UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOLOGY AND CEMENT RAW MATERIALS OF THE WINDY CREEK AREA, ALASKA

by

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ABSTRACT

The Windy Creek area, on the south flank of the Alaska Range in the Alaska Railroad belt, contains deposits of raw materials which could be utilized in the manufacture of portland cement.

Bedrock in this region includes limestone, argillaceous rocks, chert, and a wide variety of other lithologic types ranging in age from Devonian to Cretaceous.

The major geologic structures of the area are oriented parallel to the regional northeast trend of the Alaska Range. Devonian rocks crop out on the south flank of the range, with generally north-dipping strata of Mesozoic age occurring in the area to the southeast. A northeast-trending fault separates the rocks of the two eras.

Two limestone deposits of the Devonian system are of adequate size and quality for cement manufacturing purposes. They are located 7 and 11 miles west of the Alaska Railroad; argillaceous rocks occur in both the Devonian and Jurassic(?) systems and are found in many parts of the area. Chert, of Triassic age, possibly of some value as a high-silica component, was found adjacent to the Alaska Railroad near Windy Station.

INTRODUCTION

All of the portland cement and lime products used by the construction industry in Alaska at the present time are imported from the continental United States. Considerable interest has been shown, particularly since the outbreak of World War II, in the feasibility of the local manufacture of these materials.

The Windy Creek area, situated in the northern portion of the Alaska Railroad belt, contains deposits of the general rock types required to form the principal raw materials for portland cement, and possibly other lime products.

The purpose of the report is to present the principal geologic features of the area with particular emphasis on those rock types of potential value in the manufacture of portland cement.

Location of the area

The Windy Creek area is on the south flank of the Alaska Range, adjacent to the Alaska Railroad (see fig. 1). The northern portion of this area lies within the southeast corner of Mt. McKinley National Park.

For the purpose of this report the limits of the area are arbitrarily designated as latitudes 63° 23' 15" and 63° 28' 30" N., longitude 149° 15' 00" on the west and the Jack and Nenana Rivers on the east. Approximately 85 square miles are included within these boundaries.

Previous investigations

The first geological information pertaining to the Windy Creek area was obtained by Eldridge and Muldrow (1900) during their reconnaissance along the Susitna and Nenana Rivers in 1898. The eastern portion of the area was included in geological reconnaissance of the Broad Pass region carried out by Moffit (1915) and Pogue in 1913. In 1930 Capps (1932) mapped the area in its entirety on a reconnaissance scale as part of a survey of the south flank of the Alaska Range between the West Fork of the Chulitna and Jack Rivers. Waring, in 1931, (1947, pp. 5-18) briefly examined and sampled four exposures of limestone located a short distance west of Windy Station on the Alaska Railroad.

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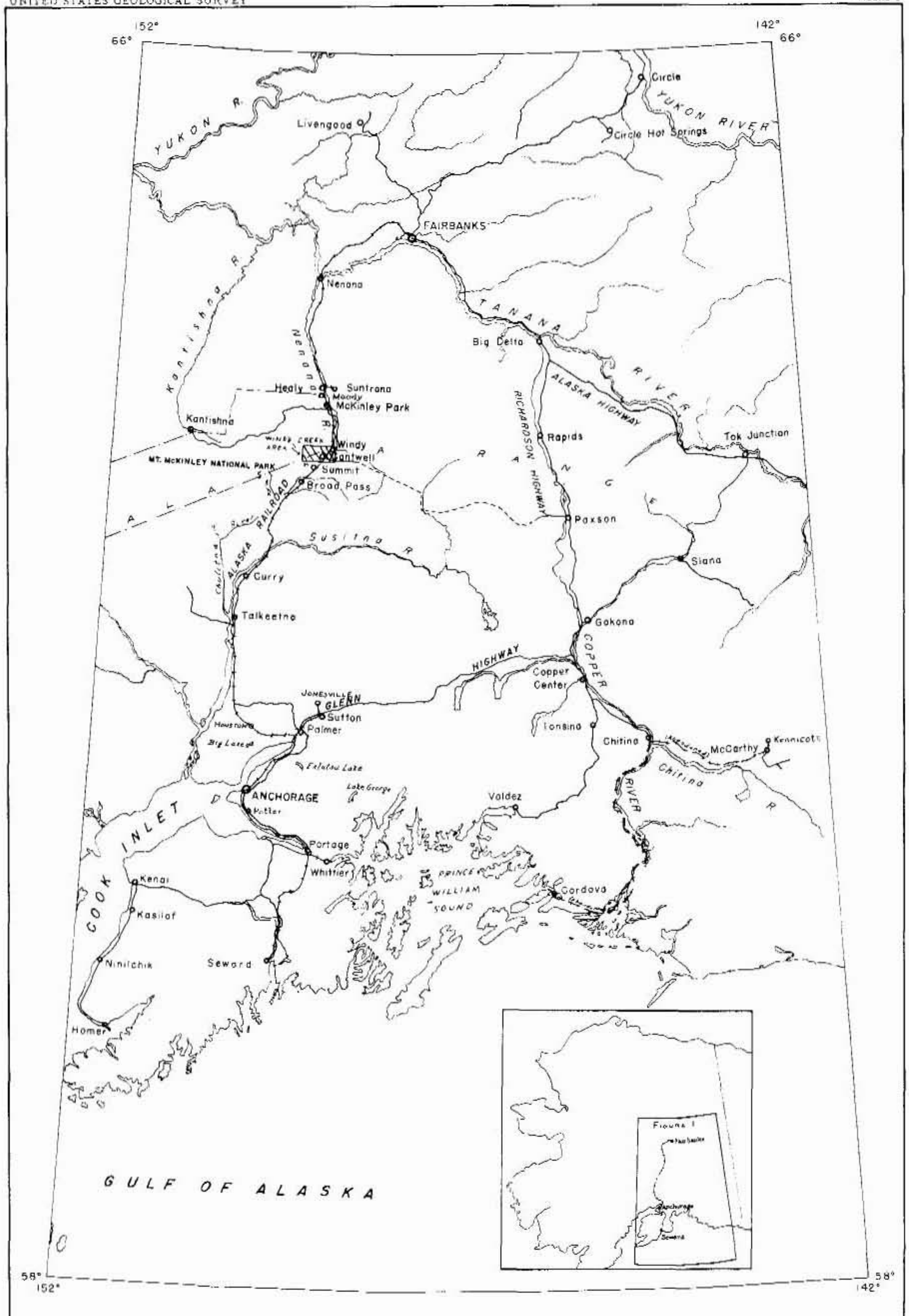
FIGURE 1



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

INDEX MAP OF
SOUTH-CENTRAL ALASKA

25 0 25 50 75 100 Miles
Scale

Present investigation

The present study of the Windy Creek area began in 1947 for the purpose of investigating potential cement raw materials. In 1947 Cobb (manuscript report in the files of the Geological Survey) mapped in detail the limestones between Little Windy Creek and the railroad. Surface samples were collected from two of the larger, more accessible deposits. R. E. Fellows of the Geological Survey made a brief field investigation in 1949 to integrate core-drilling data furnished by the U. S. Bureau of Mines, with the geological studies and to sample deposits of argillaceous materials outcropping in the vicinity of the railroad, and in the lower Windy Creek basin.

Chemical analyses of the limestone samples and cores by the Geological Survey and the Bureau of Mines respectively during the period 1947-1949 indicated that the principal limestone deposits in the area east of Little Windy Creek are not of uniform chemical character. Although this condition might not preclude the use of restricted portions of the deposits, it seemed desirable to determine whether other, more suitable limestone deposits, existed elsewhere in the Windy Creek area. In July 1950, a brief reconnaissance of the Windy Creek drainage basin west of the Little Windy Creek was undertaken, the principal objectives being 1) to locate and sample all limestone bodies of potential commercial size 2) to sample the more accessible deposits of argillaceous materials (Moxham, West and Nelson, 1951). Two limestone deposits of adequate tonnage were mapped and sampled and several deposits of argillaceous materials were investigated.

The geological investigations in the Windy Creek area described above were confined to reconnaissance surveys and detailed studies of relatively small portions of the region. In 1951 additional field work was undertaken for the purpose of integrating the previous detailed studies with the regional geology with particular emphasis on determining more precisely the occurrence and distribution of potential cement raw materials in the western portion of the area.

Field work in 1951 was carried out between May 28 and July 10 by R. M. Moxham and R. A. Eckhart, geologists, and W. A. Bakke and R. A. Wilkens, field assistants.

The U. S. Bureau of Mines has undertaken a study of the mining and development aspects of the cement materials problem in the Windy Creek area. During the period 1948-1950 that agency carried out a core-drilling program on one of the limestones mapped by Cobb. In 1949 surface samples were collected from other limestones in the area between Little Windy Creek and the railroad. Other samples were collected in 1951 from limestones mapped by the Survey in the western portion of the area, and deposits of argillaceous materials throughout the area were sampled.(Rutledge, Thorne, Kerns, and Mulligan, in preparation).

Acknowledgements

The authors gratefully acknowledge the courtesies and cooperation extended by the residents of the area. Particular acknowledgement is due Mr. Jack West and the late Mr. John E. Carlson of Cantwell and Mr. Claude Rogers of the Alaska Road Commission.

GEOGRAPHY

Topography and drainage

The topographic expression of the Windy Creek area ranges from the rugged mountainous terrain of the Alaska Range in the western part of the region to the rolling lowlands of the lower Windy Creek and Jack River basins in the eastern portion. Peaks in the higher parts of the Range reach elevations of 6,000 feet, while the lowlands to the southeast average about 2,500 feet above sea level.

Windy Creek, the principal stream in the area, has its headwaters in the northwestern part of the area and flows in a general southeasterly direction along the southern slope of the range, joining the Jack River 4 miles south of Windy station. Numerous boulders and a steep gradient prevent the use of boats of any type. Below its main forks, Windy Creek is difficult to ford on foot during intermittent periods of high water which occur in the summer months.

Climate

No weather records are kept at any locality in the Windy Creek area, but the data collected by the Civil Aeronautics Administration (Climatological Data, 1950) at Summit, a short distance south of the area, will give some indication of the climatic conditions which prevail in this region.

The total annual precipitation averages about 22 inches and the total snowfall about 100 inches. The average temperature during the summer months is approximately 50° F., and for December and January it is about 2° F. Freezing temperatures may be expected as late as the middle of June and as early as mid-September. The fall freeze-up usually occurs by late October and the break-up takes place usually by mid-May.

Vegetation

The principal varieties of trees in the area are spruce and cottonwood, with the former predominating. Most of the major stream valleys and lowlands support a moderate growth of timber up to an elevation of about 2,800 feet. Few spruce are found above that level, although cottonwood usually persist to somewhat higher elevations.

Most stream valleys below timber line are heavily overgrown with brush and shrubs consisting primarily of willows and alders.

Accessibility

The eastern portion of the area is accessible by rail and air. Cantwell, located in the southeastern part of the region, is 205 miles by rail from Anchorage and 151 miles from Fairbanks. Flagstop airline service is available at Summit, 7 miles south of Cantwell. A small airstrip at Cantwell will accomodate single-engine planes.

Road construction which will link McKinley Park station with Cantwell and with Paxson on the Richardson Highway is now in progress. At present, the McKinley Park-Cantwell portion is completed and the Cantwell-Paxson section is passable for a distance of about 20 miles east from Cantwell. Upon completion of the entire project the eastern portion of the Windy Creek area will be accessible by road from Anchorage and Fairbanks. It is estimated that the distances from Cantwell to these two cities will be 425 and 325 miles respectively.

Two tractor trails give access to the valley of Windy Creek from Cantwell. One extends from that village to the mouth of Windy Creek; the other runs westward to a National Park Service shelter cabin on Windy Creek, about 5 miles above its mouth. The valleys of Windy Creek and its west fork offer no serious obstacle to tractor travel beyond the trail's end until the headwater gorges are reached.

Devonian system

The oldest rocks in the Windy Creek area are folded, metamorphosed strata of Devonian age which crop out across the central and northern portion of the region. The rocks are characterized by rapid lateral and stratigraphic lithologic changes, so that in most instances particular beds are neither of great thickness nor laterally persistent .

Two major units comprise the Devonian system; the older, lying to the south, includes intricately folded strata which consist primarily of argillite, limestone, conglomerate, graywacke, slate, greenstone and quartzite.

In the western part of the area the older Devonian unit comprises chiefly conglomerate interbedded with argillite, graywacke and a little limestone. To the east the clastic sediments tend to become finer in texture, limestone becomes more abundant, and some greenstone, tuff and quartzite appear.

Conglomerate beds ranging from two to 60 feet in thickness are found throughout the section of the older Devonian unit. They are usually dark colored, and are composed chiefly of black chert, argillite and quartz pebbles in a siliceous matrix. The beds include material whose texture ranges from coarse grit to pebbles several inches in diameter.

The limestones in the older Devonian unit are relatively thin and discontinuous for the most part. In a few areas the calcareous beds attain a thickness of 500 feet, but the average is probably nearer 50 feet. They are usually gray or, locally, buff in color on weathered surfaces, and black or dark gray where fresh. The rock is for the most part very dense and fine-grained in texture although locally it is coarser grained as a result of recrystallization. The strata have been thoroughly shattered by intense dynamic metamorphic action and the rock is reticulated by calcite-filled fractures. In most localities 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 visible bedding.

The limestone has commonly been silicified in varying degrees, from very slight to localized total replacement by silica. In a few areas the strata are minutely banded, possibly as a result of the presence of high-magnesia layers.

Argillite is a common constituent of the older Devonian rocks in the eastern part of the area. The beds are brown to black in color and are usually thin bedded. In many parts of the area the argillite has been crumpled, sheared and intricately faulted both as a result of regional metamorphic action and, locally, a result of stresses in the fault zones which bound the unit on the north and south.

Fossils are quite scarce in the older Devonian rocks, but a few poorly preserved specimens occur in the limestone beds in several localities. In most instances they are sufficiently silicified to become etched in relief on weathered surfaces; the freshly broken rock seldom shows any trace of organic remains.

Three collections were made; the locations are shown on plate 1. The fossils consist largely of corals, but stromatoporoids and bryozoa also are found. The collections contain the following:

Fossil locality	Field collection no.	
1	47-ACb-76	Tryplasma sp., Amphipora sp.
2	50-AMx-101	Cladopora sp., pseudamplexoid coral stromatoporoids
	50-AMx-102	pseudamplexoid coral
	50-AMx-103	Coenites? sp., unidentified horn coral
	50-AMx-104	Cladopora sp., stromatoporoids
	50-AMx-105	Coenites sp., unidentified bryozoan

The fossil identifications were made by Jean M. Berdan, who reports as follows:

> "...Lot 47-ACb-76 differs from the other collections in containing the horn coral Tryplasma, which is most abundant in the Silurian but has been reported from the Middle Devonian of Germany (Etheridge, R., Geol. Survey of New South Wales, Mem. 13 p. 44,1907). This collection also contains a block with different lithology from that containing the horn corals in which there are rod-like objects which appear to be Amphipora, a form of stromatoporoid occurring in the Middle and possibly also in the Upper Devonian. The... collection... was made from talus so that more than one horizon may be represented." Lots 50-AMx-101 through 105 "contain horn corals which agree with the subfamily Pseudamplexinae described by Stumm (Geol. Soc. America Mem. 40, pp. 47-48, 1949) in possessing subcylindrical corallites with radially arranged septa, no fossula, and a septal dilation which suppresses the dissepiments in the peripheral zone. However, this subfamily is described as containing simple corals only, and some of those in the material at hand appear to be weakly faciculate. These corals are associated with the tabulate coral <u>Cladopora</u> and with lamellar and encrusting stromatoporoids. Two collections contain a tabulate coral referable to <u>Coenites</u> and one an unidentified bryozoan. All these forms range from Silurian through the Middle Devonian but...similar material (from this area) has been identified as Middle Devonian, and this is probably the best age assignment possible at present..."

The structure of the older Devonian unit is quite complex. The strata are intricately folded and faulted, but in general the beds strike in a northeasterly direction and steep southerly dips predominate.

The southern extent of the older Devonian strata is limited by a major fault zone, perhaps the outstanding structural feature of the Windy Creek area. It cuts across the area in a northeasterly direction following a remarkably straight strend. The trace of the fault is quite apparent, being marked by springs, bogs and, locally, low scarps (figs. 2 and 3). The fault zone extends far beyond the limits of the Windy Creek area, both to the east and southwest.

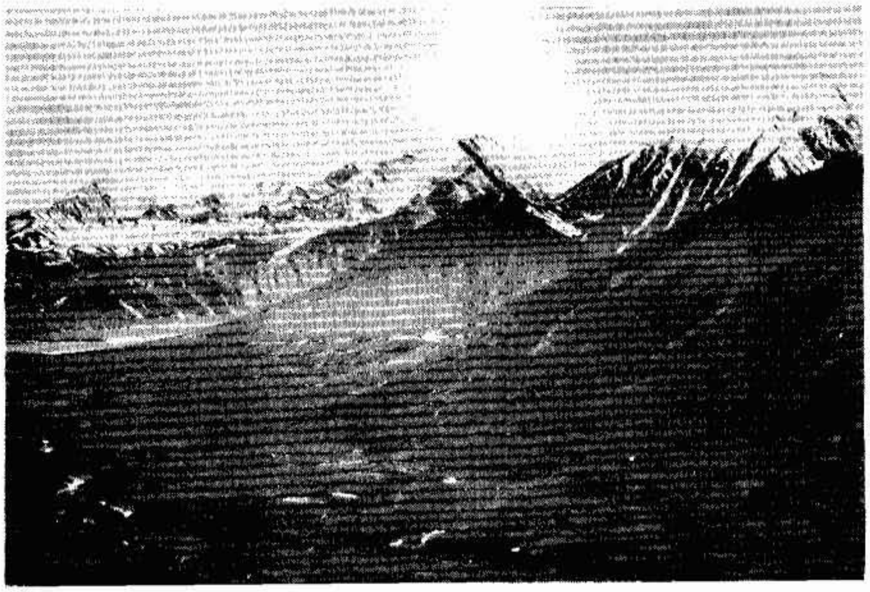


Figure 2. Northwestward view across the fault zone in Foggy Pass. The trace of the fault is marked by the low scarp in the center of the photo.

The existence of the fault in this area was first noted by Moffit (1915) who mapped it for a short distance in the vicinity of the Nenana River. Capps (1932) probably was the first to recognize that the fault zone actually extended at least from Anderson Pass, 40 miles west of Cantwell, to Nenana Glacier on the east. He also pointed out topographic features which suggested its existence beyond these limits. Geologic mapping in the eastern part of the Alaska Range (Moffit 1912, 1952) suggests that the fault zone may extend many miles farther to the southeast.

In the Windy Creek area the fault zone probably dips steeply to the north or approaches the vertical, bringing Jurassic(?) and Cretaceous rocks on the south (downthrown) side into contact with Devonian strata on the north (upthrown) side.

The northern extent of the older Devonian unit is limited by another high-angle fault which has thrust the older Devonian unit over younger beds. This line if displacement is also marked by northeast-southwest oriented drainage and an alignment of low passes extending from near the west boundary of the mapped area to Windy Creek, and probably beyond.

The younger of the two Devonian units crops out in the upper portions of the Windy and West Fork drainage basins. In contrast to the underlying rocks, the younger unit appears to be completely free of conglomerate, with calcareous rocks appearing in greater proportion.

The unit consists of closely folded, metamorphosed sedimentary strata, primarily limestone, graywacke, argillite and shale. These beds, with the exception of the more massive limestone, are generally dark colored where fresh, characteristically weathering to shades of reddish brown. The limestone generally tends to be argillaceous and with one noticeable exception occur as thin-bedded locally schistose strata.

The dominant lithologic unit of the younger Devonian strata is a massive limestone which crops out in an east-west trending belt that crosses the headwaters of the West Fork of Windy Creek. It is quite persistent, extending for at least 20 miles west of the West Fork and two miles eastward. The limestone is blue-gray to black, locally banded, and weathers to a light gray. It is usually very dense and has a fine grained texture. In some localities the rock is quite hard, and breaks with a conchoidal fracture. Calcite reticulation is abundant.

Although great variations occur in the attitude of individual beds, the limestone body as a whole probably stands nearly vertical and trends about N. 70° E.

The limestone attains a maximum thickness of 2,600 feet in the valley of the West Fork; it thins abruptly both to the east and west of this locality.

North of the massive limestone and overlying it are interbedded limestone, argillite and shale which dip steeply to the north. South of the massive limestone, similar rocks, closely folded and faulted but generally dipping steeply southward, are thought to belong to the same stratigraphic horizon as those north of the massive limestone. If this interpretation is correct, the major structural feature of the younger Devonian strata in the headwaters of the West Fork is an east-west trending anticline, although other complex folds are superimposed upon the major structure. The axis of the structure follows the outcrop of the massive limestone so that this geologic unit may represent both limbs of a closely compressed fold.

On the north, the younger Devonian rocks have been intruded by igneous rocks which range in composition from diorite to gabbro, and in the peripheral areas of the intrusion, dikes and sills, generally intermediate composition, commonly occur.

Only a rough estimate of the thickness of the younger Devonian rocks can be made at the present time, but it appears that as much as 8,000 feet may be present in the western portion of the Windy Creek area. The massive limestone probably accounts for about 1,300 feet stratigraphically.

No fossils have been found in the younger Devonian strata. Near the crest of the Alaska Range, north of the Windy Creek area, Capps (1932, p. 104) collected Middle Devonian fossils from limestone which he correlated with the massive limestone near the head of the West Fork. This seems to be the most appropriate age determination in the absence of other evidence.

Triassic system

Rocks of Triassic age overlie the Devonian beds on the north. In the eastern part of the Windy Creek area, the lower portion of the Triassic section consists of a relatively thin series of argillite, limestone, conglomerate, chert, greenstone, and slate which strike in a northeast to eastward direction and which dip steeply both to the north and south. The lithology of the lower part of the section is quite similar to the underlying Devonian, so that the placement of the boundary between the systems is open to question. The location as shown on plate 1 is based on fossil collections 1 and 3 and the predominance of greenstone in the younger system. The stratigraphic relationship of the Triassic rocks with the underlying Devonian rocks is not clear but is probably an unconformity.

The narrow belt of predominantly sedimentary rocks of Triassic age is overlain on the north by a thick series of andesitic and basaltic greenstone sills which occupy the northeastern part of the area mapped and are also thought to be of the Triassic age. The sills in general dip to the north at a moderate angle.

West of Little Windy Creek the Triassic rocks have been intruded by diorite and gabbro which are described below.

Altered greenstone extrusives or sills, interbedded with tuffs, crop out in the area west of Cantwell. Their stratigraphic relationship to the Jurassic rocks on the north is not clear, as the bedding of both units appears to be about vertical in the contact areas. In the extreme southeastern part of the outcrop area of the greenstone, some of the flows appear to dip gently to the south and to strike about northeast. They are tentatively correlated with the Triassic greenstones which crop out in the northeastern part of the area.

No Triassic rocks had previously been mapped in this part of the Alaska Range. Capps recognized the presence of greenstone, slate and chert, near the crest of the range, north and west of the Windy Creek, area between known Devonian rocks and overlying Cretaceous beds. In the absence of any evidence to the contrary he correlated the greenstone, slate and chert with the underlying Devonian. Triassic limestone interbedded with greenstone and other volcanic rocks has been found elsewhere on the south flank of the range. On the West Fork of the Chulitna River southwest of the Windy Creek area, Ross (1933, p. 298) mapped Triassic limestone and argillite which overlie Permian rocks, and in the Valdez Creek area to the east, Moffit (1915 p. 33) found Triassic limestone interbedded with greenstone.

Greenstone, chert and phyllite occur unconformably beneath the Cantwell formation in the headwater region of the Yanert Fork (Wahrhaftig, personal communication, 1952). Apparently these rocks are quite similar in lithology to those which underlie the Cantwell west of the Nenana River, and are probably Triassic in age.

One collection of fossils was made by E. H. Cobb in 1947 from a limestone near the west end of the ridge between Bain and Windy Creeks. The identifications given below are by Ralph W. Imlay:

Fossil locality	Field collection no.	
3	47-ACb-78	Megalodus(?) Mysidia
	47-ACb-79	Contains a belemnite that is definitely Mesozoic but is not well enough preserved to identify generically.

On the basis of the pelecypods in collection 78, which "are characteristic of the Upper Triassic" and the Mesozoic belemnite in collection 79, a Triassic age assignment for these rocks seems most appropriate.

Jurassic(?) system

A belt of steeply-dipping metamorphosed sedimentary strata, tentatively assigned a Jurassic(?) age, crops out between the major fault zone and the igneous and volcanic rocks which border the Windy Creek area on the south. In the western portion of the area the predominant constituents are argillite, slate, and conglomerate which are cut by dikes and sills, although the igneous rocks are quite subordinate percentagewise. The slate and argillite are black in color for the most part. The conglomerate is dark colored, and composed chiefly of chert, argillite, and quartz pebbles.

In the eastern portion of the Jurassic(?) belt, the clastic sediments become considerably coarser with graywacke predominating.

In most of the Windy Creek area the Jurassic(?) rocks are cut off on the north by the major fault zone, but in the extreme western part the Cantwell formation overlies the Jurassic strata. The complexity of the structure in this area obscures the stratigraphic relationship with the Cantwell rocks, but an angular unconformity was found between the Cantwell formation and underlying strata on the north side of the Alaska Range (Capps, 1932, p. 269), and the same condition may exist in the Windy Creek area.

In general the Jurassic(?) rocks strike slightly north of east and, although the strata are closely folded, steep southward dips prevail.

The total thickness of the Jurassic(?) system on the south side of the central portion of the Alaska Range has been estimated to be as much as 5,000 feet (Capps, 1940, p. 111), but the complete section is not present in the Windy Creek area.

No fossils have been found in the Jurassic(?) beds in the Windy Creek area and in the absence of other conclusive evidence the age assignment remains the same as that determined by Capps (1940, p. 111) who based the age of these rocks on a relatively long range correlation with the argillite of known Jurassic age found near the West Fork of the Chulitna River.

Cretaceous system

Cantwell formation

Rocks of Cretaceous age, the Cantwell formation, have a relatively wide distribution on the south side of the Alaska Range in the region southwest of the Windy Creek area. The northeast-trending belt which they occupy, however, narrows rapidly to the northeast so that only a small portion of the Cantwell section is found in the western part of the area mapped, representing the easternmost extent of the formation south of the major fault zone. The Cantwell formation in the Windy Creek area consists primarily of dark-colored, coarse, massive conglomerate and argillite which are locally cut by sills and dikes ranging widely in chemical composition. The conglomerate is composed chiefly of pebbles and cobbles of limestone, argillite, slate and chert, in a wide range of sizes, up to six inches in diameter. The general trend of the beds of the Cantwell formation is N. 60°-80° E., and they are nearly vertical in attitude.

On the north the Cantwell rocks abut against the major fault zone, while to the south they are underlain by the black argillite of Jurassic(?) age. The total thickness of the Cantwell formation in the Windy Creek area probably does not exceed 1,000 feet.

No fossils were found in the Cantwell rocks in this area. Ten miles east of the mouth of the Jack River, Moffit (1915, p. 48) collected fossil plants of Eocene age from shale and sandstone interbedded with conglomerate which he considered to be part of the Cantwell. However, on the north side of the range it is recognized that the Cantwell is definitely older than coal-bearing sediments in that area which were also determined to be of Eocene age. In 1936 Capps collected fossil plants from Cantwell rocks on the north side of the range which were determined to be of Cretaceous age. Although the few fossil collections which have been made from the Cantwell present conflicting results, an age assignment of Upper Cretaceous appears to be most satisfactory at the present time.

Quaternary system

During the Pleistocene epoch the Alaska Range was the scene of widespread glaciation. During the periods of maximum accumulation only the higher peaks of the range were exposed above the glacial ice. The results of the intense glaciation are everywhere in evidence in the Windy Creek area. In addition to the great modification of land forms, unconsolidated glacial and glaciofluvial deposits mantle the bedrock in the lowlands in the eastern part of the area. In the valley of Windy Creek 2 miles west of Little Windy Creek, glacial outwash about 60 feet in thickness covers the bedrock and probably increases in depth in a southeasterly direction.

Extensive deposition of low terrace gravels is found along the present courses of the Jack and Nenana Rivers in the eastern part of the area, and remnants of a relatively low terrace are present in the upper portions of the valley of Windy Creek and its West Fork.

In the eastern part of the area, near the Alaska Railroad, travertine is being deposited by waters emanating from springs located along the major fault zone. No information on the thickness of the material was obtained.

Igneous Rocks

The Triassic greenstones have been included in the previous discussion of the bedded rocks.

In the northwestern part of the a rea the Devonian and Triassic beds have been intruded by an igneous complex ranging in composition from medium grained diorite to an ophitic gabbro, with the more basic compositions predominating. The contact with the Devonian rocks in most places is inclined steeply to the north. In the peripheral areas the intruded beds are cut by dikes and sills, mostly of acid composition, and the country rock is locally silicified.

In all probability more than one period of intrusions is involved, but the principal igneous activity probably took place in late Cretaceous or early Tertiary time. This is based upon observations made in the region north of the Windy Creek area where the igneous mass cuts the Cretaceous Cantwell formation but is overlain by coal-bearing strata of Eocene age. Farther west however large masses of granitic rock are overlain by Cantwell rocks, indicating that major intrusive activity took place both prior to and following the deposition of the Cantwell.

In the southwestern part of the area the Jurassic(?) argillites and slates have been intruded by a light gray, coarse grained quartz diorite. The rock has a porphyritic texture in most places, with euhedral orthoclase crystals up to 1½ inches in length. The contact with the country rock dips moderately to steeply south approximately parallel to the local structure of the enclosing strata. This intrusion hasbeen correlated with the post-Cantwell igneous rocks which occur in the northwestern part of the area.

CEMENT RAW MATERIALS

The growing demand for construction materials in interior Alaska has emphasized interest in the possibility of the local manufacture of portland cement. A plant location in the Alaska Railroad belt, offering accessibility to the more populated areas of the Territory has been of primary concern. The Windy Creek area has attracted particular attention, owing to the occurrence of accessible deposits of limestone and argillaceous materials relatively near the Nenana coal field.

In order to evaluate the mineral resources of the Windy Creek area in relation to the cement problem it will be necessary to examine not only the structure, lithology, size and accessibility of the individual deposits of potential raw materials but also to take into consideration their chemical composition which is of basic importance. The cement industry today must manufacture a product which will meet exacting chemical and physical standards so that detailed knowledge of the chemical composition of the raw materials is a fundamental requirement. The presence of deleterious substances in any potential component may well eliminate it from further consideration despite all other geologic factors pertaining to its exploitation being favorable.

The chemical restrictions which apply to the various cement raw materials are governed to a certain extent by the type of cement which is to be produced. The chemical requirements formulated by the American Society for Testing Materials (1949, pp. 1-4) for portland cement Types I and II (which are employed for general construction purposes) are given in Table 1. It is possible to control cement composition in part, and within certain limits, through the adjustment of the ratio of the raw components, adjustment of the burning time and/or temperature and the use of supplemental iron and silica components. Magnesia and the alkalies however may require flotation or other special treatment and are therefore usually regarded as deleterious substances as far as the raw materials are concerned.

As each component of the raw mix, including the fuel combustion residue, contributes to the composition of the end product, it would not be possible to arrive at an upper magnesia or alkali limit for any particular raw component which would be applicable in all instances.

However, with raw components of the general chemical composition as those found in the Windy Creek area, an upper magnesia limit of 3 percent probably would be applicable to the limestone (which would ordinarily be the major contributor of this compound). The alkalies can be dealt with only in very general qualitative terms, since they probably would volatilize to an unknown extent under actual kiln operation. However, the maximum permissible amount in the cement according to federal specification (see Table 1) is 0.6 percent (total Na_2O plus .658 K_2O), which may be used as a guide in the evaluation of the ingredients.

Limestone

Limestone occurs in several localities in the Devonian and Triassic rocks which cross the Windy Creek area in an east-west direction. Deposits of commercial size have been found in three general areas: 1) between the valley of Little Windy Creek and the Alaska Railroad, 2) the ridge south of the West Fork of Windy Creek and 3) the headwater area of the West Fork.

Table 1. 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.

The three principal deposits in the Windy Creek area are designated as deposits 1, 2 and 3. Their locations are shown on Plate 1. Plates 2, 3 and 4 are detailed maps of deposits 1, 2 and 3, respectively.

The region between Little Windy Creek and the railroad, by reason of its relative accessibility, has received considerable attention during the previous investigations of the Windy Creek area. The limestone outcrops were mapped in detail by Cobb in 1947. His studies were devoted primarily to the most extensive deposit in this area, designated as deposit 1.

Deposit 1

General description: Deposit 1 is situated along the south side of the ridge between Windy and Bain Creeks. The easternmost exposure of the deposit is slightly less than one mile west of the nearest approach of the Alaska Railroad. The deposit crops out between elevations of 2,620 and 3,190 feet, the lower elevation being about 500 feet above the level of the nearest approach of the railroad.

The limestone is typically quite dense and has a fine-grained texture. It is dark gray to black where fresh and weathers to lighter shades of gray and buff. The strata have been thoroughly shattered by intense mechanical metamorphic action and the rock is reticulated with calcite-filled fractures. Where bedding is discernible the strata strike about N. 70° E. and dip 60°-70° SE., although many local variations are found.

Exposures of deposit 1 are found intermittently over a lateral (east-west) distance of about 3,000 feet. Drill holes which penetrate the deposit indicate it to have a maximum thickness of about 600 feet at about the midpoint, decreasing both to the east and west.

The southern extent of the limestone is concealed by talus, glacial deposits and vegetation but presumably the strata are terminated near the major zone of faulting which brings the rocks of Devonian age in contact with those of Jurassic(?) age. On the north the limestone is underlain by greenish to black calcareous schist and tuff.

Sampling: Fifteen samples were taken across exposures of deposit 1 along lines normal to the strike. Each sample consisted of fresh chips collected at 8 inch intervals. Locations of the samples are shown on Plate 2, and results of the chemical analyses of the samples are given in Table 2.

Core-drilling: Core-drilling and chemical analysis to determine the sub-surface continuity, extent, and composition of deposit 1 were undertaken by the U. S. Bureau of Mines during the period 1948-1950. Twelve holes, totaling 3,111 feet, were drilled. The locations of the holes are shown on Plate 2.

Chemical composition: The distribution of magnesia in deposit 1 is quite erratic. Analyses of the Bureau of Mines drill-cores show the magnesia to range between 0.3 and 17.15 percent. Some zoning of the magnesia in an east-west direction is suggested by the distribution of the compound in the rocks penetrated by drilling, but a comparison of the core analyses with those of the surface samples shows little correlation when the suggested zoning at the drill-hole level is projected to the surface. In the area tested by drilling, well over half of the limestone has an average magnesia content exceeding the arbitrary 3.0 percent limit.

Table 2. Chemical analyses of surface samples of 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.

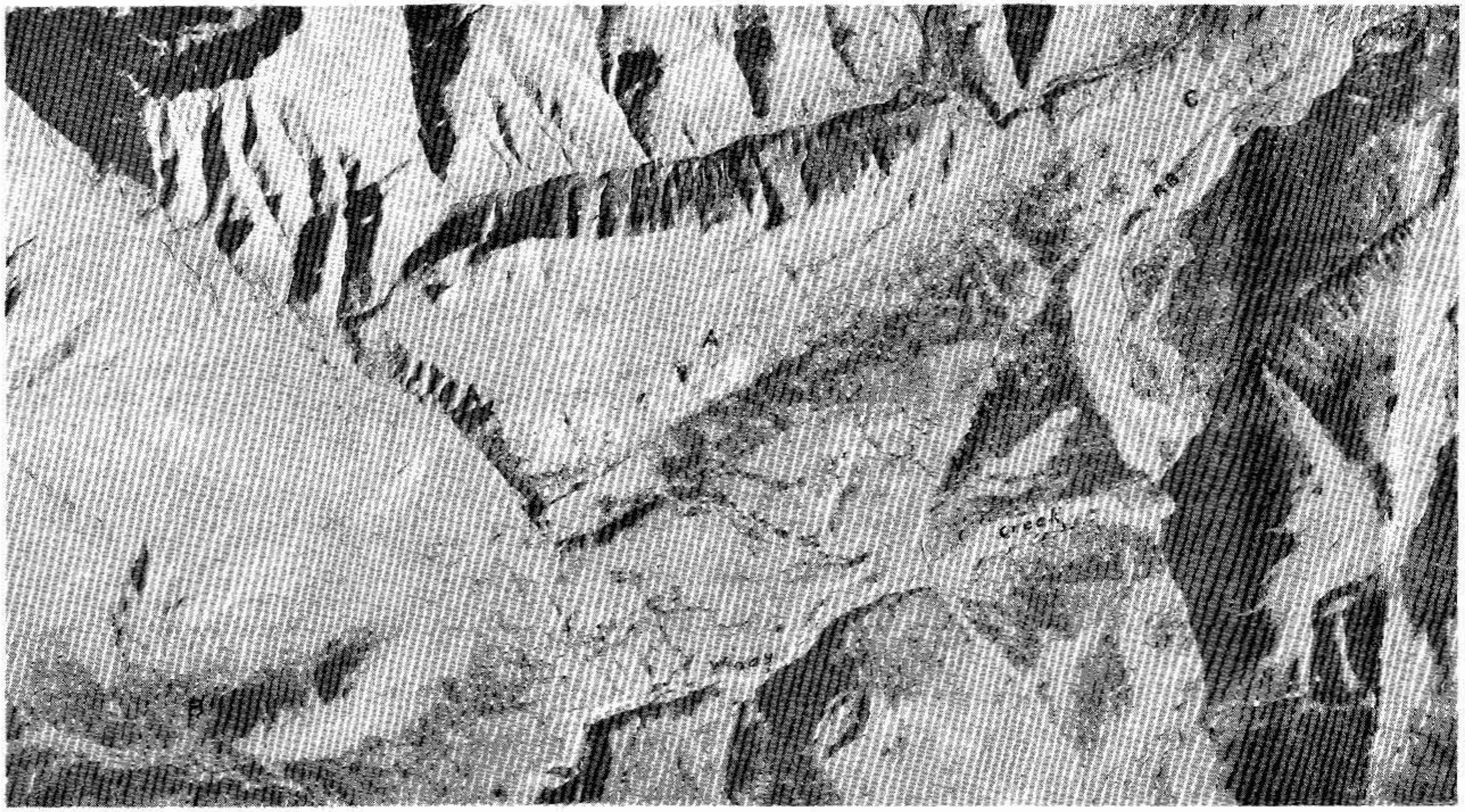


Figure 3. Aerial view of the northeastern part of the Windy Creek area. Deposit 1 is located at A. The trace of the major fault zone between the Devonian and Mesozoic rocks is discernable between points B and C.

Figure 4. Westward view of limestone deposit 2 (left foreground).

S. E. Hutton (1950), Bureau of Reclamation Engineer, has reported on some of the problems involved in the establishment of a cement plant in the Windy Creek area, utilizing deposit 1 as the calcareous component. His report emphasized the need for limestone of more uniform chemical character and the desirability of local supplies of supplemental high-silica and high-iron components.

Reserves: Deposit 1 is assumed 1) to have an average stratigraphic thickness of 500 feet over a lateral distance (east-west) of 3,200 feet; 2) the average angle of the slope of the outcrop surface is assumed to be 30° and the average dip of the limestone to be 70° SE., and 3) limestone weighs 185 pounds per cubic foot. These criteria indicate that deposit 1 contains on the order of 24,000,000 tons above the average level of its outcrops at the foot of the slope. (All reserves have been computed in terms of short tons.)

Deposit 2

General description: Deposit 2 crops out along the summit of the west end of the ridge southwest of the junction of the main forks of Windy Creek (see fig. 4). Its western limit is approximately 7.2 miles west of the Windy Creek crossing of the Alaska Railroad (measured along Windy Creek). Outcrops of the deposit are found between elevations of 3,300 and 3,550 feet. The lower elevation is about 1,180 feet above the railroad at the Windy Creek bridge.

The physical appearance of the limestone of deposit 2 is very similar to that of deposit 1. It is dark gray to black on fresh surfaces and weathers to a light gray. The original bedding is almost entirely obscured, but the trend of the body as a whole is about N. 70° E. and the strata dip on the order of 65° to 75° SE.

The thickness of the bed which comprises deposit 2 averages approximately 300 feet over a lateral (east-west) distance of 4,800 feet. Figure 5 shows a cross-section of deposit 2 along sample line 38.

Sampling: Six samples composed of fresh chips collected at 5-foot intervals were collected along lines normal to the strike. Their locations are shown on Plate 3.

Chemical composition: Results of the chemical analyses of the samples are given in Table 3. Sample 30, taken across the western end of the deposit, contains 3.2 percent magnesia, which is slightly in excess of the arbitrary limit. However, the weighted average magnesia content of all the samples is only 1.3 percent. The weighted average combined alkali content is .25 percent which, in itself, is not an excessive amount.

If the surface sampling is representative of the deposit as a whole, it would appear that the major portion of the deposit would be acceptable as far as magnesia and alkali are concerned.

Reserves: Deposit 2 is assumed to have an average thickness of 300 feet over a lateral extent of 4,800 feet and to dip 70°. It is estimated that about $6\frac{1}{4}$ million tons could be removed by quarrying to a 50-foot depth.

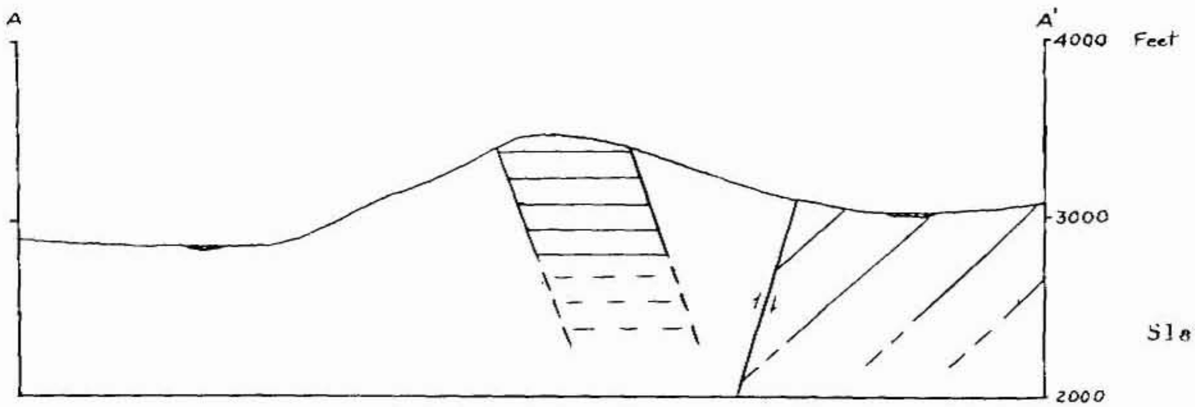
Table 3. Chemical analyses of samples of limestone deposit 2

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	52.8	.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	.11	.13	.02	.08	43.1	100
39	1.1	.00	.2	2.5	52.0	.1	.1	.1		43.4	99

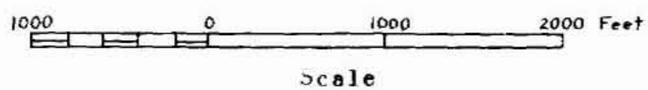
1/ Determined by flame photometer

All other determinations by rapid colorimetric and titrimetric procedures

FIGURE 5



CROSS-SECTION OF LIMESTONE DEPOSIT 2 ALONG SAMPLE LINE 38



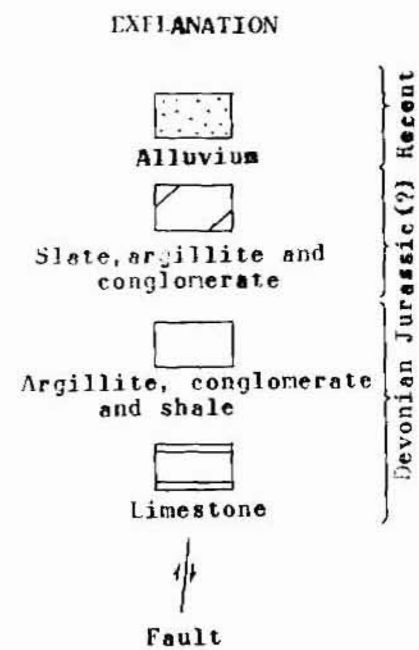


Figure 6. Northward view of the headwater region of the West Fork of Windy Creek. Outcrops of deposit 3 are visible at the upper end of the valley in the center of the photo.

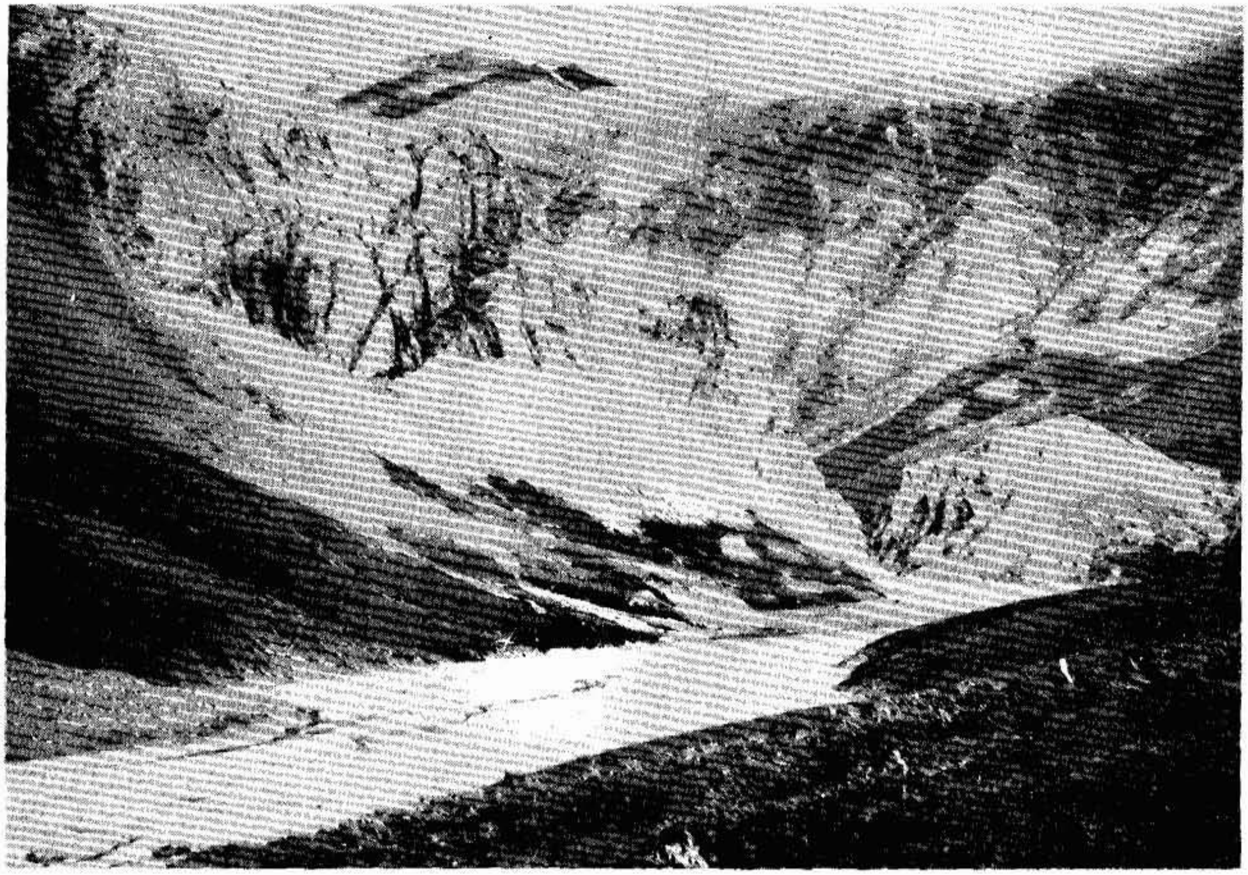


Figure 7. Northwestward view of limestone deposit 3. The West Fork of Windy Creek in the foreground.

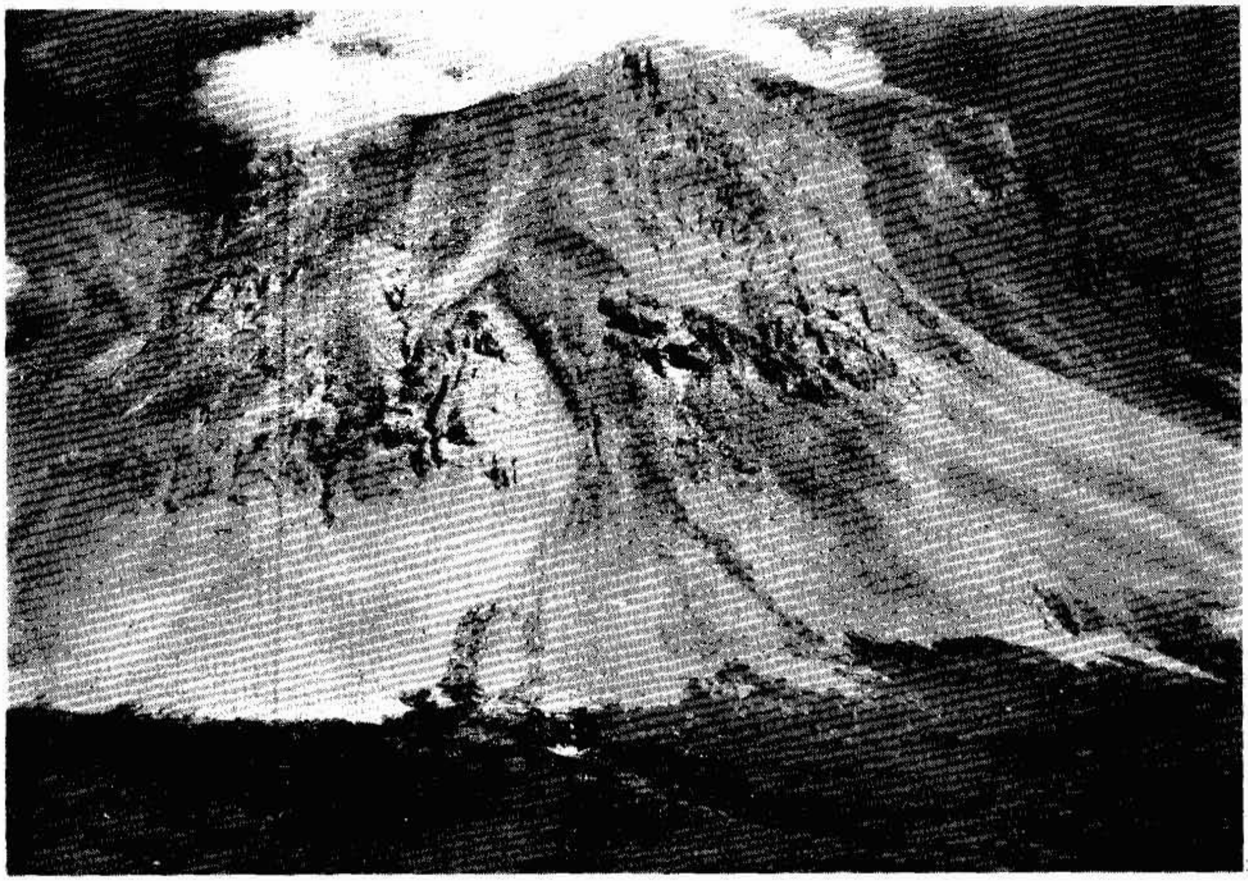


Figure 8. Eastward view of limestone deposit 3 from the valley of West Fork of Windy Creek.

Deposit 3

General description: Deposit 3 includes a portion of a massive limestone which predominates over all others in the Windy Creek area. It crops out along an east-west trending belt which crosses the valley of the West Fork of Windy Creek at the junction of the principal headwater tributaries (see f figs. 6, 7 and 8). This massive limestone unit of the Devonian system was first mapped on a reconnaissance scale and described by Capps (1932, p. 253), who traced its outcrops from the head of Windy Creek westward along the crest and southern slopes of the Alaska Range for a distance of about 20 miles.

A sketch map of the deposit was made by the Geological Survey in 1950 and samples of the principal outcrops were collected and analyzed (Moxham, West and Nelson, 1950). The boundaries of deposit 3 were mapped on a new base map (pl. 2) in 1951. The deposit was subsequently sampled in detail by the Bureau of Mines.

Deposit 3 designates that portion of the massive limestone which is generally accessible to the valley of the West Fork of Windy Creek (see pl. 4). Outcrops of deposit 3 are found from creek level (3,200 feet) to the summits of the steep, serrate ridges which form the valley walls. The lowest outcrops, at creek level, are about 11.2 miles (measured along Windy Creek and its West Fork) west of the Windy Creek crossing of the Alaska Railroad and are approximately 1,100 feet above the level of the railroad bridge.

The more accessible portion of the deposit is on the left limit of the West Fork. In this locality the bedrock of the eastern portion of the valley floor and of the lower slopes of the valley wall is mantled with talus, which has accumulated in vast quantities at the base of the more precipitous slopes (see fig. 8). Nearly continuous exposures are found on the steep slopes above the talus to the top of the ridge which forms the eastern valley wall of the West Fork.

The limestone in deposit 3 is very dense and fine-grained in texture. Fresh surfaces are dark to bluish gray, weathering to a light gray. Locally, particularly in the central portion of the deposit, the limestone exhibits a banded coloration due to thin, alternating layers of dark bluish gray and light gray material. The calcareous strata are closely folded and locally are intricately contorted, but in general the degree of shattering appears to to be somewhat less than that seen in deposits 1 and 2. The attitude of individual beds varies greatly, but the general impression is that the beds stand nearly vertical. The general trend of the deposits is about east-west.

The width of the outcrop area of deposit 3 is about 2,600 feet at its widest extent in the valley of the West Fork, although its stratigraphic thickness would not exceed half this figure if the structural interpretation is correct, that is, that both limbs of a closely compressed fold are represented.

Figure 9 shows three longitudinal sections through deposit 3.

Sampling: In 1950 the U. S. Geological Survey collected samples of the limestone along lines generally normal to the strike near creek level in the valley of the West Fork. Additional samples were taken at higher elevations, where accessible, on the east side of the valley. The sample locations are shown on Plate 4.

The portion of deposit 3 east of the West Fork was sampled in detail by the Bureau of Mines in 1951. A summary of the results is given below . Samples were taken from bedrock along the east side of the West Fork, approximately at creek level. The line is about normal to the strike and covers the full width of the outcrop. Samples 501-550 represent the southern 75 pereent of the line (approximately), and samples 551-570, the northern 25 percent.

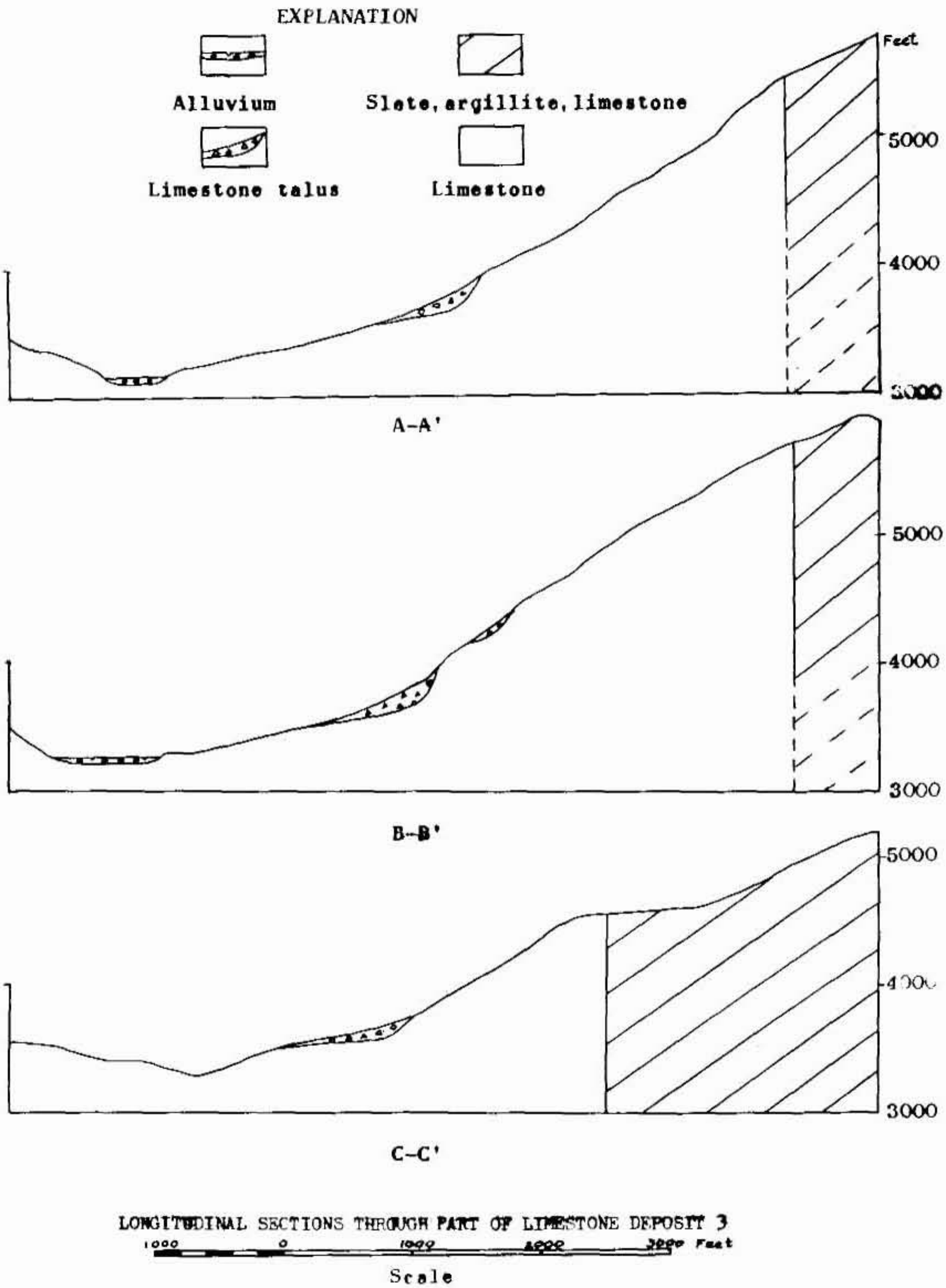
Another line of samples was taken across the northern half of the belt of talus which lies at the foot of the steep cliffs forming the east valley wall (see Fig. 8). The locations of these samples could not be shown on Plate 4. It should be noted that all samples shown on Plate 4 refer to those collected by the U. S. Geological Survey.

Chemical composition: The analytical results of sampling by the Geological Survey are given in Table 4; a summary of the Bureau of Mines analyses is given below:

Samples	Location	CaO	MgO	SiO_2	Al_2O_3	(average) Fe_2O_3
501-550	Bedrock, creek level, southern 3/4 of deposit 3	47.57	1.81	6.03	3.08	1.19
551-570	Bedrock, creek level, northern ¼ of deposit 3	47.8	1.83	5.7	3.07	.97
571-586	North half of talus deposit shown on pl. 4	50.1	1.45	3.4	2.21	.46

The bedrock of deposit 3 lying on the east side of the West Fork is quite uniform in chemical composition and the average magnesia and alkali contents are well within the required limits.

The belt of talus which lies at the foot of the east valley wall is of similar uniform character throughout approximately the northern half. South of the midway point the chemical composition tends to be somewhat erratic, with a generally lower lime content prevailing.



LONGITUDINAL SECTIONS THROUGH PART OF LIMESTONE DEPOSIT 3

Table 4. Chemical analyses of samples of limestone deposit 3

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
491	7.1	2.3	.19	1.4	48.5	.22	.11	.03	.84	38.8	100
492	3.5	2.3	.78	2.9	47.9	.30	.12	.01	.32	42.4	101
493	2.1	.80	.32	1.4	53.0	.50	.13	.01	.24	42.6	101
494	8.6	2.5	.80	1.0	47.7	.83	.28	.03	1.16	38.2	101
495	6.2	.95	.40	1.0	50.0	.38	.13	.02	.41	40.6	101
496	5.4	1.1	.46	1.8	50.3	.62	.19	.01	.35	40.4	101
497	6.0	.64	.45	1.3	50.1	.37	.19	.02	.51	40.4	100
498	25.5	5.6	2.1	2.0	33.5	1.3	.70	.06	.64	28.2	100
499	6.6	1.1	.41	1.9	50.1	.59	.20	.00	.61	39.8	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	.30	39.4	100
503	5.2	.80	.78	8.0	43.4	.33	.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	.18	42.1	100
542	2.7	.29	.19	.77	53.1	.20	.11	.01	.08	42.6	100
543	2.2	.00	.18	.76	53.7	.20	.10	.01	.12	42.8	100
544	2.2	.21	.30	.51	53.6	.20	.08	.01	.08	42.5	100
545	3.0	.83	.30	.75	52.8	.24	.08	.01	.09	42.4	100

Table 4. (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 colormetric procedures.

The greater portion of the limestone on the west side of the West Fork is relatively inaccessible. Only that on the eastern side of the valley is considered in the reserves estimate given below.

Reserves : The reserves may be divided into two categories, talus and bedrock. The approximate distribution of the talus is shown on plate 4 and the inferred cross-sectional configuration of the material is given in figure 9. Using the cross-sectional areas of the talus on AA' and BB' the northern half of the talus deposit is estimated to include on the order of 8 million tons of limestone. The bedrock on the east side of the West Fork situated between creek level and an arbitrarily chosed elevation of 4,000 feet would comprise roughly 180 million tons of limestone, based upon the 3 cross-sectional areas shown in Figure 9.

Other deposits

Limestone deposits have been found in numerous other localities in the Windy Creek area but they are generally regarded as being inferior to deposits 2 and 3, owing to some aspect of their chemical quality, size or accessibility.

A deposit comparable in size to deposit 1 is intersected by the valley of Little Windy Creek (see Pl. 1) . The material was sampled by Cobb in 1947 and by the Bureau of Mines in 1949. The Geological Survey sample locations are shown on plate 1. The analytical results, given below, indicates that about half of the limestone contains excessive magnesia.

	Sample C55	Sample C56
Insol	3.38 percent	2.64 percent
R_2O_3	.39	.18
CaO	52.04	50.14
MgO	1.66	3.98
CO_2	42.56	43.36
P_2O_5	.05	.01

Several other deposits shown on Plate 1 in the area between Little Windy Creek and the railroad were sampled by the Bureau of Mines in 1949 and several appear to be acceptable, insofar as the magnesia content is concerned, but the quantity of material present is generally regarded as insufficient or they are relatively inaccessible.

Two limestone beds averaging 40 feet in thickness crop out along the upper valley slopes on the north side of Windy Creek, west of Little Windy Creek. One chemical analysis of a sample across the thickest portion of one of the beds (see Pl. 1) is given below:

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

Argillaceous materials

The argillaceous component of a cement manufactured from materials available in the Windy Creek area probably would comprise on the order of 15 to 20 percent of the raw mix.

Argillaceous rocks of Devonian and Jurassic(?) age occurring in several localities were examined and preliminary samples collected during the present investigation. A brief description of the various lithologic types is included in Table 5, which summarizes the results of the investigations. The locations of the deposits are shown on Plate 1 and chemical analyses of the samples are given in Table 6.

Devonian system

The rapid lateral and stratigraphic lithologic changes which characterize the Devonian rocks are such that particular lithologic units are usually not of great persistency. A few exceptions however were found in the central and western portion of the outcrop area of Devonian rocks.

Samples 6 and 17 (possibly from the same bed) were collected from a brown to black, crumpled argillite which outcrops in two gullies cut into the steep north valley slopes of Windy Creek (see Pl. 1). The strata in general dip steeply to the southeast, although there are many local variations. The maximum exposed thickness at sample locality 6 is approximately 400 feet. The lateral extent of the beds is concealed by soil and vegetation, but the overburden is probably not more than 2 or 3 feet thick in most places.

Table 5: Summary of data pertaining to argillaceous materials

Sample No.	Date Collected	Description	Attitude of beds	Stratigraphic thickness	Estimated tonnage available
Cl. C2	1948	Shale	N 80 E; 35 N		
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 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
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; 60SE	70	77,000
6	1950	Black, crumpled shale.	N 75 E; 80 NW	400	100,000

Table 5. (continued)

Sample No.	Date Collected	Description	Attitude of beds	Stratigraphic thickness	Estimated tonnage available
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, calcareous argillite locally.	N 50 E; 70 SE	200	450,000
48	1950	Black to black argillite	N 55 E ; 20 SE	140	130,000
51	1950	Black, slaty argillite.	N 74 W; 80 S	400	300,000

Table 6. Chemical analyses of argillaceous materials

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	nd	nd
C 2	62.09	16.36	7.38	5.15	1.29	.97	.75	.21	nd	nd
302	77.30	9.58	5.41	2.51	.90	.65	.43	nd	.55	2.21
304	70.59	13.37	6.43	2.72	.51	.71	.57	nd	.30	4.20
305	70.91	13.73	6.09	2.40	.40	.46	.37	nd	.35	4.75
307	64.86	16.63	6.71	1.76	1.59	2.53	.61	nd	.12	4.58
308	64.58	16.37	5.07	4.56	1.66	1.16	.72	nd	.10	5.25
309	61.85	18.15	7.28	3.80	.81	1.42	.65	nd	.15	5.27
310	60.61	14.79	6.60	5.60	3.20	1.25	.70	nd	.18	6.51
311	62.90	17.75	7.44	4.10	.96	1.55	.68	nd	.07	4.17
318	70.31	15.94	4.06	2.93	.41	.28	.21	nd	.67	4.85
6	62.4	14.8	4.8	1.9	3.8	.85	2.2	.14	nd	7.9
17	64.2	16.8	5.7	1.3	.72	.94	2.4	1.4	nd	5.9
26	62.9	17.9	6.0	1.3	1.0	.84	2.7	.13	nd	6.6
43	41.8	11.2	4.3	2.1	19.9	1.7	1.5	.14	nd	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	.92	2.6	.11	.99	5.4
51	64.4	15.6	6.0	1.0	2.0	1.4	2.7	.15	.34	4.5

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

Samples 43 and 45 represent a red, green and yellow mottled calcareous argillite which crops out on the summit of the ridge southwest of the mouth of the West Fork. The strata overlie the limestone of deposit 2 and dip moderately to steeply to the southeast. They are exposed for a lateral distance of about 2,000 feet along the crest of the ridge. It is estimated that the beds are about 200 feet in thickness. Only a very thin soil mantle covers the bedrock in most of the area.

Sample 48 was collected from a brown to black argillite which crops out for a distance of about 300 feet along the south side of the West Fork from creek level to an elevation of about 2,900 feet. The beds strike N. 55° E. and dip 20° to the southeast. A stratigraphic thickness of about 140 feet is exposed.

Jurassic(?) System

The largest deposit of argillaceous material in the Windy Creek area is represented by the Jurassic(?) argillite which underlies the Cantwell conglomerate in the western part of the area. The strata are primarily black argillite, but a few layers of graywacke and conglomerate occur. The beds have been cut by acid dikes in a few localities. The Jurassic(?) argillite is well exposed in a north-flowing tributary which enters the West Fork near the east end of Foggy Pass (see Pl. 1). At this locality the strata strike about N. 75° W. and dip 80° S. Sample 51 represents a stratigraphic thickness of about 800 feet of argillite. This general lithology persists laterally at least as far as the western limit of the mapped area. To the east the sedimentary beds become increasingly coarse, containing much more graywacke.

Jurassic(?) rocks crop out immediately west of the Alaska Railroad between Windy Creek and Cantwell. The beds are composed chiefly of metamorphosed argillaceous sediments and minor amounts of limestone. In several localities the beds have been cut by dikes of acid or intermediate composition. The Jurassic(?) strata dip moderately to steeply northward and strike about N. 80° E. In 1948, Gates and Cobb (manuscript in files of the U. S. Geological Survey) sampled a shale member exposed in an outcrop located along the west side of the Alaska Railroad (samples C1 and C2, Plate 1) one mile southeast of Windy Creek. The sample was composed of material collected at 2-foot intervals over a distance of 375 feet along the railroad.

An additional sample of this material (311) was collected by R. E. Fellows in 1949.

Other outcrops of argillaceous rocks, rather limited in proportions, are found along lower Windy and Little Windy Creeks. In most of these localities the deposits are mantled by a thick overburden of glacial outwash except where exposed by the stream erosion. The locations of samples collected by Fellows in 1949 are shown on Plate 1 and briefly described in Table 4.

Chert

Modern cement manufacturing processes require very close control of the chemical composition of the raw mix in order to produce a uniform product which will meet rigorous specifications. The most common practice is to adjust the composition of the raw mix by the addition of a high iron and/or a high silica component in appropriate quantities to attain a cement of desired chemical composition. Mill scale and pyrite cinder are commonly used as high iron components; silica sand, quartz and quartzite comprise the principal high-silica materials.

No high-iron materials are known to occur in the Windy Creek or adjacent areas, but chert which occurs in the northeastern part of the area might be suitable for a high-silica component. The chert beds, probably of Triassic age, crop out adjacent to the Alaska Railroad about two-thirds of a mile north of Windy. The rock is black in color and locally weathered to a rusty hue. To the north the chert is overlain or intruded by greenstone.

The beds have a stratigraphic thickness of about 60 feet and are exposed from the railroad right-of-way for at least 100 feet in a southwestward direction.

A sample (no. 100, Pl. 1) consisting of fresh chips collected at 5-foot intervals across the width of the outcrop was taken along the railroad right-of-way. Results of the chemical analysis of the sample are given below:

		percent
SiO_2		96.31
Al_2O_3		1.59
Fe_2O_3		0.40
FeO		0.18
MgO		0.07
CaO		0.23
Na_2O		0.05
K_2O		0.35
H_2O +		0.05
H_2O -		0.31
TiO_2		0.06
CO_2		0.04
P_2O_5		0.15
MnO		0.00
	Total	99.79

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