COAL TO METHANOL FEASIBILITY STUDY BELUGA METHANOL PROJECT

DOE GRANT DE-FG01-80RA-50299

FINAL REPORT

VOLUME III
TECHNICAL

DOE/RA/50299--1119 Vol. 3

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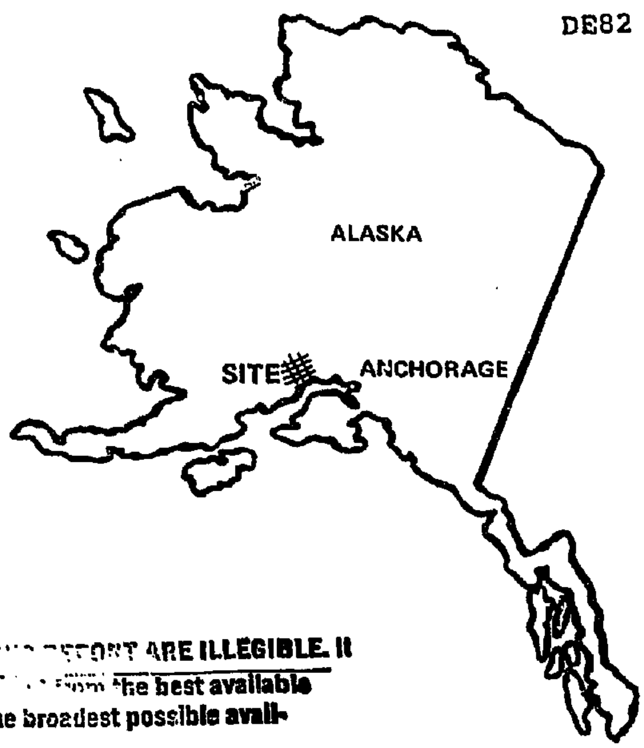

COOK INLET REGION, INC.
AND
PLACER AMEX INC.

SEPTEMBER 1981

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GEOTECHNICAL AND INFRASTRUCTURE
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TASK CROSS REFERENCE

The organization of this report does not follow the sequence of Tasks 1.00 through 9.00 in the Statement of Work and Study Schedule stipulateo in the CIRI/Placer Proposal of 25 April, 1980. It has been found more convenient and orderly to arrange the subject matter as now presented in Volumes I through V.

To enable those concerned to review the study findings with respect to the associated assigned tasks, the following cross referenced tabulation is provided.

TASK 1.00	CONCEPTUAL DESIGN	REFERENCE VOLUME	SECTION
1.01	Mine	I	All Sections
		II	Conceptual Design
1.02	Railroad	III	Railroad
1.03	Process Plant Onsites	II	All Sections
1.04	Process Plant Offsites	II	All Sections
1.05	Camp, Town & Airstrip	III	Camp, Town & Airstrip

2.00 ENGINEERING DESIGN

2.01	Mine	I	All Sections
2.02	Railroad	III	Railroad
2.03	Process Plant Onsites	II	Coal Preparation Gasification Syngas Upgrading Synthesis & Distillation Emergency & Safety Systems Building & Vehicles Dust Collection
2.04	Process Plant Offsites	II	Oxygen-Nitrogen-Air Utilities Wastewater Treatment Storage Facilities
2.05	Camp, Town & Airstrip	III	Camp, Town & Airstrip
2.06	Overall Plant Layout	Executive Review	Summary of Study
		II	Introduction
2.07	Pipeline Transport, Storage, Handling and Shiploading	III	Product Transportation

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4.00 DETAILED CAPITAL COST ESTIMATE

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4.03	Prepare Individual Cost Estimates	V	Capital Cost
	a. Mine	I	Tables
	b. Railroad	III	Railroad
	c. Camp-Town-Airstrip	III	Camp-Town-Airstrip
	d. Coal to Methanol Plant	V	Capital Cost
4.04	Prepare Overall Cost Estimate	V	Capital Cost

5.00 MARKETING

5.01	Evaluate Market Requirements	V	Marketing
5.02	Develop Marketing Methods	V	Marketing

6.00 SITE EVALUATION

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8.00 ENVIRONMENTAL, HEALTH, SAFETY & SOCIOECONOMIC ASSESSMENT

8.01	Environmental	IV	Baseline Data Environmental Effects
8.02	Socioeconomics	IV	Baseline Data Environmental Effects
8.03	Site Evaluation	IV	Site Evaluation
8.04	Health	IV	Safety and Risk
8.05	Safety	IV	Safety and Risk

9.00 TECHNICAL SUPPORT PLANS

9.01	Project Management Plan	Executive Review	Plan for Phase II
9.02	Project Manual	Issued at start of Phase I. To be expanded for each additional phase.	
9.03	Reports	Quarterly reports issued during Phase I. Progress reports will be issued as required in future phases.	

INTRODUCTION TO VOLUME III

GENERAL

This Volume III contains reports on studies done entirely or partially by various study members and their subcontractors in the following areas:

- o Geotechnical Aspects of the Project
- o Railroad System
- o Barge Dock
- o Bus System
- o Construction Camp, Townsite and Airstrip
- o Pipeline and Marine Transport

These topics and the study team members involved are listed and briefly described in the paragraphs which follow.

GEOTECHNICAL OVERVIEW (Prepared by Klohn-Leonoff, Ltd.)

This study covers the geotechnical aspects of the conceptual designs contained in other parts of this Phase I Feasibility Study, and includes an outline of additional work required in Phase II before starting final engineering design.

RAILROAD SYSTEM (Davy McKee and R. A. Fisk & Associates)

Design parameters for construction and operation of a heavy duty railroad system to transport approximately 42,000 tons of coal per day a distance of 21 miles, including:

- Alignment, profile and typical design cross sections

- Bridge structures

- Sidings, loading and unloading loops, ash loading and equipment maintenance tracks

- Train consists and scheduling

Studies done by R. A. Fisk & Associates with respect to routing, construction, capital costs and operating cost are contained in a Fisk Report which is attached to and considered to be a part of "Section 2.0 - Railroad System" in this volume.

BARGE DOCK (Davy McKee)

Preliminary design of a dock, ramp and staging area for receiving barged modular construction units, construction materials, equipment, and plant materials and supplies.

BUS SYSTEM (Davy McKee)

A plan for the transport of mine workers and construction personnel between the camp, town and mines.

INFRASTRUCTURE (CIRI/Holmes & Harver)

A conceptual plan providing preliminary guidance for the initial consideration and eventual development of 1) a construction camp for 3,000 persons; 2) an airport capable of serving Lockheed Hercules aircraft; 3) a permanent townsite for 2,600 to 4,200 persons; and a review of selected available information regarding the physical and land use characteristics of the project area and relevant socioeconomic trends of the surrounding Cook Inlet region.

PRODUCT TRANSPORTATION (Cook Inlet Pipe Line Co., Placer Amex)

Section 6.0 in this volume covers the transportation of the methanol product from the plant to the marine terminals of receivers in various market locations. This includes:

(1) A study by Cook Inlet Pipe Line Co. (the CIPL Report) covering system modifications required to permit handling of both crude oil and methanol in the existing pipeline; loading of methanol into tankers at Drift River Terminal; and a schedule of tariffs for pipeline transport and loading into tankers.

(2) A study by Placer Amex of means for marine transport of methanol from Drift River Terminal to market area terminals, including estimated freight rates under various available alternatives.

GEOTECHNICAL OVERVIEW OF
THE PROPOSED BELUGA METHANOL PROJECT

Project: BELUGA COAL

Location: TYONEK, ALASKA

Client: COOK INLET REGION, INC. AND
PLACER AMEX INC.

VA 2806 August 26, 1981

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List of Attendees - July 22, 1981

Appendix II - Beluga Coal Field - Seismicity Assessment
- Climatic Overview of Beluga Coal Fields

Appendix III - Reference list of Reports and Available Data used in Klohn Leonoff Study
- Summary of Index Tests Carried Out In the Klohn Leonoff Laboratory and by R.M. Quigley of the University of Western Ontario

DRAWING

B-2806-1 - Layout of Project

VA 2806 August 26, 1981

1. INTRODUCTION AND TERMS OF REFERENCE

The Beluga Methanol project is located along the northeast shore of Cook Inlet in Alaska, approximately 50 miles southwest of Anchorage. Main components of the proposed project, shown in Drawing B-2806-1, include two open-pit coal mines (Chuitna West and Capps pits), a 20 mile long railroad, processing plant, coal stockpile area, pier, associated access roads, and a townsite.

Klohn Leonoff was retained to provide a general overview of the geotechnical aspects of the design work carried out to date in the feasibility studies, and to outline the additional work necessary to carry the project to the final design stage. The overview was authorized in a letter from Mr. C.E. McFarland of Placer Amex, dated May 19, 1981. A copy of the scope of work is provided in Appendix I of this report.

Work included a review of available data, discussions with personnel from Placer Amex, Cook Inlet Region, Dowl Engineers, Weir Engineering, R.A. Fisk and Associates; a site visit by Messrs. M. Olsen and R. Benson of Klohn Leonoff on June 24/25, 1981; and a general meeting with representatives from all the above organizations on July 22, 1981 in Vancouver. A list of attendees is given in Appendix I.

2. GEOLOGY AND HYDROLOGY

2.1 Geology

Bedrock in the project area is comprised of sedimentary rock of Tertiary age, overlain by a discontinuous mantle of glacial till varying in thickness from 0 to about 100 ft with an average depth estimated to be 30 to 40 ft.

Bedrock is an interbedded sequence of sandstone, siltstone, and claystone containing coal layers. All rock types are poorly indurated, essentially non-cemented, and are considered to be very weak.

A major fault (Castle Mountain Fault) strikes through the project, separating the Chuitna and Capps pits. Upwards of 2000 ft of throw is suggested on the fault,* although subsequent erosion and glaciation has levelled the rock surface across the fault. In the Chuitna pit the bedrock is gently folded, but in the Capps pit, dips from 6-12° to the north. No obvious significant differences in rock quality exists between the two pits.

From the highlands area of the pits the landscape falls to the south over the Nikolai escarpment, and onto the level delta of the Nikolai River. The escarpment is a moderate to gentle slope, generally stable, but in some of its steeper areas has undergone severe landsliding and slumping. To the north the actively downcutting Chuitna River has resulted in generally unstable slopes along the entire river valley within the project area. Numerous slides are in evidence as a result of the youthful geologic environment and the weak rocks.

The area is one of strong seismicity with numerous recent shocks of Magnitude 6 or greater. A preliminary assessment of seismicity was made by Klohn Leonoff. Results of the assessment are given in Appendix II. It is apparent that seismicity is an important topic to be considered in the final design.

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* See list of references.

2.2 Hydrology

Part of the Klohn Leonoff overview of the geotechnical aspects of the Beluga Site included a preliminary assessment of the hydrology. This is presented in Appendix II.

In summary, preliminary estimates of temperature and precipitation are:

Mean maximum July temperature	61°F
Mean minimum January temperature	1°F
Mean annual precipitation	30 to 40 inches
Mean annual peak 24 hour precipitation	2 inches
100 year peak 24 hour precipitation	5 inches
24 hour probable maximum precipitation	16 inches

In the July 22, 1981, meeting, preliminary data from Dowl Engineers, Anchorage, Alaska, indicated rainfall will be higher, with mean annual precipitation at Capps of about 60 inches.

3. KEY GEOTECHNICAL FEATURES OF THE PROJECT

This section covers the principal subjects of our study and reference data. A reference list of reports and available data used in our study is given in Appendix I. Also included is a summary of index tests carried out in the Klohn Leonoff laboratory and by Dr. R. Quigley of the University of Western Ontario in Appendix III. A site plan is also included for reference.

3.1 Chuitna Pit

3.1.1 Pit Slopes

Pit slopes will encounter glacial till within the upper 100 ft overlying the soft sedimentary rocks. Final overall pit slopes should not exceed 30°. Benches and intermediate slopes of 45° not exceeding 100 ft in height could be used to develop the overall slope. Joint patterns, although probably wide and indistinct in these massive soft sedimentary rocks, will also have to be considered in final stability designs.

Drainage and pore pressure control of the pervious aquifers in the slopes, particularly coal seams will probably be necessary. We anticipate vertical pump wells installed from benches as necessary would be appropriate. Drainage ditches around the edge of the pit and along the coal seam exposures in the pit wall would control surface and subsurface drainage.

The recommendations above are considered to be preliminary and general. Additional detail work is necessary to confirm their validity, and adjustments to final slope angles and drainage requirements in local parts of the pit should be anticipated in final design.

3.1.2 Waste Dumps

We understand that waste dumps are being considered, both on the ground surface around the pit and within the pit. We believe the stability of the waste dumps is a critical matter, due to the weak and water-sensitive nature of the waste. The sensitivity of the waste materials and loss of strength due to remoulding and water is demonstrated in the large slope failures observed in the area. When the soft rocks are overstressed and/or weakened by water and subsequently fail 'en masse', they can assume a very flat profile, not unlike flow slides observed in sensitive soil deposits. It will be necessary therefore to control the access of water into the waste dumps, and restrict the development of pore pressures to acceptable levels. This problem is accentuated by the strong seismicity of the area.

We recommend for surface waste dumps that compacted dikes of glacial till be constructed to confine the waste. Finger drains should pass under the dikes and beneath the dumps to drain them. Overall slopes on the dumps should not exceed about 25°, utilizing intermediate berms and slopes not exceeding 35°. Dumps should be set back from the edge of valley walls or escarpments to ensure stability. For preliminary design we suggest 500 ft.

In-pit waste slopes should not exceed 20° overall, with intermediate benches and slopes of 30°. Control of water in the waste dumps will require surface ditches on pit benches, particularly along the coal seam exposures. These should drain along the benches into the pit, with water pumped to the surface. Dumps should be sloped to send water to the rear and side drainage ditches.

Prior to final design appropriate studies of the dike foundations, construction material for dykes and drains, strength and stability of final waste dump slopes will be necessary. Some adjustments to the recommendations given above should be expected, although we believe the recommendations given are conservative.

An observational approach combined with instrumentation (piezometers and inclinometers) should be considered to monitor performance of the piles. Adjustments to slopes can then be made as necessary.

3.1.3 Groundwater

We anticipate relatively high groundwater tables in the Chuitna Pit. These may be perched within the pervious seams such as the glacial till and coal beds. Drainage of these seams will be necessary to ensure slope stability. At present no information on water tables and permeabilities exists, so further work will be necessary prior to final design.

We recommend that prior to final design a number of drillholes fitted with piezometers be installed to assess the flow patterns in the pit area. Pump tests should then be done to assess the permeability of the aquifers and the mass rock, for use in final design of pit walls and drainage schemes. At present we do not anticipate large volumes of water being supplied from the mass rock, and flows from the till and coal seams will be modest.

3.1.4 Drainage and Sedimentation

Drainage control is required for two purposes. Firstly to control and divert existing creeks which will be intercepted by permanent works, and secondly to control and clarify construction water which becomes contaminated by surface drainage over construction works.

Diversion and control of existing creeks will require appropriate structures designed for spring flood conditions. Such water would not require clarification as this can be considered a normal hydrologic process which occurs every year. Relatively large volumes of water will have to be handled as spring floods occur in a concentrated period.

Sedimentation ponds will be required to clarify construction water which will be contaminated with silt and clay particles from drainage over waste dumps, pit walls, access roads etc. Appropriate sedimentation ponds can be established to intercept construction drainage, and to receive pumped water from within the pit. The pits will have to be sized for estimated construction and surface drainage water, and include an overflow to allow clarified water to return to original drainage courses. Flocculation agents may have to be considered in view of the large amount of silt and clay particles available from the weak rock and the silty glacial till. These are normal problems for mine developments and we anticipate no significant difficulty in meeting appropriate State and Federal water standards.

3.1.5 <u>Trafficability</u>

Trafficability is a significant problem. We anticipate that the weak rock will be easily disturbed by wheeled traffic and will not provide good bearing surfaces. This is discussed in more detail below in Section 3.4 Temporary Roads.

Dust will be generated from construction surfaces on rocks and till both in winter and summer. Frozen, snow-free surfaces are often as trouble-some as surfaces dried in the summer sun. Appropriate spraying or covering will be necessary to handle this problem.

3.1.6 <u>Excavation Equipment</u>

We understand that large shovels will be used to excavate both till and rock in the Chuitna pit. At present we believe the rock can be handled with a shovel and without blasting. We believe that large draglines or bucket-wheel excavators could also handle the rock without significant difficulty, although not as easily as power shovels. Geophysical studies combined with a detailed study of the rock cores should be done in the next phase to check for hard layers which could require blasting, although we believe the possibility is unlikely.

3.2 Capps Pit

3.2.1 Pit Slopes

Overburden materials in the Capps Pit are similar to Chuitna, with a mantle of glacial till overlying weak sedimentary rock, mainly mudstone. The sedimentary beds dip approximately 10° N. Behaviour of the pit slopes and waste piles is expected to be similar to the Chuitna Pit.

At present the mine plan calls for exploitation in a series of approximately N/S strips, uncovering the coal and sidecasting the spoil in a series of longitudinal N/S windrows opposite the exposed face of the coal. From a geotechnical point of view we believe the general plan is reasonable.

We believe the overall slope of the pit walls should not exceed 30°. Intermediate berms and slopes of 45° would be suitable for the upper benches, which are to be excavated by shovel. The lowest bench is to be excavated by dragline with temporary slopes of 65° to a maximum height of 100 ft, including the coal seam. Dragline setback is 38 ft. We believe these are reasonable criteria, which should not be exceeded at this level of design. Stability of the main lower bench will be governed by control of pore pressures in the coal seam, and the shear strength of the underclays, known to exist from drilling data. Final design will have to consider detailed stability analyses of rock when more data on groundwater and shear strength of the rock and underclay are obtained. Joint patterns, although probably wide and indistinct in these massive mudstones will also have to be considered in final stability designs.

3.2.2 Waste Dumps

Permanent waste dumps established outside of the pit boundaries should be designed similar to Chuitna with containment dikes, under drainage, and maximum overall 25^{o} slopes with berms. No dumping should be done on the major slide which exists to the northeast of the pit.

At present the mine plan envisages the majority of waste returned directly to the pit by sidecasting. Stability of the waste dumps will depend upon good drainage, and the relative height of slope angle with respect to the height of the waste pile. At present the mine plan envisages overall dump slopes of about 15^{o} comprised of a series of windrows. However, single windrows of 180 ft high with 37½^{o} slopes are contemplated. We believe that piles greater than 100 ft high should be set at an angle no greater than 30^{o}. This can be achieved either by controlled side-casting or flattening steep slopes by secondary equipment. Slopes up to 100 ft high could be up to 35^{o}. It is important that drainage of the piles be assured by appropriate sloping and ditching. Special attention may be required for the inner toe of the frontal waste pile, as drainage and softening may encourage local slumping.

An observational approach combined with instrumentation (piezometers and inclinometers) should be considered to monitor performance of the piles. Adjustments to slopes can then be made as necessary.

3.2.3 Drainage and Sedimentation

Drainage must be addressed in two areas. Firstly the interception and diversion of creeks which now flow to the northeast across the Capps pit area towards the Beluga River. Appropriate structures to handle existing flows and spring floods will be necessary. As existing creeks are now quite dirty, diversions should carry these waters to the Beluga River rather than the Chuitna, as the Beluga is presently sediment-rich due to glacial melt. This will prevent contamination of the clean Chuitna River.

Sedimentation ponds will be necessary to clarify water contaminated by construction activities. This would include water draining over waste dumps, roads, pitwalls etc. Pumping in-pit water to these ponds will be necessary. Clarified water should also be drained towards the Beluga River.

We note that additional water should not be added to the head of the major slide area on the northeast side of the Capps pit. Diversions of water excess to that which now enters the slide area, should be made to the northwest towards the Capps glacier.

3.2.4 Groundwater

Perched groundwater tables are anticipated in the Capps pit within coal aquifers and pervious seams. It will be important to drain these aquifers, particularly in the lower main bench to ensure pit wall stability. At present no significant information exists on groundwater. A number of drillholes with piezometers are recommended to determine flow patterns, and pump wells to determine permeability of the mass rock and the aquifers. This should be done in the next stage of work.

3.2.5 Trafficability

Trafficability will be a problem on the fine grained mudstone. Sand and gravel covering will be necessary for haul roads and construction surfaces. Frost action of the underlying fine grained mudstone and fill in final design. This is discussed in more detail below in Section 3.4, Temporary Roads.

We understand from the mine plan that coal surfaces may be utilized to improve trafficability in the lower pit. This should be advantageous but we note the possibility of dust generation from the coal.

Considerable dust may be generated from pit slope walls, waste piles, and other exposed surfaces in the mudstones, due to the fine grained nature of the rock. This can be true in either summer or on snow-free frozen surfaces in winter. Appropriate coverings or water will be required to overcome the dust problem.

3.2.6 Excavatibility

We anticipate that power shovels will be able to excavate the overburden without significant difficulty. Similarly draglines should also be effective in both the coal and rock of the Capps pit, but will be less effective than shovels. Bucket wheel excavators are apparently not being considered.

We suggest that geophysical studies combined with a careful review of the core be made to check for hard rock layers in the next phase of work. We note that the rocks should be somewhat harder in the Capps pit than in the Chuitna, due to the additional erosion that has occurred on the upthrown side of the Castle Mountain fault.

3.3 Transportation Corridor - Railway and Main Road

This section will address the transportation corridor; temporary access roads are described in the following Section 3.4.

3.3.1 Introduction

The coal will be conveyed to the methanol plant by unit train from one or both pits. The distance from Capps Pit to the plant is about 20 miles, a difference in elevation of 1600 ft, and an average grade of 1.5%. The physical conditions of the site fix the alignment and grade of the railway to a narrow corridor. A main roadway will approximately parallel the railway. This will provide access for staff to the pits, and access for maintenance personnel to the railway right-of-way.

In the future a branch line may be constructed to the north crossing the Chuitna Creek to service the BHW leases, owned by others.

The railway concept was studied by Davey McKee, and later R.A. Fisk and Associates reviewed the proposed railway and developed a more precise but preliminary cost estimate. The estimate for the Plantsite-Capps section varied between 77 and 99 million dollars including 7 bridges. We understand the range of costs depended mainly on assumptions for foundation conditions. Benson and Olsen flew the proposed route by helicopter in the course of a one-day site inspection. The area of side hill cut about 5 miles south of Capps Pit area may present slope stability problems. This area should be investigated early in Phase II studies in case a significant change of conditions is encountered.

We conclude that barring any significant stability and environmental problems the route is appropriate and that the geotechnical problems can be handled by normal design practice. In addition, most or all of the bridges could probably be substituted with fills. This we understand, would place the cost estimate closer to the 77 million figure.

3.3.2 Alignment and Foundation Conditions

The transportation corridor location will be defined closely by the railway grade and alignment. The roadway, with more latitude with grade, will be located nearby. The railway embankment will cut through ridges, cross swamps and creeks, and will traverse a significant length of side hill cut.

3.3.3 Proposed Cross Sections - Railway and Road

The top width of the railway subgrade will be 26 ft, with the ballast of crushed rock, ties and track placed on top.

The travelling surface of the roadway would be about 40 ft wide with additional 3 ft shoulders on each side. The details of cut or fill, side slopes ditches, cut slopes and culverts would be similar for both railway and road embankments.

The compacted subgrade fill will be about 3 to 4 ft deep, depending on the quality of the granular fill for subgrade, and on the strength of the foundation soils. This will probably apply from the plantsite to northwest of the Chuitna West Pit Area.

Described as mileage from the plantsite, from mileage 0 to about 12 to 15 the railway would be climbing up the Nikolai escarpment and pass the Chuitna West Pit Area. In the last 5 miles, the railway is located north of the Castle Mountain Fault, and is located on the upper slope of the Chuitna watershed area. The embankment is in a cut (upslope) and fill (downslope). In addition, the line crosses a number of small tributary streams of the Chuitna. In this area the railway will be in a side hill cut with compacted soil downslope. Two conditions of stability must be met. Firstly, the overall slope must be able to support the railway and adjoining roadway and secondly, the uphill slope must be stable. Siltstone and claystone may be susceptible to instability on steep slopes. The slopes may have to be flatter, such as 3h to 1v (horizontal to vertical) with a 10 ft wide drainage berm if a slope is higher than 25 ft.

The compacted downslope embankment of claystone or siltstone would have the same limitations. This precautionary note is provided for this particular area although some more stable glacial deposits may be encountered.

3.3.4 Drainage

The railway embankment must have well defined ditches to keep the water table at least 5 ft below the bottom of the ballast. The water table must also be kept at least 5 ft below the travelled surface of the roadway.

Diversion ditches are required at the top of all cut slopes to divert surface drainage away from the open slopes.

Seepage out of cut slopes will require reverse filters to prevent backward erosion which would cause the slopes to progressively fail.

3.3.5 Creek Crossings

The railroad and road will cross a number of creeks. We assume the road alignment can be adjusted to balance cuts and fills, and to keep creek crossings to a maximum depth of 50 ft of fill with an appropriately sized culvert. In some cases, the railroad and road embankment may be combined over these creek crossings and further study may allow fills to be substituted for bridges, if foundation conditions warrant.

Culverts require maintenance in the winter so they are clear of ice during runoff in the spring. This involves a steam truck to thaw out the ice periodically through the winter. In similar northern conditions two culverts are installed, one a few diameters above the other. The upper culvert would be open in the spring thaw and during any unseasonable thaws in the winter.

3.3.6 Swamps and Waste Piles

The railway and road alignment may cross swamps of significant surface area. Each swamp will have to be appraised to determine:

- if the alignment can be changed
- if the unstable swamp material (and water) can be removed, and a conventional embankment constructed
- or, if the ambankment could be constructed across the swamp.

In the latter case, appropriate adjustments would be made to the embankment dimensions and grade to accommodate long-term settlement.

Submerged embankment fills would probably be constructed of granular material on top of the existing swamp. This alternate has some construction problems but avoids the problem of storing unstable swamp waste.

Construction along the transportation corridor will require development of borrow pits and waste fill disposal areas. Borrow pits will have to be properly designed to make best use of the excavated material. In addition, the depleted pits must be left in a tidy and drained condition for reclamation.

In a similar fashion, waste piles must be constructed and shaped so they are stable and well drained. A requirement of development permits may be that topsoil must be kept separate for future reclamation treatment.

3.3.7 Geotechnical Consideration - BHW Line

This shorter railway line is a spur line located to the north, crossing the Chuitna Creek to the BHW leases. Crossing the Chuitna valley and creek is the main problem; the approach line on either side would be handled as described in previous sections.

Crossing the Chuitna could be handled by a high bridge from the top of the valley. The bridge could be in the order of 3000 ft long and 250 ft high. Alternatively the line could possibly descend the south side of the Chuitna probably in an upstream direction, cross on a low bridge and ascend the north slope. This could involve a detour of 6 to 8 miles of maximum grade in complicated side hill cuts and fills to fit railway curvature requirements.

Slides have been noted in many parts of the Chuitna Valley, and these should be avoided by approach cuts, and in siting the bridge.

The bridge abutment and piers would be founded on spread footings unless some unexpected condition required piles to resist uplift, or deep scour. Piles might be required to resist overturning of piers due to earthquake shock.

3.3.8 Construction Schedule - Road and Railroad

The road and railway construction will have to be scheduled to have the minimum impact on the Chuitna Creek. A section of the railway, and probably road alignment, an estimated 5 miles in length, will be located in a side hill cut near the Chuitna and will cross the Chuitna just south of the Capps Pit area. Runoff from the earthwork construction operations could contaminate the upper reaches of the Chuitna. This environmental problem should be carefully assessed, relative to pollution control, such as, construction during the least sensitive time of the year, or by modifying the design.

The alignment for a transportation corridor on the southwest side of the Chuitna would probably be held in this location. Alternative alignments would involve a second crossing of Chuitna and a longer route passing near Lone Ridge.

3.4 Temporary Roads

3.4.1 General

The temporary roads will be located within the open pits and waste piles at West Chuitna and Capps. Within the pits, roads will be constructed and abandoned on a regular basis as the pit faces and waste piles progress. Under these circumstances, road preparation will vary from a bulldozer keeping a shovel loading area tidy, to constructing high capacity roadways on the waste piles and up the pit side slopes, to be in use for at least a few years.

3.4.2 Road Sections

Temporary roads near the working face would probably only be required where precipitation and/or groundwater combine with an easily softened bedrock to create unstable travelling conditions. This situation would be controlled or minimized by careful drainage control at each excavation level. In many areas, sand and gravel, or sandstone waste fill perhaps augmented with filter cloth will probably be required to maintain access to the main haul roads.

The main pit access roads will probably be used for 6 months to a year or more. These roads will be sloped from bench to bench to provide access for the trucks from the top to the bottom of the pit. The pit slope would be designed to safely accommodate the access road. The road embankment would consist of at least 3 ft of compacted granular fill or fine gravel subgrade to resist rutting and heaving particularly during the spring thaw. In addition, the road embankment would have to be well drained, with a ditch at the toe of the inside slope with appropriate culverts and sumps to keep water away from the road surface. All access roads would be maintained with a suitable number of graders (road patrols) to keep the surface smooth and crowned and free of snow in the winter. The roads will be dusty in dry weather, and will probably have to be watered. Longer term temporary roads may be sealed with oil or asphalt.

3.5 Granular Borrow

3.5.1 Introduction

The obvious source of Granular Borrow is adjacent to the Nikolai River, almost at sea level. The not-so-obvious sources are:

- possible moraines at the top of the Nikolai Escarpment, south and west of the Chuitna Pit Area.
- glacial till overburden over the project area.
- granular zones, sandstone and conglomerate in the bedrock "waste" zones between the coal beds.
- the volcanic deposits of fly ash and rock southwest of Capps Pit area.
- a granitic intrusive deposit near Lone Ridge for a rock quarry.

The Nikolai-Chakachatna source appears to be readily available, but quite expensive to deliver. The other sources would become available during construction. All sources of granular borrow should be appraised prior to construction, so the available supplies can be economically developed and equitably distributed during construction.

3.5.2 Nikolai-Chakachatna Flood Plain

The Nikolai Creek drains the highland area south of Capps. The creek does not have any glacial-source water and is considered clear, although the water was cloudy during the 1981 June runoff. The creek drains off the highland in two distinct branches then flows to the ocean, parallel to the Chakachatna. The Chakachatna is the predominant river and is probably responsible for the main gravel content of the Nikolai flood plain.

Visual on-site appraisal of these gravels indicate mostly volcanic, and some granitic materials. Some of the Tertiary sedimentary materials may be present, particularly in the sand sizes. The granular material inspected at the logging company gravel pit was gap-graded sand and gravel, a trace of silt, and maximum size 3 inch with occasional particles up to 6 inch. The logging company had hauled in one truck load of granitic boulders 3 to 5 feet in size, for river bank slope protection. We understand these came from a source to the southwest.

We consider an adequate supply of high quality construction sand and gravel is available in the Nikolai Creek area. With selection and mixing, well graded pit run granular material is available. Special aggregate sizes would be obtained by processing with a screening plant.

3.5.3 Nikolai Escarpment Moraines

The geological description of the Nikolai Escarpment includes a description of some graben-like formations south and west of the Chuitna Pit area. These formations might alternatively be described as side moraines placed when a glacier might have occupied the Chakachatna Valley. The formations are more or less discontinuous, but extend sporadically for a number of miles, at the top of the escarpment.

Side moraines are frequently a source of sands and gravel discharged from fissures at the side of a glacier.

3.5.4 Glacial Till Overburden

Glacially deposited overburden (glacial till) has been reported in the exploration drilling, from very shallow depths to over 100 ft. Layers of glacial till appeared to be exposed in many of the small scarps visible in the upper banks of the Chuitna, and at the edge of the large bowl-shaped depression southeast of the proposed Chuitna West Pit.

We understand that in many of these exposures the glacial till-sedimentary bedrock contact is indicated by seeping water. In many cases, this has probably precipitated the slide forming the scarp. This indicates that in these areas the glacial till is pervious to semi-pervious. Studies in glacial transport in the central United States indicate a glacier does not carry soil more than approximately 30 miles from pickup to deposition. In the Beluga area, the glacial till probably consists of granitic and volcanic materials from the nearby mountains, together with some siltstone and claystone and even some coal. The sedimentary material could be in large particle size or alternatively could be dispersed in small particles.

The glacial till could then be a variable, and in most cases, a lower grade granular material. Probably, a significant volume of glacial till would be removed in the open pit preparations, and used for rail and road bed construction. The glacial till could be used extensively for site preparation, waste pile retention structures and in road bed construction. The design of these structures should be directed to the maximum use of the available granular material within the till.

3.5.5 Granitic Intrusion (Lone Ridge)

A granitic intrusion had been located in earlier geological field studies near the Lone Ridge area, northeast of the Chuitna Creek. This exposure suggests the possibility of a rock quarry from which granitic aggregates may be crushed. This site is on the northeast side of the Chuitna Creek, and therefore is not readily available at present.

The strength, durability, and availability of this material should be assessed during the next phase of work.

3.5.6 Sandstone and Conglomerate - Tertiary Deposits

Granular materials have been reported in the exploratory drilling for the coal deposits. These materials described as sandstones and conglomerates were considered waste materials during the exploration for the coal. In addition, the U.S.G.S. drill hole at Capps was unable to recover any core samples in these significant granular zones because of its granular and poorly cemented nature.

Zones of usable granular material will probably be available in the development of each open pit. This material could be most useful in the construction and maintenance of temporary access roads within the open pits. These materials could be used over claystone and siltstone which are firm in their natural condition, but can quickly soften and rut when exposed to rainwater and heavy construction traffic.

Similar granular material might be used for sanding icy roads during the winter.

3.5.7 Volcanic Deposits

A large volcanic deposit of mainly lapilli and ash has been observed southwest of the proposed Capps pit. Ash and lapilli are volcanic materials which have been thrown in the air by volcanic action, with lapilli being sandsize or larger. Ash-free material could provide granular backfill, and may even produce suitable railway ballast, although this source may prove to be a costly alternate.

3.5.8 Future Studies for Granular Borrow

The next phase of the geotechnical studies should consider an inventory of available materials. This would be established on the basis of a terrain analysis, with an appraisal of airphotos, available site exposures, drill cores, and test pits. In addition, each site development should conserve their own granular supplies, and make surplus granular materials available.

The inventory would be deliberately updated when new sources of granular materials are encountered. This might happen particularly on the road and railway construction.

3.6 Townsite and Plantsite

3.6.1 General

The townsite and plantsite locations have been selected in earlier studies by others. Dowl Engineers have been studying the foundation conditions at these sites. Water supply will be from an infiltration system near Nikolai Creek. Sewage will probably be processed, collected in a lagoon and discharged into the ground to drain toward the ocean.

We understand the proposed plantsite has a number of swampy areas and that the specific plantsite locations may be relocated. Benson and Olsen briefly inspected the townsite and plantsite from the helicopter. They concur that the soils underlying the sites are probably in dense fill and will provide stable foundation conditions. In some cases the dense fill will underly swamp deposits.

3.6.2 Townsite

The townsite is located on the Nikolai escarpment, about 2 miles northwest of the plantsite, on a gentle slope facing to the southwest.

The foundation soils of the townsite are probably dense and granular. While the site slopes to the southwest, control of surface and groundwater will be most important. The site is located on a ridge crossing one stream course and between two other stream courses draining down the slope. This location will ensure a lower water table. However, construction design practices should avoid charging and trapping groundwater in the townsite foundations.

3.6.3 Plantsite

The plantsite is located on the southeast end of the Nikolai Escarpment, which has a gentle slope to the southeast about 250 to 300 ft above sea level.

The foundations are probably granular, glacial till, or ancient beach deposits. The swamps may have developed behind sand bars. The water table appears to be near the surface. Control of the water table would appear to be the main problem in this area.

We assume the proposed methanol processing plant is similar to an oil refinery or a thermal generating plant. The main buildings may be steel frame with high design loads partly static, and partly a combination of wind, snowload and seismic forces. Storage tanks provide fairly high static load, plus wind and seismic loads. Stacks require resistance to overturning from wind and seismic loading. Some vibratory machinery will require special foundation consideration. The foundation would probably be spread footings or grade supported slabs.

3.7 Coal Stockpile Area

3.7.1 General

The proposed coal stockpile area will be located near the edge of the ocean, where there is a narrow tidal beach, and a sand and gravel cliff standing at repose, about 150 ft high. The stockpile site is setback from the top of this cliff, on a more or less level surface. Forest and swamp deposits cover the area.

3.7.2 Foundation Conditions

Our visual appraisal suggests the site has a dense granular foundation. A local high water table is probably encouraged by a swamp deposit on the almost flat hummocky surface.

A suitable coal stockpile site usually consists of a level area above the water table. The coal is deposited from a stacker carrying a conveyor from the unit train unloading facility. Later, the coal is picked up either by a bucket wheel excavator connected to a conveyor, or drawn off by conveyors in reclaim tunnels beneath the stockpile.

A bucket wheel excavator is usually used in an area of poor foundation conditions, a high water table, or if the coal tends to arch over a reclaim tunnel preventing withdrawal.

A tunnel system is used at a site with good foundation conditions, with a low or controlled water table, and with a product that will flow. A good foundation is required to structurally resist spreading the conveyor tunnel as the load fluctuates during the loading-unloading cycles. In certain conditions, the tunnel must be structurally designed to resist the spreading. This loading facility contains some "dead" storage outside the cone of repose above draw points. On particular occasions, bulldozers are put on the stockpile to push the dead storage into the draw off points. The proposed site appears adequate for either method of handling. The pile should have a set back of at least 150 ft from the top edge of the bank for the present design. Subsequent foundation investigation and analysis may allow relocating the pile relative to the edge of the bank.

3.7.3 Dust

Coal stock piles are frequently dusty, and the area down wind from the pile will gradually become covered with coal. Dust suppression facilities may be required in both summer and winter operations.

3.8 Pier

3.8.1 General

A pier about 2000 ft in length is planned, near the coal stockpile area. The pier would extend out into Cook Inlet to permit delivery of equipment and ultimately shipment of bulk coal.

The pier would probably be steel reinforced concrete or a wooden structure supported on high capacity steel piles.

3.8.2 Geotechnical Conditions

Recent drilling indicates the foundation consists of dense granular material, probably glacial till, delta gravels from the Chakachatna or Tertiary bedrock.

If the foundation is, in fact, Tertiary bedrock the pier foundations would probably consist of high capacity steel H piles or equivalent. These piles penetrate a reasonable depth into the bedrock as they will have low relative displacement. The piles would have a high bearing capacity and resistance to uplift. Alternatively, steel pipe piles would be concreted into pre-drilled sockets.

At the end of the pier, the coal would be discharged into the ship from an elevated conveyor. The conveyor-loading-pier facilities, and dolphin and tie up facilities for the ship are usually separate.

Alternatively, the dense granular foundation may be part of the Chakachatna delta. In this case the piles might have to be driven to significant depth to develop high capacity support and to also provide uplift resistance.

The pier structure would be designed to withstand storm waves, seismic shock, and tsunamii (seismically induced waves).

3.8.3 Waves

In tho event the prevailing storm winds or tsunamii come from a southern direction, the pier may have to be designed to provide wave protection for the ship during loading. This could consist of a backfilled cellular pile breakwater. Alternatively, a pile supported or rock fill breakwater may be suitable. Rock fill for a breakwater would probably have to be barged in from a quarry and placed by crane.

3.8.4 Dredging

We assume the length of pier has been established to achieve a sufficient depth of water for coal carriers. Cook Inlet experiences considerable silting by glacial streams and tidal action, and we understand access to nearby Anchorage is maintained by dredging. The final design for the pier should consider a structure that limits silting, and does not require maintenance dredging.

3.9 Coal Ash Disposal

Coal ash will be produced in the production of methanol. Present plans are to carry the ash by a dedicated train to the West Chuitna pit area for disposal in the pit backfill.

Normal coal ash has a number of unsuitable properties, and cannot be dumped indiscriminately into the backfill. The ash, spread in layers, can have a deleterious effect on the seismic stability of the backfill. Therefore, the ash must be incorporated into the backfill so that continuous weak layers are not developed.

An alternate solution would be to store the ash, in a slurry behind containment dikes, near the methanol plant. A suitable location may be north of the railway loop. The environmental aspects of such a scheme would have to be considered.

4. FUTURE GEOTECHNICAL WORK REQUIRED

Significant investigations and designs are required in the geotechnical aspects of the project prior to final design. The following outlines the main points to be addressed:

a) A detailed groundwater evaluation is necessary including installation of piezometers to determine groundwater conditions, and pump wells to determine permeability of mass rock and aquifers for both Capps and Chuitna Pits.

b) A study of available construction materials, particularly in the glacial till for foundations and containment dikes, granular material for roads surfacing and concrete aggregate.

c) Determination of shear strength parameters of till and rock for use in the design of temporary and permanent pit slopes and waste dumps.

d) Study of the seismicity and tsunamii potential of the site and determination of appropriate design methods and parameters for geotechnical structures and foundations.

e) Study of the hydrology of the area and determination of design approaches and parameters to ensure water handling compatible with project, State and Federal guidelines. The work must include flood diversion, and erosion and sedimentation handling.

f) Geotechnical design of dumps, pit slopes, roads and railbeds, bridges, pier, townsite, plantsite, coal dumps, coal ash disposal, water diversions and sedimentation ponds.

g) Study of the development and behaviour of major landslides in the area to assess their significance relative to stability of pit walls and dumps, particularly with respect to seismicity.

5. CONCLUSIONS AND RECOMMENDATIONS

a) The proposed Beluga Methanol Project is located in a geologic environment where important geotechnical problems will be encountered. These relate mainly to the existence of weak rocks throughout the project area. In addition the project is located in a zone of strong seismicity which will affect the geotechnical design of all significant structures.

b) We consider that the preliminary design developed to date have taken into account the main geotechnical features present at the site. In general, conventional engineering solutions can be adopted for final design of the majority of the project elements. However, we believe that special emphasis must be placed on the in-pit waste dumps, to ensure safe slopes are adopted.

c) Prior to final design comprehensive geotechnical investigations are necessary to confirm or optimize the design assumptions presently adopted. Recommendations for the main areas of work to be addressed are provided in Section 4.

KLOHN LEONOFF LTD.

Mark Olsen

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Staff Consultant

RPB

R.P. BENSON, P. Eng. (B.C.)
Vice President, Engineering

MTO/RPB/mjl/sd

APPENDIX I

SCOPE OF WORK

LIST OF ATTENDEES, JULY 22, 1981

BELUGA METHANOL PROJECT

Klohn Leonoff Ltd. Consulting Agreement

Scope of Work

Klohn Leonoff Ltd. will draw on its wide experience in design of hydro-electric dam structures and mine waste/tailings disposal systems in providing an overview of geotechnical work and mine and reclamation plans for the Beluga Methanol Project. Scope of work will include the following:

1. A visit to San Francisco to meet with B. J. G. Patsch, Senior Geologist, and review available data including stereo airphotos, topo maps of area drill hole logs and location maps, U.S.G.S. reports on the Beluga area.
2. Visit the site following a meeting with DOWL Engineers in Anchorage. Visit potential mine and spoil areas, Chuitna River cuts, Capps escarpment and slide areas.
3. Observe proposed railroad and access road routes, bridge crossings, and borrow and quarry materials for roadbed construction.
4. Meeting with representatives of the Paul Weir Company to review geo-technical design criteria, pit design, and waste disposal methods.
5. Review and comment on drainage and sedimentation pond systems in both mine areas.
6. Review geotechnical work program and data gathering planned for Phase II of the Project development.
7. Furnish a letter report by July 15, 1981.

VA 2806 — August 26, 1981

List of Attendees at the meeting in Klohn Leonoff's Richmond, British Columbia offices on July 22, 1981, when the preliminary results of this Feasibility Study was reviewed.

Mark Olsen	Klohn Leonoff Ltd.
Raymond Benson	Klohn Leonoff Ltd.
Frank Klett	Cook Inlet Region, Inc. (CIRI)
Ron Dagon	Dowl
Cole McFarland	Placer Amex
John Paulson	Dowl
V.V. Botts	Placer Amex
Bob Hilling	Railway Consultant
Richard W. Storey	Paul Weir Co. (mining)
R.A. Fisk	R.A. Fisk & Assoc. Ltd.

APPENDIX II

BELUGA COAL FIELD - SEISMICITY ASSESSMENT

CLIMATIC OVERVIEW OF BELUGA COAL FIELDS

Our File: VA2806 June 8, 1981

BELUGA COAL FIELD - SEISMICITY ASSESSMENT

This seismicity assessment outlines preliminary design criteria for the proposed open pit coal mine and tailings pile near Tyonek, Alaska.

1. Regional Faulting Characteristics: The Aleutian arc region is underlain by a highly active northward-dipping zone of earthquakes that indicate major northward thrusting of the Pacific sea floor under the continent. To the east of Anchorage, the thrust faulting gradually changes to predominantly strike slip faulting. The entire inland part of the region is underlain by a zone of thrust faulting, in addition to large strike slip faults that break the surface there (Howard & others, 1978).

   A map of young faults in Alaska (Figure 1) shows that the site is very near a major thrust fault; since the fault has undergone displacements during the last 10,000 years it should be considered active.

2. Historical Earthquake Activity: A broad zone of shallow seismicity along the coast merges inland with a zone of shallow and intermediate seismicity (see Figure 2). Large earthquakes are not uncommon in this region; Figure 3 shows all recorded events of magnitude 7 or larger.

3. Design Ground Motions: The ATC-3 Tentative Code of Seismic Design (1978) recommends the use of a 1:475 year peak horizontal ground motion of 0.4g for this region, as

3. Cont'd.

shown in Figure 4. The 1:475 acceleration has a 10% chance of being exceeded in 50 years. This risk level is considered appropriate for critical components of the mining operation, such as the face of the tailings slope in the pit, the disposal pile above the pit, and the rock slope.

For less critical areas, such as the mill buildings, design to the Uniform Building Code Standard is appropriate.

The Uniform Building Code (1976) places the site in zone 4, for which "major damage" is expected due to the proximity of major faults. The design should consider Modified Mercalli intensities of VIII or greater. Intensity VIII corresponds roughly to a peak horizontal ground acceleration of 30%g (Davenport, 1972).

For long term structures, such as a permanent tailings dam, design for the maximum credible earthquake may be required. This is a deterministic assessment of the maximum credible ground motion at the site based on the local fault potential. For this area, Thenaus et al (1980) estimates the maximum magnitude to be between 8.2 and 8.8. Very large ground motions (accelerations in excess of 1g) could be associated with earthquakes of this size. However, the ATC-3 code recommends limiting design accelerations to a maximum of 0.4g, because of the uncertainty concerning the significance and validity of higher design values. For very large earthquakes, peak ground acceleration is not a good measure of earthquake size; the damage potential is more closely related to duration of shaking and frequency content. Therefore, depending on the design proceedure, a value of 0.40g may also be appropriate for long term tailings piles. Ideally, time histories or response spectra of large recorded earthquakes should be used to check the stability.

3. <u>Cont'd.</u>

The above comments apply to motions on bedrock or firm ground. For soft sites, soil response should be considered.

Gail Atkinson

GAIL ATKINSON

References:

American Technology Council, 1978: Tentative Provisions For The Development of Seismic Regulations for Buildings ATC-3-06.

Davenport, A.G. 1972:
A statistical relationship between shock amplitude magnitude and epicentral distance and its application to seismic zoning.
Eng. Sci. Research Report, BLWT-4-72, Univ. of Western Ont.

Howard, K.A. & others, 1978:
Preliminary Map of Young Faults in the United States as a Guide to Possible Fault Activity.

National Earthquake Information Centre, 1970: Seismicity of Alaska.

GA/nd

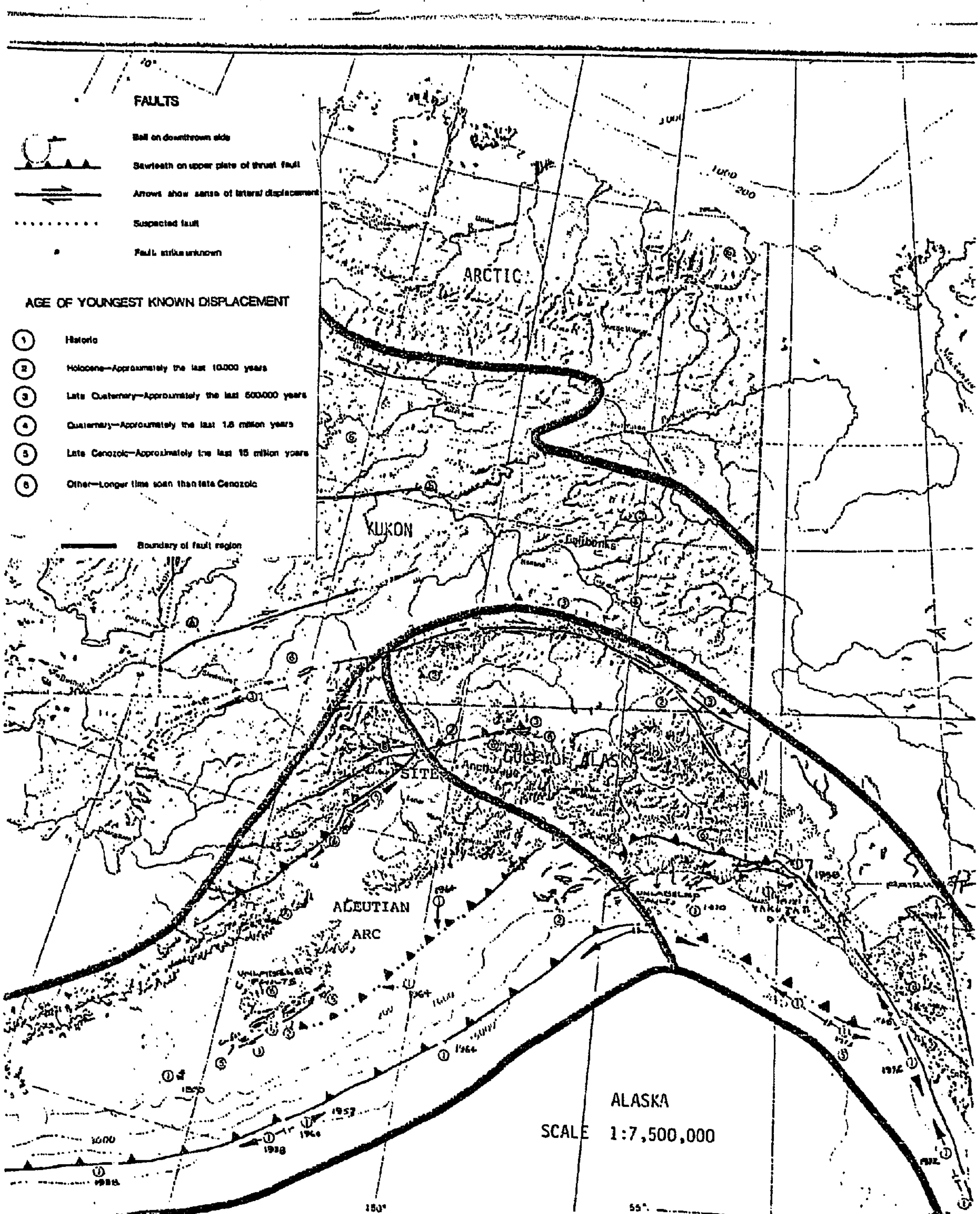
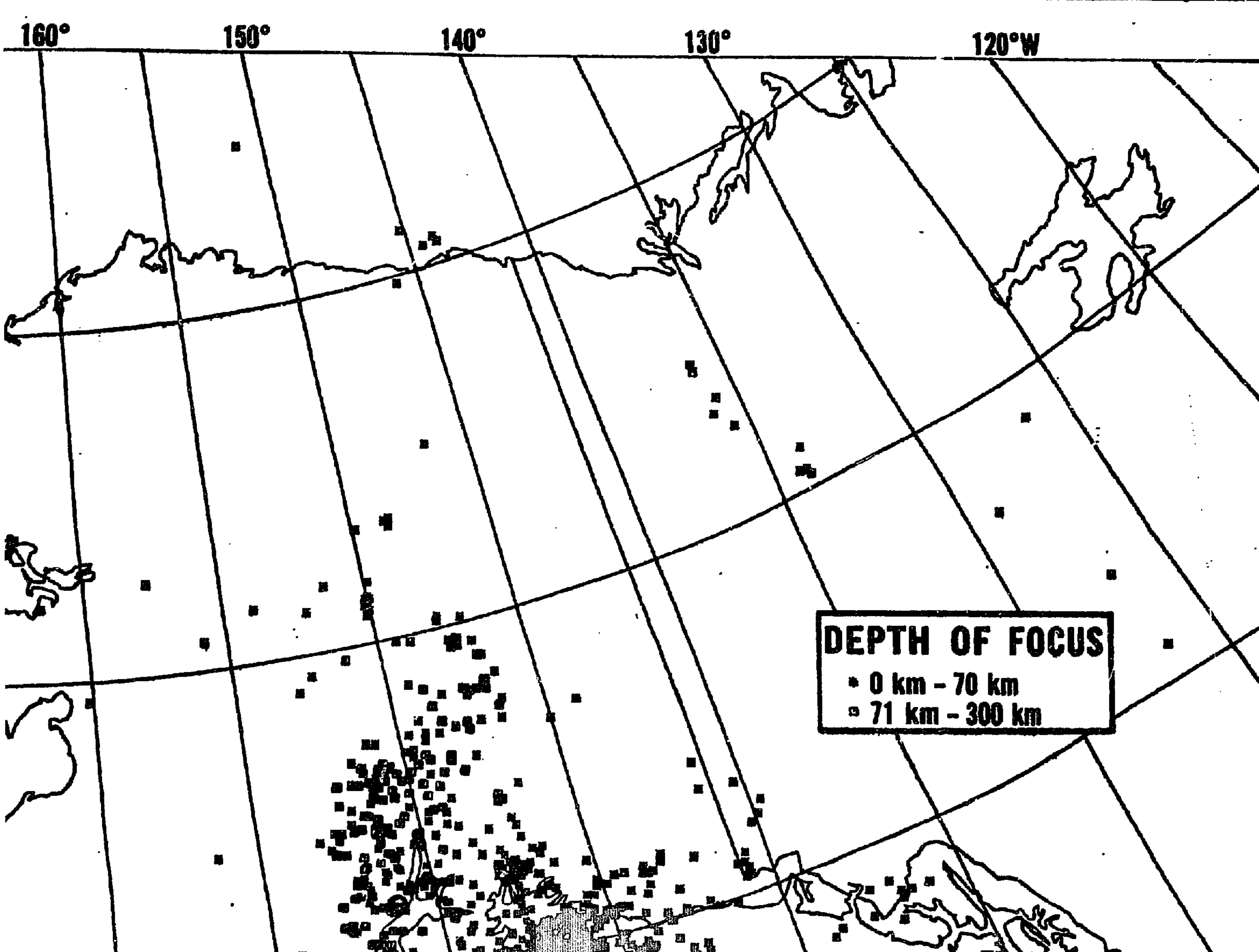


Figure 1. Young Faults in Alaska

ALASKA



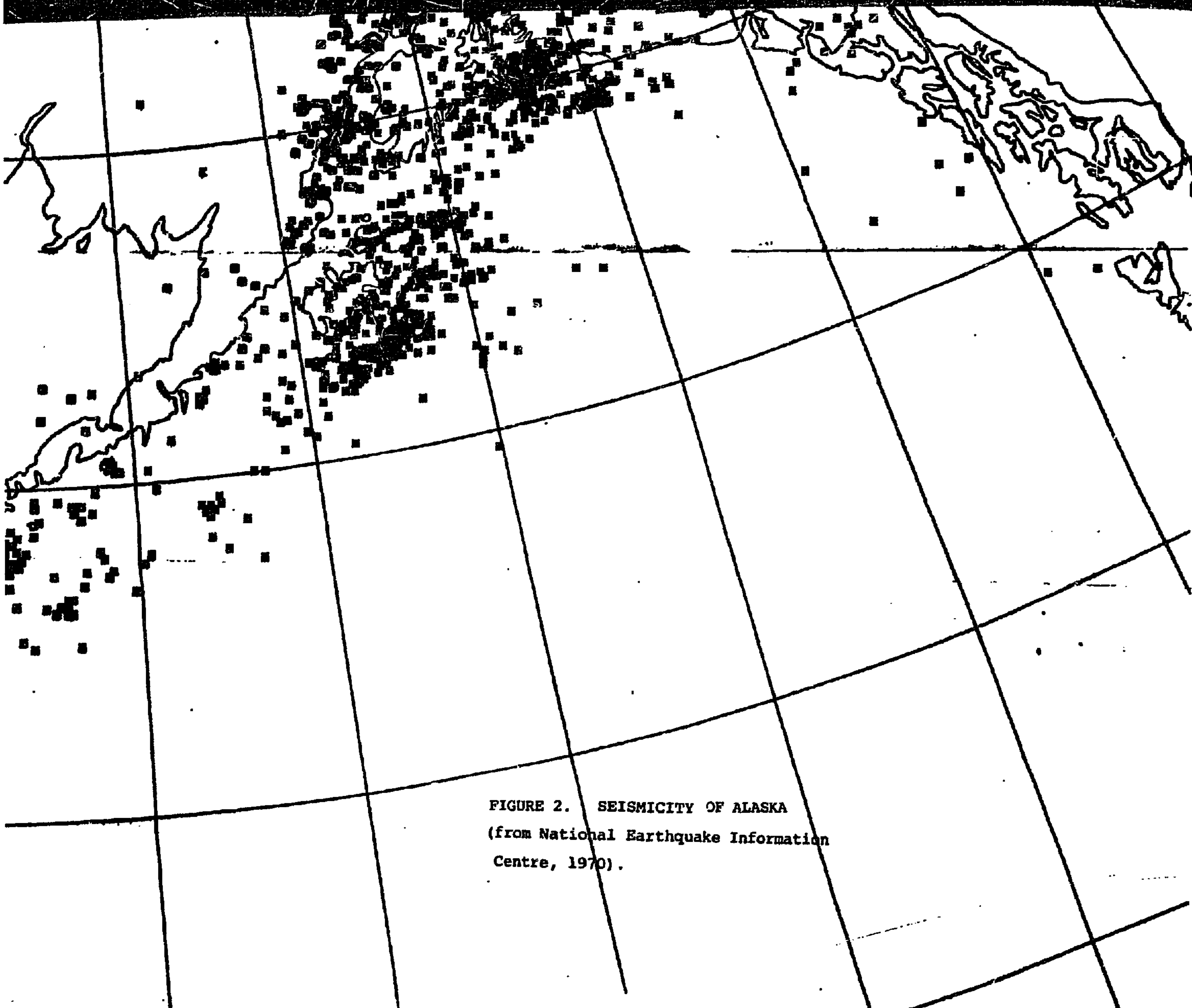
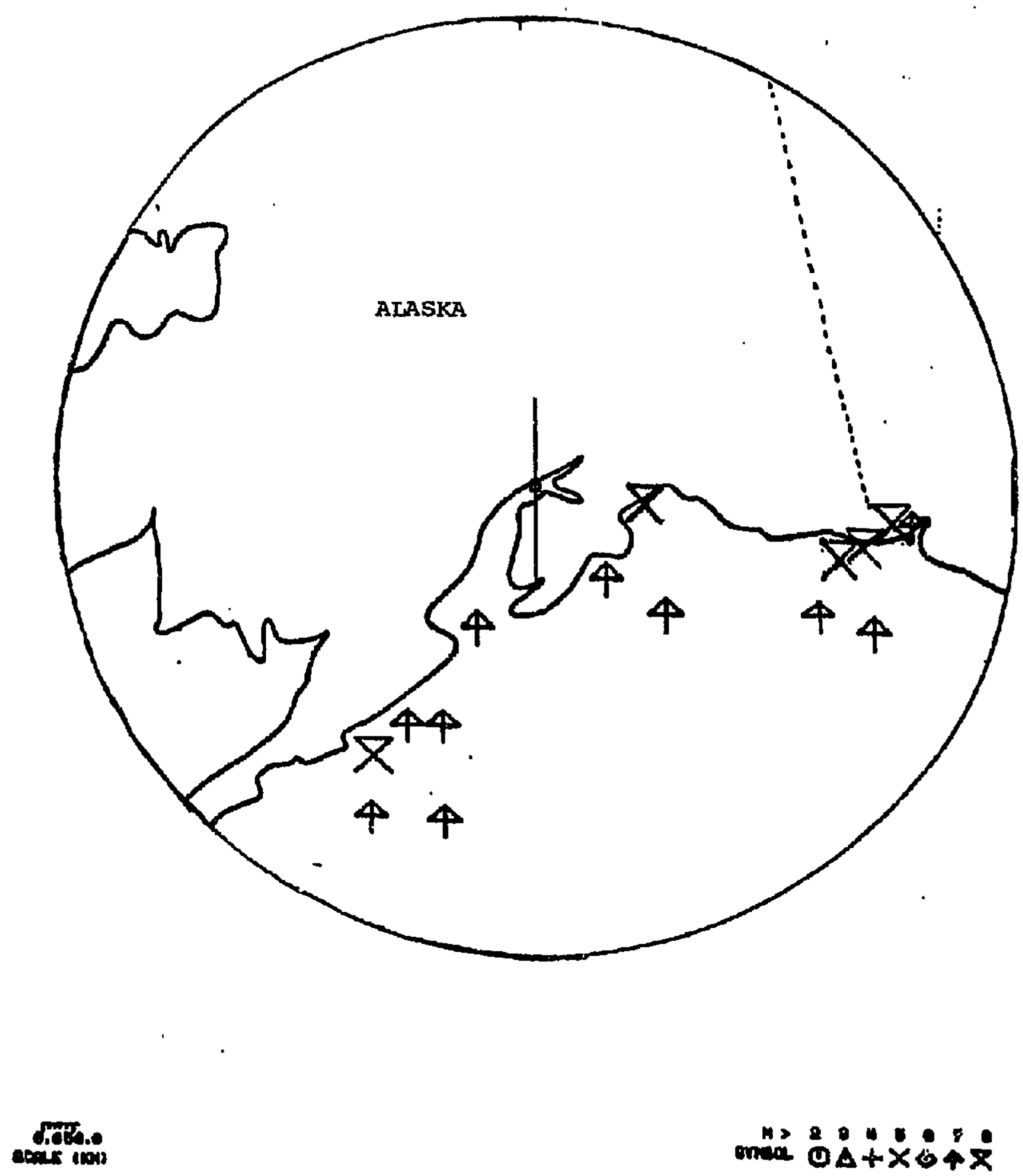
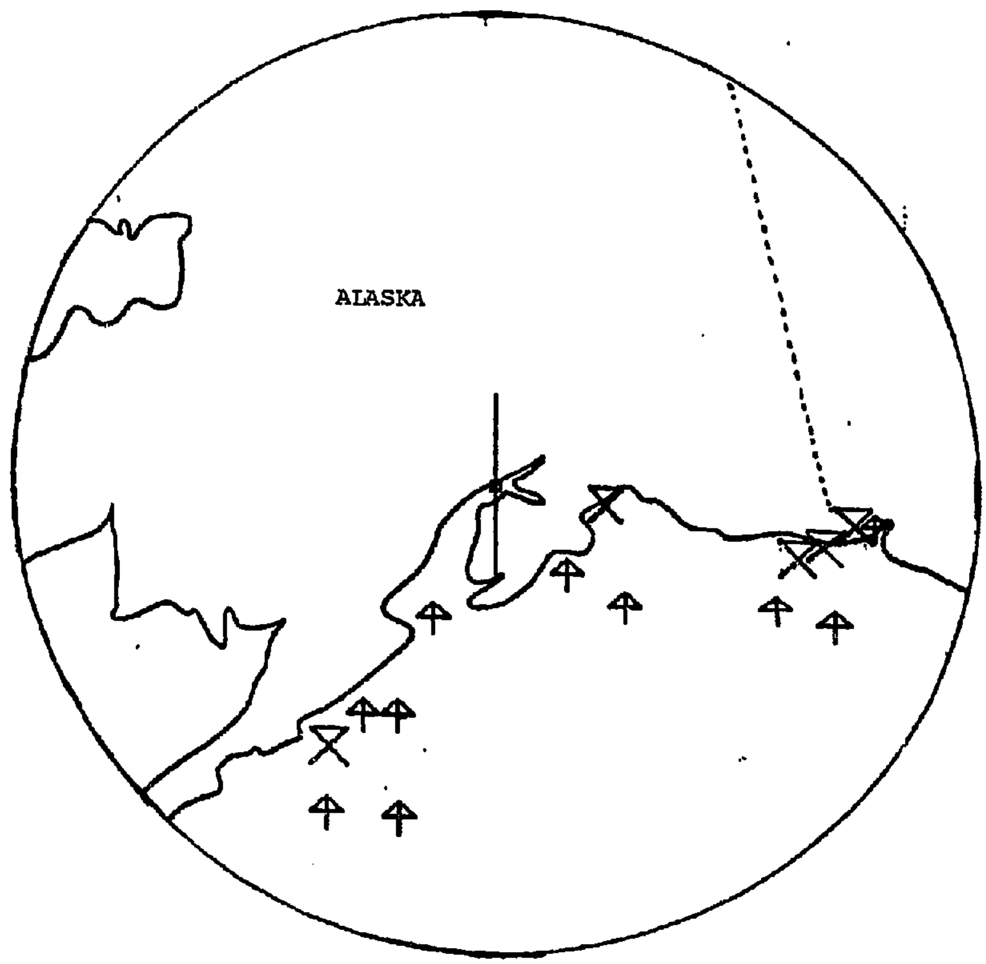


FIGURE 2. SEISMICITY OF ALASKA
(from National Earthquake Information
Centre, 1970).



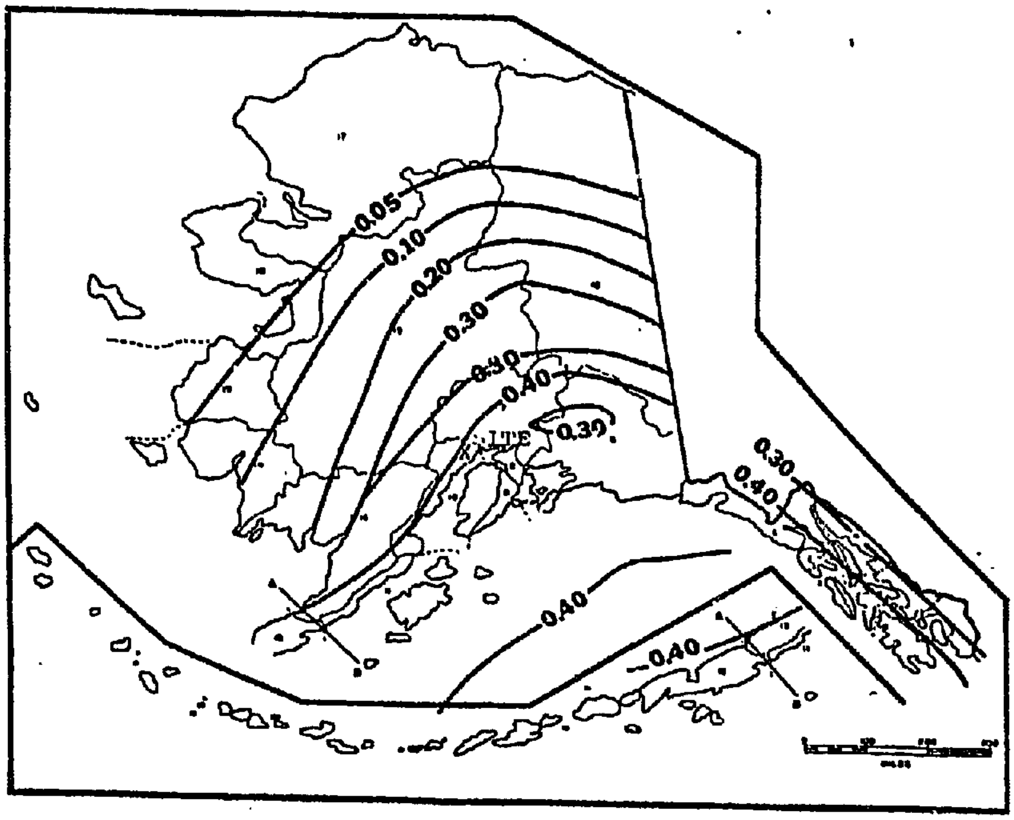
SITE COORDINATES -151.20 61.10 THRESHOLD MAGNITUDE= 7.0

FIGURE 3: MAJOR EARTHQUAKES IN ALASKA



SITE COORDINATES -151.20 61.10 THRESHOLD MAGNITUDE= 7.0

FIGURE 3: MAJOR EARTHQUAKES IN ALASKA



ALASKA

FIGURE 4 CONTOUR MAP FOR EFFECTIVE PEAK ACCELERATION

(from proposed ATC-3 code, 1978)

VA 2806 August 26, 1981

CLIMATIC OVERVIEW OF BELUGA COAL FIELDS

The climate description of the Beluga-Yentna region given in the Geological Survey Bulletin 1202-C Geology and Coal Resources of the Beluga-Yentna Region Alaska by Farrell F. Barnes, 1966 does not apply to the mine sites under consideration because of the significant elevation difference between that of the proposed coal mines and the reference weather stations on which the USGS information was based. Precipitation at the mine sites will be much greater and temperatures much lower than indicated in the USGS bulletin.

The climate of this region is affected by its proximity to the coast and exposure to the moderating southwesterly winds. The proposed coal mines sites are located on the east side of the Tordrillo and Chigmit Mountains whose peaks exceed 7,000 ft. Being somewhat protected from the open ocean, the climate, in general, is intermediate between that of the coastal areas and the interior of Alaska. The general climatic classification according to Watson (C.E. Watson 1959, Climates of the States) is transitional as shown on Figure 3.

There is considerable local variation in climate due mainly to elevation. Average temperatures decrease and annual precipitation increases quite significantly from the lowlands near Cook Inlet to the higher mountain areas of the coal mine sites. The elevation of the south coal mine site is about 1,500 ft and the elevation of the north mine site ranges from about 1,500 to 3,000 ft. Weather data from the lowland stations of Susitna, Tyonek, Talkeetna and Skwentna (below elevation 200 ft.) are, therefore, not applicable to the coal mine sites.

Preliminary estimates of temperature and precipitation follow:

Mean maximum July temperature	61°F
Mean minimum January temperature	1°F
Mean annual precipitation	30-40 inches
Mean annual peak 24 hour precipitation	2 inches
100 year peak 24 hour precipitation	5 inches
24 hour probably maximum precipitation	16 inches

Annual runoff varies with elevation as does precipitation. The annual runoff from the lower south mine area may be about 25 inches and from the higher north mine area about 34 inches. The seasonal distribution of runoff is shown on Figure 2. Minimum flows occur in March or April and peak flows occur in June or July.

Peak runoff rates may be either caused by snow melt or frontal rainstorms. The 50 year peak unit runoff is expected to be between 10 to 30 cfs/mi^2 over large catchments.

VA 2806

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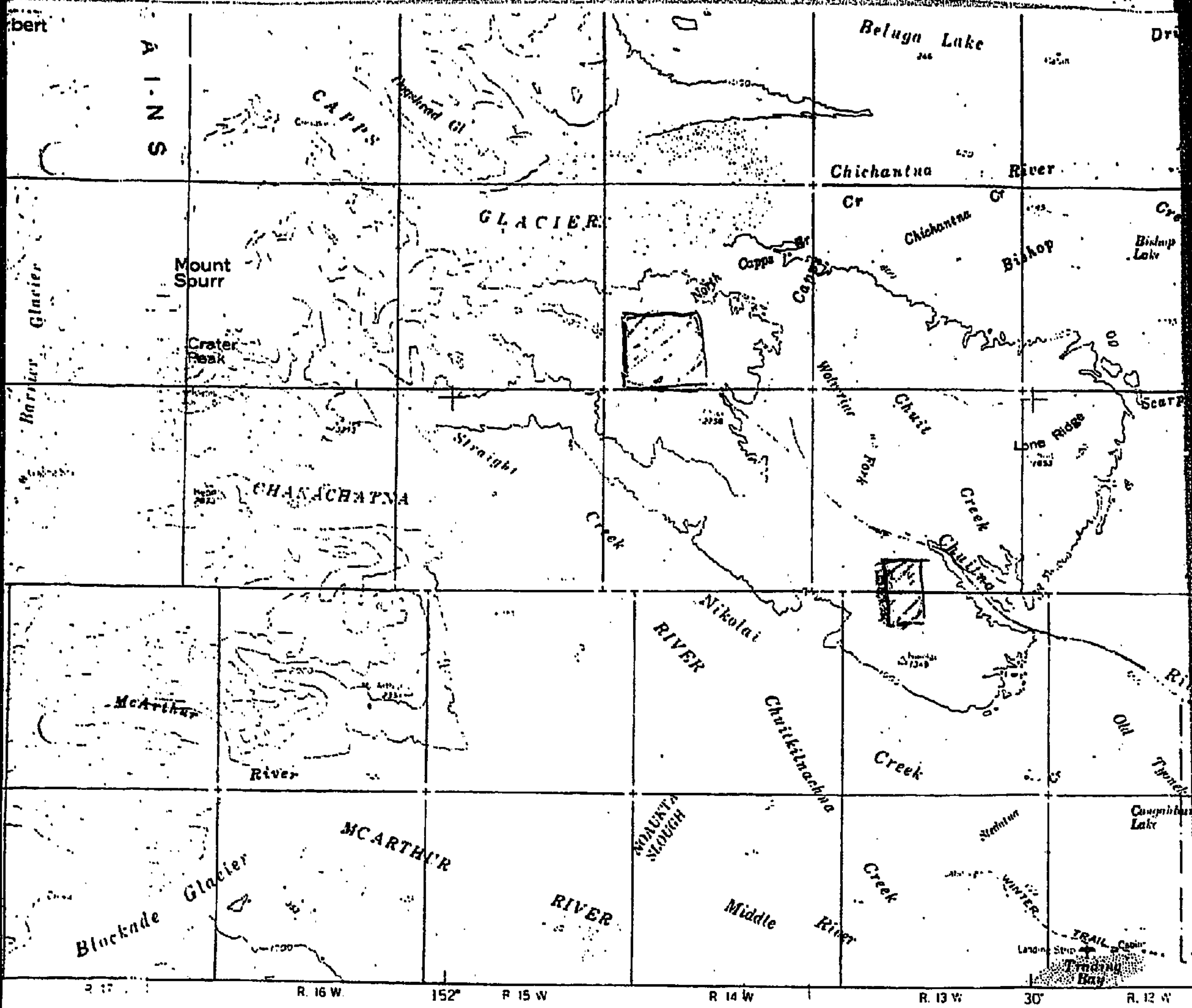
REFERENCES

- Climate of the States, Vol. 2
  A Water Information Center Publication, 1974
- Technical Paper No. 47, Probable Maximum Precipitation and Rainfall - Frequency Data for Alaska, by J.F. Miller, U.S. Weather Bureau
- Hydrologic Investigations, Atlas H.A. - 620, Sheets 1 - 4. USGS, Department of the Interior.
- Index to Water-Data Acquisition, Water Resources Region 19 (Alaska), U.S. Department of the Interior, USGS, 1980.
- Environmental Atlas of Alaska, P.R. Johnson and C.W. Hartman, Institute of Arctic Environmental Engineering, University of Alaska, 1971.



SCALE 1:250000

CONTOUR INTERVAL 200 FEET
DOTTED LINES REPRESENT 100 FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET - DATUM IS MEAN LOWER L

THIS MAP IS AVAILABLE IN BOTH SHADED RELIEF AND CONTOUR

FOR SALE BY U.S. GEOLOGICAL SURVE
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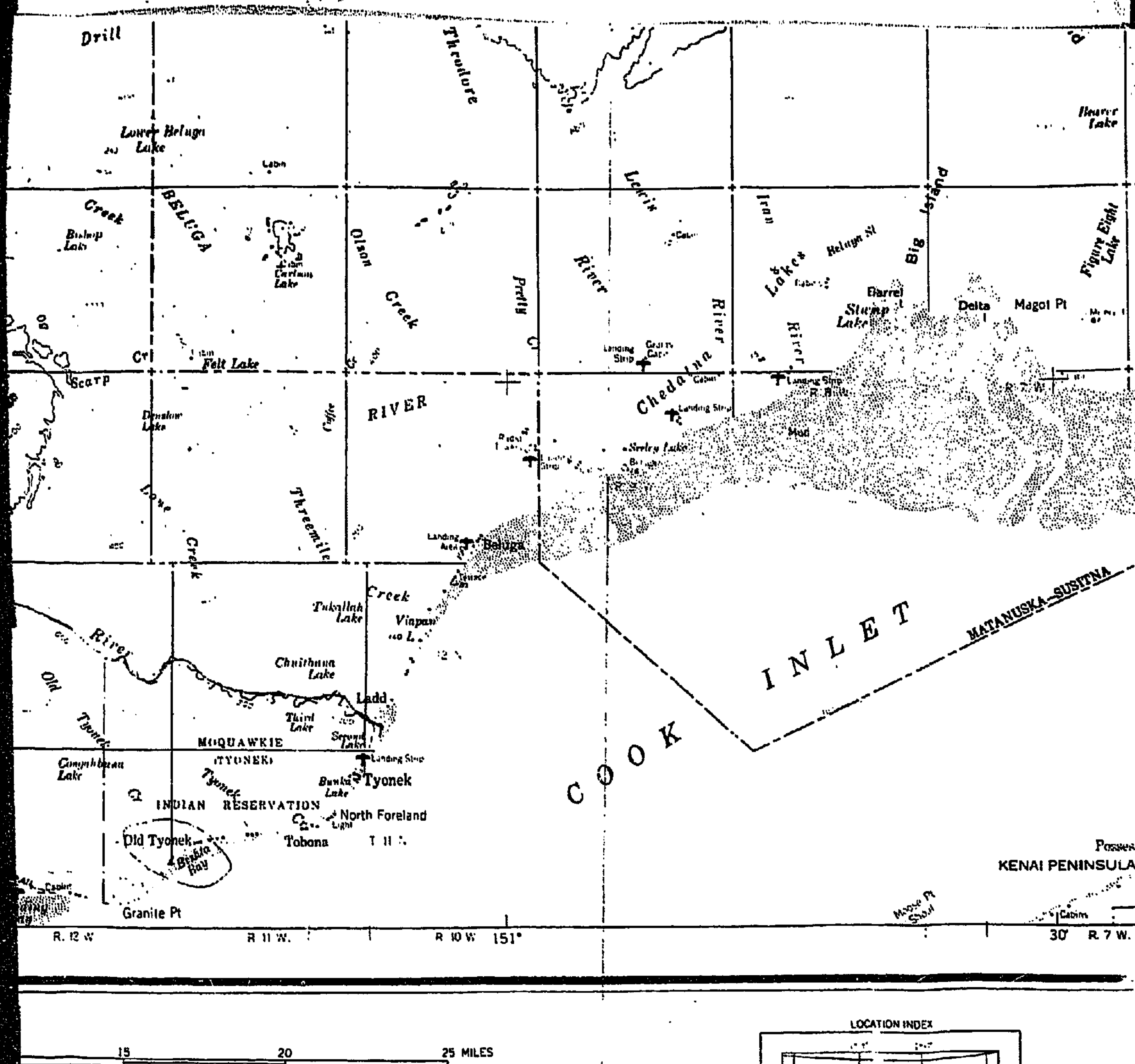

FEET
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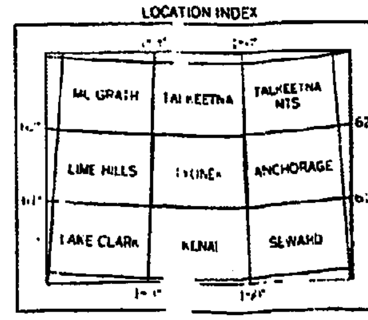
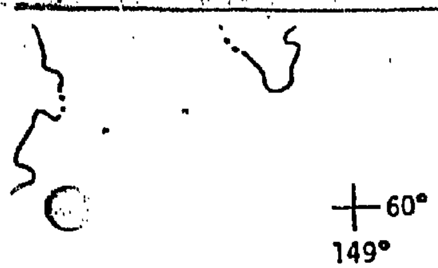
LOCATION INDEX



15294300	Skwentna R nr Skwentna
15294500	Chakachatna R nr Tyonek



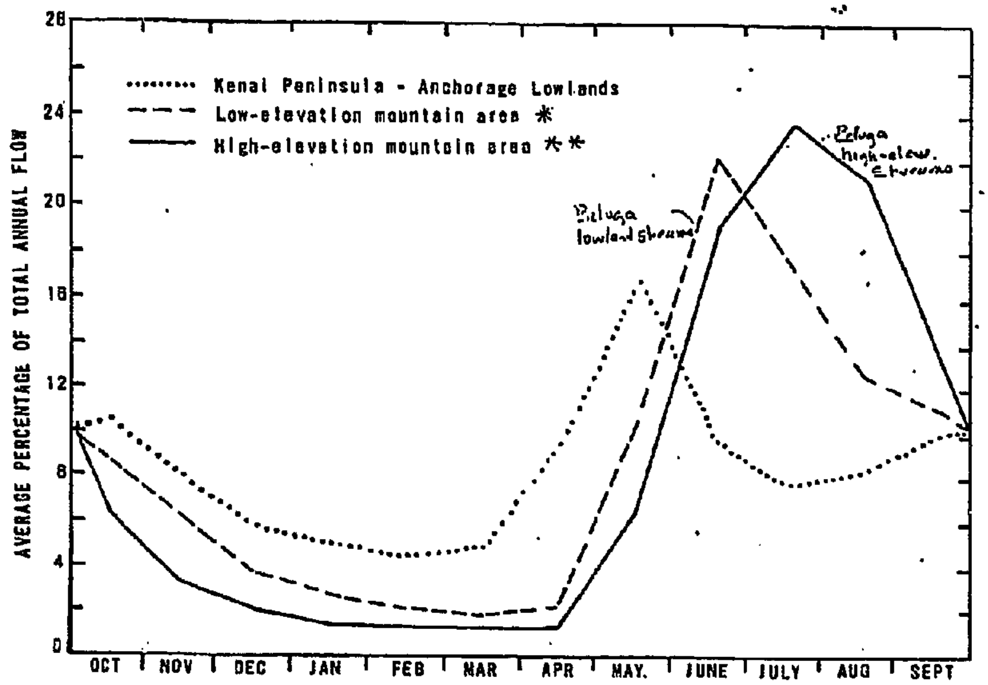


FIGURE 10.—Monthly contribution to total annual streamflow.

Station number	Stat
15239000	Bradley R nr
15239900	Anchor R nr
15240000	Anchor R at
15241600	Ninilchik R
15242000	Kasilof R nr
15244000	Ptarmigan C
15246000	Grant C nr M
15248000	Trail R nr L
15254000	Crescent C n
15258000	Kenai R at C
15260000	Cooper C nr
15260500	Stetson C nr
15264000	Russian R nr
15266300	Kenai R at S
15266500	Beaver C nr
15267900	Resurrection
15272550	Glacier C at
15273900	SF Campbell nr Anchor
15274000	SF Campbell
15274600	Campbell C n
15275000	Chester C at
15275100	Chester C at Anchorage
15276000	Ship C nr Anc
15277100	Eagle R at E
15280000	Eklutna C nr
15281000	Knik R nr Pa
15282000	Caribou C nr
15284000	Matanuska R a
15286000	Cottonwood C
15290000	Little Susitn
15291000	Susitna R nr
15291200	Maclaren R n
15291500	Susitna R nr
15292000	Susitna R at
15292400	Chulitna R n
15292700	Talkeetna R r
15294300	Skwentna R n
* 15294500	Chakachatna F

OOK INLET BASIN, ALASKA

ıd avid R. Scully

FIG. 2

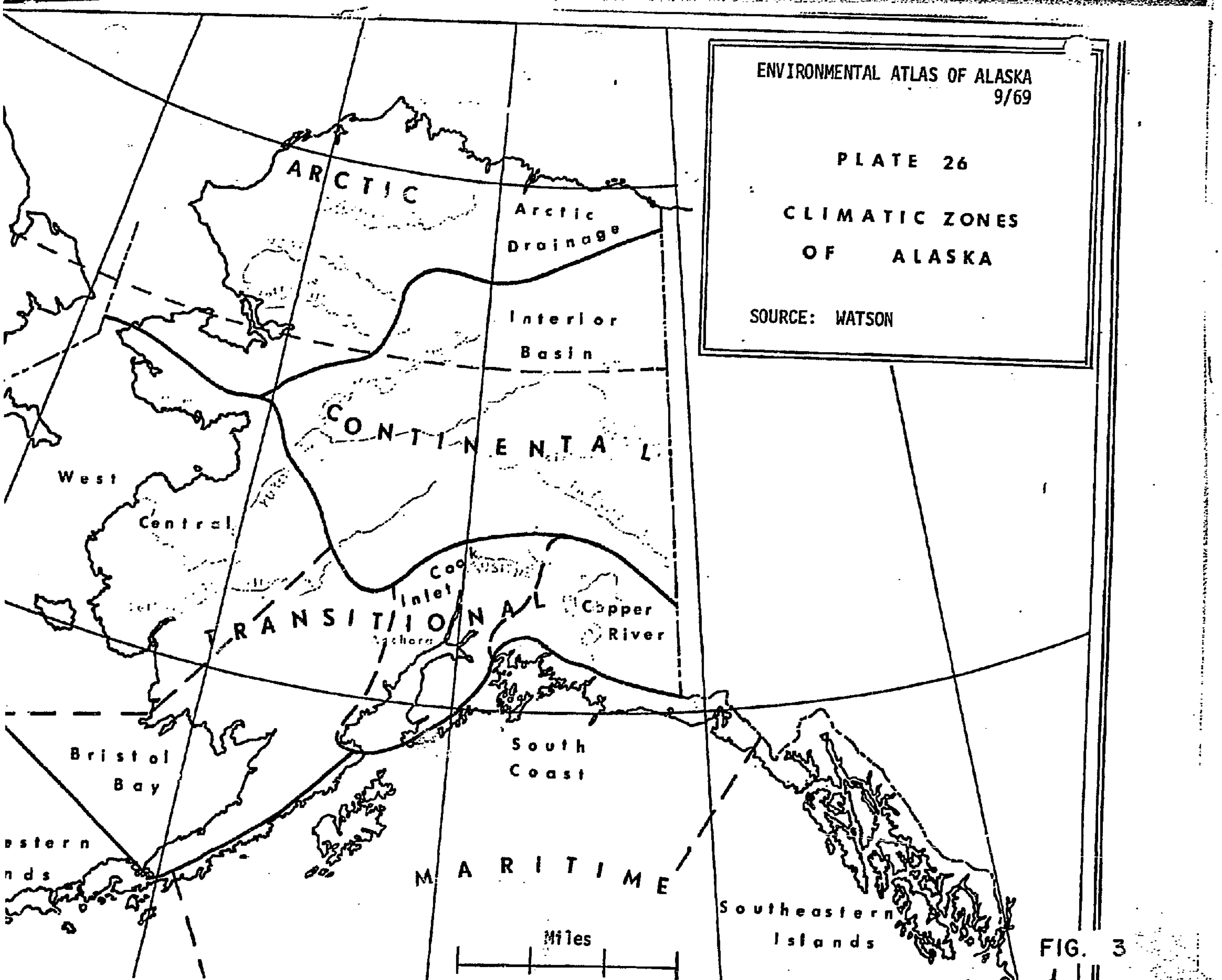

ENVIRONMENTAL ATLAS OF ALASKA
9/69
PLATE 26
CLIMATIC ZONES
OF ALASKA
SOURCE: WATSON
ARCTIC
Arctic Drainage
Interior Basin
CONTINENTAL
West Central
Cook Inlet
TRANSITIONAL
Copper River
Bristol Bay
South Coast
MARITIME
Southeastern Islands
Miles

FIG. 3

CLIMATIC ZONES OF ALASKA

Watson divided Alaska into four major climatic zones composed of nine climatological divisions as shown on Plate 26. Brief descriptions of the climates are:

Maritime: Dominated by maritime influences. Small temperature variations, high humidity, high precipitation and high cloud and fog frequencies. Little or no freezing weather. Mean annual temperature around 40°F.

Transitional: More pronounced temperature variations throughout the day and year, less cloudiness, lower precipitation and humidities. Mean annual temperature generally 25-35°F.

Continental: Dominated by continental climatic conditions. Great diurnal and annual temperature variations, low precipitation, low cloudiness and low humidity. Mean annual temperature 15-25°F.

Arctic: Temperature variations lower than the continental, precipitation is extremely light and strong winds are not uncommon. Mean annual temperature 10-20°F. The arctic climate is affected by marine influence in the summer but not to any great extent in the winter.

The range of seasonal temperature variation for each zone is given in the discussion of Plate 36. The seasonal lag of the temperature pattern is given in the discussion of Plate 37.

FIG. 4

APPENDIX III

LIST OF REFERENCE DATA

LABORATORY TEST RESULTS

VA 2806 August 26, 1981

REFERENCES

- Barnes, Farrell F. 1966, Geology and Coal Resources of the Beluga - Yentna Region, Alaska. Geological Survey Bulletin 1202-C.

- Miller, Raymond P., Shannon and Wilson, Seattle, Washington. January 8, 1976. Letter report on tests on drill core samples from West Chuitna for Placer Amex.

- Schmoll, Henry R., Pasch, Anne D., Chleborad, Alan F., Yehle, Lynn A., Gardner, Cynthia, A. Reconnaissance Engineering Geology of the Beluga Coal Resource Area, South-Central Alaska. U.S. Geological Survey.

- Chleborad, Alan F., Yehle, Lynn A., Schmoll, Henry R., Gardner, Cynthia A. 1980 Preliminary Field Geotechnical and Geophysical Logs from a Drill-hole in the Capps Coal Field, Cook Inlet Region, Alaska. Open File Report 80-393 Geological Survey, U.S. Department of the Interior.

- Samarasinge, Mahinda, and Huang, Yang H., 1980. A Literature Review of Coal Refuse Dikes. Institute for Mining and Minerals Research, University of Kentucky, Lexington, Kentucky.

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LABORATORY TEST RESULTS

Late in 1975 Shannon and Wilson inspected drill core samples from the summer 1975 Chuitna West drilling program and performed some basic index tests on the sedimentary bedrock. The results of their observations and test results were presented in their report entitled: Beluga Coal Deposit dated January 8, 1976, Shannon and Wilson addressed possible dimensions of pit slope, and bearing capacity of rock types for equipment selection relative to a possible test excavation at Chuitna West Pit site proposed for 1976. This test excavation was not made.

On June 25, 1981, Benson and Olsen inspected the drill core samples from the 1975 program described above. Some similar freshly drilled core was also available from a current drilling program at Lone Ridge. A sample of this core was obtained from Benno Patsch, Placer Amex, for index tests and preliminary mineralogical analysis.

The following is a summary of the test results:

Sample: Hole 81-80 Depth: 400 to 402
Lone Ridge Area

Description: Claystone, silty, estimated strength 200 psi

Dimensions:	Diameter	60 mm (2.4 inches) less inspection slice	
	Length	230 mm (9.1 inches)	
	Weight	1342 gms	
	Wet density	1.87 gm/cm^3 (117 lbs/ft^3)	
	Specific gravity	2.7	
	Natural water content	13.1%	
	Grainsize passing #200 (74 µ) =	98%	(silt)
	passing (2 µ) =	47%	(clay)
	Liquid limit	45%	
	Plastic limit	25%	
	Plasticity Index	20	
	Activity	0.5	
	Friction Peak	30°	
	Residual	21°	

VA 2806 August 26, 1981

A preliminary mineralogical analysis was performed by Dr. R.M. Quigley of the University of Western Ontario. This analysis was performed to determine if any active clay minerals were present. A copy of Dr. Quigley's report is attached. The mineralogy of the test sample was:

quartz	approximately	48%
siderite	approximately	16%
clay minerals	approximately	36%

A preliminary X-ray analysis indicated the following:

illite	approximately	10%
chlorite	approximately	10%
raolinite	approximately	10%
smectite	approximately	6%

The subgroups of smectite are montmorillonite and saponite with the following common properties, lattice structure, high swelling potential and low residual friction angle.

Klohn Leonoff index tests liquid limit 45, plastic limit 25, plasticity index 20 and activity 0.5 are properties consistent with the low content of smectite.

Quigley comments that in his experience the presence of siderite in clay samples is often associated with volcanic ash and bentonite beds. He speculates bentonite rich layers could exist. Such beds could have high activity values (1 to 1.5) and residual friction angle considerably lower than 21°. These tests were performed on a small sample, which we believe was similar to a number of West Chuitna cores we inspected, and which were tested by Shannon and Wilson.

Our preliminary conclusion was that no unusual low strength material appears to have been encountered and sampled in the test core holes. This will have to be confirmed during predesign sampling and analysis.

The University of Western Ontario

Faculty of Engineering Science
London, Canada
N6A 5B9

28 July 1981

Klohn Leonoff
Consulting Engineers
10180 Shellbridge Way
Richmond, British Columbia
V6X 2W7

Attention: Messrs. Mark T. Olsen and Robert Lo

Dear Sirs:

Re: X-Ray Diffraction Analyses of Claystone
Direct shear sample from DH81-80
File: VA 2806

Preliminary mineralogical analyses have been carried out on a direct shear sample of claystone in accordance with a letter of authorization from Mark T. Olsen dated July 14, 1981 and a follow-up telephone call from Robert Lo on July 21, 1981. The original work was expanded somewhat on the basis of the initial x-ray results discussed in the telephone conversation of July 21.

SAMPLE DESCRIPTION

The round disk of soil consisted of greyish silty clay containing a 2 mm thick layer of yellowish brown silty material. Dark brown organic patches seemed to be present on the shear plane contained within the sample. A mild reaction occurred when tested with dilute HCℓ, indicating the presence of some carbonate.

TESTING PROGRAM

The testing program consisted of the following:

1) X-ray powder pattern on the whole soil
2) X-ray traces on oriented fines in water wet, air dried and glycolated states
3) X-ray traces on oriented fines of K^+ saturated clay, air dried, glycolated and heated to 550°C
4) Carbonate analysis to check a 0.281 nm peak (siderite) on the powder pattern
5) X-ray powder pattern with internal standard for semi-quantitative analysis.

TEST RESULTS

The x-ray powder pattern showed the soil to consist of abundant quartz plus moderate amounts of siderite, illite and chlorite/kaolinite. Special quantitative tests showed the quartz and siderite to be present in amounts of approximately 48% and 16%, respectively. Since other non-clay minerals could not be detected on the powder patterns, clay minerals are assumed to comprise the remaining 36% of the whole soil sample.

X-ray traces on the oriented fines are shown in Figs. 1 and 2. Traces for the "natural" fractionated clay are shown on Fig. 1. The water wet trace is particularly interesting, yielding a distinct 1.96 nm peak for smectite (swelling clay) along with very strong illite (1.0 nm) and chlorite/kaolinite (0.71 nm) peaks. Air drying caused some contraction of the smectite peak which re-expanded on glycolation.

K^+ saturation did not cause significant collapse of the smectite as shown by the trace obtained on the glycolated clays in Fig. 2. This indicates the presence of montmorillonite which in this clay appears to be interlayered in part with chlorite.

Heat treatment of the K^+ saturated clay destroyed the 0.7 nm peak but left a strong 1.4 nm peak confirming the presence of chlorite (Fig. 3). The two small peaks at 2.2 nm and 1.9 nm are tentatively identified as heat collapsed phases of interlayered chlorite/smectite.

The very strong 0.7 nm peak is believed to be produced by both chlorite (002) and kaolinite (001), however, further testing would be required to confirm the presence of kaolinite.

SUMMARY AND DISCUSSION

The mineralogy of the soil is quantitatively summarized as follows:

Quartz	~ 48%	(measured)
Siderite	~ 16%	(measured)
Clay minerals	~ 36%	(by difference)

On the basis of the x-ray traces it is suggested that illite, chlorite and kaolinite are all present in equal amounts (~ 10%) leaving about 6% ± of smectite. These quantities should be checked, however, by further testing if they are critical.

The low activity (0.5 to 0.6) and the relatively high residual friction angle (~ 21°) reported on the test sample seem to confirm the presence of only a small amount of smectite. Siderite is present in many clay samples from British Columbia and in our experience is often associated with volcanic ash and bentonite beds. It could be speculated, therefore, that bentonite-rich interlayers related to ash falls exist in the vicinity. Such beds would have depressed activity values (1 to 1.5 ±) because of the divalent cation regime associated with contained carbonates, but residual friction angles could be considerably lower than the 21° reported by phone to the writer.

It is hoped that this preliminary analysis and short discussion fulfils your current needs on this project.

Yours sincerely,

R.M. Quigley

R.M. Quigley, P.Eng.
Professor and Head
Geotechnical Section

RMQ:--

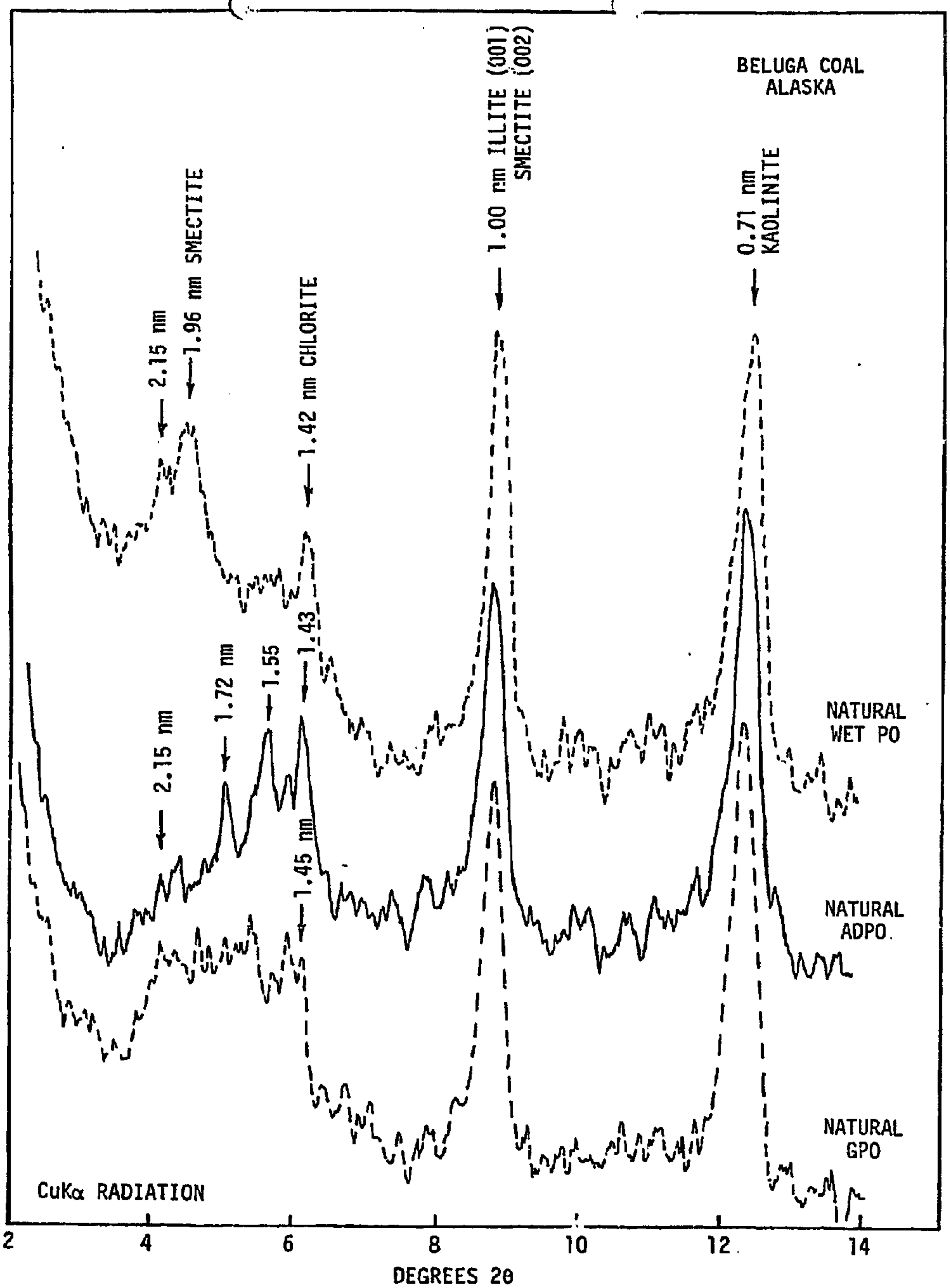


FIG. 1. X-RAY DIFFRACTION TRACES OF ORIENTED FINES, WATER WET (WET PO), AIR DRIED (ADPO) AND GLYCOLATED (GPO)

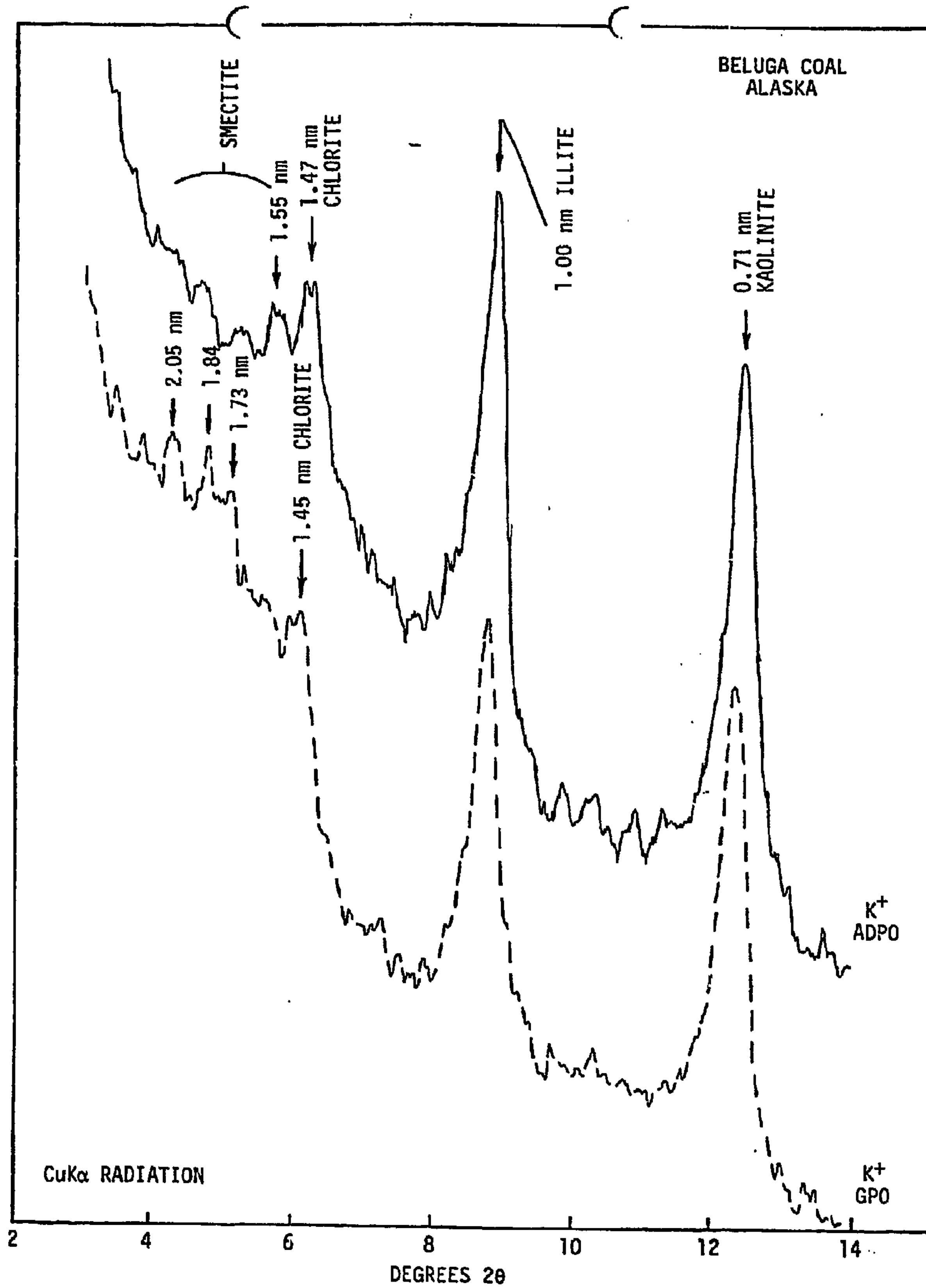


FIG. 2. X-RAY TRACES OF POTASSIUM SATURATED, ORIENTED FINES, AIR DRIED AND GLYCOLATED

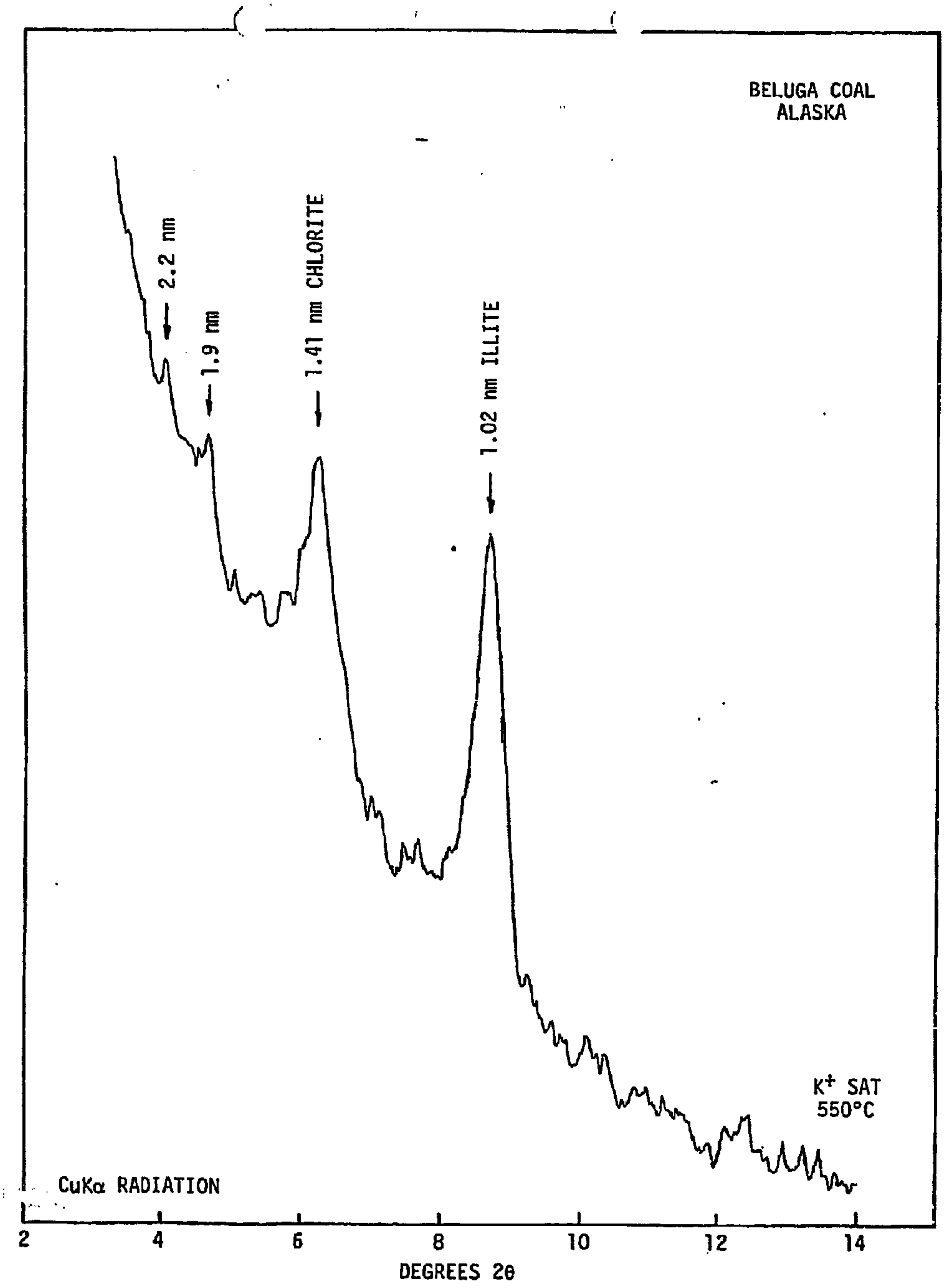
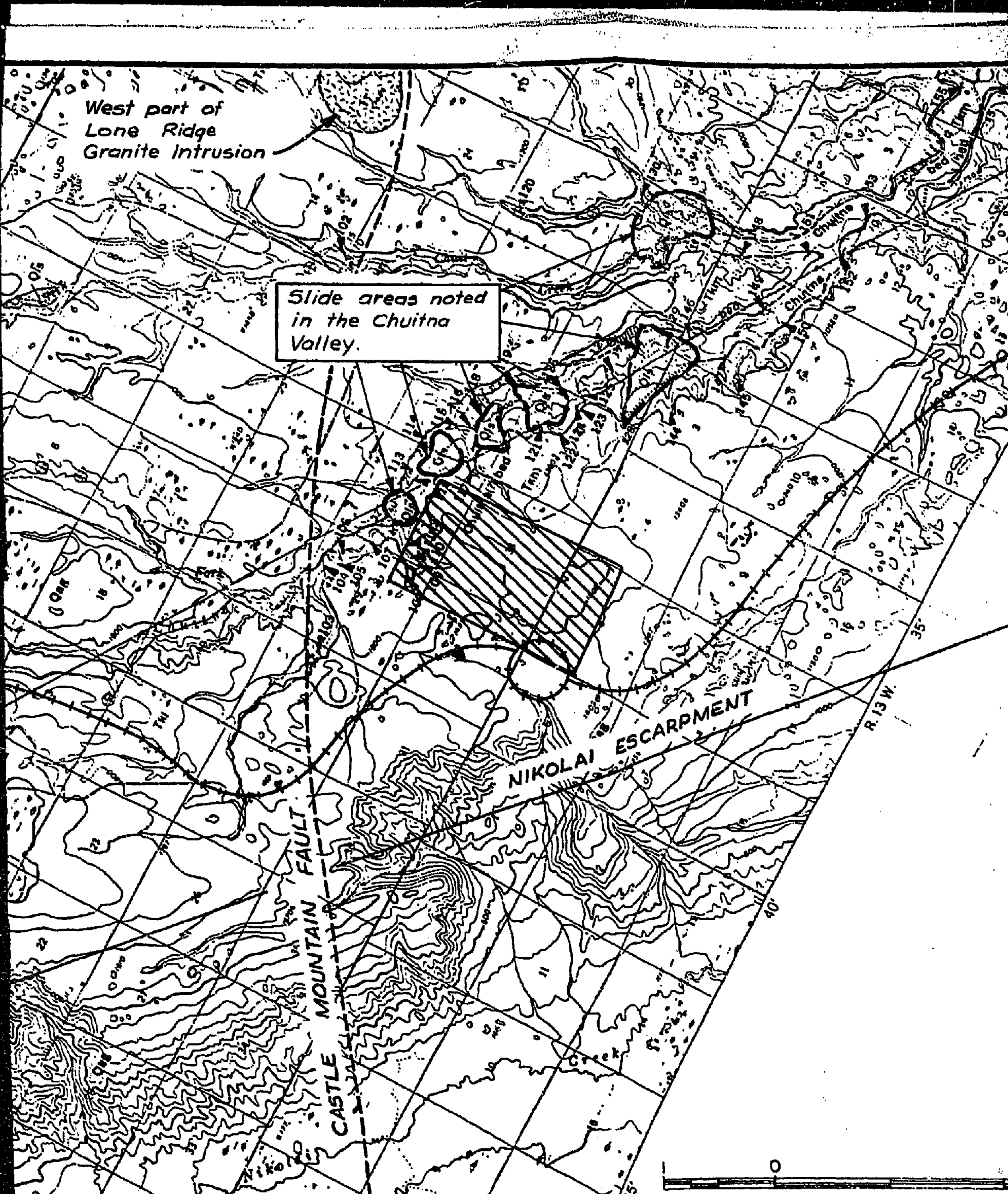


FIG. 3 . X-RAY DIFFRACTION TRACE OF K^+ SAT. CLAY HEATED TO 550°C

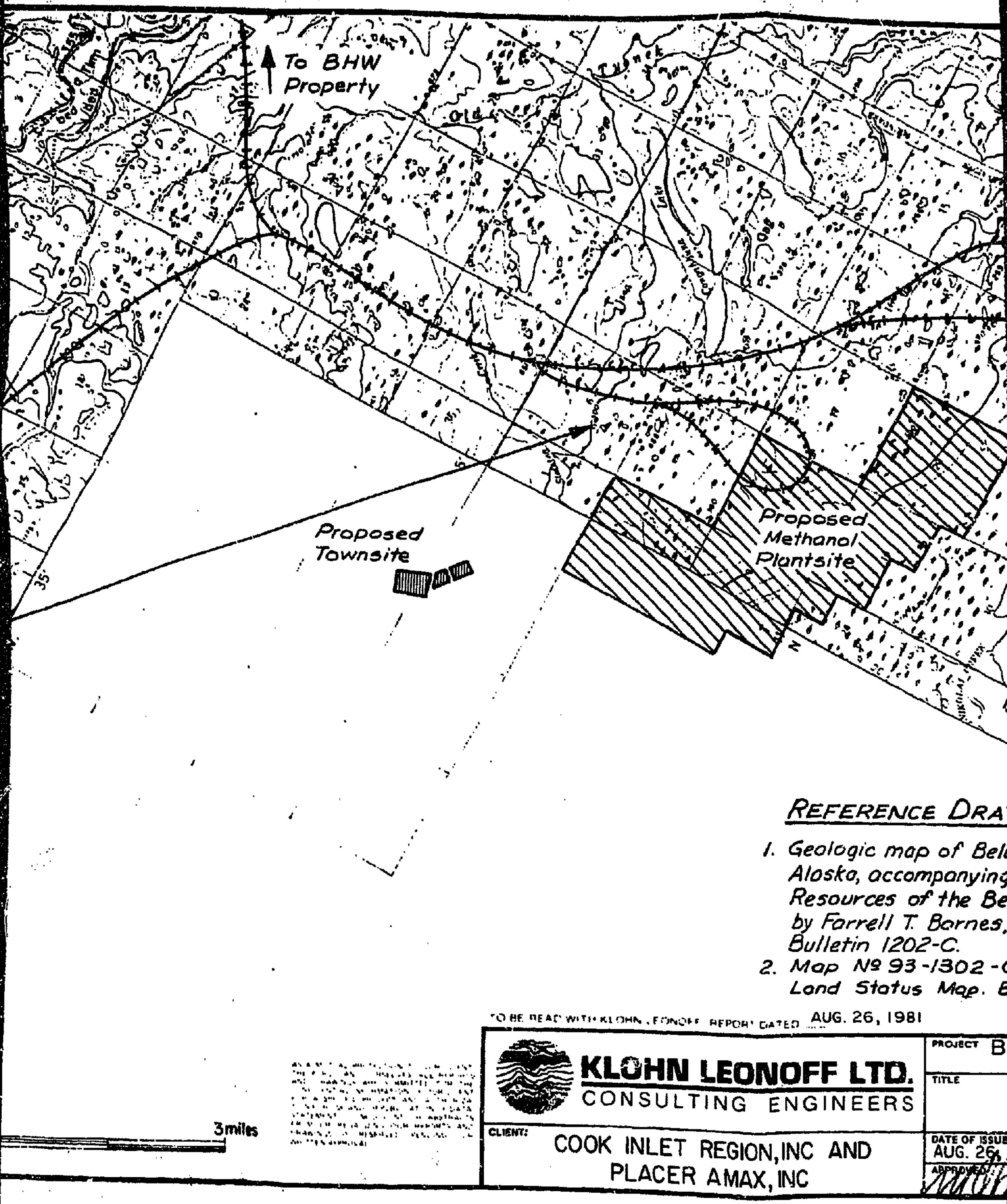
DRAWING

B-2806-1 - Layout of Project

CAPPS
SLIDE AREA
CAPPS
MINE AREA
R.14 W.
Wolverine



West part of
Lone Ridge
Granite Intrusion
Slide areas noted
in the Chuitna
Valley.
Chuitna
Creek
NIKOLAI ESCARPMENT
CASTLE MOUNTAIN FAULT
R.13 W.
35'
40'
45'
0



REFERENCE DRA

1. Geologic map of Belu
Alaska, accompanying
Resources of the Bel
by Farrell T. Barnes,
Bulletin 1202-C.
2. Map Nº 93-1302-0
Land Status Map. B

TO BE READ WITH KLOHN LEONOFF REPORT DATED AUG. 26, 1981

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

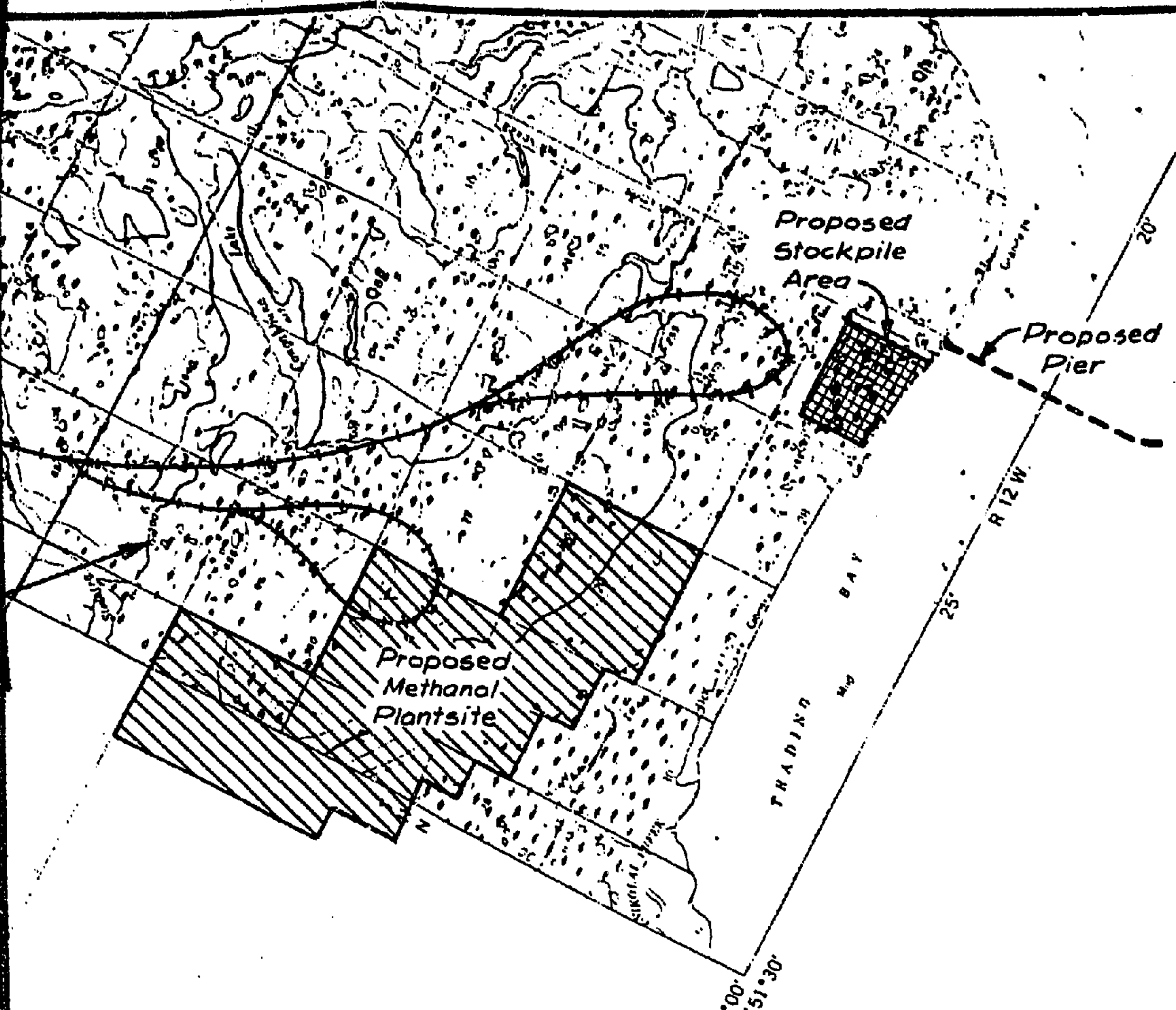
PROJECT BE

TITLE

CLIENT: COOK INLET REGION, INC AND PLACER AMAX, INC

DATE OF ISSUE AUG. 26,

APPROVED



REFERENCE DRAWINGS

1. *Geologic map of Beluga and Chuitna River areas, Alaska, accompanying the report "Geology and Coal Resources of the Beluga-Yentna Region Alaska," by Farrell T. Barnes, 1966, U.S. Geological Survey Bulletin 1202-C.*
2. *Map Nº 93-1302-03B Beluga Coal Co. Land Status Map. Beluga Coal District. Jan/81*

TO BE READ WITH KLOHN LEONOFF REPORT DATED AUG. 26, 1981

KLOHN LEONOFF LTD. CONSULTING ENGINEERS	PROJECT: BELUGA METHANOL PROJECT COOK INLET, ALASKA
	TITLE: LAYOUT OF PROJECT
CLIENT: COOK INLET REGION, INC AND	DATE OF ISSUE: AUG. 26, 1981 · APPROVED: · PROJECT No.: VA 2806 · DWG. No.: B-2806-1 · REV.: