Mineral Appraisal and Geologic Background

of the

VENETIE NATIVE LANDS

by

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and the
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CHAPTER 1

CONCLUSIONS AND MOST IMPORTANT FINDINGS

Geologic work done to date on the Venetie lands does not indicate commercial deposits of any mineral substance, but there are significant occurrences or anomalies which need follow up, as listed in tabular form.

MINERAL OR COMMODITY	LOCATION	WORK NEEDED
1. Chromium with Platinum Metals	Christian Complex in Upper Marten Ck.	Detailed geologic mapping, geochemical and geophysical survey. Placer drilling.
2. Oil Shale	Triassic rocks in or near complex--two locations.	Detailed mapping and sampling followed by physical exploration.
3. Petroleum, gas, coal	A. Tertiary basin	Seismic work, drilling.
	B. Devonian sandstone unit	Geologic work.
4. Uranium	A. Tertiary basin	Subsurface exploration.
5. Zinc and other elements in unusual amounts in soils and stream sediments.	A. Schist terrane	Follow up.
	B. Devonian terrane	Follow up.

The metal chromium is found in dark rounded masses one or two inches across scattered throughout the soil on a nearly barren ridge above the western forks of Marten Creek. The dark masses are weakly magnetic. The rocks surrounding the masses are pale tan on the surface, but are dark green to black when broken up, and are called peridotites. This manner of occurrence is geologically typical for chromium, as is the association of platinum metals which may be detected chemically.

Oil shale probably is fairly widespread in the east-central part of the Venetie lands, but based on present knowledge it is present in relatively small bodies. The oil shale is a variety called tasmanite, which is very rich in oil compared with most oil shale.

Several possibilities exist for the occurrence of petroleum or natural gas. The two most likely are in relatively young rocks completely covered by soil in the southeast part of the Venetie lands and in a much older sandstone unit. Exploration for oil and gas will have to be carried out by companies experienced in valuation of these substances. In addition, the lands also have potential for uranium, coal, and contain placer deposits of gold.

CHAPTER 2

INTRODUCTION

The lands of the former Venetie Indian Reservation have an area of about 2,200 square miles contained in a crudely diamond-shaped block one hundred miles long and fifty miles wide in northeast Alaska (fig. 2.1). This land, now owned by residents of the area at Venetie and Arctic Village is generally referred to in this report as the Venetie Lands; it was selected by its owners in lieu of other options of the Alaska Native Claims Settlement Act. These options included cash payments and joining the natives of the Doyon Regional Corporation.

2.1 Location, Access, and Geography

The Venetie lands extend northerly from the Yukon River at Venetie Landing. The Chandalar River forms the southwest boundary of the diamond; the East Fork of the Chandalar the northwest boundary; and the Christian River the southeast. The northeast boundary extends due north from a point on the Christian River about four miles east of Simon's cabin.

The extreme south part of the area is lowlands which are part of the Yukon Flats province; about fifty miles north of Venetie Landing the country changes to low rolling hills and rounded mountains which lie southeast of the

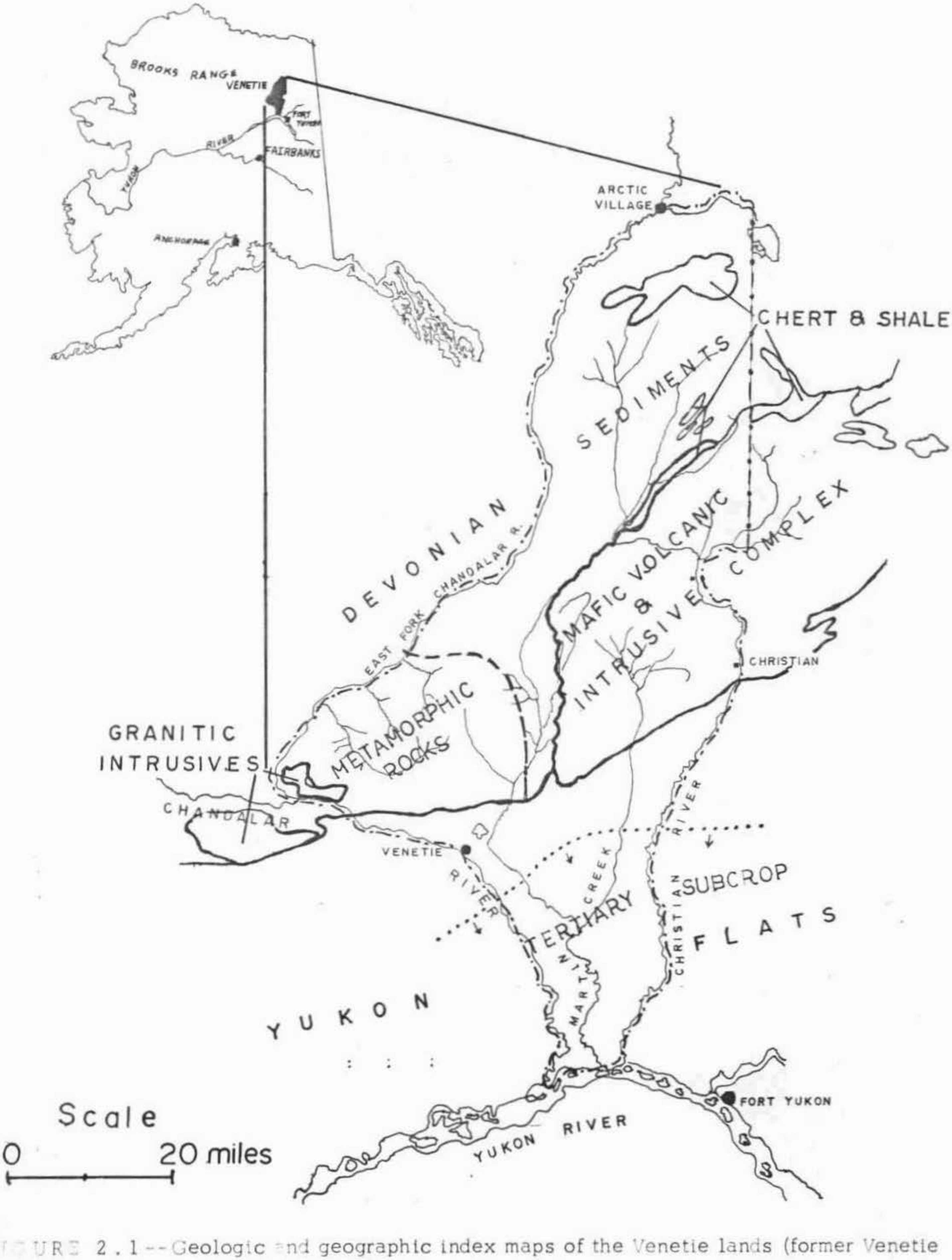


FIGURE 2.1--Geologic and geographic index maps of the Venetie lands (former Venetie Indian Reservation).

Brooks Range mountains. Elevations gradually increase in a northerly direction. A line of average 1000 foot elevations extends westerly from Christian to the junction of the Chandalar and East Fork Rivers; the former reserve reaches 2000 foot summits a few miles north of Christian, and about 3000 feet northeast of Arctic Village.

Because of the high elevation and latitude, the rolling hills, mountains, and upper plateaus are tundra. Forested land, with spruce to a maximum of about two-foot diameter but generally much smaller, occurs throughout the Yukon Flats in the better drained areas and extends up the East Fork of the Chandalar past Arctic Village and nearly to the head of the Christian River.

Settlements are at Venetie and Arctic Village. Only Jim Christian remains at Christian Village, which had about twenty persons in 1928 (Mertie, 1930). Three natives including much respected John Frank live permanently on the East Fork of the Chandalar about two miles north of Cornucopia Creek, and a lone native was constructing a new camp, garden, and airstrip on the Christian about two miles west of Simon's cabin in the summer of 1976.

Access to the area is principally by air, but in the open season river boats traverse all the Chandalar River system to Arctic Village, and in the winter snow machines follow elements of the old Fort Yukon-Christian-Arctic Village and Venetie-Christian trails. Most of the high tundra lands between

Arctic Village and Christian and the East Fork-Chandalar junctions are also accessible by snowmobile.

The main airfields are at Venetie (4400 feet long) and Arctic Village (3000 feet long). The Arctic Village is suitable for aircraft to C-130 size and both fields are easily suitable for C-46. A Supercub or marginal Cessna 180 strip is at John Frank's cabin on the East Fork; the strip must be carefully monitored, as it can be easily damaged in flooding. The airfield at Christian is presently at best marginal for Supercub.

For those interested in history and contrasts between the present and the "good old days," it is informative to read Mertie's understated account of the USGS expeditions (1930, p. 87-91) where men, dogs, and canoes moved the necessary amounts of equipment in a period of about four months in order to accomplish a two and a half month geologic field season.

2.2 Previous Geologic Work

The Venetie Lands have never been studied in detail, and locally have complex geology which will take detailed work to resolve. Nevertheless, reconnaissance work by Mertie, Brosge' and Reiser, all of the U.S. Geological Survey, provides a framework for the present and future studies.

Mertie (1929, 1930) was the first geologist to specifically survey the Venetie Lands, but this survey was incomplete and limited essentially to the river valleys. The Paleozoic schists, Devonian sandstones, chert series, and mafic intrusives were recognized by Mertie, who also first reported on oil-shale occurrence subsequently examined by Ebbley (1944) and by Banister in 1976.

The general distribution of rocks was first outlined by Brosge' and Reiser (1962) who also clarified the ages of certain rock units. In 1965 Reiser, Lanphere, and Brosge' recognized that the mafic intrusive and extensive rocks first reported by Mertie were part of the eighty-mile long unit termed by them the Christian Complex.

The Yukon Flats part of the Venetie Lands was reported on by Williams (1962) and Barnes (1967) and Brosge', Brabb, and King (1970) have studied part of the area, respectively, by gravity or aeromagnetic methods. A recent summary of all the older work was compiled by Forbes and Carver (1976) on BIA contract.

2.3 This Investigation

Availability of some funds to the U.S. Bureau of Indian Affairs and the U.S. Bureau of Mines prompted this reconnaissance study which was made during the summer of 1976 under BIA Contract No. 6E00-0102598. Geologist Geoff Garcia, assisted by Charlotte Kautzer, with aid from villager David Henry made an initial reconnaissance of the southeastern part of the land from riverboat and foot traverse from June 13 to 19. These people were joined by geologists Carl Hale and C. C. Hawley on June 20 and as much reconnaissance as possible was done in four days with helicopter support. The helicopter was furnished by ERA Helicopters; fuel was moved to Venetie by Standard Otter and Cessna 206 by Frontier Flying Service, Inc. of Fairbanks.

Based on initial study of literature, it was felt that the most economically significant results could likely be obtained in a short time from the granite-metamorphic area and the Christian Complex and work was concentrated there. The discovery of some chromite-magnetite intergrowths with anomalous Pt-metals in the Christian Complex in June led to a follow-up by D'Arcy Banister and Ulrich Jansons, U.S. Bureau of Mines. D'Arcy Banister, Bob Lambeth, and Don Baggs, all of the Bureau of Mines, also followed up on the oil-shale reported by Ebbley from September 10-12, 1976.

2.4 Acknowledgments

Most indebtedness is due to the residents of Arctic Village and Venetie and outlying camps who guided, fed, coffeed, and informed us about the area. Moses Sam, who guided Norm Ebbley to the oil-shale occurrence in 1943, also guided Banister and others in 1976. It was a real pleasure to work with an outdoorsman like David Henry, Sr. and to meet old timers Jim Christian and John Frank. Many of the younger people also helped, for example Mr. and Mrs. Robert Frank.

CHAPTER 3

GENERAL GEOLOGY

The rocks of the Venetie Lands fall into four major groups by area (fig. 2.1). Metamorphic rocks similar to the schists of the southern Brooks Range from the westernmost part of the lands, lying between the Chandalar and the East Fork. North and northeast of the metamorphic rocks are a series of mainly sandy Paleozoic rocks locally capped by chert and shale. The east-central Venetie Lands are on the Christian Complex, an enigmatic unit of interlayered mafic volcanics and cherts locally with intrusive mafic and ultramafic igneous rocks.

The fourth major terrane is the Tertiary Basin underlying the Yukon Flats south of the metamorphic and Christian Complexes.

3.1 Older Metamorphic and Sedimentary Rocks

Quartz-biotite schist and associated phyllite forms the metamorphic complex near the junction of the East Fork and Chandalar (fig. 3.1). Locally near the granite bodies, the schists are coarsened and contain andalusite, staurolite, and cordierite. In the Chandalar quadrangle (Brosge' and Reiser, 1964) similar strata are considered to be regionally and thermally metamorphosed Devonian sedimentary rocks, although Mertie (1930) thought they underlay Devonian (Silurian) strata. The relations of schist and the undoubted Devonian rocks were not determined in the Christian quadrangle, but schists give way northerly through phyllite to the Upper Devonian series of sandstone, siltstone, quartzite, graywacke, and shale.

Locally the Kanayut Conglomerate overlies Devonian fine clastic sediments in northern parts of the Venetie Lands near Arctic Village. The Kanayut Conglomerate grades from quartzite to a quartzitic conglomerate forming a coarse clastic wedge which pinches out toward the south. It may be about the same age as the Hunt Fork Shale which outcrops in western parts of the southern Brooks Range.

A laminated chert-shale sequence outcrops in the northern and western portions of the Venetie Lands. It overlies the Devonian clastic rocks and is considered late Paleozoic to Triassic in age (Brosge' and Reiser, 1962; Reiser and others, 1965; Tourtelot and Tailleur, 1965). The sequence consists of bedded partly-radiolarian chert, vari-colored shale, and argillite. The layered argillite and chert crops out stratigraphically above the Devonian sequence between Willow House and Arctic Village. Apparently similar rocks form the northwest and southeast flanks of the Christian Complex and apparently dip underneath it. Sedimentary rocks also form major inclusions or interlayers in the Christian Complex. These rocks are dominantly sandstone--including graywacke, shale, argillite, and chert. Locally the interlayered sedimentary rocks also include oil-shale (Tourtelot and Tailleur, 1965).

The sedimentary rocks of the complex differ from the underlying chert-shale sequence in higher content of sandy rocks. They have been locally dated by Scott as Triassic on the basis of pollen and spore content of a graywacke unit (Reiser, Lanphere, and Brosge', 1965) enclosed in mafic igneous rocks.

3.2 Igneous Rocks

Within the Venetie Lands are two main groups of rocks termed igneous--those rocks which originally formed from molten materials like those which emerge from volcanoes. The first group are dark-colored igneous rocks called mafic or ultramafic; these rocks form much of the Christian Complex. The second group are light-colored granitic rocks which occur within the schist country between the Chandalar and East Fork.

3.2.A--The Christian Complex: The mafic rocks described by Reiser and associates as the Christian Complex are in an oblong body eighty miles long by thirty miles across, elongated in northeasterly direction. The Christian River cuts northwesterly across the south part of the complex, then turns abruptly northeast three miles east of Brown Grass Lake to parallel the complex contact for six miles, before swinging more northerly. From the point at which the Christian leaves the contact zone, the contact zone trends about N45E for twelve or so miles to the former reserve boundary. Altogether, almost one-half of the complex is on Venetie Lands. Lack of contact effects on the Devonian rocks northwest of the complex suggest either that complex was thrust against the Devonian (as in fig. 3.1) and/or that the complex near the contact is mainly composed of volcanic rocks.

The complex appears to contain both extrusive igneous rocks and coarse-grained igneous rocks which crystallized while the area was deeply buried. In general, the intrusive rocks are exposed in the central part of the complex and are more abundant than shown by Reiser, Lanphere, and Brosge' (1965) as ultramafic intrusives were found west of the previously mapped intrusive occurrences, also east of the Christian River Canyon near VABM Blondie and in the valley east of Simon's cabin.

According the Reiser and associates, the bulk of the complex is gabbro, diabase, basalt, and diorite--a dark-colored series shown on fig. 3.1 as Tr v with a minor light-colored series in turn consisting mainly of banded hornblende gabbro, corresponding to Jihg on fig. 3.1. Associated with the banded gabbro were peridotite and pyroxenite--ultramafic rocks.

In our investigation, we looked mostly for more basic members of the series, such as the peridotite and pyroxenite, as these logically are the ones to contain deposits of chromium and other typical ultramafic elements. Peridotite with chromium-bearing magnetite was found on hill 2470 in the southwest part of T30N, R10E, and relatively basic rocks appear to underlie at least a six-mile trend northeast and southwest from that point. The rocks exposed near VABM Blondie are also peridotite (location 80, 81).

If the complex does have a basinal form, as suggested by dip directions of bordering and included strata, peridotitic rocks underlie the banded light-colored gabbro, and thus could be expected to also crop out southeast of the light-colored gabbro unit. Unfortunately, time was not available to check out this possibility.

The intrusive part of the complex has been dated by K-Ar method on hornblende as Jurassic (Reiser, Lanphere, and Brosge', 1965, p. 70). An origin which would fit with the known ages of wall rocks and intrusives and general lack of metamorphics would be:

1. Submarine volcanism in Late Paleozoic or Early Triassic localized along a northeasterly zone of weakness between Paleozoic schist and the Devonian sandy rocks. Local deposition of chert, graywacke, and shale in the same basin.

2. Intrusion of mafic-ultramafic sills (possibly lopoliths) in Jurassic within the central part of mafic volcanic-sedimentary basin.

3. Northwestward (relative) thrusting of the entire complex toward the Brooks Range sequence.

Brosge' (written communication, 1977) has suggested that the seemingly intrusive part of the Christian Complex--the leucogabbro and peridotite--may have been thrust into the area, similar to the interpretation of an ultramafic mass in the Beaver quad (Brosge', 1973).

3.2.B--Granitic Igneous Rocks: Light-colored igneous rocks consisting of quartz monzonite, aplite, and syenite intrude the schist rocks of the southwest corner of the former reserve lands (fig. 3.1). The dominant rock unit is a biotite-bearing quartz monzonite consisting of nearly equal amounts of microcline, plagioclase, and quartz. It varies from granitic to porphyritic in texture, and forms a stock-like intrusive mainly in T27N, R3E; similar intrusives in the adjacent part of the Chandalar quadrangle are Cretaceous in age (Brosge' and Reiser, 1964).

Locally the quartz monzonite is cut by aplitic dikes, and both the aplitic and quartz monzonite contain tourmaline. In this respect they resemble the Brooks Range intrusives which are locally enriched in tin.

3.3 Tertiary Rocks

There are no outcrops of Tertiary rocks on the Venetie Lands, but sedimentary rocks or deposits of Tertiary age probably underlie much of the Yukon Flats, filling an ancient continental basin.

Based on comparison with other Alaskan Tertiary Basins, the sediments are sandy and clay-rich units with local interbeds of coal. The deposits are likely less magnetic than the older basement, and based on the assumption of lesser magnetism, the northwest boundary of the Tertiary Basin could trend north-northeast, crossing the south Christian quadrangle boundary near 146^{o} west longitude. Again, based on aeromagnetic patterns which show a pronounced low southeast of Venetie, Tertiary rocks could have a maximum thickness in T42N, R10E.

The Tertiary rocks could be economically significant, as they are potential reservoirs of oil and gas, and could also contain deposits of coal and possibly uranium.

3.4 Quaternary and Recent Deposits

Most of the southern part of the Venetie Lands is covered with deposits of sand, gravel, and fine-grained wind-blown material--which range in age from the last glacial episode to the geologic recent.

Williams (1962) and others have proposed that the area has been involved in four Pleistocene periods of glaciation, with strong evidence in the Venetie Lands of periods two and three (p. 308-310). According to Williams the oldest glaciers may have extended to the Yukon Flats via the Chandalar, Marten, and Sheenjek Valleys. Deposits of the next oldest glaciation extend down the East Fork to Coal Creek, and deposits of the third period to near Lush Creek. Extensive old alluvial fans of the Chandalar River, Marten, and Christian cover much of the ground near Venetie. These fans probably were synchronous with the glacial deposits of the East Fork. The more recent deposits are in the flood-plains and lowest terraces of the modern streams.

3.5 Structural Geology

The geologic studies of the area have not been sufficiently studied to resolve major structural problems, such as the relation between schistose and undoubted Devonian rocks. The Venetie Lands are southeast of the major belt of thrust faulting in the Brooks Range, and in general the structure seems to dip toward a synclinal basin centered on the Christian Complex. Southeast of Arctic Village, faults of northwest strike offset Paleozoic strata, and there is the possibility already mentioned that the Christian Complex is thrust northwestward over the older strata.

CHAPTER 4

PROSPECTING ACTIVITY AND ECONOMIC GEOLOGY

Except for an occurrence of oil shale (Mertie, 1930; Ebbley, 1944), there are no occurrences of economic minerals or substances reported in the literature, yet the region was prospected in the early 1900s, and it does have some potential for the discovery of several valuable minerals, including oil shale, petroleum, chromium with Pt-metals, and possibly precious and base metals, including uranium. This is not to say that the reservation appears strongly mineralized, because in reference to many nearby regions, it is apparently poorly mineralized. But it is also large, still nearly unknown and with several favorable rock units.

4.1 Prospecting Activity

The western part of the Venetie Reserve was prospected during the early 1900s primarily by miners traveling to and from the Chandalar district. Small amounts of gold were detected on the East Fork of the Chandalar, and gold was mined on a very small scale by prospectors in Crater and Cornucopia Creeks (communication, John Frank, 1976). The total production of the area apparently has been only a few ounces. Prospectors of the area included Tony Zimmerman and John Butkus (sp?).

Natives in the region also knew of the oil shale occurrences in the northern part of the reserve; Moses Sam, who guided Ebbley to the occurrences in 1944 took D'Arcy Banister of the U.S. Bureau of Mines to the same localities in 1976.

It is very likely that older natives and prospectors also made other discoveries, but these were not recorded. There are rumors of an oil seep in Devonian Sandstone near Bob or Brown Grass Lakes, but this occurrence was not found, although an oil seep could well be in the area.

4.2 Results of Studies in 1976

The igneous metamorphic complex of the western Venetie Lands and the Christian complex were selected for emphasis because of mineralization in similar metamorphic terrane near Chandalar and a general association of chromium or nickel or copper deposits with ultramafic rocks like those suspected in the Christian Complex. A few samples were collected elsewhere, but the sampling bias is clearly shown in fig. 3.1, which shows sample locations superimposed on the geologic map. A few samples were collected in the Devonian sedimentary terrane, and the U.S. Bureau of Mines resampled the oil shale occurrences.

A total of about 140 samples was collected, including stream sediments, soils, pan concentrates, and chip samples of rock units (Table 4.1). Most of the stream sediment samples were analyzed for copper, lead, zinc, silver, and gold. In the Christian rocks, samples were analyzed for nickel and chromium; a few samples, mentioned later, were analyzed for other elements.

The small number of samples collected and the varieties of terrane covered do not allow for rigorous analysis of geochemical anomalies. Because of the generally subdued topography, significant anomalies could be relatively small.

In the case of copper and zinc in stream sediments average values are relatively low compared with many areas in the nearby Brooks Range. It appears that concentrations of 50 ppm (.005%) and 25 ppm (.0025%) for copper and lead, respectively, would be slightly anomalous; zinc would appear to be definitely anomalous in concentrations exceeded 200 ppm (0.02 percent). Gold was detected in only one stream sediment (No.22) and appears strongly anomalous at that locality.

Chromium, copper, and nickel values in excess of 300, 100, and 100 respectively would appear to correlate in the soils developed on relatively mafic or the ultramafic units of the Christian Complex, although chromium values may be much above the indicated anomalous level.

4.2.A <u>Metamorphic-Granitic Terrane</u>: Sampling of the schistose terrane by stream sediments indicates little enrichment in the schists or cross-cutting granites in copper, lead, zinc, or silver. Gold was detected in only one sample (No. 22), but small anomalous concentrations of gold or of other elements like tin can easily be missed in non-concentrated samples.

Besides the gold anomaly at locality 22, a tributary of the East Fork just south of Crater Creek, gold is known to exist in at least small concentrations in both Crater and Cornucopia Creek, and in the creeks opposite the John Frank cabin. A fairly high zinc content (700 ppm) was obtained in a pan concentrate (31A), but it appears likely due to zinc contained in spinel, as an associated stream sediment sample only contained 60 ppm. Both zinc and lead are also relatively high in a chip sample of a typical granitic outcrop.

Although the results are not encouraging, the sample density is too low to preclude the existence of small high-grade deposits or of deposits of other metals like uranium or tin not systematically sought. The occurrence of tourmaline in part of the quartz monzonite does suggest that it is similar to many of the Brooks Range granitic rocks which do have slight tin enrichment.

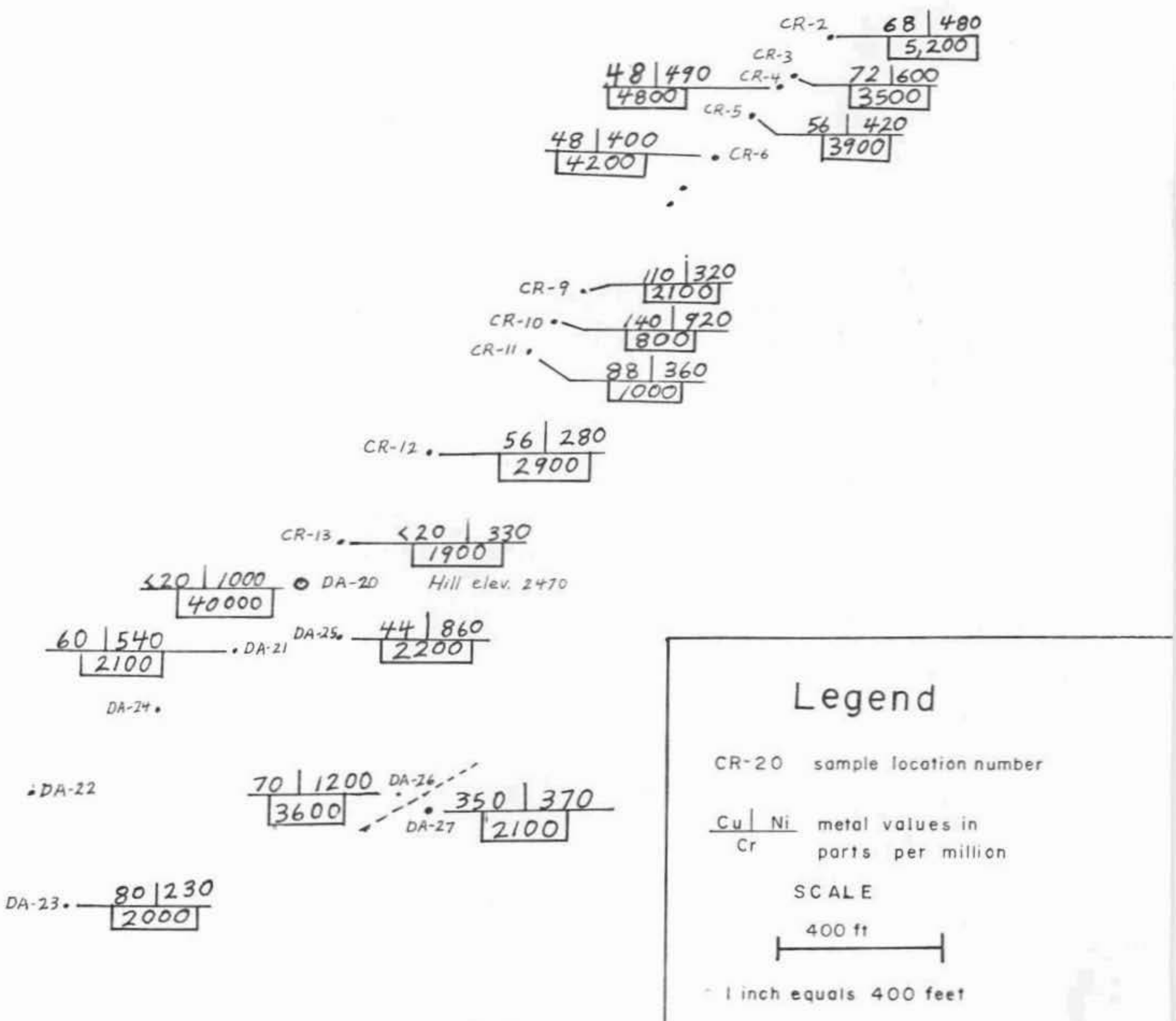
4.2.B--<u>Christian Complex</u>: Based on aerial reconnaissance and confirmed to some extent by sampling done thus far, the part of the Christian Complex most favorable for metallic deposits is a peridotite zone exposed near the head of Timber and Marten Creeks. In this zone the peridotitic or dunitic ultramafics are indicated by a characteristic yellowish soil color and sparse vegetation. To gain a preliminary knowledge of the complex, a few stream sediments and pan concentrates were collected along the Christian River, and these appear to have backgrounds characteristic of mafic and ultramafic rocks.

A few landings were also made with helicopter in the complex and on its northwestern contact. At one of these sites, a hill with elevation 2470 in T30N, R9E, peridotitic rocks are exposed and the yellowish soil contains numerous residual nodules one to two inches across of a weakly magnetic dark material. Analyses of about a two-pound sample of the nodules showed 4.5 percent chromium and a trace (0.10 ppm) of platinum and a lesser concentration of palladium. Anomalous chromium and detectable Pt-metals were also found in the soil. This occurrence was found on the last helicopter day, and a few more samples were collected at that time. On recognition of the metal content of the nodules, U.S. Bureau of Mines geologists returned to the area, and made a 2000 foot reconnaissance soil line along the ridge which includes hill 2470 (fig. 4.1). Concentrations of nickel and chromium found in the soil confirm that this part of the ridge is underlain by an ultramafic rock. Although the concentrations of chromium are not extremely high, it is possible that chromium is preferentially concentrated in more resistant and courser phases than those analyzed with soils.

The occurrence of the rocks near hill 2470, recognition of peridotite near the Christian River Canyon, sparse pyrrhotite seen near Simon's cabin, and the zoned, banded nature of the intrusive suggests that detailed geologic mapping of the intrusive is warranted. Although the platinum metal content of the rock samples is low, the topography and drainage of the area is such that placer concentrations of platinum metals may have occurred. The chromium platinum bearing occurrence is on a rounded ridge which has been eroded

FIGURE 4.1

Soil samples collected on ultramafic zone near hill 2470, Venetie



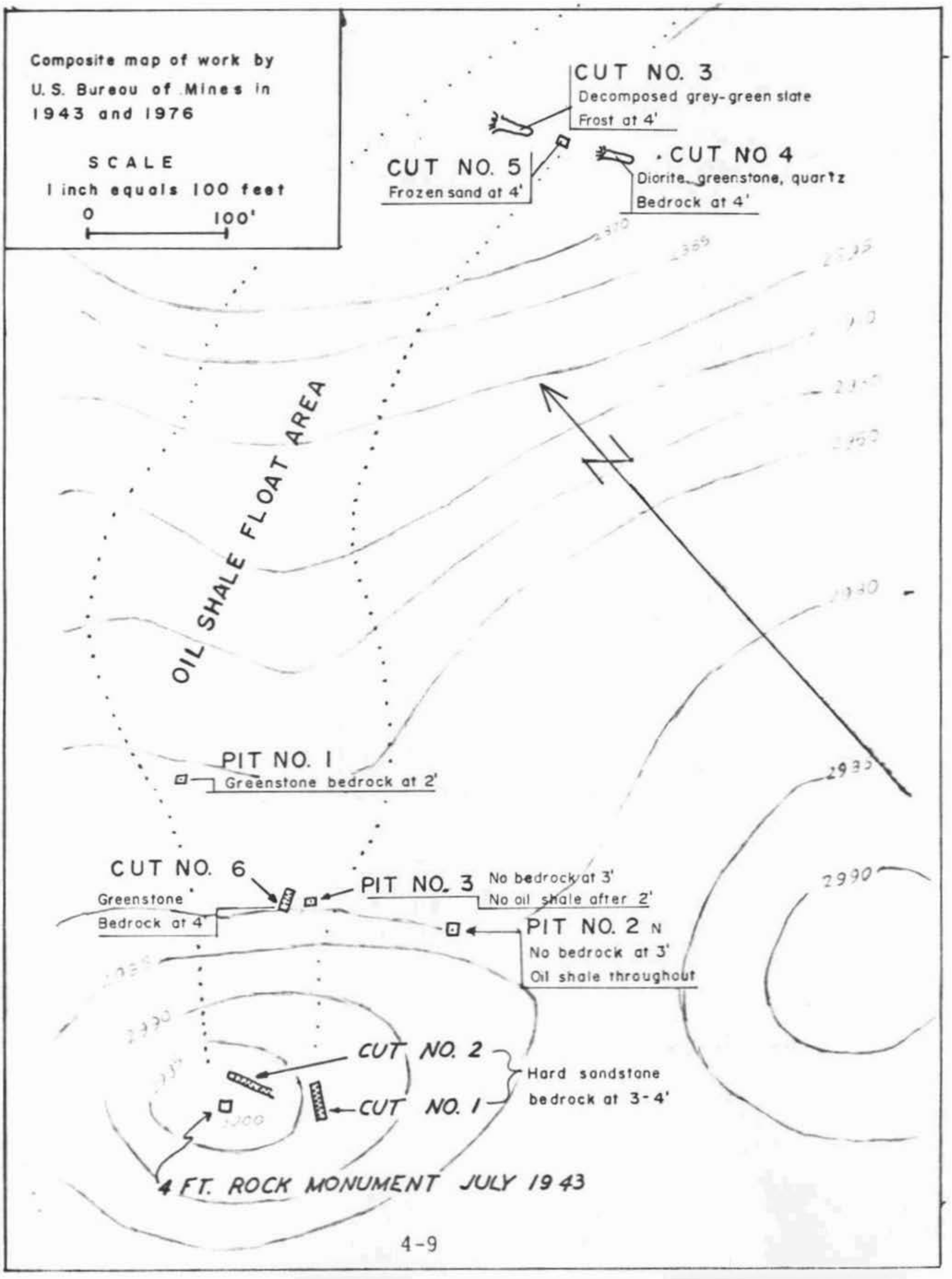
extensively, and the streams south draining particularly need sampling. The streams would include Marten and the next major stream west of Marten Creek. They are sluggish streams choked with brush and difficult to sample rapidly from helicopter. Initial sampling would likely be done with hand dug holes and pan concentration. Evidence of enrichment in chromium and/or platinum should be followed up by sampling in holes drilled or dug to bed rock.

4.2.C--Oil Shale Economic Potential: A shale with a high oil content was first reported by Mertie (1930) from an unknown locality which is now thought to be on the northeastern edge of the Venetie lands (figs. 3.1 and 4.2). An oil shale area was located and sampled in 1943 by Norm Ebbley, Jr., in an expedition by the US Bureau of Mines in search of war minerals (report in Appendix 2). The US Bureau of Mines returned to the area during 1976 to further study the occurrence. The shale is similar in appearance to a "tough, dark leathery wood, light in weight, weathering to a grey color" (Ebbley, 1944, p. 12). Pieces of oil shale float found were contorted and polished, in many instances having slicken-side faces. The shale burns readily when lit with a match. Analyses of the shale have shown it to carry between 88 and 136 gallons of oil per ton--as assayed by the US Bureau of Mines in 1976 (Appendix 3). As a comparison, shales under consideration for mining in Colorado at this time average 25 to 30 gallons of oil per ton.

Oil shale is also reported to occur in the southwest part of T31N, R9E (fig. 3.1)--written communication, William Brosge', 1977. This locality is also in the Christian Complex, but about twenty miles southwest of the previously known occurrence.

FIGURE 4.2

Oil shale occurence Venetie



Although the existence of the shale on Venetie Lands is well documented, nothing is known of the quantity, due to a thick frozen soil cover in the area. Trenches excavated near occurrences of oil shale float have bottomed in igneous rocks, sandstone, and frozen ground (fig. 4.2). The shale is included in the Christian Complex and structure and deformation associated with the mafic igneous units of the Christian Complex may make the shale difficult to trace over a large enough area to make mining of the shale feasible.

Oil shale of basic low and high yield types is widely distributed in the Brooks Range (Tourtelot and Tailleur, 1965). The high oil yield units are "tasmanites" rich in spore-like algae and can contain anomalous amounts of molybdenum (110 ppm), copper (380 ppm), zinc (70 ppm), silver (4 ppm), and equivalent uranium (70 ppm), and it may be possible to trace the Venetie oil shale by geochemical sampling for heavy metals or radioactivity in areas where ground cover obscures outcrops.

Sample locality #85 in the Paleozoic chert-shale sequence contained anomalous amounts of copper (205 ppm) and zinc (280 ppm). This is near an area in which natives of Venetie have reported finding oil shale. Although no oil shale was found by the Bureau of Mines in a brief visit in 1976 (D'Arcy Banister, personal communications), the high copper-zinc content of the shale appears to give credence to the report. Shale in other less structurally complicated areas north of the Venetie thrust should be prospected for oil and heavy metals by detailed mapping and geochemical sampling.

4.2.D Other Areas or Commodities: A few samples collected in the Devonian sandy units failed to show any unusual concentrations of copper, lead, silver, or gold. Sample Nos. 95 and 123 contained unusual amounts of zinc (270 and 210 ppm respectively) which could reflect the presence of a zinc rich shale in the area.

Although initial sampling results and poor rock exposure would discourage further work in this area, any new mineral discoveries in equivalent Devonian rocks in the northern Chandalar or southern Arctic quadrangles would suggest the need for a more detailed sampling of the Venetie Devonian rocks.

4.3 Potential for Petroleum and Uranium

Petroleum, natural gas, coal, and uranium are diverse substances but they may occur in the same geologic environment. One such common environment is that of a continental or perhaps marginal marine basin receiving continental sediments. There are two environmental zones with some potential for petroleum accumulation in the area; one of these is the Tertiary basin which underlies part of the Yukon Flats; the second is the Devonian sandy sequence northwest of the Christian Complex.

4.3.A Yukon Flats Province: The Yukon Flats were not examined geologically in 1976, as rocks of the basin are mainly covered by thick alluvial and aeolian deposits (Williams, 1962). Nevertheless sparse exposures and some drill holes indicate that rocks or poorly consolidated sediments of Tertiary age do underlie at least part of the area.

These rocks or sediments are similar in age and type to rocks and deposits which contain the coal deposits of the Nenana field and the oil, natural gas, and coal deposits of the Cook Inlet Tertiary Province. They also have some similarities with uranium-bearing Tertiary intermontaine basins of the Rocky Mountain region.

According to Forbes and Carver (1976) oil and gas lease applications held by Lousiana Land and Exploration Company, Phillips Petroleum, Standard Oil, Texaco, and various individuals cover about 415,000 acres in the Yukon Flats adjacent to the south border of the Venetie Lands.

4.3.B Devonian Sediments: The reported occurrence, although not confirmed in 1976, of an oil seep in the Devonian series in the interior Venetie Reserve, suggests that some geologic work is justified for evaluation of oil potential.

The Devonian ranges from well cemented quartzitic units through graywackes to sandstones which locally could have necessary porosity for an oil reservoir sand. The oil potential of the Devonian units should be evaluated by geologists familiar with oil and gas geology in interior Alaska.

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APPENDIX I

APPENDIX I

SAMPLE DESCRIPTIONS

The following is a description of samples collected June 15 through June 21, 1976, in the Venetie area by geologists Geof Garcia, C. C. Hawley, Carl Hale, and field assistant, Charlotte Kautzer, and of the samples collected by U.S. Bureau of Mines engineers and geologists D'Arcy Banister (DB), U. Jansons, and Robert Lambeth (L-BM).

Map No. (fig. 3.1)	Field No.	Description
1	VG-1	Stream sediment. No bedrock exposed.
16	VG-2	Soil sample. Near greenstone feldspar porphyry dike in quartz monzonite (30% quartz, 30% orthoclase, 30% plagioclase, 10% biotite) also pink orthoclase mega crysts.
17	VG-3	Chip sample. Quartz monzonite as above.
18	VG-4	Soil sample. Biotite quartz gneiss with limonitic casts possible tourmaline.
15	VG-5	Soil sample near white aplite dike (red garnets visible) red rutilated quartz along top of ridge.
14	VG-6	Soil sample. Bluish-grey quartzite with biotite casts contact between quartz biotite schist and quartz monzonite.
3-4	VG 7-8	Stream sediment samples. No bedrock seen. Quartz monzonite and quartz biotite schist alluvium.
6	VC-1	Chip sample. Quartz mica schist with sillimanite (?). Soil sample taken also.
7	VC-2	Stream sediment sample. Quartz biotite schist outcrop. Predominant alluvium quartz monzonite.
8	VC-3	Stream sediment sample. No outcrop. Granitic alluvium.
	VC-4	No sample taken. Fine-grained quartz-muscovite-biotite schist.
19	VC-5	Stream sediment sample. Outcrop muscovite-quartz-biotite schist. No granitic rocks in alluvium.

Map No. (fig. 3.1)	Field No.	Description
20	VC-6	Stream sediment sample. Outcrop. Garnetiferous, quartz-mica schist. Chip sample taken.
21	VC-7	Stream sediment sample. Quartz mica schist. Some phyllite in alluvium.
22	VC-8	Stream sediment sample. Outcrop quartz biotite schist. Fine-grained quartz-chlorite schist in alluvium.
23	VC-9	Stream sediment sample. Quartz biotite schist outcrop. Quartz-chlorite schist in alluvium.
25	VC-10	Stream sediment sample. Quartz biotite schist outcrop. Numerous pyritic, garnetiferous, olivine peridotites in alluvium.
47	VC-11	Stream sediment sample on Cornucopia Creek. Grey phyllites, quartzites, and well-rounded glacial rocks in alluvium.
48	VG-9	Stream sediment sample. No bedrock visible. Organic sample. Silt clinging to moss.
49	VG-10	Soil sample. Grey green phyllite with augen quartz.
50	VG-11	Soil sample. Same rock as above.
	VG-12	Stream sediment sample. Grey phyllite outcrop. Augen quartz.
	VG-13	Soil sample. Grey phyllite with augen quartz.
	VC-12	White aplite dike with tourmaline crystals. Chip sample.
	VC-13	Chip sample. Andesite breccia. Quartz phenocrysts.
81	VG-20	Chip sample near Christian. Dark green serpentine (Otter Creek).
80	VG-21	Chip sample. Ferruginous zone between anorthosite and serpentine.
80A	VG-22	Soil from fault zone containing white precipitate and iron stain.
80B	VG-23	Chip. Anorthosite.
79	VG-24	Sediment sample of tributary of Otter Creek near Simons Cabin. Serpentine present.
39	VG-14	Sediment sample. Tributary of Crater Creek. Organic silt. No outcrop.
40	VG-15	Organic soft silt in Crater Creek.

Map No. (fig. 3.1)	Field No.	Description
38	VG-16	Sediment sample, sandy with large chunks of sugary quartz.
37	VG-17	Sediment sample. Phyllite and quartz biotite schist in stream bed.
36	VG-18	Sediment. Sillimanite pelitic schist in stream bed.
35	VG-19	Sediment. Organic silt.
34	VG-30	Sediment. Stream bed contains quartz-biotite schist and garnet muscovite aplite dike rocks.
33	VG-31P	Pan concentrate in Crater Creek.
32	VG-32	Sediment. Organic. Sillimanite quartz biotite schist in nearby outcrop.
31	VG-33	Sediment. Sillimanite quartz biotite schist in stream entering near old cabin.
31A	VG-33P	Pan concentrate from above stream.
30	VG-34	Sediment. Swampy. No outcrop.
29	VG-35	Sediment. Swampy organic glop.
27	VG-36	Sediment. Quartz biotite schist in stream bed.
28	VG-37	Sediment. Sugary quartz-biotite schist in stream bed.
26	VG-38	Sediment. Silt in Crater Creek.
26A	VG-38P	Pan concentrate from same location. Garnets present.
88	VHx 110	Chip sample (grey phyllite outcrop). Soil sample taken.
89	VHx 120	Soil sample.
90	VHx 130	Soil sediment sample (grey phyllite outcrop).
91	VHx 140	Soil sample (grey silicified limestone outcrop).
	VHx 150	Soil sample (same rock as VHx 140).
	VHx 150	Chip sample.
9	VG-39	Quartz monzonite.
61A	VHx 35	Weakly magnetic nodules in soil on peridotite.
72	VH-1	Ridgetop soil in fine-grained fractured basalt, chert, and breccia.
73	CH-2	Soil same.
74	CH-3	Soil same.
75	CH-4	Soil. Medium to coarse grained andesite or diorite dike.
76	CH-5	Soil. Chert.
41	CH-6	Soil on ridge in layered sandstone and siltstone (sometimes schistose) with some quartz augen in syenite (?) dike.

Map No. (fig. 3.1)	Field No.	Description
42	CH-7	Soil. Andesite porphyry and sandstone and quartzite float, also diorite--gabbro (no outcrop).
43	CH-8	Soil. No outcrop. Schist and quartz in float.
68A	VHx-1P	Pan concentrate.
68	VHx-1SS	Stream sediment sample. Rock type - gneissic hornblende diorite. Some rocks grading to anorthosite-hornblende pegmatite.
69	VHx-1BSS	Main Christian River.
67	VHx-2	Serpentinitized rocks. Black-greenish.
71	VHx-3	Stream sediment sample. Very small panned concentrate.
78A	VHx-4A	Panned concentrate (chert, diabase).
78	VHx-4B	Stream sediment.
77	VHx-5P	Panned concentrate (chert, diabase).
56	VHx-8	Stream sediment sample.
87	VHx-9	Stream sediment sample.
	VHx-10	Soil-graywacke/quartz veins - 80 cts/sec.
96	VHs-11	Contact: graywacke - quartz sandstone/red shale, grey shale - some Mn stained material in shale - 60 cts/sec up to 120 cts/sec over boggy areas. Bedding Red SL N20° E, 25° NW.
102	VHx-12	Stream sediment - graywacke 80 cts/sec.
112	VHx-13	Soil sample. Sandstone - graywacke.
100	VHx-14	Gabbro, medium-grained, alt. act., ilm = 8-10%. Outcrop has crude banding. Suggests layering N; 45° E 45 cts/sec 14_s- soil sample.
108	VHx-15	Sticky soil on hummocky terrain in saddle 38 cts/sec.
107	VHx-16	Soil sample (on chert).
106	VHx-17	Soil sample (on chert near top).
55	VHx-18	Stream sediment. Swampy.
66	VHx-19	Massive, fine-grained ultramafic, probably peridotite.
70	VHx-20	Brown weathering, altered, partially serpentinized ultramafic - probably dunite.
86	VHx-21	Stream sediment (B) panned concentrate (P) mostly olivine, minor limonite.

Map No. (fig. 3.1)	Field No.	Description
85	VHx-22	Shale N, 40° E black, sheared, baked.
84	VHx-23	Stream sediment sample.
	VHx-24	Biotite quartz monzonite.
2	24A	Soil. 160 cts/sec.
5	VHx-25	Stream sediment.
5A	25P	Panned concentrate.
	25S	Soil sample. Some tourmaline crystals. No Au.
46	VHx-26	Stream sediment. 120 cts/sec. Quartz-phyllite.
53	VHx-31	Green argillite in burn: N60°E, 35° NW/chert.

Map. No. STREAM SEDIMENT SAMPLES
(fig. 3.1)

123 L-BM-1: Far from source, stream drains muskeg bog. Contains medium organics. Limestone in alluvium-glacial? Drains hills of black slate and snadstone.

111 L-BM-2: Contains medium organics. Drains area of upper Jurassic intrusives, Paleozoic cherts and shales, and the contact zone.

110 L-BM-3: Contains medium organics. Drains through muskeg bog. Drains areas of Devonian slate and sandstone and Paleozoic cherts and shales.

105 L-BM-4: Contains medium organics. Taken at mouth of small stream. Drains areas of Devonian slates and sandstone and Paleozoic cherts and shales.

104 L-BM-5: Contains medium organics. Taken at mouth of small stream. Drains areas of Devonian slates and sandstone.

103 L-BM-6: Contains medium organics. Stream flows through muskeg bog and drains areas of Devonian slates and sandstone.

101 L-BM-7: Contains medium to high organics. Very little fines in stream. Stream flows through muskeg bog and drains areas of Devonian slates and sandstone.

113 L-BM-8: Contains high organics. Flows through muskeg bog and drains areas of Devonian slates and sandstone and Paleoozoic cherts and shales.

114 L-BM-9: Contains medium to high organics. All tributaries flow through muskeg bogs. Stream drains areas of Devonian slates and sandstone and Paleozoic cherts and shales.

92 L-BM-11: Contains medium organics. Stream drains from lake and muskeg bog. Drains areas of Devonian slates and sandstone and Paleozoic cherts and shales.

Map. No. (fig. 3.1)	Stream Sediment Samples (continued)
93	**L-BM-12: Contains medium organics. Drains areas of Devonian slates and sandstone and Paleozoic cherts and shales.**
94	**L-BM-13: Contains medium organics. All tributaries flow from lakes or through bogs. Stream contains algae and is sluggish. Drains areas of Devonian slates and sandstone and Paleozoic cherts and shales.**
95	**L-BM-14: Contains medium organics. All tributaries flow from lakes or through bogs. Stream is sluggish. Drains areas of Devonian slates and sandstone and Paleozoic cherts and shales.**
100	L-BM-15: Contains medium organics. Taken from dry bed of stream draining Devonian slates and sandstones and Paleozoic cherts and shales. Sediment may have been deposited during flood stage.
99	L-BM-16: Contains medium organics. Stream drains Devonian slates and sandstone and Paleozoic cherts and shales.
120	DB76V2: Contains very high organics. Drains Devonian slates and sandstone.
124	DB76V3: Contains very high organics. Drains Devonian slates and sandstones.
118	DB76V4: Contains very high organics. Drains Paleozoic cherts and shales.
119	DB76V5: Contains very high organics. Drains Paleozoic cherts and shales and Devonian slates and sandstone.
117	DB76V6: Contains very high organics. Drains Paleozoic cherts and shales and Pzc-Ds fault contact.
116	DB76V7: Contains very high organics. Drains Paleozoic cherts and shales.
121	DB76V8: Contains very high organics. Stream drains a lake and bog. Drains Paleozoic cherts and shales.
122	DB76V9: Contains very high organics. Far from ion source. Drains Paleozoic cherts and shales (?).

Map. No. (fig. 3.1)	Background control samples:
115	**L-BM-10: Acidic sandstone from Devonian Kanayut Conglomerate?**
98	**L-BM-17: Mafic sandstone from brown-weathering Devonian slate and sandstone.**
97	**L-BM-18: Acidic sandstone from Paleozoic chert and shales.**
	DB76V1: Gray-green chert from Paleozoic cherts and shales.

APPENDIX II

APPENDIX II

OIL SHALE DATA FROM EBBLEY 1944 REPORT

Occurrence of Deposit

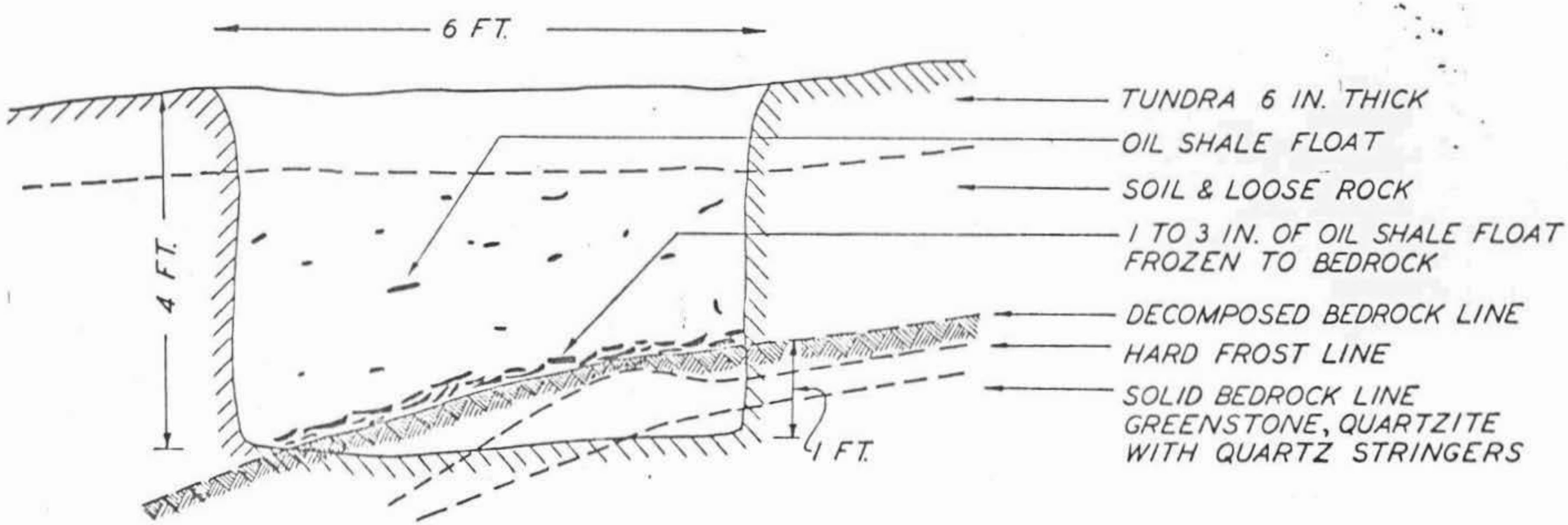
A total of six trenches were excavated endeavoring to locate the oil shale in place. This work was not successful and was discontinued as the area where the float is found is too large and the small pieces of float too sparsely scattered to justify continued work by hand methods. Figure 2 is a sketch map of the area where the float is found.

The natives reported that about 30 years ago the oil shale float was quite plentiful on top of the round dome and covered the eastern slope of the mountain. The natives while hunting caribou in the fall, camped along this ridge, it being an excellent vantage point, and burned the "oil-rock" for fuel, the nearest wood being about six miles away. During the course of many years the oil shale float became scarce, only small scattered pieces now remaining.

No float was found on the west slope, but some small pieces were uncovered directly on top of the round dome. There is a reasonable probability, of course, that these small fragments found on top of the dome may have been carried there by the natives as this high point would naturally be the best "lookout" for hunting. As indicated in Figure 2, the area where the most float was found along the slope does not correspond with the erosion depression line, but instead swings around the sidehill toward the south. Thus, it would appear that the apex of the oil shale outcrop may cut diagonally across the hill about east and west, the theoretical strike then being northeasterly.

Character of Shale

The principal form of occurrence of the Christian River oil shale deposit, as evidenced by the float found, would be termed "curly" shale. In general the pieces found, especially where concentrated on bedrock, were contorted and polished, in many instances having slickenside faces. A longitudinal section through one of the trenches is shown on Figure 3 and illustrates the occurrence of the shale. The pieces of float manifested their high oil content by curling to the knife and by burning readily when in contact with a lighted match giving off an oil odor. The better specimens resembled tough, dark, leathery wood and were very light in weight, weathering to a grey color. No fossils were observed.



(SAMPLE NO. 306 COLLECTED FROM TRENCH NO. 6 SOFT, BLACK, TOUGH, LIGHT, MATERIAL)

FIG. 3 LONGITUDINAL SECTION THROUGH TRENCH NO. 6

Sampling and Analyses

Bureau of Mines laboratories reported the following results of distillation of samples of the Christian River deposit.

Sample No.	Description	Analysis Gal.a ton	Sp.Gr. 60/60	Gravity °API
300	General sample from float taken from entire area. Small pieces, soft, tough, dark grey to black, and very light weight. Considerably weathered. Burns readily.	107.0	0.862	32.7
301	Same as 300.	88.8	0.865	
302	Sample of a large piece of float found on surface. Size 12 by 8 by 4 inches. Leathery, light weight, grey colored.	118.0	0.868	31.4
303	Same as 302.	123.8	0.870	
304	Small pieces of oil shale taken from Trench No. 3. Extremely light weight, leathery, curly, black, slickensided generally. Does not appear to be greatly altered by weathering.	76.0	0.865	32.1
305	General sample of surface float taken from extreme easterly portion of float area. Found after original area was marked.	60.5	0.870	31.1
306	Sample taken from bedrock concentration in Trench No. 6. This material is the soft black variety, tough, slickensided and curly. Does not appear to be greatly altered and covers bedrock in this trench to a depth of from 2 to 3 inches. Material is light weight and was generally frozen to the greenstone rubble bedrock. See Figure 3.	77.5	0.862	32.7
307	Not oil shale. Float sample of a hard, heavy rock shot through with thin sheets of quartz. This rock burns when in a very hot fire, but will not ignite with a match. It resembles a fine-grained diorite or a black fine-grained sandstone or quartzite; probably is a hard carboniferous sandstone. Resembles bedrock found in several of the cuts but the bedrock does not burn and has greenish and purple-colored areas; otherwise appears the same in the hand specimen. Specific gravity about the same as quartzite. When experiments proved this rock to burn it was a surprise to the Indians who had apparently never tried it before. Oil content apparently very low.	5.7	0.880	29.3
308	Same as 307	5.0		
309	Extra sample of float taken ffom entire surface area. These samples cleaned up all the visible float in the area. The bulk of this sample came from ground squirrel holes.	77.5	0.858	33.4

It should be noted that none of the shales from the United States previously listed show a yield of much more than 60 gallons a ton, whereas all of the samples of shale from the Christian River deposit are above this figure. Furthermore, the A.P.I. gravities of the Christian River shale are higher than the gravities reported in this other group. This indicates that the Christian River shale would have a relatively high yield of light distillate from which gasoline could be made. This shale does not have the general appearance of typical Green River shales in Colorado and is considerably less dense. 11/

Observation of the spent shale in the assay retorts indicates that the Christian River shales would have a definite tendency to coke--sufficient perhaps to cause trouble in retorting in the present type retorts. All of the samples were crushed to 8-14 mesh and retorted. The samples contained some moisture, but no attempt was made to dehydrate them and the yield figures are reported on the basis of the samples as received. On a moisture free basis the actual yield a ton would be increased slightly. 12/

Trench No.	Length	Width	Depth	Cubic Yards	Material	Bedrock
1	20.0	2.5	4.0	7.5	No oil shale	Hard sandstone and quartz.
2	32.0	2.0	3.0	7.0	No oil shale	Hard sandstone and quartz.
3	8.0	2.0	4.0	2.5	Much oil shale float	Decomposed grey-green slate. Frost 4 ft.
4	8.0	2.0	4.0	2.5	No oil shale float	Hard diorite, greenstone and quartz.
5	3.0	3.0	4.5	1.5	Much oil shale float	Decomposed sandstone frozen.
6	6.0	2.5	4.0	2.0	Much oil shale float	Greenstone and diorite?Rubble.

11/ Gardner, E. D., Bell, Charles W., "Proposed Methods and Estimated Costs of Mining Oil Shale at Rulison, Colorado," Bureau of Mines Information Circular 721B, November 1942.

12/ Smith, N.S.C., Supervising Engineer, Bureau of Mines Petroleum Experiment Station, Bartlesville, Oklahoma. Written communication.

APPENDIX III

APPENDIX III

OIL-SHALE ASSAYS BY MODIFIED FISCHER RETORT METHOD

Surface samples collected at the Chandalar Oil Shale Deposit near the north end of the Venetie Reservation, Alaska; at an elevation of 2900 feet MSL in the SW1/4, sec. 24, T 34 N, R 11 E, Fairbanks Principal Meridian.
Submitted by R. H. Lambeth, USBM, Anchorage

Sample number		Yield of product						Specific gravity	Properties of spent shale	
		Weight percent				Gal per ton		of oil at	Tendency to	
Laramie	Their	Oil	Water	Spent shale	Gas + loss	Oil	Water	60°/60° F	coke	Remarks
SBR76-1008x	DA-30	50.5	4.0	36.8	8.7	136.0	9.6	0.891	Heavy	
SBR76-1009x	DA-32	32.4	3.1	58.8	5.7	88.4	7.5	.879	Heavy	
SBR76-1010x	DA-33	48.7	2.5	42.1	6.7	132.4	6.0	.882	Heavy	

Description of samples:

Country rock is Devonian cherts and shales.

DA-30: Sample of high grade, brown weathering oil shale taken from Pit #1 dug 108' and N5° E of old Ebbley Pit #6. The pit stopped in greenstone bedrock at a depth of two feet.

DA-32: Sample of high grade oil shale from the vicinity of Pit #3 dug 20' southeast of Ebbley Pit #6. This pit was dug to a depth of 3'. Oil shale was found only in the upper 2'. The bottom feet contained primarily light colored sandy soil with very little oil shale. Bedrock was not intersected.

DA-33: Sample of high grade oil shale dug from Pit #2.

Samples received October 6, 1976; assays made on air-dried samples

Laramie Energy Research Center, Laramie, Wyoming Illustration No. SBR-4858P Sheet 1 of 1 October 7, 1976