CALIFORNIA STATE MINING BUREAU.

THIRD ANNUAL REPORT

OF THE

STATE MINERALOGIST

FOR THE YEAR ENDING JUNE 1, 1883.

SACRAMENTO:
STATE OFFICE, ... JAMES J. AYERS, SUPT. STATE PRINTING.
1883.

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CALIFORNIA STATE MINING BUREAU.

Part 2. Third Annual Report of the State Mineralogist.

REPORT

ON THE

BORAX DEPOSITS

OF

CALIFORNIA AND NEVADA,

GIVING THE PRODUCTION, CONSUMPTION, USES, HISTORY, CHEMISTRY, AND MINERALOGY OF BORACIC ACID AND ITS COMPOUNDS, AND OTHER GENERAL INFORMATION, WITH A MAP SHOWING THE PRINCIPAL LOCALITIES IN THE TWO STATES.

By Henry G. Hanks, State Mineralogist.

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BORAX MINERALS AND THOSE CONTAINING BORACIC ACID IN SMALL QUANTITIES.

BORAX.

Biborate of soda, native borax, or *tincal*, has been described in the body of this work. The chemical and mineralogical characteristics are given below:

It has a sweetish taste and an alkaline reaction. It dissolves in twelve parts of cold water and in two parts of boiling water. At a low heat it melts in its water of its crystallization; if the heat be continued, it swells and becomes a white porous mass. At a red heat it fuses into a transparent fluid, which becomes, when cold, a transparent solid resembling glass. Fused with fluorspar and bisulphate of potash it colors the blowpipe flame distinctly green. Luster, vitreous; color, white, gray, brown, pinkish, greenish; generally translucent, sometimes transparent; brittle, streak white; phosphorescent if powdered in the dark.

The most beautiful transparent and perfect crystals form at the borax works in weak solutions, which have been allowed to stand for a considerable time undisturbed. The purest natural crystals are found on the property of the San Bernardino Borax Company, which are shoveled into the tanks by the ton. They differ from the celebrated crystals from Borax Lake, Lake County, in being transparent and inclosing fluid in large cavities.

SASSOLITE.

Native boracic acid has been sufficiently described in the body of the work under the head of boracic acid.

ULEXITE.

Borate of Lime, Tiza, Boronatrocalcite, Natroborocalcite, Tinkatzit, Cotton Balls, Sheet Cotton, etc.

ULEXITE is a natural hydrated borate of lime and soda. This curious mineral was first found in the nitre beds of Peru in small quantities, in small globular concretions, showing when broken interlaced, silky-white crystals; sometimes also inclosed crystals of salt or gypsum. It was first examined by Ulex. His analysis of a specimen from Iquique, Southern Peru, gave:

Boracic acid	49.5
Lime	15.9
Soda	8.8
Water	25.8
Total	100.0

The mineral was afterwards analyzed by A. A. Hayes, who proposed the formula ($CaO, 2\ BO_3 + 6HO$). He supposed the soda found by Ulex to result from mechanically mixed glauberite. For some time this mineral was called "Hayesene;" but Dana, in the last edi-

tion of his work on mineralogy, gives it the name of Ulexite, in justice to the first observer.

The following extracts from "Mineraux du Pérou," by A. Raimondi, Paris, 1878, seem to show the analysis of Hayes to have been a mistake.

Ulexite was first found in the Province of Tarapaca, then named Borax or Tiza—lately found in the Cordillere de Maricunga, at an altitude of 3,800 meters (12,464 feet). Mr. Raimondi calls attention to a widespread error found in works on mineralogy, as to a borate of lime without soda, under the name of Hayesene, which, in his opinion, does not exist in Peru. In 1853, while in the employ of the Government of Peru, he visited all the known localities of the borates in the Province of Tarapaca. He examined a large number of specimens, and made a great number of excavations, and his conclusions were that the sample of borate of lime called Hayesene was Ulexite, or Boronatrocalcite. Ulexite was found for the first time in 1836–7, in Tarapaca, forty or fifty kilometers from Iquique, under the crust that covers the nitrate of soda beds, nearly always in little rounded masses from the size of a hazelnut up to that of a potato—color white, fibrous, and silky. Very often the balls of ulexite have in their interior a nucleus of glauberite. The first notice in the Scientific Press is found in the second edition of the mineralogy of Dana, 1844, page 243, in which the author says that he had received a communication from Mr. Hayes, descriptive of a new mineral, under the name of borate of lime (*borocalcius obliquus*). But in that description Mr. Hayes confounded borate of lime with glauber salt in a state of mixture:

I repeat here what I have already said, that I possess the most intimate conviction that the mineral described by Mr. Hayes as presenting rounded masses showing fibrous, white, silky crystals frequently accompanied by glauberite, is borate of lime and soda, and not simple borate of lime.

The many analyses which I made of all the specimens collected while Commissioner to the Government of Peru in 1853; the analysis made in 1855 by the distinguished chemist Rammelsberg, of the material which presented all the physical characters of the doubtful Hayesene, establishes in a manner nearly certain that in Peru there exists only a single combination of boric acid with lime, and that the combination is a double borate of lime and soda, described in works on mineralogy, under the name of ulexite or boronatrocalcite.

To complete what I have said on this important mineral, I give the composition of three specimens of boronatrocalcite found in a state of great purity in a very dry earth in the province of Tarapaca, which appear in the report which I presented to the Peruvian Government in 1854.

These results agree with those obtained by Rammelsberg, only the specimens analyzed by the latter were not pure, because the boronatrocalcite was mixed with a small quantity of chloride of sodium and sulphate of soda and lime.

ANALYSIS OF ULEXITE, OR BORONATROCALCITE.

Substance Found.	By A. Raimondi.			By Rammelsberg.
	(1)	(2)	(3)	
Boracic acid	42.98	43.13	43.04	42.12
Lime	13.94	14.14	14.06	12.46
Soda	6.96	6.92	7.05	6.52
Water	36.80	35.75	35.85	34.40
Chloride of potassium				1.26
Chloride of sodium	0.16	Traces.	Traces.	1.66
Sulphate of soda	0.12	Traces.	Traces.	0.81
Sulphate of lime				0.77
Total	100.96	99.94	100.00	100.00

Notwithstanding the fact that Mr. Raimondi failed to find hayesene there seems to be such a mineral, *a hydrous borate of lime, without soda.* Mr. N. H. Darton (American Journal of Science, 1882,) describes a mineral from Bergen Hill, New Jersey, to which he gives the name of Hayesene, which had the following composition:

Lime	18.39
Boracic acid	46.10
Water	35.46
Total	99.95

Soda, silica, and magnesia, traces.

Ulexite is found at a number of localities on the Pacific Coast, some of which have been noticed elsewhere in this paper. It occurs in rounded concretions, from the size of peas to masses ten or twelve inches in diameter. Unless the so called cotton balls are carefully selected by hand the percentage is greatly reduced by the admixture of sand, worthless soluble salts and water. Much disappointment has been experienced from this cause. Shipments have rarely failed to be much lower grade than was expected.

As early as 1871, in the examination of ulexite and impure borates from the then newly discovered Columbus marsh borax fields, I accidentally discovered that very impure borate of lime in the cotton ball form could be concentrated and purified by very simple mechanical means, which information was given to the public in a report to the Nevada Consolidated Borax Company, November 11, 1871, in the following words:

> Crude borate of lime can be easily and cheaply concentrated by simple mechanical treatment with cold water, in which it is nearly insoluble. A large vat should be constructed, in which the crude material is to be placed with a quantity of cold water. The contents of the vat must be kept in slow agitation by the proper machinery, until the borate of lime has been reduced to a pulpy form, and all mechanical impurity has settled to the bottom. When these conditions are fulfilled, a plug is withdrawn, and the contents of the tub allowed to run into a settling vat. Care must be taken not to allow the sand and other impurity to flow out with the purified borate of lime. In the settler the borate of lime will soon fall to the bottom, and the clear portion, which contains biborate of soda (if that salt was associated with the borate of lime), may be recovered by proper crystallization.
>
> The purified ulexite may then be thrown on an inclined platform and allowed to drain, and then be dried in the sun.
>
> The borate of lime so purified should have nearly the composition of the best natural product.

As borate of lime is quite voluminous in this condition, it should be compressed by powerful screws into a smaller bulk, as crude cotton is treated for the same reason. Ulexite containing twenty-four per cent of boracic acid has a market value in London of £18 per ton of 2,240 pounds.

There is a variety of ulexite called *sheet cotton* by the prospectors, which is sometimes quite overlooked. It is granular in appearance, but under the microscope it is seen to be ulexite in minute silky crystals. There is a specimen in the State Museum (No. 3590) which shows both varieties. Ten tons of boracic acid was made from this substance at the Phœnix Chemical Works at Columbus, Esmeralda County, Nevada, of which Mr. H. S. Durden was Superintendent. A sample of this acid (No. 3591) may also be seen in the State Museum. The following mechanical analyses of crude ulexite show the nature of the impurities:

No. 1.

Sand	9.25
Water hygroscopic	21.00
Soluble salts, mostly sulphate of soda and salt	17.36
Borate of lime	52.39
	100.00

No. 2.

Sand	trace.
Water	36.80
Soluble salts	11.04
Borate of lime	52.16
	100.00

CRYPTOMORPHITE.

Cryptomorphite is a very rare mineral, found with glauber salt, only in Nova Scotia, at one locality. It is white, without luster, soft, in kernels the size of a pea. When a small portion is placed under the microscope and magnified 100 diameters, the mineral is seen to consist of rhombic plates, from which the name is derived, meaning hidden form.

ANALYSIS BY HOWE.

Boracic acid	58.5
Lime	15.6
Soda	5.8
Water	20.1
	100.0

PRICEITE.

In October, 1871, Lieutenant A. W. Chase brought to the Academy of Sciences of San Francisco a sample of chalky substance which he thought to be magnesia. A small sample was given to me for examination, which I turned over to a pupil, Mr. E. J. Shipman, who spent some time over it and reported it to be borate of lime. Never having seen borate of lime in this form, I requested him to repeat his experiments, which he did, and with the same result. I then made an examination of the mineral myself, both chemical and microscopical, which led me to class it with *cryptomorphite.* The appearance under the microscope was so characteristic that I had no doubt as to its identity. At the evening meeting, November sixth, Lieutenant Chase presented it to the Academy of Sciences. Subsequently two samples were analyzed by Thomas Price, of San Francisco, which gave the following result:

	1.	2.
Boracic acid	47.04	45.20
Lime	29.96	29.80
Water	22 75	25.00
Alkalies	.25	traces.
	100.00	100.00

In 1873, Professor Silliman made a study of this mineral, and obtained the following mean of three analyses:

Boracic acid	49.00
Lime	31.83
Water	18.29
Alumina, salt, and oxide of iron	.96
	100.08

The absence of soda separates this mineral from ulexite and cryptomorphite, and seems to make it a new species, named as above by Professor Silliman. After studying this mineral and examining many specimens, I am led to believe that it is changed from ulexite by the abstraction of the soda and part of the water. I have a specimen of colemanite which has undoubtedly changed from a ulexite cotton ball.

PANDERMITE

Is a variety of priceite. The following extracts from The London Journal of the Society of Arts, August 6, 1880, by C. C. Warnford Lock, affords all that is known relating to this mineral:

I have now to deal with a new commercial borate, which, on the score of geographical position, abundance, cheapness of working, and easy manipulation, is certainly destined in a great measure to rule the markets of Europe, and particularly of Great Britain.

The new field lies on the Tchinar-Sau, a small stream feeding the Rhyndacus River, whose outlet is in the Sea of Marmora, near the port of Panderma, on the Asiatic shore. It embraces the villages of Sultan-Tchair, Yildiz, and Omerli, and the guard-house of the Demircapon pass. The area of the field is computed at over 13,000 acres (20 square miles). Its eastern confines nearly abut upon the Rhyndacus, which has been navigated by steamers up to a point called Balakeser. A company has been formed for deepening and improving the stream, and a railway has been projected from Panderma to Balakeser. The wagon road has hitherto been utilized for transporting the mineral, the distance from Panderma to the western edge of the field being about forty English miles. The port of Panderma is regularly frequented by local steamers, and offers every convenience for shipping.

The field is situated in a basin of tertiary age, surrounded by volcanic rocks, which vary from granite on the east to trachyte on the north, and columnar basalt on the west. Several basaltic hills and dikes protrude in different portions of the basin, and the presence of hot and mineral springs further testifies to the volcanic influences which have been at work, and in which, doubtless, originated the boracic mineral. The latter occurs in a stratum at the bottom of an enormous bed of gypsum, its greater specific gravity probably impelling it downwards while the whole mass was yet in a soft state. Several feet of clay cover the gypsum bed, which is here 60 to 70 feet thick, though in places it attains to double that thickness.

The boraciferous stratum varies in depth; it has been proved for a vertical distance of forty-five feet. The mineral exists in closely-packed nodules, of very irregular size and shape, and of all weights up to a ton. Von Rath has named it "Pandermite," from the port of shipment.

In outward appearance it closely resembles a snow-white, fine-grained marble. Chemically speaking, it is a hydrous borate of lime, its composition being expressed by the formula $2CaO, 3B_2O_3, 3H_2O$; in other words, it consists of boracic acid 55.85 per cent; lime, 29.78 per cent, and water 14.36 per cent. Its richness in boracic acid is at once apparent, and places it high above the other commercial borates. Thus ordinary borax (borate of soda) contains only 36.58 per cent of the acid; boro-calcite and boronatro-calcite (borates of lime and of lime and soda) vary from 8½ per cent up to 46 per cent, and average about 40 per cent, boracite and stassfurtite (borates of magnesia), containing respectively about 63 per cent and 60⅔ per cent, alone surpass it in this respect, and they can hardly be deemed commercial minerals. After very simple preparation pandermite can be very directly applied as a flux, and is more economical than borax for this purpose, thanks to its larger proportion of boracic acid.

An outcrop of the mineral was discovered by a foreigner some years since, and the bed was secretly worked; small shipments were occasionally made to Europe under the denomination of plaster of Paris, thus keeping the matter hidden, and at the same time avoiding the payment of dues and duties. The Ottoman Government has since been apprised of these irregularities and has taken energetic measures to correct them. More recently it has granted a comprehensive concession to a party of British residents, who are setting to work to develop the property. The district enjoys the great advantage of being under British protection.

The workings were at first placed under that section of the Réglement des Mines relating to quarries, but have since been transferred to the section regulating mines proper. Steps are being taken to open up the deposit in a systematic manner, by first sinking a number of boreholes—as has been done with the Kainit beds at Stassfurt—to ascertain the point of greatest development in the basin. The locality possesses a healthy climate, except in the Autumn, when there is some ague.

Labor is very cheap and abundant, Turks, Armenians, Greeks, Circassians, Tartars, and Italians being obtainable from the neighboring villages. There is a supply of water; oak and fir timber may be procured at six to seven miles distant, and scrub for fuel covers the surrounding hills.

The actual cost of the mineral, as now worked, is as follows:

Raising and dressing (exclusive of cost of tools)	10.0 paras per oke
Transport to Panderma	9.0 paras per oke
Customs duty, 1 per cent ad valorem	.5 paras per oke
Management and other charges	2.5 paras per oke
Total	22.0 paras per oke

	£	s.	d.	
At 795⅛ okes per ton, and 128¼ piastres per £ sterling (1 piastre=40 paras) this will equal	3	8	3	per ton
To this must be added government royalty, 5 per cent ad valorem, say	0	5	0	per ton
Contingencies	0	10	0	per ton
Freight and insurance	0	15	0	per ton
Making a total cost, "c., f., and i."	£4	18	3	per ton

The present values of the boracic products now in the market vary from £46 to £60 per ton, according to quality; the lowest figure ever reached here has been about £20 a ton, at which price the demand would immensely increase.

Pisani, of Paris, analyzed this mineral and obtained the following result:

Boracic acid	50.1
Lime	32.0
Water	17.9
	100.0

It will be found stated elsewhere that the variety pandermite has recently been found in apparent abundance in Death Valley, Inyo County, and at Calico, San Bernardino County, and the cryptomorphic variety at the latter locality.

COLEMANITE

Is also a variety of priceite found recently in Death Valley. The following analysis was made by Thomas Price, of San Francisco, March, 1883, by whom the original priceite was first analyzed:

Anhydrous boracic acid	48.12
Lime	28.43
Water	22.20
Alumina and oxide of iron	.60
Silica	.65
	100.00

In the analysis of colemanite, the alumina, iron, and silica are probably mechanical impurities—1.25 being added proportionately to the other constituents, gives the following percentage:

Boracic acid	48.72
Lime	28.79
Water	22.49
	100.00

This gives the approximate formula $4Bo_3, 3CaO, 6HO$, which is the same obtained by Silliman for priceite, which no doubt it is in a crystalline state. As this mineral possesses certain physical properties differing from priceite, the name colemanite has been given to it

to distinguish it from the soft chalky mineral found both in southern Oregon and San Bernardino County, California.

The name *colemanite* was given by the discoverer of the mineral in honor of William T. Coleman, of San Francisco, who has been identified with the borax interests of the Pacific Coast from the commencement.

PROPERTIES OF COLEMANITE.

Color and streak white; milky to transparent; hardness 3.5—4; specific gravity, 2.39; before the blowpipe exfoliates, decrepitates violently, and melts imperfectly; after considerable heating it imparts a reddish yellow color to the flame, which changes to green. The mineral pulverizes easily, fragments obscurely rhombic. It is wholly soluble in hydrochloric acid with heat. From the solution boracic acid crystallizes on cooling. The filtrate gives a white precipitate with ammonia and oxalate of ammonia. With sulphuric acid, or with fluorspar and bisulphate of potash, tinges the blowpipe flame green. Luster of the mineral vitreous to adamantine. It shows no perfect crystals, but appears like semi-crystalline calcite.

BECHILITE

Is a borate of lime without soda, and therefore resembling priceite, found by Bechi, from whom it was named, as an incrustation, at the baths of the lagoons of Tuscany.

The following analysis is by Bechi:

Boracic acid	52.2
Lime	20.9
Water	26.9
	100.0

Very little is known about this mineral, which was found only in small quantities. It has physical properties resembling ulexite and priceite.

HOWLITE,

A silicious borate of lime, is found in small imbedded globules in gypsum at Brookville, Nova Scotia.

Analysis by How:

Silica	15.25
Boracic acid	44.22
Lime	28.69
Water	11.84
	100.00

This mineral is too rare to have any commercial value.

TABLE SHOWING THE SIMILARITY OF THE BORATE OF LIME MINERALS.

	Ulexite.	Cryptomorphite.	Priceite.	Pandermite.	Colemanite.	Bechilite.	Howlite.
Boracic acid	43.04	58.50	49.00	55.85	48.72	52.20	44.22
Lime	14.06	15.60	31.83	29.78	28.79	20.90	28.69
Water	35.85	20.10	18.29	14.36	22.49	26.90	11.84
Soda	7.05	5.80					
Silica							15.25
	100.00	100.00	99.12	99.99	100.00	100.00	100.00

RHODIZITE.

Rhodizite—named from a Greek word meaning resemblance to a rose, from the red color imparted to the blowpipe flame—is a very rare mineral, found only in minute crystals on red tourmaline at one locality in the Ural Mountains. These crystals are modified dodecahedrons, so small that sufficient cannot be obtained for analysis, for which reason its chemical character is uncertain. Dana considers it a lime boracite, while Gmelin describes it as a borate of lime. Before the blowpipe it fuses with difficulty to an opaque glass, tingeing the flame first green and then red.

WARWICKITE

Is a borate and titanate of magnesia, with iron, alumina, and silica. The following analysis is by J. Lawrence Smith, who made a reëxamination of it in 1853:

Boracic acid	27.80
Titanic acid ($Ti O_2$)	23.82
Magnesia	36.80
Sesqui-oxide of iron	7.02
Alumina	2.21
Silica	1.00
	98.65

Hardness, 3—4; specific gravity, 3.188; color, dark brown, sometimes copper red; fracture, uneven, brittle.

This is a very rare mineral, first described by Professor C. U. Shepard, and named from Warwick, New York, the first locality. It was first supposed to be a titanate of magnesia and iron. The presence of boracic acid was discovered by Smith. It is too rare to have any commercial value, but is interesting as showing that borax minerals may exist more plentifully than is generally supposed, and that it may be to their decomposition that free boracic acid and the soluble borates are due. It occurs in a granular limestone at the locality mentioned.

LAGONITE.

Named from the lagoons of Tuscany, another rare mineral, is a borate of iron, found in earthy masses of yellow ochre, and is an incrustation at the Tuscan lagoons.

ANALYSIS BY BECHI.

Boracic acid	47.95
Sesqui-oxide of iron	36.26
Water	14.02
Magnesia, lime, and loss	1.77
	100.00

LARDERELLITE.

Named from Count Larderell, is a hydrated borate of ammonia, found in the lagoons of Tuscany. It occurs in small crystalline rhomboidal plates. It is a rare mineral, never found in quantities sufficient to have any commercial value.

ANALYSIS BY BECHI.

Boracic acid	68.556
Ammonia	12.734
Water	18.325
	99.615

BORACITE.

This mineral occurs crystallized and massive; color, white, gray, yellow, and green, streak white, fracture conchiconchoidal, uneven; sub-transparent, translucent. The massive variety which is found at Stassfurt, Prussia, under the name of *stassfurtite*, is white and hard, resembling fine grained marble; vitreous luster, inclining to adamantine; hardness, 7; specific gravity, 2.83, 2.98; pyroelectric; soluble in acids. The crystals, which are isometric or tetrahedral, have the following composition ($3MgO\ 4BO_3 + \frac{1}{2}\ Mg\ Cl$):

Boracic acid	62.33
Magnesia	27.03
Chlorine	7.91
Magnesium	2.73
	100.00

The massive variety contains sometimes six per cent of water. The boracite crystals found in the kainite beds at Stassfurt are soft and form a slimy mass with water.

The massive variety gives water in a closed glass tube; fuses in the blowpipe flame easily to a white crystalline glass, coloring the flame at the same time distinctly green; with oxide of copper on charcoal, colors the flame azure blue; soluble when powdered, in dilute hydrochloric, sulphuric, and nitric acids, found at several localities in Europe, notably at Stassfurt, Prussia, associated with salt, gypsum, and anglesite. It is reported also in Turkey, as shown by the following extract from a consular report; but as borate of lime is given as a synonym, there is some doubt as to the character of the mineral mentioned. A reference to the description of pandermite will show that the locality, if not the mineral, is the same:

[August, 1881.]

MINES AND MINERALS OF TURKEY.

[Report by U. S. Consul-General HEAP, of Constantinople.]

BORACITE (BORATE OF LIME).

This is found at Moulreh, near Yeddis, on the Asiatic side of the sea of Marmora, where one mine has been in operation for six or seven years, and another has recently commenced delivery. The present annual yield is 4,000 to 5,000 tons, of which 4,000 tons are exported to France, where it is worth from $75 to $87 per ton, delivered; the freight from Kaloninie, where it is usually shipped, ranging from 30s. per ton for sailing-vessels to 21s. per steamers. The first cost of boracite is very little.

HYDROBORACITE

Is a mineral which resembles gypsum. It is represented by a single specimen in a collection of minerals in Europe.

The following analysis is by Hess, who first noticed it: