

Reports

Blue Halite

Abstract. Remarkable deep blue and occasionally purple forms of halite (rock salt) have long been known. These occur associated with potassium minerals in the Zechstein basin of northern Germany, elsewhere in Europe, and in North America. In recent laboratory studies, data have been developed which confirm the hypothesis that this coloration in natural salt may be attributed to gamma-ray bombardment by associated potassium-40 from syl-vite, accompanied or followed by structural deformation.

Natural clear halite cleavage plates were subjected to irradiation from a 1000-curie cobalt-60 source over a period ranging from 1 hour to 4 days. Amber coloration resulted which showed an increase in intensity with the duration of irradiation. Optical absorption spectra of irradiated halite cleavage plates were then obtained with a Cary model 11 recording spectrophotometer (Fig. 1c). Colored halite samples were held in the sample holder by means of brass plates with 0.25-inch-diameter apertures. These openings allowed equal and reproducible light beams to pass through the colored sample plates for comparison with beams transmitted through colorless halite plates used for reference purposes.

The colored cleavage plates were then deformed by unconfined pressures ranging from 25,000 to 125,000 lb/in.², in increments of 25,000 lb/in.², followed by immediate exposure to artificial light. All irradiated cleavages thus exposed showed a rapid color change from amber to blue, becoming deep blue at the end of 15 minutes. Since different pressures did not noticeably affect the intensity of the blue, addi-

tional irradiated cleavages were submitted to lower forms of deformation with a vise, a mortar and pestle, and a light blow with a hammer. In all irradiated specimens thus deformed, the amber color rapidly changed to blue after exposure to light (1).

Irradiated specimens were stored in darkness under slight pressure in a small vise. After a few months these halite cleavage cubes were found to have changed from amber to light blue.

A color comparison was next made with the spectrophotometer between natural blue halite from Germany and artificially produced blue halite. A natural blue halite cleavage plate, 0.055 inch thick, was found to yield four absorption peaks (Fig. 1a). The most intense peak at 6400 Å corresponds to blue. A less intense peak at 5300 Å corresponds to green, an even less intense peak at 4300 Å corresponds to orange-red, and a least intense peak at 3700 Å falls in the ultraviolet range. The latter three peaks are relatively minor in intensity compared to the peak corresponding to blue. At the same time, to the unaided eye, the only apparent coloration is deep blue.

Artificially produced blue salt plates were examined with the spectrophotometer (Fig. 1b). A broad compound peak, which lies in the spectral range from 5700 to 6300 Å, corresponds to blue and green. In addition, two minor peaks are suggested by shoulders at about 5300 and 4300 Å. A fourth peak, which approximately conforms in shape to the 5700–6300 Å peak, extends from 4000 Å into the ultraviolet spectral range. It is significant to note that no F-band, at 4650 Å, may be detected; this coloration, observed in irradiated halite before deformation, is essentially destroyed by the application of pressure and is replaced by a new coloration.

Colored halites were also examined in thick sections with the polarizing microscope. Natural blue salt is in part optically inhomogeneous, and both blue and purple are unevenly distributed in various intensities and shades. Lines of dark blue parallel to the (110) crystal planes occur in a lighter blue matrix, and one set of streaks often transects another set at right angles. Numerous bubble inclusions and crystallites of mineral impurities such as

anhydrite are apparent. The blue coloration is intimately associated with patches of clear salt. These boundaries may be at times irregular and difficult to distinguish on account of blue shading which grades into colorless sections, but in some cases the boundaries are quite sharp and straight. Where the distinction is clear it appears that the color divisions are crystal boundaries, and it indicates a recrystallization process which has removed color from those portions now colorless.

Optically, artificial blue salt closely resembles natural blue halite. When artificial blue salt plates are allowed to stand exposed to artificial light for a few weeks, the plates bleach in irregular patches corresponding to the appearance of natural blue halite. Many of the boundaries between colorless and blue salt are straight and sharp, indicating a recrystallization process. The artificial blue salt shows slight anisotropism between crossed nicols, caused by the application of pressure in the synthesis process. Pressure results in lattice distortions causing light to be irregularly refracted to produce anisotropism.

A criterion for the recognition of coloration by irradiation is removal of the coloration by bleaching with heat,

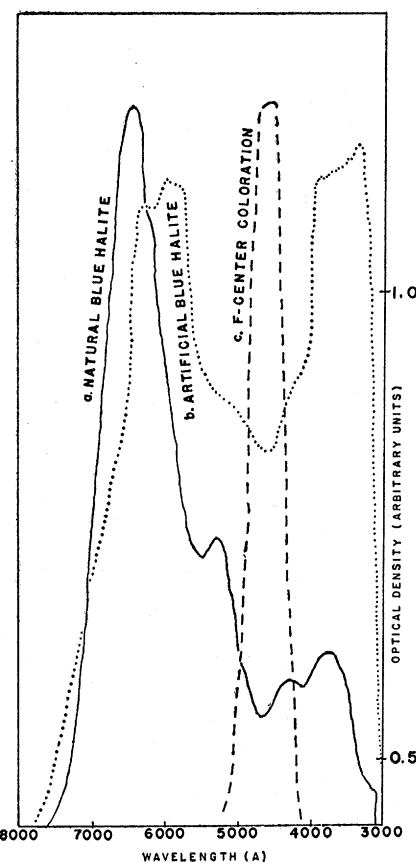


Fig. 1. Optical absorption spectra for halite: a, natural blue halite; b, artificial blue halite; c, F-center irradiation coloration in halite.

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to one 2-column figure (that is, a figure whose width equals two columns of text) or to one 2-column table or to two 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [Science 125, 16 (1957)].

light, or solution (2, 3). Natural and artificial blue salt, and unpressed amber salt, were bleached by heat, light, and solution to compare coloration properties. All apparent coloration was removed from all samples when dissolved in water. Cleavages 3 mm thick were heated over bunsen burners in crucibles with thermometers attached. One and one-half minutes at a final temperature of 150°C bleached artificial blue salt and unpressed amber salt. Two and one-half minutes at a final temperature of 220°C bleached natural blue halite. In natural blue halite, before all color bleached, a change to violet was apparent. At the end of two and one-half minutes a few blue streaks remained, oriented along diagonals to the cube faces, the known slip, or glide directions (110) caused by prior natural deformation. Such slippage would induce more intense deformation along diagonals and thus cause coloration to be more intense and more slowly bleached.

One 250-watt lamp was placed 15 cm from 3 mm-thick cleavages of natural blue salt, artificial blue salt, and amber salt to investigate bleaching by illumination. In 1 hour, the amber salt was bleached. In 8 hours, the artificial blue salt was bleached, although most of the bleaching occurred by the end of the first 3 hours. With the natural blue salt, no bleaching effects were noted after 35 hours.

Halite, upon gamma irradiation, application of pressure, and exposure to light in the order given, will change from colorless to amber and finally to blue. Long-continued minor pressure even in darkness will also turn irradiated salt blue.

Spectrophotometric examination of natural blue halite and artificially produced blue salt shows that the curves for the two agree in absorption peak positions and in the intensity of the predominant blue coloration. Figure 1 illustrates absorption spectra curves for natural blue halite, artificial blue salt, and amber F-center irradiation coloration.

Colorless halite from bedded deposits or from salt domes can be turned amber yellow to brown and even to black (F-center coloration) by gamma-ray irradiation from a cobalt-60 source. The intensity of color for a given irradiation interval is increased when specimens are subjected to confined or unconfined pressures prior to irradiation (4). Color intensity increases with exposure time, an increase of 14 times being noted between samples irradiated from 1 hour to 1 day. However, further exposure of 4 days yields an increase on the order of only two times that of a single day. This confirms that additional coloration proportionately de-

creases with longer irradiation times. Optical absorption spectra obtained with the spectrophotometer indicate that pressure causes shifts of color center band maxima, removal of some color centers, and development of more complex color centers (5).

Application of pressure prior to irradiation enhances the F-center coloration, but pressure applied after irradiation produces a change to blue. In this change to blue all amber F-center coloration is destroyed.

Gamma irradiation of natural blue halite does not appear to produce F-center coloration since spectrophotometric curves taken before and after irradiation for 1 hour are identical.

It would appear reasonable to infer that blue halite may be caused by natural gamma irradiation followed by deformational rock pressures (6). This interpretation is supported by the reported occurrence of blue halite in areas of deformation, such as accompany faults, shear zones, and contorted strata (2). Study indicates that even minor earth pressures may be adequate to yield blue in naturally irradiated salt (7).

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7. The courtesy of Prof. Erwin A. Amick, Jr., and Dr. William H. Cropper of the department of chemical engineering of Columbia University in making available a cobalt-60 facility is gratefully acknowledged.

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An Inherited Male-Producing Factor in *Aedes aegypti*

Abstract. An inherited factor causes a predominance of males in certain strains and in progeny of single pairs of *Aedes aegypti* L. This factor appears to be transmitted only by males and is not due to differential mortality, at least in postgametic stages. Mass release of male-producing males might be used in control operations.

With few exceptions, data on the sex ratio in mosquitoes have been collected only as a part of investigations of other phenomena. For some species, conflicting reports have given figures ranging from equal numbers of the sexes to a

strong preponderance of one sex. In *Culex pipiens*, Qutubuddin (1) found that apparent departures from a 1:1 ratio were not statistically significant. Such a ratio would be expected since Gilchrist and Haldane (2) have shown that maleness appears to be due to a single dominant factor (male M/m, female m/m) in this species. While no controlled studies of sex ratio have been made for *Aedes aegypti*, most reports indicate that males predominate [35 to 45 percent female (3)].

In a study of genetic variability in populations of *A. aegypti* (4), laboratory strains were found to differ with respect to sex ratio. Among 16 strains of diverse origins, there were variations from 38 to 52 percent female. However, certain other strains were 18 to 32 percent female. Replicate counts on some strains over several generations indicated that the frequency of females was constant and predictable for each strain.

To investigate the abnormal ratios observed, frequency of the sexes was determined in the progeny of single pairs. Virgin adults were selected at random from laboratory strains having either high or low female ratios. Single-pair matings were made both within and between these strains. Repeated blood meals were offered to insure satisfactory egg production. Crosses giving fewer than 20 offspring, an infrequent occurrence, were not included in the results. In general, about 50 to 80 eggs were deposited after each blood meal, the total number of eggs from a cross depending upon the number of blood meals taken. Progeny in subsequent batches from any particular mating showed similar sex ratios. For example, a cross with 210 offspring gave 16, 12, 10, and 7 percent females in four egg batches. Since such variations were not statistically significant, the frequency of the sexes was computed from the total progeny produced in a cross.

Special efforts were made to discount the influence of mortality in the immature stages on the sex ratio. All eggs from each pair were collected, counted, and subjected to a hatching stimulus. Unhatched eggs were checked for embryonation. No correlation was observed between frequency of unembryonated or unhatched eggs and sex ratio. Newly hatched larvae were counted and carefully reared in uncrowded containers on a diet of liver powder. Pupation was usually completed by the 7th day after hatching. Sex ratios were determined initially on pupae and were later checked on newly emerged adults. All individuals from each egg batch were counted, even though a few required more than 7 days for pupation. Mortality levels for immature stages were below 10 percent