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THE TALC DEPOSITS NEAR MILLADORE WISCONSIN

by

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Talc File. 42-1

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A research report by
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UNIVERSITY OF WISCONSIN
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Summary of Conclusions

1. The Milladore talc deposits are included within a relatively small area of "greenstone" or chlorite-schist which apparently is a roof-pendant.

2. From the following report the talc deposits are considered to be the result of the magmatic intrusion under hypothermal conditions of basic rock high in ferro-magnesian minerals.

3. The possibilities of more talc of marketable grade are good.

THE TALC DEPOSITS NEAR MILLADORE, WISCONSIN

Introduction and Acknowledgments

A small area near Milladore, Wisconsin, is significant for its deposits of talc and massive soapstone. These deposits, although exploited commercially in the past, have never been studied in any detail, and almost nothing has been written about the area except in a very general way. It is not the purpose of this paper to give a greatly detailed account of the geology of the area, but to give only a generalized picture of the geological history from beginning to end with some detail where the talc and soapstone deposits are closely related to particular geological events.

Since outcrops in the area are few and rather poor[1], the conclusions drawn are not absolute, but are largely based on geological theory and therefore always open to question. In the author's opinion, however, the conclusions drawn are logical and consequently as nearly correct as the following account of the geology of the area permits them to be.

Acknowledgment is due to John J. Ronan for assistance in deciphering the history of some of the rocks; to Professor R. C. Emmons for constructive criticism of the work; and to Mr. E. F. Bean, state geologist of Wisconsin, for access to state geological records and at whose suggestion this work was undertaken.

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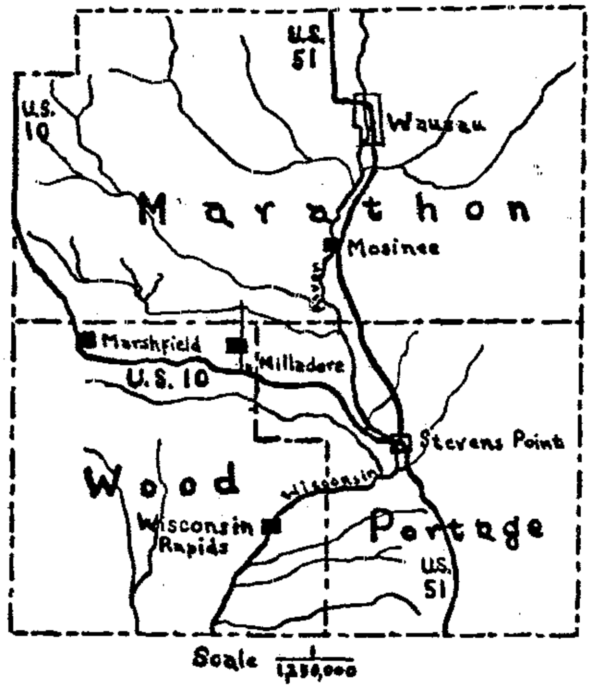
1. The area is relatively flat and consequently, few outcrops are found.

Location and Topography



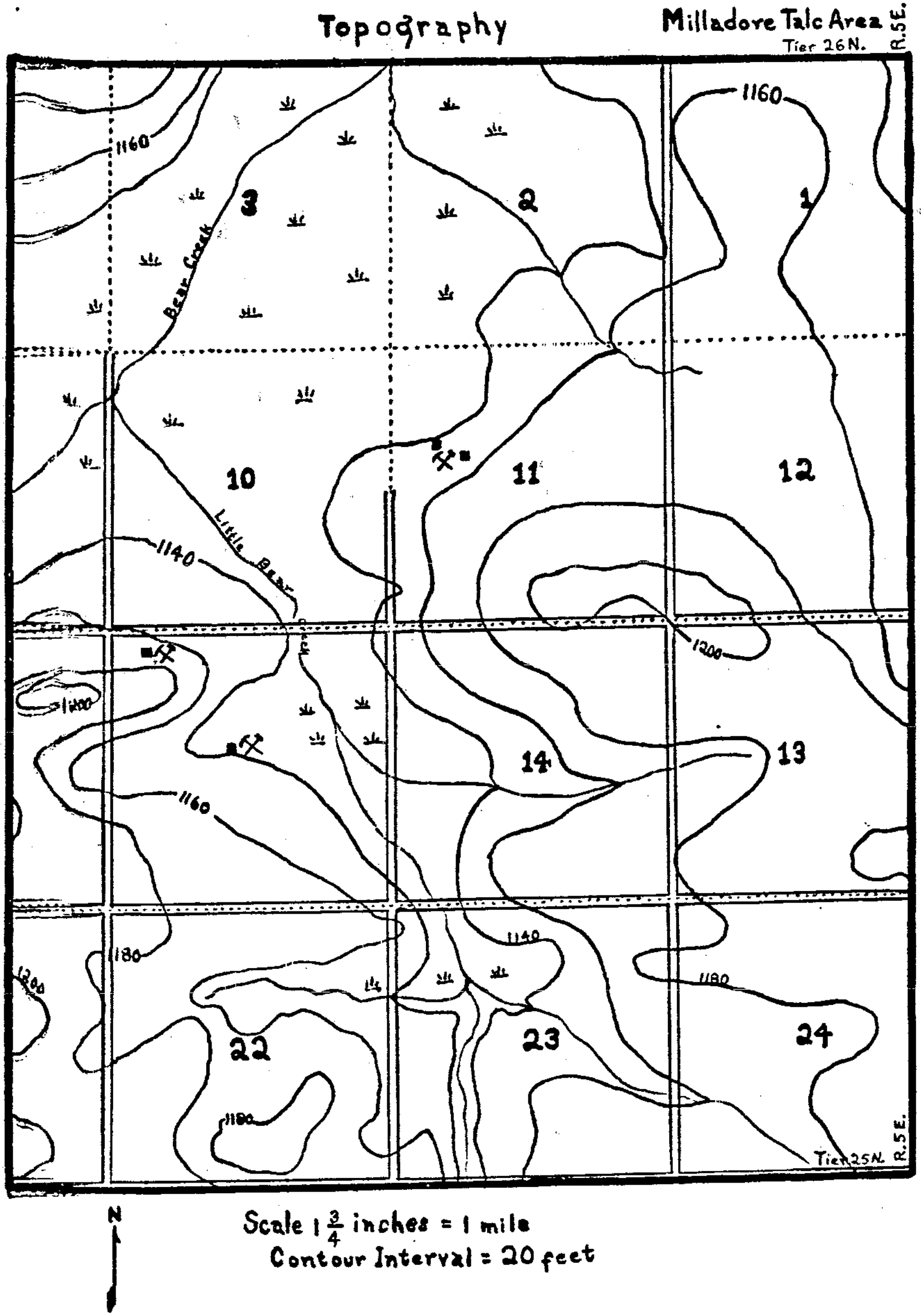
The talc area is part of a relatively flat country about three miles north of Milladore, and approximately sixteen miles northwest of Stevens Point. More specifically, the area occupies sections 9 up through 16, and 21 through 24, in ~~Tier~~ Town 25 N. and Range 5 E. The accompanying sketch map of the counties of Wood, Portage, and Marathon in north central Wisconsin shows this location.

Topographically, the area is unimpressive. There is relatively little relief; much of it is swampy since it is poorly drained by Bear and Little Bear Creeks. The soil is very thin, some of it residual, but most of it probably consisting of old glacial drift (ground moraine) the origin of which was prior to the last stage of glaciation. Cobbles of soapstone are frequent in the fields and particularly in sections 11 and 15. (See page 5 for section map.)

The ground in many of the fields is moist to the point of being soggy and is suggestive of an impervious substratum not far below the ground surface.

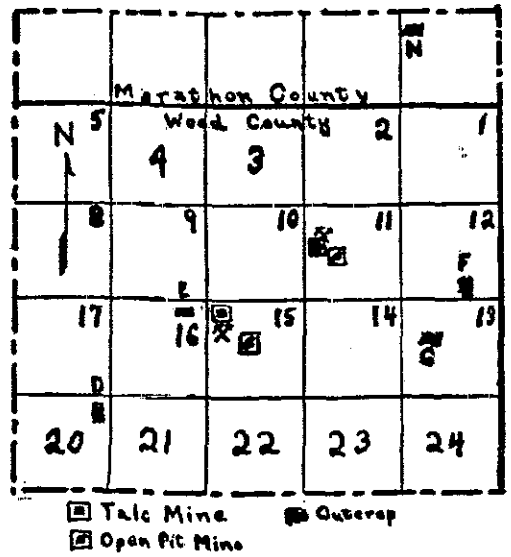
Powers Bluff lying to the southwest of the talc area is the only feature near by that is of topographic prominence. It is a hill of pink quartzite and the result of differential erosion so that it remains as a monadnock on a ressurected Pre-Cambrian peneplain. Glacial alluvium now covers this peneplain with a superimposed drainage resultant.

On the following page is a topographic map of the Milladore Talc Area.



Scale 1 $\frac{3}{4}$ inches = 1 mile
Contour Interval = 20 feet

Structure



Location Map of Outcrops

In an area of low relief it is commonly found that there are not many true rock exposures and that pseudo-outcrops consisting of erratic boulders of diverse origins more often occur. Also, the outcrops that may be found on low slopes are seldom very good. This is true of the Milladore talc area where only five outcrops and two small mines constitute the material basis of the following structural interpretation. But despite the lack of many outcrops, those found here are so situated that it is possible to obtain a reasonably good idea of the structure of the area. The adjacent section plat map shows the location of the outcrops and mines.

In order to understand the field relationships of the outcrops they will be briefly described according to the code used in the plat map at the top of the page. In section 20 the outcrop labeled "D" consists of two granites exposed in what at first appears to be a mass of promiscuously grouped boulders. One of the granites is dark and basic in character since it is high in ferro-magnesian minerals and biotite; the other is of lighter color and is about half pink feldspar with the other half for the most part consisting of quartz, biotite, and chlorite. The basic granite contains several inclusions which appear to be a greenstone schist. The contact between the two granites could not be seen.

In section 16 is another outcrop of granite (labeled "E" on the map) which in most respects resembles that just described. Here again, the outcrop consists of residual boulders appearing much like a pseudo-outcrop. The granite weathers to a whitish-gray but is dark on a fresh surface and is somewhat gneissic in character. It appears that this is probably the same granite as that in section 20 and that the gneissic character is a local difference.

At "G" in section 13 is a third outcrop of granite somewhat porphyrytic in texture and containing white feldspar in aggregates and dispersed crystals. It is high in dark minerals, biotite, chlorite, and ferro-mags, and in appearance again is similar to the other two granites.

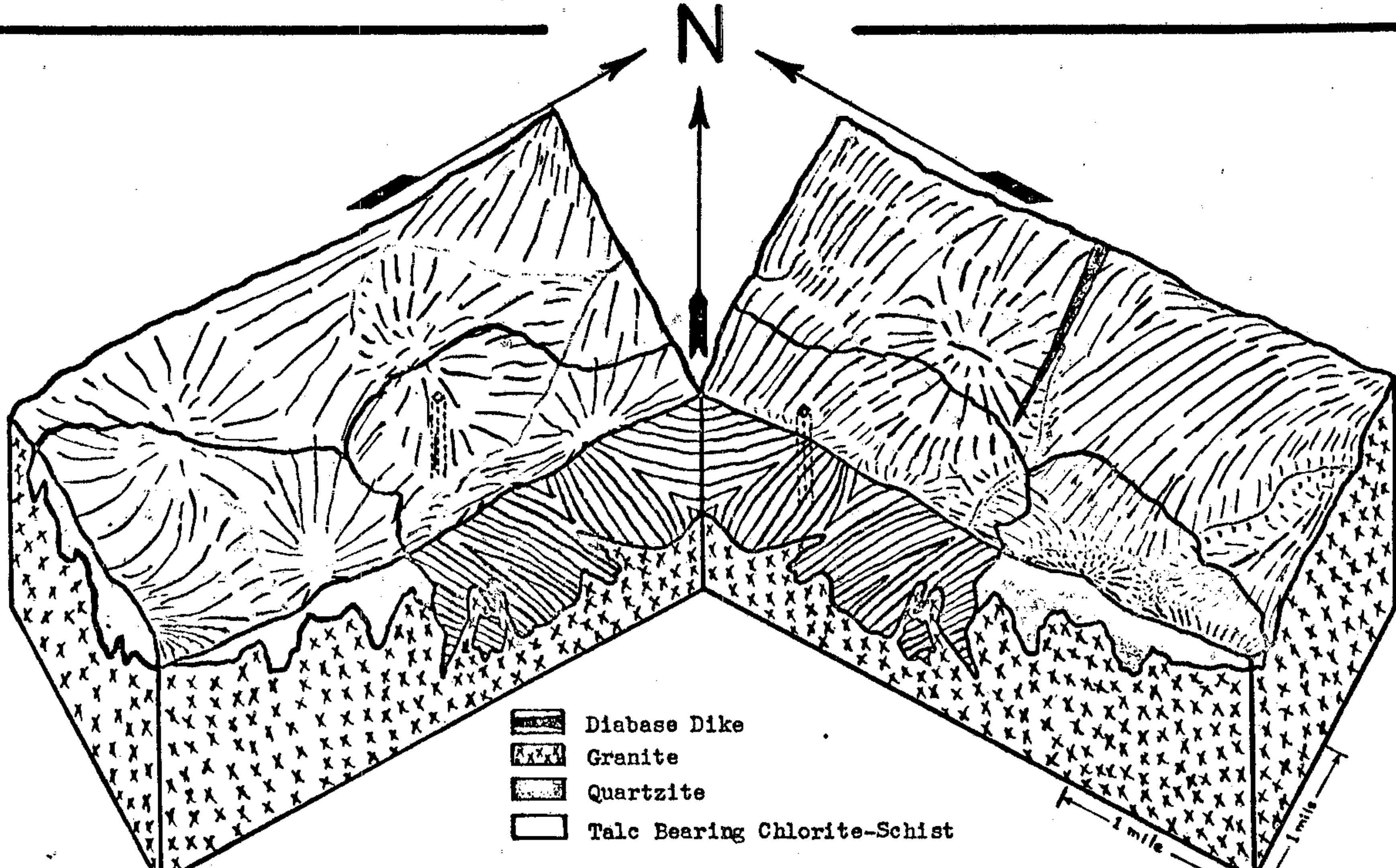
In section 12 at "F" this same granite is exposed, but here it is in contact with a dike of diabase which lies to the north of the granite. About sixty feet of the dike is exposed; how much thicker it may be cannot be determined. The east-west limits of the dike likewise are not known as no exposures of it are found in these directions.

Another outcrop of granite ("N") in Marathon County although outside and north of the talc area, warrants attention since it helps to delineate the structural relationships of those rocks within the area. This granite is quite different from those previously described in that it is very low in basic minerals and high in pink feldspar and quartz. Physiographic conditions indicate that it is probably in contact with the granites in the talc area to the south, or possibly that a gradation from one granite to another takes place.

The talc mines in sections 11 and 15 are located in a highly metamorphosed country rock of dark green chlorite-schist. This schist contains large amounts of talc and also the minerals magnetite, pyrite, malachite, calcite, and serpentine. The magnetite occurs both in crystal (euhedral octahedrons) and massive form, whereas the other minerals are found only rarely in crystal form.

In the south part of the area and especially in sections 14, 15, 21, and 22 are scattered cobbles and boulders of pink quartzite. Farmers have cleared the larger ones from the fields and placed them in large piles at the fields' edges. Presumably, a quartzite underlies this part of the talc area and might well be the impervious substratum responsible for the soggy soil referred to previously in this report. Although no outcrop could be found, the large numbers of quartzite boulders present in these sections seem to justify the conclusion that part of the area is underlain by quartzite.

From the plat map and the brief descriptions given it is readily seen that the small area of green chlorite-schist containing the talc deposits is entirely surrounded by intrusive granites with the possible exception of the northwest side. This area is marsh, but superficial investigation to the northwest of this marsh revealed more granites. It is logical to conclude, therefore, that the chlorite-schist with its deposits of talc is a roof-pendant and is the result of the magmatic intrusion into a basic rock and a subsequent erosion. The split block diagram on the following page depicts this structural interpretation.



Split Block Diagram of the Milladore Talc Area

The Rocks of the Area

All the rocks of the area are either igneous or metamorphic. The sedimentary Potsdam Sandstone outcrops a few miles to the south, however.

The granites of the area may be divided into two classes on the basis of composition: those which are basic and high in ferro-magnesian minerals, and those which are acidic and relatively high in feldspars. In general, it may be said that the farther from the chlorite-schist --- the more acidic are the granites; and the closer to the schist --- the more basic they become. This is probably the result of differences in the amount of assimilation of the greenstone (chlorite-schist) by the granite intrusive.

The granite "N" lying to the north of the talc area in Marathon County (see section plat map, page 5) may be considered more or less typical of the acidic rocks found in this locality. It is fine-grained and high in feldspar (about 50%) most of which is plagioclase, but microcline is common and perthite is also present. The rest of the rock is quartz (35%) and biotite (15%). In thin section all of these minerals show strain which is probably due to dynamic stress while the granite was either in a semi-solid or solid state. There is little or no alteration of the minerals.

The basic granite is more variable in composition and its characteristics, but all of the outcrops and specimens may be considered as a group. All of them are relatively low in feldspar varying from about ten to twenty-five percent. The feldspar generally consists of both orthoclase, which is usually cloudy and highly altered, and plagioclase, which is sometimes of secondary twinning and often with albite and pericline twinning which may or may not be continuous. The alteration products of the feldspars are talc and kaolin. The amount of quartz present is highly variable, in some specimens it being about fifty percent and in others only about ten percent. Most generally the quartz is sutured though not always. Chlorite is present in all the basic granites and was found altered in every case. Commonly it has a preferred orientation but is not consistent in this respect. The chlorite in these granites is an alteration product of amphibole, pyroxene, or biotite, and a rock may have chlorite as a result of the alteration of all three. Sericite is also common throughout these dark granites. Other minerals present but in smaller quantities are zircon and epidote, a secondary mineral in this locality.

Evidence of strain in all these minerals shows up clearly in thin sections. Quartz in particular shows strain shadows, and in many cases the crystals are twisted and contorted so that extinction is relatively slow under the microscope. Brecciation of the quartz and often of the other minerals is characteristic.

The pink quartzite is relatively pure for the most part, but near the chlorite-schist it is very contaminated and contains talc, hematite, magnetite, and ilmenite in greater or lesser amounts. Recrystallization has taken place to a large extent. The pink color becomes dark red on nearing the schist undoubtedly due to the increasing amount of iron oxide present. In thin sections some of the quartz appears strained, but boundaries of the grains are fairly well rounded and in some instances are secondarily enlarged.

The chlorite-schist is largely the result of the metamorphism of the greenstone --- the metamorphism due to the intrusive granite. Samples taken from the tailings piles at the mines were high in talc, contained abundant octahedral crystals of magnetite, and smaller quantities of pyrite and malachite.

The diabase composing the dike contains more minerals than any of the other rocks of the area. Pyroxene, chlorite, and biotite are present in considerable quantities, the chlorite and biotite as alteration products. Magnetite is very common and is associated with the chlorite and biotite. Feldspar is rather common also, appears cloudy in thin section, and is altered to what probably is kaolin. Olivine constitutes part of the rock but is mostly altered to magnetite and chlorite. The chlorite is an alteration product of the biotite as well as of the olivine. Garnet is found in appreciable amounts.

Mineral Deposits

Of the various minerals found in the roof-pendant talc and its compact form, soapstone, are both most abundant and most important. The other minerals, magnetite, hematite, malachite, pyrite, serpentine, and calcite are present in relatively minor quantities and will be considered only as supporting (and non-supporting) evidences concerning conclusions as to the origin of the talc.

It has been shown by mineralogists that talc may occur in several ways. Since it is a hydrated magnesium silicate, $(H_2Mg_3SiO_3)_4$, it may readily result from the hydration of enstatite, $(MgSiO_3)$. Enstatite is considered the basis for talc; its formula indicates why. Talc is very often the hydration product of magnesian rocks like gabbro, pyroxenite, peridotite, or crystalline limestone containing such pyrometasomatic minerals as enstatite, tremolite, or actinolite. Or, it may be formed from any magnesian amphibole or pyroxene if acted upon by H_2O and CO_2 in accordance with the following equation:

$$4MgSiO_3 + CO_2 + H_2O = H_2Mg_3Si_4O_{12} + MgCO_3 .$$

Solutions active near the contacts of intrusive rocks are perhaps most capable of effecting this change and that, with moderately high temperature, would furnish the best conditions. This could well have been the condition responsible for the formation of the talc in the Milladore area where intrusives penetrated a rock rich in basic minerals, and high temperatures were undoubtedly existent at the time.

That the talc was deposited from solutions is very probable. Cavities lined with foliated talc are very common, and in some cases the cavities are lined with calcite also so that the talc appears to have actually been deposited on the calcite. The calcite, however, is meteoric in origin and is much later than the talc.

The quartzite near the chlorite-schist also contains talc in varying amounts. This lends further support to the theory that alteration and solution is responsible for the deposits. Quartzite as it occurs here is quite pure and would tend only to recrystallize upon intrusion by the magma. The talc and other foreign material must have come in solution from the magma and schist.

Magnetite and hematite are found in considerable amounts. Most generally, the magnetite occurs in octahedral crystals and imbedded in the schist, whereas the hematite is more common in massive form and mostly in the quartzite in proximity to the schist. Magnetite commonly occurs where talc is formed by the hydration of ferro-magnesian minerals since the iron is left in surplus and readily combines with oxygen to form magnetite. Hematite and not magnetite occurs in the quartzite probably because of the lack of sufficient oxygen in the quartzite to produce magnetite, or the iron may have been originally present in the quartzite as an oxide and then altered to hematite by metamorphism.[2]

2. Note; This statement may seem to conflict with a previous one when it was said that the quartzite was "very pure". By pure is meant that the quartzite contains nothing other than sufficient iron oxide to give it its pink color. This color becomes a dull red nearer the contact between the quartzite and the schist. Otherwise the quartzite is relatively uniform over a large area.

Pyrite is common and is disseminated throughout the greenstone. Considering the widely varying conditions under which it may occur its presence means little with regard to the talc deposits. Likewise, the occurence of malachite in small quantities is of little importance. It is undoubtedly meteoric in origin and therefore much later than the talc in deposition. It is possible to have malachite deposited from magmatic solution, but this does not seem to be the case at Milladore or one should expect to find more extensive deposits of it. It occurs only as coatings on the greenstone. The former deposit of copper ore (that may have come from magmatic sources) from which the malachite was carried in solution has in all probability been removed by erosion.

It has been previously noted that the rocks of this area show much strain and brecciation as evidenced in thin sections. Also, slickensides indicate that faulting has occurred. Talc is sometimes defined as a "high pressure" mineral, and it is likely that some of the talc of this area is due to the dynamic stresses that were resolved into faults and brecciation. However, talc (and serpentine) resulting from such processes are localized and limited in extent, and the deposits at Milladore are too large to be accounted for in this way.

It is concluded, therefore, that the Milladore talc deposits are the result of the alteration and solution of basic rocks containing magnesian minerals, and was induced by the magmatic intrusion of the basic rocks under hypothermal conditions. Other alternatives of talc origin are not sufficiently supported by the geologic evidence as found in the Milladore Talc Area.

Sequence of Events

The rocks of the Milladore Talc Area are all of Pre-Cambrian age. It is the Pre-Cambrian period of the earth's history about which geologists know the least for certain, and the rocks of this area are no exception. The following account of the sequence of the geological events is therefore generalized since the evidence is insufficient to allow for much detail.

The oldest known rock of the talc area is the chlorite-schist or its unmetamorphosed equivalent, greenstone. The source of this greenstone is much of a mystery, but it is thought to be volcanic. Upon what base the greenstone was laid down is also unknown because everywhere granite intrusives have destroyed underlying rocks and part of the greenstone through assimilation. With a fair degree of certainty it may be said that the greenstone was laid down upon a basement of Archean rocks, presumably igneous.

Correlation of this general area with the rest of the Lake Superior Region suggests the greenstone to be of Keewatin age. The Keewatin greenstone schists around Lake Superior are intruded by granites in much the same way the greenstone is in the Milladore Talc Area. A general folding of the schists took place throughout the Lake Superior Region after Keewatin time, and presumably this happened in the talc area also although it was impossible to determine a strike or dip since there was no actual outcrop of the beds of schist. Slickensides on pieces of the chlorite-schist found at the mines indicated that faulting had occurred in the area, but whether the faulting was due to the folding of the schist is not known. It could have been caused by other diastrophic movements, and no doubt some movement was set up through stresses by the intruding granite.

After the folding of the greenstone and before the Timiskaming a period of erosion set in. The sea readvanced over the Lake Superior Region, and sedimentary deposition took place resulting in great thicknesses of sandstone which were subsequently metamorphosed into the quartzite. These quartzites, once over three thousand feet thick, were folded in the great diastrophic movements of the earlier Pre-Cambrian which made a mountainous area of the whole Lake Superior Region. Subsequent erosion wore down the mountains to the so-called "Pre-Cambrian peneplain" but left such resistant quartzite hills as Rib Hill near Wausau, and Powers Bluff near Wisconsin Rapids, as monadnocks. The pink quartzite of the Milladore Talc Area is the same as that of Powers Bluff. The source of the sands originally making up these quartzites is unknown. That the source materials were tremendous in thickness and probably also in extent to produce over three thousand feet of very pure quartzite is undoubtedly so, but more than that nothing is known. It is one of the enigmas of the Lake Superior Pre-Cambrian.

Whether the granite intruded the quartzite and greenstone before or after this folding is problematical. For other parts of the Lake Superior Region the quartzites are not intruded by the Laurentian Granite, but lie unconformably above it. In the talc area and that surrounding it the granite does intrude the quartzite. If the quartzites of Rib Hill, Powers Bluff, and the talc area can be correlated to those of other parts of the

Lake Superior Region, it would date the intrusive as Algoman since this granite does penetrate the quartzites, whereas the Archean granite (Laurentian) does not. This interpretation seems plausible.

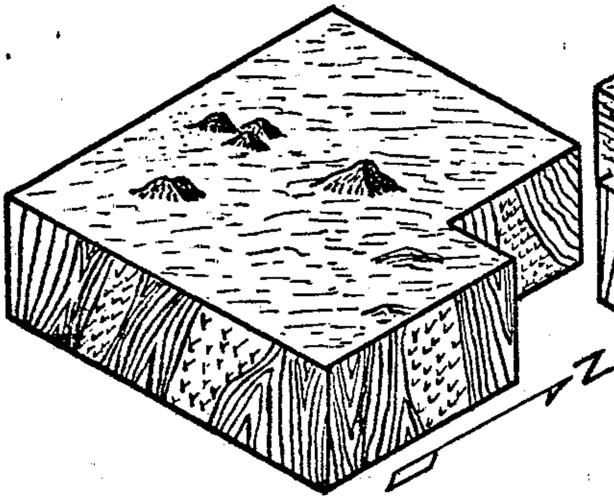
Concurrent with the intrusion of the granite was the formation of the talc deposits. This is discussed under the section titled "Mineral Deposits".

After the long-continued erosion resulting in the peneplain at the end of the Pre-Cambrian, the sea again advanced over the region. Deposition of sediments (mostly sandstones and limestones) completely buried such monadnocks as Powers Bluff and Rib Hill. According to Weidman[2], Paleozoic formations up to the Niagaran may have been deposited over the area.

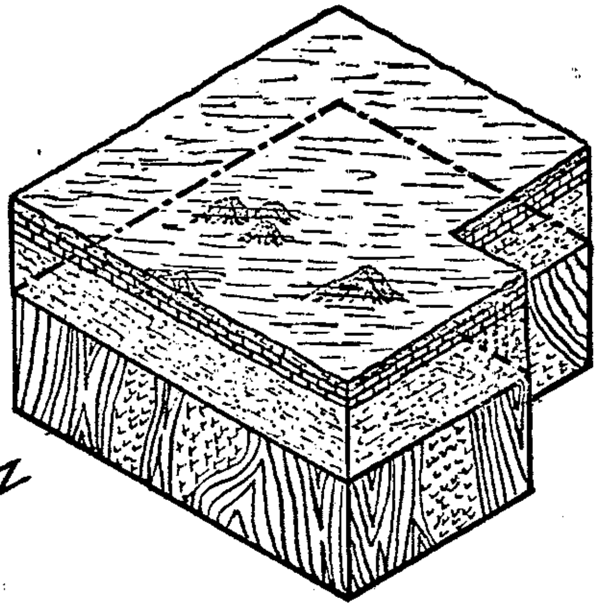
With the gradual withdrawal of the sea erosion again took place and continued relatively undisturbed until the beginning of the Pleistocene. Great thicknesses of sedimentary rocks were removed, and, from the point of view of erosion, Lobeck[3] thinks that it is more impressive than the Grand Canyon of the Colorado River. Only small portions of the sediments such as the Potsdam Sandstone remain in the area. Pleistocene glaciation is responsible for considerable alluvium and drift so that a superimposed drainage is the present result on a ressurected Pre-Cambrian peneplain. The quartzite hills of Powers Bluff and Rib Hill are as high as before. The block diagrams[4] on the following page depict the four main stages of the geologic history of Wood County and the Milladore Talc Area.

2, 4 Weidman, S.---"The Geology of North Central Wisconsin",1907
3 Lobeck, A.K.--- "Geomorphology" 1941

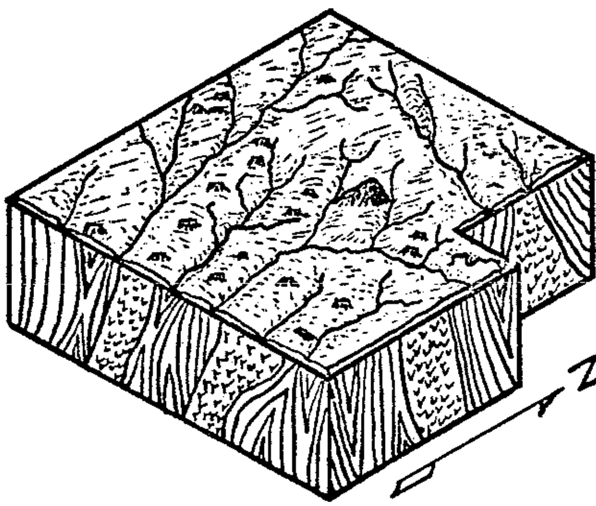
FOUR STAGES IN THE GEOLOGIC HISTORY OF WOOD COUNTY



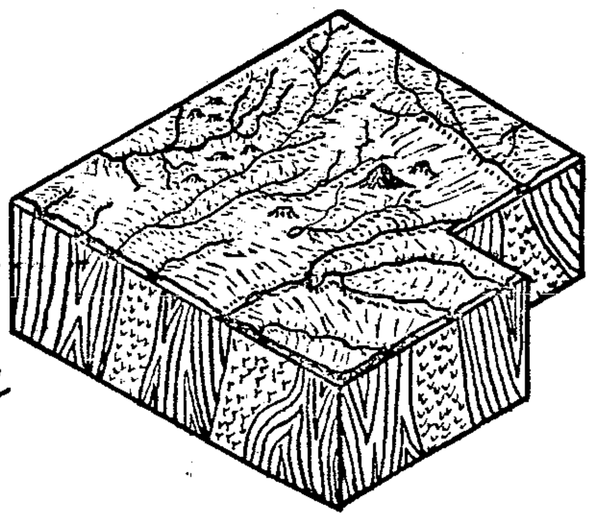
Pre-Cambrian Peneplanation.



Paleozoic Sedimentation.



Post-Paleozoic Erosion.



After Glaciation. (Present.)

ECONOMIC GEOLOGY

As stated previously, the talc deposits of the area have already been exploited to an extent. "Extent" is indefinite, but the limits of the talc that can be mined at a profit cannot be definitely stated. Lack of sufficient market and drop in prices at the height of the economic "depression" in 1932 caused the discontinuance of mine operations.

Trowbridge Mine in Section 11 was operated by the American Talc Co. of Plymouth, Wisconsin. No maps of the mine are available, but according to a previous field report[5] 'the work here has shown up a body of mixed talc and soapstone measuring approximately eighty-five feet vertically, fifty feet in cross-cut, and possibly seventy-five to one-hundred feet longitudinally'. Assuming these estimates to be reasonably correct, the mass of soapstone and talc represents a volume of something less than 500,000 cu. ft. This figure may be considered to be a maximum since very probably there is a considerable amount of impurity present in the mass such as chlorite, greenstone, serpentine, and also intrusive dikes. Samples of the talc ore from the mine showed a wide degree of variability in the pureness of the soapstone, the range being from a talc-schist (mostly chlorite) to a practically pure soapstone.

Another mine in Section 15 was operated and closed about the same time as the Trowbridge Mine. No information on this mine was available, but operations went down to a depth of about ninety feet. Examination of specimens from the tailings piles seemed to indicate generally that the soapstone was of lower grade than that from the Trowbridge Mine. More impurities were present.

The mining at these locations was first done in open pits, the mine shafts being sunk when it was found that sufficient soapstone of high enough grade was present to make underground mining profitable. Since the soapstone occurs practically at the surface, and cobbles of it are common in the fields, it seems quite probable that test pits would locate other bodies of the soapstone and that diamond drilling would then determine the extent of the new deposits. The probability of finding more of the mineral is very good.

In 1929, the first year of reported sales[6], The American Talc Co. mined at Milladore 4,350 short tons of talc and soapstone with a gross value of $14,238; and in 1930, 1,078 short tons with a value of $3,499. Thus, in one year there was a decline of about 300% in both quantity and value of the mineral. For the country as a whole the average price of rough talc from the mine in 1930 was $9.84 per short ton. The value of the 1,078 short tons produced in 1930 by the American Talc Co. indicates that the rough talc from the Milladore Talc Area sold for less than half the average price per ton for the whole country. It seems that the Milladore talc was either of inferior grade or lacked a suitable market. It may have been both.

The price of talc continued to decline until 1936 when there was an upswing again, and in 1940 the average price per ton reached $11.

Talc and ground soapstone today finds 75% of its use in paints, ceramics, roofing, paper (filler), and in dusting rubber

6 Minerals Yearbook(s) 1929-1940

to prevent sticking to molds. About half of the amounts of talc produced goes into paints, and most of the remaining half into the other industries named in their order of importance. The present war has inspired research and the developmentof plastics in an effort to replace metals to a large extent, and talc has been utilized as a filler in these plastics. Wood flour, however, is used to a greater extent in the plastics than ground soapstone.