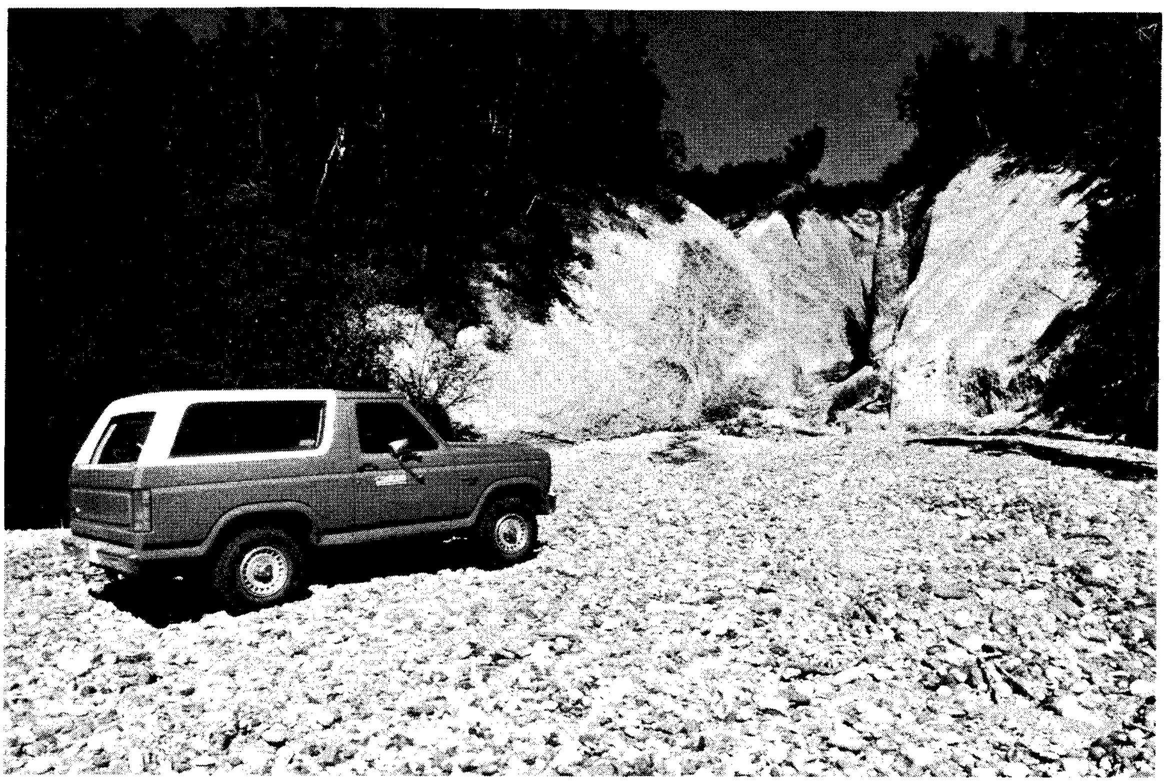
INDUSTRIAL MINERALS OF THE VALDEZ CREEK MINING DISTRICT, ALASKA

By D. D. Southworth



Sand and Gravel Deposits, east fork Chulitna River

U.S. DEPARTMENT OF INTERIOR
Manuel Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

OFR 28-90

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot
ft^3	cubic foot
in	inch
lb	pound
kg	kilogram
mm	millimeter
km	kilometer
oz	troy ounce
oz/st	troy ounce per short ton
%	percent
ppb	parts per billion
ppm	parts per million
st	short ton
yd^3	cubic yard

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ABSTRACT

In 1987, the Bureau of Mines initiated a mineral assessment of the 5.7 million-acre Valdez Creek Mining District (VCMD). Following a literature search and interviews with persons knowledgeable about deposits within the district, limited on-site field visits were made to various deposits. Present within the district are the industrial minerals limestone, argillite, granite, basalt, perlite, zeolite, and sand and gravel.

At least six limestone deposits of potentially economic size and grade are known to exist within the district. Adjacent to the Parks Highway and marginal to the district, a limestone deposit is currently being mined as a source of agricultural lime.

A perlite occurrence near Yacko Creek was evaluated but proved not to be of industrial grade.

The sand-and-gravel resources of the district are vast, but high silt content renders many of the glacial deposits unsuitable for use in construction applications.

INTRODUCTION

The Bureau of Mines (Bureau) began a mineral resource assessment of the VCMD in 1987. The VCMD project was designed as a four-year study to determine the mineral development potential of that portion of Alaska (fig. 1). Program objectives are to determine reserves, study the application of modern beneficiation technologies on known deposits, complete economic feasibility studies, perform probabilistic computer reserve studies, and address economic and legislative effects on mineral development. The objectives of this portion of the study were to catalog various deposit types and to evaluate the economic potential of industrial materials within the VCMD.

ACKNOWLEDGMENTS

The author gratefully acknowledges John Fritz, Tom Ottley, and Mike Grahek of the State of Alaska, Department of Transportation and Public Facilities (DOTPF) for valuable discussions and for opening DOTPF material site files to the Bureau. Ric Breese, Senior Geologist with Manville Corporation, provided helpful

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[1]Geologist, Alaska Field Operations Center, Bureau of Mines, Anchorage, Alaska.

information on perlite and examined specimens from the area. Professor Dan Hawkins of the University of Alaska, Fairbanks, enthusiastically provided information on zeolites in the Horn Mountains.

LOCATION

The VCMD is located in southcentral Alaska (fig. 1). The district comprises most of the Susitna River drainage basin (17)[2]. It is bounded on the north by the crest of the Alaska Range and on the south by the Talkeetna Mountains; the Kahiltna Glacier marks the western boundary, and the Copper River Basin constitutes the eastern boundary. The geography varies from broad glaciated lowlands with irregular, morainal topography and outwash plains at elevations of 300 ft, to rugged glaciated peaks, including Mt. McKinley (elevation 20,320 ft.) (15).

Talkeetna (population 269) is the largest settlement in the district.

The principal transportation routes within the VCMD are the Parks Highway, which runs north-south, connects Fairbanks and Anchorage, and cuts through the eastern portion of the district; the Denali Highway, which runs east-west and connects the Parks Highway with the Richardson Highway to the east; and the Alaska Railroad, which essentially parallels the Parks Highway (fig. 2).

LAND STATUS

The VCMD includes both Federal and State land, as well as land belonging to native corporations and private individuals (1) (fig. 3). Some of the Federal lands are open (available) for mineral entry. The Federal lands are administered by the Bureau of Land Management (BLM) and the National Park Service. Current land status can most accurately be determined by inspecting Master Title Plats on file at the BLM office located in the Federal Building at 7th and A Streets in Anchorage, Alaska.

PREVIOUS STUDIES

In 1953, Rutledge and others (19) of the Bureau reported on industrial minerals accessible to the Alaska Railroad (ARR). Later, Waring (22) reported on a source of granitic rock adjacent to the ARR right-of-way. Prior to construction of the Denali Highway, connecting the Richardson Highway with Mount McKinley (now Denali) National Park, several studies of the engineering geology and availability of construction materials along the proposed route were prepared by the U.S. Geological Survey (12, 13). Hawkins (8, 9, 10) has reported on zeolites in the Horn Mountains, just south of the VCMD boundary. Information on industrial minerals within

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[2]Underlined numbers in parentheses refer to the references found in the reference section preceding the appendix.

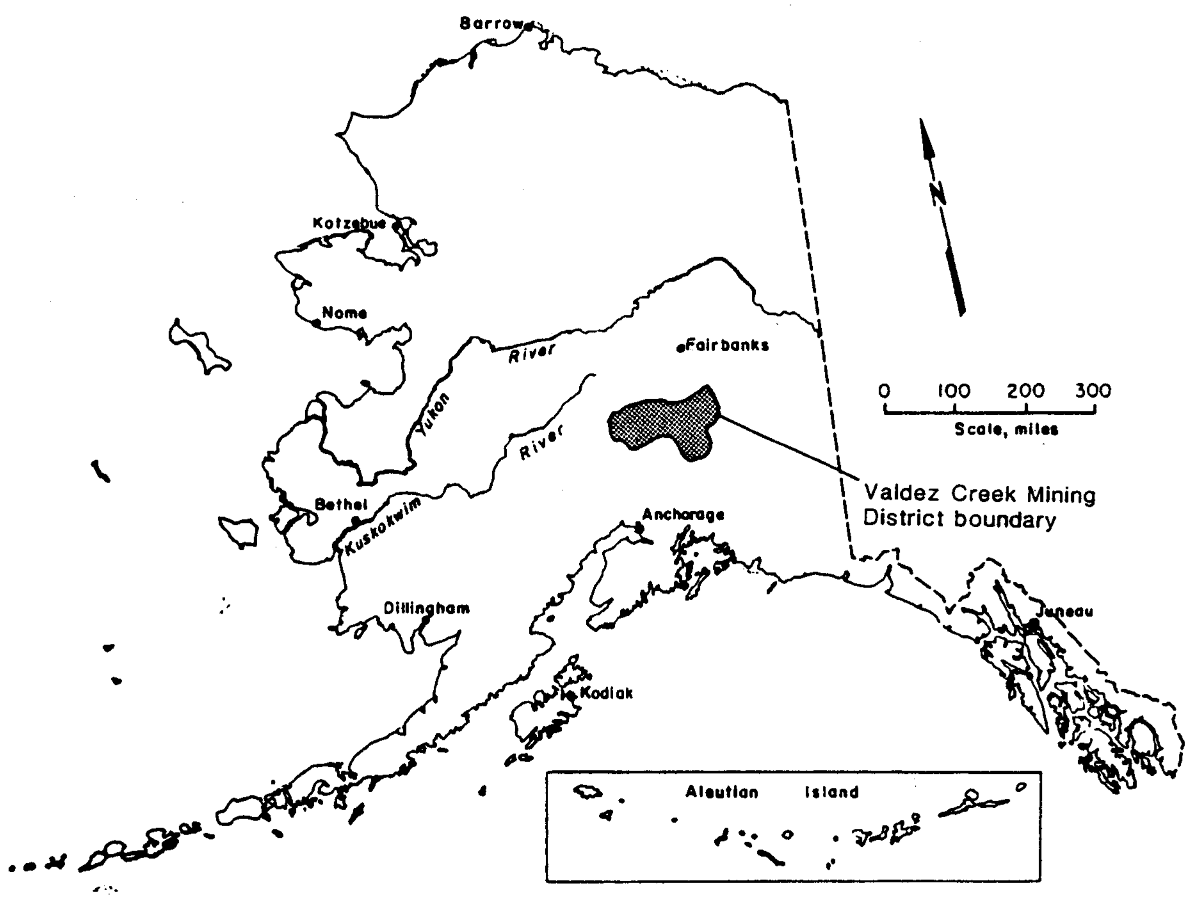

Figure 1.--Index map of Alaska showing the Valdez Creek Mining District

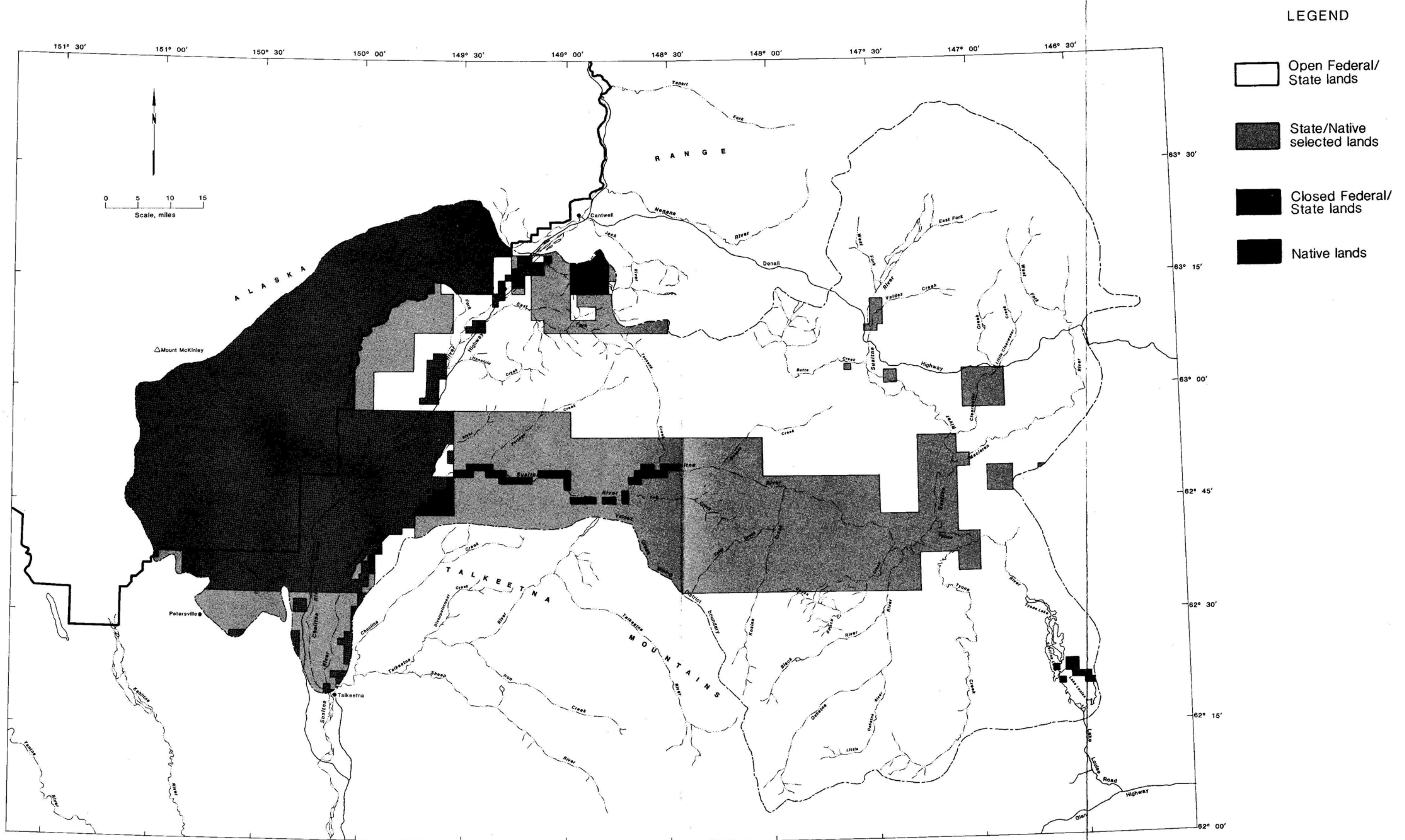

Figure 3. -- Land status map for the Valdez Creek Mining District, Alaska

the Chulitna Mineral Belt was prepared by Hawley (11). A summary of references to the mineral exploration and development of the VCMD is given by Kurtak and others (15).

VALUE ESTIMATES OF INDUSTRIAL MINERALS

In the past, geologic mapping, sampling and testing of many of the industrial mineral occurrences along the ARR has been conducted by the Bureau (19). During the present study, a literature search was undertaken and interviews with representatives of the appropriate native regional corporations, and the State of Alaska, DOTPF were conducted.

Although all of the material (sand and gravel) sites along the George Parks and Denali Highways were visited briefly during the summer of 1989, most of the information on material sites was found in the files of DOTPF at their offices in Anchorage and Fairbanks. Information on industrial minerals sites, including argillite, limestone, granite, and zeolite within the VCMD was derived from previously published material and conversations with experts in the concerned fields.

BUREAU INVESTIGATIONS

The main focus of this study was on the industrial mineral deposits already known in the area, plus those identified during the first two years of the VCMD study. Most known industrial mineral occurrences were identified prior to or during construction of the primary transportation routes in the VCMD. Early studies focused on materials of possible use in completing a particular project; hence the ARR focused on identifying sources of rip-rap, limestone, and argillite. During construction of the Denali Highway, sand and gravel and other potential sources of aggregate were of primary importance.

As part of its investigation of possible sources of industrial minerals within the VCMD, the Bureau sampled and tested several Permian and Triassic argillite beds to evaluate their potential as a source of light-weight aggregate (19). The Bureau also identified several limestone deposits of potential use in the manufacture of cement; basalt and granitic rock as potential sources of rip-rap; perlite, a commodity used as insulation and as a filter material; zeolite, a family of minerals with multiple industrial applications, primarily based on their catalytic and absorbent properties; and sand-and-gravel, used in the construction of highways and in concrete.

ARGILLITE

Argillite, after preparation by roasting in a kiln to bloat (expand) it, can be used as a lightweight aggregate to provide bulk in concrete building blocks, in lightweight structural and pre-cast concrete units, and in other structural and/or insulation applications (16). Concrete made using lightweight aggregate instead of ordinary gravel is from 15 to 40 percent lighter than normal concrete. This lighter weight concrete has numerous advantages over normal concrete. In structural concrete, the reduction of the dead load weight of the concrete allows an increase in the number of stories of a building and decreases the cost of supporting trusses and footings. Especially important for Alaska is the lower thermal conductivity and enhanced insulation properties of concrete made with lightweight aggregate.

Argillaceous materials tested for suitability as lightweight aggregate by the Bureau included samples from two general areas within the western portion of the VCMD: Indian River (fig. 4) and Colorado Creek (fig. 5). Only the samples that yielded the best results are discussed here.

At the Indian River occurrence (fig. 4), three samples collected from an approximately 130-ft-thick argillite bed contained in a sequence of interbedded argillite, shale, limestone, and graywacke gave good bloating results (19). Another sample, representing a 216-ft-thick argillite bed, gave fair results. The Indian River argillites are considered to represent "a very good potential source of raw material for light-weight aggregate production" (19, p. 70). It is concluded that these characteristics and the location of the Indian River argillites along the ARR right of way favor their exploitation for use as light-weight aggregate.

In the Colorado Creek area (fig. 5), samples from unit A, representing a 510-ft layer of gray to black argillite of Triassic age (19), yielded "fair" test results.

Samples from unit B (fig. 5) had "very good" bloating characteristics (19). Samples from unit C, did not bloat through the range 1100°-1300° C, and is therefore unsuitable material.

However, both location A and B are in the recently extended Denali National Park boundary and are, therefore, no longer available for use. No reserve or tonnage estimates are available.

LIMESTONE

The greatest potential market for limestone in the VCMD is probably its use in the manufacture of Portland cement.

The theoretical composition of commercial Portland cement is approximately 70-75 percent $CaCO_3$, 15-25 percent combined SiO_2, Al_2O_3, and Fe_2O_3, and 5 percent MgO. This theoretically requires that one begin with a limestone that contains less than 3.3 percent magnesia (MgO)(19, p. 90).

In the VCMD, limestone has been identified in the West Fork Chulitna River area near Foggy Pass (fig. 2, no. 85); between Long and Copeland Creeks (fig. 2, no. 67); near the West Fork Glacier (fig. 2, nos. 1-3); at White Hill (fig. 2, no. 19); at Limestone Gap (fig. 2, no. 21); and adjacent to Tsisi Creek (fig 2, nos. 22-24).

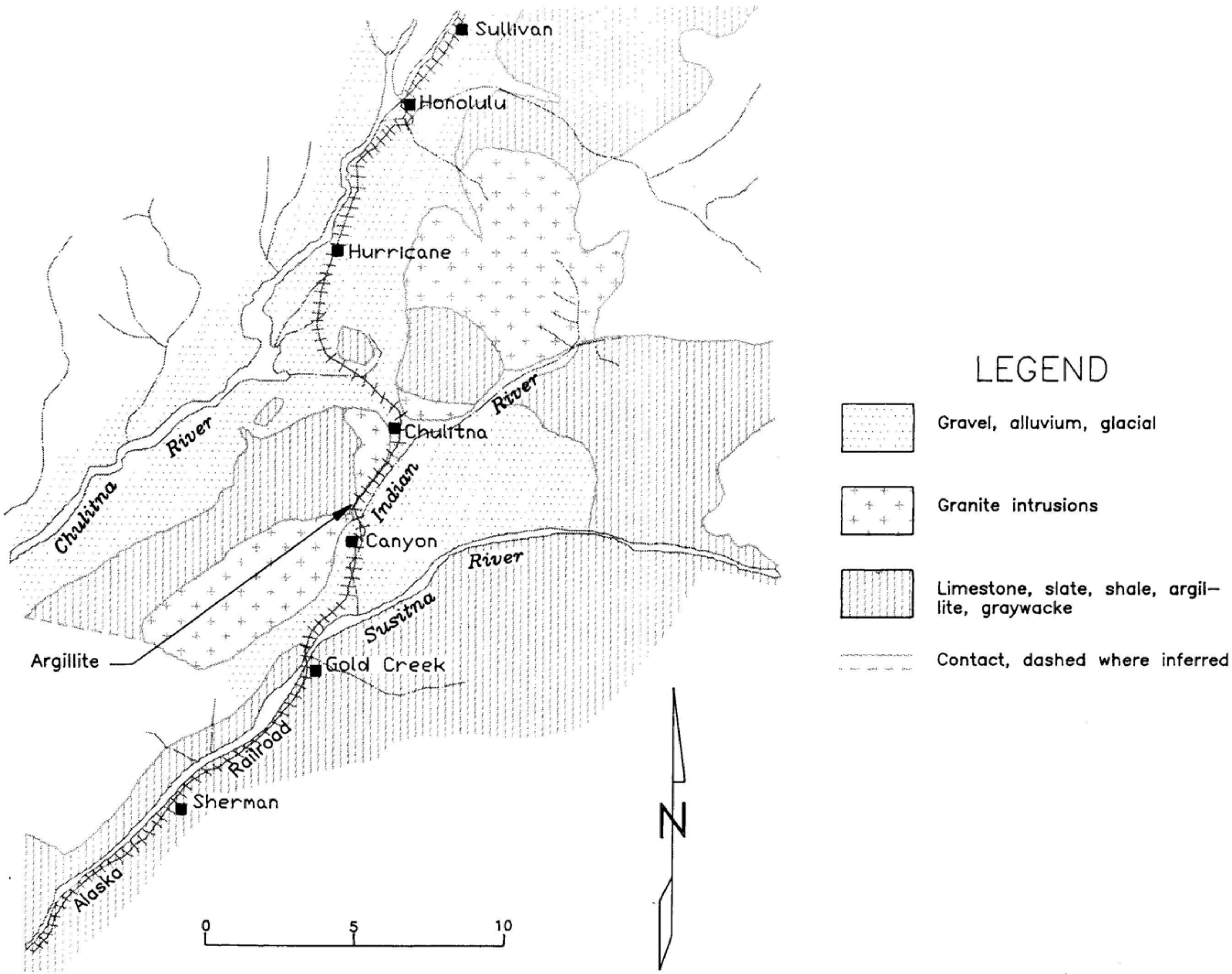

Figure 4. -- Location map, Indian River argillite and granite occurrences.

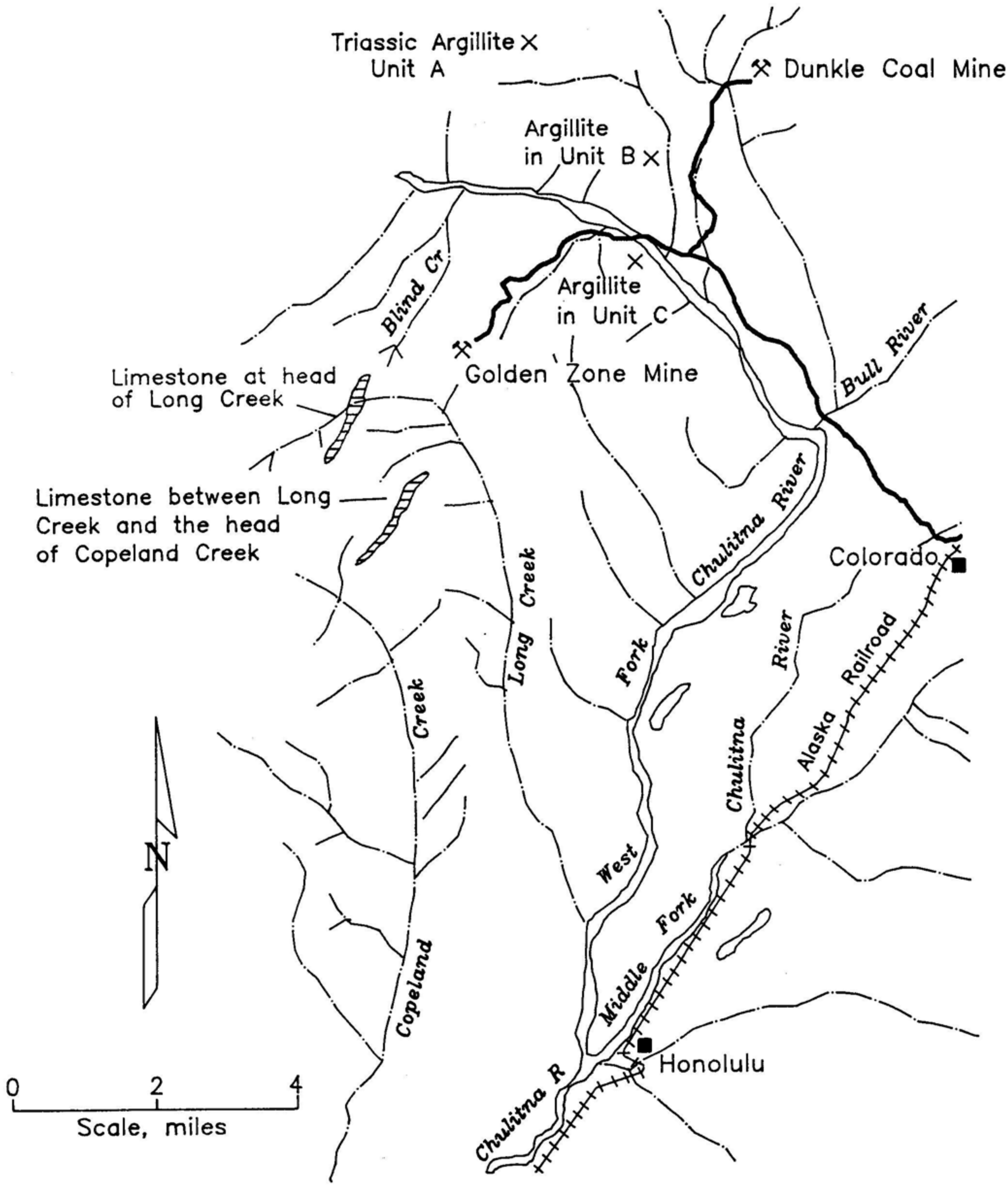

Figure 5 -- Location of samples of limestone and argillite taken along west fork Chulitna River.

Foggy Pass

A limestone deposit located near Foggy Pass (fig. 6, sample nos. 1-8; fig. 2, no. 85) was examined by the Bureau (19). Of the Chulitna area limestones tested by earlier workers, the samples that yielded the best results were from the Foggy Pass area (table 1). Most of the Foggy Pass samples contain less than 3 percent magnesia, and the silica content is relatively low. The Foggy Pass area was included in the 1980 addition to Denali National Park, however, and is no longer available for development.

Long Creek

Triassic limestone near the head of Long Creek (fig. 7) was generally acceptable chemically, but in several of the samples, impurities (both alumina and magnesia), were sufficiently high to cause concern for the suitability of these limestones as sources of Portland cement (fig. 8, sample nos. 1-10; fig 2, no. 68). In other samples the MgO, Na_2O, K_2O, and Fe_2O_3 content was within the specified range for commercial limestone, but some of the samples contained a relatively high proportion (up to 13.4 percent) of silica (19, p. 120).

Copeland Creek

The area referred to here as Copeland Creek (fig. 9) is actually an area located on the ridge between the headwaters of Copeland and Long Creeks, four miles south of the Golden Zone Mine (fig. 9, sample nos. 1-5; fig. 2, no. 67). The limestone beds are white to gray, fractured, fossiliferous, and dip moderately to steeply (60° to 70°) to the northwest (19). The limestone at Copeland Creek is interbedded with shale and siliceous rocks. Some of the samples from the Copeland Creek occurrence are acceptable chemically, but most are probably too high in impurities, especially silica and alumina (table 1, samples 1-10), to be considered for industrial use.

Preliminary analyses (table 1) indicate that several of the limestone deposits near the Chulitna River may be suitable for use in the manufacture of Portland cement. Difficulty of access, lack of a nearby market[3], widespread faulting, fracturing, and erratic magnesia distribution in the rock, however, render most of the Long

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[3]The value of many industrial minerals depend on their proximity to where they are to be utilized. Such minerals are said to have "high place value" (7). The "unit value" (e.g., cost per ton) of these minerals is usually low. An example of a material with high place value and low unit value is sand-and-gravel. It is not unusual for a distant, high quality deposit of a material with high place value to be bypassed in favor of a lower quality but more accessible deposit.

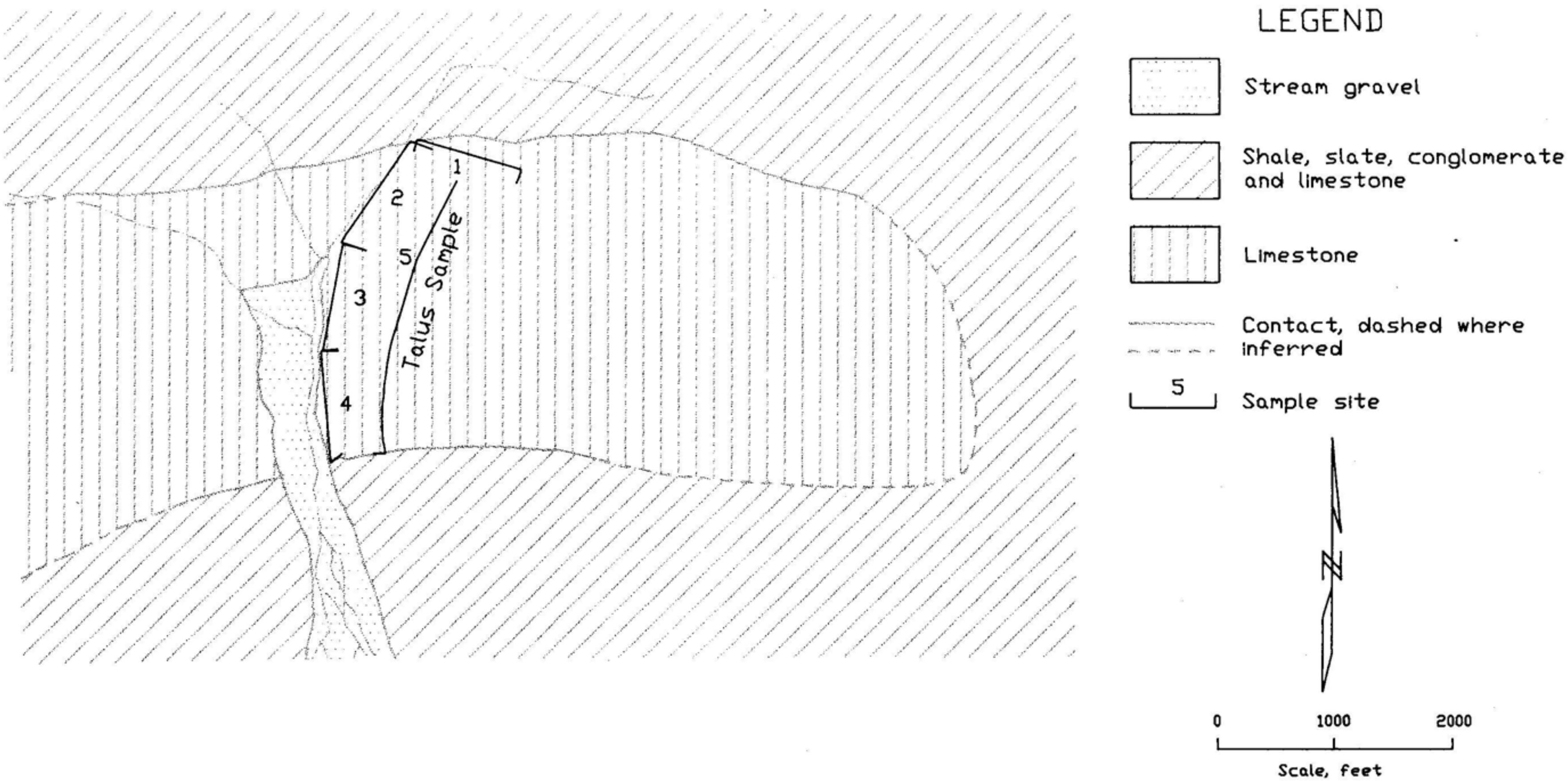

Figure 6. -- Foggy Pass deposit, showing location of Burueau of Mines samples.

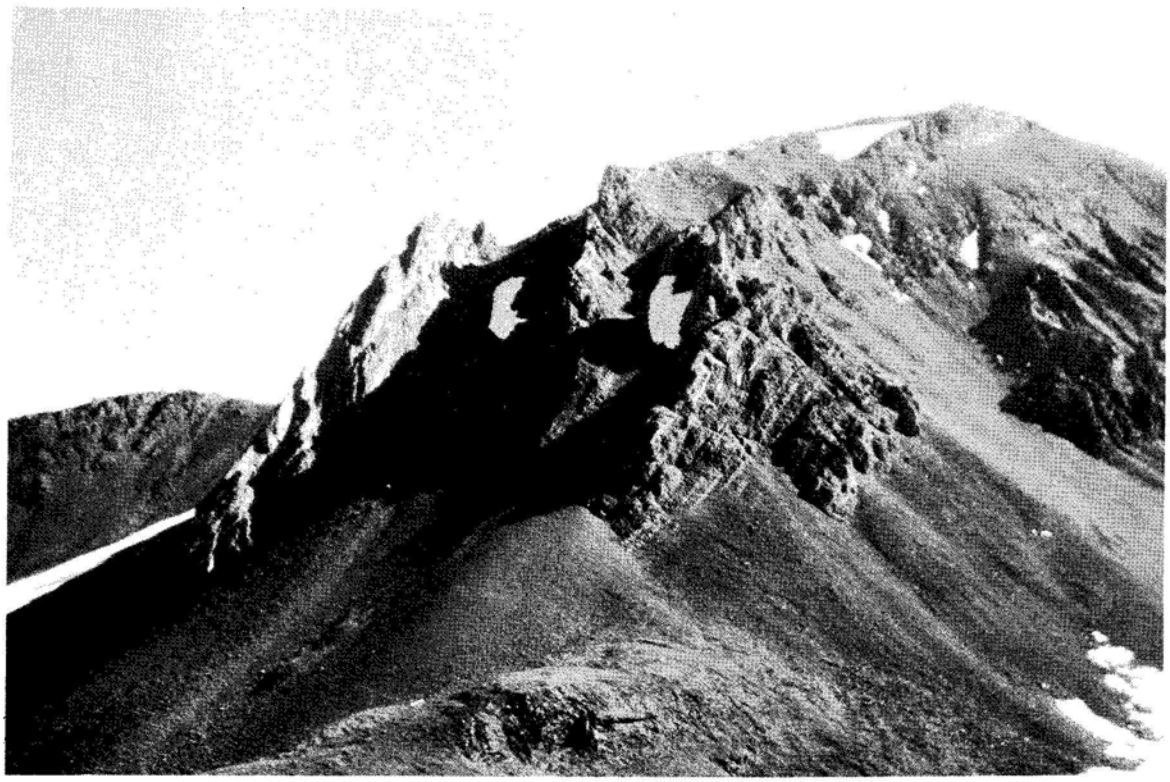

Figure 7 - Photograph of limestone outcrop above the head of Long Creek

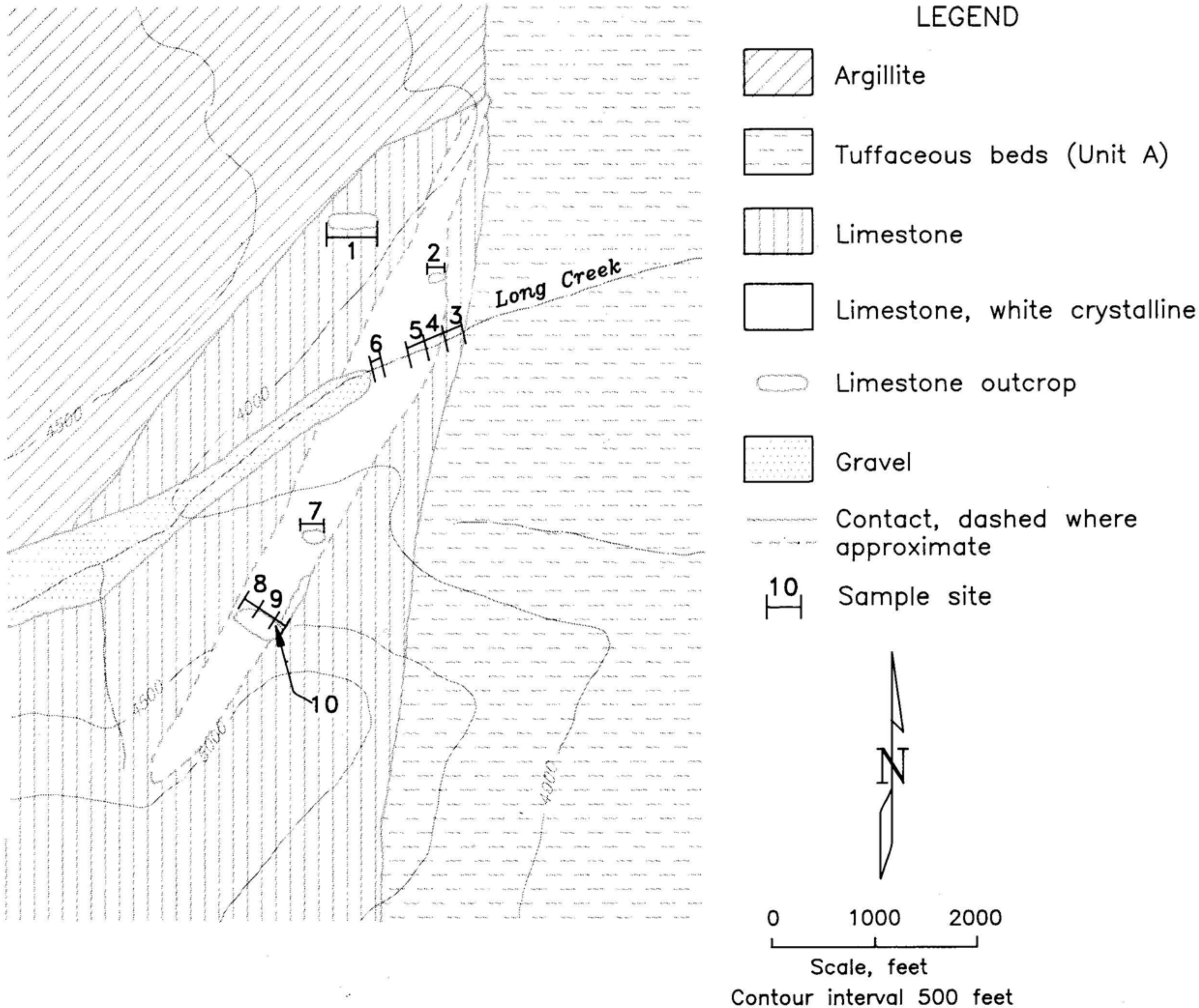

Figure 8. -- Sketch map of limestone outcrop at head of Log Creek, showing sample locations.

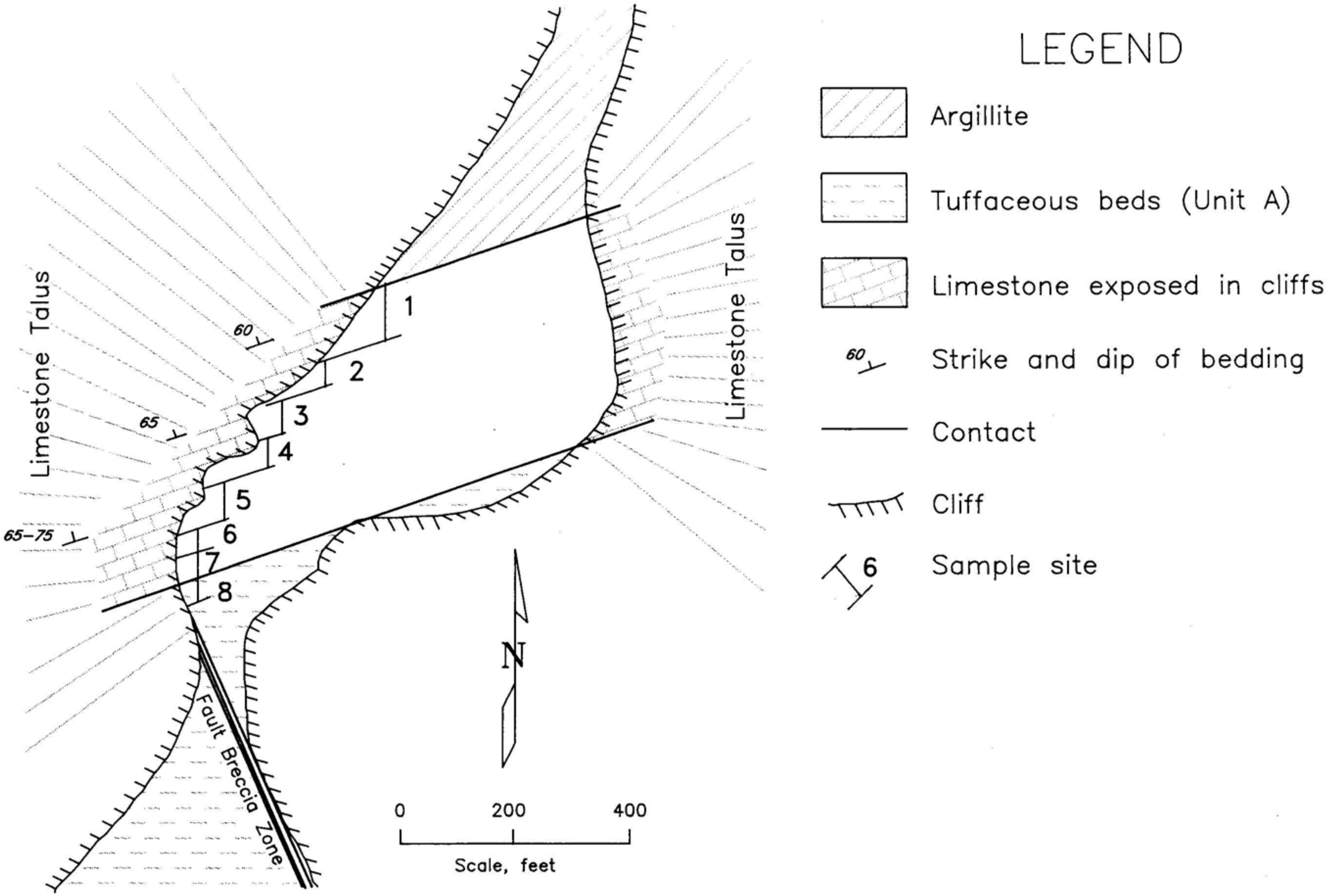

Figure 9. -- Sketch map of Copeland Creek limestone deposit, showing sample locations.

TABLE 1 - PRELIMINARY ANALYSES OF LIMESTONE OCCURRENCES IN THE VALDEZ CREEK MINING DISTRICT

Map no.*	Sample no.	SiO_2 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	LOI** %	CO_2 %	Al_2O_3 %
67	173***	1.10	0.37	1.10	54.0	NA	NA	NA	Na	0.53
67	174	2.70	0.37	0.60	53.8	NA	NA	NA	NA	0.83
67	175	1.50	0.34	0.60	54.5	NA	NA	NA	NA	0.76
67	176	1.70	0.31	0.30	54.4	NA	NA	NA	NA	0.69
67	177	10.00	1.40	0.90	46.4	NA	NA	NA	NA	3.40
67	178	2.60	1.36	0.70	52.4	NA	NA	NA	NA	1.36
67	179	2.60	0.40	0.60	53.4	NA	NA	NA	NA	1.10
67	180	2.40	0.45	0.50	53.5	NA	NA	NA	NA	1.05
67	181	3.20	0.66	0.70	52.6	NA	NA	NA	Na	1.64
67	182	3.50	0.63	0.80	51.6	NA	NA	NA	NA	1.87
68	185	5.8	0.51	0.01	50.8	NA	NA	NA	NA	1.79
68	186	3.70	0.23	0.10	53.0	NA	NA	NA	NA	0.97
68	187	10.80	0.28	0.10	48.2	NA	NA	NA	NA	1.52
68	188	22.8	1.35	0.10	37.6	NA	NA	NA	NA	5.25
68	189	10.4	0.57	0.10	47.0	NA	NA	NA	NA	2.43
68	190	7.20	0.48	0.10	50.6	NA	NA	NA	NA	1.52
68	191	19.0	1.05	0.10	41.0	NA	NA	NA	NA	5.15
68	192	26.0	4.30	0.60	31.0	NA	NA	NA	NA	8.90
68	AVC1201	5.23	1.14	0.48	50.4	0.0	0.10	40.9	Na	1.07
68	AVC1202	4.31	0.82	0.49	51.0	0.0	0.20	41.7	Na	0.98
68	AVC1203	2.18	0.65	0.42	52.7	0.0	0.0	42.7	Na	0.48
68	AVC1204	4.79	2.02	0.58	50.7	0.03	0.30	41.3	NA	2.02
68	AVC1205	3.20	0.78	0.56	52.1	0.01	0.20	41.9	NA	1.01
68	AVC1206	2.53	0.60	0.58	51.4	0.04	0.50	39.8	NA	0.55
68	AVC1208	4.57	1.23	3.04	46.6	0.06	0.90	39.3	NA	1.03
68	AVC1209	2.74	0.65	0.51	51.3	0.05	0.90	40.2	NA	0.50
85	163	4.10	0.43	0.35	51.40	NA	NA	NA	NA	1.15
85	164	7.70	0.68	0.75	47.10	NA	NA	NA	NA	2.20

TABLE 1 (CONT.) - PRELIMINARY ANALYSES OF LIMESTONE OCCURRENCES IN THE VALDEZ CREEK MINING DISTRICT

Map no.*	Sample no.	SiO_2 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	LOI** %	CO_2 %	Al_2O_3 %
85	165	5.90	0.58	0.25	49.80	NA	NA	NA	NA	1.60
85	166	5.40	0.51	0.65	50.30	NA	NA	NA	NA	1.60
85	167	4.00	0.50	0.40	51.40	NA	NA	NA	NA	1.30
87	AVC2084	0.61	0.41	19.0	32.2	0.08	0.08	45.7	47.0	0.27
87	AVC2085	6.00	0.81	1.3	49.3	0.21	0.01	41.0	40.7	0.81
87	AVC2086	10.85	0.49	0.2	47.7	0.21	0.01	38.7	39.1	0.49
87	AVC2087	3.34	0.50	14.7	35.2	0.03	0.01	44.3	44.0	0.48
87	AVC2088	1.29	0.50	7.13	46.1	0.01	0.01	44.3	44.3	0.81
87	AVC2089	11.44	0.83	1.06	46.4	0.15	0.27	35.9	35.9	2.07
87	AVC2090	13.53	0.94	1.19	45.8	0.32	0.01	34.4	34.4	2.02
87	AVC2091	4.89	0.16	0.82	50.2	0.21	0.01	41.4	42.3	0.49

* Map numbers shown on figure 2.
** LOI- Loss on ignition includes volatiles H_2O, CO_2, etc.
*** The 100 series of sample numbers are from Rutledge and others, 1953 (19).
Numbers with AVC prefix are from current BOM studies of the VCMD (15).

and Copeland Creek limestones less attractive as potential economic sources than the Foggy Pass limestone to the north.

The West Fork Maclaren Glacier and Tsisi Creek limestones were not analyzed.

Other occurrences

Other limestone occurrences exist in the district (fig. 2, nos. 19-24). Some of these were evaluated by the Matanuska-Susitna Borough during their assessment of mineral resources within the borough (18), but they were not visited by the Bureau. Adjacent to Tsisi Creek (fig. 2, nos. 22-24), at White Hill (fig. 2, no. 19), and at Limestone Gap (fig. 2, no. 21), there are limestone deposits that "appear to be of commercial grade, and . . . likely contain in excess of 100 million tons each" (18). Limestone has been mapped along the West Fork of the Maclaren Glacier (fig. 2, map nos. 4-6), but these occurrences have not been evaluated.

"Alaska Limestone" (fig. 2, no. 87, table 1), is located just outside and north of the northern boundary of the VCMD. Alaska Limestone has been producing limestone for agricultural use from this deposit for several years. The owner reportedly mined about 4800 tons of limestone in 1988 (6), and he eventually hopes to produce cement. Five of the eight samples collected by the Bureau meet the requirements described above for the production of Portland cement; however, several of the samples contained relatively high percentages of impurities, such as silica and alumina[4].

INTRUSIVE ROCK

Intrusive rock is used as railway ballast, and is crushed for use as highway rip-rap. There are extensive outcrops of intrusive igneous rocks within the VCMD; however, only rock immediately accessible from the ARR or the Alaska highway system were considered for this report.

Granitic rock crops out along the ARR about 2 miles south of Curry (fig. 2, no. 50). This exposure was examined by Waring in 1946 (22 p. 3). The granitic rock is a quartz diorite that has intruded black slate and schist. The quartz diorite is exposed for at least one-half mile along the railroad tracks and for approximately 600 vertical ft. A siding was installed to facilitate exploitation of this deposit, and the outcrop was quarried by the ARR for use as railroad ballast for several years. The quarry was abandoned in the late 1940's due to concern about the safety of the quarrying operations and the steepness of the working face (22).

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[4]Sampling of the limestone from "Alaska Limestone" was not rigorous, and the sample results reported here are not necessarily representative of the deposit, although they give a rough indication of the quality of the limestone.

Quartz diorite also crops out along the Denali Highway, in the eastern portions of the study area. Rock there may be suitable for use as railroad ballast, rip-rap and road metal (19), but because of its distance from the highway, it has not been exploited and was not investigated by the Bureau. Use of granitic rock from this area would require further prospecting and testing of the resource.

BASALT

Basalt is used both as railway ballast and, when crushed, as rip-rap. Basalt is present in the VCMD as talus in some of the steep-walled valleys within the foothills along the Denali Highway. The talus consists of bedrock pried from cliffs during formation of formerly active rock glaciers and rubble sheets, and deposited on the slopes below.

Basaltic rubble along the south flank of the Amphitheater Mountains forms detrital blankets up to 10 ft thick, and angular basalt boulders there represent a potential source of good borrow. Permafrost is not present (12). Material ranges from about 1/2 inch up to 3 ft in diameter and generally lacks fines. Crushing would be necessary before the basalt could be used in road construction, and, because of this added expense, has not been developed.

PERLITE

Perlite is a natural volcanic glass, some of which contains from two to five percent water. On heating, this hydrous perlite expands up to ten times its original volume. Expanded perlite is valued as both an insulator and as filter material (2, 14).

Thin-section examination of several volcanic rock specimens collected from the Jurassic Talkeetna Formation near Yacko Creek (fig. 2, no. 18) by the Bureau revealed a glassy rock containing numerous "perlitic" cracks. In 1989, the location of these samples was re-visited and additional samples collected. The 1989 samples were sent to the Manville Corporation, Denver, Colorado for evaluation and testing of their suitability as commercial-grade perlite. Mr. Ric Breese, a Senior Geologist with Manville Corp, inspected the samples and determined that they contained too few cracks and too many impurities, in the form of microphenocrysts, to be of commercial grade.

Suitable industrial perlite, however, is usually found in volcanic rocks of Tertiary age (2, 3). There are volcanic rocks of that age within the central portion of the VCMD, but they were not sampled during this study.

ZEOLITE

Zeolites are formed by chemical reactions of seawater with volcanic rock extruded in the marine environment, and they are common in oceanic volcanic sedimentary rocks and as vesicle fillings in submarine basalt. Zeolites have been found to possess catalytic and absorbent properties that make them valuable in many areas of industrial and agricultural technology. Modern technologies have produced synthetic minerals that supplant zeolite in developed countries, but in undeveloped countries zeolites are cost effective, especially in agricultural applications.

Alaskan zeolites may find use in local agriculture or may be mined for export to third-world, Pacific rim countries. A market has not been developed, however.

Large, possibly world-class, zeolite (especially mordenite) deposits of commercial grade occur in the Talkeetna Formation along the southern flank of the Talkeetna Mountains (8, 9).

Within the VCMD, the headwaters regions (fig. 2, no. 17) of Oshetna River, Little Oshetna River, and Caribou Creek contain rocks of the Talkeetna Formation and have been identified as having potential for hosting additional commercial-grade zeolite deposits (10, p. 10).

SAND-AND-GRAVEL

Sand-and-gravel is required for highway construction, as aggregate in the manufacture of cement, and as foundation fill and gravel pads for building where there is permafrost. The construction and paving industries are the principal consumers of sand-and-gravel (7). It is estimated that a road built across land similar to that found in the VCMD requires approximately 40,000 yd^3 of gravel per mile (20). Due to the glacial processes that have affected most of the VCMD, sand-and-gravel deposits occur throughout the district. However, glacially-derived deposits tend to be very poorly sorted, and tend to have a significant silt content. The presence of too much silt in the gravel is considered deleterious because silt restricts drainage and the material becomes frost-susceptible.

Location of the sand-and-gravel deposit is important in determining whether or not a deposit will be exploited. In southcentral Alaska, a haulage distance of 4 miles or less has been estimated to be economically efficient during construction, but for maintenance use, haulage distances may reasonably be extended to 10 miles (12). As seen on Figure 2, material sites along the Parks Highway are reasonably close together and fairly evenly spaced.

Along the Denali Highway, however, there are fewer material sites and longer stretches exist between sites. During the summers of 1988 and 1989, DOTPF and Ahtna Native Regional Corporation (Ahtna) engaged in a joint effort to identify additional sand and gravel resources along the Denali Highway, but, as of this writing, the results of that investigation have not been released.

Summary data (Appendix A) of engineering tests of sand-and-gravel from DOTPF material sites along the Parks and Denali Highways include one or more of the following: the Los Angeles abrasion test; sieve analysis; specific gravity; frost susceptibility; plastic index; sulfate soundness; plastic limit; and the liquid limit. These tests were performed by DOTPF at their materials laboratories in Fairbanks and Anchorage. Materials definitions (table 2) and engineering test descriptions (table 3) are provided.

SUMMARY

Present within the VCMD are potential sources of argillite, limestone, intrusive rock, basalt, perlite, zeolite, and sand-and-gravel. As with virtually all industrial minerals, the cost of transportation to potential markets is of fundamental importance.

At least six limestone deposits of potentially economic size and grade are known to exist within the VCMD. Adjacent to the Parks Highway and marginal to the VCMD, a limestone deposit is currently being mined as a source of agricultural lime. There are additional limestone deposits in the central and northeastern portions of the VCMD that may become economic.

Deposits of argillite, granitic rock, and basalt of commercial grade are known to exist within the VCMD, and some of these were exploited during construction of the ARR and the Parks and Denali Highways.

A perlite occurrence near Yacko Creek was evaluated but proved not to be of commercial quality.

There is potential for commercial-grade zeolite deposits within the Talkeetna Formation. This volcanic unit hosts large zeolite (mordenite) deposits near the VCMD in the Horn Mountains of the upper Matanuska Valley. However, even if there are similar zeolite deposits within the VCMD, distance to potential markets would hinder development of the resource.

There are large deposits of glacially-derived sand-and-gravel within the VCMD, but high silt content and distance to construction sites render much of this material unsuitable. The Alaska DOTPF and Ahtna are currently jointly exploring potential sand-and-gravel resources along the Denali Highway.

TABLE 2. Materials Definitions

(Sizes as specified by the
American Society for Testing & Materials-ASTM, 20, p. 60)

Bituminous aggregate (ASTM)---Nominal gradations from 88.9 mm to 12.7mm maximum.

Concrete aggregate (ASTM)---Nominal gradations from 88.9 mm to 11.7mm.

Road metal---Broken stone or cinders used in making and repairing roads or in ballasting railroads.

Rip-rap (ASTM)---Heavy irregular rock chunks (up to 2 or 3 feet diameter), used in construction of roads, jettys and harbors.

Railroad ballast (ASTM)---Nominal gradations of crushed stone from 63.5 mm to No. 4 sieve size (4.699 mm). Used to form railway beds or substratum for new roads.

TABLE 3. Engineering Test Descriptions

The Los Angeles abrasion (LA) test determines strength and wear characteristics of material by measuring the amount of fines produced by abrasion in a revolving metal drum.

There are two important parameters in the sieve (P2) test: (1) less than 45% of the material may pass through two consecutive sieve sizes and (2) no more than 5% of the material may pass through a 200 mesh screen (screen openings of 0.074 millimeter).

The sulfate soundness (ss) test determines strength and the susceptibility of the material to frost damage due to expansion of absorbed water.

The specific gravity (s.g.) of the material should not exceed 2.5 grams per cubic centimeter.

The plastic index (PI) is a measure of the range over which a material behaves plastically (that is, the range over which the material, deforms rather than fractures).

The liquid limit (LL) is the percent moisture content at which a material behaves as a liquid, rather than as a solid.

Acceptable sand-and-gravel resources within the VCMD can be found in some types of glacial deposits and in alluvium (sand and gravel deposited in and along streams and rivers).

Glaciers have at least twice covered most of the VCMD below about 4000' elevation during the Pleistocene (18), resulting in substantial quantities of silt being introduced into most of the glacial depositional environments. Hence, much of the sand-and-gravel within the VCMD contains too much silt to be used in road construction; the fine silt particles find their way into the spaces between the larger grains, restricting drainage and resulting in moisture-laden material. As the ground freezes in winter, ice forms, causing "frost heaves" and, as the ice thaws, subsidence.

TABLE 4. Classification of Glacial Deposits

In general the glacial deposits of the VCMD can be subdivided into silty till, sandy till, rubble till, channeled till complexes, moraine complexes, kame-esker complexes, outwash deposits, pitted outwash, and channeled outwash (12).

Because of high silt content, silty till is deemed unsuitable for use in highway construction. Sandy till containing as little as 3 to 10 percent silt may contain sufficient ice to cause the material to flow, therefore, sandy till, too, frequently presents problems in highway construction.

Rubble till, a talus-like debris, usually consisting of materials derived from nearby bedrock, consists of 40 to 80 percent angular cobbles and boulders in a matrix of sand and silt (12). Above elevations of about 3500 ft, rubble till commonly contains ice and is perennially frozen. At altitudes below 3500 ft, rubble till is usually free of ice and hence, subsidence due to thawing of permafrost does not present a problem, but angular boulders up to 5 ft in diameter are difficult to handle with standard earth-moving equipment. Before it can be used for highway surfaces, rubble-till requires crushing. Since crushing represents a significant added expense, rubble-till is not a desirable source for obtaining highway aggregate.

Channeled-till complexes consist of "discontinuous channels and terraces, mantled by washed sand and gravel superimposed upon slopes and ridges of sandy till"(12). Gravel from terraces and channels may be used for subgrade in some places, but channel-till commonly contains too much coarse material than is desired for highway surfaces.

Sandy till is the dominant constituent of moraine complexes. Moraine deposits form actively at the front and along the sides of advancing glaciers, and moraine deposits are also left behind as glaciers retreat. Because of relatively high silt content, sandy till is an undesirable material for road surfaces. The silt content is commonly enough to cause frost-heaving problems, loss of strength, and flowage during the spring thaw. Borrow pits from which the upper, silt-rich layer has been stripped, however, can provide material suitable for subgrades (12).

Because they represent washed material and are generally silt-free, kame-esker complexes offer good sources of borrow. Because they also provide generally good highway foundations, much of both the Parks and Denali highways have been built directly on eskers, accounting for the sinuosity of portions of those roads

Outwash gravels are sediments deposited by meltwater streams; they are present along Clearwater Creek and in numerous other places in the VCMD. In well-drained areas, outwash provides good roadbeds and good sources of borrow. In many cases the groundwater table occurs near the surface of outwash deposits, and thereby limits the practicable depth of borrow pits.

TABLE 4 (Continued). Classification of Glacial Deposits

Pitted outwash exists in areas where outwash was deposited on top of scattered blocks of glacial ice. Melting of the ice blocks have resulted in kettle holes 10 to 100 ft deep, occasionally floored by silt or containing ponds or swamps, although, in general, pitted outwash is well-drained and therefore represents good potential for gravel borrow sites (12).

Channeled outwash occupies low-lying, marshy areas, covered by peat and silt or silty sand. Because of the high silt content, channeled outwash deposits are not good potential sources of useable borrow.

Gravelly alluvium of the streams tributary to the Chulitna, Susitna, and Maclaren Rivers are excellent sources of washed gravel, but the water table usually lies at less than 5 ft, so borrow pits are limited to that maximum depth.

Silty and sandy alluvium occupy flood plains of the larger rivers of the VCMD. These areas are usually poorly drained and mantled by peat (12, p.11). The relatively high silt content renders these deposits unattractive as borrow.

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APPENDIX A.- DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES MATERIAL SITES WITHIN THE VALDEZ CREEK MINING DISTRICT

Explanation of abbreviations

P	Poor
F	Fair
G	Good
K	Thousand

Tests

LA	Los Angeles Abrasion Test
DG	Degradation
FV	Frost Susceptibility
P-2	% Passing 200 mesh screen
SS	Sulfate soundness
SG	Specific Gravity
LL	Liquid Limit[1]
PI	Plastic Index[2]
OR	Organic Content

Water Bodies

00	None
01	River
02	Stream
03	Creek
04	Intermittent Stream
05	Lake
06	Pond
07	Bog

Site type

ACT	Active Site
INA	Inactive Site
DPL	Depleted
STK	Stockpile
HWY	Highway
STA	Maintenance Station
PRV	Private Pit

Access

00	<1 mi from road
01	Next to secondary road
02	Next to primary road

Recommended Use

MTN	Maintenance use
STA	Maintenance Station
SND	Sand Source
FTR	Future Use
TST	Further Testing
REL	Relinquish
RRP	Rip Rap
WDA	Waste Disposal Area
BOR	Borrow
AGR	Crushed Aggregate
STK	Stockpile

LL Liquid Limit --- Percent moisture content at which a soil behaves as a liquid.

PL Plastic Limit --- Percent moisture content at which a soil behaves plastically.

APPENDIX A - DOTPF MATERIAL SITES WITHIN THE VALDEZ CREEK MINING DISTRICT, ALASKA

Map No.	DOTPF No.	Meridian	Section	Township	Range	Acre	Quantity Reserve/Produced	Material Type	Access	Tests	Recommended Use	Comments
7	522029-2	Fbnks	34	20S	1E	12	NA/NA*	Terrace	02	NA	BOR:MTN	2 small pits
7A	F-029047	Fbnks							02	NA	BOR:MTN:STK	Susitna construction campsite
8	522028-2	Fbnks	10	21S	1E	19	NA/450	Sand	02	NA	BOR:MTN	Till
9	522027-2	Fbnks	14	21S	1E	5	NA/	Sand&Gravel	02	NA	BOR:MTN:AGR	Pit partially overgrown
10	522025-2	Fbnks	33	21S	2E	8	NA/NA	Borrow	02	NA	BOR:MTN:STK	Gravel quite angular
11	522024-2	Fbnks	1	22S	3E	NA	NA/NA	Borrow	02	NA	BOR:MTN:STK	Small pit
12	521035-5	Fbnks				5.2	NA/NA	Borrow	02	NA	AGR	Small pit
13	521031-5	Fbnks	16	21S	6E	2	NA/NA	Borrow	02	NA	BOR:MTN:REL	Small pit
14	521032-5	Fbnks	7,8	21S	6E	4	NA/NA	Borrow	02	NA	BOR:MTN:STK	Small pit
15	521033-5	Fbnks	18,19	21S	6E	4	NA/NA	Sand	02	NA	BOR:AGR:STK	Undeveloped, Small pit
16	521034-5	Fbnks	6	22S	5E	5	NA/NA	Terrace	02	NA	BOR:MTN:AGR	Inactive, permafrost probable
23	3535002-1	Seward	20	26N	5W	83	300K/275K	Outwash	04	LA:16%	FTR:BOR:MTN	Site boundaries in dispute
24	3535010-1,011-1	Seward	7,8	26N	5W	60	104K/27K	Silty	04	P-2=5%	TST:FTR:MTN	Small stockpile of granite boulders
25	3535012-1	Seward	29,30	27N	5W	152	NA/199K	Gravel	04	SG=2.67	STA:STK:HWY	Chulitna maintenance station
26	3535013-1	Seward	17,18	27N	5W	80	NA/NA	Gl** Outwash	04	NA	FTR	Scattered swampy areas
27	3535014-1	Seward	6	27N	5W	153	NA/000	Gl Outwash	04	NA	FTR:TST	Based on 2 hand-auger holes
28	3535015-1	Seward	17,20	28N	5W	238	225K/38K	Gl Outwash	04	LA=15%	BOR:TST:FTR	14 acres developed of sizeable area
29	3535016-1	Seward	17	28N	5W	90	NA/NA	Gl Outwash	04	NA	TST:FTR:BOR	Site straddles hwy
30	353003-1	Seward	NA	28N	5W	164	NA/NA	Outwash	04	NA	TST:FTR	Haul road would cross clay slope
31	353007-1	Seward	9,16	29N	5W	78	110K/20K	Moraine	04	P-2=2%	AGR:TST:FTR	Straddles hwy, overgrown

APPENDIX A (CONT.) - DOTPF MATERIAL SITES WITHIN THE VALDEZ CREEK MINING DISTRICT, ALASKA

Map No.	DOTPF No.	Meridian	Section	Township	Range	Acre	Quantity Reserve/Produced	Material Type	Access	Tests	Recommended Use	Comments
32	353008-1	Seward	9	29N	5W	257	90K/000	Moraine	04	P-2=5%	FTR	Straddles hwy, adjoins 353007-1
35	353009-1	Seward	4	29N	5W	196	199K/25K	Gl Outwash	04	LA=18%	TST:FTR:BOR	Now troublesome Ck trailhead
36	353010-1	Seward	33	30N	5W	290	575K/270K	Terrace	04	SS=0.5	BOR:AGR:MTN	2500yd^3 stockpiled; combined w/010A
	353010A-1	Seward	33	30N	5W							Site straddles hwy w/010-1
37	353013-1	Seward	3,4 9,10	30N	5W	215	462K/000	Fluvial	04	LA=16%	AGR:BOR:FTR	Former construction campsite
38	353014-1	Seward	3	30N	5W	51	NA/NA	Outwash	04	NA	FTR	Information from air photos
39	353016-1	Seward				19.3	250K/000	Outwash	04	P-2=3%	AGR	Byers Lake campground site
40	353017-1	Seward	20	31N	4W	7	NA/50K	Channel	04	NA	WPA	Used as waste storage site
41	353018-1	Seward	10	31N	4W	7	203/000A	Eskers	.04	NA	REL	Not tested, access difficult
42	353019-1	Seward	10	31N	4W	7	000/000	Till/Peat	04	LL=18%	FTR	Unsuitable material
43	353020-1	Seward	4,15	31N	4W	42	375K/200K	Alluvial Fan	04	P-2=5%	DPL:REL	Access is via site 353020A-1
44	353020A-1	Seward	10,11	31N	4W	5	NA/NA	No Tests		NA		Original road crossed water body
45	353021-1	Seward	2	31N	4W	6	NA/NA	Till/Peat	04	P-2=30%	FTR	Unsuitable
46	353022-1	Seward	2	31N	4W	8	000/000	Till/Peat	04	P-2=36%	FTR	Unsuitable for use
47	353049A-1	Seward	2	31N	4W				04	NA	ACC	Haul 0.35 miles
48	353049-1	Seward	2	31N	4W	83	300K/275K		04	P-2:04	FTR:BOR:AGR	Royalty payments
49	353058-1	Seward	1	31N	4W	6	226K/Undev.		04	NA	FTR:BOR:AGR	Used with 049 pit
50	353023-1	Seward				28.3	443K/000	Sand&Gravel	04	P-2:10%	AGR:BOR	
51	353024-1	Seward	17,20	32N	3W	162	Undeveloped	Untested	04	NA	FTR	Includes +30 acres of bog

APPENDIX A (CONT.) - DOTPF MATERIAL SITES WITHIN THE VALDEZ CREEK MINING DISTRICT, ALASKA

Map No.	DOTPF No.	Meridian	Section	Township	Range	Acre	Quantity Reserve/Produced	Material Type	Access	Tests	Recommended Use	Comments
52	353027,028	Seward	16,17	32N	3W	136	505K/380K	Sand&Gravel	04	DG=30%	AGR:BOR	Outwash, till, and esker
53	353029-1	Seward	9,10 15,16	32N	3W	401	170K/116K	Gravel	04	LA:18	BOR:AGR	Water table at 6-ft depth
54	353030-1	Seward	10	32N	3W	2	15K/000	Outwash	04	P-2=13%	BOR:AGR:FTR	Wet zone at 3 ft, Undeveloped
55	353031-1	Seward	10	32N	3W	9	85K/75K	Outwash	04	P-2=5%	TST	Considerable material remains
56	353032-1	Seward	10	32N	3W	83	Unkn/000	Unkn	04	NA	FTR	Site untested and undeveloped
57	353033-1	Seward	10,11	32N	3W	115	100K/60K		04	NA	FTR:BOR	Sizeable quantity material remains
58	353034-1	Seward	1	32N	3W	144	405K/50K	Terrace	04	P-2=3%	FTR:BOR:AGR	Pit 1.2 acres, 25 ft deep
59	353035-1	Seward	29-32	33N	2W	249	470K/290K	Gravel	04	LA=21%	FTR:BOR:AGR	Crusher on site
60	354001-1	Fbnks		22S	2W	6	5K/5K	Sand&Gravel				Pit mostly worked out
61	354025-2	Fbnks	27	22S	2W	43	NA/AN	Sand&Gravel	04	NA	BOR:AGR:MTN	Good material on left side of pit
62	354048-2	Fbnks	12,13	22S	11W	358	NA/NA		None	NA	ZZZ	Undeveloped, difficult access
63	354047-2	Fbnks	36	21S	11W	63	NA/NA	Terrace	04	NA	AGR:BOR:MTN	Is part of 354017-2
64	354046-2	Fbnks	30,31	21S	10W	501	NA/NA	Sandy Gravel	04	P-2=3%	AGR	Includes pits 354018-2, 019-2
70	354045-2	Fbnks	8,9 16,17	21S	10W	238	NA/NA	Outwash	04	NA	NA	May be better mat'l to east, high amt. of fines
71	354044-2	Fbnks	9	21S	10W	51	NA/NA		04	NA	NA	Undeveloped
72	354043-2	Fbnks	4,9	21S	10W	68	NA/NA	Terrace	04	NA	NA	Undeveloped
73	354020-2	Fbnks	9	21S	10W	10	NA/8.9K	Terrace	04	P-2to36%	NA	Undeveloped
74	354021-2	Fbnks	3,4	21S	10W	12	NA/100K	Terrace	04	LA=23%	BOR:AGR:MTN	3 small pits within this pit

APPENDIX A (CONT.) - DOTPF MATERIAL SITES WITHIN THE VALDEZ CREEK MINING DISTRICT, ALASKA

Map No.	DOTPF No.	Meridian	Section	Township	Range	Acre	Quantity Reserve/Produced	Material Type	Access	Tests	Recommended Use	Comments
75	354042-2	Fbnks	3,4 9,10	21S	10W	10		Sandy Gravel	04	LA=18%	BOR:AGR:MTN	Undeveloped
76	354041-2	Fbnks	3	21S	10W	257	NA/NA	Terrace	04	NA	NA	Undeveloped
77	354040-2	Fbnks	34	20S	10W	138	NA/4K	Terrace	04	NA	NA	Undeveloped
78	354029,39-2	Fbnks	26,35	20S	10W	165	NA/NA	Terrace	04	NA	NA	Contains State campground
79	354038-2	Fbnks	23-26	20S	10W	198	NA/1.5K	Terrace	04	LA=26%	BOR:AGR:MTN	Stockpile of +150 yd^3
80	354030-2	Fbnks	5	20S	9W	3	NA/NA	Terrace	04	P-2=22%	BOR:STK:MTN	Pit is nearly depleted
81	354031-2	Fbnks	5	20S	9W	10	NA/NA	Terrace	04	P-2=5%	BOR:STK:MTN	Pit is nearly depleted
82	354032-2	Fbnks	22	19S	9W	27	NA/0.8K	Sandy Gravel	04	P-2=3%	BOR	Good material spotty
83	354024-2	Fbnks	11	19S	9W	2	000/000	Sandy Silt	04	P-2=50%	NA	Unsuitable for use
84	354028-1	Fbnks	3	18S	8W	4	000/000	Silty Sand	04	NA	NA	Unsuitable for use

* NA = Information not available
** Gl = Glacial