may, as a first approximation, be expressed by the equation

$$P = P_m \left[1 - \left(\frac{r}{r_0}\right)^2\right]$$

where r_0 is the radius of the anvil surface and P_m is the pressure at the center of the cell.

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27 March 1964

Twilight Phenomena Caused by the Eruption of Agung Volcano

Abstract. *Increase in twilight glow and in the dust stripes in the twilight arch have been observed from several places in the northern hemisphere from the fall of 1963 until now. Measurements of the twilight brightness indicate a considerable increase of dustiness in the stratosphere; this turbidity may be due to drifting ashes from the eruption of Agung volcano on Bali.*

Since the early fall of 1963, very intense twilight glows have been observed in the United States (*1, 2*) and in Europe (*3*). Many observers assumed they were caused by ashes ejected into the stratosphere during the eruption of Agung volcano on Bali Island (9°S, 114°E) on 17 March 1963. In the Southern Hemisphere, strong sunset afterglows were noticed soon after the eruption (*4*). A considerable reduction of star and solar radiation by about 0.4 stellar magnitudes at 5000 Å was measured over Australia and South Africa (*4*), and a bright disc of white light was seen around the daytime sun (*5*).

The twilight glow observed in the Northern Hemisphere appears when the sun is depressed about 5 deg below the horizon (about 30 minutes after sunset) as a purple-colored disc, of lateral size about 40 deg, centered above the position of the sun. This disc is much more purple than the normal disc at this time. Shortly afterward, the purple glow contracts toward the horizon, with a relatively sharp upper border parallel to the horizon; the color is deep crimson, like the faint stripes of color that usually appear along the horizon (*6*). Crepuscular rays, caused by distant clouds casting a bluish shadow in the dust layer, increase the spectacular appearance of the twilight glows. The crimson glow fades very low at the horizon at a sun depression of about 9 deg.

Apart from this general change of twilight, fine ripple cloud formations (dust lenses) have been observed occasionally from sunset until the sun is depressed to about 6 deg in the lower part of the twilight arch. The lenses are usually about 0.3 deg by 3 deg wide, and are arranged with some regularity, sometimes slightly inclined to the horizon; they are similar to noctilucent clouds, being of whitish-silvery tone. Such clouds have often been observed after strong volcanic eruptions and are called "ultra cirri." Their first appearance as isolated wisps may have been as early as 25 September 1963 over Colorado (*7*); Mitchell (*2*) observed them on two clear evenings in late October in Washington, D.C. I observed similar phenomena at Weissenau, south of Stuttgart, on the evening of 17 November, the morning and evening of 20 November, and in the evening of 25 November. Since then, I have not seen these wisps, the observations being partly hampered by fog and by considerable haziness near the ground. But the twilight clouds were again observed from Feldberg Observatory, Black Forest, on 8 and 9 December by Schreiber (*3*). During the same periods, color pictures clearly showing the dust stripes were taken in southern England by F. Ludlam.

From the relation between the maximum elevation angle and the solar depression presented in Fig. 1, I estimate that the dust "lenses" were at an altitude of 20 to 25 km. Similar clouds of unknown origin observed occasionally from November 1961 to January

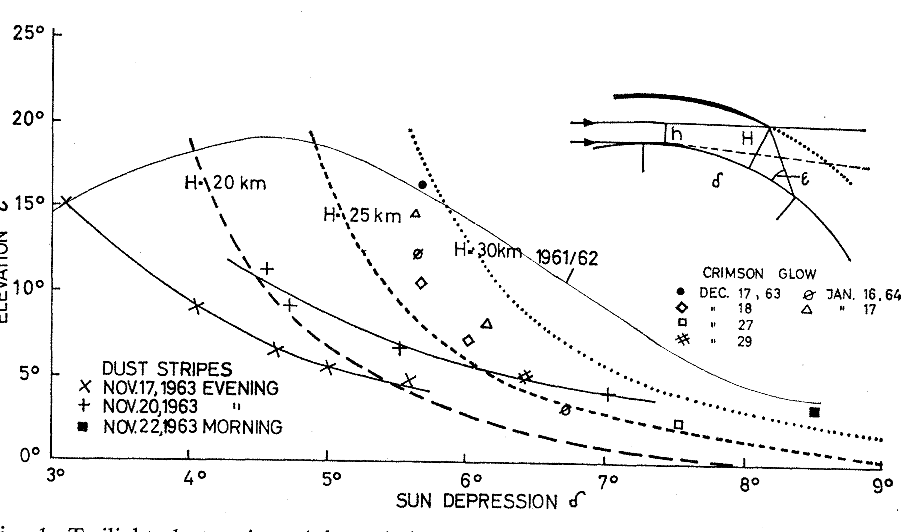

Fig. 1. Twilight dust stripes (ultra cirri) and crimson glow, maximum elevation, ε, versus sun depression, δ. Dust stripes observed in November 1963 at Weissenau and during the winter of 1961–62. Dotted lines: maximum elevation of the visibility of dust clouds at an altitude of 20, 25, and 30 km (*H*) if the minimum height (*h*) for solar illumination is 10 km. According to observers of noctilucent clouds, *h* may be even larger than 10 km for the faint dust stripes but may be smaller for crimson glows as revealed by the appearance of crepuscular rays.

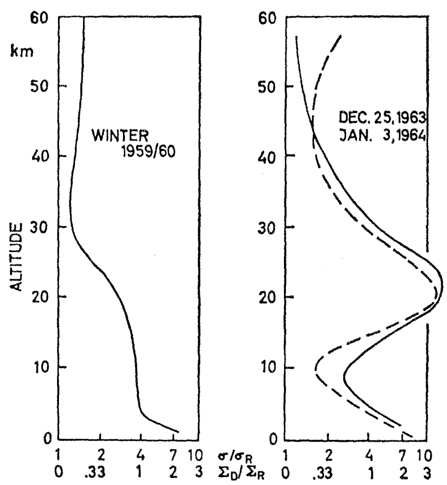

Fig. 2. Turbidity profiles according to twilight measurements at 20° elevation during the winter of 1959–60 (Blue Hill Observatory) and the winter of 1963–64. Abscissa: σ/σ_R, ratio of observed scattering to Rayleigh scattering; Σ_D/Σ_R = ratio of attenuation coefficient by dust and air. Wavelength, 6600 Å.

1962 (*8*) were definitely higher, from 30 to 45 km. The dust layer producing the crimson glow may have extended to about 22 km. Its elevation curve fits rather well to the computed curves.

Fortunately, twilight measurements which were made at Blue Hill Observatory, Harvard University, near Boston, Mass., during the undisturbed period from September 1959 to December 1961 (*9*) could be continued at Weissenau with similar equipment. The twilight course on 9 October 1963 seemed to be as usual; on 12 October the red intensity at 4.5 deg sun depression and 20 deg elevation was already 1.5 times larger than previously and about 2.8 times larger during January 1964. In Fig. 2, turbidity profiles derived from two typical twilight measurements of the end of 1963 are compared with average profiles of the previous normal period and indicate considerable amounts of new dust in the northern stratosphere. However, the turbidity increase was much smaller than over the Southern Hemisphere; measurements of solar radiation at Zugspitz Observatory (2960 m) near Garmisch indicated a dust attenuation by less than 0.02 magnitudes.

There seems to be no doubt that the dust came from the eruption of Agung volcano. In the Northern Hemisphere September and October are the months during which there is a strong exchange of air between low and high latitudes in the stratospheric circulation. At the Krakatoa eruption in 1883, at the same time of year, similar observations of dust were made in the United States and Europe (*10*). The dust stripes may perhaps be explained as undulations of the upper borders of dust-laden, rather laminar, layers, or as undulations of the borders of inversions.

According to observations after earlier volcanic eruptions and to the results of radioactive fallout studies of atomic bomb tests, the present stratospheric dust disturbance may slowly fade in the course of about 2 years.

It is unlikely that the submarine volcano at 63°N, 20°36′W, which has been emitting ash and dust since 14 November up to an altitude of 8 km, produced any of the aforementioned phenomena. However, specks in the twilight arch, and areas of slightly different brightness of about 7 deg extension, were noticed at Weissenau on some evenings around 20 November for about 20 minutes after sunset. The specks may well be attributed to diffuse dust clouds produced by this volcano within the upper troposphere.

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20 February 1964

Homocitrulline and Homoarginine Synthesis from Lysine

Abstract. *After the injection of* L-*lysine and uniformly labeled* L-*lysine-carbon-14 into the rat, labeled homocitrulline and homoarginine are found in the liver and kidney. The ingestion of lysine by seven normal adults results in an increased urinary excretion of homocitrulline and homoarginine. These data suggest the occurrence of an unreported metabolic pathway for lysine in the rat and man.*

A quantitative study of the free amino acids of tumor tissues revealed the presence of the amino acid homocitrulline in human tumors and in the C_3HBA mammary adenocarcinoma (*1*). This amino acid had not previously been described in normal or malignant tissues.

Gerritsen *et al.* have reported homocitrulline in the urine of infants and young children but not in adults (*2*). Studies have provided evidence that the homocitrulline was of dietary origin (*3*). The imide of homocitrulline, homoarginine, was not found in any of the urine samples examined (*4*).

Stevens and Bush (*5*) observed a limited growth response in lysine-deficient rats fed homoarginine, indicating conversion of homoarginine to lysine. Our study was initiated to determine if lysine is the metabolic precursor of homocitrulline and homoarginine.

Homoarginine was determined chromatographically by using the 50-cm column and the buffer (*p*H 5.28, 0.7*N*) described by Kominz (*6*). After arginine is eluted, the addition of 69 ml of buffer results in the elution of homoarginine. The identity of the homoarginine was established by the addition of L-homoarginine, guanido-C^{14} (0.005 μc), to the unknown samples. The eluent from the column was pumped through a 2.0-ml flow cell in a scintillation counter and then returned to the reaction coil of the Spinco Amino Acid Analyzer. The shape and position of the radiograph curves were compared with the colorimetric curves of the unknown. Since labeled homocitrulline was not available, the samples were analyzed again after the addition of known amounts of homocitrulline to establish the identity of the homocitrulline peak. Homocitrulline is eluted from the 150-cm column after the addition of 400 ml of *p*H