = 550 to 1,100. (Without allowance for the small fraction of the world affected, it would be 1,850 to 3,700.)

The estimates of quantity of solid matter dispersed and of q (the quantity sent up as dust) could be too high if the seamount were of oval section or if the South African Navy soundings (Baker, 1967, p. 73) failed to cover the position of a remaining shoal. On these grounds, the likeliest values of *DVI* to be derived from formula (2) should perhaps be in the range 300 to 600.

The evidence pointing to the destruction of "Thompson Island" in a great volcanic eruption in 1895 or 1896 is thus self-consistent. The temperature and ice anomalies of the following 10 to 12 yr. in the higher southern latitudes were, however, uncommonly prolonged. It may be therefore that, by coincidence, something else besides contributed to these anomalies. Exceptionally large tabular icebergs, calved-off portions of the ice shelves of Antarctica, were sighted in temperate latitudes of the Southern Ocean in 1892–94 and again in 1904–07. The Bellingshausen Sea (west of the Antarctic Peninsula) was reported abnormally clear of floating pack ice in 1893. These observations suggest some catastrophic event, probably in the Pacific sector of the Antarctic coast, involving break-up of an ice shelf and drifting away of the ice masses to chill the ocean surface surrounding Antarctica. Either a surge in the flow of an ice stream within the Antarctic Ice Sheet or activity of the volcanoes near the coast of Antarctica (Fig. 2) in the Pacific sector could have been responsible.

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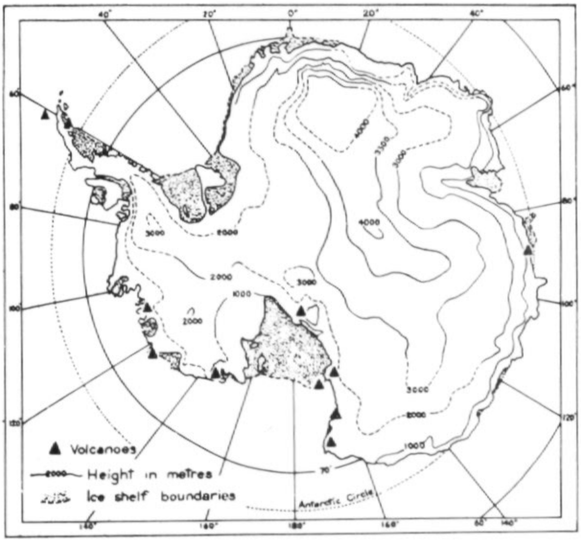

Fig. 2. Distribution of post-Tertiary and active volcanoes in Antarctica.

REFERENCES

BAKER, P. E. 1967. Historical and geological notes on Bouvetøya. *British Antarctic Survey Bulletin*, No. 13, 71–84.

LAMB, H. H. Unpublished. Volcanic dust in the atmosphere: meteorologically significant and other eruptions —an assessment and a chronology from A.D. 1500.