plied that they tended to be different. The statistics of Fig. 4 confirm his comment.

Many of us who are now observing the sun are most familiar with the minimum of 1954. In spite of the high preceding and subsequent maxima, the years 1953 and 1954 provided relatively long intervals of solar calm. Details of the 1954 minimum are summarized in Tables 4 and 5.

Intervals of true solar quiet similar to those of 1954 are what solar astronomers would like to recognize in advance for geophysicists during the IQSY. However, it seems possible that the sun, during the coming minimum, may not be truly quiet for extended intervals of time. The high values of sunspot numbers at the minima in cycles 1, 2, 3, 4, 8, 9, and 18 give warning that solar minimum can take place without true solar calm.

As of December 1963 there is evidence that at least another year will be required before old cycle activity will have diminished to the level associated with the truly calm solar circumstances of 1954. This evidence includes the current relatively high values of monthly mean sunspot numbers, mean latitude of old cycle spots, and 2800 Mcy/sec flux. The small number of spotless days and the unusually great solar activity of September and October 1963 indicate that if the anticipated minimum is to be at a truly low level, it will probably not be reached prior to January 1965. If new cycle activity does not develop rapidly this indeed may be the course of the activity cycle. On the other hand, two of the three new cycle centers of activity already observed have been well developed and relatively long-enduring. If these regions indicate that the new cycle is on the threshold of rapid development, then the statistical minimum between cycles 19 and 20 can be near at hand, with the mean level of residual activity unusually high.

It is possible that many of the programs planned for the Years of the Quiet Sun will not be vitiated by the existence of a certain residual solar activity. Nevertheless, it should be noted that on 26 and 27 August 1954 high resolution radio frequency instruments at Nagoya, Ottawa, and Sydney detected radiation from a new-cycle region with a small spot for which the calcium plage was of only moderate intensity and for which the area was no greater than 200 millionths of the solar hemisphere. After the almost complete absence of geomagnetic storms and plages and spots in May and June 1954, geomagnetic stations began reporting storms (albeit minor ones) in July and August, the same months that saw the formation of the first enduring new-cycle calcium plages and spots. Apparently solar measurements and the earth-sun system are exceedingly sensitive to the existence of even minor forms of solar activity.

In the months ahead, the guidance or comments of solar astronomers on the expected specific course of solar activity should be looked upon with uncertainty and perhaps even with skepticism. At the present time there is so little true understanding of why spots and plages form when and where they do, or why they endure or die, that attempts to forecast solar activity are undertaken only in the spirit of trying to evaluate, as best one can, the day-to-day situations in the light of past solar cycles. Let us hope that the activity of the new cycle remains low, and that the activity of the old cycle diminishes quickly, so that 1964–65 will provide the long intervals of solar quiet desired by the geophysicists during IQSY.

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30 December 1963

Basaltic Cone Suggests Constructional Origin of Some Guyots

Abstract. *A basaltic cinder cone was built beneath the waters of Mono Lake in Pleistocene time. This cone is now exposed. Its internal structure, external form, and petrography suggest that it was constructed with a flat top.*

A flat-topped, conical accumulation of more or less horizontally stratified basaltic cinders and tuff-breccia occurs in the desert of eastern California within the area once occupied by Pleistocene Mono Lake. It stands on the northern shore of the present lake, well below the late Pleistocene high-water level, and is known simply as Black Point. The basaltic debris consists largely of perfectly clear, pale-brownish-green glass having a refractive index of about 1.57. Such glass, in contrast to the dark brown semiopaque variety clouded by iron oxides, has heretofore been considered evidence of subaqueous eruption (*1*). The peculiar form and structure of Black Point also seem to have resulted from subaqueous pyroclastic eruption and accumulation. The characteristics of this cone may, therefore, provide evidence regarding the internal structure and origin of some guyots and seamounts.

Interpretation of submarine volcanic forms has been based of necessity on comparison with forms of subaerial volcanoes. Except for the "table mountains" of Iceland and the "tuyas" of northern British Columbia which were built within lakes in ice sheets (*2*), volcanoes with primary flat tops have not been recognized. Hence, the flat tops of guyots have been considered "anomalous," requiring special explanation (*3*). The flat tops of guyots are generally considered to have been produced by erosional truncation of volcanoes by wave action at or near sea level (*4*). The presence of basaltic debris on the tops and flanks of guyots has seemed to support this hypothesis. The basaltic cone at Black Point indicates, however, that flat tops and basaltic debris alone do not prove the erosional origin of guyots. It suggests, on the other hand, that these features may result from subaqueous pyroclastic eruptions, providing support for Nayudu's suggestion (*5*) that some guyots may be primary constructional features of submarine vulcanism.

The region surrounding Mono Lake has been characterized by vulcanism almost continuously since the Miocene epoch (*6*), and the structural basin containing the lake has been the site of both Pleistocene and Recent vulcanism. Indeed, the waters of Mono Lake are reported to have boiled and emitted puffs of steam in 1889, presumably as a result of subaqueous eruptions (*7*), and hot springs and steam vents are still to be seen on Paoha Island in the lake.

Black Point consists of poorly consolidated debris. It could not have survived erosion during an entire interglacial stage, for even the waves of the present shallow lake have cut a wide bench in its side. Terraces high on its flanks indicate that it was an island during higher stands of the lake. If the lake level were to rise again to the elevation of its late-Pleistocene highstand, Black Point would be submerged by about 72 m of water and would lie 3 or 5 km from the nearest shores. The cone was probably built during the last pluvial high stand of the Wisconsin glaciation and has been eroded only during the post-Wisconsin decline in lake level.

The Black Point cone is composed of olivine basalt lapilli ash, some of which is consolidated to form tuffs and tuff-breccia. The debris is very evenly stratified in beds that are generally between 10 and 20 cm thick. The volcanic fragments are angular, roughly equidimensional, and generally unsorted or poorly sorted. In marked contrast are sparse, well-rounded pebbles and cobbles of granitic and metaphoric rocks, presumably derived from glacial outwash through which the volcano erupted. Blocks of basalt in the breccias generally range from 5 to 15 cm in diameter, but there are a few as large as 30 cm in diameter. Basaltic fragments of all sizes are highly vesicular, and the vesicles in most fragments are remarkably circular when seen in thin section. The smaller fragments are typically bounded by concave surfaces. A crude reverse grading is to be seen in some beds, the larger fragments being concentrated toward the tops. Individual fragments consist of olivine, plagioclase (approximately An_{70}), and pyroxene in a matrix of glass. Most of the glass is clear and very pale brown to apple-green, but some, particularly in larger fragments, is black and opaque. Some of the glass has been altered to a brownish palagonite which, x-rays show, contains kaolinite, illite or muscovite, and quartz.

The most unusual feature of the volcano is the overall horizontality of its bedded structure. The broad flat summit is underlain by almost perfectly horizontal strata, as seen in gaping, discontinous extension fissures which run northeast-southwest across the top of the cone. On the flanks of the cone, the beds tend to dip outward at an angle of about 5 deg, but locally at angles up to about 20 deg. Local unconformities produce divergent dips. In a small area near the south edge of the summit, there is a narrow, arcuate belt of outcrops in which the beds are inclined outward at angles of 30 to 45 deg; this may be a remanent of a small crater wall. In the wave-cut cliffs along the southwest flank of the volcano, large blocks of stratified tuff-breccia are imbedded in chaotic array in a matrix of unstratified cinders. These minor irregularities superimposed on the generally simple structure of the volcano presumably resulted from the shifting of fissures and vents as the volcano grew.

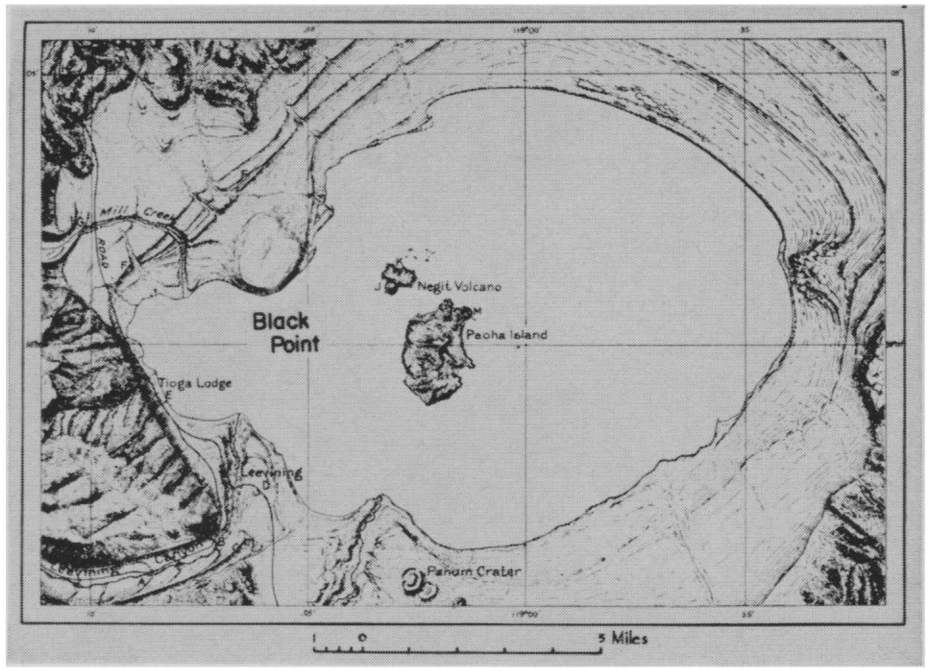

Fig. 1. Mono Lake area, California. [Modified from Russell, 1889]

The external form of the volcano conforms to the structure indicated by the bedding, namely a cone with a broad, flat top. A bench has been cut into the cone by waves at the present level of the lake on the southwest (windward) side, and other terraces are present higher on the flanks of the cone. The debris on these terraces, although of the same composition as the rest of the cone, is well-rounded and sorted; on the other hand, the loose debris on the top of the cone is neither rounded nor sorted. Locally around the edge of the circular, flat top there is a slightly elevated rim. The flat top and horizontal strata occupy a very slight and incompletely developed central depression that is expressed in both the internal structure and external form of the cone.

The foregoing features indicate that the original form of the Black Point volcano has been modified only slightly. The broad summit area of horizontally stratified, angular and unsorted ejecta denotes that the original volcano had a flat top. Wave action can have played no essential role either in producing stratification or in shaping the top. If the cone was indeed built underwater, then the lack of effect of wave abrasion on the summit indicates that the lake level must have declined very rapidly.

Subaqueous eruptions provide a rationale for the distinctive features of Black Point and for the paucity of similar features on land. A number of recent studies have dealt with distinctive aspects of submarine eruptions and of "aquagene" pyroclastic rocks (*8, 9, 10*). These studies have pointed out the contrast between volcanic ash produced by explosive separation of gas from magma and the fragmental debris produced by rapid and intense shattering, granulation, or decrepitation that occurs when silicate melts are quenched with cold water. The bedded debris at Black Point is clearly related to explosive eruptions rather than to granulation of quenched basalt. Individual fragments are highly vesicular and bounded by concave surfaces common in ash fragments formed by explosive eruptions. The stratification cannot have been produced by deposition from subaqueous ash flows traveling down the bottom slope, such as those described by Fiske (*9*), because the bedded debris at Black Point constitutes the top of the cone. We think that the eruptions here violently blasted vesiculating debris into the water and that the stratification and reverse graded bedding were formed by settling of debris from water over and around the vent. Extreme turbulence of the water and low settling velocities of the vesicular debris could account for the relatively wide lateral dispersal of debris and for the broad flat form of the cone, as compared to subaerial cinder cones.

If explosive submarine pyroclastic eruptions typically build flat-topped cones regardless of depth, then some of the inferences that have been drawn from deep submergence of guyots will have to be reconsidered. Black Point, however, was built within about a hundred meters of the lake surface, and perhaps proximity to the air-water interface was important in determining the form of the cone. We cannot answer this question definitively. However, it would seem, a priori, that if the eruptions broke through to the atmosphere, fragments falling back into the water from the air would exhibit lateral distribution characteristic of products of subaerial eruptions; because this is not the case, a mechanism of sedimentation in turbulent water must still be invoked to account for the observed phenomena. Therefore, it seems probable that the distinctive features of Black Point result from a subaqueous volcano-sedimentary process and that similar volcanic structures might be expected at any depths at which submarine pyroclastic eruptions occur. McBirney (*10*) has introduced thermodynamic arguments to solve the question of possible maximum depths in the oceans of explosive eruptions.

The basaltic cone of Black Point is small compared to guyots, and its exposed parts consist entirely of pyroclastic debris, without any massive flows. The larger submarine volcanoes are undoubtedly more complex both in structure and in form; but where pyroclastic eruptions have played a significant part in their growth, flat-topped structures may be expected, particularly since pyroclastic material is abundant among the volcanic islands of the Pacific and in samples collected from guyots.

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11 December 1963

Acid of Krypton and Its Barium Salt

Abstract. *An acid of krypton is formed when krypton tetrafluoride is slowly hydrolyzed by ice at −30° to −60°C. The yield is 2 to 3 percent (mole). A barium salt of this acid, thermally stable at room temperature, is formed by the hydrolysis of krypton tetrafluoride with a 0.35*N *solution of barium hydroxide at 0° to 5°C in a yield of approximately 7 percent by weight.*

The hydrolysis of krypton tetrafluoride, KrF_4, (*1*) like the hydrolysis of xenon tetrafluoride, XeF_4, with water (*2*) leads to its practically quantitative decomposition as follows:

$$KrF_4 + 2H_2O \rightarrow Kr\uparrow + O_2 + 4HF. \quad (1)$$

If the hydrolysis is carried out slowly between −30° and 0°C, the resulting aqueous solution contains a very small amount of an oxidizing species that liberates iodine from acidified iodide solution. The oxidant is not NO_2^- or NO_3^- ion, either of which could form from NO or NO_2 if traces of air leaked into the electrical discharge vessel during the preparation of krypton tetrafluoride (*1*). We now present evidence that this oxidizing substance is an acid of krypton.

In a typical preparation, 100.0 mg (0.63 mmole) of pure krypton tetrafluoride (*3*) were sublimed in a Pyrex glass tube (25 cm long, 1.6 cm inside diameter) and condensed at the bottom of the tube. Water (2.00 g) was distilled into the tube and frozen, in the form of a thin layer, above the krypton tetrafluoride. The tube was kept for 3.0 hours at −30°C, then at −20° to −10°C for 4.0 hours, and finally it was warmed to 0°C. During the first period (−30°C), 0.35 cm^3 (N.T.P.) of gas was evolved; in the next period, during 4.0 hours, 9.40 cm^3 were collected. During the final period, at 0°C, 18.25 cm^3 of gas were obtained; after about 15 minutes, all of the krypton tetrafluoride crystals reacted. The total gas (28.0 cm^3 at N.T.P.) was analyzed (O_2 by Orsat absorption and Kr by heating with Ca and Na to 500°C in a steel tube, and determining the volume and vapor pressure or melting point of the residue) and found to contain 14.2 cm^3 of krypton and 13.8 cm^3 of oxygen. The aqueous solution 2.00 cm^3 contained 47.0 mg HF (determined by titration). These quantitative data substantiate the stoichiometry of Eq. 1.

In addition, the solution contained 0.0183 mmole or 2.9 percent of kryptic acid based on krypton tetrafluoride. The assumption was made that, like xenic acid, kryptic acid oxidizes potassium iodide to iodine according to the equation:

$$KrO_3 \cdot x\,H_2O + 6\,KI + 6\,HCl \rightarrow Kr + 3\,I_2 + 6\,KCl + (3+x)\,H_2O \quad (2)$$

In a similar experiment, krypton tetrafluoride was hydrolyzed yielding a solution containing 3.90 mmole of hydrogen fluoride and 0.021 mmole of kryptic acid, or a yield of 2.2 percent (mole) based on krypton tetrafluoride; the gas evolved during the hydrolysis contained 51.6 ± 1.5 percent (mole) krypton and 49.6 ± 0.5 percent (mole) of oxygen values, in agreement with Eq. 1.

The questions whether our kryptic acid has the formula $Kr(OH)_6$ comparable to $Xe(OH)_6$ for xenic acid, or H_2KrO_4, in analogy to selenic or some other acid, and whether it contains the krypton in VI-, VIII- or IV-valence state, are as yet undecided; until these are decided, we in our laboratories refer to the acid as "cryptic acid."

Like barium xenate (*4*), a barium salt of a kryptic acid would also be expected to be practically insoluble in water and the yield of the kryptate