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MATERIAL STUDIES ALONG KUSKOKWIM RIVER, MCGRATH TO KALSKAG, SOUTHWEST ALASKA

By

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CONTENTS

CONTENTS (con.)

CONTENTS (con.)

CONTENTS (con.)

FIGURES

CONTENTS (con.)

CONTENTS (con.)

TABLES

EXECUTIVE SUMMARY

During July 9-22, 1987, and September 17-20, 1988, the Alaska Division of Geological and Geophysical Surveys conducted a reconnaissance survey of riprap, armor stone and crushed aggregate resources along the Kuskokwim River from Stewart Bend above McGrath to Upper Kalskag on the proximal edge of the Yukon-Kuskokwim Delta, a river distance of approximately 500 mi (fig. 1). The principal objectives of these studies was to provide geologic information concerning the location and possible extraction of riprap and crushed aggregate mainly for local community needs.

Bank erosion problems and seasonal flooding have plagued a number of communities along the Kuskokwim River. Bank erosion accelerated by permafrost degradation is causing significant property loss at Bethel. Normal channel migration is eroding silt banks at Aniak and McGrath, resulting in property damage as well as road relocation projects. Upper and Lower Kalskag need sources for crushed aggregate for construction of roads, airports and building foundations. Local rock sources for these projects could result in considerable savings for proposed construction and erosion control projects, because of high costs of transporting associated with heavy rock and aggregate.

Thirty-nine rock sites were examined and described in this study, the results of which are summarized here.

Several limestone outcrops and bluffs upstream from McGrath hold potential for supplying riprap for local erosion-control needs. Favorable physical properties including shape, T-13 Degradation tests, and fragment size indicate that sites 87MDT4, 87MDT5, 87MDT7, and 87MDT8 near Stewart Bend could qualify as Class I or II (state DOTPF classification) riprap.

Igneous rocks and hornfels in the Roundabout Mountain and Candle Creek area west of Candle Landing (sites 87MDT9 and 7BT379) may also be suitable as sources for riprap. Some naturally fractured surface materials will probably pass Class II, III, and IV state riprap requirements; however, intrusive rocks on Roundabout Mountain and near Candle Creek (87MDT11; 78BT379) were found to be generally unsuitable by recent private company drill results because intensive groundwater effects have weathered the intrusive rock into grüss to considerable depth.

Fragment size of most sandstone-siltstone outcrops examined in the study area were found to be marginal or unsuitable for riprap applications. However, several sites with abundant massive sandstone layers contain Class-I-sized and some limited amounts of Class-II-sized riprap and deserve additional evaluation if local needs arise. They include: (1) 88MDT14, near Stoney village; (2) 87MDT18, about 10 mi downstream from Sleetmute; and (3) 87MDT31, on flank of southeast Russian Mountains. However, Alaska T-13 Degradation values for all of these sites were found to be below the minimum required for most Alaska riprap applications.

Igneous dikes and sills intruding the Kuskokwim and Gemuk Groups hold the most promising but limited resources of Class I-III riprap in the Crooked

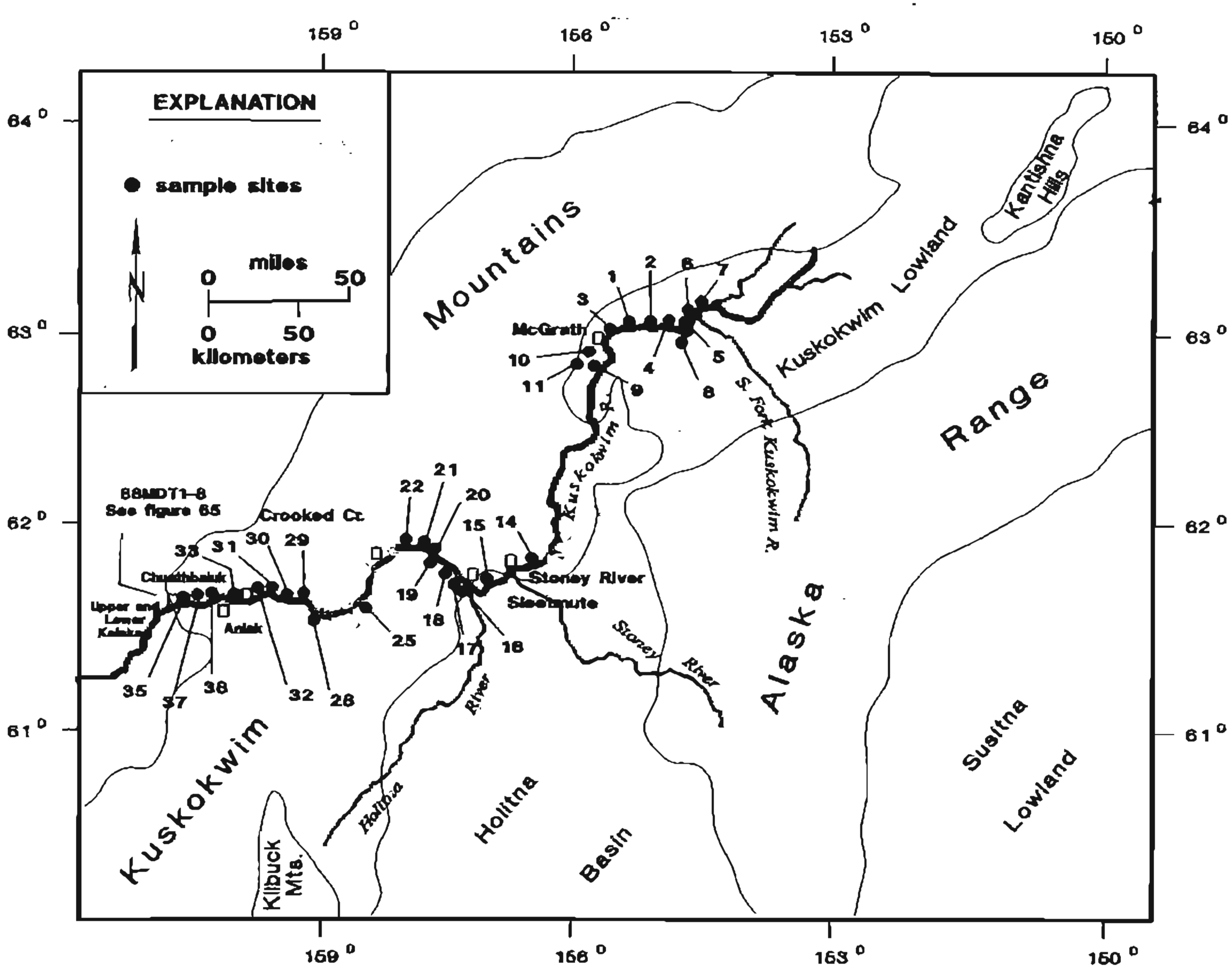

Figure 1. Location map showing geographic regions, study area, and locations of sample sites.

Creek, Aniak, and Kalskag areas. The following locations exhibit favorable shape, gradation, size of eroded clasts, and density properties: (1) 87MDT21 Lower Georgetown site above village of Crooked Creek; (2) 87MDT25 "Rhyolite Hill" site below Crooked Creek; (3) 87MDT33, near Chuathbaluk; and (4) 87MDT35, 36, 37, and 38--all sites midway between Aniak and Upper Kalskag. The first three sample sites failed to pass T-13 degradation testing. However, all of the sites below Aniak but 87MDT37 passed Alaska T-13 Degradation tests. Most sites are limited by steep bluffs with significant overburden and narrow beaches. These locations could require expensive drilling and bench mining or quarrying methods, which would add to extraction costs.

Quartz-monzonite intrusive rock on the southern limit of the Russian Mountains (site 87MDT124) probably contains the largest volume of riprap in the Aniak area. Shallow surface reserves include several million cubic yards of blocky material that qualify as Class II, III, and even IV riprap. Suitable size, gradation, specific gravity, and shape properties exist; and the site yielded the highest Alaska T-13 Degradation value (85) of any samples analyzed in the study. The site could be accessed from Chuathbaluk about 3 mi south of the site. However, because monzonite intrusive rock regionally has experienced intensive groundwater weathering, subsurface testing is recommended.

Crushed aggregate potential was assessed on Portage Mountain immediately north of Upper Kalskag village. All four bedrock sites examined contained acceptable degradation, absorption, moisture, and specific gravity properties and would probably be suitable for crushing and use in road or foundation construction. Sample site 88MDT8, which has been suggested by Turley (1987) as a preferred excavation site, also passed minimum degradation standards.

The results and conclusions reached during this investigation are limited by lack of subsurface investigations and reconnaissance laboratory testing. Additionally, land ownership configurations for the sample site areas have not been rigorously analyzed. Hence, we emphasize that no specific sites are being recommended for development.

ACKNOWLEDGMENTS

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ANTICIPATED MATERIAL SOURCE NEEDS IN STUDY AREA

Bank erosion problems and seasonal flooding have plagued a number of communities along Kuskokwim River, including McGrath, Red Devil, Aniak, and Bethel (fig. 1). At Bethel river erosion is occurring because of permafrost degradation, wind and wave action, and channel (thalweg) shifts (Lanning, 1986). At Bethel and throughout the Yukon-Kuskokwim Delta, thermoniching, or thermal erosion of a permafrost bank at or below water level, has caused large sections of bank material to cave into the river. Thermoniching, which occurs because of heat transfer from the river into the frozen banks, is predominantly a summer erosion process as opposed to a spring breakup phenomenon. Because of severe bank erosion problems, a 6,950 ft long steel piling bulkhead was constructed and backfilled with sand and gravel derived from sources near Kalskag. After the bulkhead was completed in 1984-85, more thermoniching eroded the lower end of the erosion-control project. The bulkheads have since been extended and riprap was placed on the river bottom to stabilize the channel. However, if the main channel continues to migrate, the bulkheads and bank remain in jeopardy. Heavy riprap has been suggested as an alternative to the gravel-sand-based sheet-piling bulkheads currently in place.

At McGrath (fig. 1) the west bank of Kuskokwim River is eroding at an average rate of 5 ft annually (McDonald, 1986). Bank erosion has caused the city of McGrath to relocate Takotna Avenue between H & I Streets. Even the new alignment of Takotna Avenue is projected to be in jeopardy in the mid-1990s due to progressive erosion of the river bank. If a prominent meander below McGrath is breached, then bank erosion could accelerate even further. McDonald (1986) estimated that if a local quarry site could supply riprap armor (as opposed to cast-in-place, articulated-concrete-block construction), a savings of $2 million could be realized. If bank erosion continues, total economic losses for McGrath, which include losses in utilities, property, and revenue, are projected at $15.8 million.

The city of Aniak (fig. 1) continued to have bank erosion problems related to spring flooding and migration of the thalweg and active channel of Kuskokwim River. A silt dike constructed on the river's south bank by the U.S. Army Corps of Engineers in the early 1980s began to fail in the spring of 1987 and partially caved into the river. An estimated 200 yd of beach is threatened. Some mitigation measures, including benching and gravel emplacement, were completed in 1988. Emplacement of large Class III and Class IV riprap is a preferred solution for the bank-erosion-control problem. Preliminary cost estimates for the project range from $875,000 to several million dollars, depending on distance to the riprap source. Fully 75 percent of projected costs would be for transport and delivery of basalt riprap from either St. George in the Pribilof Islands or sites along the Alaska Peninsula. A high-quality, local riprap source could result in a considerable savings for the proposed project.

Other villages along the river require protection flow bank erosion or rock for road, airport, and building construction. Upper and Lower Kalskag villages are searching for an aggregate source to construct a road network, upgrade airport facilities, and other needs in their area (fig. 1). The U.S.

Army Corps of Engineers have initially denied these villages permits to mine floodplain and river-channel gravels due to environmental and engineering problems (Joyce and others, 1980; Woodward Clyde Consultants, 1980). The village is searching for upland aggregate sources to satisfy these needs.

Red Devil, Sleetmute, and Crooked Creek are periodically flooded due to ice jamming during spring-breakup conditions. During these events, channel migration has rasulted in bank erosion and subbase damage to artificial structures, although concern for protection is not as acute as for McGrath, Aniak, and Bethel.

PREVIOUS MATERIALS STUDY INVESTIGATIONS

Most material-site studies in the study area have been for the exploration and development of sand-and-gravel resources. Primary uses of these materials have been for airport, road, public building, and erosion-control projects. Most sand-and-gravel usage is not accurately documented. File data from Alaska Department of Transportation and Public Facility (DOTPF) projects or from permit stipulations from the U.S. Army Corps of Engineers (Corps) provide some estimates of materials use in the study area. From 1978-87, the Corps issued 22 permits for extraction of 1,406,800 yd^3 of material, mainly from the Kuskokwim River channel near Birch Tree Crossing and McGrath (Talbot, 1987). Bundtzen and others (1986) reported that approximately 270,000 yd^3 were extracted in southwest Alaska from 1982 to 1985.

Studies of material sites have been limited to those by DOTPF, State of Alaska DNR, private and U.S. Bureau of Indian Affairs investigations. Moore and Homenway (1973) drilled 60 shallow holes in the McGrath area searching for borrow and foundation materials near McGrath. These investigations also briefly searched upland areas for crushed aggregate sources. They could not locate a gravel deposit suitable for crushing near McGrath but determined that suitable gravel resources exist 25 mi up the Takotna River. They also located a crushed aggregate source 2 mi from Candle Landing on the Candle-Ophir road. Kline and Bundtzen (1985) drilled 12 auger holes along the Kuskokwim River near McGrath and found pea gravels at 15 to 25 ft depths in several point-bar deposits. Recently McDonald (1986) searched for riprap sources near McGrath to be used to control bank erosion. Acomb (1988a,b) completed the search for a rock quarry site and suggested a limestone locality 10 mi east of McGrath for development. Similar studies were recently completed near Nome (Perdichizzi, 1983), and Brevig Mission (Ottley and Pavey, 1980).

Using air photographic techniques, Krause (1984) mapped surficial-geologic units from Sleetmute to Kalskag and outlined potential sand and gravel resources in floodplain areas. Turley (1987) has investigated possible sources of sand and gravel and crushed aggregate in the Kalskag area and made recommendations for aggregate development at one site 2 mi north of Upper Kalskag.

FIELD METHODS AND DEFINITIONS

During three weeks in June and July, 1987 and two days of September, 1988, the authors examined 39 rock sample sites along 470 mi of the Kuskokwim River from Stewart Bend above McGrath to Kalskag. Two inflatable Zodiac boats powered by 25 h.p. motors were the principal means of transportation used to study and collect samples. Sites were described and referenced to nearby villages, geographic features, Vertical Angle Bench Survey Marks (VABM), and the mouths of major rivers. In all, 1,193 lb of rock samples (sample average = 54 lb) were collected and submitted to DOTPF Laboratory facilities in Anchorage, and to Alaska Test Labs, Inc. in Fairbanks. Incidental to the riprap crushed aggregate investigation, samples of sand and gravel were collected from six sites along the river. Field data from these sites is on file at DGGS offices in Fairbanks.

Most rock-sample sites were investigated for riprap potential. Those near Kalskag were also analyzed for crushed-aggregate potential. Geologic sketches of 21 to 39 rock-quarry sites were constructed using standard Bruton and tape traverses. Petrographic samples taken at each site were examined under the microscope with transmitted light using methods summarized by Moorhouse (1959). Individual site narratives follow standard material specifications used by the U.S. Army Corps of Engineers and Alaska DOTPF (Hickey, 1988; Perdichizzi, 1983; Staff, 1980). Gravel samples were described according to classifications summarized by Pettijohn (1957).

The following definitions are derived from 1988 ASTM and Alaska DOTPF specifications (Staff, 1988a,b; Hickey, 1988).

Quarried Riprap - Riprap is defined as "a layer, facing or protective mound of stones randomly placed to prevent marine or river erosion of shoreline embankments, harbors, channels, or other structures impacted by water degradation activities". Riprap is a common choice of bank-erosion-control projects along rivers because it can adjust and compact, can be easily repaired, and is often the most economical--especially if a local source can be found. The State of Alaska subdivides riprap into four major material classes[1]:

Class I - No more than 10 percent of the stone shall weigh more than 50 lb per piece and no more than 50 percent of the stones shall weigh less than 25 lb per piece.

Class II - No more than 10 percent of the stone shall weigh more than 400 lb per piece and no more than 15 percent of the stones shall weigh less than 25 lb per piece. The stones should have even gradation and an minimum of 50 percent of the stones should weight 200 lb or more per piece.

[1]Riprap specifications summarized here do not conform to those used by McDonald (1986) and Acomb (1988a,b) during their assessment of quarry sites near McGrath.

Class III - No more than 10 percent of the stones shall weigh more than 1,400 lb per piece and no more than 15 percent of the stones shall weigh less than 25 lb per piece. Even gradation is required and at least 50 percent of the stones should weigh 700 lb or more per piece.

Class IV - No more than 10 percent of the stones shall weigh more than 5,400 lb per piece and no more than 15 percent of the stones shall weigh less than 400 lb. Even gradation is required with at least 50 percent of the stones weighing more than 2,000 lb.

Stone size - The required stone size depends on existing hydraulic conditions at the project site. For example, McDonald (1986), determined minimum dimensions for erosion-control applications at McGrath capable of withstanding flood and ice impact effects. He concluded D50 or 4-in. diam Class I riprap at 2.65 specific gravity were sufficient to protect and prevent erosion. Minimum requirements for proposed erosion control efforts at Aniak were shown to be 12- to 14-in. diam (Class III) "compaction" riprap by preliminary Peratrovich Nottingham and Drage studies (Brent Drage, oral. commun., 1987).

Gradation - Riprap or armor design requires a systematic grading of stone size for interfitting and interlocking of material into an erosion-control structure. Generally this means 50 percent of the stones are larger and 50 percent of the material would be smaller than the preferred average. However, a wide range of gradation is permitted. Stone-layer thicknesses should not be less than the diameter of the largest material so that protrusions exposed to high velocity currents can be avoided. As an example of a design presented by McDonald (1986) for the McGrath project, 20 percent of the stone weight would be finer than 1/2 D50 and the minimum allowable size would be .20 x D50. For the maximum size, 20 percent would be twice the D50 size.

Shape - Riprap application generally require rocks with angular, equant shapes. State DOTPF specifications require that no rocks should have a length greater than three times its least dimension. Additionally, no more than 25 percent of the rock would have a length of twice the width or thickness.

Quality - Degradation, absorption, abrasion, moisture, and specific gravity all bear on the design and assured performance of proposed erosion-control or construction projects. These properties are precisely determined in the laboratory and can only be approximately estimated in the field.

Crushed aggregate - Material crushed from a rock or gravel source for use in road, foundation, airport or other artificial construction activities. Suitability for design of project depends on a variety of properties, including specific gravity, degradation, absorption, and locally abrasion.

Alaska Test Method (T-13) Degradation Value - This procedure determines the susceptibility of an aggregate to degradation during agitation in water, and is the most widely used test for riprap applications. Numerically assigned values range from 0 (lowest) to 100 (highest); state of Alaska DOTPF projects recommend a minimum value of 45 for riprap application.

Surface saturated dry specific gravity - The ratio of the density of a substance to the density of pure water (62 lbs/ft^3) when measured in air. For example, a cubic yard of material with specific gravity of 2.74 (88MDT3, this study) would weigh (62.1 by 2.74 by 27) 4,594 lb or 2.3 short tons.

Moisture content after crushing - Moisture content of material after careful weighing and application of oven heat in the laboratory. The test is used to evaluate moisture content in fractures and joints.

Los Angeles Abrasion (Grade B) - A measure of degradation of mineral aggregates and riprap resulting from a combination of actions including abrasion or attrition, impact, and crushing in a rotating steel drum containing a specified number of steel spheres. As the drum rotates, the spheres create an impact-crushing effect. After a prescribed number of revolutions during a specific time interval, the sample residue is sieved, measured, and measured as a percentage loss.

Absorption value - Is used to calculate the change in weight of an aggregate due to water absorbed in the pore spaces within constituent particles, compared to dry conditions. The sample is in contact with water long enough to satisfy absorption potential. High absorption values suggest that freeze-thaw activities can disrupt riprap and coarse aggregate.

GEOLOGY AND GEOGRAPHY OF THE STUDY AREA

Layered bedrock units within the study area range in age from Ordovician to late Tertiary (fig. 1). These consist of Paleozoic limestone and shale mainly upstream from McGrath (Patton, 1980), Triassic, Jurassic, and Early Cretaceous volcanic flows, tuffs, and chert near Aniak and Kalskag (Bundtzen and Gilbert, 1983), and Late Cretaceous, turbidite-dominated, sandstones, siltstone, and shale of the Kuskokwim Group (Cady and others, 1955) throughout the study area. More than 75 percent of the bedrock outcrops underlying the study area consist of rock types typical of the Cretaceous Kuskokwim Group, a turbidite dominated sedimentary rock section. Intruding and overlying older layered-rock sections are Late Cretaceous to Early Tertiary andesitic, volcanic-flow units, monzonitic intrusive rocks, and rhyolite sills and dikes. Most of these elliptically shaped complexes in the Kuskokwim region are not close to the Kuskokwim River, but two were mapped and sampled during our investigations--the Roundabout Mountain complex near McGrath and the Russian Mountains complex north of Chuathbaluk.

The youngest bedrock units consist of Late Tertiary to Quaternary volcanic rocks exposed northeast of Aniak.

Quaternary geologic units are dominated by those formed by eolian (wind) and fluvial (river) processes. Most of the Kuskokwim Basin under study was not glaciated; however, upland areas 2,200 to 4,200 ft in altitude, such as the Beaver, Horn, and Russian Mountains, have been occupied by up to four glacial episodes. Outwash from the Russian and Horn Mountains form large outwash fans that reach Kuskokwim River south of the Horn and Russian Mountains.

Fluvial deposits dominate in the study traverse and consist of several genetic types: 1) channel gravels and sands deposited from river-channel erosion including bar accretionary units; 2) overbank deposits formed during flood stages; 3) flood-basin deposits formed during extensive Spring overbank flooding (included here are slackwater and flood-channel deposits); and 4) terrace deposits formed during the evolution of Kuskokwim River.

Active floodplain deposits consist primarily of moderately to well-stratified bar-accretionary units of sand, fine cobble or pebble gravels, and silt. The character of the deposits changes significantly from the upper to lower reaches of Kuskokwim River within the study traverse. In the upper Kuskokwim region, floodplain deposits are dominated by silt, fine sand, and rarely pebbles deposited adjacent to thalwegs of modern and ancient stream channels. Beginning at the confluence of Tatalawiksuk and Kuskokwim Rivers, some 120 mi downstream from McGrath, channel lag and floodplain deposits become notably coarser as a result of increased gradient and resulting higher energy environments. Hence, pebble sands and gravel are common in cutbanks from Tatalawiksuk River to Kalskag.

The Kuskokwim River flows through and adjacent to the Kuskokwim Mountains, a mature upland composed of rounded accordant ridgelines separated by broad alluvial valleys. Most of the study area is below timberline, and vegetation covered most of the sites that we investigated. Bedrock cuts along the river provide most of the best material site exposures in the region. Originating in glacial sources of the Alaska Range, Kuskokwim River carries a heavy sediment load. During flooding, extensive deposits of silt and fine sand blanket the river banks and adjacent terraces.

SITE 87MDT1: 'WHITWORTH LIMESTONE' LOCALITY, MCGRATH D-5 QUADRANGLE

Location

This locality is the first limestone outcrop on the river 8 mi upstream from McGrath at NE¼, NE¼, Sec. 10, T33N, R33W, McGrath D-5 Quadrangle near a homesite owned by Marcia Whitworth of McGrath (fig. 2). The limestone occurs in rubble along the beach and against a vegetated bluff about 150 ft high. No exposures of bedrock were observed or encountered in test pits (figs. 3 and 4).

Geologic Description

Rubble consists of medium to dark gray, strongly effervescent, distinctly laminated, locally tan or bleached, rhombehedrally veined grainstone with iron-stained boundstone layers centimeters to meters thick. In thin section nearly 96 percent of the groundmass was found to be calcium carbonate with 3 to 4 percent quartz and graphite. The age is probably Devonian on the basis of correlation of similar outcrops described by Patton and others (1980) in the Medfra Quadrangle.

Structure, Physical Properties and Volume Estimate

The laminated limestone breaks parallel to bedding into slabs 1 to 6 in. thick. Slabs vary greatly in dimension from 1 to 35 in. long, from 2 to 6 in. thick, and 2 to 80 in. wide. Over half the material is estimated to be 6 by 8 by 12 in. Beach rubble indicates the zone is about 425 ft long, 375 ft of which includes coarse material. In terms of size, some of the material could pass DOTPF Class I riprap specifications, but because no coherent bedrock was found in place, quarry potential would need to be determined by subsurface investigations. A 45 lb sample submitted to the DOTPF Anchorage materials lab yielded a T-13 Degradation value of 47, which exceeds slightly minimum DOTPF standards recommended for riprap.

SITE 87MDT4: LIMESTONE BLUFF, LOWER STEWART BEND, McGRATH D-5 QUADRANGLE

Location

A steep bluff of limestone occurs on the lower end of Stewart Bend (SW¼, SE¼, Sec. 11, T33N, R32W, F.M.), about 25 mi upriver from McGrath (fig. 3). An 80-ft-high bluff exposes a layered section of limestone and talus screen (fig. 5).

Geologic Description

The massive cliff exposes competent, dark gray, fossiliferous, highly effervescent, medium-grained grainstone, mainly of bioclastic origin. In thin section, the grainstone is composed of interlayered grains of calcium carbonate (86 percent), quartzose sand (4 percent), and undetermined carbonaceous shale (10 percent). Some textures locally include concretions ranging from 0.1 to 1 in. diam probably indicating reprecipitation after deposition. Locally masses and lenses are rich in brachipods, coral

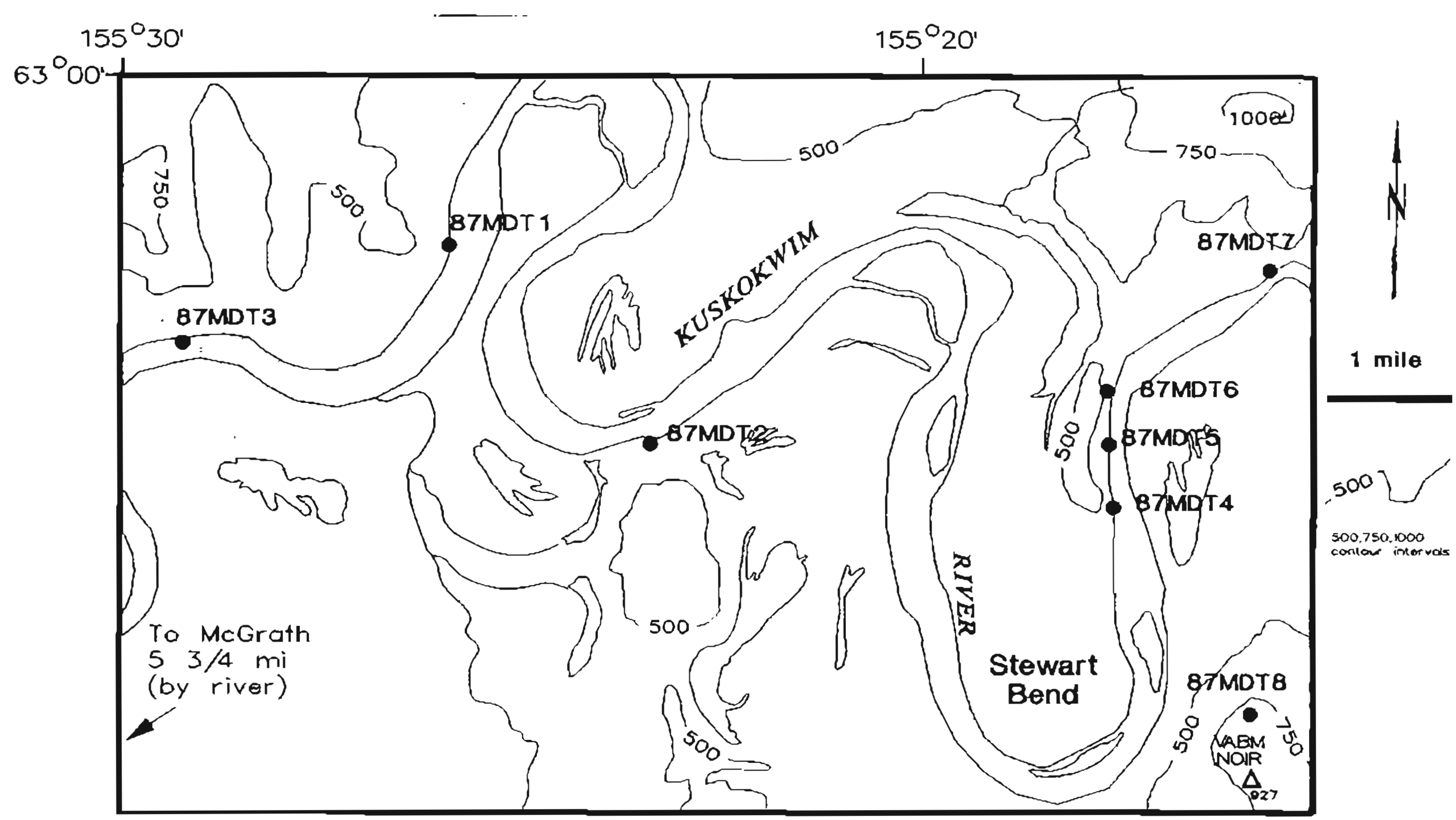

Figure 2. Location of riprap sampling sites on Kuskokwim River above McGrath.

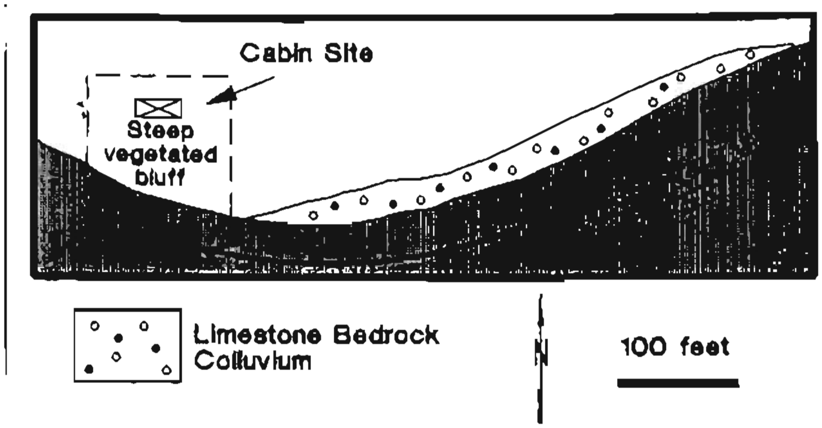

Figure 3. Field sketch of "Whitworth" limestone rubble area (site 87MDT1), McGrath D-5 Quadrangle, Alaska.

Figure 4. Photograph showing extent and physical properties of limestone rubble at sample site 87MDT1.

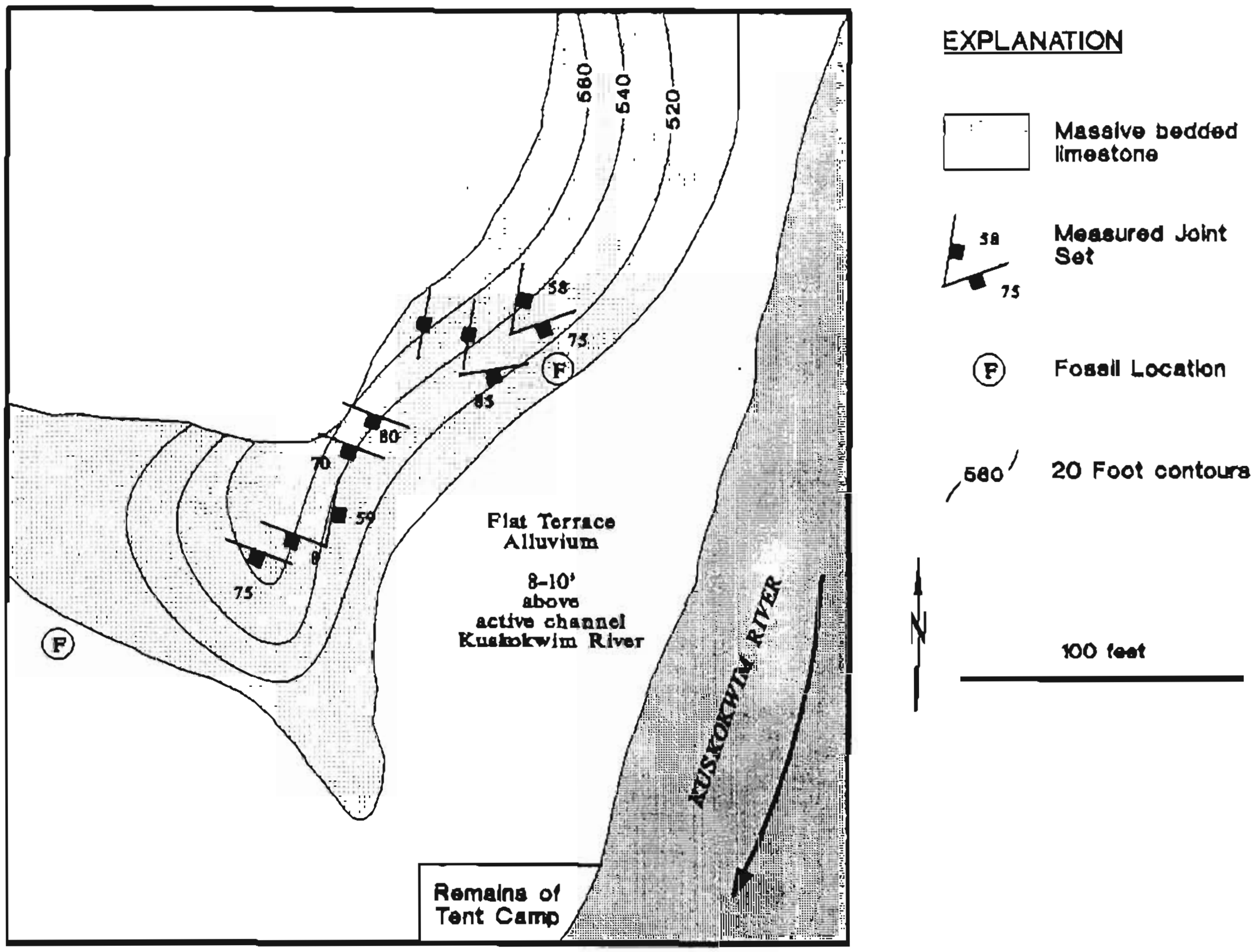

Figure 5. Geologic sketch of limestone bluff, lower Stewart Bend site (87MDT4), McGrath D-5 Quadrangle, Alaska.

fragments, and bryozoan hash of probable Devonian age (Patton and others, 1980).

Structure, Physical Properties, and Volume Estimate

The material breaks up into talus averaging 12 by 6 by 10 in., some blocks with dimensions of 36 by 25 by 35 in. were observed along the base of the cliff face (fig. 6). Smallest fragments average 2 by 2 by 3 in. in size. In terms of size (hardness adequate), at least 75 percent of the material may qualify as Class I riprap with a smaller percentage passing Class II standards. A 55 lb sample yielded a T-13 Degradation value of 42--near the minimum recommended by Alaska DOTPF for riprap (table 1). Rock measurements along the exposed cliff (150 by 427 by 35 ft) indicate a minimum of 100,000 yd^3 of material is available for easy excavation if needed. Volumes would increase substantially if excavation continued into the cliff; however, exploitation of those resources would require several bench levels and removal of extensive overburden. The 150-ft-wide terrace adjacent to the active floodplain could provide an adequate staging area for development. Acomb (1988a) also conducted quarry site studies at site 87MDT4 on the bluff above our sample site. He conducted a seismic velocity studies and a limited drilling program and reported fragments greater than 3 in. in diam dominating the drill core from 16 to 50 ft in depth.

SITE 87MDT5: MIDDLE STEWART BEND LIMESTONE BLUFF, McGRATH D-5 QUADRANGLE

Location

An interlayed rock section consisting of limestone and sandstone is exposed along the beach of Kuskokwim River (NW¼, SE¼, Sec. 11, T33N, R32W, F.M.) about 1/2 mi upstream from site 87MDT4 (fig. 7).

Geologic Description

The sample area at 87MDT5 is a continuation of the geologic section exposed at site 87MDT4. Outcrops are composed of dark gray, well-bedded, dark gray, very fossiliferous medium- to coarse-grained grainstone. Debris beds up to 3 ft thick contain fossil hash rich in dendrostelloid corals and minor bryozoans. Individual sedimentary beds range from 8 in. to 3 ft thick (fig. 8). Conspicuous bedding at sample site 87MDT5 contrasts with the more massive appearance of material at site 87MDT4. Scour-and-fill features in the limestone indicate outcrops are not overturned.

Structure, Physical Properties, and Volume Estimate

Joints occur in a conjugate set of N10°W vertical and N70°W 80°NE. Joint spacings range from 12 in. to 40 in. and average 18 in. in most of the exposures. Rubble on the beach averages 8 by 10 by 12 in., similar to the Lower Stewart Bend site (87MDT4). Bedding strikes N23-27°E and dips 33-40°NW. In terms of size, at least 50 percent of the material would qualify as Class I riprap--especially the more massive upper end of the section. Many clasts at the lower end have excessive length to width ratios.

A minimum volume estimate of material at the site (140 by 45 by 100 ft) is about 25,000 yd³ of Class I and some Class II riprap. Evaluation of possible additional resources would require excavation and subsurface exploration. A 60 lb sample yielded a T-13 Degradation value of 39, lower than the minimum (45) recommended by DOTPF for riprap applications.

SITE 87MDT6: UPPER STEWART BEND SANDSTONE-SILTSTONE SITE, MCGRATH D-5 QUADRANGLE

Location

Outcrops of sandstone and siltstone occur 1/3 mile north of site 87MDT5 (NW¼, NE¼, Sec. 11, T33N, R32W, F.M.) along the east side of the Kuskokwim River.

Figure 6. Photograph of limestone bluff at sample site 87MDT4.

Table 1. Summary of Alaska T-13 Degradation values and size classification estimates of rock samples, Kuskokwim River, McGrath to Kalskag, Alaska.[1]

Sample number	Location	Sample weight lb	Rock description	Degradation value	Remarks[2]
87MDT1	NE¼, NE¼, Sec. 10, T33N, R33W, McGrath D-5 Quad.	45	Limestone--variation, laminated grainstone with interbedded boundstone.	47	Poorly exposed in beach-head; no resource estimates available.
87MDT4	SW¼, SE¼, Sec. 11, T33N, R32W, on Stewart Bend, McGrath D-5 Quad.	55	Limestone--variation, highly fossiferous, bioclastic grainstone.	42	Class I and II riprap available; minimum 100,000 yd^3 reserve.
87MDT5	NW¼, SE¼, Sec. 11, T33N, R32W, on Stewart Bend, McGrath D-5 Quadrangle	60	Limestone--variation, massive to laminated grainstone.	39	Class I and II riprap available; minimum 25,000 yd^3 reserve.
87MDT7	NW¼, NE¼, Sec. 11, T33N, R32W, on Stewart Bend, McGrath D-5 Quadrangle	60	Limestone--variation, micritic bound.	45	75% Class I riprap, remainder is mixture of Class II and III riprap; minimum 5,000 yd^3 reserve.
87MDT10	SE¼, SW¼, Sec. 32, T33N, R33W; near VABM About, McGrath D-6 Quadrangle	30	Massive, porphyro-blastic hornfels	48	Potentially large resources of Class I riprap.
87MDT17	NE¼, SW¼, Sec. 25, T18N, R44W, near Sleetmute in Sleetmute C-3 Quadrangle	40	Quartz porphyry sill instrusive into sand-stone	16	80% judged below Class I riprap quality; 21,000 yd reserve.
87MDT18	NE¼, SE¼, Sec. 14, T20N, R45W, near Eight Mile Village, Sleetmute Quad.	47	Coarse grained, massive lithic sandstone	13	Class I riprap sizes available; estimated 13,000 yd^3 reserve.

Table 1. (Continued)

Sample number	Location	Sample weight lb	Rock description	Degradation value	Remarks[2]
78BT379a[3]	SW¼, SE¼, Sec. 16, T32N, R36W, F.M., Sugarloaf Mountain	55	Olivine pyroxene monzonite	58	Class I and II riprap sizes available, perhaps 20,000 yd^3.
78BT379b[3]	SW¼, SE¼, Sec. 16, T32N, R36W, F.M., Sugarloaf Mountain	40	Thermally altered basalt	62	Class I riprap with some II available, large resource.
87MDT21	SE¼, Sec. 27, T21N, R47W, near Georgetown, Sleetmute Quadrangle	35	Porphyro-aphanitic quartz porphyritic-rhyoite dikes	28	About 70% Class I riprap sizes; minimum 50,000 yd^3 reserve.
87MDT25	SE¼, NW¼, Sec. 24, T18N, R49W, 8 mi from Oskawalik, Sleetmute Quadrangle.	55	Porphyro-aphanitic quartz porphyry intrusion	21	Riprap quality data not determined; potential large resource needs subsurface work.
87MDT30	NW¼, NW¼, Sec. 13, T17N, R52W, near Kolmokof village, Sleetmute Quad.	25	Coarse grained, bedded lithic sandstone	44	No riprap sizes recognized; large (>185,000 yd^3) resource.
87MDT33	NW¼, SE¼, Sec. 12, T11N, R55W, near Chuathaluk Village, Russian Mission C-1 Quadrangle	65	Olivine-pyroxene basalt	10	Large blocky material with Class I and II riprap sizes; minimum 13,000 yd reserve.
87MDT35	SW¼, NE¼, Sec. 16, T17N, R60W, at VABM Spruce, 12 mi upriver from Kalskag, Russian Mission Quad.	70	Fine grained, hornblende, pyroxene andesite sill	75	Dominantly Class I riprap with Class II material available; minimum 70,000 yd^3 reserve.

Table 1. (Continued)

Sample number	Location	Sample weight lb	Rock description	Degradation value	Remarks[2]
87MDT36	SE¼, NE¼, Sec. 10, T17N, R60W, near VABM Spruce, Russian Mission Quad.	40	Massive to heavily jointed, pyroclastic andesite intrusive sill.	50	Limited quarry volume (3,000 yd^3) of Class I and II riprap.
87MDT37	NE¼, NW¼, Sec. 7, T17N, R58W, 4 mi downstream from Crow Village site, Russian Mission Quad.	65	Massive to layered, crystal tuff of intermediate composition.	22	Larger (165,000 yd^3) quarry volume of 60% Class I riprap.
87MDT38	NE¼, SW¼, Sec. 6, T17N, R58W, 8 mi downriver from Aniak, Russian Mission C-2 Quadrangle.	80	Massive to porphyritic, hornblende andesite sill.	44	Virtually all of minimum estimate 8,000 yd^3 reserve is Class I and II riprap.
87MDT124	SW¼, NW¼, Sec. 23, T18N, R55W, about 3.5 mi north of Chuathbaluk Village, Russian Mission C-1 Quad.	110	Medium grained, equigranular, biotite, quartz monzonite.	84	Large resource (2,650,000 yd^3) of Class I and II riprap; some Class III on surface; needs to be drilled.

[1] Alaska T-13 Degradation tests by Thomas L. Moses, Department of Transportation and Public Facilities, South Central Region Materials Laboratory, Anchorage, Alaska.
[2] See text for further discussion and information.
[3] Analyses by Alaska Test Labs Inc., Fairbanks, Alaska.

Geologic Description

Bedrock exposures consist of very crumbly, dark gray, limonite-stained, siltstone and minor fine-grained lithic sandstone (fig. 9). Field inspection suggests that the outcrops are indistinguishable from Cretaceous Kuskokwim Group lithologies common along river outcrops in the general area. Thin sections show plagioclase (albitized) laths randomly oriented in a ground mass of prehnite, chlorite, graphite, and iron oxide. Elliptical organic remains 1 to 3 mm in diam with seriate tooth-like rims with light brown cores have been identified as Pennsylvannian fusilinids. Hence, the tuffaceous clastic sediments are probably correlated with late Paleozoic (Mystic Terrane?) lithologies that may overlie carbonates in the Nixon Fork terrane (Bundtzen and Gilbert, 1983).

Structure, Physical Properties, and Volume Estimate

The material is highly sheared and incompetent; the largest material measured 4 by 2 by 3 in. and the average size is much smaller. We judge the site does not qualify as a riprap quarry site.

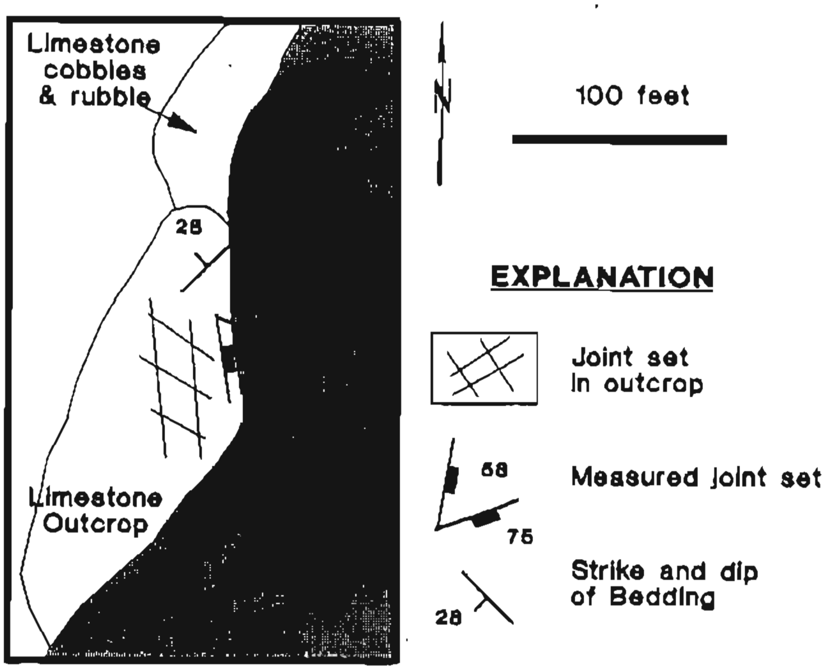

Figure 7. Geologic sketch of middle Stewart Bend site (87MDT5), McGrath D-5 Quadrangle, Alaska.

SITE 87MDT7: UPPER STEWART BEND LIMESTONE SITE, MCGRATH D-5 QUADRANGLE

Location

The site is located on the north bank of Kuskokwim River (NW¼, NE¼, Sec. 11, T33N, R32, F.M.) about 1 mi upstream from site 87MDT6 (fig. 10). A small limestone bluff decreases in height upstream to a silt-covered stream mouth. A seasonal fish camp is located about 350 ft below the bluff.

Geologic Description

Exposures consist of heavily veined, light-to-medium gray, micritic limestone--variation boundstone. Bedding strikes N33°W and dips 30°SW. Lag and rubble upstream from the outcrop contain concretionary layers and zones up to 18 in. diam (fig. 10).

Figure 8. Close examination of sample site 87MDT5 showing detailed stratigraphic features in limestone.

Structure, Physical Properties, and Volume Estimate

Joint sets occur in a conjugate set striking N4°W and dipping 82°NE and striking N60°W dipping 80°SW. The joint spacing ranges from 15 to 40 in. and average 25 in. The material breaks up into blocks, varying from fist size to 4 by 12 by 12 in. with the narrowest dimension parallel to bedding. Some blocks of up to 1 yd^3 in volume were noted. The bluff (80 by 40 by 40 ft) contains about 3,000 yd^3 of material; limestone rubble occurs for 470 ft along the bank so that a much larger yardage is likely available at the site. Some of the material (25 percent) ranges into Class II and Class III riprap sizes; however, bedding that predominates through most of the outcrop produces excessive length to width ratios in rubble and bedrock. A 60 lb sample from the site yielded a T-13 degradation value of 45 which just meets riprap standards recommended by DOTPF (table 1).

SITE 87MDT8: VABM NOIR MOUNTAIN SITE, MCGRATH D-5 QUADRANGLE

Location

NOIR Mountain is a broad, isolated hill on the south side of Kuskokwim River at the lower end of Stewart Bend (NE¼, SW¼, Sec. 24, T33N, R32W, F.M.) about 25 mi upriver from McGrath (fig. 2). Unlike other riprap prospects,

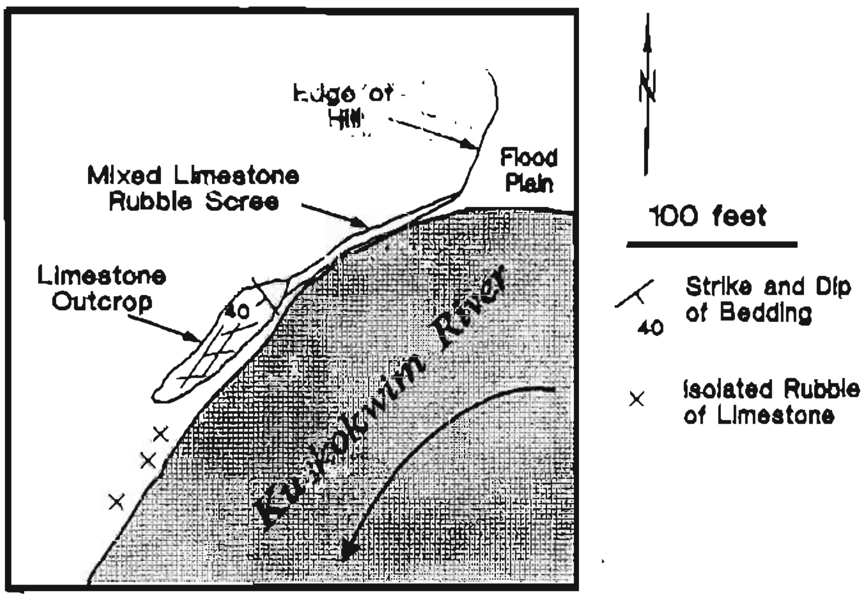

Figure 9. Sketch of Stewart Bend site (87MDT6), McGrath D-5 Quadrangle, Alaska.

NOIR occurs on the same side of the river as the McGrath erosion control project site described by McDonald (1986).

Geologic Description

NOIR mountain is covered by vegetation from foot to summit, and no bedrock exposures were located. The lower 1/3 of the hill is covered by a thick apron (≥ 20 ft thick) of mixed colluvium, and loess and eolian sand that has been extensively dissected by small streams radially draining the summit. Above 450 ft in elevation, the eolian cover markedly thins and bedrock colluvium can be located in test pits and underneath tree "blowdowns." Material from three localities underneath tree "blowdowns" consists of light gray, fine-grained, highly effervescent grainstone and boundstone similar to sites 87MDT4, 87MDT5, and 87MDT7, previous described. Bedrock exposures are limited to mainly rubble-crop on the central and south flanks of the ridgeline.

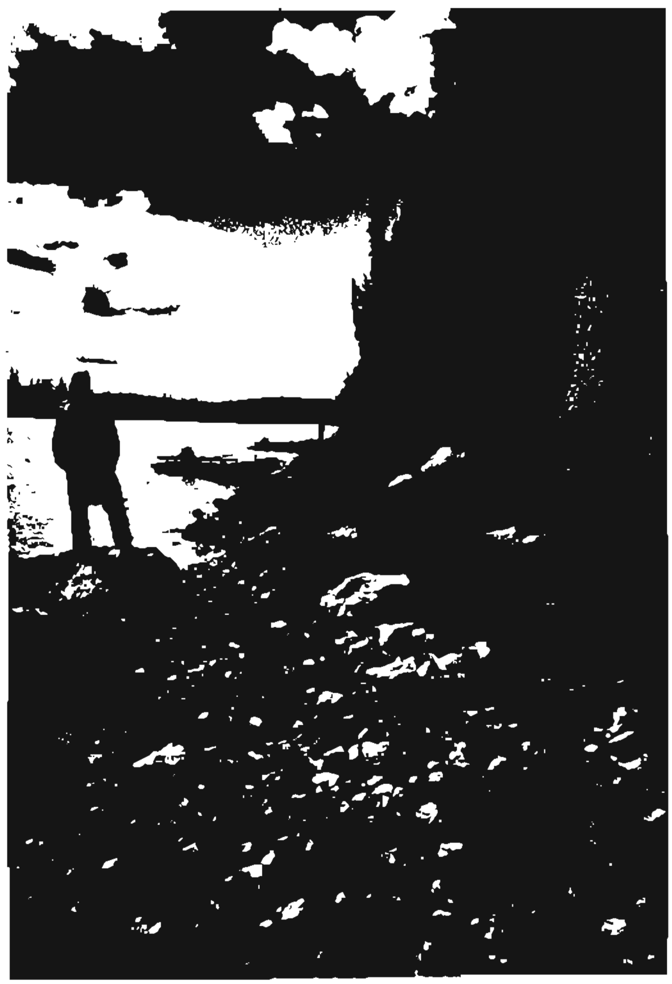

Figure 10. Photograph of limestone rubble upstream from sample site 87MDT7.

Structure, Physical Properties, and Volume Estimate

Structural data was not collected in any rubble-crop areas examined. Bedrock rubble examined was weathered into rounded, cobble-sized pieces within the regolith zone; hence, such sparce material cannot be used to estimate the physical properties of underlying material. The underlying limestone is similar to material described at sites 87MDT4, 87MDT5, and 87MDT7. VABM NOIR is probably completely underlain by the Paleozoic limestone unit and a sizeable resource--in the millions of cubic yards--could be available for excavation and possible development. Acomb (1988b) conducted a drilling program and a test blast on NOIR Mountain to determine the material's suitability for riprap applications. Six drill holes up to 60 ft deep were located on the ridge top from Bench Mark NOIR southward for approximately 1 mi. The test blast site yielded material with a T-13 degradation value of 26--below that recommended for riprap by DOTPF. However, other drill sites yielded higher T-13 values that passed state specifications. Acomb (1988b) concluded that portions of NOIR Mountain could provide suitable material for riprap applications.

SITES 87MDT3 AND 87MDT2--SANDSTONE/SHALE SITES, MCGRATH D-5 QUADRANGLE

Location

Two sites along a near-continuous exposure of Kuskokwim Group sedimentary rocks were examined along the north site of the river 6 to 10 mi upstream from McGrath (fig. 2). The semi-continuous exposures occur on a steep inclined bedrock ramp 30 to 100 ft above mean high water mark of Kuskokwim River (fig. 11).

Figure 11. Photograph showing sheared, fine-grained sandstone and shale at sample site 87MDT3; similar to sample site 87MDT2.

Geologic Description

Sites 87MDT2 and 87MDT3 consist of dark gray, incompetent, highly micacous, plant-rich, lithic siltstone and fine-grained sandstone of the Cretaceous Kuskokwim Group. Bedding attitudes range from N70° dipping 65°NW to N40°E dipping 25°SE. Bedding structures such as flutes and load casts, indicate the section is generally not overturned.

Structure, Physical Properties, and Volume Estimate

Closely spaced joint sets of variable orientation--mainly striking N70°W and dipping 65°SW and striking N30°W and dipping vertically create fine crumbly siltstone and sandstone pellets with maximum ½ by ½ by 1 in. sizes. None of the material observed at either site would qualify by size for riprap or "heavy stone" applications. Suitability for crushed aggregate uses would need further laboratory testing.

SITE 87MDT9: EAST ROUNDABOUT MOUNTAIN SITE, MCGRATH D-6 QUADRANGLE

Location

The Kuskokwim River cuts the eastern-most rim of Roundabout Mountain (NW¼, NW¼, Sec. 1, T32N, R35W, F.M.) about 10 mi downriver from McGrath. Outcrops of siltstone and hornfels occur discontinuously along the west bank of the river for a distance of about 1½ miles (fig. 12).

Geologic Description

Outcrops consist of incompetent, dark gray, limonte-stained, siltstone, shale, fine sandstone and minor monzonite dike rock as 'in-place' rubble. All lithologies show thermal effects presumably from an underlying intrusion. Pyrite concretions or replacements up to 4 in. diam occur in shear zones near monzonite dike rubble.

True bedding strikes N60°E and dip 25°SE, but several distinct cleavages obscure bedding relationship in most outcrop areas.

Structure, Physical Properties, and Volume Estimate

A conjugate joint set (N40°W dipping vertical--N80°E dipping vertical) is closely spaced averaging 1 in. apart; the resultant cross-cutting joints have cut the material into equant to pencil-shaped shards ½ by 1 by 1 in. in size. The material is judged to be unsuitable for riprap or coarse aggregate.

SITE 87MDT10: CENTRAL ROUNDABOUT MOUNTAIN HORNFELS SITE, MCGRATH D-6 QUADRANGLE

Location

Samples were collected from the 900-ft elevation of Roundabout Mountain (NE¼, NE¼, Sec. 2, T32N, R35W, F.M.) about ½ mi northwest of Site 87MDT9.

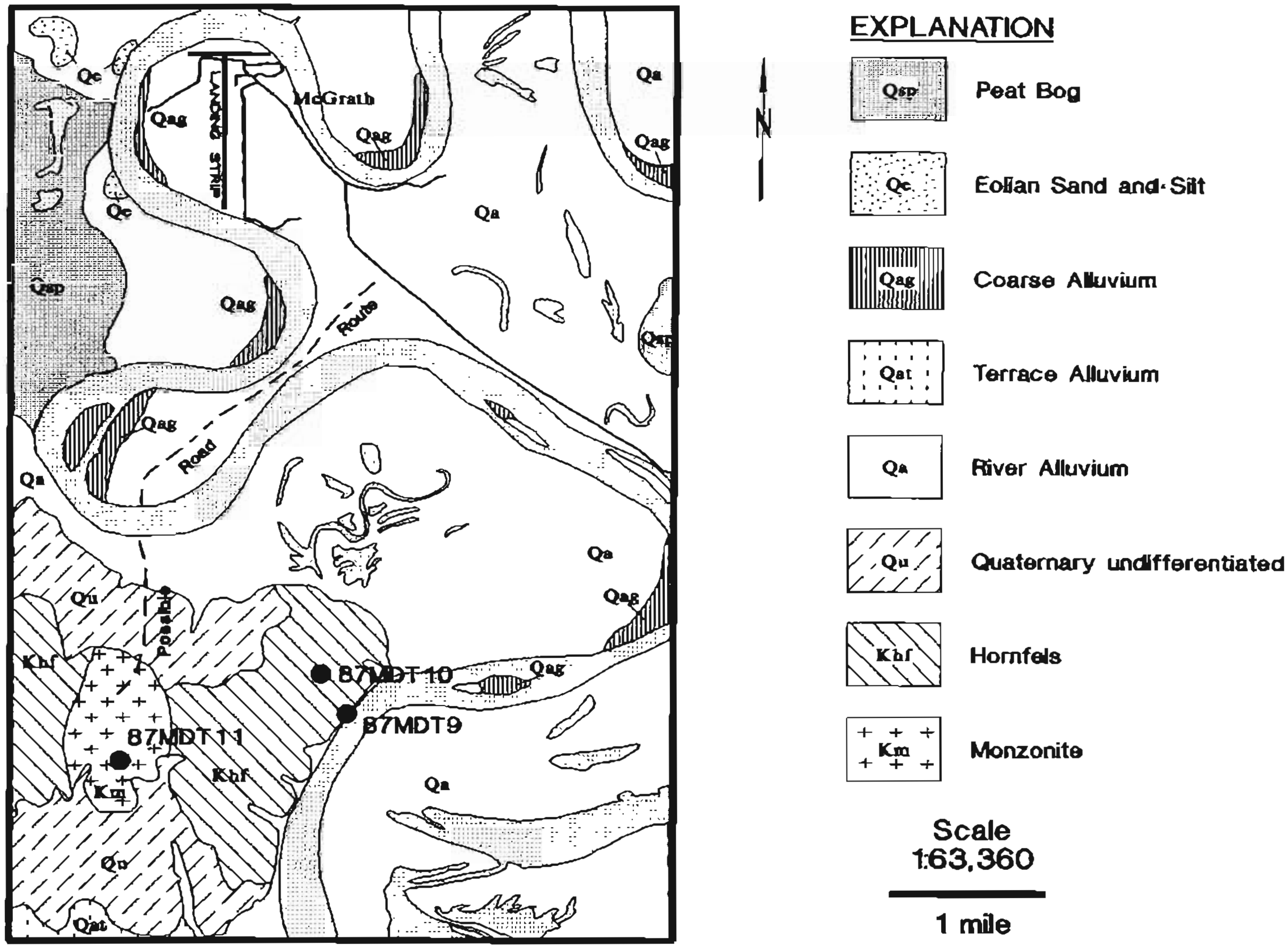

Figure 12. Location map showing sample sites on the vicinity of Roundabout Mountain; geologic data from Bundtzen and Laird (1983).

The area of investigation is heavily vegetated and no bedrock exposures were found. Sampled material was discovered beneath a thin mat of low bush cranberries and sphagnum moss.

Geologic Description

Bedrock rubble consists of very dark gray, resistant, blocky, massive, porphyroblastic hornfels. Sedimentary banding is preserved only in sandy layers; otherwise, the siltstone/shale protolith appears as massive, unfoliated hornfels difficult to distinguish from fine-grained, mafic volcanic rocks.

Structure, Physical Properties, and Volume Estimate

No structural data could be obtained because of the absence of outcrop. Hornfels occurs as elognate slabs ranging in size from 4 by 8 by 10 in. to 16 by 14 by 12 in. An average in the rubble size of 6 by 8 by 12 in. indicates that fairly large material is available at the sample site. Based on size, about 50 percent of the rocks examined would pass as Class I riprap. A specific volume estimate containing slabs is not possible; however, a large area of about ½-mi-diam is present near the nose of the ridge, indicating that significant yardage (tonnage) might be available for riprap use. A 30 lb test sample yielded a T-13 degradation value of 48 passing the minimum requirement recommended by DOTPF for riprap (table 1).

SITE 87MDT11: ROUNDABOUT MOUNTAIN MONZONITE SITE, MCGRATH D-6 QUADRANGLE

Location

The Roundabout Mountain monzonite was examined from an 1,100-ft summit area to a lower altitude of 680 ft (NE¼, SE¼, Sec. 3, T32N, R35W, F.M.), where thick loess, hillslope colluvium, and thick vegetation cover outcrops and bedrock rubble (fig. 13). The sites are about 2½ mi west of Kuskokwim River and 5 mi due south of McGrath (fig. 12). The pluton, as originally mapped by Bundtzen and Laird (1983), covers approximately 1 mi^2 and is best exposed in two tors at the top of the rib that forms the east-west-trending summit of Roundabout Mountain (fig. 14).

Geologic Description

The rubble crop exposures consists of fine- to medium-grained, light gray to lichen-covered, phaneritic, resistant, equigranular intrusive rock. Two distinctive phases were recognized on the field: 1) coarse grained pyroxene olivine gabbro; and, 2) diopside, pyroxene monzonite or monzodiorite. The most mafic phase occurs as isolated xenoliths and evidently preceeded the monzonite. In thin section, the rock type is composed of olivine, biotite, diopside, and calcic plagioclase grains, in an undetermined, feldspar-rich groundmass. A well-developed reaction series olivine-diopside-biotite suggests that a strong differentiation trend took place. About 1 percent of the thin sections examined contain chromite (Cr_2O_3) which is altered and rimmed by biotite and undetermined oxide components.

Structure, Physical Properties, and Volume Estimate

Monzonite exposures observed at the summit and downslope to the north to an altitude of 680 ft contain massive blocks ranging from 14 by 20 by 25 in. to 36 by 36 by 56 in.--many averaging nearly a cubic yard (fig. 13). The blocks are equant and subangular in shape. The monzonite in exposure contain a consistent conjugate joint set averaging N75°E dipping 70°NW-N5°E dipping 80°SE. Joint fractures are consistently widely spaced, averaging 36 to 48 in., which may account for the large size of blocks observed. Large material appears not only in outcrop but also beneath thick sphagnum moss and black spruce "blow downs".

Surface exposures of monzonite generally show superior riprap properties. Based on size, much of the ridge top contains Class III and IV material. However, recent drilling conducted by Acomb (1988a) indicates that most monzonite at the sample sites have serious competency problems. Five test holes drilled in the area indicates that the material is evidently unsuitable for riprap. Large boulders and outcrop sampled at the surface are apparently floating on a deeply weathered zone of igneous grüss. Past weathering, freeze-thaw cycles have mechanically disintegrated the bedrock to depths exceeding 60 ft and there is no indication that fresher material exists at deeper levels.

Hence, despite apparently excellent material exposed at the surface, the riprap resource is questionable and more detailed subsurface data needs to be collected and analyzed.

Figure 13. Monzonite bedrock at sample site 87MDT11.

SITE 78BT379: CANDLE CREEK, MCGRATH D-6 QUADRANGLE

Location

Rubble-crop of both monzonite and altered basalt occur on Sugar Loaf Mountain near the Candle Landing-Takotna Road at SW¼, SE¼, Sec. 16, T32N, R36W, F.M., about 10 road mi west of Kuskokwim River. Most of the best exposures, as mapped by Bundtzen and Laird (1983), occur at an altitude of 1,600 ft.

Geologic Description

The rubble-crop exposures consist of the major rock types: 1) medium grained, equigranular, biotite, clinopyroxene, olivine monzonite, and 2) porphyroblastic, thermally altered, biotite olivine basalt. The biotite seen in the basalt is secondary and a result of thermal alternation by the underlying monzonite pluton. The two rock types are representative of Late Cretaceous-Early Tertiary volcano-plutonic complexes which intrude the

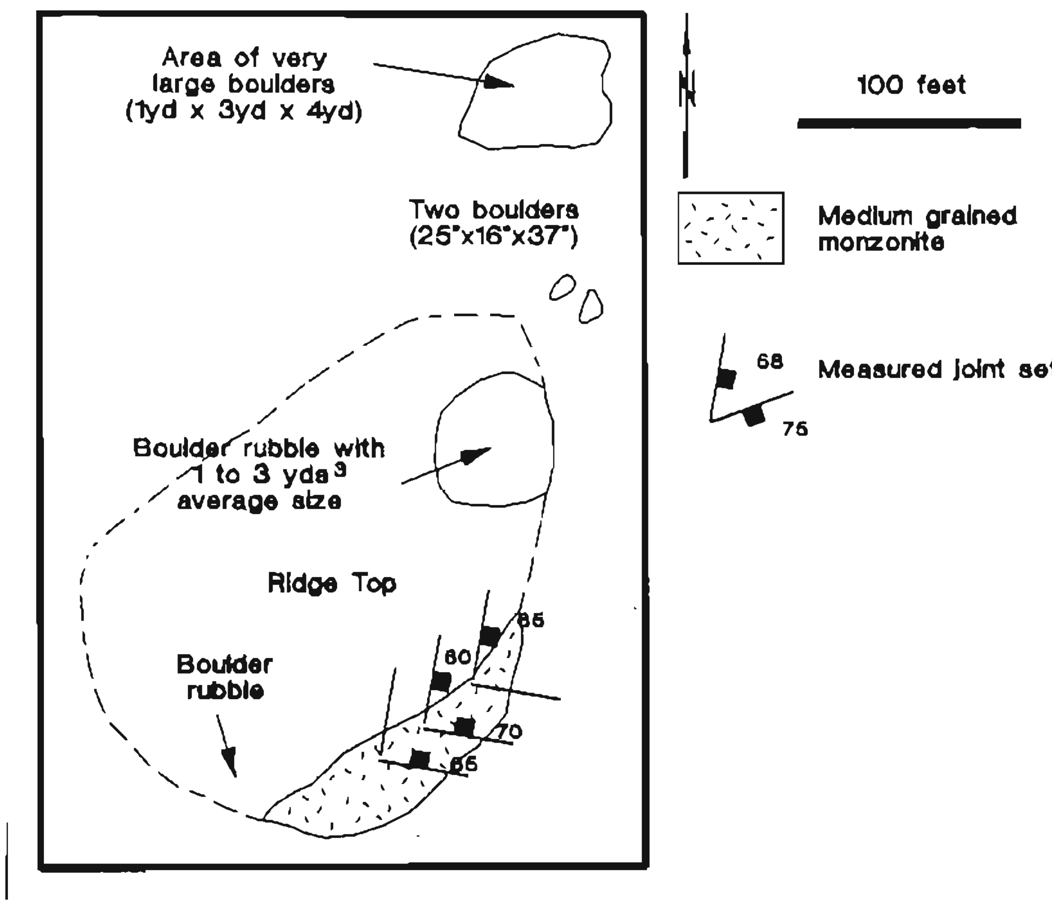

Figure 14. Geologic sketch of Roundabout Mountain monzonite prospect (87MDT11), McGrath D-6 Quadrangle, Alaska.

Kuskokwim Group sedimentary basin along a 400 mi long zone. As at the Round About intrusion, chromite (Cr_2O_3) is the conspicuous acessory mineral observed in thin section.

Structure, Physical Properties, and Volume Estimate

The altered basalt and monzonite were assessed by Bundtzen and Laird (1983) and later during a 1986 visit with the senior author and Larry Acomb of R and M Consultants and Harold Noyes of Doyon Ltd. The volcanic cap rocks consistantly display a conjugate joint set with orientations of N35°E 83S°E and N40°W 70S°W. Joint fractures are spaced 28 to 42 in. apart and surface material commonly averages 12 by 20 by 20 in. in diam. The monzonite is in direct contact with overlying basalt and contains blocks of up to 1 yd^3 in exposures, road cuts, and boulder fields. Virtually all surface material passes both Class I and II riprap specifications and 1986 laboratory analyses by Alaska Test Labs, Inc. show T-13 degradation values of 62 and 58 for basalt and monzonite respectively (table 1). Additionally, specific gravity estimates of 2.88 and 2.74 were obtained for basalt and monzonite respectively.

Acomb (1988a) completed a seismic survey of the general sample area and drilled a 54-ft-deep hole into monzonite and monzodiorite bedrock (we did not differentiate the two phases in the field). As at Roundabout Mountain, the drilling encountered a significant percentage of decomposed monzonite unsuitable for riprap; however, monzodiorite in the core "appeared hard to very hard" and had a T-13 degradation value of 47, which passes state riprap specifications. The difficulty in assessing the intrusive rock at the site area is determining the percentage of monzodiorite versus monzonite of a potential quarry site. Acomb (1988a) judged it would be difficult to separate the two phases of the intrusion during excavation.

To date, the altered basalt on Sugar Loaf Mountain has not been specifically examined for its riprap potential, and considering its favorable surface characteristics, deserves to be explored with subsurface investigations. Additionally there may be enough surface material at the site of suficient physical character to warrant exploitation of both intrusive rock and basalt for riprap.

SITE 87MDT13: TATLAWIKSUK RIVER, SLEETMUTE D-1 QUADRANGLE

Location

Riverside outcrops of the Kuskokwim Group were examined at the west limit of the Kuskokwim River immediately downstream of Tatlawiksuk River at NW¼, NE¼, Sec. 19, T21N, R38W, F.M. (figs. 1 and 15). A short rapids zone occurs immediately below the site.

Geologic Description

The river exposures along 3,500 ft of bank consist of highly sheared, medium- to dark-gray, lithic medium- to coarse-grained sandstone interbedded with micaceous siltstone and shale. Sandstone-shale ratios in the section

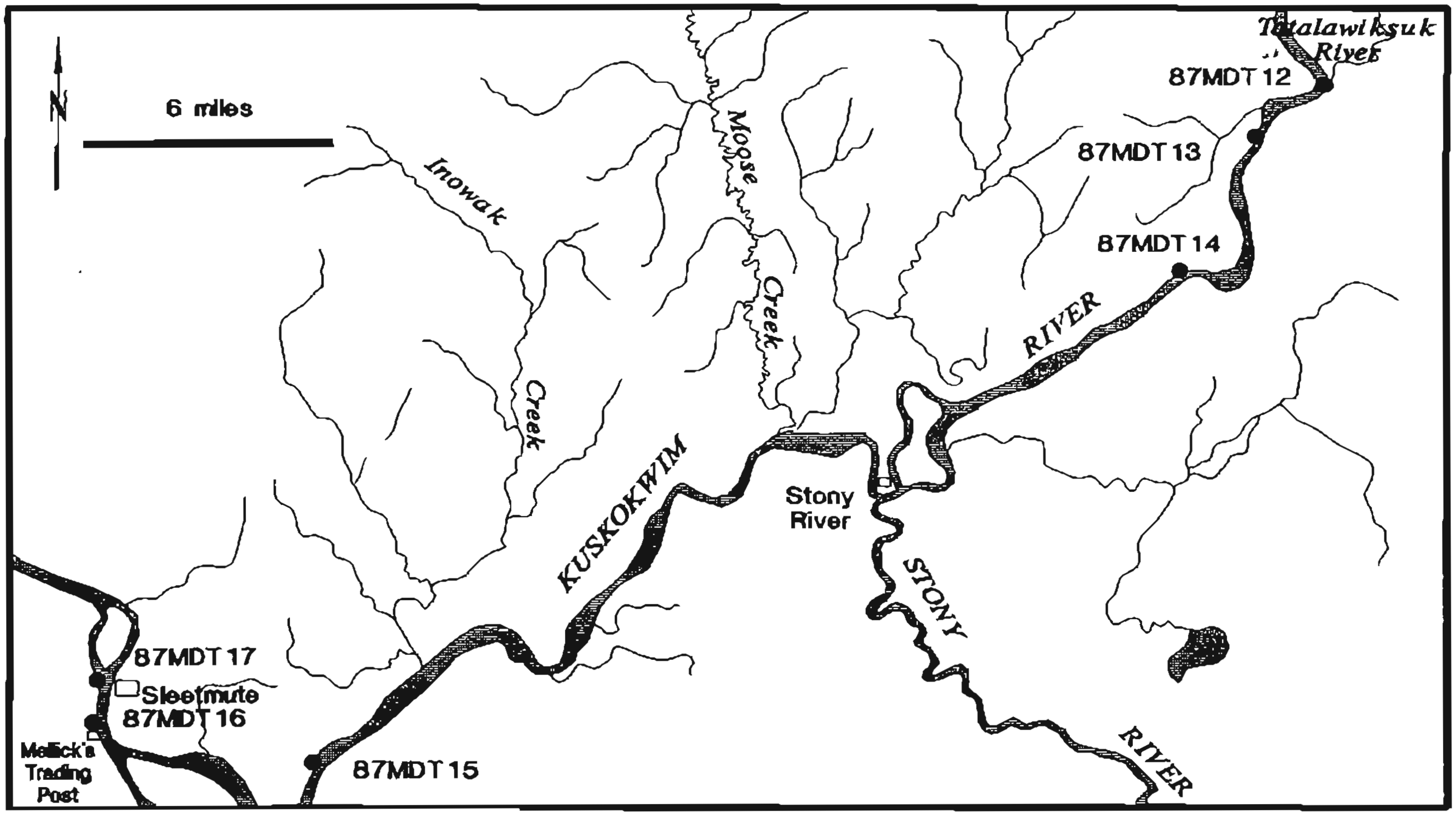

Figure 15. Quarry sampling sites along Kuskokwim River from Tatalawiksuk River to Sleetmute.

range from 1:1 to 5:1 and average 2.5:1. In thin section, sandstones consist of coarse, subangular clasts of quartz and chert (65 percent), white mica (8 percent), calcite (4 percent), slate clasts (15 percent), and metamorphic clasts (8 percent). The dominantly sedigenic clasts are locally cemented with calcite.

Structure, Physical Properties, Volume Estimate

Two distinct cleavages that cut the highly folded sedimentary section strike E-W, dipping vertically and striking N65°W dipping 60°NE and completely obscure the original bedding orientation. A prominent N40°W striking and vertically dipping joint set cleaves outcrops into closely spaced stacks of sand and silt blocks rarely more than 3 in. thick. The overall result of the complex deformation is to break up rock units into small fragments. Those fragments average ½ by 1 by 2 in. in size and few larger fragments were observed. No riprap quality material was identified.

SITE 87MDT14: STONEY FISH CAMP SANDSTONE SITE, SLEETMUTE D-1 QUADRANGLE

Location

A prominent bluff of sandstone occurs on the west bank of Kuskokwim River (SW¼, NE¼, Sec. 4, T20N, R39W, F.M.) about ¼ mi down "Stoney Fish Camp." The bluff exposure is at least 80 ft high and probably extends for at least 300 ft into the hillslope (fig. 16).

Geologic Description

Bedrock at this site consists of dark gray, lithic sandstone and shale striking N49°E dipping 25°NW. The bluff face contains several massive sandstone lenses each nearly 40 ft thick. The average sandstone-shale ratio is about 4:1.

In thin section the lithic sandstone is composed of chert (35 percent), polycrystalline quartz (20 percent), shale/slate clasts (10 percent), white mica (2 percent), mafic to intermediate volcanic detritus (20 percent), and calcite cement (10 percent). Limey sands are very poorly sorted and most clasts exhibit subangular configurations. Flute casts indicate the section is upright.

Structure, Physical Properties, and Volume Estimate

A conjugate joint set--striking N7°E, dipping 80°SE and striking N68°E, dipping 55°SE--breaks sandstone lenses into relatively large blocks ranging from 4 by 4 by 2 in. to 4 by 6 by 6 in. Bank armor rock is platey with flattened surfaces parallel to bedding planes. The sandstone section contains material passing Class I riprap specifications but the sandstone does not contain desirable length-width ratios. The bluff is an intact block measuring 250 by 90 by 450 ft and contains a conservative estimate of 375,000 yd^3 of sandstone and siltstone about 75 percent of which is the former lithology (fig. 17). No degradation tests are available from the site.

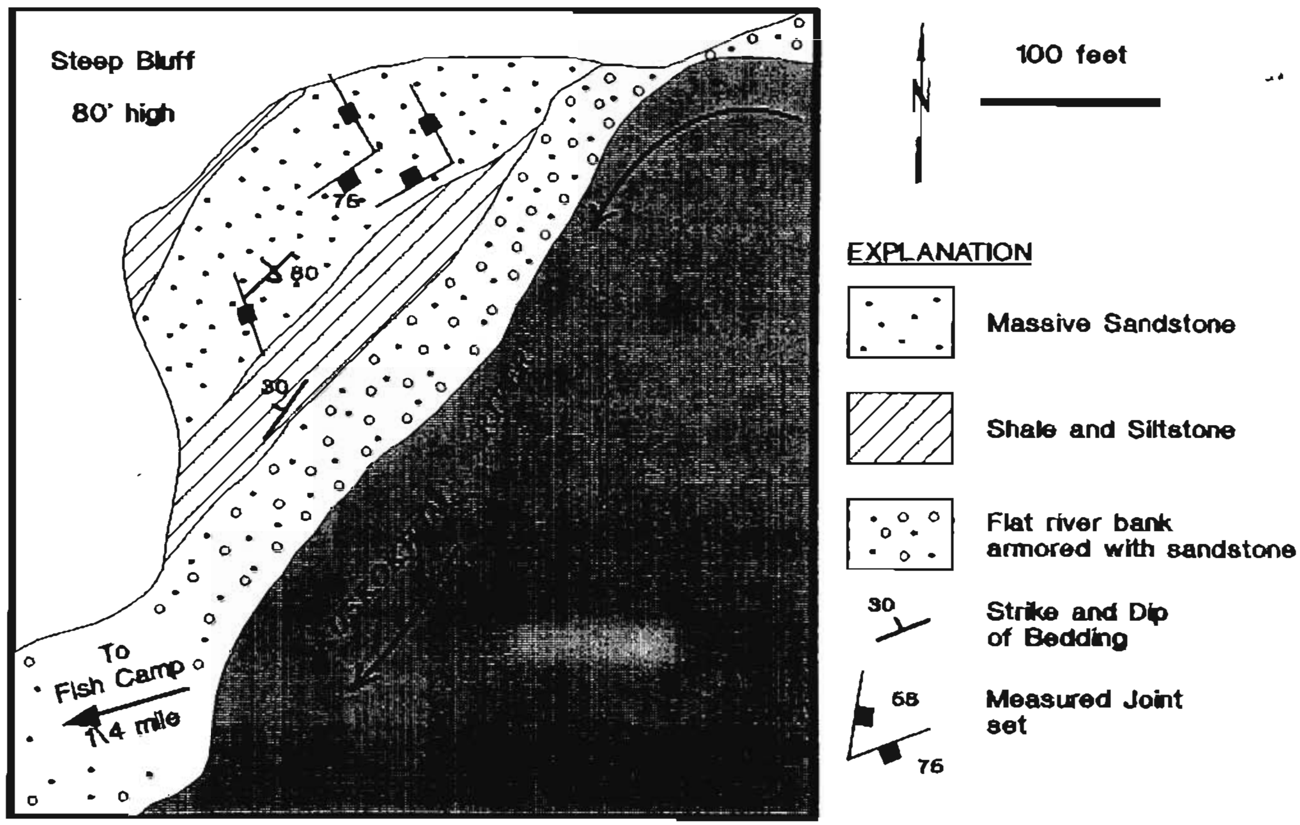

Figure 16. Geologic sketch of Stony Fish Camp site (87MDT14), Sleetmute D-1 Quadrangle, Alaska.

SITE 87MDT15: VABM TOWER SILTSTONE SITE, SLEETMUTE C-1 QUADRANGLE

Location

Interbedded sandstone and shale of the Kuskokwim Group crop out in prominent bluff exposures on the west bank of Kuskokwim River about 7 mi upriver from Sleetmute, Alaska at SW¼, SW¼, Sec. 2, T18N, R42W, F.M. (fig. 15).

Geologic Description

Most beach exposures consist of highly incompetent, sheared micaceous siltstone that crumbles into small fragments less than 1 in. diam. In two areas along the beach, tan-weathered, lithic-rich, medium-grained sandstone beds form resistant ribs protruding through the incompetent siltstone. In thin section, the sandstone is a very poorly sorted, highly calcareous clastic containing calcite rhombs (30 percent), polycrystallaine quartz (35 percent), chert (10 to 15 percent), white mica (1 percent), and chlorite-rich metamorphic clasts (3 percent).

Structure, Physical Properties, and Volume Estimate

Outcrops are deformed by two cleavages; the two most prominent are N70°W dipping 65°W and N42°W dipping vertical. Cleavage planes, spaced 1 to 2 in. apart, fragments the siltstone and sandstone into small ½ by 1 by 1 in. blocks and books that are unsuitable for riprap quality applications.

Figure 17. Photograph showing residual sandstone blocks on beach at sample site 87MDT14.

SITE 87MDT16: MELLICK RHYOLITE SITE, SLEETMUTE C-4 QUADRANGLE

Location

Altered rhyolite dikes intrude Kuskokwim Group clastic rocks about 100 yd downstream from Mellick's Lodge (NE¼, NW¼, Sec. 1, T18N, R44W) which is immediately south of the village of Sleetmute (fig. 18).

Geologic Description

Altered quartz-porphyry dikes 15 to 30 ft thick cut incompetent siltstone and shale in a N50°E trend. Igneous rocks are exposed at the beach and extend under vegetative cover 80 to 100 ft from Kuskokwim River. Contacts with sediments are sharp with chilled margins. In thin section, the igneous rocks are composed of quartz phenocrysts up to 1 cm diam in a groundmass of sericite, quartz, feldspar, and propylized biotite. Both dikes are hydrothermally altered.

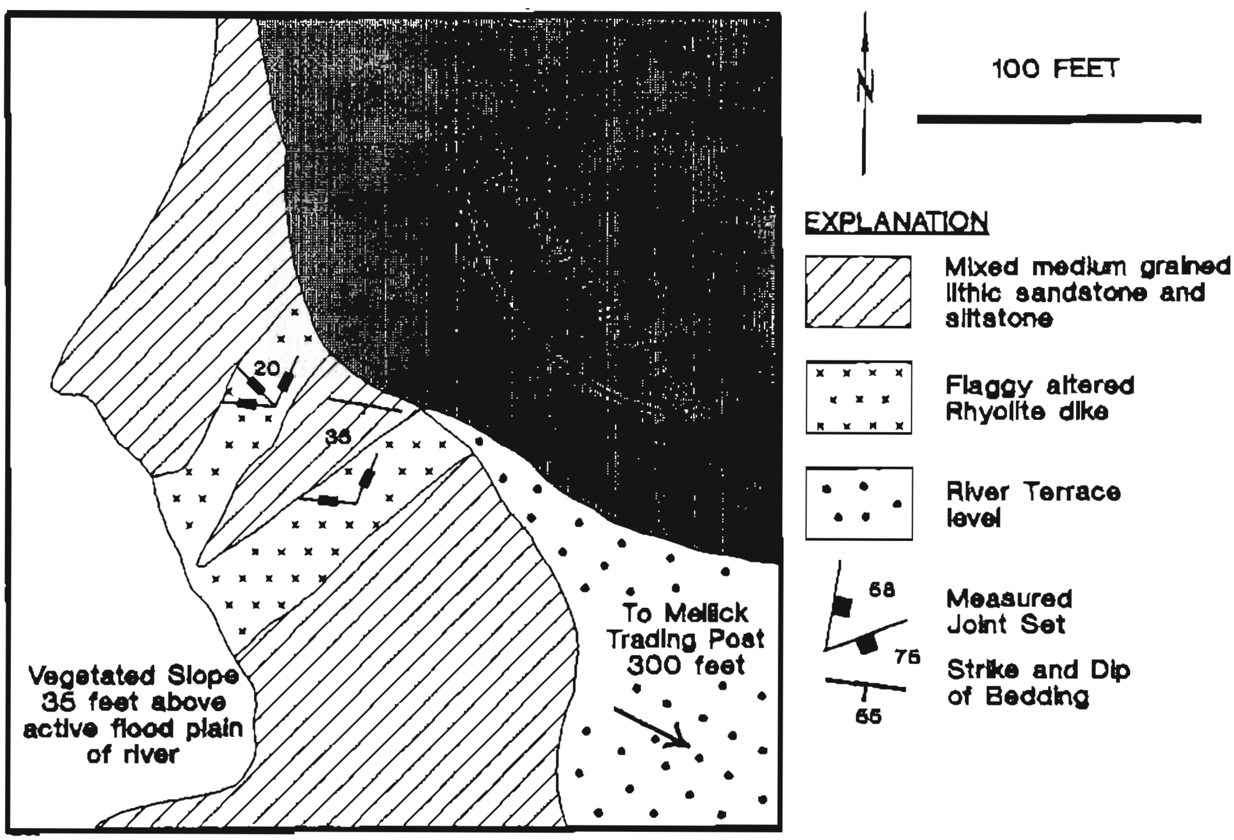

Figure 18. Sketch of Mellick rhyolite dike site (87MDT16), Sleetmute C-4 Quadrangle.

Structure, Physical Properties, and Volume Estimate

Dikes exhibit a sheeted joint set with a dominant N5°E striking, dipping 50°NW joint and secondary N80°E striking, dipping 70°SE joint. The first joint produced flat sheets that form prominent rubble along the beach. Flattened rubble fragments measure 1 to 6 in. wide and 3 in. thick. An 80 by 25 by 65 ft area contains a 5,000 yd^3 resource. We estimate that 25 percent of this volume would qualify as Class I riprap. Although incremental volume increases may occur farther into the vegetated hillslope, rhyolite dikes in the region are inconsistent in strike and dip.

SITE 87MDT17: SLEETMUTE RHYOLITE SITE, SLEETMUTE C-4 QUADRANGLE

Location

A rhyolite dike or sill is exposed in a cutbank directly across from Sleetmute (NE¼, SW¼, Sec. 25, T18N, R44W) and about 1 mi downstream from site 87MDT16 (fig. 19).

Geologic Description

Quartz porphyry (rhyolite) is exposed as distinctly tan-weathered bedrock rubble in contrast to the gray-brown-colored enclosing sedimentary rocks of this Kuskokwim Group. The dike or sill trends N5°E and dips shallowly west.

Structure, Physical Properties, and Volume Estimate

The quartz porphyry sill (?) contains a distinct conjugate joint set striking N86°E, dipping 22°NW and striking N27°E, dipping 80°SE. Intersecting joints create broad flaggy blocks as rubble for a distance of approximately 270 ft. Largest blocks measure 10 by 12 by 12 in. but most average 2 by 4 by 6 in. The bedrock cut is 35 ft thick and extends about 60 ft into a vegetated hillslope; these minimum dimensions suggest that about 21,000 yd^3 of material would be easily accessible on the bedrock bench. Less than 20 percent of the rhyolite could pass as Class I riprap but the material might be more suitable for riprap applications than sections of the Kuskokwim Group sandstone exposed in this area. However, a 40 lb rock sample of quartz porphyrx yielded a T-13 degradation value of 16, far below the minimum (45) recommended by DOTPF for riprap.

SITE 87MDT18: 'PARKS' SANDSTONE SITE, SLEETMUTE D-4 QUADRANGLE

Location

A prominent bluff composed of massive sandstone and siltstone occurs near the Parks mercury prospect (NE¼, SE¼, Sec. 14, T20N, R45W) 3 mi upstream from the village fishing site of "Eight Mile" (fig. 20).

Geologic Description

The northern portion of the 100-ft-high bedrock bluff consists of medium-gray, medium- to coarse-grained, lithic sandstone--probably representing a massive turbidite sand lens (fig. 21). The section generally strikes N70°-80°W and dips 18°-22°SW. Flutes were observed on two surfaces, indicating the section is upright. A series of rhythmically interbedded siltstone-sandstone beds make up the southern half of the outcrop.

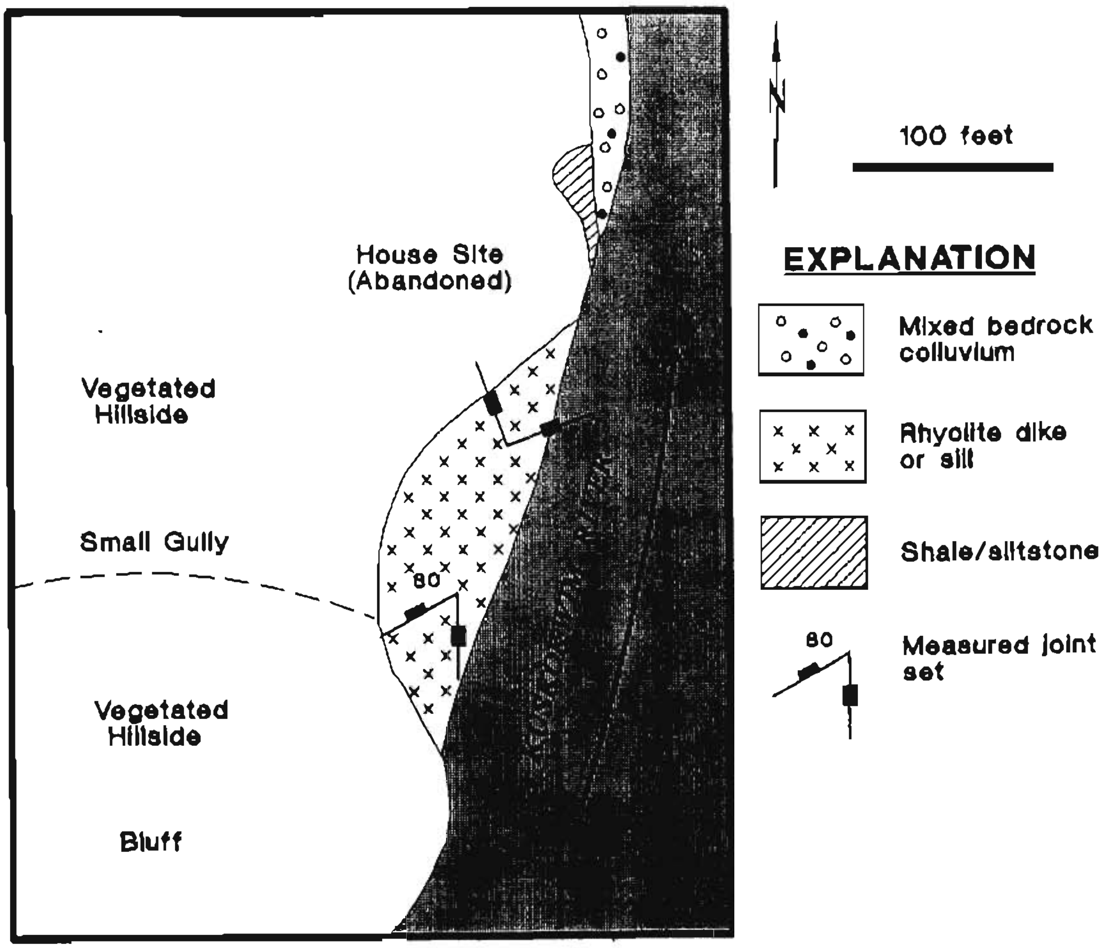

Figure 19. Sketch of Sleetmute Village rhyolite site (87MDT17), Sleetmute C-4 Quadrangle, Alaska.

Structure, Physical Properties, and Volume Estimate

Sandstone lenses break into platy blocks ranging from 2 by 4 by 2 in. to 6 by 12 by 20 in. in size; plates parallel bedding and run perpendicular to joints striking N39°E and dipping 50°NW joints (fig. 22). Large blocks are available with minimum volume of 350 by 25 by 40 ft or about 13,000 yd^3 of material. Based on size, an estimated 75 percent of the measured volume is Class I riprap. However, a 47 lb sample from this site yielded a T-13 degradation value of 13, well below the minimum (45) recommended by DOTPF for riprap applications.

SITE 87MDT19: EIGHT MILE SILTSTONE SITE, SLEETMUTE D-5 QUADRANGLE

Location

Outcrops occur about 2 mi downriver from Eight Mile Village site at SE¼, SE¼, Sec. 3, T20N, R45W, F.M. (fig. 20).

Geologic Description

A dark-gray, carbonaceous, siltstone-rich section is exposed mainly at the beach. Most of the adjacent hillslope is covered by vegetation and siltstone rubble. At the beach a 6-ft-thick section of medium-grained, quartz-rich, sublithic siltstone and minor fine-grained sandstone strikes N80°W and dips 75°NE. Outcrops continue for 350 ft along the cutbank.

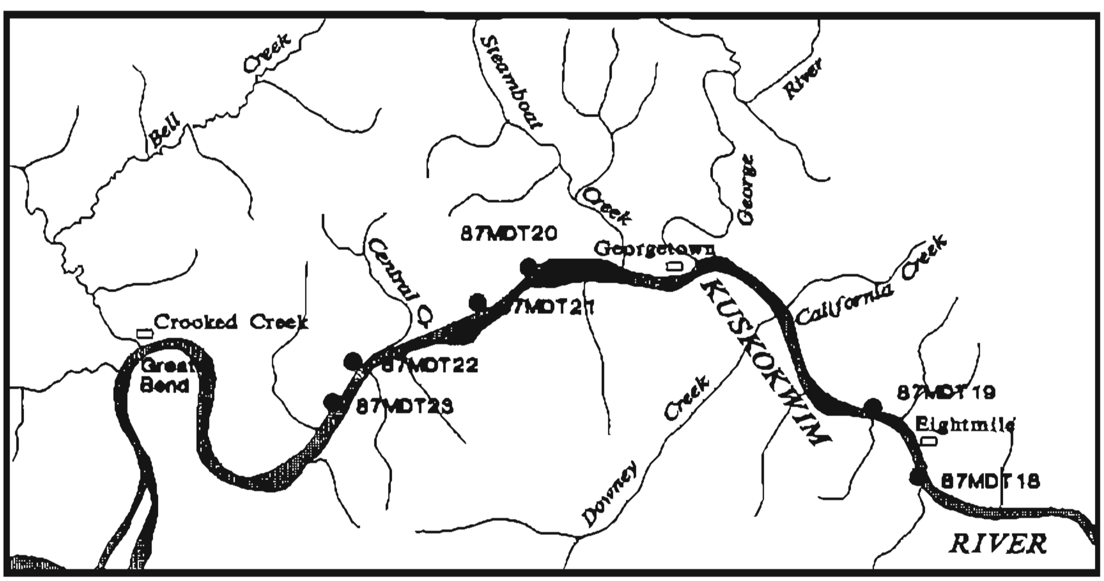

Figure 20. Riprap sampling sites from Eight Mile Creek to Crooked Creek, Kuskokwim River.

Structure, Physical Properties, and Volume Estimate

The material at this site is generally judged to be incompetent and commonly breaks down to small 1 by 1 by 2 in. material. No riprap classes were identified.

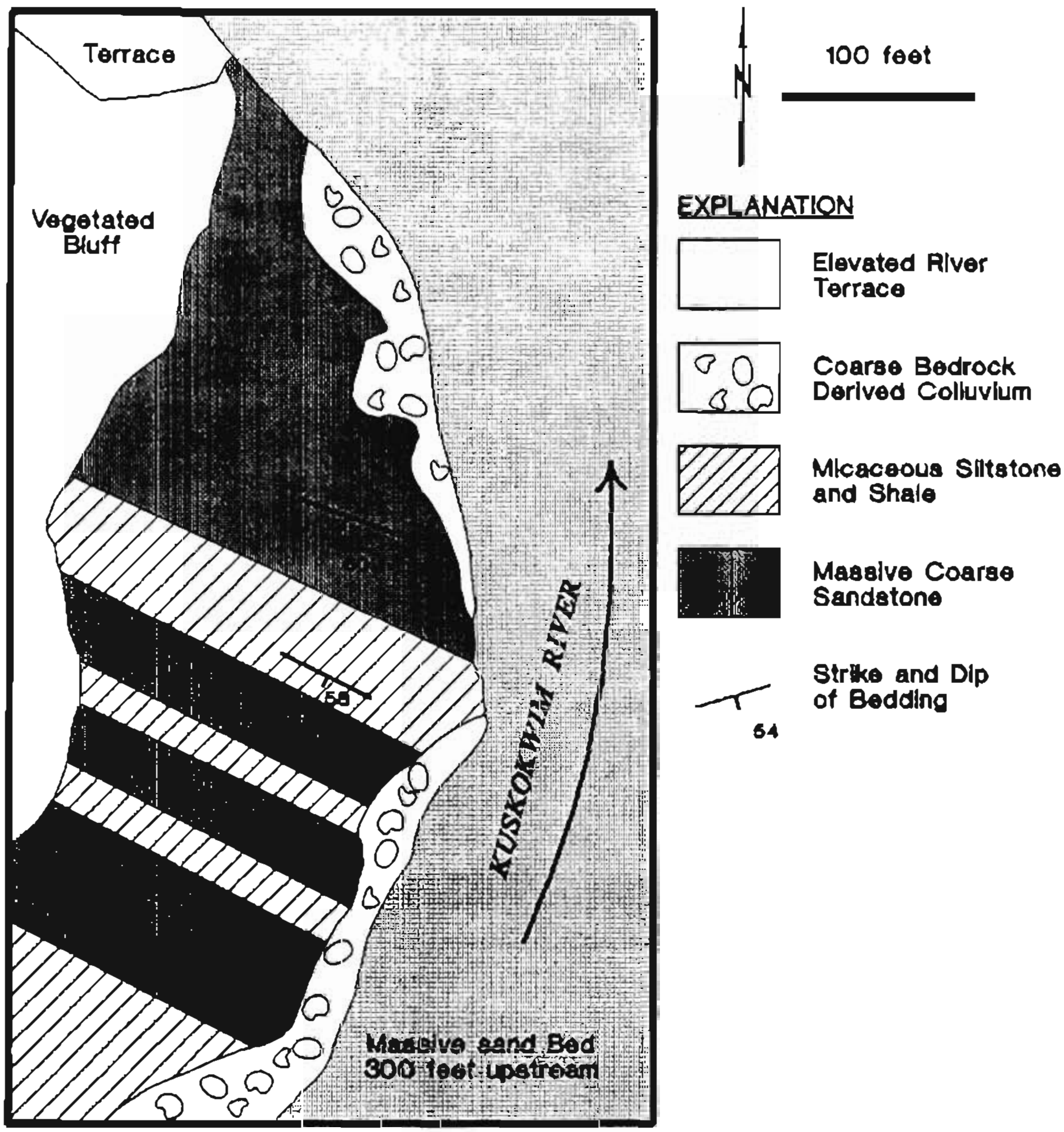

Figure 21. Geologic sketch of Eight Mile Creek (87MDT18) site, Sleetmute D-5 Quadrangle.

SITE 87MDT20: GEORGETOWN SANDSTONE SITE, SLEETMUTE D-5 QUADRANGLE

Location

A massive sandstone bed 8 to 10 ft thick occurs along a steep bluff on the north side of Kuskokwim River about 3 mi downriver from the village of Georgetown at NE¼, SE¼, Sec. 19, T21N, R46W (fig. 20).

Geologic Description

A massive, medium-gray, sheared, lithic sandstone bed about 10 ft thick strikes N70°W and dips 75°NE for about 500 ft. The sandstone unit is overlain by a 85-ft-thick section of interbedded fine-grained sandstone and micaceous siltstone. The beds form semicompetent beds perpendicular to the strike of the shoreline. Sandstone: siltstone ratios are about 1:2.

Structure, Physical Properties, and Volume Estimate

The massive sandstone bed at the base breaks into 4 by 8 by 18 in. blocks on the average and could conceivably be utilized as riprap; however, we judge that the volume that could be generated for use is small when overburden removal requirements are taken into consideration.

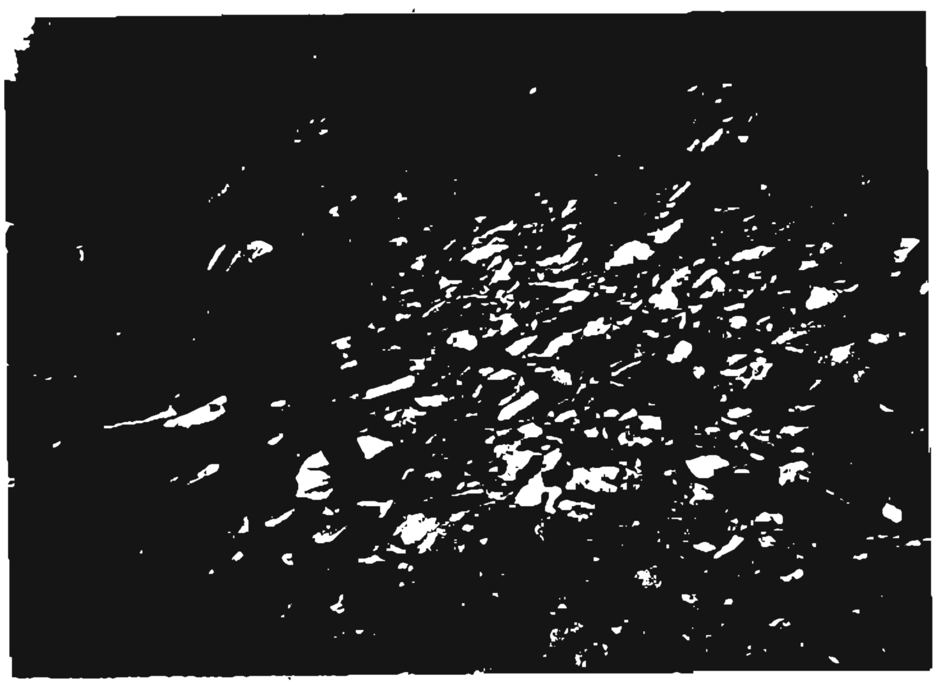

Figure 22. Sandstone beach lag at sample site 87MDT18.

SITE 87MDT21: LOWER GEORGETOWN RHYOLITE SITE, SLEETMUTE D-6 QUADRANGLE

Location

A very steep bluff composed of rhyolite dike and altered siltstone occurs on the north bank of Kuskokwim River (SE¼, Sec. 27, T21N, R47W) about 4 mi below Georgetown (fig. 23).

Geologic Description

The bedrock outcrop area sampled at site 87MDT21 is composed of three parallel rhyolite dikes. The dikes strike approximately N15°W and dip 65°-70°SW. Geologic relationships suggest that the three dikes coalesce into a single dike about 65 ft thick that forms sharp contacts with enclosing sedimentary rocks of the Kuskokwim Group. Thermal effects on the host rock

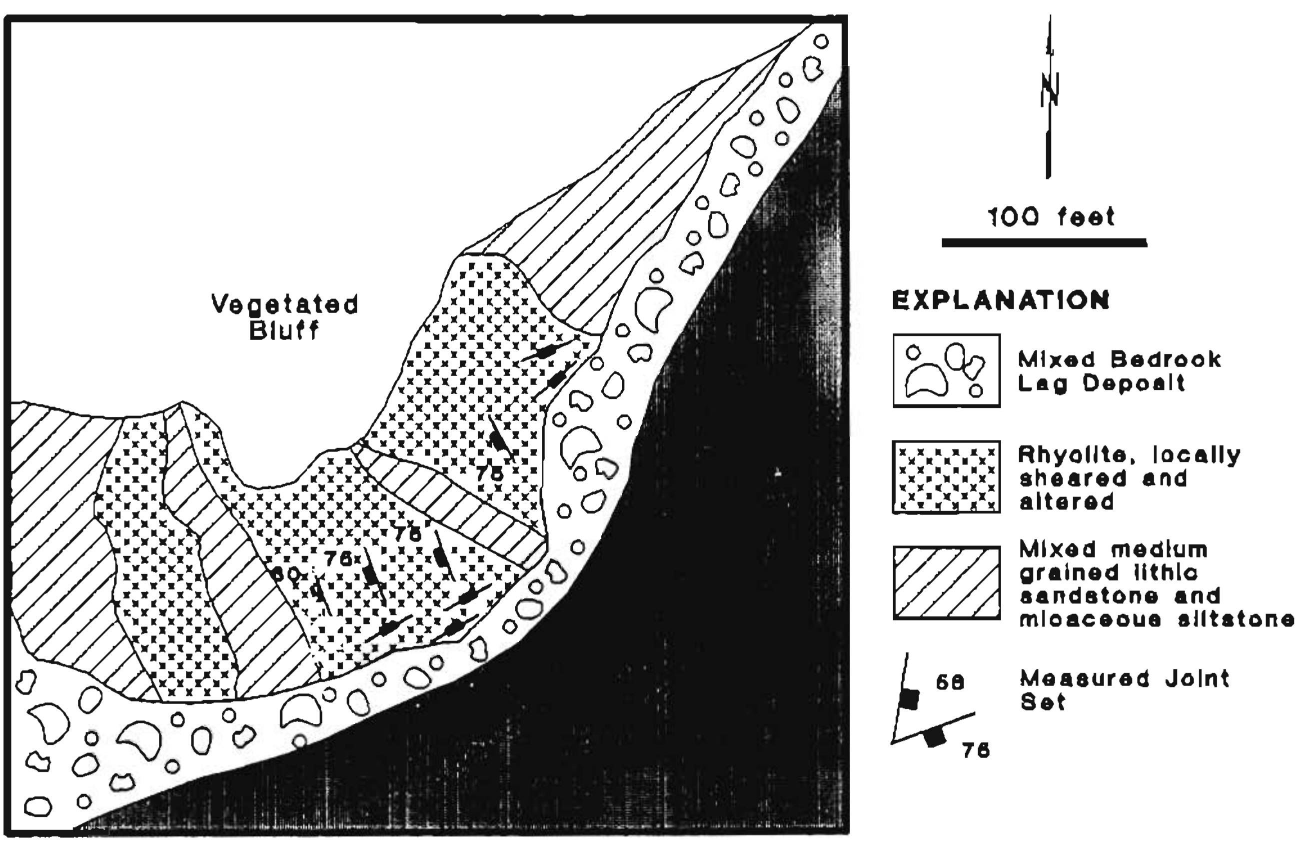

Figure 23. Geologic sketch of Lower Georgetown site (87MDT21), Sleetmute D-5 Quadrangle, Alaska.

were not recognized. The rhyolite is composed of quartz and potassium-feldspar phenocrysts averaging 0.5 mm diam. in a groundmass of muscovite, feldspar, leucoxene, and minor biotite.

Structure, Physical Properties, and Volume Estimate

A well developed conjugate joint set striking N15°W and dipping 75°SW and striking N55°E and dipping vertically cuts the rhyolite dikes but not sedimentary host lithologies (fig. 23). Well-developed joints result in the spalling of equant to rhombahedral blocks averaging 6 by 10 by 10 in. (fig. 24). The total rhyolite exposed in the bluff has minimum inferred dimensions of 40 by 225 by 150 ft or approximately 50,000 yd^3 of material. Based on size about 70 percent of this material would qualify as Class I riprap. Some Class II material is also available. Extensions of a speculative excavation into the bluff would incrementally add to the resource but also would involve removal of enclosing siltstone host rock above the bluff. However, a T-13 degradation value of 28 from this sample area is below the DOTPF minimum recommended for riprap applications (table 1).

SITE 87MDT22: CENTRAL CREEK SANDSTONE SITE, SLEETMUTE D-6 QUADRANGLE

Location

Bluffs of interbedded sandstone and siltstone are exposed on the north bank of the Kuskokwim River approximately 7 mi above Big Bend and the village of Crooked Creek at SE¼, NW¼, Sec. 4, T21N, R47W (fig. 20).

Figure 24. Rubble from rhyolite dikes at sample site 87MDT21.

Geologic Description

Bedrock crops out for approximately 750 ft along the river. Lithologies consist of medium-grained, lithic sandstone and micaceous siltstone with a sandstone-shale ratio of about 1:1. The 2-ft-thick sandstone beds are sandwiched between silt layers of about equal thicknesses (fig. 25). The beds strike N41°W and dip 40°SW.

Structure, Physical Properties, and Volume Estimate

Massive sandstone lag deposits along the beach range in size from 2 by 4 by 4 in. to 6 by 6 by 6 in. Coarse material is derived from a massive sandstone bed about 25 ft thick that is sandwiched between by highly incompetent micaceous siltstone. Hence, both footwall and hanging wall competency problems make material excavation questionable at this location. No volume estimates of the site area were calculated, and no riprap quality material was recognized.

SITE 87MDT25: RHYOLITE HILL SITE, SLEETMUTE D-7 QUADRANGLE

Location

A distinct elongate ridge that parallels Kuskokwim River in a N45°E orientation is largely composed of rhyolite. The 'rhyolite hill' occurs on the south side of the river about 8 mi downstream from the village of Oskawalik at SE¼, NW¼, Sec. 24, T18N, R49W (fig. 26).

Figure 25. Interbedded sandstone, shale and siltstone at sample site 87MDT23.

Geologic Description

No bedrock outcrops of in-place bedrock could be found on the shoreline. The hillslopes immediately above the flood plain cutbank consist of lichen-covered, light gray, fresh- to tan-weathered, porphyro-aphanitic, biotite-muscovite rhyolite rubble. In thin section, the intrusive rock is myrmekite (10 percent), oligoclase (15 percent), and quartz (10 percent) grains subhedrally shaped and averaging about 0.3 mm in size. The porphyro-aphanitc groundmass ntains white mica (6 percent), biotite (3 percent), indetermined feldspar (30 percent) and quartz (14 percent).

Structure, Physical Properties, and Volume Estimate

No outcrops were available for structural measurements. Rubble size of the rhyolite is highly variable and ranges from ½ by 1½ by ½ in. to 12 by 10 by 36 in. It is difficult to determine the average size. The material breaks up into rhyolite sheets 1 to 3 in. thick and up to 20 in. square in surface dimension. Some water-washed material on the beach appears as fresh,

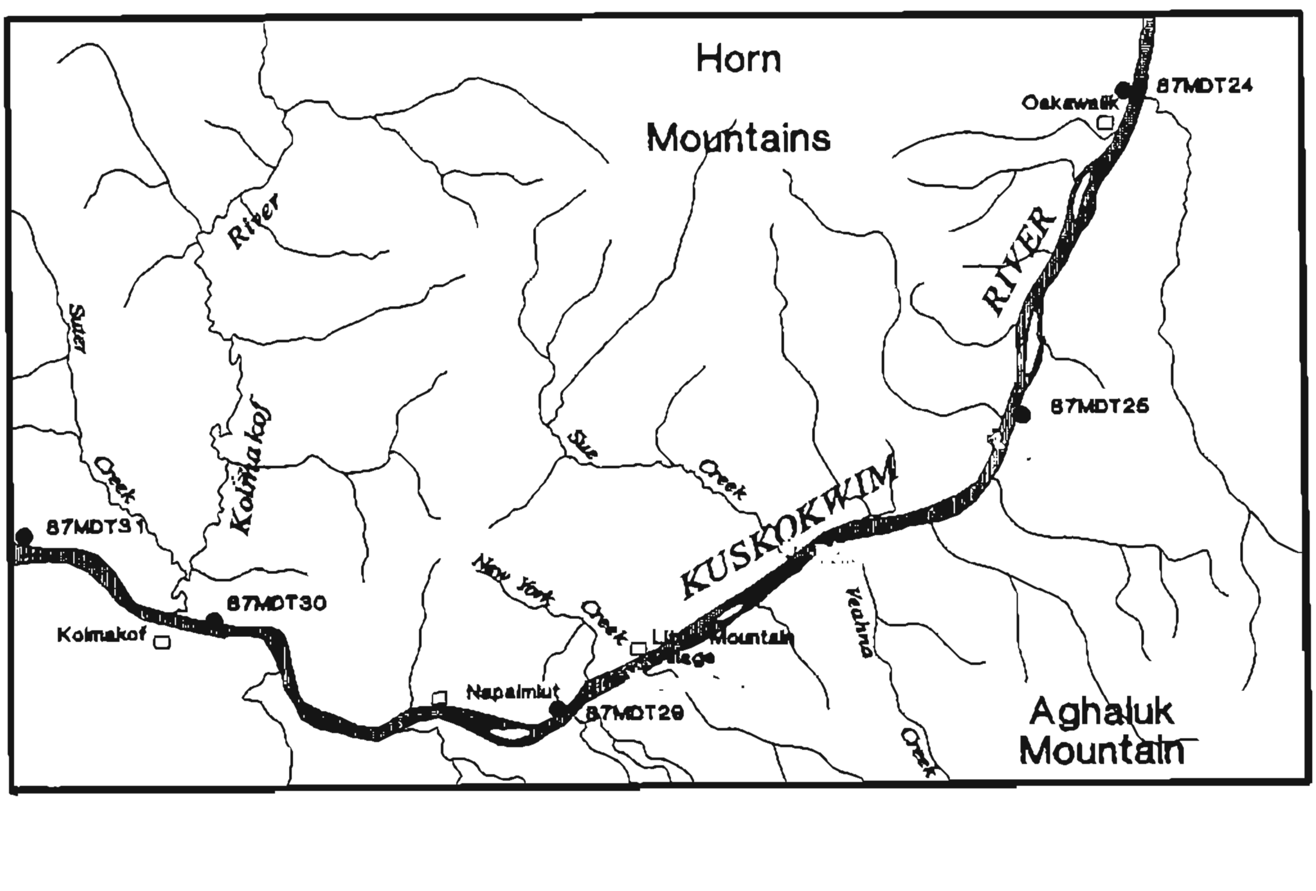

Figure 26. Riprap sampling sites from Oskawalik to Kolmakof, Lower Kuskokwim River, Alaska.

angular blocks up to 36 by 18 by 12 in. in dimension (fig. 27). Small zones on the hillslope contain Class I-sized fragments, but it is impossible to determine a resource size. A 55 lb sample from the shoreline yielded a T-13 degradation value of 21, well below the minimum (45) recommended by DOTPF for riprap. It is difficult to further evaluate the quarry potential of the prospect without trenching and drilling.

SITE 87MDT29: NAPAIMIUT-GIBRALTAR POINT SANDSTONE SITE, SLEETMUTE C-7 QUADRANGLE

Location

Conspicuous bluff exposures of sandstone and siltstone occur at Gilbraltar Point (NE¼, NW¼, Sec. 30, T17N, R52W) about 4 mi upstream from the village of Napaimiut (fig. 26).

Geologic Description

Impressive exposures of interbedded lithic sandstone, siltstone, and shale crop out for a distance of about 2 mi in the Gibraltar Point area (fig. 28). Thin-bedded units strike N40°E and dip moderately to the northwest. Inverted plates, graded bedding, and sole marks indicate that the stratigraphy of the entire outcrop area is upside down (fig. 29). Individual sandstone layers are thin and range from 6 to 36 in. In thin section, medium-grained sandstones are composed of quartz (25 percent), chert (20 percent), myrmekite (10 percent), white mica (4 percent), chlorite (3 percent), volcanic (5 percent), and calcite cement, (25 percent). The sandstone is classified as a highly calcareous lithic calcarenite.

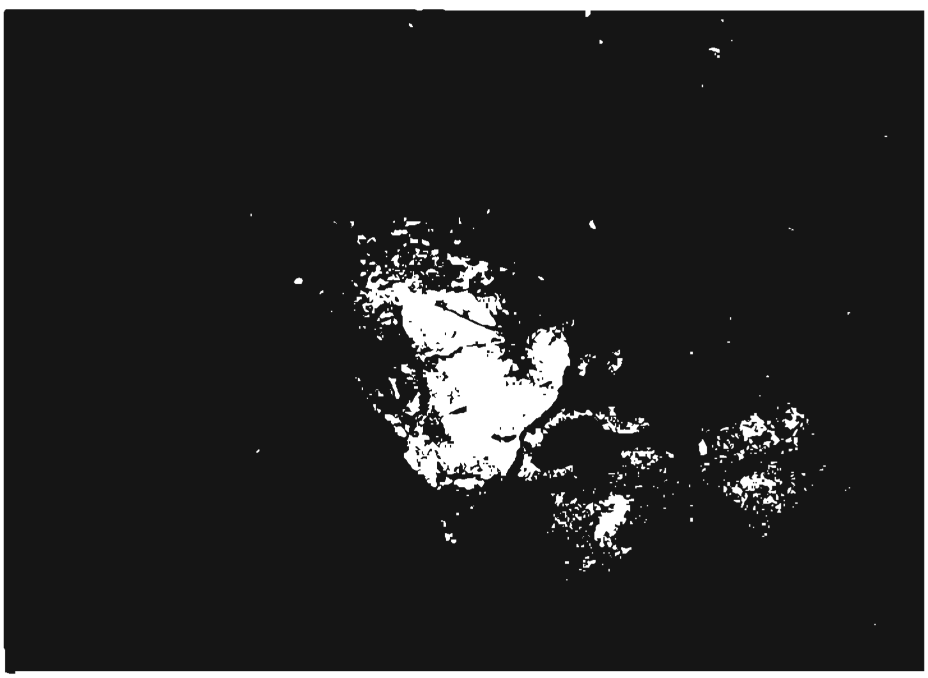

Figure 27. Rhyolite slab on beach, sample site 87MDT25.

In the largest bluff exposure (fig. 29), siltstone and shale overlie more sandstone-rich zones. The average sandstone-shale ratio in the bluff exposure is about 2:1.

Structure, Physical Properties, and Volume Estimate

Although the exposures appear relatively undeformed, both fine and coarse-grained clastic units are cut by closely spaced fractures and joints, that create beach rubble with individual fragments larger than 2 by 2 by 4

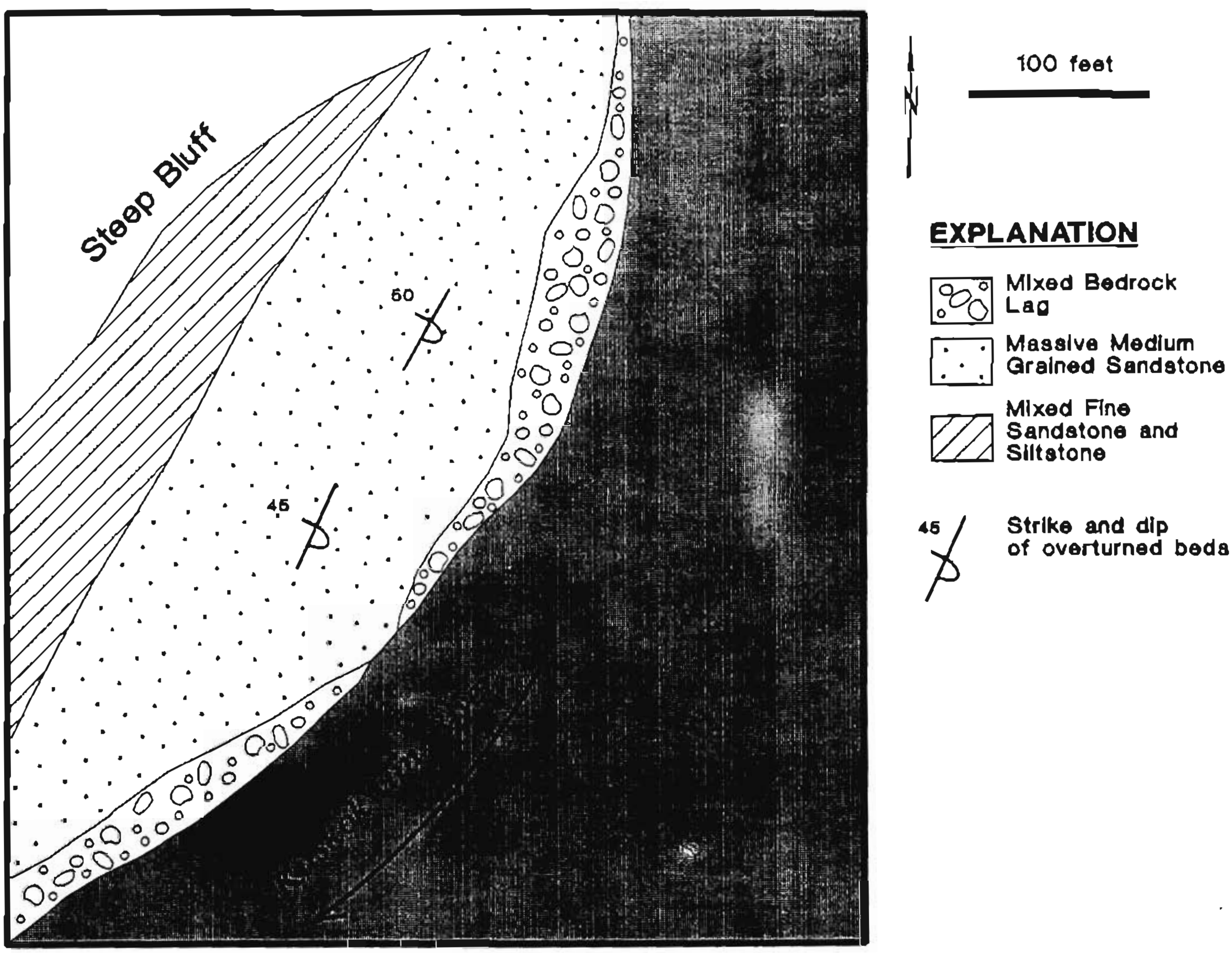

Figure 28. Geologic sketch of Napaimiut-Gibraltar Point site (87MDT29), Sleetmute C-7 Quadrangle, Alaska.

in. No material is judged to be of riprap quality. However, at least 700,000 yd^3 of rock possibly suitable for crushed aggregate is available at beach level.

SITE 87MDT30: KOLMAKOF SITE, SLEETMUTE C-8 QUADRANGLE

Location

Extensive bluffs underlain by interbedded sandstone and siltstone are exposed 2 mi upriver from the mouth of the Kolmakof River (NW¼, SE¼, Sec. 12, T17N, R55W) and near the old village site of Kolmakof (fig. 26).

Geologic Description

Well-exposed outcrops consist of coarse lithic sandstone and highly micaceous siltstone striking N50°E and dipping 40°-45°NW (fig. 30). On the basis of graded bedding and flutes, the section appears to be right-side-up. Several Inoceramus shells were identified in beach rubble, confirming the section is Late Cretaceous in age. In thin section, sandstones are mainly composed of clasts of sedegenic origin. Subangular clasts are chert (35 percent), polycrystalline quartz (30 percent), white mica (2 percent), volcanics (5 percent), slate clasts (15 percent), graphite (6 percent), prehnite (4 percent), and calcite (3 percent).

Figure 29. Interbedded turbidite sandstone and shale, sample site 87MDT29. Section is overturned.

The section shows distinct cyclic sedimentation with coarse "Bouma" A-C intervals in sandstone-rich zones. Overbank siltstone deposits are dominated by B-E 'Bouma' intervals. Overall, the rock section probably represent a mid-fan turbidite fan environment.

Structure, Physical Properties, and Volume Estimate

An evenly spaced conjugate joint set strikes N25°W and dips vertical and strikes N45°E and dips 64°SE, breaking sandstone-rich zones into sizes ranging from 2 by 2 by 2 in. to 4 by 6 by 8 in. About 35 percent of the rubble adjacent to the beach probably averages 4 by 4 by 4 in.

On the basis of a minimum volume of 50 by 500 by 200 ft, the site contains approximately 185,000 yd^3 of variable lithologies. Surprisingly, a 25 lb sample from the shoreline yielded a T-13 degradation value of 44--about the minimum requirement outlined by DOTPF for riprap applications. Riprap

Figure 30. Rubble clasts of turbidite section at sample site 87MDT30 near Kolmakof River.

quality material is generally not present, but some subsurface investigation might be warranted.

SITE 87MDT31: SOUTHEAST RUSSIAN MOUNTAINS SITE, SLEETMUTE C-8 QUADRANGLE

Location

Outcrops of sedimentary and igneous (dike) rock are exposed in steep slopes in the north side of the Kuskokwim River (SW¼, NE¼, Sec. 1, T17N, R54W) near the Sleetmute-Russian Mission Quadrangle boundary.

Geologic Description

Semicontinuous outcrops of massive, distinctly green to greenish gray, lithic sandstone rich in plant fragments underlie a siltstone-dominated turbidite section for at least 650 ft (fig. 31). Intruding the sedimentary rocks are two, medium-gray, andesite dikes. In thin section dike rocks are composed of 70 percent oriented trachytic andesite laths; 3 to 5 percent prehnite as alteration mineralogy; 5 to 8 percent carbonate as alternation of feldspar, 6 to 8 percent isolated euhedral hornblende grains, and 11 percent mixed leucoxene, clinopyroxene, epidote, and chlorite. The rock types are classified as an andesite porphyry intrusive into sedimentary rocks of the Kuskokwim Group. The dikes strike approximately N45°E and dip steeply northwest.

Structure, Physical Characteristics, and Volume Estimate

No distinct joints or fractures were observed in outcrop. Massive andesite porphyry dikes spall off equant to rectangular slabs of material averaging 4 by 6 by 8 in. (figs. 32 and 33). Similarly, the coarse, greenish, silicified sandstone, part of which may be hornfeled near the dikes, breaks up into very angular blocks ranging from 4 by 6 by 10 in. to 6 by 10 by 14 in. (fig. 33). Most of the coarsest material qualifies in terms of size as Class I riprap. Some dike rock is of Class II size.

The beach is 36- to 60-ft wide and a quarry prospect exists in the central dike area. Utilizing both thermally altered green sandstone, and andesite porphyry as the resource base, a minimum dimension of 55 by 275 by 100 ft or 56,000 yd^3 is available for extraction with overburden ratios of less than 3:1. This estimate assumes that both the silified sandstone and andesite have similar physical properties (hardness, etc.); however, no degradation values are available from either rock type from the site.

SITE 87MDT32: SOUTHCENTRAL RUSSIAN MOUNTAINS SITE, RUSSIAN MISSION C-1 QUADRANGLE

Location

The same steep bluff section described in the section on site 87MDT31 was sampled about 6 mi upstream from the village of Chuathbaluk (fig. 34).

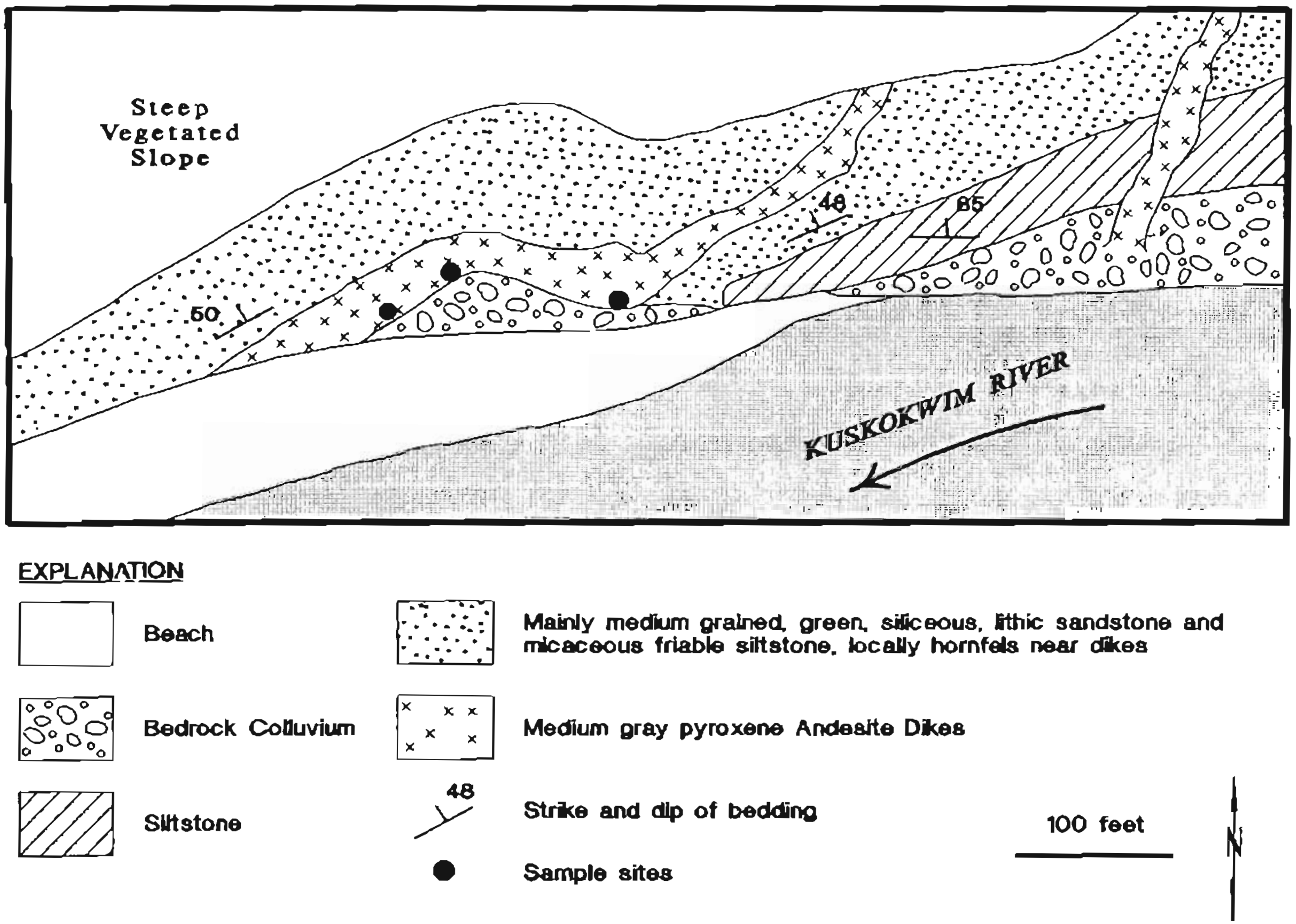

Figure 31. Geologic sketch of 87MDT31 site, Sleetmute C-8 Quadrangle, Alaska.

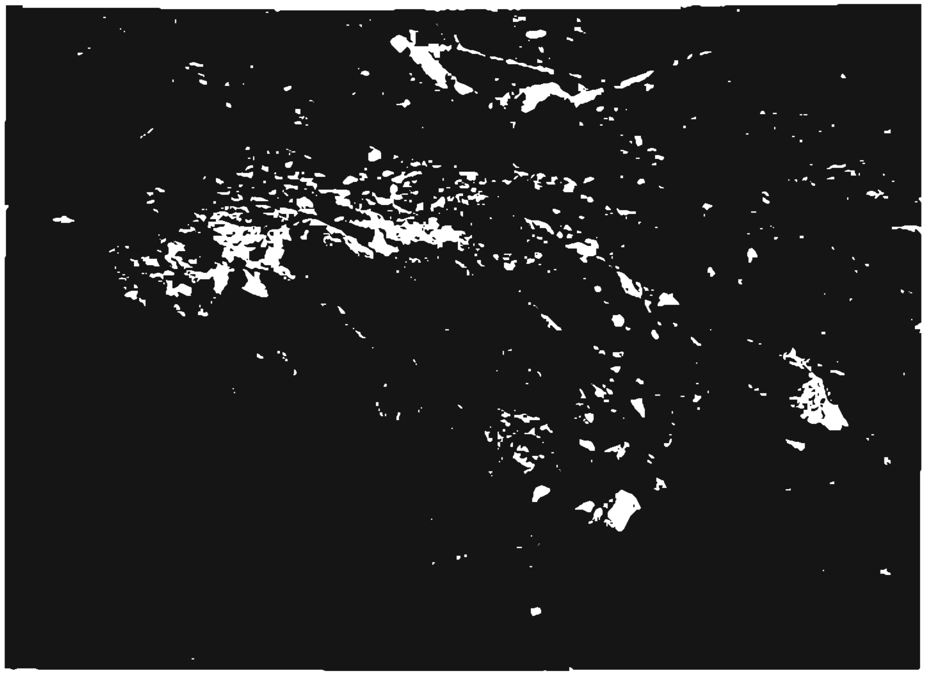

Figure 32. Massive andesite porphyry dike intruded into Kuskokwim Group sandstone, sample site 87MDT31.

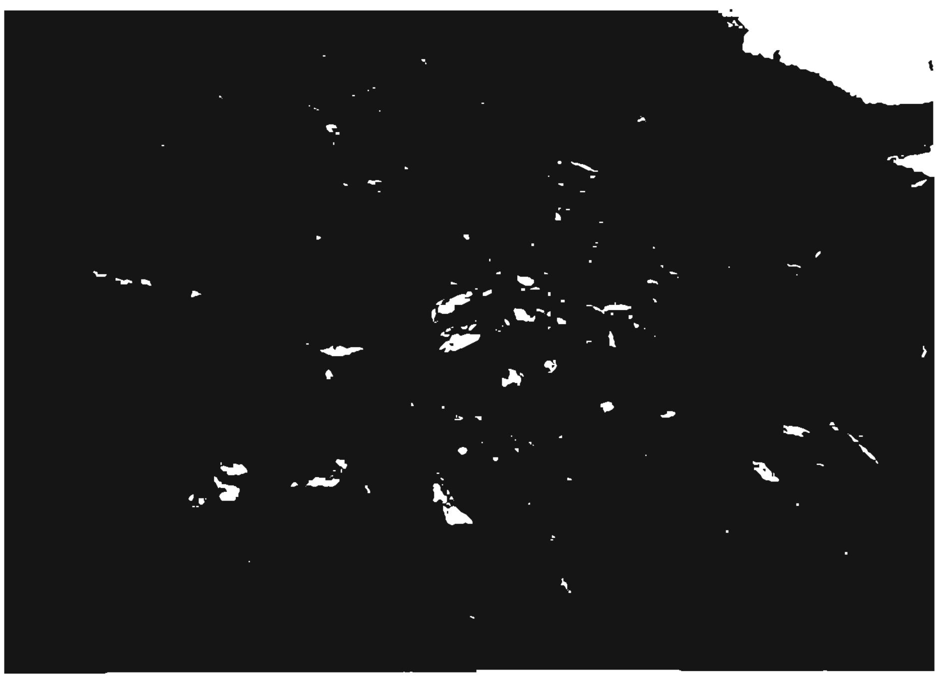

Figure 33. Rubble of coarse, lithic sandstone at sample site 87MDT32.

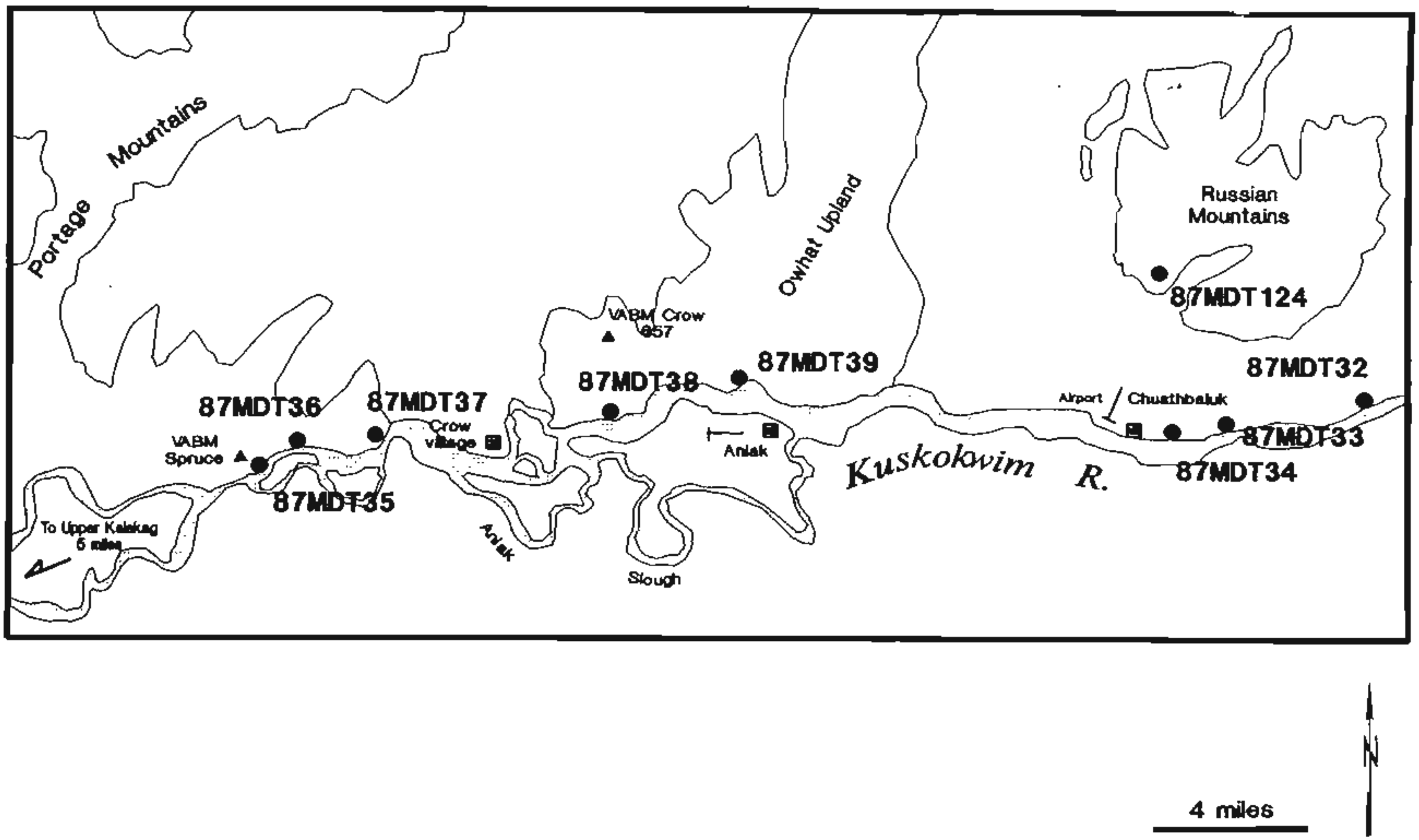

Figure 34. Location of riprap and gravel sample sites from Russian Mountains to Portage Mountains, Kuskokwim River.

Geologic Description

Interbedded, medium-grained, gray lithic sandstone and siltstone of a mid-fan turbidite section strike N52°E and dip 32°NW, similar to that of site 87MDT31. Sandstone in this locality is very calcareous. In thin sections, sandstone is composed of calcite matrix (40 percent), calcite grains (10 percent), quartz (20 percent), chert (15 percent), slate clasts (5 percent), granite (3 percent), white mica (2 percent), and albite (5 percent). Flutes indicate that the section is upright. Estimated average sand-shale ratio is about 3:1 over a 150-ft-thick section.

Structure, Physical Properties, and Volume Estimate

Closely spaced, N50°W striking, vertically dipping joints cut the rock lithologies into small 1 by 2 by 2 in. fragments. Pieces in float larger than 2 by 2 by 4 in. are rare. The site is judged to be unsuitable for riprap.

SITE 87MDT33: CHUATHBALUK SITE, RUSSIAN MISSION C-1 QUADRANGLE

Location

A steep cliff of igneous and sedimentary rocks crops out near a prominent bend on the north side of Kuskokwim River (NW¼, SE¼, Sec. 12, T17N, R55W) about 2 mi upstream from the village of Chuathbaluk (fig. 34).

Geologic Sketch

A prominent, northwest-trending basalt-andesite dike system cuts dark-gray Kuskokwim Group sedimentary rocks. During its intrusion, the dike generated enough heat to produce a hornfels aureole about 50 ft wide, which is unusual for such a small intrusive body. The 45- to 60-ft-thick basalt andesite dike has vertical contacts with enclosing hornfels.

Structure, Physical Properties, and Volume Estimate

Dikes have a well-developed 'columnar-like' joint set with N12°W striking 60°NE dipping, N30°E striking 30°SE dipping, and N5°E striking 30°NW dipping orientations (figs. 35 and 36). Evenly spaced joints have created large blocky material averaging 6 by 10 by 12 in. The largest dike has a surface dimension of 55 by 70 by 70 ft and the eastern subsidiary dike has a measured dimension of 25 by 75 by 45 ft. Total inferred volume at the beach is about 13,125 yd^3; incremental additions to this resource are probable but not assured when one considers the irregularities of dike swarms in the area. At least 85 percent of the dike material qualifies in terms of size as Class I riprap and nearly 40 percent achieve Class II size specifications. However, a 65 lb sample of basalt from this site yielded a T-13 degradation value of only 10--far below the minimum (45) recommended by DOTPF for riprap applications (table 1). We have no explanation why the material performed so poorly in lab testing and additional lab work is suggested.

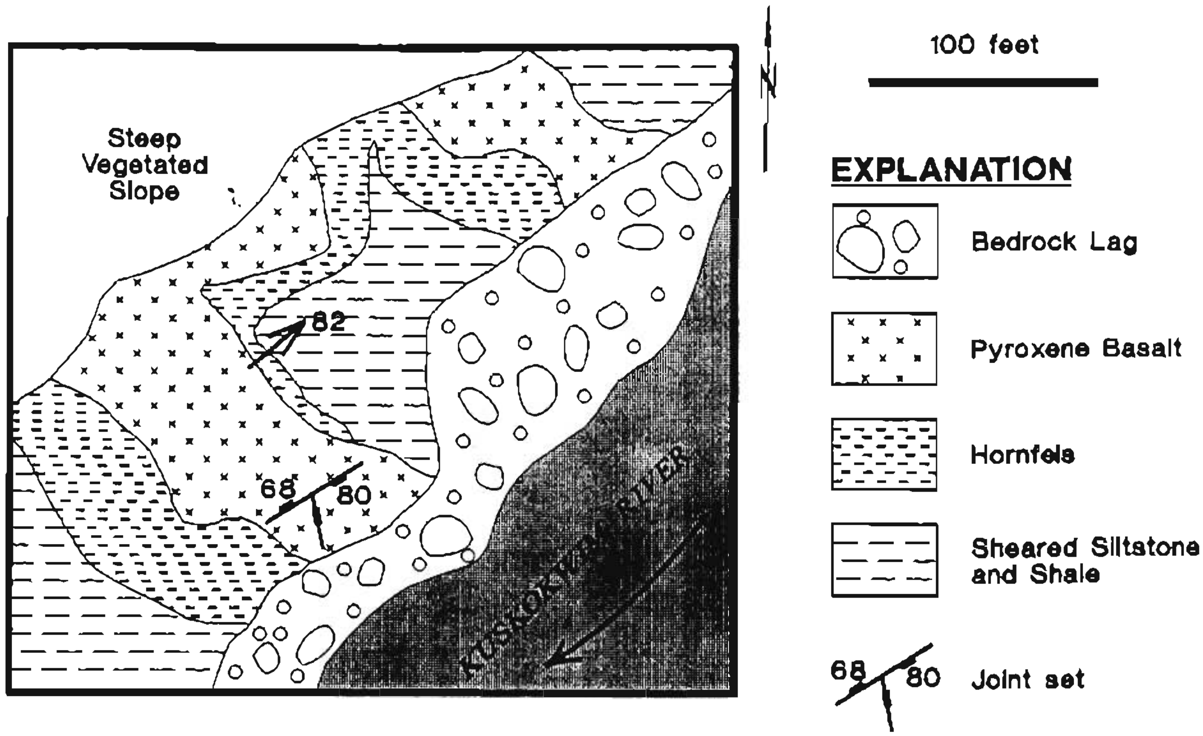

Figure 35. Geologic sketch of Mission Creek site (87MDT33), Russian Mission C-1 Quadrangle, Alaska.

Figure 36. Blocky basalt sill at sample site 87MDT33.

SITE 87MDT35: VABM SPRUCE SITE, RUSSIAN MISSION C-3 QUADRANGLE

Location

Bluff exposures of andesite porphyry and volcanic tuff crop out on the north side of the Kuskokwim River (SW¼, NE¼, Sec. 16, T17N, R60W) about 12 mi upriver from Upper Kalskag village.

Geologic Description

An andesite sill complex intrudes greenish tuffaceous sandstones of the Paleozoic-Mesozoic Gemuk Group (Cady and others, 1955) in two mappable phases. The outer phase consists of greenish-gray, very fine-grained, sheared andesite with extensive epidote alteration grains. The core area (fig. 37) consists of a massive porphyritic, blocky andesite less altered than the outer rim phase. In thin section, the epidotized andesite is composed of clinopyroxene phenocrysts altered to chlorite and prehnite (8 percent), and a matted groundmass of calcic plagioclase, leucoxene, and chlorite (60 percent). The groundmass is overprinted by epidote and clay alteration (32 percent).

Structure, Physical Properties, and Volume Estimate

The core phase of the sill has evenly spaced, high angle joints of E-W vertical; striking N20°W dipping 80°SW orientations and the outer rim shows very closely spaced conjugate cleavage striking N70°E dipping 80°SE and striking N10°E dipping 80°SE. The more massive core phase spalls off into remarkably uniform 4 by 4 by 6 in. blocks with occasional blocks measuring 24 by 16 by 12 in. (fig. 38). A 70 lb sample of andesite yielded a T-13 degradation value of 75 well above the minimum (45) recommended by DOTPF for riprap and the second highest value obtained during the study. A possible riverside quarry site of the massive material measures 370 by 100 by 55 ft or 75,000 yd^3 of material. We estimate that fully 90 percent of the sill volume qualifies as Class I riprap, based on size. Some Class-II-sized material is also present. Any further expansion of this resource would involve extensive overburden removal of the 200-ft-high bluff face.

SITE 87MDT36: UPPER VABM SPRUCE SITE, RUSSIAN MISSION C-3 QUADRANGLE

Location

Rocks of mainly igneous parentage crop out in more bluff exposures (SE¼, NE¼, Sec. 10, T17N, R60W) about 2½ mi upstream from the 87MDT35 'Spruce' site (fig. 34).

Geologic Description

The outcrop consists of Gemuk Group pillow basalt, tuff, chert, and overlying andesite intrusive or pyroclastic flow rock (fig. 39). The competent blocky, 25-ft-thick pyroclastic flow or intrusive is the riprap target. The unit trends N15°E for 220 ft where it disappears into the steep 150-ft-high bluff away from the river.

Structure, Physical Properties, and Volume Estimate

About 40 percent of this unit spalls into 8 by 8 by 10 in. blocks, but the potential quarry size is quite limited due to the bluff face. A 40 lb sample of andesite sill yielded a T-13 degradation value of 50, above the minimum (45) recommended by DOTPF for riprap (table 1). A 150 by 15 by 30 ft volume or about 2,500 yd^3 could be made available for use. Virtually all of this volume is Class I and Class II riprap (based on size).

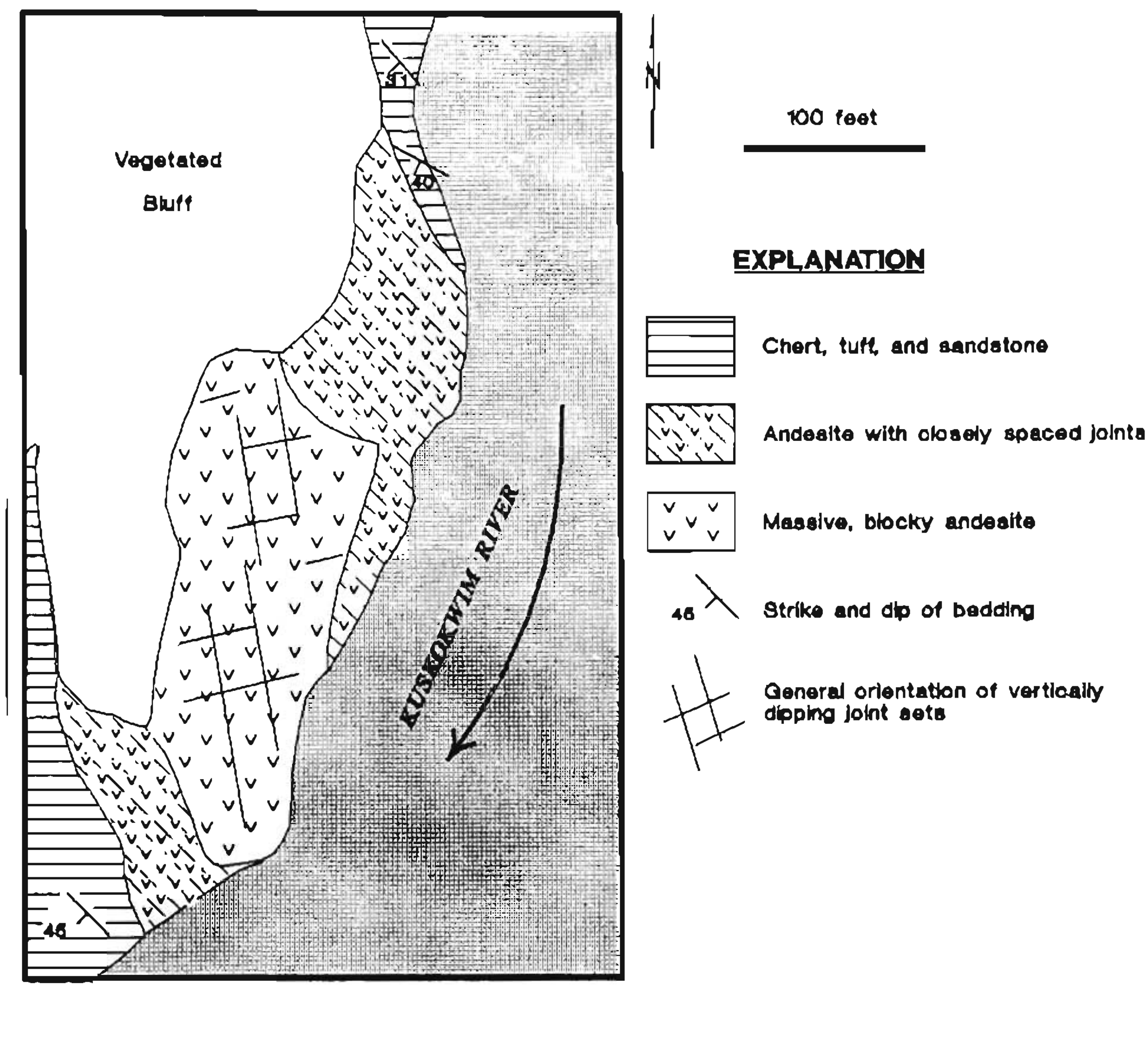

Figure 37. Geologic sketch of VABM Spruce site (87MDT35), Russian Mission C-3 Quadrangle, Alaska.

SITE 87MDT37: EASTERN PORTAGE MOUNTAINS SITE,
RUSSIAN MISSION C-3 QUADRANGLE

Location

Bluffs of Gemuk Group volcanic and sedimentary rocks form the easternmost area of the Portage Mountains upland (NE¼, NW¼, Sec. 7, T17N, R58W) about 4 mi downstream from Crow Village (fig. 34).

Geologic Description

Bedrock exposures in the steep bluff face consist of a mixture of green tuffaceous sedimentary rock and either intrusive sill or extrusive andesite. Contacts with the underlying sediments are roughly conformable, but chilled margins are also evident.

Figure 38. Massive-jointed andesite sill, sample site 87MDT35.

Two separate phases--1) closely jointed and 2) massively jointed equigranular to porphyritic andesite are depicted on the geologic sketch (fig. 40). The more massive phase appears to be the lowest of the two in stratigraphic arrangement. In thin section, the andesite is extensively altered with pennine chlorite comprising nearly 40 percent of the groundmass. The remaining groundmass contains sphene (10 percent), altered plagioclase (35 percent), magnetite (6 percent), and prehnite (9 percent).

Structure, Physical Properties, and Volume Estimate

Three major joints were measured in the most massive basal phase: striking N35°E dipping 80°SE; striking N80°E dipping 40°SE; and striking N15°E dipping 39°SE. Fractures and joints result in beach-lag blocks, equant in shape, ranging from 2 by 2 by 4 in. to 6 by 8 by 10 in. Assuming a strike length of 750 ft, and width and height of 80 and 75 ft respectively, a quarry potential of 165,000 yd^3 exists at the sample site. We estimate that 60 percent of this volume is Class-I-sized riprap. However, a 65 lb sample of andesite tuff yielded a T-13 degradation value of 22 effectively failing the minimum (45) recommended by DOTPF for riprap.

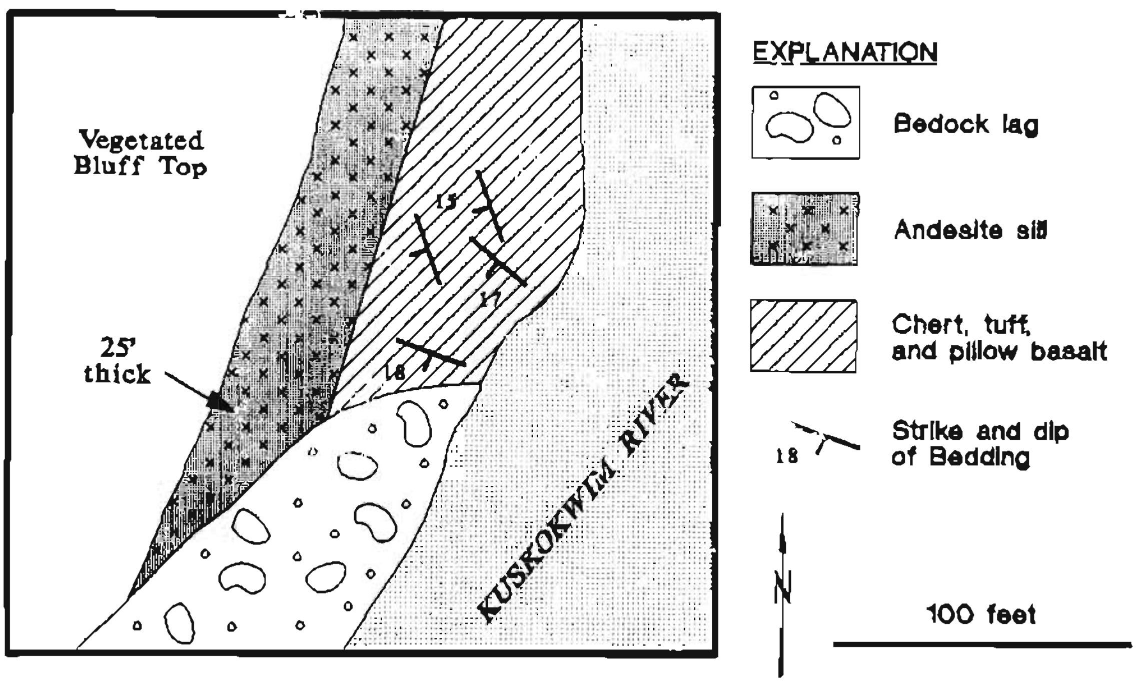

Figure 39. Geologic sketch of sample site 87MDT36, Russian Mission C-3 Quadrangle, Alaska.

SITE 87MDT38: VABM CROW SITE, RUSSIAN MISSION C-2 QUADRANGLE

Location

Bluff exposures of andesite tuff and flow rock crop out on the north side of Kuskokwim River (NE¼, SW¼, Sec. 6, T17N, R58W) about 8 mi downriver from Aniak (fig. 34).

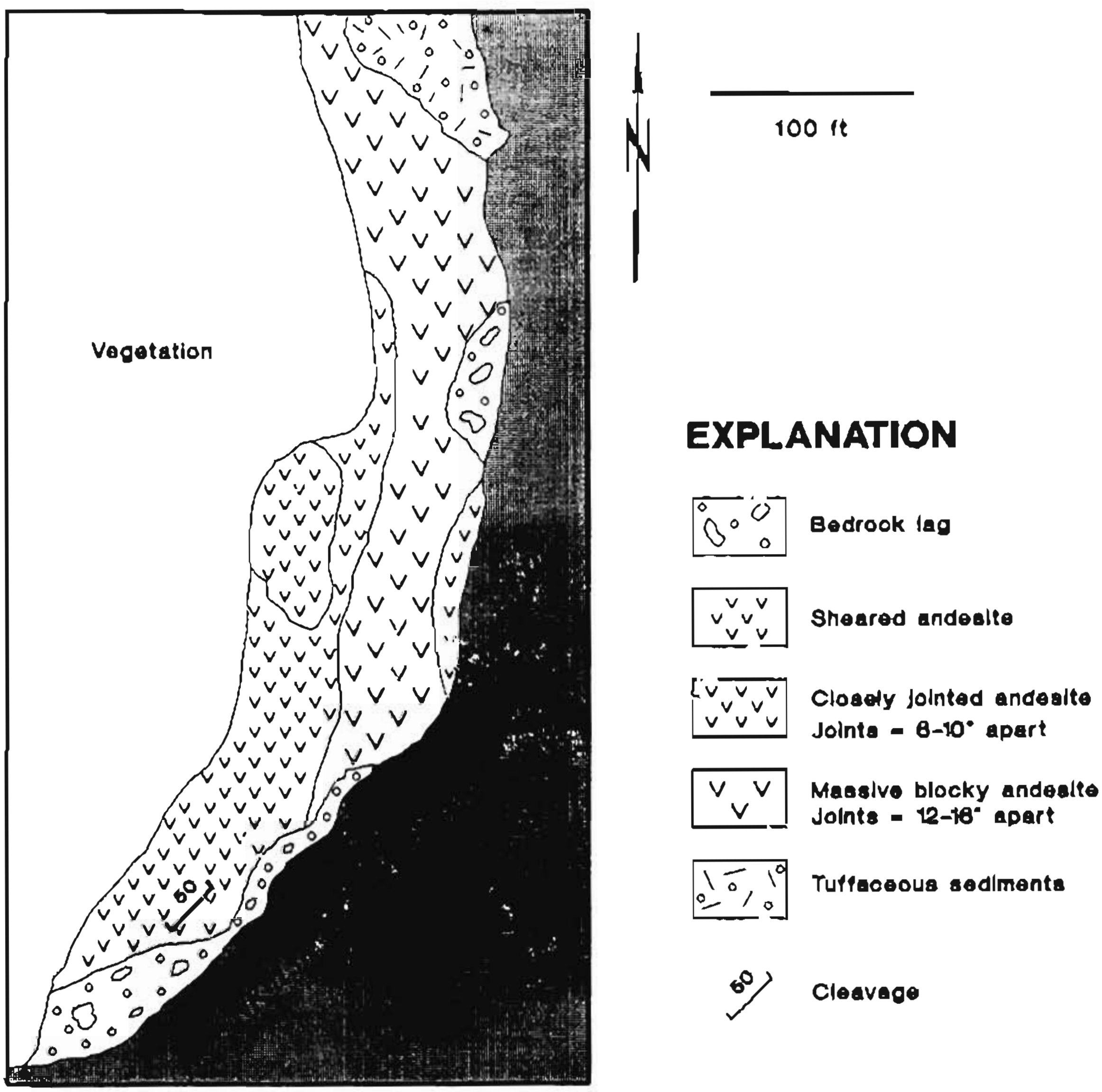

Figure 40. Geologic sketch of site 87MDT37, Russian Mission C-3 Quadrangle, Alaska.

Geologic Description

As at site 87MDT37, two phase of igneous lithologies were recognized: 1) sheared, equigranular, altered andesite; and, 2) more massive, blocky, andesite tuff. The latter is exposed as a roughly equant block lined by the more sheared and fractured variety (fig. 41).

Structure, Physical Properties, and Volume Estimate

In the massive phase, evenly spaced, N85°E striking and dipping 65°NW and N5°W striking and dipping 45°SE joints have produced blocks ranging from 2 by 2 by 4 in. to 12 by 12 by 10 in. with the larger range predominating. A wide beach ramp accesses the massive unit at the west end of the mapped exposures. Volume estimates are limited by steep bluffs at the site (fig. 42). Assuming dimensions of 250 by 35 by 25 ft, 8,000 yd^3 of material are available without benching. In terms of size, virtually all of this volume is Class-I and II riprap. A 80 lb sample of andesite yielded a T-13 degradation value of 44--about at the minimum (45) recommended by DOTPF for riprap. Drilling along the bluff tops and benching will probably block out much more riprap material.

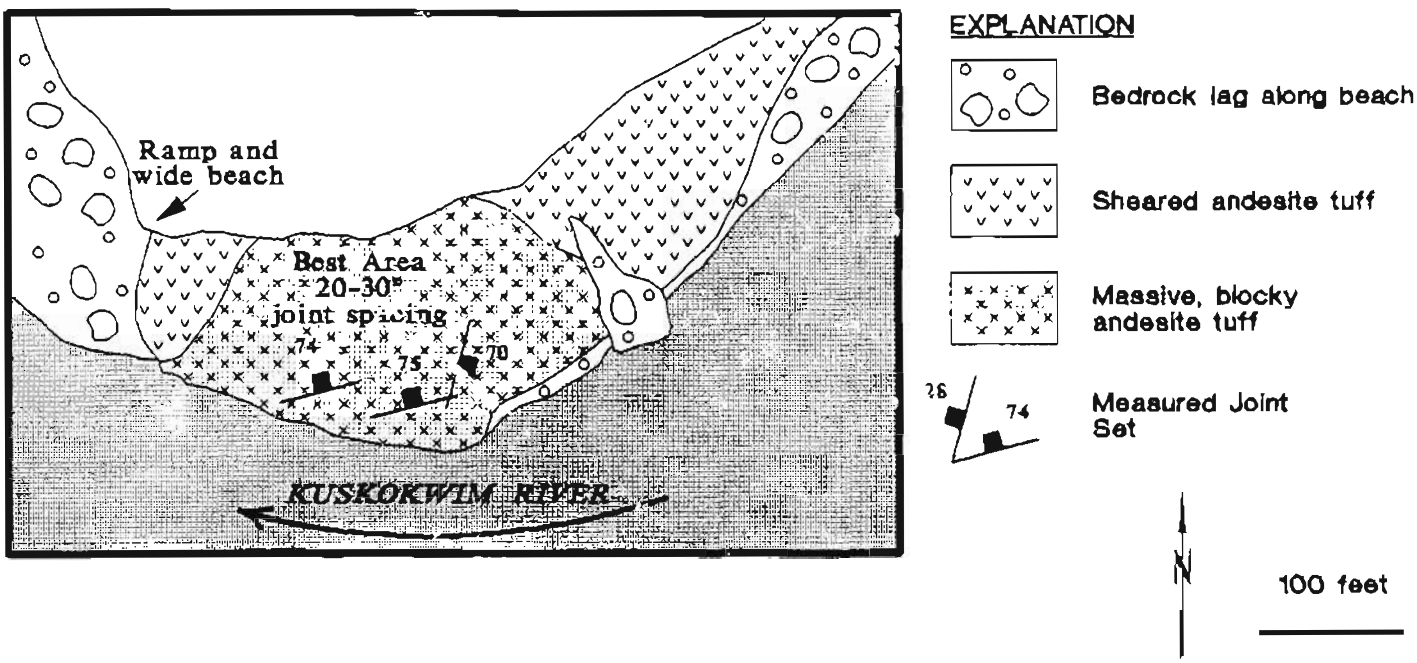

Figure 41. Geologic sketch of VABM CROW site (87MDT38), Russian Mission C-2 Quadrangle, Alaska.

SITE 87MDT39: ANIAK BLUFF SITE, RUSSIAN MISSION C-2 QUADRANGLE

Location

Steep andesitic greenstone bluffs were examined opposite Aniak on the north bank of Kuskokwim River.

Geologic Description

Steep bedrock bluffs near Aniak are composed of massive to sheared, heavily altered greenstone--probably similar to andesite described at sites 87MDT35 through 87MDT38. However, unlike the previous occurrences, the andesite at this site is completely altered so that original igneous minerals have been completely changed to a groundmass of calcite, chlorite, leucoxene, and magnetite.

Figure 42. Massive-jointed andesite at sample site 87MDT38.

Structure, Physical Properties, and Volume Estimate

Major shear planes striking N20°E and dipping 20°NW pervade the outcrop. Small cross-cutting shears intersect a prominent shear zone and have created small 1 by 2 by 2 in. sized fragments (fig. 43). The site is judged to be unsuitable for riprap.

SITE 87MDT124: RUSSIAN MOUNTAINS QUARTZ MONZONITE SITE, RUSSIAN MISSION C-1 QUADRANGLE

Location

Very prominent exposures of quartz monzonite occur at the base of the Russian Mountains (SW¼, NW¼, Sec. 23, T18N, R55W) about 3½ mi north of the village of Chuathbaluk (figs. 34 and 44).

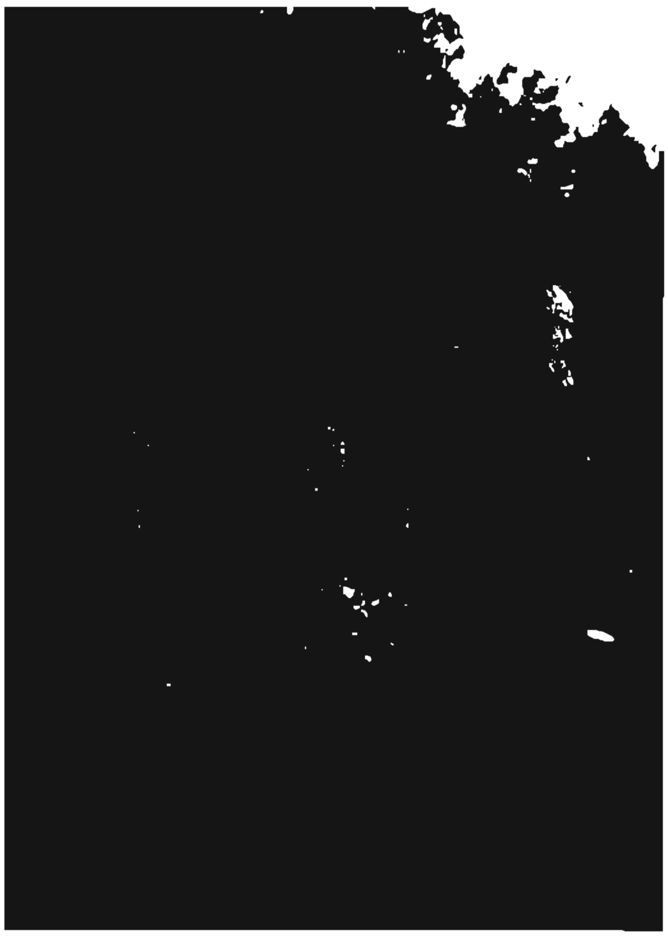

Figure 43. Incompetent greenstone 4 mi downriver from Aniak, sample site 87MDT39.

Geologic Description

Bedrock exposures examined at this site consist of massive, medium-grained, equigranular to porphyritic, diopside-biotite quartz monzonite. The monzonite is the southwest rim of a pluton, about 20 mi^2 in area, that forms the core of the Russian Mountains.

Structure, Physical Properties, and Volume Estimate

Several joint sets occur in rock exposures. The most prominent measured strike N75°E and dip 60°NW, striking N10°E and dipping vertical, and striking N85°W and dipping 15°SE. The latter joint is a pervasive exfoliation joint or cleavage that is found in lower-most isolated outcrops (fig. 44).

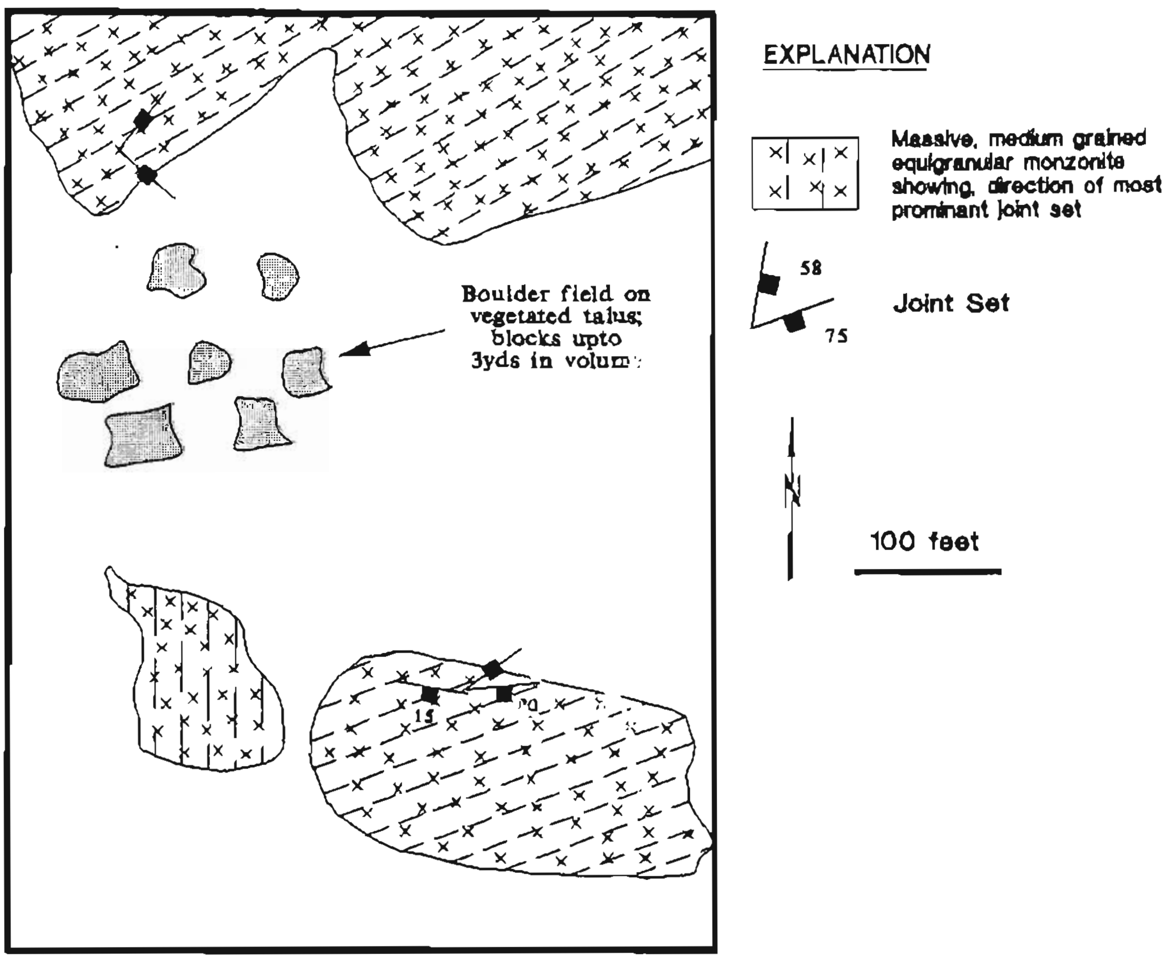

Figure 44. Geologic sketch of Russian Mountains quarry prospect (87MDT124), Russian Mission C-1 Quadrangle, Alaska.

The material on the surface forms large angular blocks averaging 24 by 14 by 30 in. but much larger material is available (figs. 45 and 46). The entire site contains a very large resource of riprap. We suggest that a quarry could excavate material at the toe of the steep ridge. The site has not been drilled and the possibility of intersection of decomposed grüss as at site 87MDT11 (Roundabout Mountain) near McGrath needs to be evaluated. However, we estimate that a 750 by 400 by 60 ft zone or at least 650,000 yd^3 of reserves are available. In terms of size, all of this volume would pass both Class I and II riprap specifications, at least 50 percent would probably qualify as Class III and IV riprap, pending subsurface and blasting confirmation.

A 110 lb sample collected in the isolated outcrops away from the mountain base yielded a T-13 degradation value of 84, the highest analysis found in 22 samples submitted for this test (tables 1 and 2). We emphasize that no subsurface data is available and that similar groundwater weathering to that encountered at Roundabout and Sugarloaf Mountains near McGrath might preclude development. However, we judge that shallow surface volume observed in outcrops alone is of sufficient size to consider this a good riprap quarry site.

KALSKAG MATERIALS SITE STUDIES, PORTAGE MOUNTAINS

Introduction

Seven material sites were sampled and examined in uplands immediately north of Upper Kalskag village, Alaska. The bedrock sites occur on the last upland area in the Kuskokwim River drainage (fig. 47). Downstream from this point the Yukon-Kuskokwim Delta is dominated by thick deposits of fluvial (river), lacustrine (lake), and eolian deposits (wind blown) deposits, and muskeg.

Unlike the previous bedrock sampling sites, the primary focus of these investigations was to locate a source of aggregate for local road and airport construction. Laboratory analyses were commercially obtained for most of the sampling sites and summarized in the following individual narratives and in table 2.

SITE 88MDT1: EASTERN FLANK OF PORTAGE MOUNTAIN

Location

Metamorphosed volcanic rocks were sampled from the 500-ft elevation on a eastern ridge 1 mi northeast of Upper Kalskag village (fig. 48). The site is just above timberline and accessible only on foot.

Geologic Description

Bedrock 'pavement' consists of fine- to medium-grained, medium- to dark-green, feldspar, prehnite-rich meta-andesite. Prehnite infills amygdaloidal cavities and fractures. Also identified in thin section were pyrite, olivine altered to iddingsite and augite altered to leucoxene.

Figure 45. Closeup of tors at sample site 87MDT124.

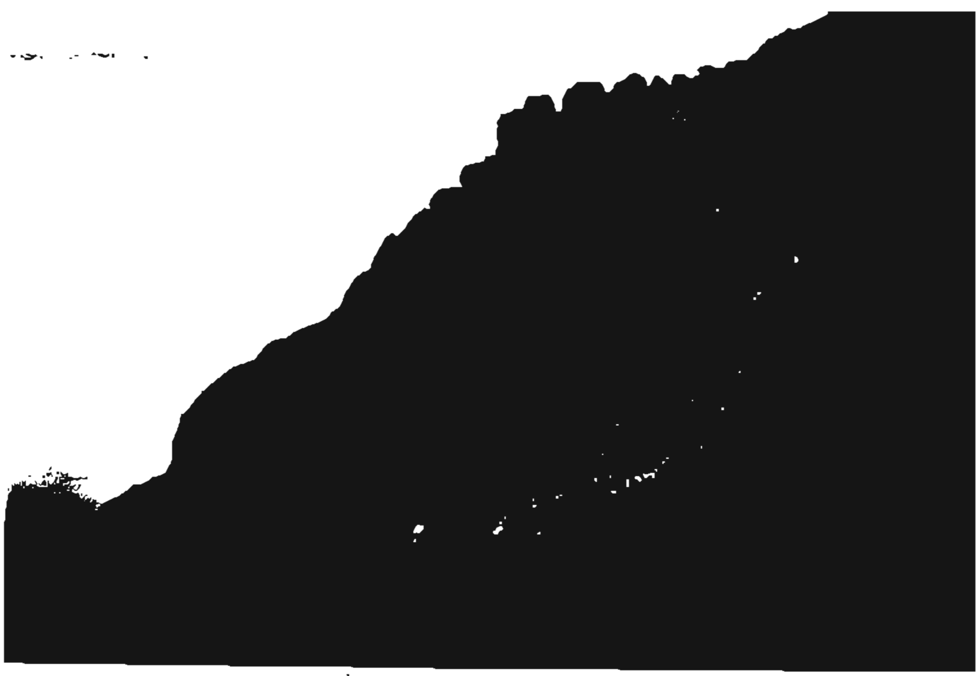

Figure 46. Rugged bedrock hillslope above sample site 87MDT124 about 3 mi from Chuathbaluk.

Table 2. Laboratory test results, material samples from Upper Kalskag Area, Russian Mission Quadrangle, Alaska.[1]

Sample No.	Surface Saturated Specific Gravity	Alaska Test Method (T-13) Degradation	Absorbtion	Percent Moisture	Los Angeles Abrasion Grading B (% loss)	Petrographic Analysis
88MDT1	2.72	56	0.012	0.9	--	Clinopyrexone andesite with andesine plagioclase (15%), quartz (11%), hornblende (10%), undetermined alteration and groundmass (49%)
88MDT2	2.76	83	0.003	0.2	--	Indurated hornfels with biotite (5%), prehnite (?) (5%), finely interlocking quartz and feldspar (90%)
88MDT3	2.74	65	0.004	0.5	--	Pyroxene Diorite
88MDT8	2.78	73	0.005	0.9	12.3	Sheared Andesite

[1]Analyses by Alaska Test Labs Inc., Fairbanks, Alaska.

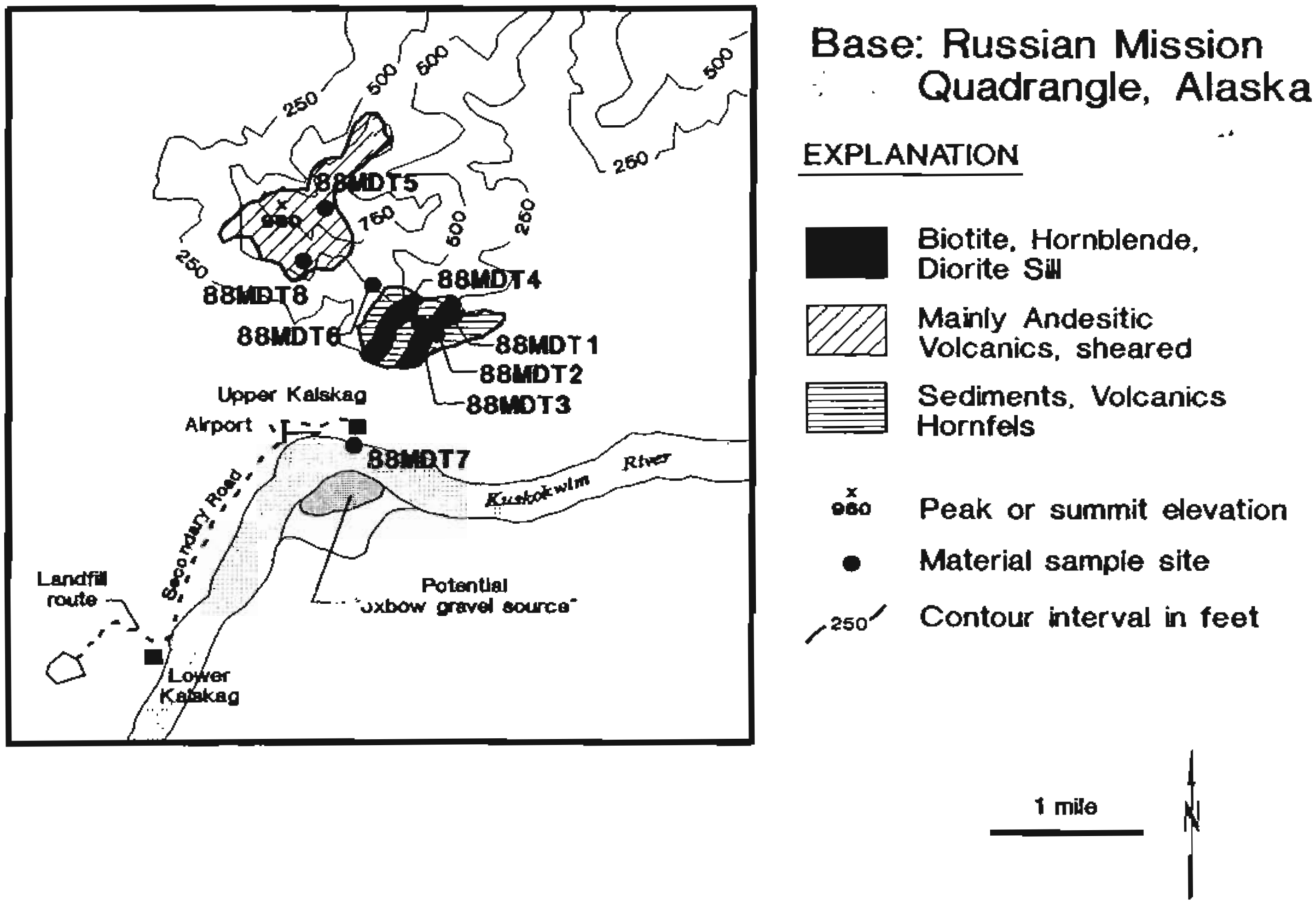

Figure 47. Location map showing generalized bedrock geology sketch and sample sites for Kalskag materials study.

Structure, Physical Properties, and Volume Estimate

Rubble ranges in size from ½ by 1 by 1 in. to 3 by 3 by 6 in.; the average for flattened, lichen-covered pavement is 2 by 3 by 4 in. The material has a saturated, dry specific gravity of 2.72, and absorption value of 0.012, and a moisture content after crushing of 0.9 percent, and an Alaska Test Method T-13 degradation value of 56. The last test indicates that the material passes Alaska DOTPF minimum aggregate degradation limits of 45.

The entire eastern flank of the ridge crest is underlain by the meta-andesite unit. Assuming a strike length of 1,200 ft, a minimum quarry width of 300 ft, and a single bench depth of 150 ft, a minimum 2 million yd^3 of this material could be available for extraction.

SITE 88MDT2: HORNFELS, EASTERN PORTAGE MOUNTAIN

Location

Massive, blocky to sheared hornfels is exposed about 600 ft west of site 88MDT1 at 520 ft elevation on the eastern rib of Portage Mountain (fig. 47).

Geologic Description

Blocky outcrops consist of dark-gray, resistant, heavily jointed, massive, aphanitic hornfels. Outcrops are limited to above timberline and on the steep slope south of the ridge crest (fig. 49).

Structure, Physical Properties, and Volume Estimate

The hornfels in outcrop contains three distinct joints: 1) striking N25°W dipping 80°NE; 2) striking N60°W dipping 55°NE; and 3) striking N60°E dipping 40°SE (fig. 49). The N25°W-striking joint is the most pervasive and is consistently spaced (2- to 3-in.). Intersection of joints and fractures produces rubble in the 2 by 3 by 2 in. to 6 by 4 by 12 in. size range. Although a few larger '10-in.' boulders exists, they are generally uncommon.

The hornfels has a specific gravity of 2.76, an absorption value of 0.003-units, a moisture content after crushing of 0.2 percent, and a Alaska Test Method, T-13 degradation value of 83. Like site 88MDT1, the material passes minimum aggregate requirements for degradation and has favorable moisture and specific-gravity properties.

The hornfels zone is adjacent to a northeast-trending diorite sill. Field evidence indicates that the zone is approximately 250 ft wide and extends for about 800 ft along the diorite contact (fig. 47). Assuming that a quarry site could be located on the steep slope to the south and evoking a 150 ft vertical pit limit, then a 200 by 200 by 150 ft zone or about 250,000 yd^3 might be made available offsite of the ridge crest.

Figure 48. Upper Kalskag village viewed from sample site 88MDT1.

Figure 49. Blocky, jointed hornfels on east flank, Portage Mountain, at sample site 88MDT2.

SITES 88MDT3 AND 88MDT4: MONZODIORITE, EAST PORTAGE MOUNTAIN

Location

Two northeast-trending, monzodiorite sills crop out along the eastern and western flanks of Portage Mountain, about ½ mi from the summit and abandoned radio-tower facility.

Geologic Description

Two intrusions about 750 ft wide trend N50°E for about ½ mi before they are buried on both ends by vegetation and colluvium. The intrusions are composed of medium-grained, equigranular augite-biotite-hornblende monzodiorite. A fine-grained chilled margin occurs immediately adjacent to the hornfels country rock. These diorite sills form the summit of Portage Mountain.

Structure, Physical Properties, and Volume Estimate

No outcrops were available for structure measurement, as exposures consisted of frost-rived rubble. However, large planar boulders ranging in size from 12 by 25 by 40 in. to 14 by 30 by 60 in. are common on hillslopes (fig. 50).

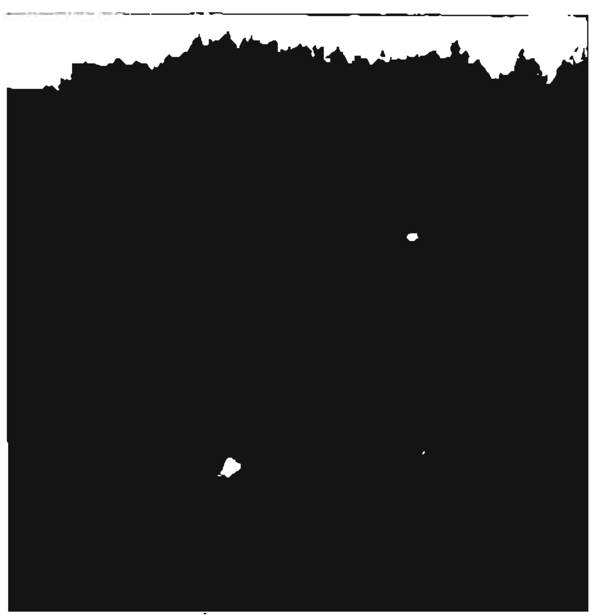

Figure 50. Monzodiorite sill on east flank of Portage Mountain, at sample site 88MDT3.

Laboratory tests show that the diorite has a specific gravity of 2.74, an absorption of 0.004, a moisture content after crushing of 0.5 percent, and an Alaska Test Method T-13 degradation value of 65. The material passes minimum standards for aggregate useage. Much of the volume--especially the eastern most sill would also qualify as Class I and II riprap.

About three-quarters of the top of Portage Mountain is underlain by the two intrusions. Using minimum dimensions of 900 by 1,200 by 150 ft, the site contains an estimated resource of 3 million yd.

SITES 88MDT8 AND 88MDT5: WEST TRAIL RIDGE SITES

Location

Two sites of sheared metavolcanic and metasedimentary rocks were investigated for aggregate potential 2 mi north-northwest of Upper Kalskag (fig. 48). Locality site 88MDT8 is one cited as a possible aggregate source by Turley (1987).

Geologic Description

Bedrock at both sites consists of highly fractured, predominantly fine-grained, dark-gray (when fresh) metabasalt or basaltic andesite and minor interbedded metasiltstone. Outcrops are usually highly fractured and jointed. Three prominent joints were measured at site 88MDT6: 1) striking N27°W dipping vertical; 2) striking N65°E dipping 50°SE; and 3) striking N80°E dipping 52°NW. Three were also measured at site 88MDT8: 1) striking N28°W dipping vertical; 2) striking N50°E dipping 35°SE; and 3) striking N62°W dipping 62°NE. In both areas a N27-28°W-trending, high-angle joint is the most prominent measured, which is consistent with measurements from sample sites 88MDT1 and 88MDT2.

Structure, Physical Properties, and Volume Estimates

Both sites contain a variety of rock-fragment sizes ranging from 1 by ½ by 1 in. fragments to 12 by 10 by 12 in. boulders. Most of the material is quite small due to the highly deformed nature of the outcrops. There is no riprap at either site. However, the aggregate potential was tested with laboratory work at site 88MDT8, where the sample yielded a specific gravity of 2.78, an absorption of .005, a moisture content after crushing of 0.9 percent, a Los Angeles Abrasion Grading B of 12.3 percent (loss), and a Alaska Test Method T-13 degradation value of 73. The sample passed the state degradation minimum standards of 45 for aggregate. The Los Angeles test result of 12.3 percent loss is considered high but not excessive for aggregate.

Using dimensions of 600 by 400 by 100 ft for a speculative bluff quarry, about 900,000 yd^3 of aggregate could be excavated from the sample area 88MDT8.

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