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Helena and Ennis Talc Deposits

Howard N. Anderson

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HELENA AND ENNIS TALC DEPOSITS

BY

Howard N. Anderson

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements of the Degree of
Bachelor of Science in Geological Engineering

Montana School of Mines
Butte, Montana
May, 1942
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HELENA AND ENNIS TALC DEPOSITS

Introduction

The purpose of this report is to collect geologic data concerning two Montana talc occurrences at Helena and Ennis and to offer some explanation as to their origin. The two deposits cited are in somewhat similar lithologic settings and both possess the same mineralogical and structural features. Because of this similarity only the Helena deposit is covered in detail. The ages of the country rock in the two deposits differ greatly (pre-Cambrian and Mississippian) but the modes of formation are undoubtedly the same. Both are in dolomites in regions of igneous intrusions.

Field work was done in October and November of 1941 and in April 1942 during which three trips were made to the Helena deposit and one to Ennis. Much of the most valuable information on the Helena deposit was not available until the spring of 1942 when Mr. McKelvey, owner, drove a development drift into the south side of the deposit.

Mapping was done by means of a Brunton compass, sight alidade, and plane table. Distances were measured by pacing.

The writer wishes to thank Frank Casey of Helena and Mr. McKelvey, owner and operator of the deposit, for assistance while working on the Helena deposit. Appreciation should also be expressed to Lewis Clark, co-owner of the Ennis talc deposit, for contributing information regarding that occurrence.
Mineralogy and Characteristics of Talc

Talc is a hydromagnesian silicate (H$_2$Mg$_3$(SiO$_3$)$_4$ or 3 MgO · 4 SiO$_2$·H$_2$O) composed of 31.7% magnesia, 63.5% silica, and 4.8% water. Nearly all talcs contain small amounts of alumina, iron, lime, and in some cases, nickel. Its color may be white, pale green, dark green, dark gray, or resinous brown. The green variety is by far the most common. Chemically it differs from serpentine only in the amount of water present. Serpentine forms by simple hydration of rock consisting of enstatite and olivine and contains twice the amount of water that is present in talc. It is a soft (H=1) sectile, mineral with a pearly luster and soapy or greasy feel. Its specific gravity is 2.8. The structure of talc is most commonly foliated or massive.

Deposits formed by alteration or tremolite are often psuedomorphous after the tremolite and therefore preserve its fibrous texture. It is chemically inert and therefore is not attached by acids or alkalies. Fusion takes place at a high temperature; over 1200 degrees centigrade or 2000 degrees Fahrenheit. It also has a low conductivity for heat and electricity.

There are few minerals that are likely to be mistaken for talc. Serpentine and brucite most closely resemble this material, but it is softer than either of these.

Varieties:

Foliated talc: The micaceous or laminated, semi-translucent variety.

Talc schist: A rock composed entirely or partly of talc flakes having parallel orientation.

Soapstone: A massive, fine-grained talc generally sufficiently compact to be sawed into blocks, - the impure variety.

Steatite: Same as soapstone.

Rensselaerite: Talc derived from pyroxene and which retains the form of pyroxene.
Pseudomorphs: Tale is frequently pseudomorphous after such minerals as enstatite, pyroxene, amphibole, and chrysolite.

Tale may be formed from any magnesian amphibole or pyroxene if acted upon by H₂O and CO₂ according to the following reaction:

\[ 4Mg\text{SiO}_3 - CO_2 - H_2O = H_2Mg_3Si_4O_12 - MgCO_3 \]

All of the notable deposits of the United States are associated with intrusive igneous bodies either directly or indirectly.

Utilizing Talc

The physical and chemical properties of talc vary greatly as is commonly the case with non-metallics. The use to which a talc is to be put, depends of course, upon its properties; talc that is satisfactory for one purpose may be totally undesirably for something else, just as all clays will not make good bricks. Some of the properties of ground talc which should be determined to find its adaptability to various uses are:

Physical properties: grain size, shape of grains, color, impurities, malting point, vitrification range, adsorption, bonding strength, colloidal properties.

Chemical properties: presence of lime, iron, and other impurities, amount of uncombined water.

Uses:

Paper

Probably the largest use of talc is as a paper filler or in loading material in paper. The manufacture of newsprint consumes the largest quantities. For the manufacture of the finest grades of paper the requirements are: freedom from grit, alkalies, and carbonates; a fine grain size. Talcs are cheaper and in some respects superior to the white clays now being used.
Lava Gas-Tips and Electrical Insulation

The term "lava" is used as a trade name for talc that has been heat-treated. Certain varieties of talc, when heat-treated, will form a material of great strength, hardness, tenacity, resistance to high heat, compressive strength, and a high dielectric strength. The lava is used in a great variety of forms for gas-tips and burners and for heat and electrical insulation. "Lava grade" talc must be fine grained, homogenous, compact, fairly soft, and must contain little or no water.

The aënis talc cited in this report is of "lava grade".

Pottery

Talc has been used in large quantities in the ceramic industry as a filler in pottery and porcelain ware. European countries, especially Germany, are far ahead of the United States in this respect. It promotes the translucency of the ware and also produces a more vitreous product. The main value of using talc in the ceramic industry lies in its cheapness as compared to china clay.

Paints

For a number of years talc has been used as a filler in the manufacture of mixed or ready-prepared paints. Some of the essentials of a mineral filler for paints are; fineness, good color, freedom from grit, and uniformity. Paint-trade talc is known as talcose, soapstone, and talc. It was first regarded as an adulterant, but tests later showed that it had valuable properties that improved the paints. Some fire resistant paints contain over 30 per cent talc.

Other

A few of the other uses are: lubricants, linoleum and oil cloths, textiles, cosmetics, insulation, glass, cement and plaster, color crayons, water filters, molds for casting metals, refractory brick, putty, polishes and many others.
Occurrences

United States:

Vermont is the largest talc producing state. Over 7,000,000 tons have been blocked out by only two companies. New York was the leading producer for many years and still produces nearly as much as Vermont at present. A fibrous variety known as asbestine is mined. California produces a very high-grade variety of pure white, talc suitable for toilet purposes. North Carolina is on the decline as a talc producer, but in the past large quantities of talc for pencils and lava products have been mined.

Foreign:

Italy produces the world's best talc. The main use for this product is medicinal purposes, toilet powder, and lava blanks. France is an important producer of toilet and lava grades. Canadian talcs are being produced in increasingly larger quantities and command a slightly higher price than United States talcs.
THE HELENA DEPOSIT

Location and Accessibility

The Helena talc deposit is just south of the city limits of Helena, Montana about a thousand feet from the edge of the residential district. It is situated on the west bank of Grizzly Gulch about 100 feet above the creek bottom. The area is easily accessible by car or by foot since it lies beside a good road at the outskirts of Helena.

Topography

The topography of the immediate region is quite rough although the relief is not over 200-250 feet. Grizzly Gulch cuts across a series of tilted limestone beds perpendicular to their strike. No prominent cliffs have been formed in spite of the fact that much of the rock has been laid bare by erosion. The few small creeks of the region have adjusted themselves to the structure following the least resistant bedding planes of the upturned Madison limestone. The accompanying photograph shows the topography well.

Stratigraphy

Only strata of the Devonian and Mississippian periods are present in the area covered. The Madison limestone, lower Mississippian, is the predominant rock and covers about 95 per cent of the region. As may be seen by the geologic map on the following page, this formation crops out along Grizzly Gulch for a total distance of 6000 feet, interrupted only once by an exposure of faulted Three Forks shale (Devonian) just south of the deposit. In general, the beds of sediments are dipping to the south at 45 degrees, and have a strike of north 45 degrees west. The dip ranges from 22 degrees, south on beds 1000 feet north of the deposit to 45 degrees in the immediate vicinity of the talc. The Three Forks formation shown in the photo has been
Map of Montana showing the location of the Helena and Ennis Deposits

- Missoula
- Great Falls
- Helena Deposit
- Butte
- Ennis Deposit
thrust up by normal faulting that has taken place along the valley south
of the talc exposure. Another fault of lesser magnitude occurs along
Grizzly Gulch.

Three Forks Formation (Devonian)

The Three Forks formation consists mainly of green fissile shale in the
lower portion of the outcrop grading into interbedded shales and limestone
near the top. About 50 feet have been exposed by movement along the fault
mentioned on the preceding page. The strike of this faulted portion is
north 50 degrees west and dip is 48 degrees northeast.

The lower 30 feet consist of gray to dark green, fissile, shale with
cleavage planes spaced about \(\frac{1}{4}\) inch apart. The surface and joint planes are
colored dark brown with iron oxide stain. Dendrites of \(\text{MnO}_2\) are common, and
vary in color from dark brown to black. No fossils or worm tracks are
present.

The upper 20 feet of the formation differs lithologically from the lower
portion in that an abundance of limestone concretions and nodules are present.
In some places the limestone concretions are lenticular and sometimes appear
as strata interbedded with the shale. More often, however, they appear to be
tabular concretions lying along the bedding planes. The photograph on plate
VI shows this interbedding as it occurs in the upper portion of the formation.
About 20 feet from the top of the Three Forks is a pronounced change in color:
from a dark green to a light greenish brown. This last 12 feet is mostly tan
limestone interbedded with darker, tanish-green limestone. The contact with
Madison is marked by a conglomerate of well rounded light brown limestone
pebbles bonded by a limestone cement.

Madison Formation (lower Mississippian)

The Madison is by far the most important formation present both because
of its thickness and extent and because of the fact that the talc occurs
General view of the Helena deposit, looking northwest. The fault along the valley on the left side of the photograph has resulted in the exposure of the Three Forks and lower Madison shown in the central lower part of the picture. About 50 feet of Three Forks shale has been exposed by this normal faulting. The adit shown on page 20 has been driven at the point marked with an X since the picture was taken. The white spots in the valley are dumps from the mines that were operated here during the 1930s. The white mark on the distant cliff marks the western most limit of the mine outcrop.
The most notable thing about this formation in this vicinity is its unusual high magnesium content. Ordinarily it is practically free from this element. This happens to be a local condition probably due to introduction of the magnasium by igneous solutions which resulted in this dolomitization of the limestone and formation of inclusions of magnesite. This action was pre-faulting since the fault gouge contains pebbles of the dolomite and magnesite showing evidence of brecciation. According to analyses of the Madison "lime" several feet from the talc outcrop the composition is as follows:

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<tbody>
<tr>
<td>Silica</td>
<td>1.10%</td>
</tr>
<tr>
<td>Fe$_2$O$_3$ and Al$_2$O$_3$</td>
<td>.80</td>
</tr>
<tr>
<td>CaCO$_3$</td>
<td>54.60</td>
</tr>
<tr>
<td>MgCO$_3$</td>
<td>43.30</td>
</tr>
<tr>
<td></td>
<td>99.80</td>
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An analysis given the writer by Mr. McKelvey made on the burnt line from a quarry 150 feet to the north of the talc body shows the following results:

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<tbody>
<tr>
<td>Silica</td>
<td>2.10%</td>
</tr>
<tr>
<td>Fe$_2$O$_3$ and Al$_2$O$_3$</td>
<td>1.60</td>
</tr>
<tr>
<td>CaO</td>
<td>57.20</td>
</tr>
<tr>
<td>MgO</td>
<td>39.00</td>
</tr>
<tr>
<td></td>
<td>99.9</td>
</tr>
</tbody>
</table>

Analyses show that the magnesium content is consistently high throughout the Madison of this area.

The Lodge Pole, or lower member of the Madison formation, lies conformably on top of the Three Forks. The basal conglomerate of light colored limestone pebbles has been mentioned above. The marked difference in color and relatively thin bedding makes the lower member of the Madison easily distinguishable from the upper Mission Canyon member. The stratum directly above the Three Forks-Madison contact is light gray, saccharoidal, and thinly bedded. Between 10 and 20 feet from the contact the limes begin to darken and show a mottled appearance. The dark blotches causing this variation
GEOLGY MAP

OF

The Area Surrounding The Helena Talc Deposit

1" = 500'
in color are magnesite inclusions in the dolomite. At 40 feet above the contact the first signs of talc appear. A band of yellow, soft, clay-like, talc occurs along a bedding plane associated with angular fragments of the country rock. The mottled rock continues without much variation for 250 feet up the hillside. (see photograph) Then, at the crest of the hill the mottled dolomite abruptly stops and the white, saccharoidal, massive, upper Mission Canyon member shows up. This member accounts for most of the Madison exposed in this locality.

**Igneous Rocks**

Adjacent to the Madison (see map) on the south there occurs a dike of a basic intrusive 120 feet wide. The exposed rock is colored a dark brownish red from alteration of the iron to limonite. Freshly broken samples show a high percentage of ferromagnesium minerals present in the form of roughly spherical grains, and comprising about 40 per cent of the rock. Judging from the aphanitic ground mass, color, and phenocrysts the rock is an intrusive andesite. A hundred feet to the south of this dike granitic rocks typical of the boulder batholith are exposed.

**Other Sediments**

Just south of the andesite described above there occurs 100 feet of a crystalline, vitreous, white, limestone. Due to its vitreous luster, at first glance the rock looks like a pegmatite intrusive of "bull quartz". The weathered surface is dark brown and sugary hiding the true character of the rock beneath. Bedding is very poor but the general strike and dip are north 40 degrees west and 50 degrees southwest respectively. Several small intrusions of a biotite-rich diorite cut the lime and have resulted in the formation of small amounts of epidote and traces of other skarn minerals. A prospect pit has been dug into the andesite-limestone contact on the south side of the creek (see map) and there are some signs of sulphide mineralization.
Contact between the Lodge Pole (lower) and the Mission Canyon members of the Madison formation. The dark, mottled color of the Lodge Pole may be plainly seen. Nearly all of the talc occurs in this magnesite-rich member. Most of the area is covered by the white, weathered, Mission Canyon.
Interbedded greenish tan and gray limestones near the Madison-Three Forks contact. The upper 20 feet of the Three Forks are composed of these interbedded limestones and shales. Near the top of the photograph may be seen the basal conglomerate of well-rounded limestone pebbles that marks the contact. The first signs of talc appear 40 feet above this contact.
Alluvium

The alluvium is composed of angular fragments of light gray, limestone pebbles, probably eroded from the Madison, embedded in clay. The material ranges in size from silt to pieces two and three inches in diameter, and is poorly sorted although there are some signs of stratification. A small percentage of the alluvium is quartz, especially the material of silt-size.

Mineralogy

The Helena talc is characteristically a snow-white, massive to foliated, material showing rich streaks of a white, powdery variety of CaCO₃. Its specific gravity is 2.80, hardness 1, and it has the soapy to greasy feel and sectility that is characteristic of all talc. Lime concentrations are found mainly at the contact with the country rock and around included horses of unaltered dolomite. The purest talc occurs near the center of the body away from the contact. This limey part of the ore is discarded as waste during mining operations, but in spite of careful selection 10 per cent of the first shipments had to be discarded when they arrived at the mills in the east because of high lime content.

Associated minerals are few. Calcite nodules containing concentrations of black magnesite are commonly found scattered throughout the deposit. These inclusions or concretions are composed of a hard crystalline variety of calcite breaking with a hackly fracture and showing a vitreous luster. Pieces of unaltered country rock are abundant throughout the deposit. Solution, or replacement, action has rounded these inclusions of dolomite to nearly spherical boulders. Nearly all are coated with a film of white powdery calcite. Silica is also quite common especially near the borders of the talc body. Its presence would be the logical result of an invasion by silica-rich solutions.
Contact between the talc and dolomite. The angular-grained material on the right is dolomite containing stringers of limonite and some inclusions of magnesite. The left half is composed of talc with several scattered grains of unaltered dolomite.
Petrographic Study

Several thin sections of the contact rock were made and studied with a petrographic microscope to determine the nature of the alteration. The photograph on the following page shows this contact. On the right hand side is the characteristic angular grain pattern of calcite which, in this case, has been dolomitized. Small inclusions of magnasite are evident throughout the dolomite together with streaks of iron oxide. The black streak extending through the dolomite from the lower right to the center is limonite. In fact, a thin line of this mineral was evident along nearly all of the contact zone. Talc and dolomite comprise about 90 per cent of the section with magnesite and limonite making up the rest.

The white, fibrous to platy, material on the left hand side is the talc. Reminders of unaltered crystals of dolomite may still be seen scattered through the white talc showing the replacement character of the contact. The alteration has taken place "along a front" that is, it has proceeded as a wave instead of replacing from numerous capillary openings or fractures. Otherwise the thin section would show talc inclusions in the mass of dolomite and not such a clear-cut division between the two.

Talc is thought to crystallize in the monoclinic system but no euhedral crystals have yet been found. The indices are; alpha = 1.539, beta = 1.589, and gamma = 1.589. A 010 section therefore shows high birefringence and the 001 section, that is, parallel to the cleavage, is practically isotropic. Since all sections happened to be parallel to 010 the talc and dolomite division was easily distinguishable. In sections of the Ennis material, however, the talc appeared isotropic and was consequently hard to distinguish from the dolomite country rock.
General Character of the Helena Deposit

The bulk of the Helena talc is concentrated in one body on the west bank of Grizzly Gulch but a thin outcrop is evident for over a thousand feet to the west of this point. The photograph on plate II clearly shows the extent of this outcrop. However, where the vein is thin the talc is of poor quality and varies from nearly pure lime to a lime-rich talc. Most of the outcrop is covered by talus and is evident only in the form of float. The above mentioned body is the only commercial occurrence yet discovered in the district.

It is very irregular but is roughly lenticular with the long axis oriented a little west of south. The dimensions are eight feet high, six feet wide, with a present stope length of 35 feet. These dimensions are of the drift left after the talc has been mined and is therefore the maximum reached by the vein. Boulders or horses of country rock are very common and are a detriment to mining. The character of the vein may be seen in the photograph on plate IX. The irregularity of the vein and the presence of faults makes mining hazardous. In the tunnel mentioned, the talc was terminated by a fault at a distance of 35 feet from the surface. According to Mr. McKelvey, owner of the property, the talc is always found in the "blue lime" that is, the dark magnesite-rich material. Stratigraphically, the largest occurrence is located near the transition zone from lower to upper Madison where the mottled dolomite ends and the white, more massive, dolomite begins. The section on plate IV shows its approximate position with respect to this contact.

The main talc body or vein has a nearly vertical dip and does not seem to follow any definite path such as a bedding plane or fault zone.
View looking north showing the adit driven into the talc outcrop. The thin outcrop in the upper left of the photograph widened out to the three foot vein shown on plate IX at a distance of 10 feet from the collar of the adit. In mining, a jack-hammer is used for drilling. The broken ore is hand picked and trammed to the adit entrance in a wheel barrow.
View of the talc vein opened up by the adit shown on plate VIII. An inclusion of country rock, rounded by solution action, may be seen near the center of the picture. The white material covering the rock near the contact is powdery CaCO$_3$. 
Origin

All evidence indicates that this deposit has resulted from alteration or a magnesite-dolomite under the influence of silica-bearing igneous solutions. The mineralogy also indicates that the deposit is of low temperature hydrothermal origin or epithermal. It therein differs from most other United States deposits since nearly all were formed from alteration of magnesium silicates such as pyroxenes and amphiboles.

The most potent factors supporting the replacement origin theory are the presence of horses and of silicified country rock in and adjacent to the deposit. The horses alone almost provide conclusive evidence of replacement since no other mode of origin would leave unsupported masses of country rock, rounded by solution action, scattered through the deposit. The presence of silicified dolomite can most readily be explained by injection of silica-bearing solutions. The silica contained in the talc was probably derived from the nearby acid granite intrusives that crop out several thousand feet to the south.

The extreme irregularity of the deposit is evidence in favor of this theory, but alone it is not conclusive. Replacement deposits characteristically pinch and swell.

Gradual fading limits, a criteria of replacement deposits, are not found in this occurrence. However, according to Lindgren, a replacement of dolomite by silica may take place with a definite front because such replacement takes place "along a wave" instead of stead of starting at numerous points and consequently stops with a sharp contact.

A question involved in the problem of genesis is the source of the magnesium, that is, assuming that the immediate source was the dolomite and magnesite, what caused the concentration of magnesium in the Madison formation which is ordinarily free from this element? The answer to that problem is most likely the igneous bodies to the south. Magnesium-bearing solutions emanating from these intrusives during the later stages of their cooling
replaced some of the CaCO₃ to form dolomite some of which was then replaced by magnesite.

Economics

The whiteness and purity of the Helena talc make it exceptionally well suited for use as a filler for high-grade paper and as a base for cosmetics. The current price paid for this material is $10 per ton. Several 100-ton shipments have been made in the past year and judging from discoveries of the past three months, there still remains considerable tonnages of workable talc. About the only expense involved is that of mining since the talc is separated from the country rock by hand during the process of mining thus eliminating the cost of milling.
The Ennis talc deposit is 16 miles south of the town of Ennis and 3 miles west of the Madison River along the eastern fringe of the Gravelly Range Mountains. The highway to West Yellowstone runs along the Madison and from there the deposit is reached over an ungraded but passable dirt road.

Topography

The relief of the immediate vicinity is not over 100-150 feet. Most of the area consists of rolling grass-covered hills with an occasional exposure of dolomite poking through the mantle of detritus. The hills in which the deposit occurs rise gradually from the flat flood plain of the Madison Valley a mile to the east. The accompanying photographs will give the reader a better idea of the topography than will a written description.

General Geology

In general, the region is made up of highly metamorphosed sediments of pre-cambrian age, intruded by pegmatite dikes. The dominant rock types of the surrounding region are mica schists, hornblende schists, garnet schists, the Black point dolomite, Flathead quartzite, and the recent Bozeman Lake Beds in the Madison Valley. The Black Point dolomite is the predominant rock of the immediate vicinity and contains all of the talc bodies. This formation consists of a dark, highly metamorphosed, crystalline dolomite, or perhaps more properly marble, that weathered to a dirty brown, saccharoidal surface looking much like a fine-grained sandstone at the surface. Strike and dip of these beds are South 50° west and 80° northwest respectively. Igneous activity is evident in the form of numerous pegmatite dikes that crisscross the country in long white stringers of milky quartz. There is a
View of the Ennis talc deposit, looking north. The pit near the top of the hill follows an irregular, lenticular, talc body. An adit is being driven beneath the deposit to facilitate mining. At the time that the deposit was visited, the adit was in 20 feet from the surface and had gone through dark red calcite and dolomite without striking any traces of talc. The dark rock to the right of the dump is Black Point dolomite.
fairly large deposit of psilomelane in the vicinity of largest of the talc bodies, and manganese oxide has caused the formation of numerous dendrites throughout the body. The west side of this particular occurrence is bordered by a 5-6 foot band of dark red calcite.

Characteristics of the Talc Bodies

Most of the talc bodies are confined to an area of about 160 acres. They are tabular to lenticular and vary in size from small stringers to bodies nearly a hundred feet in length. There were five bodies exposed by trenches at the time that the field work was done (Nov. 16) but only one was being worked. It had been mined by open pit methods for a distance of 30 feet into the hill and averaged about 6 feet in thickness. The photograph on plate X shows this body and the method of mining. There seems to be no set trend to the deposits or any structural correlation between the individual bodies. The deposits are very irregular and are oriented in different directions regardless of the directions of the bedding planes of the dolomite country rock. At places along the erosion valley running in a east-west direction in front of the main body there are small, thin, elongated, stringers of talc extending up into the dolomite indicating a replacement origin. Large horses of unaltered country rock are present in the face of the open cut especially near the borders of the talc vein. The long axis of most of the bodies is steeply dipping and in no sense do they lie along bedding planes of the country rock.

Mineralogy

The Ennis talc is characteristically greenish with black mottlings caused by microscopic grains of what is possibly magnetite. Most of the material is very massive and compact with little of the foliation that is present in the Helena variety. The occurrence of psilomelane directly over the largest of the talc bodies probably accounts for the dendrites in the talc immediately below since only this one body has the great abundance of dendrites.
General view of the Ennis deposit, looking north. The white dump in the central part of the photograph is the same as that shown on plate X. All rocks that crop out along the valley in the foreground are Black Point dolomite. The Madison valley lies in the background.
An analysis of the talc showed the following results:

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<table>
<thead>
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<tbody>
<tr>
<td>SiO₂</td>
<td>66.5%</td>
</tr>
<tr>
<td>Al₂O₃ and Fe₂O₃</td>
<td>3.4</td>
</tr>
<tr>
<td>MgO</td>
<td>24.8</td>
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<td>94.7</td>
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(water accounts for the discrepancy)

The white calcite that was so prevalent in the Helena deposit is not nearly so common in this occurrence. An interesting feature of the main talc body is the presence of a dark red calcite along the west border and beneath the deposit. The psilomelane occurrence already mentioned extends across the top of the talc as shown in the photograph. The specific gravity of the mineral is 2.71, and hardness is greater than that of the Helena material. Its compactness and massiveness are the most distinguishing features of the Ennis talc, and the presence of striking dendritic patterns of manganese oxide in certain of the material is noteworthy.

Origin

There is a marked similarity between the geologic settings of the Helena and the Ennis deposits. Both are in dolomites in regions of former igneous activity. Irregularity, sharp contacts, horses, and other replacement criteria are characteristic of both deposits. It has been concluded, therefore, that the talc has formed from alteration of dolomite under the influence of siliceous igneous solutions. The calcium bearing solutions, remaining after the replacement, precipitated some of their load of CaCO₃ along the talc-dolomite contact, but most was removed in solution.

Economics

The discoloration of the Ennis talc by iron and manganese renders it unfit for many commercial uses that require a pure white talc. However, it has the peculiar property of becoming extremely hard when heat-treated, and it is there-
fore of possible value as a "lava" raw material. However, the American Lava Corporation of Chatanooga Tennessee has made tests on the Ennis talc and the results are not too promising.
1. Ladoo, R. B.
   Talc and Soapstone, Their Mining, Milling, Products and Uses: U.S.B.M.,
   Bull. 213, 1923.

2. Ladoo, R. B.

3. Lindgren, Waldemar

4. Diller, J. S., Fairchild, J. G.,
   and Larsen, E. S.

5. Wilson, M. E.
   Talc Deposits of Canada: Canada Geol. Surv., Econ. Geol. Series, No. 2

6. Burfoot, J. D., Jr.
   The Origin of the Talc and Soapstone Deposits of Virginia: Econ. Geol.,
   Vol. 25, PP 805-826, 1930.

7. Ford, William E.