Marl Deposits in the Knik Arm Area Alaska

GEOLOGICAL SURVEY BULLETIN 1039-A

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By R. M. MOXHAM *and* R. A. ECKHART

INVESTIGATIONS OF CONSTRUCTION MATERIALS IN ALASKA

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A description of the marl deposits and the possible use of this marl for making portland cement

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MARL DEPOSITS IN THE KNIK ARM AREA, ALASKA

By R. M. Moxham and R. A. Eckhart

ABSTRACT

Marl occurs in and adjacent to at least five lakes in the Knik Arm area in south-central Alaska. The most significant deposits are near Wasilla, about 30 miles north of the city of Anchorage.

Accumulation of the calcareous material has taken place in sheltered embayments and shallow marginal areas of the lakes; algae probably act as the precipitating agents. In some places the embayments have been completely filled with marl and subsequently covered by a layer of muskeg, effectively sealing off the deposits from the lakes proper.

The marl is probably chemically suitable for the manufacture of portland cement, but the inferred reserves—about one million tons (dry weight)—would be insufficient for modern large-scale operations.

The deposits described represent only the more obvious occurrences of marl, found during a brief reconnaissance of a small part of the Knik Arm area. If further investigation should become warranted, particular attention should be directed toward finding buried shoreline deposits that are usually higher in $CaCO_3$ than the other lacustrine materials found in the area.

INTRODUCTION

The occurrence of marl at several localities in the Knik Arm area of south-central Alaska (fig. 1) has been known for many years. In 1916 Daniel M. Lynch discovered a deposit of the lime-rich material on the margin of Otter Lake (pl. 1), on what is now the Fort Richardson Military Reservation adjacent to the city of Anchorage. A few tons of the marl was calcined to produce lime for agricultural purposes (Martin and others, 1919, p. 27). About this same time, or possibly a few years before, a Mr. Stearns found marl on his land on the south shore of Wasilla Lake about 30 miles north of Anchorage. This deposit is now called the Edlund deposit. Other deposits of marl near the east shore of Big Lake, about 40 miles north of Anchorage, were reportedly used locally for agricultural purposes for many years.

PREVIOUS INVESTIGATIONS

Capps (1940) made a reconnaissance survey of the geology of the Knik Arm area. Dobrovolny and Miller [1] mapped the geology of the Anchorage area, with major emphasis on the unconsolidated deposits of the Knik Arm lowlands. In the period 1949–51, Trainer (1953) made a detailed study of the northern part of the region in connection with an investigation of the geology and ground-water resources of the Matanuska Valley agricultural area.

In 1950 the Territorial Department of Mines surveyed the Edlund deposit and made chemical analyses of auger-hole samples that had been collected by William Edlund.

The only previous investigation of the marl deposits by the Geological Survey was a brief examination of the Otter Lake deposit by Martin (Martin and others, 1919, p. 27).

A detailed examination of the marl deposit on the south shore of Wasilla Lake was made by Dachnowski-Stokes (1941) in connection with an investigation of the peat resources of Alaska.

PRESENT INVESTIGATION

This study of the marl deposits in the Knik Arm area was undertaken in conjunction with the Geological Survey's investigation of industrial minerals in Alaska. The principal purpose of the work was to determine the potential value of the known deposits of marl as a portland cement component and to determine whether additional deposits existed in the region.

The meager information available at the outset of the investigation indicated that the area between Palmer and Big Lake, in which two of the three known marl deposits had been found, held the most promise of additional deposits. The major part of the fieldwork, therefore, was done in that area.

A preliminary examination of the Edlund deposit indicated that the marl occurred in a muskeg-covered former embayment of Wasilla Lake. The present lake bottom immediately adjacent to the filled-in area appeared to be covered with marl or calcareous mud and was thought to represent the lakeward growth of the Edlund deposit. It seemed likely, therefore, that the presence of calcareous deposits on present lake bottoms, in addition to being of possible economic significance in themselves, might indicate additional lake-margin deposits, now buried and concealed by muskeg.

Most of the lakes in the Knik Arm area are relatively shallow, and the water is clear. As the marl and associated calcareous mud are

[1] Dobrovolny, Ernest, and Miller, R. D., 1950, Descriptive geology of Anchorage and vicinity, Alaska: U. S. Geol. Survey Open File Report.

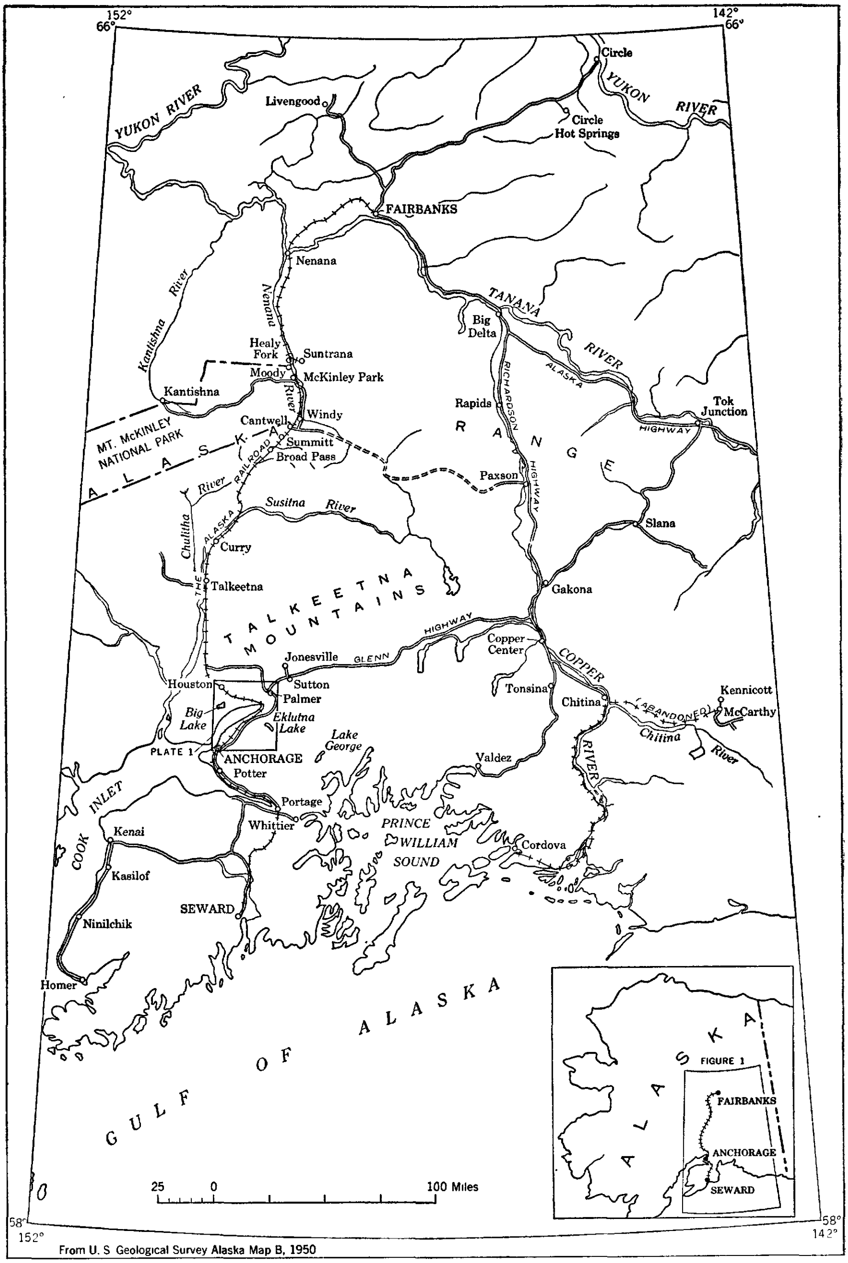


FIGURE 1.—Index map of south-central Alaska.

generally light in color, an aerial reconnaissance was considered to be the quickest means for determining at least the general distribution of the more extensive areas of lake-bottom calcareous deposits. An aerial reconnaissance was made over the northern part of the region (north of the north shore of Knik Arm) between Palmer and Big Lake. From the air, the color of the calcareous bottom deposits ranges from greenish white in shallow (2 to 4 feet) water to light green and gray in deep water, and it was noted that the most extensive deposits of light-colored material occur in four lakes—Wasilla, Finger, Lucile, and Big Lakes.

Subsequent to the aerial reconnaissance, the lake-bottom deposits were tested from a boat by means of a 6-inch diameter Iwan auger or a 2-inch diameter spiral auger. Three- to six-foot lengths of 6-inch diameter stove pipe were driven into the bottom deposits to case the upper few feet of the hole, preventing caving. Auger holes also were drilled in the Edlund deposit adjacent to Wasilla Lake, and in other shoreline areas of Lucile, Finger, and Big Lakes, at localities thought to be former embayments of those bodies of water.

The present investigations were made during July 1951 by the writers assisted by R. A. Wilkens and Winton Bakke.

ACKNOWLEDGMENTS

The authors acknowledge the help and cooperation of D. L. Irwin, Director of the Alaska Agricultural Experiment Station and William Edlund, who generously gave his time and assistance to the authors and made available the map of the deposit and the results of his test drilling.

GEOGRAPHY

The geographic limits of the Knik Arm area have been arbitrarily chosen and are indicated by boundaries on plate 1. The region includes the city of Anchorage and the Matanuska Valley agricultural area, two of Alaska's most heavily populated and economically important areas. Several major airlines, the Alaska Railroad, and a network of all-weather highways provide easy access the year around.

The major portion of the region is occupied by the lowlands adjacent to Knik Arm, a northward extension of Cook Inlet, and the swampy flats of the lower Susitna and Matanuska River drainage systems.

Southeast from Knik Arm, the steep, heavily forested slopes of the Chugach Mountains rise abruptly from the lowlands to altitudes from 6,000 to 7,000 feet. The southernmost ridges of the Talkeetna Mountains border the lowlands in the extreme north-central and northeastern portion of the region.

The climate of the Knik Arm area, in comparison to the interior of Alaska, is relatively mild; the temperature during the summer months averages about 55° F. and the winter average is about 15° F. Snow can be expected by late October and sometimes occurs as late as May. The average total precipitation is about 18 inches (U. S. Weather Bureau, 1950).

GENERAL GEOLOGY

The rocks in the Knik Arm area range in age from Pre-Cambrian to Quaternary (pl. 1). Bedrock is exposed chiefly in the mountainous areas that border the Knik Arm lowlands on the east and north, and in the valley of the Matanuska River.

SEDIMENTARY ROCKS

The pre-Quaternary rocks that border the Knik Arm lowlands range in age from Pre-Cambrian to Eocene. Brief descriptions of the major units are given below.

PRE-CAMBRIAN

The Birch Creek schist crops out on the south flank of the Talkeetna Mountains. The unit comprises mica, quartz, and chlorite schists and phyllite, generally dark colored, weathering locally to a rusty hue. The rocks are massive where fresh and assume a platy or fissile structure where weathered.

CRETACEOUS

A thick series of dark-colored slate, graywacke, and argillite form the core of the Chugach Mountains bordering the Knik Arm area on the east. The rocks are typically fine grained and occur in alternating bands of the several lithologic types.

The Matanuska formation—shale, graywacke, and sandstone—occupies the lower slopes of the Matanuska Valley. Shale dominates the lower part of the formation, with sandstone and graywacke predominating in the upper part.

EOCENE

Eocene rocks, comprising mainly shale, sandstone, arkose, conglomerate, and coal, crop out on the south flank of the Talkeetna Mountains. The basal part of the Eocene section is chiefly conglomerate and arkose with fine-grained clastic sediments and coal in the upper part.

PLEISTOCENE AND RECENT

The lowlands that constitute the major part of the Knik Arm area are mantled by thick unconsolidated sediments of glacial and glaciofluvial origin, as well as terrace, beach, estuarine, lacustrine, and alluvial deposits. In the northern part of the area the Pleistocene deposits are nearly everywhere overlain by 1 to 3 feet of Recent gray loess.

During postglacial development in the lowland areas, physical, chemical, and organic conditions in certain of the lakes became conducive to the precipitation of $CaCO_3$, particularly in sheltered embayments and shallow, nearshore areas. At some localities the lake-pond-muskeg sequence has progressed to such an extent that the embayments are now completely filled with lime-rich deposits and are overlain by muskeg, that effectively seals these areas from the lakes proper. The calcareous deposits comprise two major stratigraphic units in most localities (fig. 2); the lower unit, deposited on a sand or gravel bottom, is relatively high in $CaCO_3$ and ranges in color from white through light gray to light tan. In general, the lighter color reflects a relatively high $CaCO_3$ content while the darker shades indicate a decrease in $CaCO_3$ and an increase in organic and terrigenous material. Where present, the lower of the two calcareous units ranges in thickness from a few feet to 20 feet or more. The marl is quite soft while wet, very sticky, and usually plastic. It dries in coherent masses of finely granular material that may be crushed to a powder between the fingers.

The lower marl deposits are nearly everywhere overlain by a layer of light-tan to light-gray calcareous silt that ranges in thickness from less than 1 foot up to 8 feet. In some localities the marl is gradational into the overlying silt. Elsewhere the contact is fairly sharp. The silt layer apparently reflects either a change of the regional base level whereby a greater proportion of terrigenous and organic debris was deposited in relation to the chemical sediments or a change in the chemical or physical environment that decreased the precipitation of $CaCO_3$.

The calcareous deposits, from a genetic standpoint, are hybrid in character in that they represent accumulations of chemical precipitates mixed with varying amounts of clastic sediments and organic matter. As the $CaCO_3$ content of the deposits sampled ranges from 12 to 77 percent, the more impure materials would be more properly classified as calcareous silt rather than marl; 25 percent $CaCO_3$ is commonly used as an arbitrary lower limit for marl (Pettijohn, 1949, p. 286). For simplicity, however, all the light-colored calcareous lacustrine deposits are referred to as marl in this paper.

Diatoms from marl collected by the authors at two localities in the Knik Arm area were identified by K. E. Lohman. Sample 3606 is from the southwest end of Wasilla Lake (drill hole 3, fig. 3); sample 3607 is from the east end of Big Lake. The following forms were reported:

	3606	3607
Achnanthes flexella (Kützing) Brun	F[1]	---
Amphora ovalis Kützing	F	F
Caloneis bacillum (Grunow) Nitzsch	R	---
obtusa (Wm. Smith) Cleve	F	F
cf. *C. silicula* (Ehrenberg) Cleve	F	---
Cocconeis placentula Ehrenberg	R	---
Cyclotella antiqua Wm. Smith	R	---
operculata (Agardh) Brebisson	R	---
cf. *C. temperi* Brun	R	---
Cymbella aequalis Wm. Smith	---	R
cf. *C. cistula* (Hemprich) Grunow	F	---
cuspidata Kützing	F	---
cf. *C. cymbiformis* (Ehrenberg) Van Heurck	F	---
ehrenbergii Kützing	C	F
gracilis (Rabenhorst) Cleve	---	F
cf. *C. heteropleura* (Ehrenberg) Kützing	R	---
mexicana (Ehrenberg) Schmidt	R	---
turgida Gregory	---	R
ventricosa Kützing	F	R
sp.	F	---
Epithemia intermedia Fricke	---	R
sorex Kützing	---	R
turgida Gregory	F	---
turgida var. *granulata* (Ehrenberg) Grunow	F	---
zebra var. *porcellus* (Kützing) Grunow	F	R
Gomphonema bohemicum Reichelt and Fricke	R	---
constrictum Ehrenberg	---	R
intricatum Kützing	F	---
Mastogloia smithii var. *lacustris* Grunow	---	R
sp.	F	R
Navicula cuspidata Kützing	R	---
oblonga Kützing	F	R
cf. *N. peregrina* (Ehrenberg) Kützing	C	C
pupula var. *capitata* Hustedt	R	---
pupula var. *rectangularis* (Gregory) Grunow	---	R
radiosa Kützing	F	F
scutelloides Wm. Smith	R	---
tuscula (Ehrenberg) Van Heurck	F	F
Neidium amphirhynchus (Ehrenberg) Boyer	F	F
bisulcatum (Lagarstedt) Cleve	F	F
iridis (Ehrenberg) Cleve	F	---
sp.	R	---
Nitzschia cf. *N. frustulum* (Kützing) Grunow	R	---
cf. *N. heufleriana* Grunow	R	---
Pinnularia dactylus var. *demararae* Cleve	R	---
major (Kützing) Wm. Smith	F	R
microstauron (Ehrenberg) Cleve	F	---
viridis (Nitzsch) Ehrenberg	F	R
sp.	F	---
Rhopalodia gibba (Kützing) O. Muller	R	---
Stauroneis sp.	C	C
Surirella linearis var. *constricta* (Ehrenberg) Grunow	R	---

[1] The letters refer to the abundance of the forms in the samples: C, common; F, frequent; R, rare.

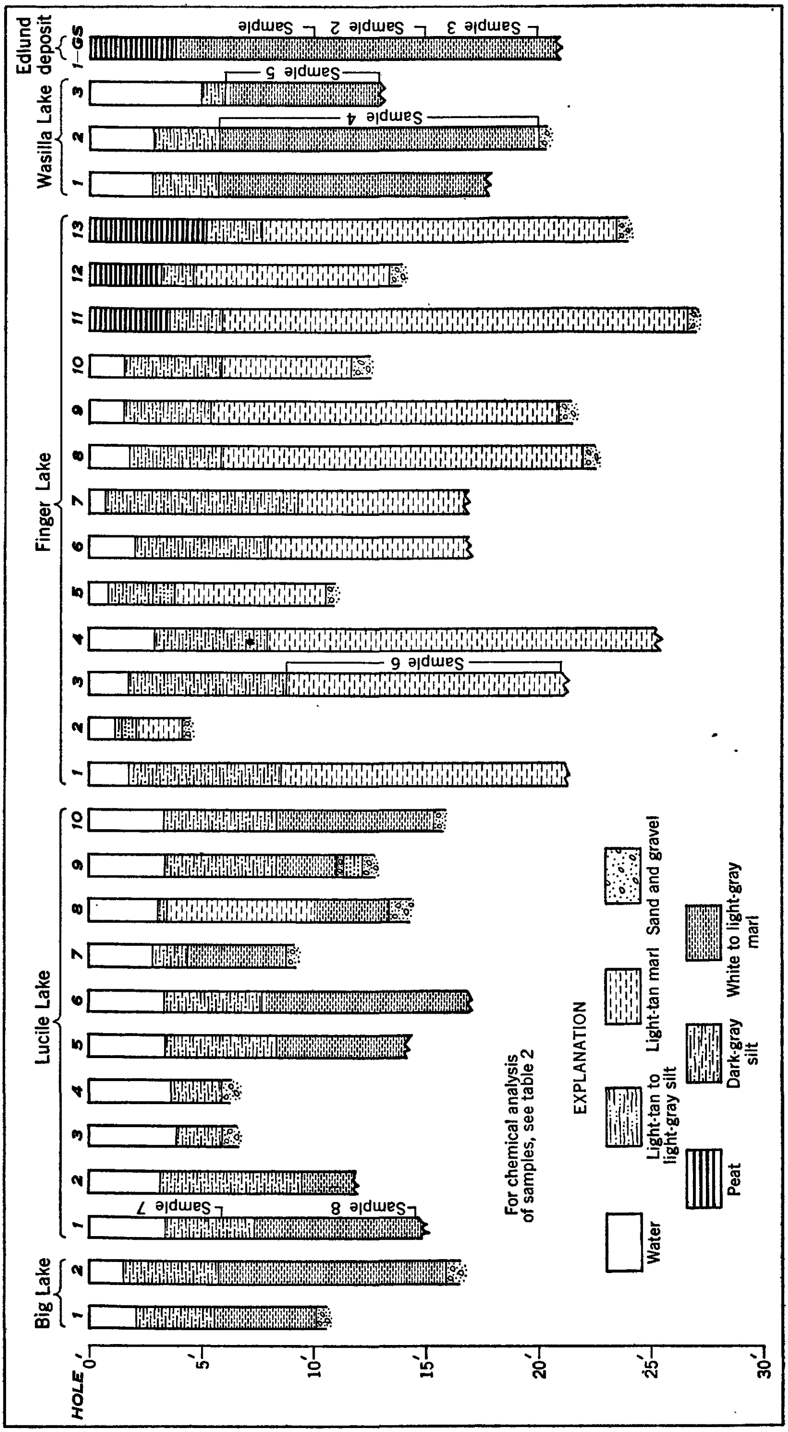


FIGURE 2.—Columnar sections of marl deposits in the Knik Arm area.

Lohman states—

This diatom assemblage is made up almost entirely of species and varieties now living in cool to cold fresh-water lakes in northern United States and Canada. Many of them also occur in Pleistocene deposits such as the Provo formation of central Utah, which contains 40 percent of the species found in the Cook Inlet samples. The Provo formation is dominantly a calcareous silt containing what appears to be chemically precipitated lime, fresh-water molluscs and diatoms.

The deposition of marl in hard-water lakes is fairly common especially in those parts of the world blanketed by glacial drift. The physiographic setting of the marl deposits in the Knik Arm area is similar in many respects to that which has proven favorable for accumulation of marl in the Great Lakes region (Hale, 1903; Stout, 1940), where the calcareous deposits have formed in lake-filled basins within areas mantled by glacial drift.

Several conditions must generally be fulfilled for lake marl to accumulate. The relatively high ratio of chemical sediments to terrigenous and organic debris necessitates a terrain having very low topographic relief, a precipitating agent or mechanism, and physical and chemical conditions such that precipation exceeds dissolution of the carbonates.

The precipitation of $CaCO_3$ in fresh-water marls is commonly attributable to some form of organic action. Probably the most common deposits result from lime encrustations produced by *Chara* (stonewort), a shallow-water bottom-rooted alga. Other calcareous deposits have been attributed to Myxophyceae (blue-green algae), higher aquatic plants, plankton, bacteria, and mollusks (Welch, 1935, pp. 176–182).

There is little evidence to indicate the agent responsible for the precipitation of marl in most localities of the Knik Arm area. A small lake near the Agricultural Experimental Farm contains many specimens of *Chara* that are heavily encrusted with $CaCO_3$ (D. L. Irwin, personal communication, 1952). No examination of the lake-bottom vegetation in the principal marl lakes in the Wasilla area, a short distance north of the Experimental Farm, was made by the authors, but the marl in the Edlund deposits was described as a *Chara* marl by Dachnowski-Stokes (1941, p. 56–58), who made a detailed examination of the muskeg and marl at that locality in 1939. He gives the following description—

0–42 inches; the upper 6 inches consists of light reddish-brown sphagnum moss peat, spongy fibrous in texture, acid and relatively free from woody material; it grades into a mixture of brown moss and sedge peat which contains roots and rhizomes of the growing vegetation from the 10- to 18-inch level; the material rests on a thin seam of volcanic ash; below it, is reddish-brown sphagnum moss peat to a depth of 38 inches below the surface, which contains the matted network of roots and rhizomes from tussocky sedges; near the four-foot level is a layer of dark brown woody sedge peat with stumps of spruce and birch on marl.

42–108 inches; gray *Chara* marl; yellow-tinted to pink in color at lower levels; at the base it merges into brown organic sediments, about 2 to 3 inches thick and derived from aquatic plants and plankton organism.

108–110 inches; sandy gravel.

He has interpreted the succession of materials comprising the muskeg to indicate—

> * * * the presence of an early lake and a primary free-floating aquatic vegetation which was soon replaced by species of *Chara* and probably certain blue-green algae; they are the chief agents responsible for the great precipitation of lime over the floor of the lake. Thereafter, trees of spruce and birch with their associates appeared over the surface of the marl, indicating a change to drier conditions. This was followed by a cool moist period associated with the active growth and spreading of sphagnum mosses and sedges.

A microscopic examination of one auger-hole sample of marl from the Edlund deposit showed a few fragments of organic remains (stems and oöspores of charophytes), but none of the marl fragments are identifiable specifically as the remains of *Chara* encrustation. It is possible, however, that in this particular sample the original characteristic surficial configuration of the *Chara* may have been destroyed by augering.

Deposition of $CaCO_3$ elsewhere in the world is known to have resulted from physical and chemical processes without the benefit of organisms. To determine whether seasonal temperature changes or other purely physical phenomena, or both, might be at least in part responsible for the marl in the Knik Arm Lakes, the $CaCO_3$ saturation of the water of Wasilla Lake has been calculated. Chemical analyses of water from Finger and Lucile Lakes and Cottonwood Creek (outlet for Wasilla Lake) are given in table 1. Sample 672 which appeared to most nearly approach $CaCO_3$ saturation was used in the calculation below.

The $CaCO_3$ saturation pH at 15°C has been calculated from an expression derived by Larson and Buswell (1942, p. 1676)—

$$\text{saturation pH} = \log \frac{Ks}{K_2} - \log\,[Ca^{++}] - \log\,[\text{alky}] + 9.3 + \frac{2.5\sqrt{\mu}}{1+5.3\sqrt{\mu}+5.5\mu}$$

where

Ks = the solubility product for $CaCO_3 = 6.11 \times 10^{-9}$ (at 15°C)
K_2 = the second ionization product for $H_2CO_3 = 3.72 \times 10^{-11}$ (at 15°C)
$\mu = 2.5 \times 10^{-5} \times$ total dissolved solids $= .0035$

and $[Ca^{++}]$ and [alky] are in ppm (as Ca and $CaCO_3$, respectively).

Substituting the values given above and from water analysis sample 672, table 1,

$$\text{saturation pH} = \log \frac{6.11\times10^{-9}}{3.72\times10^{-11}} - \log 37 - \log 112 + 9.3 + \frac{2.5\sqrt{.0035}}{1+5.3\sqrt{.0035}+5.5(.0035)}$$
$$= 8.0$$

TABLE 1.—*Chemical analyses, in parts per million, of water from lakes in the Knik Arm area*

[Analyst: G. W. Whetstone]

Location	Lab. no.	Collection date	Total hardness as $CaCO_3$	Noncarbonate hardness	pH	SiO^2	Fe	Ca	Mg	Na+K	CO_3	HCO_3	SO_4	Dissolved solids
Cottonwood Creek (Wasilla Lake outlet):														
1 mile below Wasilla Lake	SLC 2057	Oct. 19, 1948	86.0	0		9.2		28.0	4.0	5.1	0	110.0	6.0	108.0
Do	64	May 19, 1949	72.0	0	7.7	9.0		23.0	3.4	3.9	0	90.0	5.4	90.0
Do	523	Oct. 31, 1950	100.0	0	7.5	8.7	0.02	33.0	4.4	3.9	0	126.0	3.8	117.0
Do	672	Mar. 21, 1951	111.0	0	8.0	12.0	.01	37.0	4.6	5.1	0	136.0	8.0	139.0
Do	691	May 24, 1951	100.0	13.0	8.0	7.9	.03	33.0	4.4	2.8	0	121.0	5.4	115.0
Finger Lake:														
At depth of 8 feet	794	Aug. 1, 1951	81.0	0	8.3	2.5	.02	26.0	4.0	1.4	0	100.0	1.2	85.0
At surface	795	do	73.0	0		4.5	.02	22.0	4.5	2.4	0	93.0	.2	81.0
Lucile Lake:														
At depth of 4 feet	797	do	53.0	0		8.6	.04	16.0	3.1	2.4	0	68.0	1.3	66.0
At surface	797	do	55.0	2.0		8.6	.02	15.0	4.3	.2	0	65.0	.8	62.0

Thus, the calculated saturation pH is the same as the measured pH, which would indicate that the lake water is probably saturated with respect to $CaCO_3$. Solubility of $CaCO_3$ is dependent upon temperature, ionic strength, pH, and particularly upon total CO_2 in solution. There are few data available on the range of variation of these factors, but as the water is at or near $CaCO_3$ saturation, the possibility of precipitation owing to a change in one or a combination of these factors cannot be disregarded.

IGNEOUS ROCKS

Granitic intrusive rocks of Cretaceous age, mostly light-gray medium- to coarse-grained granite, have intruded Cretaceous volcanic rocks and the Matanuska formation in the Chugach Mountains.

Volcanic rocks of Mesozoic age, chiefly tuffaceous and extrusive greenstone, occupy a synclinal basin along the western flank of the Chugach Mountains.

Volcanic rocks of Tertiary age, principally mafic extrusive rocks whose exact stratigraphic relations are not known, crop out on the south flanks of the Talkeetna Mountains.

ECONOMIC GEOLOGY

The desirability of local sources of cement for the Alaskan construction industry has long been recognized, but adequate deposits of chemically suitable raw materials are not plentiful in areas accessible to transportation. Other economic problems relating to the development of the known deposits have also been major obstacles.[2]

The marl deposits in the vicinity of Wasilla, in the northern part of the Knik Arm area, are far better situated geographically than any other known deposit of high-lime material in central Alaska. The Wasilla area has year-round access to the two largest potential markets, Anchorage and Fairbanks, by the Alaska Railroad and also by highway. Coal is available from mines at Houston, 13 miles northwest of Wasilla, and at Jonesville, 20 miles northeast of Wasilla. The mines at both localities have rail connections with Wasilla. Power costs are relatively low in comparison with costs in other parts of the Territory.

MARL DEPOSITS

WASILLA LAKE

The inferred distributon of marl in and adjacent to Wasilla Lake is shown in figure 3.

The Edlund deposit is on ground that is relatively level and poorly drained. A 3- to 4-foot layer of water-logged muskeg, which overlies

[2] Moxham, R. M., and others, 1953, Geology and cement raw materials of the Windy Creek area, Alaska: U. S. Geol. Survey Open File Report.

AERIAL VIEW OF WASILLA LAKE

View from the south showing the muskeg-covered embayment underlain by marl at the Edlund deposit.

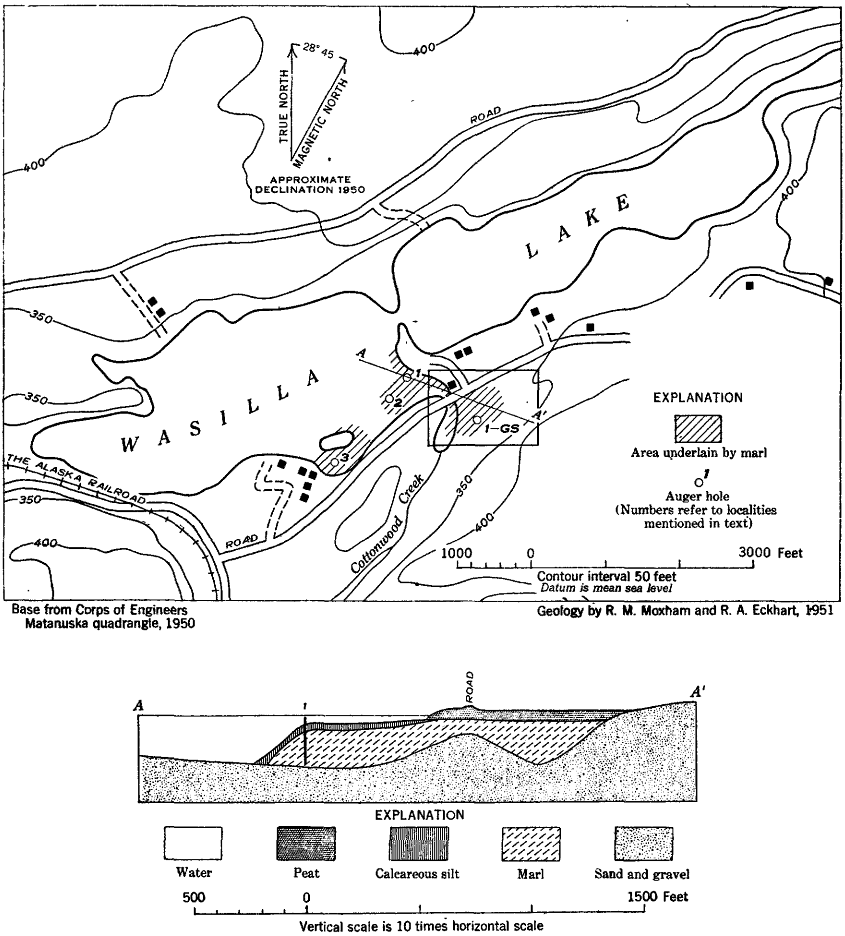


FIGURE 3.—The inferred distribution of marl at Wasilla Lake.

the marl, supports a sparse growth of scrubby spruce and brush, in sharp contrast to the moderately to heavily timbered area immediately adjacent. (See plate 2.)

Many auger holes have been drilled by Mr. Edlund to determine the thickness and extent of the deposit. The Territorial Department of Mines surveyed the property and determined the locations of the various test holes. A map of the deposit (fig. 4) was made available. One auger hole (1–GS) was put down by the authors near the center of the deposit. Chemical analyses from core recoveries at the 10-, 15-, and 20-foot levels in this hole are given in table 2.

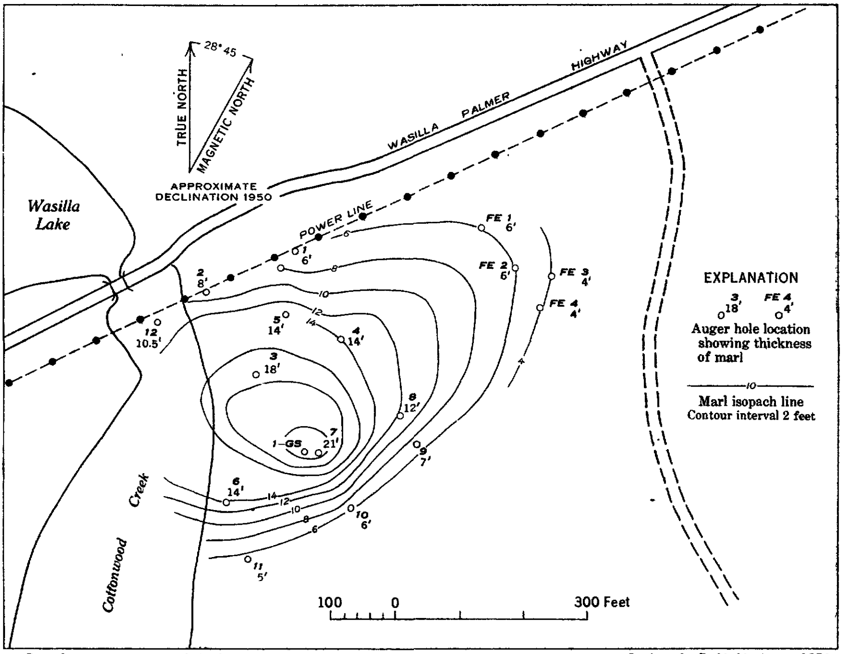
The marl is fine grained and is mostly light gray to cream colored when wet and white when dried. Layers tinged with traces of red and green, and two thin bands of dark-gray silt were found, but in general the material appears to be uniform in composition.

TABLE 2.—*Chemical analyses of auger-hole samples of marl*

Analysts: E. A. Nygaard and S. M. Berthold]

Sample no.	Hole no.	Depth of sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Ignition loss [1]	Not determined
Edlund deposit:											
1	1-GS	10-foot level	8.4	0.12	0.54	45.0	0.54	0.34	0.20	43.2	
2	1-GS	15-foot level	3.4	.00	.26	50.0	.41	.22	.13	45.6	
3	1-GS	20-foot level	18.6	.24	1.4	37.8	1.1	.67	.37	35.8	
Average			10.1	.12	.7	44.3	.7	.41	.23	41.5	2.0
Wasilla Lake:											
4	2	Composite	18.0	1.8	1.0	37.0	.97	.48	.28	39.3	
5	3	Composite	16.3	.95	1.1	37.8	.59	.48	.34	40.0	
Average			17.2	1.4	1.1	37.4	.78	.48	.31	39.7	
Finger Lake:											
6	3	Composite	32.8	3.2	1.6	21.9	.62	.82	.39	36.8	1.9
Lucile Lake:											
7	1	6-foot level (calcareous silt)	40.4	9.4	3.0	8.2	1.1	1.6	.94	36.6	
8	1	15-foot level	10.2	1.3	1.2	40.6	.56	.48	.27	43.6	
Average			25.3	5.4	2.4	24.4	.8	1.0	.61	40.1	1.6

[1] Includes ignition loss due to oxidation of FeO.



Base from survey maps of the Territorial Department of Mines and J. C. Baldwin, 1950

Geology by R. M. Moxham, 1951

FIGURE 4.—Isopachous map of the Edlund marl deposit.

The Edlund deposit is roughly oval in outline and apparently occupies a basinlike depression; the upper surface is relatively level. The deposit is thickest (about 21 feet) near the center and thins rapidly toward the periphery. The isopachs shown on figure 4 indicate the general configuration of the deposit.

In Wasilla Lake, immediately adjacent to the Edlund deposit, calcareous silt is being deposited on the lake bottom. It is probable that this accumulation represents the lakeward growth of the muskeg-covered marl deposit described above, although the material being deposited in the present physiographic cycle contains a greater percent of terrigenous debris than the underlying marl. (See cross section of the marl at Wasilla Lake, fig. 3.) A layer of marl was also found a quarter of a mile west of the Cottonwood Creek outlet. The marl in both areas is white to very light gray, plastic, and very sticky. It contains abundant mollusk fragments and a relatively small amount of well-preserved plant remains. The semiconsolidated marl is overlain by 1 to 3 feet of light-gray to light-tan mud and 3 to 4 feet of water. The lakeward margin of the marl deposit is generally quite abrupt, with the marl surface sloping steeply lakeward to a sand or gravel bottom.

Three auger holes were sunk in the Wasilla Lake deposits. Columnar sections of the material are shown in figure 2. Results of chemical analyses of the marl in holes 2 and 3 are given in table 2.

FINGER LAKE

Marl was found in several embayments in Finger Lake, and in two muskeg-covered areas near the southern and eastern shores of the lake. (See fig. 5.) Ten auger holes were drilled in deposits on the present lake bottom and three in the adjacent shoreline deposits. The marl is generally light tan when wet, but is white in local streaks. It is buff to grayish white when dry. The present lake-bottom deposits are overlain by 2 to 8 feet of light-tan mud and by 3 to 4 feet of water; the adjacent shoreline deposits are overlain by a thin layer of brown mud capped by 3 to 5 feet of peat.

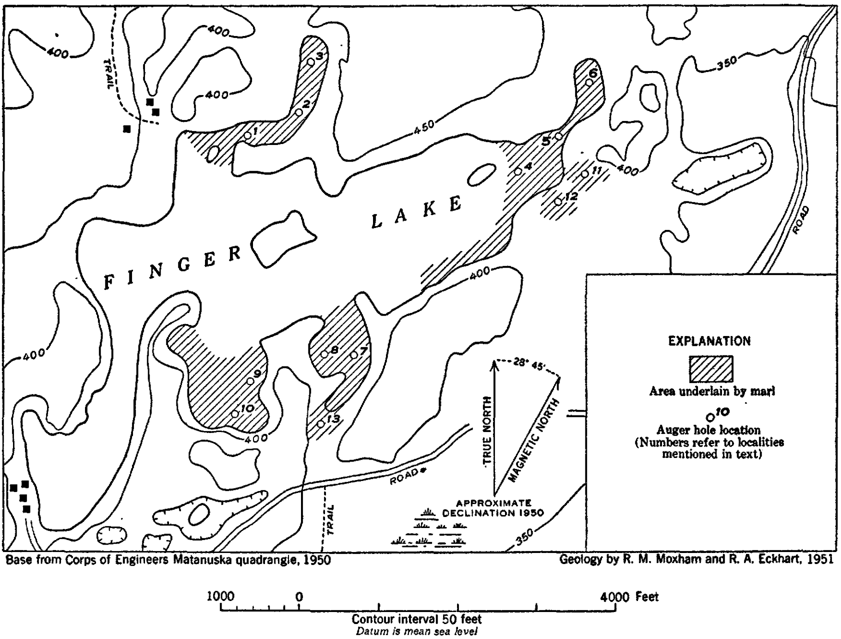


FIGURE 5.—The inferred distribution of marl at Finger Lake.

Table 2 gives the results of chemical analysis of marl in hole 3 in an embayment on the north side of the lake. Insofar as its megascopic characteristics are concerned, the material from hole 3 appears to be representative of the marl found in the Finger Lake area.

Columnar sections of the Finger Lake deposits as indicated by the drill cores are shown in figure 2. The marl is at least 18 feet thick at one locality (hole 4) at the east end of the lake; the hole did not reach the bottom of the marl. On the east margin of the lake about 200 feet east of the shoreline, holes 11 and 12 show that the marl is at least 21 feet and 8 feet thick, respectively, at these localities. Another muskeg-covered embayment on the south shore of the lake (hole 13) contains 16 feet of marl.

LUCILE LAKE

Marl deposits were found in the west and east ends of Lucile Lake. (See fig. 6.) The material is white to light gray, plastic to sticky in consistency, and overlain by 1 to 6 feet of light-tan to brown mud. Test holes were drilled west and south of the lake shore, but no buried marl was discovered; several test holes were abandoned on striking permafrost. Columnar sections of the material in the lake are shown in figure 2. Chemical analyses of the marl in hole 1 are given in table 2.

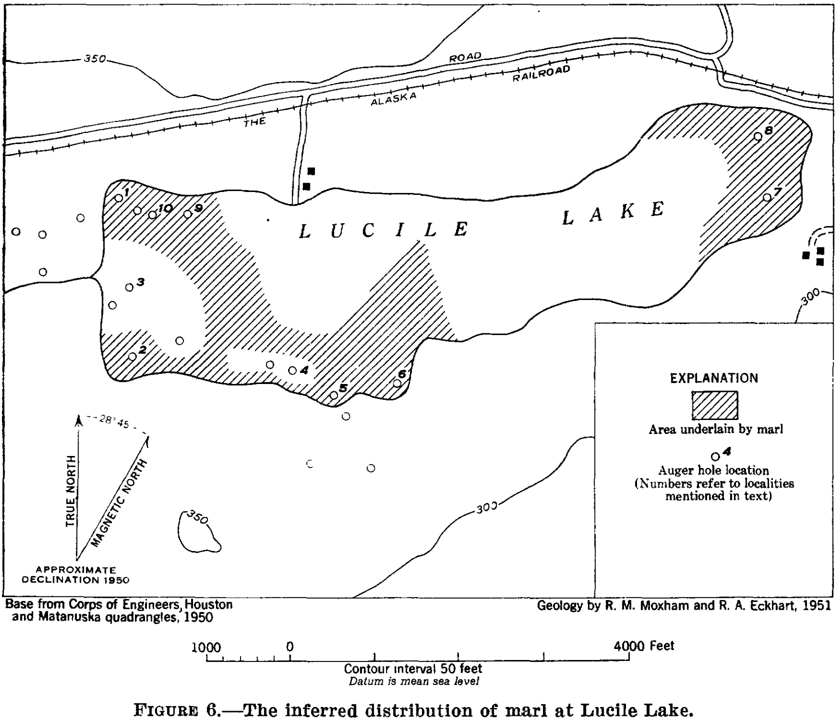


FIGURE 6.—The inferred distribution of marl at Lucile Lake.

The marl deposits in Lucile Lake seem to be generally thinner and less persistent laterally than those in the other two lakes described. The maximum thickness of marl found at the east end of the lake was about 10 feet. In the northwest part of the lake bottom, the marl is 7 feet thick (hole 1), and an embayment in the south shore contains white marl at least 9 feet thick (hole 6); the bottom of this deposit was not reached.

BIG LAKE

Fourteen auger holes were drilled in the bottom deposits and along the margin of Big Lake. The auger-hole locations are shown in figure 7. Marl was found only in holes 1 and 2. Hole 1 was drilled through about 5½ feet of light-gray marl, overlain by 3½ feet of tan mud and 2 feet of water; hole 2 found 10½ feet of white to cream-colored marl overlain by 4 feet of brown mud and 1½ feet of water. The bottom deposits from the other holes consisted primarily of dark-brown to tan mud and minor amounts of tan clay.

OTTER LAKE

The marl deposit at Otter Lake, SW¼ sec. 24, T. 14 N., R. 3. W., was not examined by the authors. The land is now within the boundaries of the Fort Richardson Military Reservation. The following description is from the field notes of Martin (1919), who visited the site in 1917:

Muck	3 feet
Marl	10 feet
Sand and gravel	

Top of marl about lake level. Occurs on beach 3 feet above lake, and 100 to 200 feet wide. Ground then goes up in steep banks.

MARL RESERVES

It is estimated that the marl deposits described above, in and adjacent to Wasilla Lake, contain on the order of 195,000 tons (dry weight), assuming the average thickness of the lake bottom deposits (fig. 3) is at least 10 feet. It is further assumed that the dry weight of the material is 54 pounds per cubic foot and the moisture content of the marl in place is about 50 percent.

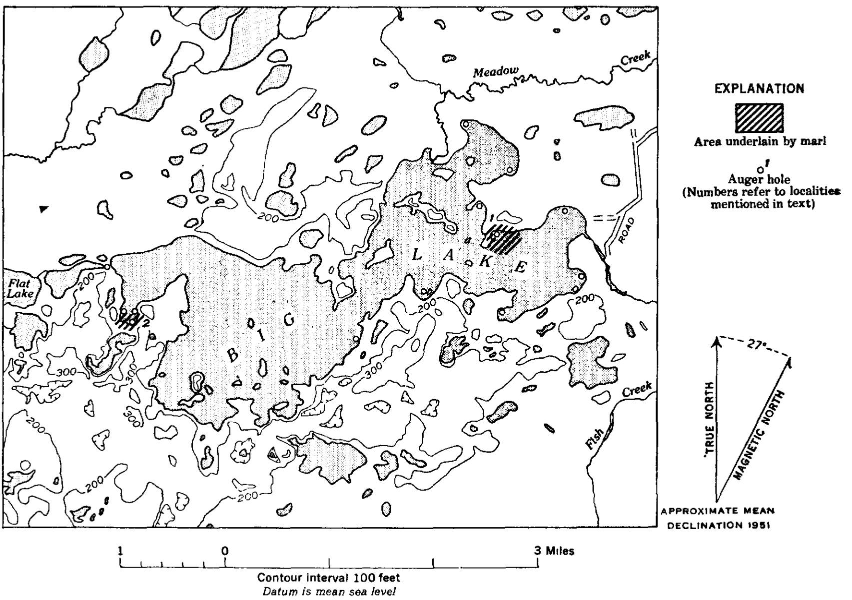


FIGURE 7.—The inferred distribution of marl at Big Lake.

At Finger Lake it is estimated that the marl may aggregate on the order of 500,000 tons (dry weight) assuming that the average thickness of the deposits is 10 feet (fig. 5). The thickness and distribution of the buried marl in the shoreline area of Finger Lake were not determined owing to an insufficient number of test holes.

Tonnage figures relating to Lucile Lake based on present data indicate only order of magnitude. A total of 700,000 tons might be represented by the two principal areas of deposition shown in figure 6, on the assumption that the marl averages 5 feet in thickness.

It is not possible to estimate the marl reserves in Otter and Big Lakes owing to insufficient drilling.

The inferred reserves given above include only the principal deposits in the Wasilla portion of the Knik Arm area and are based upon a brief reconnaissance, entailing relatively few drill holes. The Big Lake deposits and those known to exist along the shores of Finger Lake are not included. Additional small lake-bottom deposits of marl are known to occur at other localities in the area, and it seems reasonable to consider the brief exploratory work to date as inadequate, insofar as the buried shoreline deposits are concerned. The amount of marl reserves is relatively small for the manufacture of cement by present standards. It should be pointed out, however, that Alaska's unique economic position may greatly alter the criteria normally applicable in evaluating raw materials such as are involved in this problem.

CHEMICAL COMPOSITION OF THE MARL

The chemical requirements for portland cement recommended by the American Society for Testing Materials (table 3) are generally accepted by the industry. These requirements serve to govern to a large degree the chemical restrictions applicable to the raw materials.

The natural composition of most of the marl (see table 2) in the Knik Arm deposits is deficient in at least two respects: an excess of silica (minute quartz grains, glass shards of volcanic origin, and a minor amount of clay minerals) and organic matter is present at most localities, and there is a deficiency of CaO. This is particularly true of the upper part of the lake-bottom deposits, which is quite high in silica and organic material.

The magnesia content of the marl is well within acceptable limits, and the alkalies do not appear to be excessive.

COAL

Coal for a cement operation is available from mines at two localities in the Matanuska Valley field—Houston and Jonesville (fig. 1). The average analyses of mine samples from Houston (1) and Jonesville

(2), as delivered to the Alaska Railroad, are given below (Cooper and others, 1946, p. 60).

Sample no.	Proximate (percent)				Ultimate (percent)	Calorific value (Btu)
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
1	17.0	37.6	31.0	14.5	0.2	[1] 8,670 [2] 10,440
2	36.7	----------	41.0	14.9	.3	[2] 11,000

[1] Sample as received.
[2] Dried at 105° C.

The Jonesville coal is ranked as high-volatile *B* bituminous, having a moist calorific value of about 13,500 Btu. No data are available on the moist calorific value of the Houston coal.

Analyses of ash are available for only three coal samples from the Matanuska Valley field; the mine(s) from which the coal originated is not identified (Selvig and Gibson, 1945, p. 10). The average of the three analyses is given below.

	Percent		Percent
SiO_2	50.1	Na_2O	0.6
Al_2O_3	27.9	K_2O	.8
Fe_2O	8.7	SO_3	3.3
CaO	5.9	TiO_2	1.4
MgO	1.8		

POTENTIAL CEMENT COMPOSITION

It is generally accepted that the total lime-silicate content of a portland cement should be between 70 and 80 percent. In order for these compounds to form in the desired quantities it is necessary that the ratio of lime to the acid oxide components of the raw mix (including the coal ash) be between 1.9 and 2.2. The average marl analyses given above and available analyses of Matanuska Valley coal ash (Cooper, 1946, p. 60) show that none of the individual lake deposits would meet this requirement, assuming that the raw mix would consist of 98 percent marl and 2 percent coal ash. The average lime-silicate ratios of the various lake deposits are too low. The Edlund deposit on the other hand has an excessively high lime-silicate ratio. By mixing the low and high ration materials in appropriate proportions, a suitable raw mix might be obtained.

The chemical composition of the marl and coal ash may be used to calculate the approximate composition of a cement made from these materials. The phase composition of the cement in the system $CaO–MgO–Al_2O_3–SiO_2–Fe_2O_3$ under conditions of crystalline equilibrium can be calculated, and the percentages of the synthetic compounds tricalcium aluminate, dicalcium silicate, tricalcium silicate, and tetracalcium alumino ferrite can be determined from the composition of the raw materials given above.

A number of methods have been devised to calculate the constitution of portland cement. They have been described in detail by Bogue (1947, p. 47–50) and Witt (1947, p. 39–57) and will not be dealt with here. The method devised by Bogue has been used to compute two potential cement compositions shown in table 3.

Mix 1 utilizes a raw mix consisting of 70 percent Edlund deposit marl, 28 percent Lucile Lake marl, and 2 percent coal ash. Mix 2 utilizes 77 percent Edlund deposit marl, 21 percent Finger Lake marl, and 2 percent coal ash. The marl compositions used in each computation are the averages of the auger-hole recoveries (listed in table 2); the coal-ash composition is the average of the three analyses available. Since the source(s) of the coal is unknown except that it is from the Matanuska Valley, the analyses used in the computations may vary widely from that actually available.

TABLE 3.—*Calculations of potential cement compositions*

	Mix 1 (Percent)	Mix 2 (Percent)		Mix 1 (Percent)	Mix 2 (Percent)
SiO_2	24.7	25.2	Ignition loss	0.6	0.6
Al_2O_3	3.6	2.2	Not determined	2.9	3.1
Fe_2O_3	2.3	1.6			
CaO	62.8	63.4	Total	100.7	99.9
MgO	1.2	1.0			
Alkalies	1.0	1.3			
SO_3	1.6	1.5	Tricalcium silicate	35.8	45.2
			Dicalcium silicate	43.9	38.2
			Tetracalcium aluminate	5.7	3.1
			Tetracalcium alumino ferrite	6.7	4.9

The potential cement compositions given above appear to be within the limits specified in table 4.

It should be emphasized, however, that the computations given above are based upon relatively few chemical analyses. The necessary assumption that these samples are representative of the deposits from which they were collected may not be valid. Additional drill holes and sample analyses would be necessary to determine the lateral and vertical chemical variation of the marl.

TABLE 4.—*Chemical requirements for type II portland cement*

[Specifications are those of the American Society for Testing Materials. Federal specifications are identical except that when the purchaser specifies "low-alkali cement," the alkali content (Na_2O+0.658 percent of the K_2O) shall not exceed 0.6 percent. Percent column: All values are maximum amounts with the exception of SiO_2, which is minimum amount]

Constituent	*Percent*	*Constituent*	*Percent*
SiO_2	21.0	Ignition loss	3.0
Al_2O_3	6.0	Insoluble	.5
Fe_2O_3	6.0	Tricalcium silicate	50.0
MgO	5.0	Dicalcium silicate	----
SO_3	2.0	Tricalcium aluminate	8.0

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