UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
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CEMENT RAW MATERIALS AVAILABLE TO THE WINDY CREEK AREA, ALASKA

BY

R. M. MOXHAM, W. S. WEST AND

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ABSTRACT

The high cost of imported cement and the strategic advantages of a local source of supply for the military establishment have led to a growing interest in the possibility of cement manufacture in interior Alaska. A plant location in the Alaska Railroad belt seems desirable in view of the advantages of rail transportation and the accessibility of the principal interior markets.

A cement manufacturing operation would require essentially four types of raw materials: 1) calcareous material, 2) argillaceous material, 3) fuel and 4) gypsum.

The relatively favorable location of limestones near Windy station on the Alaska Railroad has led to the investigation of the potential raw materials which would be available to that region.

Three limestone deposits of commercial size occur in the Devonian rocks of the Alaska Range in the Windy Creek area. Two appear to be of suitable chemical character. They are located approximately 7 and 11 miles west of the Railroad respectively.

Twenty-four deposits of various types of argillaceous materials in the Healy River and Windy Creek areas have been sampled and analyzed chemically.

Sufficient and presumably suitable fuel for a potential cement operation appears to be available from the coal mines in the Healy River area.

Gypsum occurs at Sheep Mountain, 120 miles southeast of the Windy Creek area. Potentially sufficient tonnages are available to meet the requirements of a cement plant, but little has been done to develope the deposits.

The raw materials now available probably would be suitable for type I cement, although the alkali limit probably would be exceeded if no means of beneficiation were employed.

INTRODUCTION

It is generally conceded that the normal economic development of interior Alaska is being seriously retarded by the high cost of construction materials. This condition is due primarily to the costs involved in the importation of such materials from west coast sources of supply. Cement, which is an essential material in modern construction, is one of the imported commodities thus affected. As a result, the price of cement in many areas in the interior is several times greater than the west coast price.

Aside from purely economic considerations, the necessity of importing cement is an obvious disadvantage to the military establishment, in view of Alaska's position in Western Hemisphere defense.

The increased demand for construction materials owing to the rapid growth of the population and the accelerated military activity in the Territory in recent years has resulted in considerable interest in the possibility of the manufacture of cement in interior Alaska.

In view of the advantages of rail transportation and the accessibility of the principal markets of the interior, a plant location in the Alaskan Railroad belt has seemed most feasible, if the proper raw materials were available.

The raw materials required

Stated briefly, portland cement is made by sintering a finely ground mixture of calcareous and argillaceous materials to form hydraulic calcium silicates. The calcareous materials in general use in the U. S. at present are:

limestone	coquina
marl	alkali waste
chalk	

The common forms of argillaceous materials include:

clay	slate
shale	ashes
blast furnace slag	

Coal is the most widely used source of heat for sintering, although fuel oil and gas are also employed.

A small percentage of gypsum is added to the sintered product to control the rate-of-set.

Four principal raw materials therefore are necessary to the cement manufacturing process: 1) calcareous material, 2) argillaceous material, 3) fuel and 4) gypsum.

In the manufacture of certain types of cement, a high silica or high iron component may also be required to offset chemical deficiencies of the argillaceous ingredients.

Previous ihvestigations

The only known sources of calcareous material for a potential cement operation in the railbelt consist of a relatively few occurrences of limestone. Some of the most accessible deposits are those in the vicinity of Windy Creek, west of Windy station.

The relatively favorable geographic distribution of deposits of the other principal ingredients in relation to the Windy Creek area has led to the investigation of the raw materials available to that region.

Limestone was first mapped in this area by Moffit (1915, p. 24) and Capps (1932, pp. 247-256) during reconnaissance geological surveys. In 1931 Waring (1947, pp. 5-18) briefly examined and sampled four exposures of limestone a short distance west of Windy. The first detailed geologic work undertaken in this area for the specific purpose of investigating cement raw materials was carried out by Cobb and Flint (manuscript report in the files of the Geological Survey) in 1947. Limestone outcrops located between the railroad and Little Windy Creek (see fig. 2) were mapped and sampled and argillaceous deposits near Suntrana were investigated.

In 1948 the U. S. Bureau of Mines began a core-drilling program on one of the limestones mapped by Cobb. This work is still in progress.

R. E. Fellows of the Geological Survey made a brief field investigation in 1949 to integrate the drilling data with the geologic studies and to sample deposits of argillaceous materials in the Windy Creek area.

Present investigation

A preliminary study of the results obtained through the previous investigations indicated that the larger limestone deposits in the immediate vicinity of Windy are not of uniform chemical character. Although this condition might not preclude the use of certain portions of the deposits, difficulties in quarrying probably would be encountered. In July, 1950, the Geological Survey undertook a reconnaissance of the Windy Creek drainage basin west of the area previously studied, the principal objectives being 1) to locate limestone deposits of more uniform character and of sufficient size for a potential cement manufacturing operation and 2) to sample the more accessible deposits of argillaceous material. The present writing represents a progress report on the Geological Survey's study of the potential cement raw materials available to the Windy Creek area. It includes a considerable amount of heretofore unpublished data obtained by the earlier workers mentioned above in addition to the results of the 1950 investigation.

GEOGRAPHY

All of the principal limestone deposits under investigation are located within the Windy Creek drainage basin. However, it will be necessary to refer to deposits of supplementary raw materials which are to be found at some distance from the Windy Creek area.

The Windy Creek area as referred to in this report includes in general that region west of the Alaska Railroad drained by the tributaries of Jack River. (See fig. 2).

Windy Creek, the principal stream in the area, flows in a general southeastward direction along the southern slopes of the Alaska Range, joining the Jack River four miles south of Windy (See fig. 3). Its steep gradient and the abundance of boulders prevent the use of boats of any type. The stream may be forded on foot without difficulty throughout most of the summer months.

The topographic expression of the area ranges from the rugged, mountainous terrain of the Alaska Range in the northwestern part of the region to the [illegible] lowlands of the Jack and Nenana Rivers in the eastern portion. Elevations in the higher parts of the Range average about 6000 feet while the valleys to the southeast are about 2500 feet in elevation.

The eastern portion of the Windy Creek area is accessible by rail and air. Windy is located 212 miles by rail from Anchorage and 144 miles from Fairbanks. Scheduled airline service to both cities is available from Summit, 15 miles south of Windy. A smaller airstrip at Cantwell, 7 miles southwest of Windy, will accommodate single engine craft.

Road construction which will link Cantwell and McKinley Park with the Richardson Highway is now in progress. Upon completion of this work in 1953, the eastern part of Windy Creek area will be accessible by paved highway from Anchorage and Fairbanks. It is estimated that the distances to these two cities by road from Cantwell will be 425 and 325 miles respectively.

Figure 3. Eastward view of the Alaska Range and the valley of Windy Creek. The valley of the Jack River is shown in the background.

GEOLOGY

General statement

Bedrock in the Windy Creek area ranges in age from Devonian to Cretaceous and includes a wide variety of sedimentary rocks which have been metamorphosed and in some localities, intruded by or interbedded with igneous rocks. In general, the older rocks crop out along the southern slopes of the Alaska Range with successively younger beds appearing in the foothills to the southeast. Pleistocene glacial deposits and Recent alluvium cover the bedrock in much of the lowland areas, particularly in the southeastern portion of the region.

Devonian rocks

Most of the area drained by the headward portions of Windy Creek is occupied by metamorphosed sedimentary rocks which are primarily Devonian in age. They comprise argillite, shale, limestone, conglomerate, quartzite, and greenstone named in the approximate order of their abundance. From the standpoint of this report the unit outstanding interest in the succession of Devonian rocks is a massive, dark gray limestone which crops out in northwestern part of the area. It has been correlated with similar units in other parts of the Alaska Range which, on the basis of fossil evidence, have been determined to be Middle Devonian in age. The Devonian rocks have been intricately folded and faulted such that the age relationship of the various units is obscure, but it is probable that their total stratigraphic thickness amounts to several thousand feet.

Jurassic(?) rocks

South of the area of Devonian rocks and in fault contact with them is a belt of Jurassic(?) rocks about five miles in width. It comprises chiefly shale and conglomerate with lesser amounts of argillite and graywacke. In most places the Jurassic(?) rocks have been closely folded, crushed and faulted. Fossils have been found at only one locality and have been determined to be either Jurassic or Lower Cretaceous in age. Although in the Windy area the Jurassic(?) rocks are quite similar in appearance to overlying Cretaceous units, Capps (op. cit., p. 263) has correlated them with rocks west of the Windy Creek area which are probably Jurassic in age.

So little detailed work has been done in this area that the total thickness of the Jurassic(?) rocks can only be roughly estimated. The relief and extent of the outcrop area would indicate the total thickness to be in excess of 5000 feet.

Cretaceous rocks (Cantwell formation)

The Cantwell formation of Upper Cretaceous age is found only in the extreme southwestern and northeastern parts of the Windy Creek area. The formation includes a variety of clastic sedimentary rocks ranging from coarse conglomerate to sandstone and shale. The coarse material is generally found in the lower parts of the section although there are many local variations in the stratigraphic sequence. The Cantwell strata are locally deformed, particularly in the areas of extensive faulting, for the most part but their structure is somewhat less complex than that of the older strata in the Windy Creek area.

The total thickness of the Cantwell formation has been estimated to be 4000 feet, although probably not more than 1000 feet is exposed in the Windy area.

Igneous rocks

The hills immediately west of Cantwell are composed of basic lava flows and associated fragmental materials which may be Triassic in age.

The sedimentary rocks in the northern and southwestern parts of the Windy Creek area have been intruded by coarse-grained granitic rocks of Tertiary age.

A variety of small dikes and sills of unknown age, which vary in composition from diabase to tranite, intrude the Devonian rocks of the Alaska Range and a similar assemblage of intrusives cuts both the Jurassic(?) and Cretaceous rocks of the Windy Creek area.

Quaternary deposits

The effects of intense glaciation during the Pleistocene epoch is everywhere in evidence in the Windy Creek area. In addition to the great modification of land forms, unconsolidated glacial and glaciofluvial deposits cover the bedrock in much of the lowland areas. Terrace gravel is quite common particularly in the valleys of the larger streams in the southeastern part of the region.

In Recent time, many of the Pleistocene deposits have been reworked. The larger glacial-fed streams are depositing ice-eroded debris in wide, braided flats below the termini of the glaciers high in the Range.

Structure

The Alaska Range extends in a great arc from the Canadian border to the Alaska Peninsula with the Windy Creek area being located about midway along the arc.

Present evidence indicates that in general the Range is of synclinal character. In the Windy Creek area the major structural features of both the Paleozoic and Mesozoic rocks are oriented in a northeast-southwest direction, parallel to the regional trend of the axis of the Range.

One of the principal structural features is a great fault zone which follows the trend of the Range along the Windy Creek valley. Its trace is marked by a line of topographic depressions, springs and swamps. Displacement in the zone of faulting has brought the Devonian rocks in contact with the Mesozoic rocks.

So little detailed geologic work has been done in the Windy Creek area that an entirely satisfactory interpretation of the structural conditions cannot be made. However, to present the problem in greatly over-simplified terms on the basis of the data now at hand it appears that the intricate folding and faulting of the Devonian rocks are superimposed upon an anticlinal structure whose axis lies between Windy Creek and the crest of the Range. The southern flank of the fold is terminated by the zone of faulting. Northward from the fault the prevailing dip is at a steep angle southeastward. As the crest of the range is approached the intricately folded strata stand nearly vertical with steep northwesterly dips appearing in a northward direction.

Adjacent to the fault zone on the south, the Mesozoic beds dip steeply southeastward giving way in a southerly direction to a reversal and moderately northward dipping strata.

CEMENT RAW MATERIALS

Calcareous materials

Since the occurrences of calcareous material in the Windy Creek area are relatively few in comparison to the other raw materials required, the deposits of limestone will be treated in somewhat greater detail than those of the supplementary constituents.

The only calcareous materials known to occur in the Windy Creek area in quantity suitable for cement purposes are the Devonian limestones outcropping along the southern flank of the Alaska Range. Limestones of variable thickness and character occur in several areas between the fault zone and the crest of the Range (See fig. 2). Three principal limestone deposits have been examined in detail.

Limestone deposit 1

General description.--Deposit 1, which was mapped and sampled by Cobb in 1947, occurs on the south side of the ridge between Bain and Windy Creeks (See fig. 2 and 4). Outcrops of the limestone are found from elevations of 2610 to 3210 feet, or heights of about 465 to 1065 feet above the level of the railroad at Windy Creek.

The limestone is very dense and in general is extremely fine-grained in texture. It is dark gray to black in color on fresh surfaces, weathering to lighter shades of gray and buff. The strata have been thoroughly shattered by intense dynamic metamorphic action and the rock is reticulated by calcite veinlets. In many instances the original bedding of the limestone is obscured by secondary structural features to such an extent that the rocks have assumed a massive character, devoid of any layered structure. The limestone body as a whole strikes about N. 73 E. and dips about 65 southeastward. Exposures are found intermittently over a lateral (east-west) distance of 8000 feet. Drill holes through the central portion of the deposit indicate an average thickness of 500 feet.

Deposit 1 is terminated on the south by the fault zone whose strike and dip coincides with that of the limestone. Where penetrated by drilling the limestone is underlain on the north by greenstone.

Sampling.--Fifteen samples were taken across exposures of deposit 1. The locations are shown in figure 4. The material was collected along lines normal to the bedding. Each sample consisted of fresh chips taken at eight inch intervals. Results of the chemical analyses of the samples are given in Table 1.

Core-drilling.--A core-drilling program to determine the sub-surface continuity and extent of the deposit was begun by the U. S. Bureau of Mines in the fall of 1948. By July 1950, seven holes totaling 1712 feet had been drilled and preparations were being made to put down additional holes. The locations of the holes drilled prior to 1950 are shown in figure 4.

Reserves.--The portion of the deposit between the lateral limits of the drilling and extending from the surface to the plane containing the drill holes is estimated to contain approximately 15,000,000 tons of limestone. Since the lateral dimensions of the deposit are considerably greater than that included within the limits of drilling the inferred reserves are considerably in excess of the figure given above.

Limestone deposit 2

General description.--The belt of Devonian rocks widens appreciably southwest of Little Windy Creek. Limestone beds occur intermittently throughout the stratigraphic section, interbedded with shale, argillite, slate, conglomerate, quartzite and greenstone.

The largest body of limestone south of Windy Creek crops out along the crest of a hill south of the West Fork of Windy Creek (See fig. 2, 5, and 6). Limestone outcrops are found from elevations of approximately 3075 to 3600 feet or 930 to 1455 feet above the level of the railroad at Windy Creek. The western limit of the deposit is about 7.2 miles from the railroad via Windy Creek and the tributary which drains the south slopes of the deposit. Outcrops of the limestone comprising deposit 2 are shown in detail in figure 5.

The physical appearance of the limestone in deposit 2 is very similar to that of deposit 1. The original bedding has been almost entirely obscured but where discernable the strata dip 70° southeastward and the strike coincides with the regional trend of about N. 70° E. The thickness of the deposit averages 300 feet over a lateral distance of about 4800 feet.

Table 1. Chemical analyses of surface samples from limestone deposit 1

Sample no.	HCl insol.	R_2O_3	CaO	MgO	CO_2 1/	P_2O_5 2/	Total
53	.76	.26	44.76	9.66	45.37	.04	100.85
54	.96	.18	47.08	7.52	45.07	.02	100.83
56	1.38	.25	46.46	7.66	45.15	.03	100.93
58	.84	.18	51.92	3.29	44.29	.02	100.54
59	.84	.24	49.26	4.94	44.18	.01	99.47
60	.76	.26	44.84	9.04	44.94	.01	99.85
61	1.94	.24	46.06	7.64	44.40	.01	100.29
62	1.04	.12	49.32	5.30	44.37	.01	100.16
63	.80	.24	46.50	7.92	45.00	.01	100.47
64	4.90	.24	52.58	.68	42.04	.01	100.45
65	4.86	.30	51.96	1.02	42.61	.01	100.76
66	2.84	.30	53.22	1.05	42.84	.01	100.26
67	2.42	.20	51.96	2.33	44.04	.01	100.96
68	1.78	.22	53.24	1.58	43.52	.01	100.35
69	1.72	.18	52.20	2.42	43.43	.01	99.96

1/ Calculated from CaO and MgO

2/ The P_2O_5 may be less than .01 percent, but was present in appreciable amounts and was designated as being .01 percent.

Deposit 2 is situated north of the fault zone in much the same structural setting as deposit 1, and probably represents a stratigraphically equivalent unit. However in this instance, vertical displacement along the fault has been somewhat greater, such that beds of red, green and yellow calcareous argillite are exposed between the fault and the limestone. Dark, chert conglomerate crops out beneath the limestone on the north. A series of dark shales and relatively thin beds of limestone are found in a northerly direction from the crest of the hill to the valley of the West Fork of Windy Creek. None of the thinner limestones appear to be of economic interest and none have been included in deposit 2.

Sampling.--Samples composed of fresh chips collected at five foot intervals were taken along lines normal to the strike. The locations are shown in figure 5. Results of the chemical analyses of these samples are given in Table 2.

Reserves.--On the assumption that the deposit would average 300 feet in thickness over a lateral distance of 4800 feet, it inferred that a quarry 100 feet in depth could remove about 11,000,000 tons of limestone.

Limestone deposit 3

General description.--Deposit 3 is located in the northwestern part of the Windy Creek area, in the headwater region of the West Fork of Windy Creek (see fig. 2, 7, 8 and 9) and comprises the thickest of the Devonian limestones. It was first mapped and described by Capps (op. cit., p. 253) who had traced the calcareous strata from the head of Windy Creek westward along the crest and southern slopes of the Alaska Range for a distance of about 20 miles.

In the Windy Creek area, the limestone occurs in a steep, serrate ridge which is intersected by the valley of the West Fork (See fig. 9). Exposures are found from an elevation of 2950 feet in the floor of the valley of the West Fork, to the ridge tops both east and west of the creek. The lowest outcrops

Table 2. Chemical analyses of samples from limestone deposit 2

Sample no.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O 1/	K_2O 1/	P_2O_5 1/	SO_3	Ig. Loss	Total
30	1.4	.00	.2	3.2	51.2	.1	.1	.1		43.3	100
32	1.5	.30	.16	1.1	52.[illegible]	.29	.12	.00	.08	43.3	100
34	1.4	.30	.30	.07	54.1	.16	.11	.02	.06	43.5	100
36	2.2	2.4	.30	1.5	51.5	.17	.14	.01	.08	42.8	101
38	1.5	.46	.32	.07	54.0	[illegible]	[illegible]	.02	.08	43.1	100
39	1.1	.00	.2	2.5	52.0	.1	.1	.1		43.4	99

1/ Determined by flame photometer

All other determinations by rapid colorimetric and titrimetric procedures

Figure 6. View westward along the crest of the hill south of the West Fork of Windy Creek. Outcrops of limestone deposit 2 are shown on the left.

are approximately 800 feet above the level of the railroad at Windy Creek and are 11.4 miles west of the railroad via Windy Creek. Bedrock in the lower parts of the valley are concealed by soil and talus in many localities, while on the steeper slopes the strata are generally exposed.

The limestone in deposit 3 is very dense and fine-grained in texture. Some specimens exhibit a conchoidal fracture. Fresh surfaces are dark gray to bluish gray in color. Calcite reticulation is abundant. The calcareous strata are folded and contorted, but in some localities particularly in the lower parts of the valley of the West Fork, the degree of shattering appears to be somewhat less than that encountered at deposits 1 and 2. Although great variation is noted in the attitude of individual beds the limestone body as a whole probably stands nearly vertical. The prevailing strike is about N. 65 E. The intricate folding has undoubtedly caused a repetition of bedding so that the thickness of the unit can only be roughly estimated. The width of the outcrop area in the valley of the West Fork indicates a stratigraphic thickness of about 2000 feet.

To the north the limestone is succeeded by slate, shale and thin beds of limestone which dip in a northerly direction. Shale and conglomerate which dip steeply southward are the predominating rocks cropping out in a southerly direction from the limestone.

Sampling.--Samples consisting of fresh chips taken at five to 30 foot intervals were collected along lines both normal and parallel to the trend of the deposit. The locations of the lines and samples are shown in figure 10 and the results of the chemical analyses are given in Table 3.

Reserves.--Only a relatively small part of the total outcrop area could be sampled in the time allotted for the investigation in 1950. The portion within the area sampled is considered to have a lateral (east-west) extent of about 4000 feet and to include a stratigraphic thickness of 1500 feet. The eastern limit of sampling is assumed to be 1200 feet above the lowest exposures in the creek valley. Using the above criteria it is estimated that the ridge east of the West Fork contains about 290,000,000 tons above the level of the creek.

Other limestone deposits

Several deposits of limestone occur in the Windy Creek area in addition to those described above. They have not been dealt with in detail due either to their restricted size, unfavorable chemical composition or a lack of detailed information concerning them. One such deposit crops out in the valley of Little Windy Creek about one half mile northwest of deposit 1 (Cobb, op. cit.). The physical appearance of the rock is similar to that of deposit 1. Two samples consisting of fresh chips collected at 15 to 25 foot intervals were taken across the deposit. Results of the chemical analyses of the material are given below:

	Sample C 55	Sample C 56
Insol.	3.88	2.64
R_2O_3	.39	.18
CaO	52.04	50.14
MgO	1.66	3.98
CO_2	42.56	43.86
P_2O_5	.05	.01

Cobb estimates this deposit to contain 10,000,000 tons inferred.

Several other smaller limestone bodies east of Little Windy Creek probably contain a total of several million tons but they have not been investigated in detail.

Two relatively thin limestone beds outcrop intermittently along the valley slopes on the north side of Windy Creek west of Little Windy Creek.

Figure 7. Northward view of the headwater region of the West Fork of Windy Creek. Limestone deposit 3 outcrops on the ridge toward the foreground.

Figure 8. Northwestward view of limestone deposit 3, showing outcrops north and west of the West Fork of Windy Creek.

Figure 9. Eastward view of limestone deposit 3 from the valley of the West Fork of Windy Creek.

Table 3. Chemical analyses [illegible] deposit 3

Sample no.	SiO_2	Al_2O_3	Fe_2O_3	MgO	[illegible]	[illegible]	[illegible]	P_2O_5 1/	SO_3	Ig. Loss	Total
491	7.1	2.3	.19	1.4	[illegible]	[illegible]	.11	[illegible]	[illegible]	[illegible]	100
492	3.5	2.3	.78	2.9	47.9	.30	.12	.01	.32	[illegible]	101
493	2.1	.80	.32	1.4	53.0	.50	.13	.01	.24	[illegible]	101
494	8.6	2.5	.80	1.0	47.7	.83	.28	[illegible]	[illegible]	[illegible]	101
495	6.2	.95	.40	1.0	50.0	.28	[illegible]	[illegible]	[illegible]	40.6	101
496	5.4	1.1	.46	1.8	50.3	[illegible]	[illegible]	[illegible]	[illegible]	40.4	101
497	6.0	.64	.45	1.3	50.1	.37	.19	[illegible]	[illegible]	[illegible]	100
498	25.5	5.6	2.1	2.0	33.5	1.3	.70	[illegible]	[illegible]	[illegible]	100
499	6.6	1.1	.41	1.9	50.1	[illegible]	.20	[illegible]	[illegible]	39.6	101
501	3.2	.31	.34	.83	53.1	.21	.07	.01	.19	41.9	100
502	7.9	1.3	.85	2.4	46.9	.63	.16	.03	[illegible]	39.4	100
503	5.2	.80	.78	8.0	43.4	[illegible]	.08	.01	.11	41.8	101
504	5.9	1.0	.64	2.1	48.4	.18	.09	.02	.16	40.5	99
541	3.9	.59	.19	2.0	50.7	.23	.15	.01	[illegible]	42.1	100
542	2.7	.29	.19	.77	53.1	.20	[illegible]	.01	.08	[illegible]	100
543	2.2	.00	.18	.76	53.7	.20	.10	.01	[illegible]	42.8	100
544	2.2	.21	.30	.51	53.6	.20	.08	.01	[illegible]	42.5	100
545	3.0	.83	.30	.75	52.8	.24	.08	.01	.09	42.4	100

CO_2	trace	trace	trace	0.10	0.11
Loss on Ign.	21.09	13.98	10.00	18.82	11.45
H_2O (220°C)	5.91	10.94	5.21	4.42	6.92
Gypsum (calc. from sol. SO_3)	30.41	54.70	24.63	23.94	33.71
Alunite (calc. from insol. SO_3)	28.71	nil.	0.96	23.81	1.55
K alunite (calc. from K_2O)	7.02	nil.	0.70	9.65	0.35
Na alunite (Total alunite-K alunite)	21.69	nil.	0.26	14.16	1.20

Fifty-seven line and pit samples of gypsiferous rock from six principal deposits on Yellowjacket and Gypsum Gulches average 29.3 percent gypsum. Eckhart has estimated these deposits to contain 310,000 tons indicated, or 348,000 tons inferred ore.

Development work consists of truck roads from the Glenn Highway to the mouths of Yellowjacket and Gypsum Gulches and a road to a nearby proposed mill site. A small calcining plant was erected in 1947 and 50 tons of calcined material was produced. The work was done by the Alaska Gypsum Products Co., which leased 14 claims held by the Alaska Gypsum Queen Corp. No production has taken place since 1947.

Apparently considerable beneficiation of the ore is required due to the admixed greenstone. Further exploitation of the deposits probably will be contingent upon the development of a satisfactory method of ore beneficiation. Whether or not the tonnages required by a potential cement operation would be sufficient incentive to carry out further development work is open to question.

SUITABILITY OF THE RAW MATERIALS

The suitability of the raw materials insofar as it pertains to the geologic phase of the problem will be partially dependent upon such matters as structure, lithology, size and accessibility of the deposits which have been discussed above. The chemical fitness of the raw materials will depend to a large extent upon the type of cement to be manufactured.

is situated about one mile north of the Glenn Highway, and approximately 60 miles via the Glenn Highway from Sutton, the nearest point on the Matanuska Valley spur of the Alaska Railroad.

The principal ore deposits, located on Yellowjacket and Gypsum Creeks, are composed of gypsiferous rock formed during the hydrothermal alteration of the greenstone country rock. Eckhart (in preparation) has given a detailed description of the deposit, which is summarized below:

"The deposits are closely associated with dikes and although their shapes are irregular, at least to some degree, shape is controlled by the attitude of the dikes and the enclosing greenstone. Masses of quartz-sericite rock and greenstone, ranging from less than a foot to tens of feet in size, are found within the deposits. Their presence is unpredictable. These masses are intricately cut by small stringers and pods of gypsum. Pyrite is abundant in many of the greenstone masses. The change from greenstone to relatively high grade gypsiferous rock may be abrupt and take place within a few inches. A narrow limonitic zone usually separates the greenstone from the gypsiferous rock. The change from greenstone to gypsiferous rock may also be gradational through quartz-sericite rock."

Chemical analyses of five representative samples of the gypsiferous rock are given below:

Sample No.	D1-10	D2-14	D2-17	D2-19A	D2-193
SiO_2 Insol.	55.64	44.70	70.24	62.50	63.75
Fe_2O_3 (Total)	1.48	1.35	1.69	2.65	1.47
Al_2O_3 (Total)	14.27	9.31	15.59	14.24	12.29
TiO_2 (Total)	0.53	0.53	0.53	0.60	0.60
CaO (Total)	9.90	17.54	8.46	7.42	10.65
MgO (Total)	0.09	0.11	0.04	1.57	0.09
SO_3 (Acid sol.)	14.14	25.43	11.45	11.13	15.67
SO_3 (Acid insol.)	11.08	nil.	0.37	9.19	0.60
K_2O*	0.80	0.04	0.08	1.10	0.04
Na_2O*	1.48	0.14	0.30	1.20	0.10

CaO	14.7
MgO	4.7
SO_3	5.2
TiO_2	1.1
P_2O_5	.9
Na_2O+K_2O	2.2
Total	100.0

The Suntrana coal is classified as sub-bituminous B and C, according to A.S.T.M. Standards.

The latest figures available (Minerals Yearbook, 1948) show that 150 cement plants using both wet and dry processes consumed an average of 122.3 pounds per barrel (376 pounds) of cement produced and that power consumption averaged 22.2 kilowatt-hours per barrel. The heat value of the Suntrana coal is probably substantially less than that of the average coal in use in U. S. plants at present so that fuel consumption of an operation utilizing Healy River coal would be expected to be somewhat higher than the average figures given.

Production facilities in the Healy River field appear to be adequate to meet the requirements of a potential cement operation, and the coal reserves in that area are relatively high. Wahrhaftig (op. cit., p. 7) has estimated the reserves of minable coal to be 850,000,000 tons, of which 460,000 tons could be strip mined.

The burning characteristics of the coal on the effect of its various ash components probably could be determined only by kiln tests.

Gypsum

The only gypsum deposit of commercial size in interior Alaska is located at Sheep Mountain, about 85 miles (airline) northeast of Anchorage. The deposit

In 1947 Cobb and Flint sampled a number of clay and claystone deposits in the vicinity of Suntrana.

Windy Creek area

In 1947 Cobb sampled a Jurassic(?) shale which crops out along the right-of-way of the Alaska Railroad one mile southeast of Windy Creek.

In 1949 Fellows sampled several deposits of Jurassic(?) claystone which crop out in the valley of Little Windy and Windy Creeks. Additional samples of shale were collected along the railroad south of Windy Creek.

Six deposits of argillaceous material occuring in the Windy Creek area were examined and sampled during the 1950 investigation. Five are found in the Devonian rocks and one in the Jurassic(?) rocks.

Fuel

Coal would be necessary in the cement manufacturing process for kiln heat and possibly to supply power. The fuel source nearest to the Windy Creek area is the Healy River coal field. At present one underground mine and three open pits are in operation. All are accessible to the Alaska Railroad via the Healy River spur (See fig. 11).

Analyses of five coal samples from the New Suntrana mine of the Healy River Coal Corp., gave the following average results (Selvig, 1944, p. 668):

Ash	10.2 percent
Sulfur	.3 percent
B.t.u. per pound	8854.
Ash-softening temp.	2332 F.

Chemical analyses of the ash gave the following average results:

SiO	42.9 percent
Al_2O_3	23.0
Fe_2O_3	5.3

Table 5. (Continued)

Sample no.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O 1/	K_2O 1/	P_2O_5 1/	SO_3	Ig. Loss
302	77.30	9.58	5.41	2.51	.90	.65	.43		.55	2.21
304	70.59	13.37	6.43	2.72	.51	.71	.57		.30	4.20
305	70.91	13.73	6.09	2.40	.40	.46	.37		.35	4.75
307	64.86	16.63	6.71	1.76	1.59	2.53	.61		.12	4.58
308	64.58	16.37	5.07	4.56	1.66	1.16	.72		.10	5.25
309	61.85	18.15	7.28	3.80	.81	1.42	.65		.15	5.27
310	60.61	14.79	6.60	5.60	3.20	1.25	.70		.18	6.51
311	62.90	17.75	7.44	4.10	.96	1.55	.68		.07	4.17
318	70.31	15.94	4.06	2.93	.41	.28	.21		.67	4.85
6	62.4	14.8	4.8	1.9	3.8	.85	2.2	.14		7.9
17	64.2	16.8	5.7	1.3	.72	.94	2.4	1.4		5.9
26	62.9	17.9	6.0	1.3	1.0	.84	2.7	.13		6.6
43	41.8	11.2	4.3	2.1	19.9	1.7	1.5	.14		16.9
45	47.6	12.6	4.2	2.6	14.5	1.2	2.2	.12	.19	14.2
48	69.3	14.7	3.8	.80	.72	.90	2.6	.11	.99	5.4
51	64.4	15.6	6.0	2.0	1.0	1.4	2.7	.15	.34	4.5
52	58.6	14.4	8.1	2.2	5.1	.95	1.9	.09	.83	8.8

1/ Determined by flame photometer

All other determinations by rapid colorimetric and titrimetric procedures

Table 5. Chemical analyses of argillaceous materials from the Healy River and Windy Creek areas

Sample no.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O 1/	K_2O 1/	P_2O_5 1/	SO_3	Ig. Loss
C 1	60.61	15.74	7.81	4.59	1.17	.91	.59	.20		
C 2	62.09	16.36	7.38	5.15	1.29	.97	.75	.21		
C 39 A	57.50	17.00	7.15	2.42	2.03	1.94	2.57			9.15
C 39 B	57.44	17.18	7.43	2.25	2.02	1.81	2.82			8.63
C 39 C	55.83	17.19	8.79	2.30	1.54	1.07	2.63			10.04
C 39 D	59.26	15.84	7.91	1.69	1.62	1.25	2.16			9.56
C 39 E	60.36	16.80	6.65	1.47	1.42	.84	2.11			9.51
C 40	61.75	17.21	5.08	2.32	1.47	1.56	2.40			8.46
C 41 A	61.56	15.60	7.05	1.72	.80	.51	2.86			9.04
C 41 B	59.96	15.84	7.36	1.61	.98	.46	3.03			8.67
C 41 C	59.98	16.05	7.33	1.69	1.00	.51	3.46			9.26
C 41 D	59.98	16.01	7.51	1.76	.95	.34	3.30			9.34
C 41 E	61.03	15.87	7.26	1.62	.84	.40	3.35			8.78
C 42	70.83	10.79	5.05	1.35	.94	.83	2.02			6.71
C 43	69.96	12.16	6.51	.51	.60	.28	1.12			7.87
C 44	60.17	16.40	6.93	1.94	.16	.96	2.48			8.97
C 45	56.02	17.23	8.08	2.27	1.61	1.29	2.53			9.79

Table 4. (Continued)

Sample No.	Date collected	Description	Attitude of beds	Stratigraphic thickness	Estimated tonnage available
307	1949	Black, sandy claystone; somewhat platy with limonite on cleavage faces.	N 60 E; 85 SE	20	10,600
308	1949	Black claystone	N 70 E; 55 SE	50	67,000
309	1949	Dark gray, platy siliceous claystone	N 62 E; 55 SE	25	19,500
310	1949	Dark gray, siliceous claystone	N 50 E; 55 NW	60	37,000
311	1949	Black, siliceous claystone	N 70 E; 67 NW	45	16,000
318	1949	Dark gray, sandy claystone, iron stained.	N 60 E; 60 SE	70	77,000
6	1950	Black, crumpled shale	N 75 E; 80 NW	400	100,000
17	1950	Brown to black, crumpled shale	E ; 70 SE	100	40,000
26	1950	Black shale and slaty argillite	N 80 E; 75 SE	100	40,000
43, 45	1950	Red, green and yellow mottled slaty argillite, locally calcareous.	N 50 E; 70 SE	200	450,000
48	1950	Black shale	N 55 E; 20 SE	140	130,000
51	1950	Black, slaty argillite	N 74 W; 80 S	400	300,000
52	1950	Black shale	N 38 E; 35 SE	100	

Table 4: Summary of data pertaining to argillaceous materials

Healy River area

Sample No.	Date collected	Description	Attitude of beds	Stratigraphic thickness	Estimated tonnage available
C 39	1947	Claystone		59	
C 40	1947	Clay		3	
C 41	1947	Claystone and clayey siltstone		56	
C 42	1947	Clay, grab sample			
C 43	1947	Clay			
C 44	1947	Claystone		12	
C 45	1947	Clay			
C1, C2	1947	Shale	N 80 E; 35 N.	10-20	

Windy Creek area

Sample No.	Date collected	Description	Attitude of beds	Stratigraphic thickness	Estimated tonnage available
302	1949	Dark gray, fine-grained sandstone with pyrite in small cubes and irregular grains.	N 55 E; 55 SE	10	6,500
304	1949	Gray, argillaceous sandstone and claystone with small carbonate veinlets and pyrite cubes.	N 55 E; 55 SE	145	266,000
305	1949	Black, platy, siliceous claystone; limonite on cleavage faces.	N 55 E; 55 SE	50	163,000

Neither is continuous for an appreciable distance along the strike due to lateral lithologic variations as well as fault displacement. One chemical analysis of line sample across the thickest portion of one of the beds (see fig. 2) gave the following results:

	Sample 5
SiO_2	4.3 Percent
Al_2O_3	.1
Fe_2O_3	.5
MgO	15.8
CaO	34.4
Na_2O	.1
K_2O	.1
P_2O_5	.2
Ig. Loss	44.4
Total	99.9

Argillaceous materials

Several types of argillaceous materials occuring in the Healy River and Windy Creek areas were examined during the 1947-1950 period as possible sources of cement ingredients. A brief description of the various lithologic types is included in Table 4, which summarizes the results of the investigations. The locations of the deposits are shown in figures 2 and 11 and the chemical analyses of the samples are given in Table 5.

Healy River area

The geology of the Healy River area has been discussed in detail by Wahrhaftig and Freedman (mimeographed report). The coal-bearing formation of Tertiary age in which argillaceous materials under consideration occur, consists chiefly of sandstone, conglomerate, siltstone, claystone, clay, shale and coal.

Table 3. (Continued)

Sample no.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O 1/	K_2O 1/	P_2O_5 1/	SO_3	Ig. Loss	Total
546	5.9	.69	.40	1.6	50.3	.37	.11	.01	.33	40.7	100
547	4.3	1.9	.27	1.1	50.7	.32	.10	.01	.30	42.6	101
548	4.2	1.4	.19	1.2	51.0	.28	.09	.01	.12	42.0	100
549	4.0	1.6	.24	1.2	51.0	.26	.08	.01	.13	42.1	101
5410	3.8	.79	.16	1.0	51.8	.30	.11	.01	.10	41.8	100
5411	4.9	1.4	.11	.60	51.4	.26	.08	.01	.29	41.3	100
551	16.2	2.5	1.2	1.2	43.6	1.1	.31	.09	.68	34.6	101
555	12.5	2.4	1.3	1.3	45.9	.60	.47	.04	.43	35.0	100
559	16.4	3.3	2.0	1.2	42.3	.82	.62	.04	.10	32.2	99
561	6.5	.4	.4	1.6	49.6	.3	.1	.1	.00	41.0	100
562	7.7	.6	.4	1.3	48.8	.3	.1	.1	.2	39.6	99
563	6.1	1.3	.6	1.9	49.0	.3	.2	.1	.4	40.0	100
564	5.5	.6	.4	2.5	49.5	.3	.1	.1	.2	41.3	100
565	4.2	.6	.3	1.1	51.4	.2	.1	.1	.2	41.6	100
566	7.3	.4	.3	1.0	49.4	.4	.1	.1	.3	40.0	99
567	2.4	.3	.2	.6	53.2	.2	.1	.1	.1	42.6	100
568	4.3	.4	.1	1.3	52.0	.2	.1	.1	.00	42.2	100
569	2.6	.1	.1	.4	54.2	.1	.1	.1	.00	43.1	101
5610	3.4	.5	.2	1.8	51.0	.3	.1	.1	.2	42.1	100

1/ Determined by flame photometer. All other determinations by rapid titrimetric and colorimetric procedures.

REFERENCES CITED

Bogue, R. H., The chemistry of portland cement: Reinhold Publishing Co., 1950, 572 pp.

Capps, S. R., The eastern portion of Mount McKinley National Park: U. S. Geol. Survey Bull. 836-D, 1932.

Cobb, E. H., Limestone in the Windy Creek area: U. S. Geol. Survey, manuscript report in files of the Geol. Survey.

Eckhart, R. A., Gypsiferous deposits on Sheep Mountain, Alaska: U. S. Geol. Survey, report in preparation.

Moffit, F. H., The Broad Pass region: U. S. Geol. Survey Bull. 608, 1915.

Selvig, W. A., Ode, W. H., and Davis, J. D., Low temperature carbonization of Alaskan coals: U. S. Bur. Of Mines Tech. Paper 668, 1944.

Standard specifications for portland cement, Amer. Soc. for Testing Materials, Part 3, C-150-49, 1949.

Wahrhaftig, Clyde and Freedman, Jacob, Coal deposits in the valley of the Healy River: U. S. Geol. Survey mimeographed report.

Waring, G. F., Non-metalliferous deposits in the Alaska Railroad belt: U. S. Geol. Survey Circ. 18, 1947.

Minerals Yearbook, U. S. Bur. of Mines, 1949.

Duplicating Section, Interior Dept., Wash. 25, D. C. 95834

The argillaceous materials tested to date represent a very minor percentage of such material available to the Windy Creek area. There are a great variety of deposits which still warrant sampling. There are vast quantities of clays, claystones and shales in the Healy River area which have not been examined. Clay deposits, probably glacial lake deposits, are known to occur along the Alaska Railroad in the vicinity of Moody. There are also large quantities of argillaceous material in the Windy Creek area itself which have not been examined. It is entirely possible that one or more of these deposits would yield material which would not require beneficiation or the addition of supplemental silica or iron.

Limestone deposit 2

A few individual samples from deposit 2 are slightly excessive in magnesia but the weighted average of the six line samples across the deposit is 1.5 percent. If the composition of the deposits as a whole should approach that of the weighted average of the surface samples the material would appear to be acceptable insofar as the magnesia is concerned.

The weighted average alkali content is 0.21 percent which in itself is not an excessive amount.

Limestone deposit 3

The analyses of samples from deposit 3 indicate that for the most part the strata are fairly uniform chemically. The average magnesia content appears to be within acceptable limits. Sample 503 on line 50 however, contains excessive magnesia which arouses the suspicion that there may be restricted zones of unacceptable material in that area. On the basis of the data now on hand it seems reasonable to expect that more detailed sampling or a drilling program could delineate an area of acceptable magnesia content in deposit 3.

As in the case of deposit 2, the alkali content probably would be acceptable with the proper argillaceous constituents.

The argillaceous materials

In general the magnesia content of most of the argillaceous materials is within acceptable limits. Nearly all of the materials sampled however, contain considerable alkali. While the silica, alunina and iron contents of most of the argillaceous materials would be acceptable for the manufacture of type I cement, the alumina content would probably prove excessive for type II. This might be remedied by a flotation process or the addition of a high silica or high iron component.

The chemical requirements for type II include those which apply to type I and in addition, limits are set on the percentages of the simple oxides present as well as on the amounts of the various synthetic compounds formed during the sintering process. The percentages of the simple oxides which are present in the cement will be directly proportional to the amounts of such compounds contributed by the various raw components. The percentages of the complex compounds will depend upon the phase composition of the clinker in the system $CaO - Al_2O_3 -$ $SiO_2 - Fe_2O_3$ (Bogue, 1950, p. 184).

In order to determine whether any one raw ingredient would be acceptable chemically it woudl be necessary to know the constitution of the other ingredients with which it was to be used in a particular raw mix. Dust losses and ash gain occuring under actual operating conditions would also have to be known. Therefore it will be possible to discuss the general fitness of the raw materials in only a broad sense.

Limestone deposit 1

Limestone deposit 1 appears to be the most favorably situated for exploitation. However, it contains zones which are quite high in magnesia. The distribution of this compound is erratic as will be seen in the chemical analyses of the surface samples and drill cores. In addition, a comparison of the drill core analyses with those of the surface samples indicates that variations take place along particular beds or zones normal to the strike as well as from one series of beds to those stratigraphically adjacent. Figure 12 shows the stratigraphic distribution of the magnesia as determined from analyses of the drill cores by the Bureau of Mines.

It might be pointed out that a large part of deposit 1 has not been adequately sampled. It is possible that a detailed investigation of other portions of this limestone body would reveal an area containing more uniform material in commercial quantity.

Table 6. Chemical requirements of A.S.T.M. specifications for type I and type II portland cement.

	Type I	Type II
SiO_2 (min.)	...	21.0 percent
Al_2O_3 (max.)	...	6.0 "
Fe_2O_3 (max.)	...	6.0 "
MgO (max.)	5.0 percent	5.0 "
SO_3 (max.)	2.0[b] "	2.0 "
Ig. Loss (max.)	3.0 "	3.0 "
Ins. res. (max.)	.75 "	.5 "
$3CaO\ SiO_2$ (max.)	...	50.0 "
$2CaO\ SiO_2$ (min.)	...	...
$3CaO\ Al_2O_3$ (max.)	...	8.0 percent

[b]The maximum limit for SO_3 content of type I cement shall be 2.5 percent when the $3CaO\ Al_2O_3$ content is over 8.0 percent.

Note: Federal specifications are the same except that when the purchaser specifies "low alkali cement", the alkali content (Na_2O + .658 K_2O) shall not exceed 0.6 percent.

Various specifications for standard portland cement have been formulated by governmental and private agencies (A.S.T.M., 1949, pp. 1-4) for the protection of the consumer. The specifications usually cover five different types of cement, each particualr type possessing certain chemical and/or physical characteristics which may be desirable in various types of construction. Specifications for the chemical requirements for types I and II, which are employed for general construction purposes are given in Table 6.

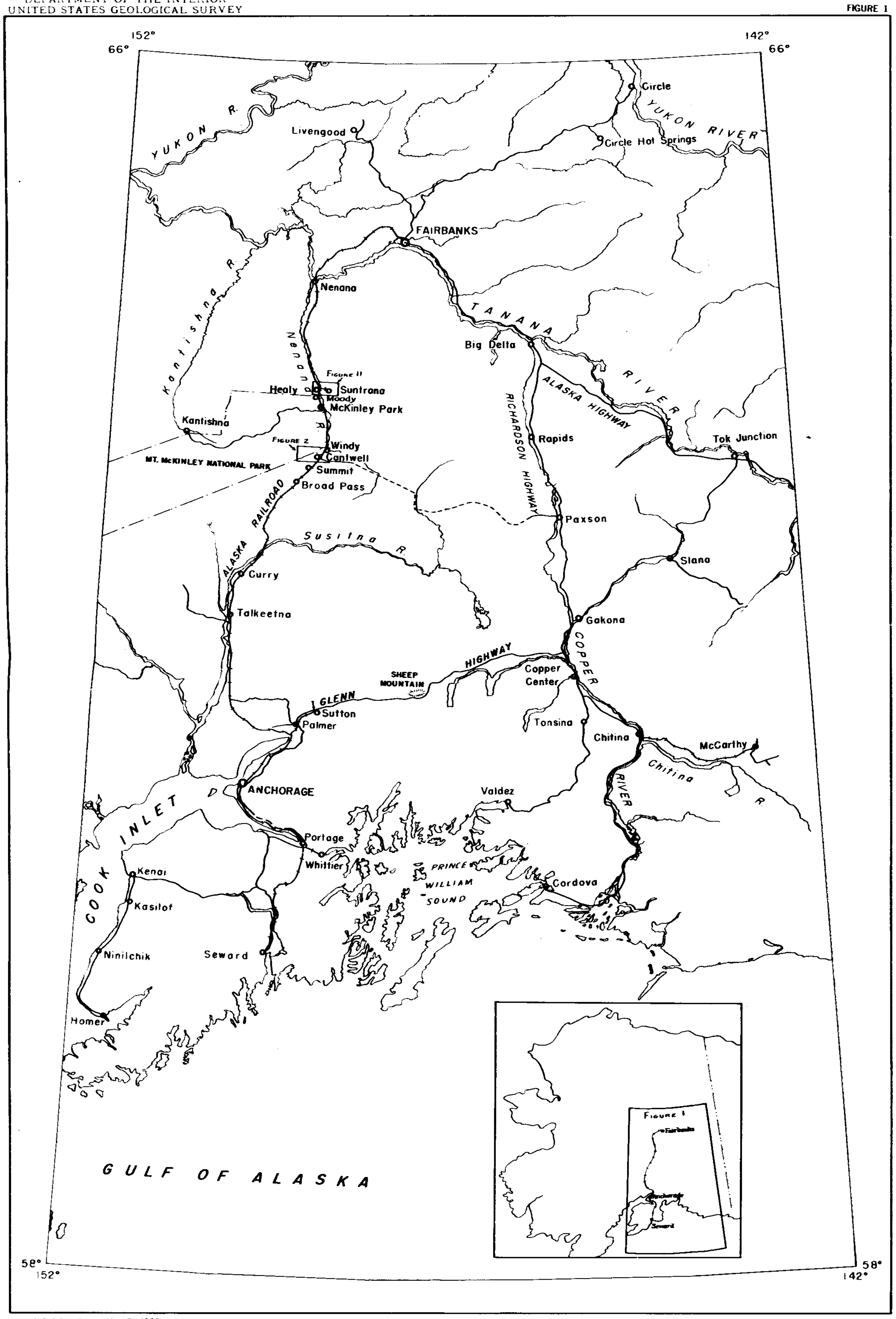
Of the various oxides listed in the specifications, the magnesia and alkalies are considered deleterious in both types and excessive alumina may be considered undesirable in type II. These compounds are usually associated with mica and other complex silicates which appear in the raw materials as detrital grains or as secondary metamorphic minerals.

At those localities where raw materials contain such undesirable compounds, flotation cells are usually employed to remove the offending minerals so as to attain an acceptable raw mix. This practice has proven particularly successful in the Lehigh Valley district where metamorphosed limestones are used extensively.

The maximum amount of magnesia permitted in either type of cement is 5 percent so that the total amount of this compound contributed to the raw mix by the various raw materials cannot exceed approximately 3.2 percent, the difference in the two figures representing essentially the losses due to ignition during sintering.

Although no maximum limit is set by the A.S.T.M. on the alkali content of cements, federal specifications state that the alkali content shall not exceed 0.6 percent, where the alkalies are considered to comprise the total Na_2O plus 0.658 percent of the K_2O.

FIGURE 1



From U.S.G.S. Alaska Map B, 1950

SOUTH-CENTRAL ALASKA

25 0 25 50 75 100 Miles
Scale

This map is preliminary and ha
been edited or reviewed for confo
with U. S.

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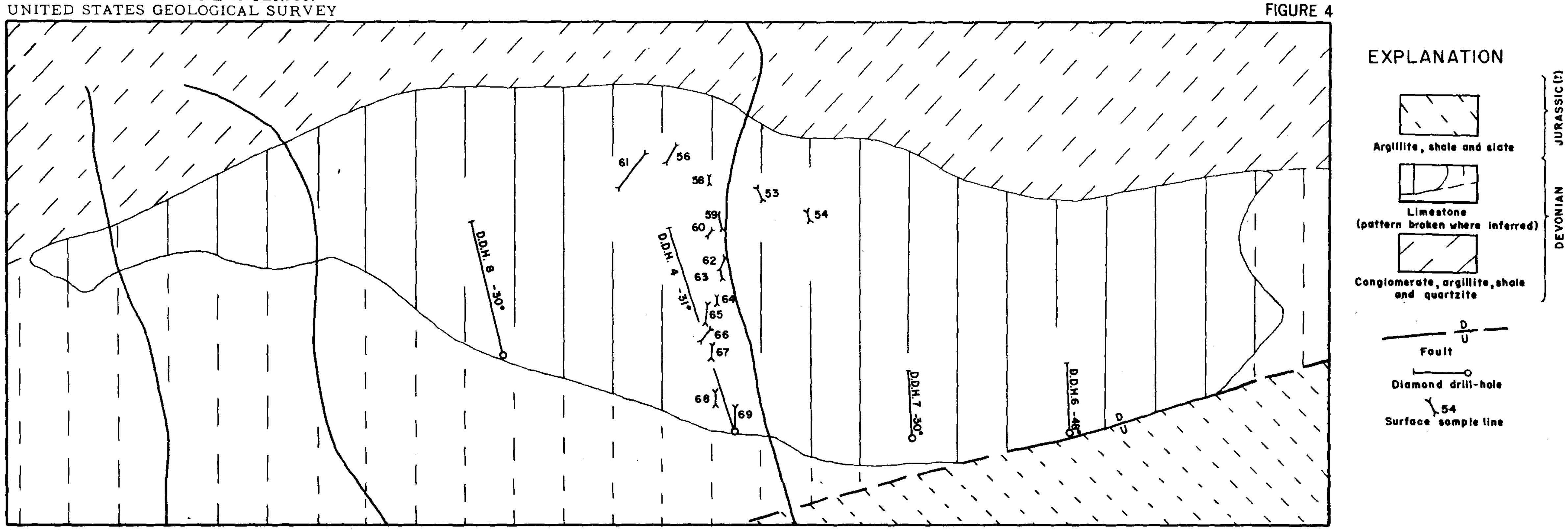
FIGURE 4



Surveyed by J.W. Zydik, 1947

Geology by E.H. Cobb, 1947, R.E. Fellows, 1949
with revisions by R.M. Moxham, 1951

N

GEOLOGIC MAP OF LIMESTONE DEPOSIT I

0 500 1000 1500 Feet

Scale

This map is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

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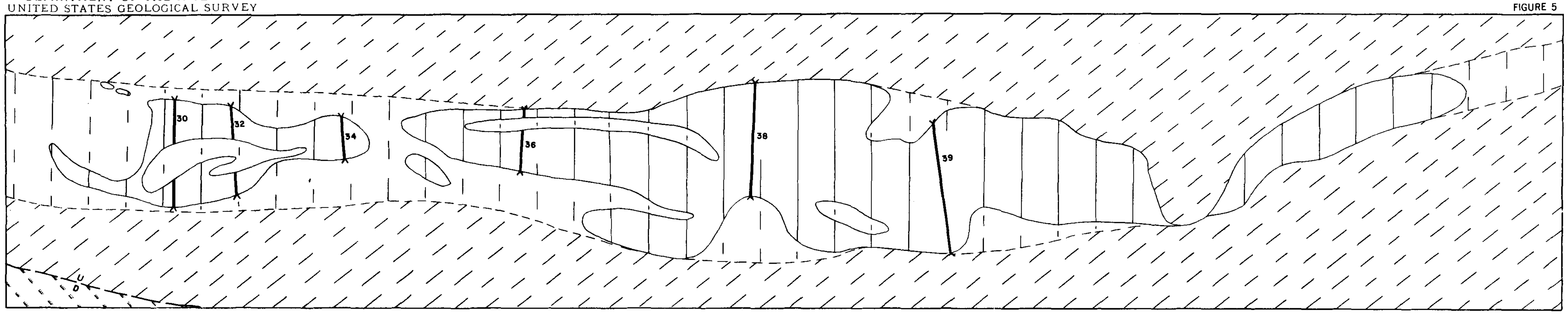
FIGURE 5



GEOLOGIC SKETCH MAP OF LIMESTONE DEPOSIT 2

Geology by R.M. Moxham, W.S. West and A.E. Nelson, 1950

0 200 400 600 800 1000 Feet
Scale

EXPLANATION

Cantwell formation (shale) — CRETACEOUS

Limestone (Pattern broken where inferred) — DEVONIAN

Argillite, conglomerate and shale — DEVONIAN

34 Sample locality referred to in text

D/U Fault

This map is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

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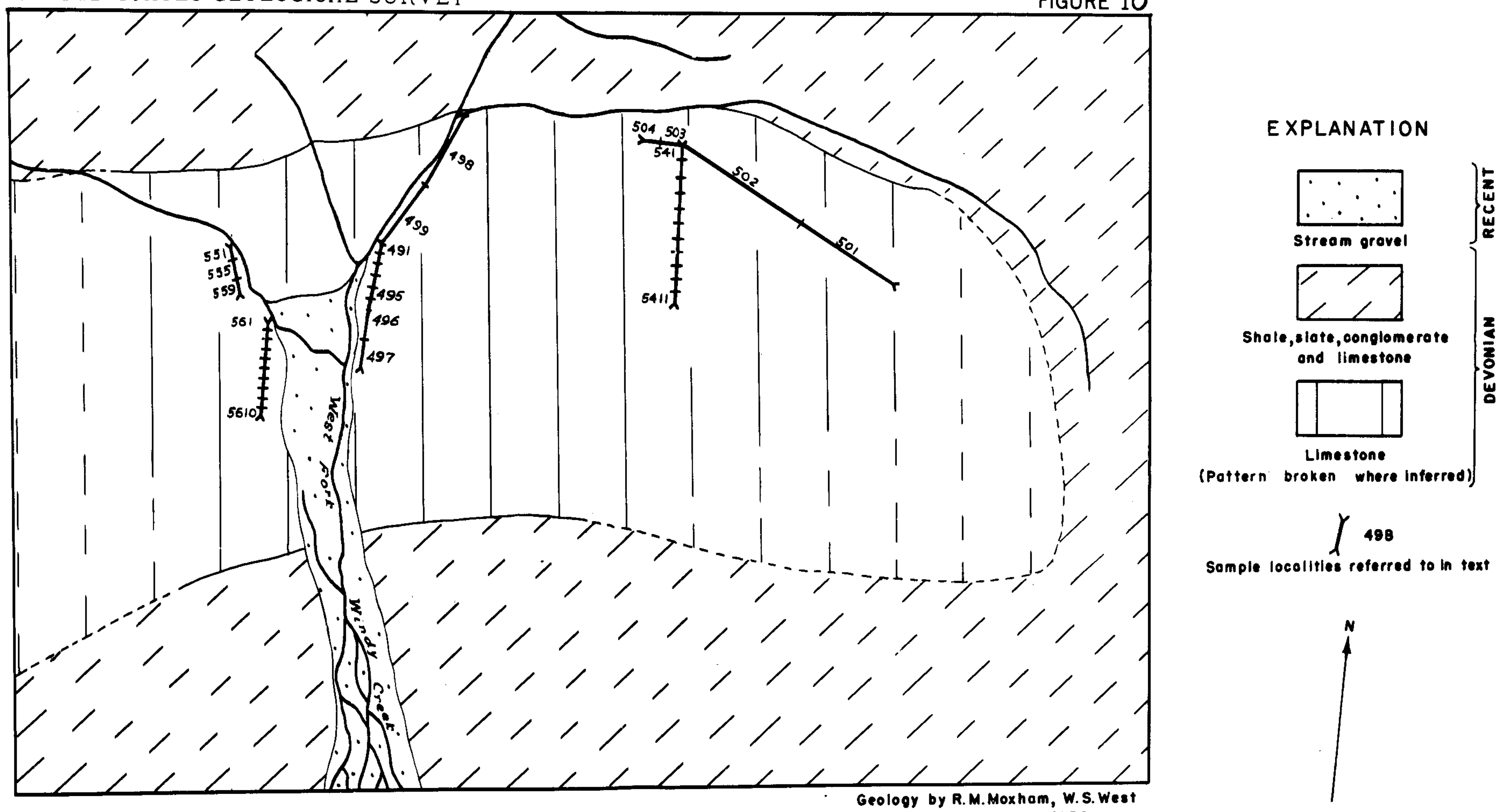
FIGURE 10



Geology by R.M. Moxham, W.S. West and A.E. Nelson, 1950

GEOLOGIC SKETCH MAP OF LIMESTONE DEPOSIT 3

0 1000 2000 3000 4000 5000 Feet

Scale

This map is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

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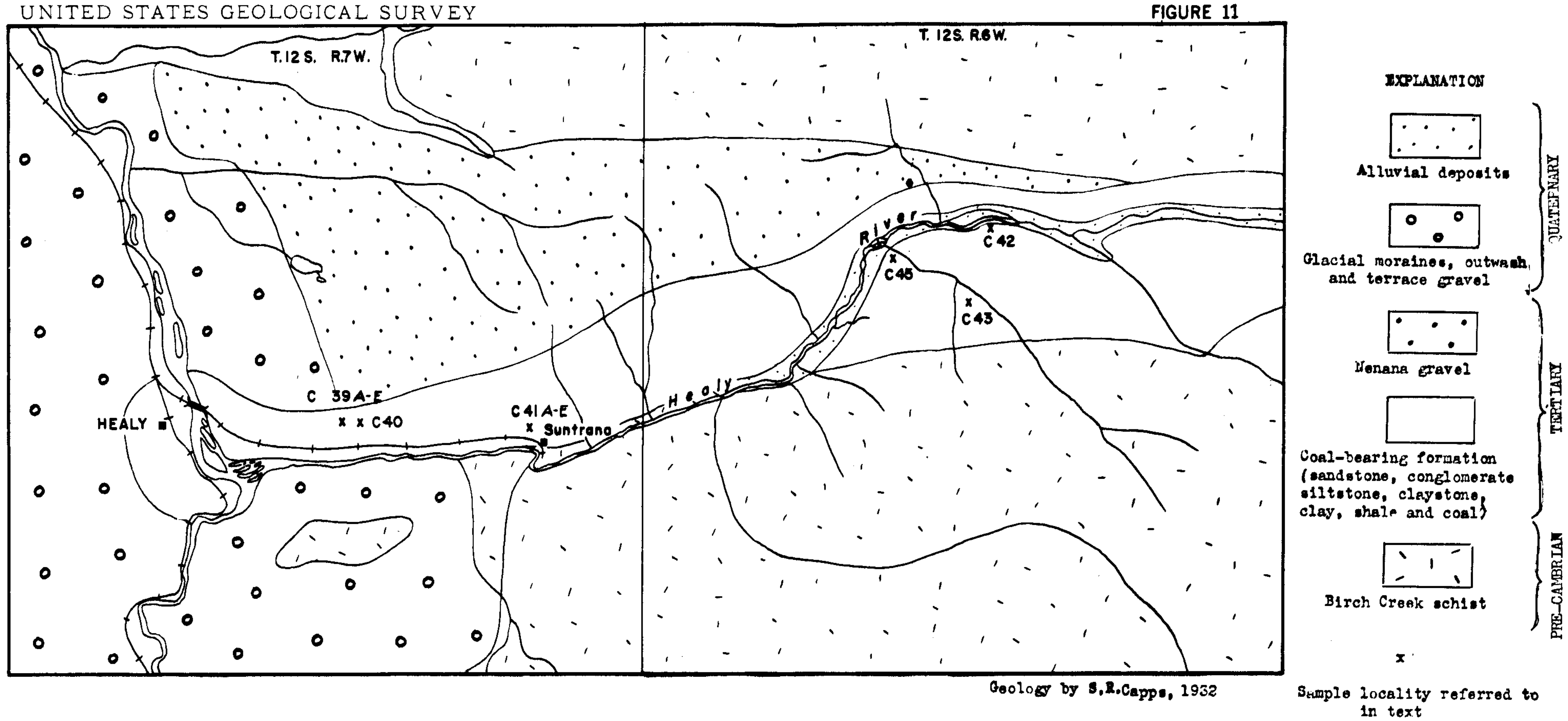
FIGURE 11



GEOLOGIC MAP OF THE HEALY RIVER AREA

0 1 2 3 4 Miles

Scale

This map is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.