UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary
GEOLOGICAL SURVEY
W. C. MENDENHALL, Director

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CIRCULAR 4

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SOME DEPOSITS OF ORNAMENTAL STONE IN MONTANA

BY

G. R. MANSFIELD

WASHINGTON

1943

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ILLUSTRATIONS

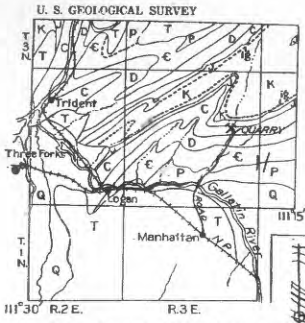
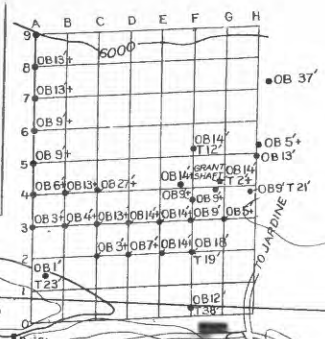
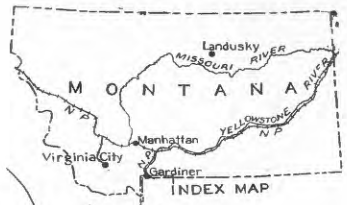
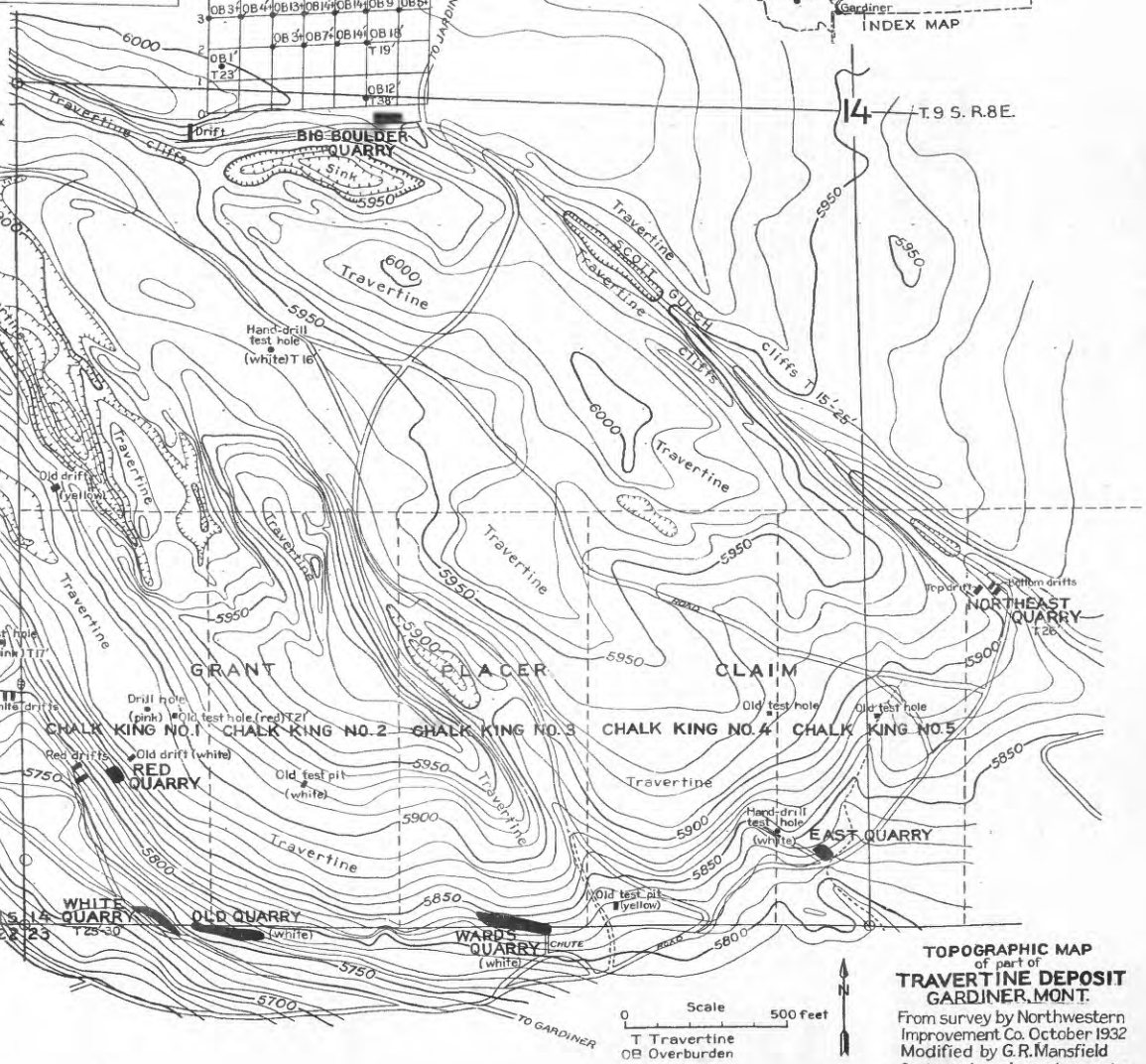


Fig.1. Geologic map of Manhattan area, Mont., showing location of onyx quarry (U.S.G.S.)

EXPLANATION
Q Quaternary
T Tertiary
K Cretaceous
J Jurassic
C Carboniferous
D Devonian
€ Cambrian
P Pre-Cambrian
ig Igneous
111°15' — Fault







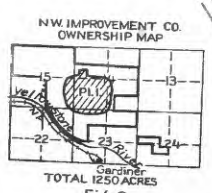


Fig.2.

TOPOGRAPHIC MAP
of part of
TRAVERTINE DEPOSIT
GARDINER, MONT.

From survey by Northwestern Improvement Co. October 1932
Modified by G.R. Mansfield
Contours based upon barometer elevations
Contour interval 10 feet
Datum is mean sea level

SOME DEPOSITS OF ORNAMENTAL STONE IN MONTANA

By G. R. Mansfield

Abstract

Four interesting occurrences of ornamental stone are described in this paper. Two are of onyx marble, one is of travertine, and the fourth is a siliceous rock, possibly an altered volcanic ash.

The two larger calcareous deposits, those at Manhattan and Gardiner, are accessible to the Northern Pacific Railway and are being explored with a view to production by the Northwestern Improvement Co., a subsidiary of that railroad. Both deposits are capable of supplying ornamental stone in blocks of desirable size. No estimates of quantity are available for the Manhattan locality, but for the Gardiner locality estimates for a 200-acre tract show about 2,613,000 cubic yards, or 5,880,000 short tons, of material suitable for ornamental uses. This figure, however, does not allow for waste in manufacturing finished products, which might amount to 50 or 75 percent. The entire deposit of 1,250 acres may contain five or six times that amount. The nature of both deposits is such that successful operation will depend largely upon the selection and sorting of the material intended for ornamental uses and the building up of stocks of the various merchantable types. Thus the cost of operation will doubtless be high, and to obtain a profit it may be necessary to utilize the accompanying thinner-bedded and broken material as well as the waste from the sawing and finishing operations. It is thought that sugar factories and various more or less local construction projects would furnish the principal potential markets for such by-products. At present such outlets are relatively meager.

The onyx marble deposit west of Landusky is not developed, and its size is not known. The material has some possibilities for use in small ornamental objects, such as paper weights. It is far from a railroad.

The siliceous deposit is also far from a railroad. It has not been developed sufficiently to afford much information about its availability for ornamental use in any large way. The material is attractively banded and colored and polishes well. It may have commercial possibilities.

Introduction

Several deposits of ornamental stone in Montana have recently attracted attention. These include the so-called "onyx" north of Manhattan and west of Landusky, the travertine near Gardiner, and a siliceous deposit, probably an altered volcanic ash, near Virginia City. Two of these, the Manhattan and Gardiner properties, are relatively near the Northern Pacific Railway, which owns them and through a subsidiary, the Northwestern Improvement Co., is carrying on explorations with a view to development. This article deals mainly with the deposits near Manhattan and Gardiner but includes brief notes on the other two deposits mentioned. (See pl. 1.)

Although true onyx is composed of silica, the practice of referring to banded calcite as "onyx marble" or even "onyx" is so common that the term "onyx" is so used here.

Field work and acknowledgements

The writer examined the Manhattan and Gardiner properties on November 25 and 26, 1932. He is particularly indebted to Messrs. W. A. Stalnaker and B. F. Segur, field representatives of the Northern Pacific Railway, who showed him the property and extended many personal courtesies, and to Mr. P. E. Thian, consulting engineer in the St. Paul office, who supplied him with maps and other engineering data and a set of polished samples representing the principal varieties of ornamental stone products available at the two localities.

Manhattan onyx deposit

Location.- The Manhattan onyx deposit is in the NW¼SE¼ sec. 14, T. 2 N., R. 3 E., about 5 miles in a direct line north of Manhattan, Mont. The distance by road is somewhat longer.

General features.- The general nature of the country around Manhattan and in the vicinity of the deposit is shown in the geologic folio on the Three Forks quadrangle. 1/ The deposits have been briefly described by Rowe. 2/ Manhattan itself is on a flat, underlain by Tertiary rocks, which constitutes part of the Gallatin Valley. The road to the property crosses the river about 2 miles north of the town and ascends a dry tributary canyon which, according to Mr. Stalnaker, prior to the earthquake of 1925 contained in its lower part active springs that supplied a small permanent flow. The onyx occupies veins in limestone beds that cross the canyon 3 miles or more above its mouth. (See fig. 1, on pl. 1, which is modified from the geologic map in the Three Forks folio).

1/ U. S. Geol. Survey Geol. Atlas, Three Forks folio (no. 24), 1896.

2/ Rowe, J.F., Some economic geology of Montana: Montana Univ. Bull. 50, Geol. ser. 3, p. 48, 1908.

Geologic setting.— The country north of the Gallatin River is underlain by folded sedimentary rocks that trend generally northeast and have been intruded in several places by sills of igneous rock that conform with the folding. The sedimentary rocks range in age from pre-Cambrian in the foothills just north of the river to Upper Cretaceous farther back in the mountains. The folded rocks pass under a cover of Tertiary beds in different directions, and patches of the Tertiary beds, representing erosion remnants, lie here and there upon them. The southeasternmost fold is a relatively broad syncline whose axis trends northeast, but near the southwest tip of this fold the beds strike more nearly east and dip north. This part of the fold is cut by numerous veins containing calcite, the largest of which is the one now being quarried for onyx.

Country rock.- The limestone at the quarry forms relatively thin beds of purplish-gray color which correspond fairly well to the "laminated linestones" mentioned by Peale, the author of the Three Forks folio, as constituting the lower 325 feet of the Madison formation. The hill to the north is underlain by massive beds of gray limestone, which agree very well in character with Peale's middle division of the Madison, to which he ascribes a thickness of 350 feet. The upper division of this formation, which he says is 575 feet thick, and is sometimes called the "jaspery limestone," from beds near the top, lies still farther north and was not seen by the writer. At the quarry the strike as measured is N. 78° E. and the dip 30° N., though farther down the canyon in the older formations the strike varies somewhat and the dip is in places steeper.

Calcite veins.- The calcite veins are in general steeply inclined or vertical and at right angles to the strike of the beds. They range in width from a few inches to tens of feet and cut the older limestones as well as those of the Madison formation.

Principal deposit.- The principal vein that is now being explored extends from the quarry southward about a quarter of a mile and northward about half a mile. Thus its known length, as indicated by outcrops and a few small openings, is about three quarters of a mile. At the quarry face the width of the vein is about 65 feet. It strikes N. 10° W. and dips 88° W. (See pl. 2, A.) One set of practically vertical joints conforms with the attitude of the veins. A second set is parallel with the bedding of the country rock, and a third dips south, intersecting the bedding at approximately right angles. (See pl. 2, B.)

The east half of the quarry face exposes material that is slabby and broken; part of it is brecciated, and some of it looks like slide material that has become recemented. The rock exposed in the west half is more massive and would yield larger blocks. (See pl. 2.) A zone about 10 feed wide is massive enough to furnish blocks 2 or 3 feet thick, 5 feet or more long, and 3 or 4 feet wide. The rock in the rest of the exposure is thinner-bedded and more slabby.

Plate 2, A. General view of the onyx workings at Manhattan, Mont., looking south.

Plate 2, B. Onyx quarry north of Manhattan, Mont., showing the three major joint systems.

Development.- Aside from a few earlier pits here and there along the outcrop of the vein the only development is the present quarry, the face of which has been opened 15 to 25 feet for much of the width of the vein. At the time of the writer's visit the face of the quarry had not been entirely cleaned. Stripping with plow and scraper at the top was just beginning, and men were working on the massive layer, removing blocks of about the dimensions indicated above. A test hole in the massive layer, drilled about 20 feet deep in the floor of the quarry, had disclosed similar material to at least that depth. The blocks were separated by drilling holes close together and by wedging rather than by blasting, in order to avoid damage. These blocks were hauled by truck to the railroad. The material thus far shipped has been sent to St. Paul, where it has been sawed and polished for use in demonstrations.

The onyx

General character.- The stone being quarried exhibits a vertical banding structure, in which the larger bands, each composed of thinner layers, are about half or three quarters of an inch wide. These bands of pure calcite have formed successively in what appears to have been a progressively widening fissure. Throughout much of the massive zone and in a lesser degree in other parts of the vein the successive layers are joined firmly together to form a solid mass that has few or no visible openings. In some places in this zone, however, and to a greater extent elsewhere in the vein the vertical layers do not completely join, so that cavities ranging from those of minute size to some 1 foot or more in longest dimension have been formed. These have been filled progressively to a greater or less extent, so that they are themselves walled by curved bands of calcite. Some have been completely filled; others are still open but lined with projecting crystals that form mammillary groups or peculiar clusters or individuals, the whole giving the effect of a series of geodes.

The progressive opening of the fissure, with perhaps some differential movement of the walls during the process of deposition of the onyx, has served to fracture some of the material previously deposited and to permit later filling of the newer fractures. Thus a considerable degree of irregularity of deposition has occurred, and this serves to provide ornamental stone with different patterns, markings, and textures.

The onyx polishes well, and many beautiful patterns or combinations of patterns may be obtained, according to the nature of the block selected and the direction in which the block is sawed. For example, a vertically banded block sawed at right angles to the direction of banding will give slabs that have a characteristic banded effect, somewhat wavy because the bands are more or less irregular. If sawed parallel to the banding the material will tend to be more uniform, depending on the regularity of the banding and the relative amount of fracturing. If a block containing some of the other irregularities noted is chosen the direction of sawing will affect the appearance of the resulting slabs in corresponding but different ways.

The color of the onyx ranges from white (chiefly in the streaks caused by minor veinlets) through amber to deep honey-yellow. Slabs not too thick are translucent when backed by a strong light.

Quarrying.- Owing to the nature of the deposit, as described above, quarrying operations cannot be carried on effectively by machine methods as in the ordinary marble quarries. The process here must be selective, and the product will be individual blocks of irregular sizes and shapes.

Possible uses of onyx.- Many uses for such stone suggest themselves. The larger blocks may be sawed into slabs for wall panels or wainscoting or into blocks for pedestals, mantels, balustrades, small columns, etc. Some smaller blocks can be adapted to similar uses, and others to various types of ornaments or works of art such as vases, statuettes, paper weights, and pen-stand bases.

Available quantity.- At the time of the writer's visit exploration of the deposit had not progressed far enough to indicate how much of the more desirable stone is available. From the exposure at the quarry it is evident that only a small proportion of the vein as a whole may be expected to produce large blocks of good quality. Nevertheless if the material exposed at the quarry may be regarded as a fair sample of the vein as a whole, it is clear that even on the basis of such a proportion a vein three quarters of a mile long and having a maximum width of 65 feet, if worked to depths of 50 feet or more, may be expected to yield in the aggregate a large amount of good-sized material. With every reduction in size requirements, the proportion of usable material would increase.

Utilization of waste.- Even after every allowance is made for the classification of the material of the vein into usable sizes and grades of ornamental stone, there must still remain a large proportion, perhaps more than half of the mass, that through fractures, irregularities of deposition, discoloration, and other causes cannot be used for ornamental purposes. The working up of acceptable material in the shop will also involve considerable waste. The successful exploitation of the property will therefore require due consideration of all these factors, including plans for the possible disposal of the waste from both the quarry and the shop in the form of merchantable by-products. For example, chips might be sold for mosaic, terrazzo, and facing of ornamental concrete or artificial stone.

Travertine deposits

Location.- The travertine deposits are in secs. 14, 15, and 22 to 24, T. 9 S., R. 8 E., near Gardiner, Mont. (See fig. 2, on pl. 1.)

General features.- The general nature of the country around Gardiner and in the vicinity of the travertine deposits is shown in the geologic folio on the Livingston quadrangle.1/ Gardiner lies in the Yellowstone Valley, just at the entrance of the Yellowstone National Park. The north side of the

1/ U. S. Geol. Survey Geol. Atlas, Livingston folio (no. 1), 1894.

valley rises abruptly to a terrace that stands 600 to 800 feet above the river and extends northwestward for 5 or 6 miles. The travertine deposits occupy parts of this terrace at distances of half a mile to 2 miles or more from the town. The road to the deposit winds back and forth up the hill and is considerably longer than the distances named.

Geologic setting.- On the south side of the river the land in the immediate vicinity of Gardiner appears to be underlain by glacial outwash or modified moraine, which, a short distance from the river, gives place to slumped volcanic material with irregular surface. The land slopes gently toward the river from higher hills, which are composed partly of igneous and partly of sedimentary rocks. A conspicuous landmark is Electric Peak (altitude 11,155 feet), which is within the park about 7 miles west-southwest of Gardiner.

As shown in the Livingston folio, the terrace on the north side has been carved in rocks ascribed mainly to the Livingston formation, here probably of Cretaceous age but elsewhere in part Tertiary. A mile or more east of Gardiner this terrace also includes older Cretaceous and Paleozoic rocks. Basalt has been poured out on this terrace. The travertine lies partly on this basalt and partly on old discolored and disintegrated gravel that from its lithology may be Livingston but is more probably either of late Tertiary or early Pleistocene age. Beneath the travertine in places is basalt showing deep spheroidal weathering. This may also be part of the Livingston formation, which is known to contain igneous bodies as well as sedimentary rocks; but it is more probably an altered part of the later basalt flows, which are of late Tertiary or early Pleistocene age. The mountains bordering the terrace on the north consist of ancient granite, gneiss, etc., with scattered patches of younger igneous rocks. They rise to heights greater than 10,000 feet. The contact between the gneiss and the younger rocks is mapped in the folio as a fault with downthrow to the south. This fault is thought to have played an important part in the formation of the travertine by affording a means of escape for the carbonated waters that caused the deposit.

Extent and thickness.- As mapped in the Livingston folio, the main body of travertine extends about 1½ miles along the terrace northwestward from the vicinity of Gardiner. A few outlying patches lie to the southeast, including one that caps a butte south of the river opposite the mouth of Bear Gulch. The deposits here considered include most of these areas as shown in figure 2, on plate 1. They are grouped in two tracts, one large and one small, which amount in all to 1,250 acres.

The travertine, whose general thickness ranges from a few feet to more than 20 feet, apparently underlies the entire area northeast of the Sienna quarry (pl. 1) to the vicinity of the mountain base north of the Grant shaft. On the southeast it is bounded roughly by the road that passes southwestward from the Northeast quarry. Northwestward, as shown in figure 2, the travertine extends some distance beyond the area represented by plate 1 where present exploration is in progress, but this part of the deposit and the small area in sec. 24 were not visited.

Surface features.- The travertine deposits form a succession of low ridges trending northwest with intervening depressions, a number of which are sinks, as shown on plate 1. The land southeast of the principal travertine area contains many exposures of a rather fresh and roughly broken basalt, which displays in places a remarkable development of columnar jointing. The line of sinks in Scott Gulch is continuous southeastward with a narrow basalt-walled depression which comes out to the road near the southeast corner of sec. 14 and may mark a line of minor faulting. The travertine is doubtless thin or absent in the bottoms of the sinks, though no special observations bearing on this point were made.

Origin and nature.- The travertine here, like that of the Mammoth Hot Springs in the Yellowstone Park, has been deposited on the surface by hot-spring waters, in part through the agency of algae. This has given it a general horizontally banded structure. No doubt it was originally porous and somewhat earthy, like the travertine at Mammoth Hot Springs, but it has been consolidated into a hard and generally compact mass. It still, however, contains irregularly distributed pores and openings ranging from those of pinhole size to streaky, irregular discontinuities or cavities in all gradations from mere lines a fraction of an inch long to openings a foot or more across and several feet in length. The minor irregularities and smaller openings noted serve to make the stone attractive for ornamental use or interior construction in buildings, but where these features are of undue number and size the material becomes unfit for such purposes.

Metallic oxides, chiefly iron, have imparted colors to some parts of the deposits, so that the tints in different places are grayish, flat white, cream, yellow, pink, or even fairly deep red.

Chemical and physical properties.- According to information furnished by the company, chemical and physical tests of the travertine have been made as follows:

Analyses of travertine from Gardiner, Mont.

	U.S. Geological Survey	University of Minnesota	Engineer of tests, Northern Pacific Railway
Silica	0.05	0.05	Tr.
Ferric oxide	.04	.04	0.40
Calcium carbonate	99.74	99.47	98.92
Magnesium carbonate	.07	.07	.53
Sulphate lime a/	.00	.00	.00
Sulphate anhydrate a/	.00	.25	.00
Phosphorus	.00	.00	.00
Organic matter	.00	.00	.00

a/ The meaning intended by these terms is not understood-G.R.M.

A cube of travertine 6 by 6 by 6 inches, weighing 12 pounds, was immersed in water and weighed at intervals, with the following results, according to the engineer of tests, Northern Pacific Railway:

	Percent
Water absorbed after 2 hours	1.20
4 hours	1.22
6 hours	1.22
8 hours	1.23
24 hours	1.23

A compression test by the engineer of tests, Northern Pacific Railway, on a cube 6 by 6 by 6 inches, under a maximum load of 294,760 pounds, showed an ultimate strength of 8,188 pounds to the square inch.

A determination in the laboratory of the Geological Survey indicated for a specimen of a rather coarsely crystalline facies of the rock a specific gravity of 2.69. Finer-textured material if free from pores would be expected to yield a slightly higher result.

Development.- The travertine near Gardiner has been used to some extent for lime-burning and was once included in a fairly pretentious project for cement manufacture, a mill site having been selected and partly prepared north of the river and below the northwestern part of the deposit. The present development, which is designed principally to quarry the rock for ornamental use in the interior of buildings, was begun early in 1932.

Because of the variety of coloration in the rock eight quarries have been opened in different places by the Northwestern Improvement Co., and roads have been built connecting them with Gardiner. These quarries are shown on plate 1. Two groups of core test holes, also shown on plate 1, have been drilled - one near the Sienna quarry and one in the vicinity of the Grant shaft. In addition many scattered test holes and pits and some larger openings such as Wards quarry, have been made, most of which antedate the present development.

The equipment on the ground includes, besides smaller tools, compressors, etc., a Bucyrus Diesel shovel with crane attachment and a 25-ton Linn tractor.

The rock is taken from the quarries in the form of rough blocks ranging in size from 2 or 3 feet on a side to 6 or 8 feet in longest dimension. These are separated by drilling closely spaced holes and wedging rather than by blasting, to avoid damage to the stone. Prior to the middle of October 1932 six carloads of such blocks had been shipped to St. Paul, Minn., where the material has been sawed and polished for use in demonstrations.