# HILGARDITE, A NEW MINERAL SPECIES, FROM CHOCTAW SALT DOME, LOUISIANA

CORNELIUS S. HURLBUT, JR., *Harvard University*, AND
RALPH E. TAYLOR, *Louisiana State University*.

## ABSTRACT

In the insoluble residue from a brine well in the Choctaw Salt Dome, Louisiana, is found an unusual mineral assemblage. Hilgardite, a new species, is found there in association with anhydrite, danburite, boracite, and other minerals. Hilgardite is monoclinic-domatic; $a:b:c=1.0147:1:0.5585$, $\beta=90°00'$. It is clear and colorless with a vitreous luster. Cleavage: $\{010\}$ perfect, $\{100\}$ difficult. $H=5$. $G=2.71$. Biaxial positive, $2V=35°$, $r>v$, $nX=1.630$, $nY=1.636$, $nZ=1.664$. The dimensions of the unit cell: $a_0=11.35Å$, $b_0=11.12Å$, $c_0=6.20Å$. The space group is either $Pc$ or $Pm$. The chemical formula expressing the content of the unit cell may be written: $Ca_8(B_6O_{11})_3Cl_4 \cdot 4H_2O$. Named in memory of E. W. Hilgard.

## INTRODUCTION

Studies of the water-insoluble residues of rock salt from Gulf Coast salt plugs reveal the presence of an interesting and rather distinctive mineral assemblage. Residues from the different salt plugs have a similar composition,[1] but the one from the salt plug of Choctaw Salt Dome, Iberville Parish, Louisiana, contains several unusual minerals which have not been found in the others. Hilgardite, the new mineral species described in this paper, danburite, boracite, and magnesite were found only in the Choctaw residue.

The Choctaw residue comes from the Solvay Process Company number four brine well and represents water-insoluble materials liberated from the rock salt during the production of brine. The insoluble material accumulated at the bottom of the well and was brought to the surface when the well was washed. The samples studied were collected from the sump into which the washings were discharged. As the casing through which the brine is pumped extends to some 1200 feet below the top of the salt, this residue comes from well within the salt plug. Analyses of salt cores from a test-well drilled close to the number four well indicate that the rock salt contains from two to four per cent of insolubles. The brine from number four well shows a trace of potash salts, and its production is accompanied by the liberation of appreciable amounts of methane, hydrogen sulphide and other gases.

The residue is a light bluish-gray sand of fine-to-medium-sand size and is composed chiefly of anhydrite grains. Fragments of friable, gray,

---

[1] A general discussion of the residues will be presented in "Water-Insoluble Residues from the Rock Salt of Louisiana Salt Plugs," which the junior author will publish in the *Bulletin of the American Association of Petroleum Geologists* for October, 1937.

argillaceous sandstone, and of black, calcareous shale are also present. The sandstone is composed of poorly sorted quartz sand and a subordinate amount of the heavy minerals tourmaline, zircon, rutile, ilmenite and leucoxene. The minerals[2] which have been identified from the residue, exclusive of those in the sandstone, are, in order of abundance: anhydrite, dolomite, magnesite, hilgardite, pyrite, calcite, boracite, danburite, quartz, sulphur, limonite, hematite, marcasite, hauerite, and gypsum.

## Morphology

Hilgardite, the new species, is present in the residue as distinct and well-formed crystals. It belongs to the domatic class of the monoclinic system, and is thus unusual in that only one other previously described mineral, clinohedrite, falls in this class. The goniometric and $x$-ray measurements both give rectangular axes; but, since the external morphology shows only a plane of symmetry, monoclinic symmetry is indicated with $\beta = 90°00'$. Most of the crystals are similar in appearance with a pronounced tabular habit and hemimorphic aspect as shown in Figs. 1, 3 and 4. They range in size from 0.5 mm. to 15.0 mm. in maximum dimension.
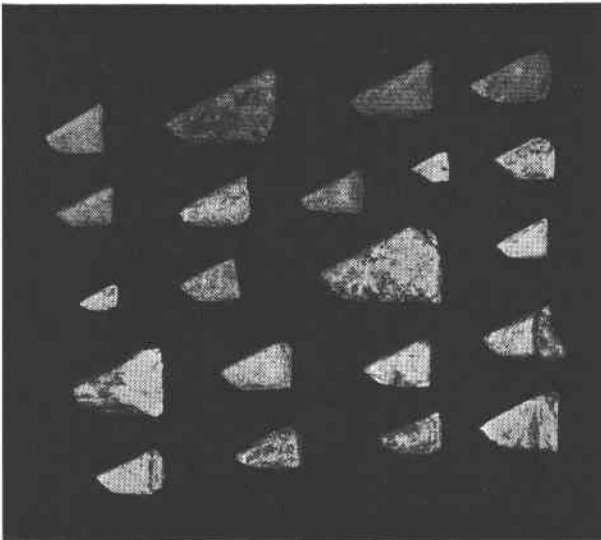


Fig. 1. Crystals of hilgardite lying on (010)
(Natural size)

[2] A more detailed paper on the paragenesis and crystallography of the minerals associated with hilgardite is in preparation.
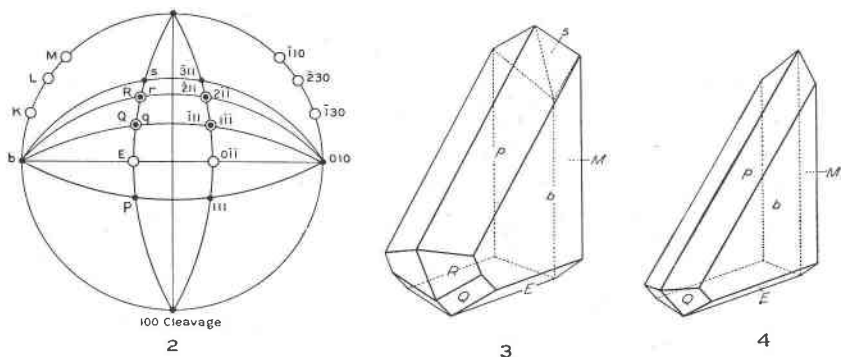
Fig. 2. Stereographic projection of hilgardite. The open points in the prism zone represent those forms found only at the back of the crystals; other open points are the poles of the parallel opposite faces.

Figs. 3 and 4. Hilgardite.

Although the characteristic form of most of the crystals is well preserved, either solution or abrasion has produced a matte surface on many of the faces so that goniometric measurements are difficult. However, two excellent cleavages, {010} and {100}, enable one to orient any crystal accurately and thereby obtain fairly good readings on the few measurable faces. Of forty crystals examined only seven were suitable for measurement. All of the crystals have $b\{010\}$ as the dominant form with $p\{111\}$, $M\{\bar{1}10\}$ and $E\{0\bar{1}\bar{1}\}$ well developed. $Q\{1\bar{1}\bar{1}\}$ is usually present, but the remaining forms are represented only by occasional faces. Two-circle measurements on the selected crystals are given in Table 1; and the elements and angles calculated from them in Table 2.

TABLE 1. HILGARDITE: TWO-CIRCLE MEASUREMENTS OF SEVEN CRYSTALS

| Forms | | Faces | Measured Range | | Measured Mean | |
|---|---|---|---|---|---|---|
| | | | $\phi$ | $\rho$ | $\phi$ | $\rho$ |
| b | 010 | 14 | 0°00′ | 90°00′ | 0°00′ | 90°00′ |
| K | $\bar{1}$30 | 2 | −18°11′ — −19°12′ | 90 00 | −18°11 | 90 00 |
| L | $\bar{2}$30 | 2 | −33 12 — −34 37 | 90 00 | −33 18 | 90 00 |
| M | $\bar{1}$10 | 4 | −44 30 — 44 54 | 89°57′ — 90°04′ | −44 35 | 90 01 |
| E | 0$\bar{1}\bar{1}$ | 3 | 180°00′ | 150 48 — 150 46 | 180 00 | 150 47 |
| p | 111 | 3 | 44 22 — 44 51 | 38 02 — 38 08 | 44 36 | 38 04 |
| Q | 1$\bar{1}\bar{1}$ | 1 | 135°34′ | 141°52′ | 135 34 | 141 52 |
| q | $\bar{1}$11 | 3 | −44 30 — −44 54 | 37 58 — 38 09 | −44 37 | 38 06 |
| R | 2$\bar{1}\bar{1}$ | 2 | 116 47 — 116 43 | 127°15′ | 116 45 | 127 15 |
| r | $\bar{2}$11 | 1 | −64°34′ | 51°48′ | −64 34 | 51 48 |
| s | $\bar{3}$11 | 2 | −69 52 — −71 38 | 60 30 | −70 53 | 60 30 |

TABLE 2. HILGARDITE: ANGLE-TABLE

Hilgardite—$Ca_8(B_6O_{11})_3Cl_4 \cdot 4H_2O$
Monoclinic; domatic—$m$

$a : b : c = 1.0147 : 1 : 0.5585$    $\beta = 90°00'$
$p_0 : q_0 : r_0 = 0.5504 : 0.5585 : 1$    $\mu = 90°00'$
$r_2 : p_2 : q_2 = 1.7905 : 0.9855 : 1$
$p_0' = 0.5504$    $q_0' = 0.5585$    $x_0' = 0.00$

| Forms | | Calculated | | | | |
|---|---|---|---|---|---|---|
| | | $\phi$ | $\rho = C$ | $\phi_2$ | $\rho_2 = B$ | $A$ |
| $b$ | 010 | 0°00' | 90°00' | — | 0°00' | 90°00' |
| $K$ | $\bar{1}30$ | −18 11 | 90 00 | 180°00' | 161 49 | 108 11 |
| $L$ | $\bar{2}30$ | −33 18½ | 90 00 | 180 00 | 146 41½ | 123 18½ |
| $M$ | $\bar{1}10$ | −44 35 | 90 00 | 180 00 | 135 25 | 134 35 |
| $E$ | $0\bar{1}\bar{1}$ | 180 00 | 150 49 | −90 00 | 119 11 | 90 00 |
| $p$ | 111 | 44 35 | 38 06 | 61 10½ | 63 55½ | 64 20 |
| $Q$ | $1\bar{1}\bar{1}$ | 135 25 | 141 54 | −61 10½ | 116 04½ | 64 20 |
| $q$ | $\bar{1}11$ | −44 35 | 38 06 | 118 49½ | 63 55½ | 115 40 |
| $R$ | $2\bar{1}\bar{1}$ | 116 54 | 129 00½ | −42 15 | 110 35 | 46 08 |
| $r$ | $\bar{2}11$ | −63 06 | 50 59½ | 137 45 | 69 25 | 133 52 |
| $s$ | $\bar{3}11$ | −71 18½ | 60 10½ | 148 48 | 73 52 | 145 15 |

## PHYSICAL AND OPTICAL PROPERTIES

The cleavage of hilgardite is perfect and easy parallel to {010} and just as good but difficult parallel to {100}. The hardness is 5. The specific gravity determined by suspension in bromoform is 2.71. On fresh surfaces it is clear and colorless with a vitreous luster. The optical properties of hilgardite are as follows:

|  | $n$(Na) | Positive |
|---|---|---|
| X : $c = 88\frac{1}{2}°$ | 1.630 ⎫ | |
| Y = $b$[010] | 1.636 ⎬ ±0.002 | 2V = 35° |
| Z : $c = 1\frac{1}{2}°$ | 1.664 ⎭ | $r > v$ |

## X-RAY MEASUREMENTS

Weissenberg photographs were taken of the zero and first layer lines with both $b$[010] and $c$[001] as the axes of rotation. These photographs gave an apparent orthorhombic net with the dimensions:

$$a_0 = 11.35 \text{ Å}, \quad b_0 = 11.12 \text{ Å}, \quad c_0 = 6.20 \text{ Å}$$

giving $a_0 : b_0 : c_0 = 1.027 : 1 : 0.559$. This ratio compares favorably with the morphological ratio: $a : b : c = 1.0134 : 1 : 0.5585$, but inasmuch as only poor crystals were available for goniometric measurement it is believed

that the x-ray data are more reliable. The density of hilgardite is 2.71, the volume of the unit cell 786 cubic Å, and hence the molecular weight of the unit cell $M_0 = 1290$.

Examination of the Weissenberg photographs showed certain spots to be missing that should be present in true orthorhombic symmetry. Accordingly, Laue photographs were taken normal to the {010} and {100} cleavages. The only symmetry element shown in the former is a two-fold axis, and in the latter only one reflection plane. The monoclinic character of hilgardite is thus definitely established even though the angle $\beta$ is 90°00′ and extinction angle is negligible.

Hilgardite falls in the space group $C_s^1$—$Pc$ or $C_s^2$—$Pm$ as determined by the space group criteria:

| $h00$ | halved |
|-------|--------|
| $0k0$ | halved |
| $00l$ | halved |
| $h0l$ | present for $h$ odd |
| $hkl$ | present for $h$ odd |
| $hkl$ | present for $h+l$ even |

### COMPOSITION

Table 3 gives the chemical analysis and the atomic content of the unit cell using the molecular weight, $M = 1290$.

TABLE 3. ANALYSIS OF HILGARDITE AND CONTENT OF UNIT CELL

|  | 1 | 2 | 3 | 4 | | 5 | |
|--|----|----|----|----|--|----|--|
| CaO | 34.41 | 35.14 | .6265 | Ca | 8.1 | CaO | 35.67 |
| $B_2O_3$ | 49.18 | 50.22 | .7211 | B | 18.6 | $B_2O_3$ | 49.86 |
| $H_2O$ | 6.31 | 6.44 | .3580 | $H_2$ | 4.6 | $H_2O$ | 5.73 |
| Cl | 10.37 | 10.59 | .2986 | Cl | 3.9 | Cl | 11.28 |
| Insol. | 1.89 | | | | | | |
|  | 102.16 | 102.39 | | | | | 102.54 |
| Less O | 2.34 | 2.39 | | | | | 2.54 |
|  | 99.82 | 100.00 | | | | | 100.00 |

1. Analysis by F. A. Gonyer. 2. Insolubles deducted. 3. Molecular ratio. 4. Atomic contents of unit cell. 5. Calculated composition for $Ca_8B_{18}O_{33}Cl_4 \cdot 4H_2O$.

Hilgardite belongs to the group of soluble borates, but the presence of chlorine makes it distinct from the others. A comparison of the chemical formulae below shows the relation that it bears to hydroborocite and colemanite.

| Hydroboracite | $MgCaB_6O_{11} \cdot 6H_2O$ |
|---------------|------------------------------|
| Colemanite | $Ca_2B_6O_{11} \cdot 5H_2O$ |
| Hilgardite | $Ca_8(B_6O_{11})_3 \cdot Cl_4 \cdot 4H_2O$ |

*Pyrognostics.* On charcoal before the blowpipe hilgardite fuses at 2 to a compact white globule, and colors the flame the yellowish green of boron. In the closed tube, water is driven off easily that gives a strong acid reaction. At a low temperature some chlorine is apparently driven off which dissolves in the water.

It seems fitting to name this new borate found in a salt well in Louisiana, hilgardite, after E. W. Hilgard, an early geologist of Mississippi and one of the first to make observations on the salines of Louisiana.

### Acknowledgments