

TRANSPORTATION OF ALASKA'S NORTH SLOPE COAL

by Paul R. Clark

The following is a summary of the more detailed report, "Transportation Economics of Coal Resources of Northern Slope Coal Fields, Alaska," M.S. thesis, 1973, submitted to the Mining Engineering Department of the University of Alaska. The thesis will soon be published in its entirety as Mineral Industry Research Laboratory Report No. 30.

some of which is coking coal. This coal may be in an advantageous geographical position to one of the world's largest importers of coking coal, Japan. This study was undertaken to determine the economics of transporting coal from these coal fields to Japan.

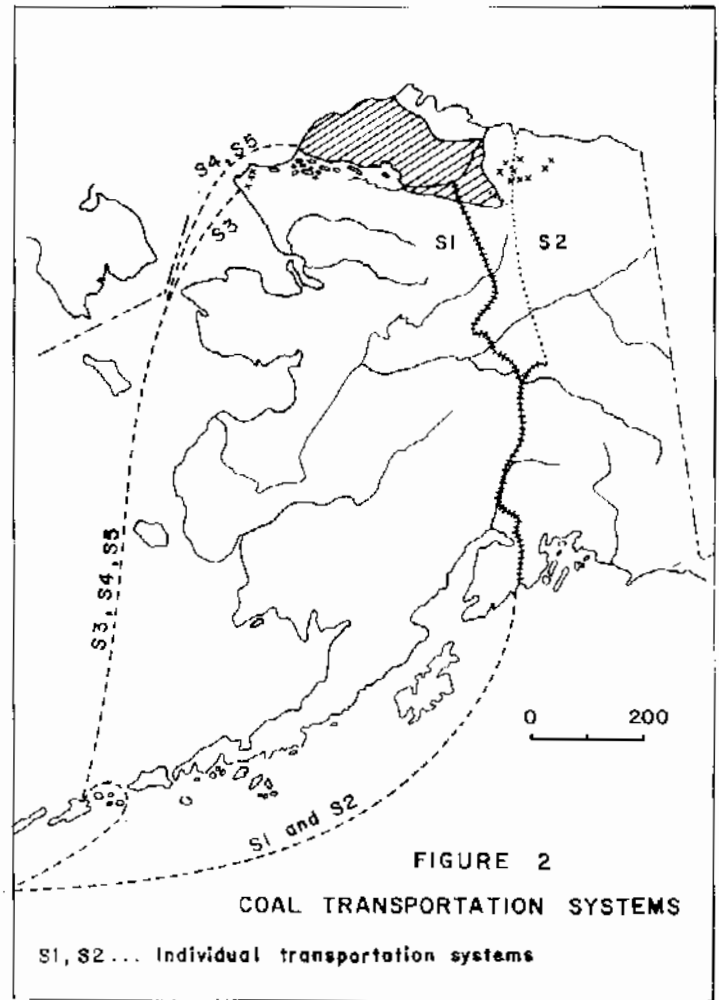
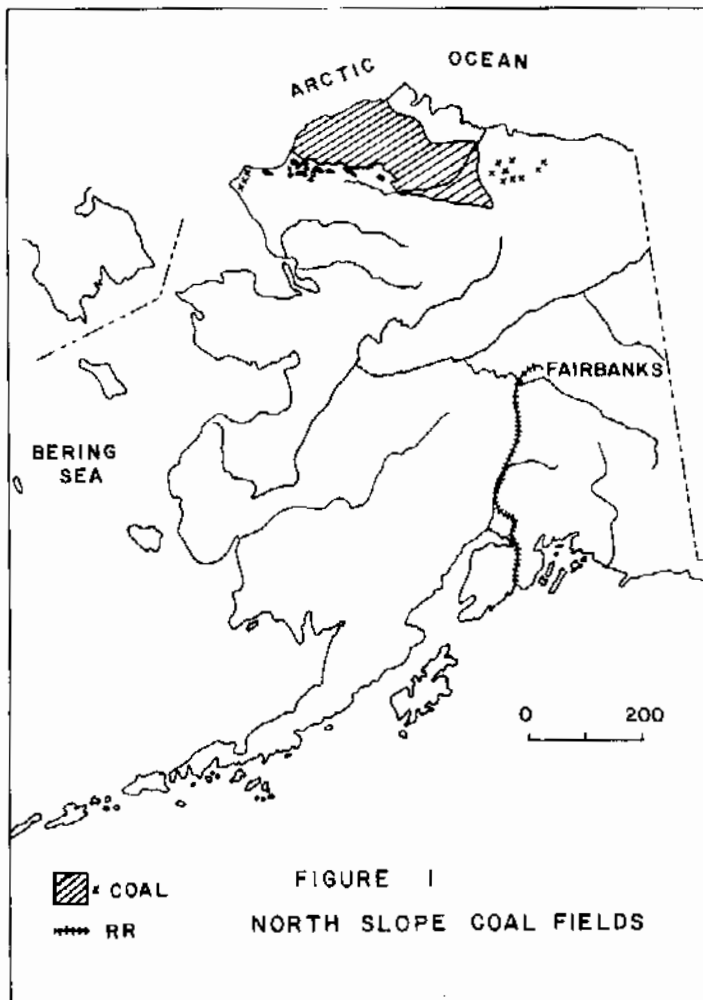
Figure 1 shows the location of the northern coal fields. Barnes (1967) estimated the coal resources of the region to total 120,197 million tons under less than 3000 feet of overburden, of which 19,292 million tons is bituminous coal in beds of

significant coking qualities, as well as low moisture, ash and sulfur content.

MARKET

At the present time, Japan is the most favorable market for coking coal from Alaska (Japanese Government regulations restrict the importation of steam coal). Alaskan coal has a geographical advantage over many of Japan's other coking coal suppliers; this advantage could result in a favorable competitive position through lower shipping costs.

In 1971, 34.4 percent of U.S. coal exports were shipped to Japan, all of which originated from the east coast of the U.S., 9500 miles from Japan. In re-



On the North Slope of Alaska, there is approximately 120 billion tons of subbituminous and bituminous coal,

more than 14 inches thick and 100,905 million tons is subbituminous coal in beds of more than two and one half feet thick.

Analysis of the bituminous coal from the Kukpowruk River and Cape Beaufort areas has revealed that these coals have

cent years, coal from Australia and western Canada has captured an increasing portion of the Japanese market. The average selling price per short ton of coal in Japan was \$19.20 in 1971.

The U.S.S.R. has proposed to Japan the development of the South Yakutsk,

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Siberia coal field at a cost of 175-185 million dollars (International Coal Trade, May 1972). Japan conveyed its intention of importing up to 10 million tons per year from this field in the late 1980's provided the quality meets its requirements.

Carbonization tests performed to date on the North Slope coal indicate that it is a blending coal, not a premium coking coal and would therefore sell at the medium to low coking coal prices.

COAL TRANSPORTATION METHODS

Railroads

Railroads have been constructed and operated successfully in northern areas for many years. Recently a transportation study was performed to evaluate the cost of a railroad from Nenana, Alaska on the existing Alaska Railroad, to Deadehorse on the North Slope of Alaska (Tudor, Kelly, Shannon, 1972).

In the lower 48 states, most large coal producers ship their coal to a port or market by unit trains. The unit train technique involves the dedication of a train or number of trains exclusively to the haulage of the bulk material, from one source to one destination, and with a predetermined loading, unloading and travel time. The use of the unit train technique normally results in minimal transportation costs through maximum utilization of equipment for haulage.

Slurry Pipeline

The movement of a fine, suspended material through a pipeline is not a new concept, although its application over long distances has only developed in recent years. One of the most noted applications to coal is the 273 mile long, 18 inch diameter, Black Mesa pipeline which transports approximately five million tons of coal annually between Arizona and Nevada.

A slurry pipeline has only one source and one destination. Each application is a separate case and normally cannot be used interchangeably with other materials.

The cold northern climate poses some unique problems to slurry pipeline construction and operation: the scarcity of water in northern, particularly arctic,

areas in the winter may require consideration of seasonal operation, a smaller water supply line from a large water source, or recirculation of water. Normally pipelines are buried except over river crossings or when traversing a mountainous terrain. Burying a pipeline in permafrost may cause complications. Heat is generated from the abrasion of the slurry along the pipe and pump walls. Although this heat generation is not great, it will have to be accounted for.

A year round pipeline system would have to be insulated and/or heated. Facilities would be required to permit rapid drainage of the pipeline if a breakdown occurred in low temperatures. No long distance commercial slurry pipelines exist in areas where freezing of the line is a problem.

Roads and Trucks

Compared to other modes of bulk transport, trucking is considered to be one of the most flexible since the transportation system can be expanded simply by adding more trucks. This flexibility advantage is offset somewhat by inherently high operating and maintenance costs over other bulk transportation methods.

There are two major classes of trucks for the movement of bulk materials: on-the-highway trucks and off-the-highway trucks. Off-the-highway trucks have capacities up to 250 tons and are normally used for short hauls in open pit mining operations or on large construction projects. On-the-highway trucks can be of two types: those operating on public roads and those operating on private roads. Trucks operating on private roads are not normally subject to restrictions except those imposed by the condition of the road on which they operate. Trucks operating on public roads are subject to length, width and weight restrictions. As a result of these restrictions, truck payloads usually range up to 25 or 30 tons.

Belt Conveyors

Until recently, belt conveyors were not considered for long distance transportation because the strength of the cotton carcass limited the length of the

belt to short distances. New developments such as the nylon belt, steel cord belt and the cable belt have increased belt tension ratings, which have permitted increases in the length of single flight belt conveyors.

Conveyors are widely accepted as transportation vehicles for two main reasons: ease of operation and low operation and maintenance costs. Similar to pipelines, long distance conveyor systems are inflexible to increased tonnage since they are designed for a specific tonnage, source and destination.

The primary consideration in the construction of a belt conveyor system is belt alignment. A misaligned belt will result in excessive belt wear and possible spillage. Alignment will be a more serious problem in northern areas because of land shifts caused by frost action. Belt conveyors have operated successfully below 45 degrees F and belts can be designed to operate in temperatures as low as -67 degrees F. Conveyors which are operated in cold climates are shut down only for short periods of time. When material is not being transported, the conveyor continues to run but at a creep speed substantially lower than the normal operating speed.

Shipping

The ice free season on the northwestern coast of Alaska averages three months at Point Hope to about two months at Barrow. For the movement of large amounts of coal from the North Slope of Alaska, stockpiling and handling at both Japanese ports and the northwestern coast of Alaska would be minimal if year round shipping could be achieved. However, the problems involved with year round shipping in this area of Alaska may become paramount over the alternative extra handling problems. To date, there has been no successful navigation north of the Bering Strait in winter, even by icebreakers. Alternatives to year round shipping include shipment of all the coal to Japan during the ice free season, shipment of the coal to an ice free transshipment point during the ice free season for furtherance to Japan for the remainder of the year, and extension of the shipping season.

In the transportation systems analyses, 100,000 ton dwt. ships (draft of 50 feet) were used for the computation of shipping costs. This size of ship was selected as a trade-off between economy of scale and the vessel draft. The draft of the ship is an important consideration due to the shallow waters along the northwestern coast of Alaska.

Ocean freight rates for coal to Japan are approximately \$4.00 per ton from the U.S. east coast and \$2.75 per ton from Vancouver, British Columbia.

Barging

Tug and barge combinations for the movement of bulk materials have traditionally been confined to inland water ways and coastal areas. It has only been in the last few years that ocean barge developments have become significant.

The use of a trans-ocean tug-barge system for the movement of coal from northern Alaska has a number of advantages over self-propelled ships: tugs require a smaller crew than ships; a tug-barge can operate in much shallower waters than a ship; and further, there is no tug port time except to change barges. However, tug-barge combinations have a lower cruising speed than ships and are restricted to very light ice conditions.

Harbors

Natural, deep water, ice free harbors exist in the southern areas of Alaska, but these harbors are at least 600 miles from the northern coal fields. On the tip of Cape Darby on Golovnin Bay, water depths of 60 feet exist close to shore. This site is approximately 380 miles from the northern coal fields. Also on the Seward Peninsula is the natural harbor of Port Clarence, which is between 40 and 45 feet deep. Port Clarence has good potential for harbor development, but will require dredging if large ships are to be used. Its usefulness to the northern coal deposits is again limited by the distance between the coal and the harbor. The next natural harbor past Port Clarence is at Herschel Island in the Canadian Arctic.

A potential site for the construction of an artificial harbor close to the coal is at

the mouth of Ogortoruk Creek, south of Cape Thompson. At this site, the shoreline is fairly flat and the sixty foot water depth is closer to shore (three miles) than at most points on the northwestern coast. A nuclear device was considered for the excavation of an artificial harbor at this location (Project Chariot). The ecological consequences of this detonation were determined to be long lasting, and the projected movement of materials through this harbor was not sufficient to warrant the expenditures required for its construction at that time.

The information available on the seabottom of the northwestern coast near Cape Thompson indicates that bedrock is at or near the surface of the seafloor. The cost of removing sediments from the seafloor is up to \$2.50 per cubic yard, while the cost of blasting and removing rock from the seafloor can be as high as \$25.00 per cubic yard (Koisich, 1971). An excavation close to shore and a channel to this excavation large enough for large ore carriers would require the removal of approximately 10 million cubic yards of material. It is doubtful that the exploitation of the coal deposits alone could carry the economic burden of the construction of an artificial harbor by conventional methods.

This does not necessarily rule out shiploading in this area. Other methods which may be alternatives to an artificial harbor are structural steel, concrete or earth filled piers to deep water; an artificial island in deep water to act as base for smaller, lighter craft from shore; a slurry pipeline from shore to a moored vessel in deep water; and the use of lighter craft to a ship moored in deep water. The two most practical designs appear to be a rock and gravel filled pier, and slurry loading. These are the only two designs used in the cost analyses.

TRANSPORTATION SYSTEMS

Cost analyses were performed on five separate systems used for transporting coal from the North Slope of Alaska to Japan (See Figure 2). These analyses were confined to single use transportation. The establishment of a new overland transportation system and harbor facility with the specific goal of the

movement of coal would benefit other resource developments, but no attempt was made in this study to evaluate the magnitude of these benefits.

System I consists of a railway which connects a mining area on the eastern portion of the coal deposits to the port of Seward on the Pacific coast of Alaska. The system requires the construction of a 492 mile railroad from the existing Alaska Railroad at Nenana to the coal deposits, and the construction of coal handling facilities at Seward. Unit trains transport the coal directly from the northern coal fields to Seward without any handling or excess waiting time between the source and destination. Coal is unloaded at Seward, stockpiled, then loaded onto 100,000 ton deadweight ore carriers for year round conveyance to Japan.

System II proposes the use of the road that is to be constructed from Fairbanks to Prudhoe Bay. The coal deposits are reached by traveling on this road and a secondary spur road to the coal deposits. These two roads supply a linkage to the Alaska Railroad where the coal is loaded into railway cars and shipped to Seward for furtherance to Japan. The trucks used in this system have a capacity of 25 tons.

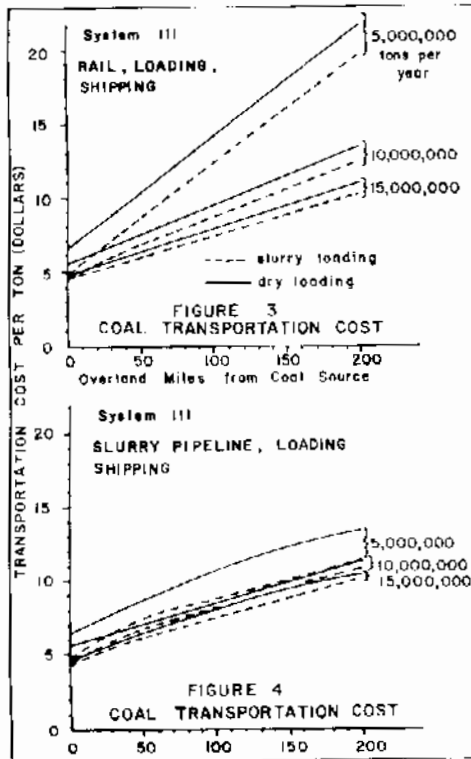
System III involves the movement of coal by an overland system to a harbor near Cape Thompson on the Chukchi Sea.

During the ice free season, the stockpiled coal at this port is shipped simultaneously to Japan and to an ice free transshipment port at Dutch Harbor in the Aleutian Islands. The purpose of the simultaneous shipment is to maintain a consistent delivery schedule to Japan. The coal shipped to Dutch Harbor is stockpiled until the ice begins to form at the Chukchi Sea port. At this time, the coal stockpiled at Dutch Harbor is shipped to Japan.

Three types of overland systems were considered in *System III*: railroad, slurry pipeline and belt conveyors. Two types of shiploading techniques were also considered: dry loading and slurry loading. In the analysis performed for slurry pipelines, the costs of a secondary smaller pipeline was added to the total cost.

Because of the scarcity of an inland supply of water in this region, feed water would either have to be recirculated or transported from a large lake or the ocean in order to operate a slurry pipeline year round.

In order to use slurry loading for ship loading, two ponds would have to be constructed on shore, one for the actual loading of the coal to the 100,000 ton dwt. ship and the second as a settling pond for the fine, suspended material decanted from the ship.



Figures 3, 4, and 5 are graphical illustrations of the results of cost analysis on *System III*.

System IV consists of a railroad, pipeline, or conveyor system to a port near Point Lay. At this port, the coal is loaded onto 60,000 ton capacity ocean barges by either dry loading or slurry loading. The greatest advantage of a port at Point Lay over a port near Cape Thompson is its proximity to the major portion of the coal reserves. A limitation of the port is its shorter ice free season of 75 days compared with a 90 day ice free season at a port near Cape Thompson.

During the ice free season, the coal is transported to Japan and simultaneously to a transshipment point at Dutch Harbor. The coal stockpiled at Dutch Harbor would then be transported to Japan by ocean barges when the Point Lay area is non-navigable due to ice conditions.

System V is similar to *System IV* except 100,000 ton dwt ships have replaced the barges. A slurry loading system loads the ships anchored eight to 10 miles offshore.

CONCLUSIONS

The results derived from the analysis of *System I* indicate that it would not be economically feasible to construct and operate a railroad from the North Slope to Fairbanks if the coal deposit must support the entire construction and operation. The economics may be entirely different if the additional benefits to other users were considered.

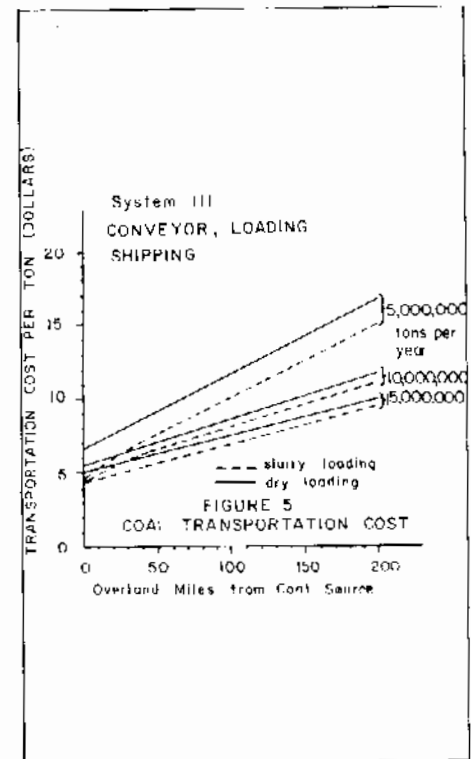
System II, the transportation of coal by truck from the coal fields to Fairbanks, would be prohibitively expensive even if the coal did not have to support any of the main road construction and maintenance.

The cost of moving the coal to the northwestern coast of Alaska (*Systems III, IV, and V*) appears to be competitive with the transportation costs of existing coal suppliers to Japan, particularly if these coal deposits are on or near the coast. As the overland distance to the coal deposits increases, the costs become greater and the coal becomes less competitive.

Future Research

There are many aspects of coal transportation in northern Alaska which require further research. These include marine terminals and shiploading techniques, arctic slurry pipeline operation, extension of the shipping season, and probably most important, the delineation of favorable coal mining areas.

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(A complete bibliography can be found in the M.S. thesis or M.I.R.L. Report No. 30).

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