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Volcanic Sunset-Glow Stratum: Origin

Abstract. *Reexamination of the phenomenon of volcanic-dust sunsets, as typified by the Krakatoa event, supports a theory that the scattering layer is produced by the interaction of ozone and sulfur dioxide in much the same manner as is the normal "Junge" aerosol layer at 20 kilometers.*

The phenomenon of volcanic-dust sunsets, such as have been noted after major eruptions of volcanoes, is well known. The extensive observations included in Symon's report (*1*) on the Krakatoa eruption constitute a standard reference work concerning the heights of the glow stratum and ash layer from the most famous eruption of modern times. The eruption of Agung in 1963 has also drawn wide attention to the high-altitude dust that it distributed all over the world. We (*2*) have continued our observations of the height of the scattering layer by the twilight method, and believe that a new interpretation of the dust-layer hypothesis is required by all the evidence now available.

It is rather surprising that the dust layer, as evidenced by the sunset-glow stratum, persists for many years although the particle sizes responsible for the scattering of the sunlight (approximately 1 μ) should have a settling time of the order of 1 year. The Krakatoa sunsets were still being observed after 5 years, when the Symons report went to press, and the Agung sunsets are still conspicuous after 3 years.

It is also surprising that the height of the glow stratum is constant with time after the event, and that separate eruptions produce layers at the same height. One would not expect different volcanoes to eject dust to the same altitude, well above the tropopause, since the violence of eruptions varies widely. The eruption of Agung, for instance, was clearly less violent than that of Krakatoa, yet our heights of 20 to 22 km agree within experimental error with those for the Krakatoa event. There have been several other eruptions in rapid sequence since Agung: in Costa Rica, Iceland, the Philippines, and Indonesia. We believe that our observations show that these minor eruptions have contributed reinforcement of the twilight glows, but we find no evidence of the multiple layers that would be expected if the height of injection of the scattering layer depended on the ballistic or convective mechanics of each event itself.

We suggest that the sources of worldwide effects of volcanic "dust" can be considered as: (i) an initial ash layer that is broadly distributed in height and that settles in the first few weeks or months, and (ii) a more-persistent aerosol layer of chemical rather than ash origin. We believe that the "dust" layer responsible for the persistent twilight-glow stratum results from continual precipitation of sulfates upon nonscattering condensation nuclei.

The sulfates responsible for the "dust" are produced by interaction of atmospheric ozone and the SO_2 that is temporarily augmented by the mass of volcanic gaseous effluent. According to this theory, the glow stratum is not ejected to high altitude by a violent event but results from diffusive mixing of a large injection of SO_2. The origin of the volcanic "dust" aerosol layer therefore appears to be identical with that of the natural sulfate aerosol layer, at 20-km altitude, described by Junge (*3*) and Mossop (*4*), except that the abundance of SO_2 in the case of the volcanic leads to more or larger particles (or to both). Persistence of the enhanced glow stratum after an eruption then depends on constant replenishment of the sulfate-coated particles by chemical means rather than on suspension of particles that were injected during a single event.

The association in our records of dates of stronger glows with polar air masses accords with this hypothesis of sulfate precipitation, since higher concentrations of ozone at the low side of the 25-km ozone maximum are associated with polar air masses. However, one must also remember that under these conditions the sky is very clear, and reddened sunlight of higher-than-normal intensity characterizes the grazing rays.

This hypothesis evokes many interesting questions: what is (i) the global production of SO_2 from volcanoes; (ii) the extent of annual fluctuations in this quantity; (iii) the entire aerochemical reaction chain if the end product is in the form of ammonium sulfate, as in the case of the normal 20-km aerosol layer (*4*); (iv) the global influence of a variable rain of highly hygroscopic particles? It is unfortunate that the U-2 experiments by Mossop were stopped on 15 March 1963 by the eruption of Agung; this event would have provided a wonderful opportunity to examine this hypothesis, even though Mossop's original object, study of extraterrestrial particles, was cut off by the eruption.

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Marine Dolomite of Unusual Isotopic Composition

Abstract. *A piston core taken off of the coast of Oregon in 358 meters of water contained an indurated calcareous layer composed partly of dolomite with a composition $Ca_{58.7}Mg_{41.3}$. Dolomites of this chemical composition are typical of the supratidal environment. However, the dolomite has isotopic composition $\delta O^{18} = 5.8$ per mille, $\delta C^{13} = -35.1$ per mille relative to the Chicago PDB-I standard. The unusual carbon isotope ratio is similar to that of calcites produced as a byproduct of bacterial breakdown of hydrocarbons.*

This report on deep marine dolomites is the first to include a complete study of the samples (*1*). The dolomite that we used came from a piston core taken at 46°03.2′N, 124°45.7′W. This location is 30 nautical miles (56 km) west of the mouth of the Columbia River on the continental slope near the south edge of Astoria Canyon at a depth of 358 m (Fig. 1).