Diatomaceous Marl From Western Kansas, a Possible Source of Hydraulic Lime

STATE GEOLOGICAL SURVEY OF KANSAS
University of Kansas, Lawrence, Kansas

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Raw materials that appear from preliminary tests to be suitable for manufacture of hydraulic lime have recently been found in Kansas. Since the United States now imports this substance from Europe, the possibility of developing a good domestic source of hydraulic lime has considerable commercial importance. The Kansas deposits that may prove to be such sources are here called diatomaceous marl.

Three localities of diatomaceous marl in Wallace County, Kansas, have been discovered and studied by M. K. Elias, of the Kansas Geological Survey. The largest one, on the Marshall ranch on the North Fork of Smoky River, has been called chalk rock by local people and also has been supposed to be volcanic ash, since similar white powder-rock with abrasive or polishing qualities is widely distributed in western Kansas. A microscopic examination under high magnification (300 times or more) discloses the fact that this rock in Wallace County consists almost entirely of the siliceous tests of fresh-water diatoms and of flaky calcium carbonate.

Chemical Characters of the Marl

Preliminary quantitative analysis of an average sample prepared from the upper 5 feet comprising about half of the bed at the Marshall ranch showed th dry rock with moisture expelled at about 105° C. consists of about 81 per cent of matter soluble in hydrochloric acid. This is chiefly, if not entirely, fine, flaky calcium carbonate. About 90 to 95 per cent of the remaining insoluble part consists of siliceous tests of diatoms, and of siliceous spicules of sponges. Fine to medium grained quartz sand with a slight mixture of feldspar constitutes the balance of the insoluble part. Due to the construction of the box-shaped empty tests of diatoms the percentage of the volume occupied by these tests is much greater than the percentage by weight. Roughly estimated about one half of the rock by volume is made up of diatoms.

Possible Use

Due to the large amount of calcium carbonate, it is appropriate to call the rock a diatomaceous marl instead of diatomaceous earth. Another reason for this term for the Marshall ranch rock lies in the different practical use which can possibly be made of diatomaceous marl compared with the pure or nearly pure varieties of diatomaceous earth as obtained from southern California and other localities.

The diatomaceous earth which consists chiefly or entirely of the tests of diatoms is a highly porous rock and is used now chiefly as a sound and heat insulator in building construction, as a filter for purifying drinking water an in other cases where high porosity, neutrality to acids, or hardness and sharpness of the minute tests of diatoms are of advantage. The rock from the

Marshall ranch might be regarded as a diatomaceous earth mixed with a large amount of flaky calcareous matter. It is softer and much less porous than ordinary diatomaceous earth and not at all neutral to acids. Thus, though the diatomaceous marl of Wallace County can probably be used in some cases where diatomaceous earth is now applied (for instance, as sound and heat insulators, as an abrasive, etc.), it is obviously an inferior material compared with the purer grades of the latter. On the other hand, the intimate mixture of the diatomaceous tests with calcium carbonate appears to have peculiar useful properties of its own which will decide its place and its value among other mineral resources of this country.

It was noticed in some limestones of Europe that when the amount of silica, and to a much lesser extent alumina and some other impurities in these rocks, is increased to about 12 per cent or more, lime manufactured from them begins to acquire the property known as "hydraulicity", that is it can harden or "set" under water. The natural cement which is made of these limestones is known as "hydraulic lime". Hydraulic lime is white and in this and some other important respects differs from the ordinary yellow or brown natural cements of the "Roman cement" type, which contain a much smaller amount of calcium carbonate and in which alumina and iron constitute a considerable part. A typical natural cement of this latter kind is manufactured at Fort Scott, Kansas. The limestone from which the Fort Scott hydraulic cement is made contains: Silica 18.09 per cent, alumina 3.44 per cent, iron oxide 4.27 per cent, lime 35.32 per cent and magnesia 4.62 per cent (average analysis, Eckel--8). The most famous and typical hydraulic lime is that known as Le Teil or La Farge, made from a limestone found in Ardèche, France. This limestone consists of calcium carbonate very intimately intermixed with finely divided silica. It contains very little alumina and oxide of iron, which are the constituents generally necessary to bring about the union of silica and lime to form a cement, but in spite of this the silica is so finely divided and so well distributed that it unites readily with the lime when the limestone is burned at a sufficiently high temperature. When, subsequently, a little but proper amount of water is poured in, it slakes or disintegrates into fine powder and thus does not need to be ground, which is an unavoidable expense in the manufacture of ordinary cements of both the Portland and the natural hydraulic cement (Roman) types.

As has been said, the Wallace County diatomaceous marl is a chalky substance with about 18 to 19 per cent silica. It is composed chiefly of very fine tests of diatoms intimately mixed with flaky calcium carbonate. There may be a trace of alumina. It remains to be seen if the two most important components of the Marshall ranch rock, calcium carbonate and silica, are fine enough and mixed intimately enough to produce a good natural hydraulic lime after being burned.

One hundred pounds of the diatomaceous marl from the Marshall ranch has been shipped by the Kansas Geological Survey to the United States Bureau of Standards which agreed to make tests in order to find if the rock can be used for manufacture of hydraulic lime. The experiments of the Bureau of Standards are not completed but preliminary study shows "from the work up to date it would appear that this material can be burned so as to produce a lime having hydraulic properties." 1/

1/ Letter of Bureau of Standards, Dec. 29, 1930.

Hydraulic lime has some properties which make it different from Portland cement and from natural hydraulic cements. It sets more slowly than these cements but ultimately becomes as strong as Portland cement. The slow setting is an advantage for some special purposes, as for foundations and abutments where settling may occur. The structure is free to take its permanent position before the lime sets, and cracks are thus avoided. It is used, for instance, in place of Portland cement as grouting outside the cast iron tubes used for lining tunnels made by the shield system. Being low in iron and soluble salts, hydraulic lime is light colored and does not stain masonry, having thus a fair market for architectural uses in cities, especially in the east and southeast of the United States where a considerable amount of this cement is now imported annually (8).

The available American or French literature lacks precise description of lithologic characters of the Le Teil marl but the reported chemical constitution is almost identical to that of the Marshall ranch diatomaceous marl. The following are analyses of some European limestones from which hydraulic lime is manufactured (8):

	Le Teil, France		Senonches France	Hansbergen Germany
Silica (SiO_2)	12.40	16.80	17.00	11.03
Alumina (Al_2O_3)	0.60	0.81	1.00	3.75
Iron oxide (Fe_2O_3)	0.50	trace	not determined	5.07
Lime (Ca O)	47.49	45.40	44.80	43.02
Magnesia (Mg O)	not determined	not determined	0.71	1.34
Carbon dioxide (CO_2)	37.31	35.67	35.99	35.27

The Marshall ranch diatomaceous marl is a fresh-water deposit of Lower Pliocene age while the siliceous marl of Le Teil constitutes the Criocera marls of the marine Lower Neocomian of the Cretaceous. The source of the finely distributed silica in the beds from Le Teil is unknown. The possibility of the presence of diatoms in these rocks is not excluded, for the tests of these organisms are known in marine Cretaceous limestones of European Russia and California.

Description of the Marshall Ranch Deposit

The Marshall ranch diatomaceous marl outcrops on the south side of the North Fork of Smoky Hill river in sections 10, 11 and 12, T. 11 S., R. 38 W., Wallace County, and extends into sec. 7, T. 11 S., R. 37 W., Logan County. The total length of the exposures, interrupted in places by loess, is slightly more than 3 miles. The thickness of the bed ranges from 2 or 3 feet in the middle of section 11, to 11 feet in the eastern part of this section. The average thickness from here to the easternmost exposure in Logan County is about 7 feet. In the western half of section 11 the diatomaceous marl is more limy and hard but in the northwest quarter of section 10 it is somewhat softer. On the top of the bed there is nearly always a thin hard ledge of white limestone, usually full of small cavities representing molds of fresh-water gastropods. This limestone is a few inches to one foot thick. At the base of the

diatomaceous marl there is generally a light gray clay with some mixture of calcareous matter and diatoms, but locally there is greenish sand in place of clay at the base. A number of mammalian and other bones have been found in this sand.

The constitution of the diatomaceous marl is fairly uniform throughout. It is always a snow-white chalky rock, light and very fragile. However, it resists weathering and together with the capping thin limestone forms low cliffs and benches on the southern slope of Smoky River valley. In a few places erosion has formed separate cliffs of the diatomaceous marl which are scattered on the smooth, gently descending slope of the valley. The rock is usually massive and is cut by widely spaced vertical joints into large blocks. However, it has also a distinct horizontal stratification and can be broken with comparative ease along the closely spaced bedding planes.

The Ogallala formation, to which the diatomaceous marl bed belongs, is slightly folded in this area and accordingly the bed is not at the same elevation along the outcrop. It is about 60 feet above the level of Smoky Hill river at the west end of the exposure, and varies from 80 to 120 feet above in the middle and east while the river drops about 50 feet.

The overburden above the diatomaceous marl consists of the thin hard limestone and in some places of nearly 15 feet of Ogallala grit, slightly cemented by calcium carbonate. Above this lies gravel and loess of Pleistocene. The specific gravity of air-dry rock is about 1.53, which is approximately three times greater than that of pure diatomaceous earth from California.

The supply of diatomaceous marl at the Marshall ranch locality can be roughly estimated in the following way. The length of the exposures of the marl with average thickness of 6 feet is about 2½ miles. The zig-zag like arrangement of exposures along this length permits observation that the thickness of the bed does not decrease appreciably within at least one-eighth of a mile at right angles to the general trend of the outcrop. The overburden varies from 0 to 30 feet in thickness. Considering that this strip of diatomaceous marl, which is 2½ by one-eighth square miles in area, is decreased to about one half by the numerous canyons and gulches in which the rock is eroded away, the total volume of the remaining diatomaceous marl of the divides between the small canyons is about 26,136,000 cubic feet. As the diatomaceous marl weighs about 85 pounds per cubic foot this volume corresponds to more than 1,000,000 tons. This estimation does not pretend to be exact, but gives the correct idea as to the amount of diatomaceous marl which could be stripped with overburden not exceeding 30 feet.

Other Deposits of Diatomaceous Marl

Two other outcrops of diatomaceous marl in Wallace County have been studied. One that was shown to Elias by Mr. Jas. T. Madigan is in the SE. ¼ of SE. ¼ of sec. 35, T. 11 S., R. 39 W., at the very head of one of the numerous draws on the south side of Lake Creek. The soft, snow white diatomaceous marl of apparently the same qualities as that of the Marshall ranch, makes here a small inconspicuous outcrop. The small size of the outcrop is probably due to the absence of the hard limestone at the top of the bed. The thickness of the outcropping rock is about 3 or 4 feet, but neither the base nor the top are visible. A few feet above the outcrop loess can be seen in the bluffs at the head of the canyon while below and somewhat down the canyon a few outcrops of Ogallala grit can be observed.

The third locality of diatomaceous marl and the one in which the diatoms were first recognized by Elias in 1928, is in the NE. corner of NW. ¼ of sec. 29, T. 12 S., R. 41 W., about one-half mile east of the Collins ranch. The diatomaceous marl of this locality is of somewhat different color and texture. It is light gray in color and softer than the rock from Marshall ranch. There is probably less calcium carbonate and more diatoms and there is a mixture of clayey material in this rock. The bed is 4 feet thick. It is slightly harder at the top and is capped by limestone partly silicified into compact, tough chert. The bed is underlain by greenish-gray clay. The lateral extent of the bed seems to be insignificant.

Soft, light-colored rocks in which diatoms constitute a considerable part are known in southwestern and western Nebraska (2, 3) and in Beaver County, Oklahoma (5, 6, 7), from which locality they probably extend into Meade and Seward counties of southwestern Kansas. According to Adams (1) the soft chalky limestone, which he compares with the diatomaceous deposit of Beaver County, is exposed on both sides of the Cimarron River in Seward County, Kansas, and is there 10 feet thick.

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