

STATE OF OREGON  
DEPARTMENT OF GEOLOGY & MINERAL INDUSTRIES  
PORTLAND, OREGON

# THE ORE.-BIN

VOL. 5 NO. 6 PORTLAND, OREGON ~~June~~ 1943



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CARBON MONOXIDE AGAIN

On May 1 last, two miners working at the McIntyre mine, a small gold mine near the old Sanger mine north of Baker, started their gasoline engine-driven compressor and descended into the mine to begin work in a winze. They turned on the compressed air and soon were dead. Carbon monoxide had struck again.

The air compressor and automobile-type gasoline engine at this mine were set close together in a small, tightly walled and roofed building erected close to the collar of the shaft. The building had two doors and four 30-inch square windows. The exhaust pipe from the engine went down through an opening in the floor and out beyond the wall of the building. There was a break in the exhaust pipe, permitting exhaust fumes to enter the building through the floor opening. The intake of the air compressor was inside the building only a few feet from the engine exhaust pipe. If doors and windows of the building were closed, exhaust fumes would be drawn into the compressor and sent underground. Apparently such were the conditions pertaining to ventilation of the building when the two men went into the mine.

These statements are made not to chronicle this particular tragic happening, but rather to emphasize as pointedly as possible the danger of disregarding elementary safety practices. Both the discharge of the exhaust pipe of the engine and the air intake of the compressor should have been outside the building and so separated that there would have been no possibility of sucking the exhaust fumes into the compressor.

The vital function of providing the human system with sufficient oxygen is maintained through breathing air into the lungs where oxygen is absorbed by the red blood corpuscles or hemoglobin in the blood stream. The oxygen is transferred by them to the tissues. Carbon monoxide is absorbed by the hemoglobin three hundred times as readily as is oxygen. When 60 to 80 percent of hemoglobin in the blood stream becomes carbon monoxide carriers instead of oxygen carriers, death comes quickly.

Carbon monoxide is produced in the combustion of hydrocarbons such as petroleum products and may be present in the exhaust gases of gasoline engines in amounts up to 13 or 14 percent, probably averaging 6 or 7 percent. Concentrations of carbon monoxide of 0.1 percent and above are dangerous, and air containing 0.4 or 0.5 percent carbon monoxide produces unconsciousness and asphyxiation in a few minutes.

This deadly gas gives practically no warning. It is tasteless, colorless, and odorless. Its weight is very nearly the same as air.

Persons using internal combustion engines should give especial attention to the hazard of exposure to even low concentrations of exhaust fumes. Neglect of precautions which should be taken represents ignorance or negligence that might have fatal results such as those at the McIntyre mine.

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## ICELAND SPAR

Introduction

Iceland spar is a variety of calcite that is transparent, waterclear, and perfectly crystallized. When free from mineral inclusions and other foreign particles, gas bubble holes or cavities, incipient cleavages, and cloudy or milky portions, it has great value for optical use. The demand for optical grade material is relatively small but the supply is so limited that the search for it has become world-wide.

Little did the discoverer of this mineral realize what far-reaching effects it was to have in furthering scientific research. It was discovered early in the 17th century in a stream bed in Iceland; hence the name. Little attention was given the discovery until 1669 when Erasmus Bartholinus first perceived its power to form double images (double refraction). His conclusions regarding this peculiar property were published in 1670, but it was not until 8 years later that the Dutch scientist, Christian Huygens, discovered the law governing the action of the refracted rays of light as they passed through the calcite crystal. In 1809 the French physicist, Etienne Louis Malus, discovered Iceland spar's polarizing effect on light rays, and he published a paper describing the phenomenon. William Nicol's work closely followed that of Malus, and in 1828 Nicol designed the prism which bears his name and which is used to this day as the means by which polarized light is obtained in most optical instruments.

Properties and Uses

Iceland spar (calcium carbonate) has the same properties as the more common varieties of calcite. It has a hardness of 3 and is easily scratched with a knife. Specific gravity is 2.71; luster is vitreous. It effervesces freely in hydrochloric acid.

The apparent brittleness of calcite is due to its well-known rhombohedral cleavage, perfect in all three directions with angles of intersection of  $75^\circ$  and  $105^\circ$ . The crystal habit is quite variable, and may be either scalenohedral or rhombohedral (hexagonal crystal system), often with modifying forms. The rhombohedral-shaped cleavage fragments from large crystals are sometimes mistaken for the outline of the crystals themselves. Calcite has two indices of refraction of widely different value; or, to be more explicit, light entering a crystal of Iceland spar is split into two rays which travel different courses at different speeds, (see fig. 1). These paths are markedly separated, more so than in most other minerals. This optical property of Iceland spar is the basis of its use in optical instruments.

Malus in 1809 discovered that light rays were polarized when they passed through Iceland spar. That is, he noticed that the rays of light from an ordinary source, after passing through the Iceland spar crystal, no longer sent out vibrations in all planes perpendicular (normal) to the axis of the ray; but instead sent out vibrations in only one plane perpendicular to the axis of each of the two rays, and that these two planes intersected at right angles, (see fig. 1). If both planes of vibration (or polarization) were parallel instead of perpendicular, the plane-polarized light could be directly employed in optical instruments. As the planes are not parallel, one plane of vibration or polarization must be eliminated. The two paths followed by light through Iceland spar are widely separated, therefore the elimination of one ray is possible; Nicol accomplished this in 1828 when he made the first Nicol prism. This prism is made by cutting the crystal the long way from one obtuse angle to the opposite obtuse angle. The surfaces are smoothed and then cemented together with Canada balsam (a clear cement having an index of refraction between the two indices of calcite). The edges of the crystals are then made perpendicular to the plane of the Canada balsam. The crystal is set in cork, blackened on the inside. Light entering the Nicol prism is broken into two different rays. One ray continues through the Canada balsam medium in an almost unaltered course; the other strikes the plane (or mirror) of balsam at such an angle that it is totally reflected toward the side and absorbed by the blackened cork, (see fig. 2).

Consequently, light vibrating in only one plane emerges from the Nicol. This light is very useful in determining the optical properties of minerals in a thin section of rock when examined by means of a microscope. The petrographic microscope uses two prisms oriented with their planes of polarization at right angles to each other. Additional optical properties can be determined by the use of the two prisms.

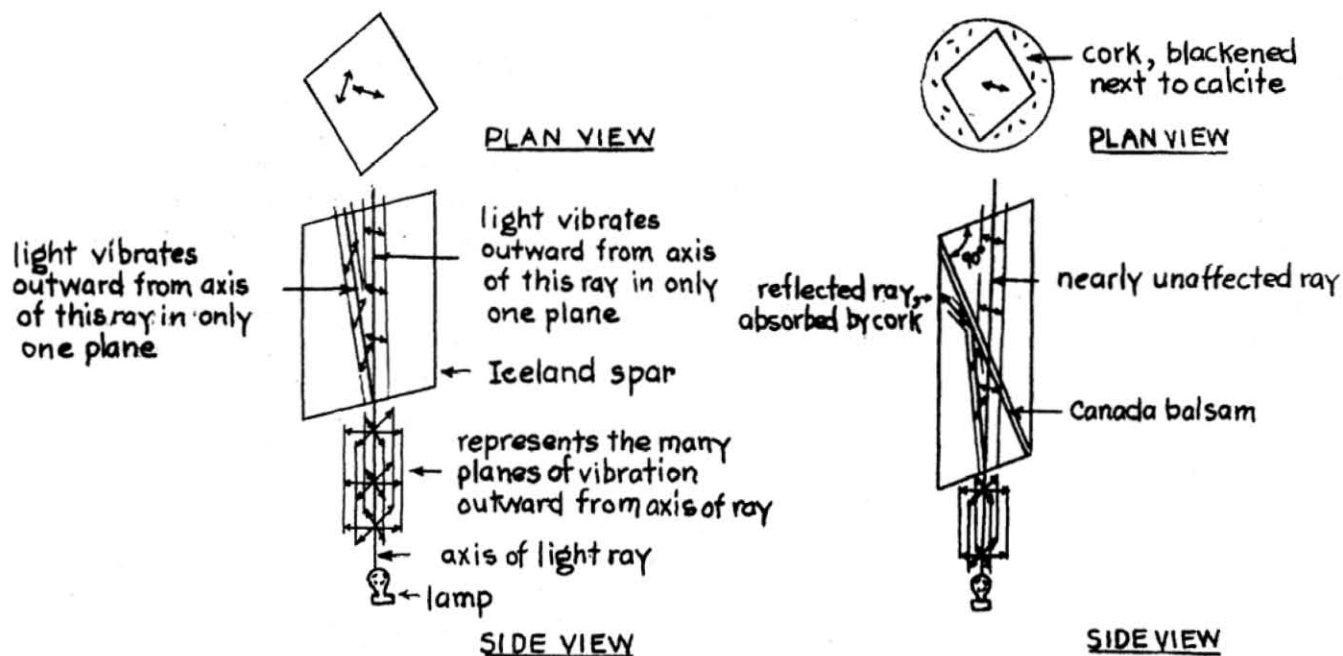


Figure 1. ACTION OF LIGHT  
PASSING THROUGH ICELAND SPAR

Figure 2. ACTION OF LIGHT  
PASSING THROUGH A NICOL PRISM

Nicol prisms or modifications thereof are used in other optical devices which aid in keeping a close check on the quality and uniformity of manufactured products. Thus colorimeters are used to compare the depth of a color with a standard; saccharimeters, to determine the sugar content of solutions; dichroscopes, to reveal dichroism (difference in color of a substance in different directions); photometers, to measure the intensity of light; spectrometers, to ascertain index of refraction; spectroscopes, to form and examine spectra; and polariscopes and polarimeters, used in polarized light studies. Iceland spar is also used in X-ray analysis in determining crystal structure.

#### Geological and Geographical Occurrences

Iceland spar is deposited from aqueous solutions, but the conditions under which it is formed instead of ordinary calcite are imperfectly known. Some authorities favor a theory of deposition from magmatic water instead of the more commonly held theory of deposition from meteoric or ground waters. Possibly, it may originate in both ways. Deposits are generally associated with basic igneous rocks such as basalt and diabase. Iceland spar occurs mainly as masses of crystal aggregates together with associated residual clay in cavities of the country rock. Some deposits which have a definite vein structure are found in sedimentary rocks and this spar appears to have been deposited from ascending heated water which dissolved calcium carbonate from underlying limestone areas.

Deposits of Iceland spar are scattered sparingly over the earth, and most of these deposits contain a relatively small proportion of optical grade calcite. The best known

occurrence, now largely of historical interest only, is that in Iceland. Though discovered in the early 1600's, this deposit was not exploited until 1850. The country rock is an alternating series of decomposed and unaltered rock. The cavities were in part formed by the disintegration of the rock and contain red clay. The best crystals were embedded in this clay. As true of all deposits, many crystals were small. The first cavity opened is reported to have been almost entirely filled with pure crystals of enormous size, the largest a yard across. One of the large crystals taken in the early mining operations is in the British Museum. It is part of a larger crystal, measures 24 inches across by 16 inches thick, and is nearly free from fractures and inclusions.

In mining the Iceland deposit the country rock was blasted away to get at the cavity-fillings. Undoubtedly this blasting spoiled a considerable portion of optical grade calcite. Operations were discontinued for several years during the first World War. At that time a large pit about 100 feet long, 70 feet wide, and 50 feet deep had been excavated. It was filled with water to prevent weathering and later, when reopened, the grade of the crystals had deteriorated. It has since been worked only intermittently, and consumers have sought spar from other sources.

South Africa has supplied much of the demand in recent times. The more important deposits are in the Kenhardt district, northwest Cape Province. Their value was first recognized in 1920. The spar in this district occurs as variously sized, irregular aggregates in cavities in weathered diabase, and is removed entirely by hand operations. Prior to the present war much of the production went to Germany which was the world's leading consumer of Iceland spar. Some of the spar, however, reached the United States.

Small quantities of optical grade spar have been produced in Spain and shipped to both Germany and the United States. Deposits have been reported from Canada but no production has been reported. One deposit is said to be near the headwaters of Lake Creek in the Trout Lake mining district, about 20 miles from Ferguson, B. C. Deposits near Kamloops, B. C. are veins in limestone. Samples of Iceland spar were sent to the United States from Buenos Aires, Argentina in 1920 and proved promising, but nothing more is known of this source. In 1921 an American manufacturer reported that Iceland spar could be purchased in Brazil.

Several occurrences in the United States should be noted though domestic production has been relatively small. Large, relatively undeveloped deposits near Greycliff and Big Timber in Sweet Grass County, near Livingston, Montana, have been known since 1907. Some spar was produced which apparently was in part of optical grade, although the predominance of imperfect crystals appears to have made operations unprofitable.

Some optical-grade spar was produced from a deposit in the Warner Range near Cedarville, Modoc County, California in the 1920's. Specimens of crystal aggregates weighed as much as 80 pounds. Many of the crystals were twinned. Mining was by open cut and during the winter of 1920-21, about 1000 ounces was sold. Pieces weighing one ounce sold at the rate of \$8 a pound with a premium of 50 cents additional for each one-fourth ounce increase in weight of the crystal. Originally thought to be an important source of supply, the deposit was worked out before 1925.

By far the most promising recent development is the deposit in the Copper Mountain mining district, Taos County, New Mexico, about 30 miles southwest of Taos. This occurrence is in a fault zone and although much calcite is present, optical-grade material represents only a small percentage and is found near the edges of the deposit where crystals have formed in a decomposed schist of clayey character. The quality is reported by consumers to be excellent. Production began in 1939 and high-grade rhombs as much as 17 pounds in weight have been recovered.

There are several promising deposits of calcite located on both sides of the Owyhee Reservoir, Malheur County, Oregon. These deposits are found in an area 9 miles square in the vicinity of the mouth of Dry Creek. The calcite forms definite veins in both basaltic



extrusive rocks and overlying lake beds. The veins are quite constant in width and range from 8 inches to 25 feet. One vein about half a mile long averages 6 feet in width.

Crystals taken from some of these deposits are as much as 8 inches on a side. The veins have not been explored at depths greater than several feet. Clear pieces of float and pieces from larger crystals at even these shallow depths appear to approach optical grade. These deposits were examined recently by the Department.

Other possible sources of optical grade material are known in the western states. Production from near Indio, California, has been reported.

#### Mining Methods

Open-pit mining has been employed in recovering the spar from most deposits. The country rock is blasted away and the clay pockets containing crystals are worked by hand. Extreme care must be used at all times in handling Iceland spar. Equal care must be used in transporting it. It is generally well wrapped and then packed in sawdust for shipping. Undoubtedly the use of powder has ruined many crystals of optical grade and, if at all possible, its use should be avoided. Iceland spar is far more subject to flawing than marble (mainly recrystallized calcite), yet marble is recovered by channeling and wedging, using great care. If a deposit of spar is large and the quantity of optical grade material promising, the use of a channeling machine may be warranted. Wall cuts might be made along the vein and the vein matter removed by drilling and wedging. The chunks could thus be removed and reduced in size by means of wooden wedges. The use of unslaked lime in breaking the rock away from crystals is rather ingenious. A hole is drilled in the rock. A slender metal rod is inserted and the hole filled with lime. The rod is taken out and a cotton string saturated with water is suspended one-half inch from the bottom. The opening is then sealed and the water dripping from the string causes the lime to expand, breaking the rock with a minimum of damage to the spar.

#### Specifications

Iceland spar suitable for optical use should be at least one inch long and half an inch thick each way, though smaller pieces have limited use. Each piece must be absolutely transparent, free of all imperfections such as inclusions, cavities, foreign particles, internal iridescence or rainbow colors caused by incipient cleavages. Twinning planes or lamellae, even invisible to the naked eye, rule out some crystals for optical use, though these, if sufficiently large, may sometimes be cut down to avoid the twinning defect.

A twinned crystal can be identified by placing it over a dot or hole in a piece of paper. If the crystal is normal (untwinned) two dots appear which vary little regardless of the movement of the crystal along the paper. If, however, additional, indistinct dots appear, the crystal is twinned. The twinning planes can be seen sometimes by noting the surface reflections from a crystal.

#### Prices, Markets, and Consumption

There is no fixed price for Iceland spar of optical grade. It varies with the quality and size of the spar and the amount to be sold. A consumer company's reserve supply determines to a marked extent the price it is willing to pay. The price before the present war ranged from \$7 to \$35 a pound. Depressions or seasonal fluctuations have little effect on the price of Iceland spar. Since the war started, especially desirable crystals have brought a maximum price of \$40 a pound.

The consumption in the United States before the war was probably not much more than 200-300 pounds a year. Yet there is a ready market both in the United States and abroad for optical-grade spar in peacetime. Since the war began, the demand has markedly increased. Polaroid Corporation, 718 Main Street, Cambridge, Massachusetts, uses a certain amount of sub-optical grade calcite in sizes not less than 2 inches on each edge. These sell for

about \$10 a pound, but this demand is reported to be met largely by Montana and California sources. Bausch and Lomb Optical Company, 626 St. Paul Street, Rochester, New York; Spencer Lens Company, 19 Doat Street, Buffalo, New York; and possibly others, demand colorless and absolutely perfect specimens at least one inch on each edge for certain uses at the present time. Still larger sizes are preferred. These sizes are urgently needed at present and command good prices.

When world conditions were favorable for international trade, many German manufacturers of optical instruments, several English, and one Swiss company were in the market for high-grade spar.

Samples for collectors, schools, and museums generally bring from \$1 to \$3 a pound, though crystals of high optical grade have the same value as those employed in optical instruments. Calcite sufficiently pure to be used in laboratories for standardizing purposes (standardizing spar) sells for \$1 - \$2 a pound.

#### Acknowledgements and References

Much of the information used in this report was obtained from the U.S. Bureau of Mines Information Circular No. 6468R.

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W.D.L.

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#### QUICKSILVER SURVEY

Mr. Francis Frederick, consulting geologist of San Francisco, has been retained by the Department to make a survey of Oregon quicksilver deposits. This survey has as its object the study of possibilities of encouraging new production. Mr. Frederick has had a wide experience in examination and development of quicksilver properties. His report will be published as a department bulletin as soon as possible, probably this fall.

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#### NOTICE

The Portland office of the Department, 702 Woodlark Bldg., is in Zone 5, and the address of all mail to this office should include this zone number.

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