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# PRELIMINARY REPORT ON THE GEOLOGY ALONG THE ROUTE OF A PROPOSED TUNNEL TO DEVELOP HYDROELECTRIC POWER FROM EKLUTNA LAKE, ALASKA

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July, 1947

Open for public inspection by
press notice dated Feb. 15, 1948.
48-11

# PRELIMINARY REPORT ON THE GEOLOGY ALONG THE ROUTE OF A PROPOSED TUNNEL TO DEVELOP HYDROELECTRIC POWER FROM EKLUTNA LAKE, ALASKA

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## INTRODUCTION

A preliminary investigation of the geology of the ridge northwest of the lower end of Eklutna Lake was made in the period June 11-18, 1947, by the writer, assisted by L. A. Hale. The purpose of this study was to obtain geological information bearing on the feasibility of constructing a tunnel through this ridge as part of a hydroelectric power development under consideration by the city of Anchorage.

Several traverses were made up each side of the ridge in a belt judged to include the most logical routes for the proposed tunnel. For the purpose of localizing the study two tentative routes were selected, of which one would require the shortest possible length of tunnel, and the other would be somewhat longer but would place the lower portal of the tunnel at a location considered to be the most favorable for the construction of the penstock and power plant. The first route extends northwestward from the most westerly embayment on the north shore of the lake to the canyon about half a mile east of Pioneer Creek (see map). The second route extends from the same point in the lake to the nearest point on the steep slope southwest of the mouth of Goat Creek. The distance along the first route from the lake shore (elevation 862 feet) to the 800-foot contour on the north side of the ridge is 4.3 miles. The distance between corresponding points along the second route is 4.5 miles. The length of the tunnel would exceed these distances by amounts depending on the elevation and grade at which the tunnel is constructed.

## GEOLOGY

The following description of the geology of the proposed tunnel route should be read with the understanding that even with unlimited bedrock exposures, the results of the most thorough geological examination of surface outcrops enable the prediction of conditions to be encountered in the tunnel only within rather wide limits. This is especially true in the present investigations, in which bedrock exposures were far from continuous, particularly on the north side of the ridge, and in which some of the exposures examined are as much as 4,000 feet above the proposed tunnel line. Therefore, allowance must be made for conditions that may have been undetected in areas with no outcrops, and also for variations in conditions in the tunnel from those observed at overlying points on the surface. These conditions include both the type of rock to be encountered, and the extent to which the rock may be affected by faulting, fracturing, and chemical alteration.

### Surface Geology

South slope. For about half a mile from the shore of Eklutna Lake to the lowest bedrock outcrops, the surface along the tunnel line is underlain by an unknown depth of glacial-terrace and alluvial-fan deposits. The south slope of the ridge, up to about the 3,500-foot contour, is underlain by a series of interbedded slate and graywacke beds in which the graywacke greatly predominates. The graywacke is thin-bedded and somewhat schistose, which gives it a platy fracture. The slate has characteristic slaty cleavage. The foliation of both types of rock is parallel to the bedding, which in this section has an east-west strike and a fairly uniform dip of about 40° to the north.

Between the 3,500- and 4,000-foot contours the slate-graywacke series consists predominantly of slate, and the structure is more complex. Vertical dips and abrupt changes in strike and dip are common.

Along the east side of the canyon that heads between the two highest peaks of the ridge, the slate has been complexly folded and crumpled. During the deformation the few interbedded graywacke layers did not fold readily and were broken into isolated segments within the contorted mass of the more easily deformed slate. The complex folding is probably related to a large fault that was traced for several hundred feet up the narrow gorge that forms the extreme head of the canyon. Intense shearing in the bordering rock and numerous slickenside surfaces indicate strong movement along the fault, which strikes N. 30° W. and is approximately vertical. The fault zone where observed was about 4 feet in width and has been filled with quartz and calcite, at least part of which has also been sheared. No evidence was seen of recent movement along the fault. A second quartz-filled fault fissure was noted a few hundred feet west, striking N. 50° W. Several prominent fissures in the side walls of the gorge probably represent branch faults or shear zones.

Above the 4,000-foot contour graywacke is again the predominant rock in the slate-graywacke series, which also includes a few irregular masses of greenish-gray fine-grained andesitic rock, representing either interbedded lava flows or small intrusive masses. In places this rock has a fine blocky fracture and is strongly weathered to a rusty green, so that it is difficult to get a fresh fracture. In the vicinity of these strongly weathered masses the graywacke itself has a greenish cast. The andesitic rock becomes predominant at about the 4,500-foot contour and appears to form the mass of the highest peaks, although scattered outcrops of slate and graywacke were noted up to an elevation of 4,900 feet.

The contact of the andesitic rock with the slate-graywacke series appears to be several hundred feet lower west of the large fault than on the east, and thus may give a clue to the direction and approximate magnitude of displacement along the fault.

No extensive decomposition of bedrock, other than surface weathering, was noted on the south slope. In fresh exposures along the stream channels, both the slate and graywacke were hard and firm and showed relatively little fracturing, even where adjoining weathered outcrops were highly jointed and fractured. The slate is considerably less resistant to weathering and erosion than the graywacke, which fact was abundantly illustrated along the ridge crests underlain by these rocks, where the slate invariably formed saddles between higher points of graywacke. In places the andesitic rock appeared to be extensively altered, particularly where it showed a blocky fracture, but it seems likely that this alteration was largely the product of weathering and not of deep-seated origin. At several points along the crest of the main ridge rusty exposures suggest the presence of oxidized mineralized zones. One such rusty exposure was examined, and the oxidation appeared to be due merely to accelerated weathering along a minor shear zone.

North slope. The determination of the geology of the north slope of the ridge was made difficult by the general scarcity of bedrock exposures. The most favorable localities for examining bedrock were along the few streams that have cut gorges into the mountain side, all of which were traversed up as far as bedrock was exposed.

On Pioneer Creek bedrock was exposed only between the 800 and 1,500-foot contours and above the 2,800-foot contour. The lower section consists of basic intrusive rocks, including pyroxenite, locally chromite-bearing, and finer-grained rocks of similar composition. Below the 1,100-foot contour and above the 1,300-foot contour the rocks are comparatively fresh and only moderately jointed. Between those two contours, however, the rocks are extensively sheared and decomposed to crumbly masses consisting largely of serpentine.

Outcrops at the head of Pioneer Creek and on both walls of the cirque it drains consist of a greenish-gray fine to medium-grained intrusive rock, probably andesitic in composition. This rock is similar to that near the top of the south slope of the ridge, except that it is very fresh and unaltered, because of the rapid erosion of the cirque walls.

The small stream half a mile east of Pioneer Creek was traversed nearly to its head. Although no bedrock exposures were found, float in the stream channel and residual boulders near the crest of the small spur to the east consist largely of basic rocks similar to those on Pioneer Creek.

The stream that crosses the highway about a mile east of Pioneer Creek was traversed to about the 1,500-foot contour, and excellent exposures were found. These consist entirely of pyroxenite and finer-grained basic intrusive rocks, which are little altered and form massive outcrops where undisturbed, but are highly decomposed and altered to serpentine in several shear zones that cross the gorge. All the shear zones strike about N. 60° E. and dip steeply to the southeast. Above the 300-foot contour the rock in a shear zone about 150 feet wide is thoroughly decomposed to a mass of serpentine and serpentinized blocks. A narrow shear zone in similarly altered rock crosses the stream at about the 800-foot contour. Above the 1,000-foot contour is an intensely sheared and crumpled zone several hundred feet wide, in which the rock is thoroughly decomposed and easily eroded, as shown by large slides that extend down both canyon walls. A similar zone is marked by large slides above the 1,500-foot contour on the west fork of the canyon.

Goat Creek was traversed to about the 1,000-foot contour on the lowermost west fork, above which the canyon opened into a V-shaped valley without outcrops. The rocks on Goat Creek are largely fine-grained dark-colored igneous rocks that have apparently invaded and almost completely replaced or altered rocks of the slate-graywacke series. Very little typical graywacke was seen, and much of the slate appears to have been converted to a dense sooty black extremely fine-grained rock with little or no slaty cleavage. At other points the slate shows its normal bedded character and cleavage.

Although these rocks show considerable jointing and local shearing, at no point have they been extensively decomposed. Examination of the float in the stream bed at the head of the canyon indicated that much of the drainage basin of this tributary is underlain by graywacke.

## Relation of Surface Geology to Conditions to be Expected in the Tunnel

Many of the defects observed in the bedrock at the surface are characteristic of the zone of weathering and are not to be expected at any great depth. These defects include much of the extensive jointing and shattering of surface outcrops and a certain amount of chemical alteration. Other defects are more deep-seated in origin and may be expected to continue to great depths. These include the major faults and shear zones, and such extensive chemical alterations as the serpentinization of the basic rocks on the north slope. Also, many of the extensive joint systems that were observed in nearly all the large outcrops, such as cliffs along the streams and the crags near the crest of the ridge, may extend to considerable depth.

There is little doubt that a tunnel along either of the routes considered in this investigation would encounter sheared and decomposed rock near the north portal because the observed sheared and serpentinized exposures are very close to the probable portal site. It is impossible, however, to predict from existing evidence what length of tunnel would be affected by observed shear zones and by similar zones that may have been undetected in areas of no outcrops.

The extensive deformation of the rocks adjoining the large fault near the crest of the ridge on the south slope shows that it is a major displacement that may be expected to extend to tunnel depth. However, as no extensive altered and shattered zones were observed along this fault at the surface, it is possible that little difficulty would be encountered in driving a tunnel through the fault zone.

## CONCLUSIONS

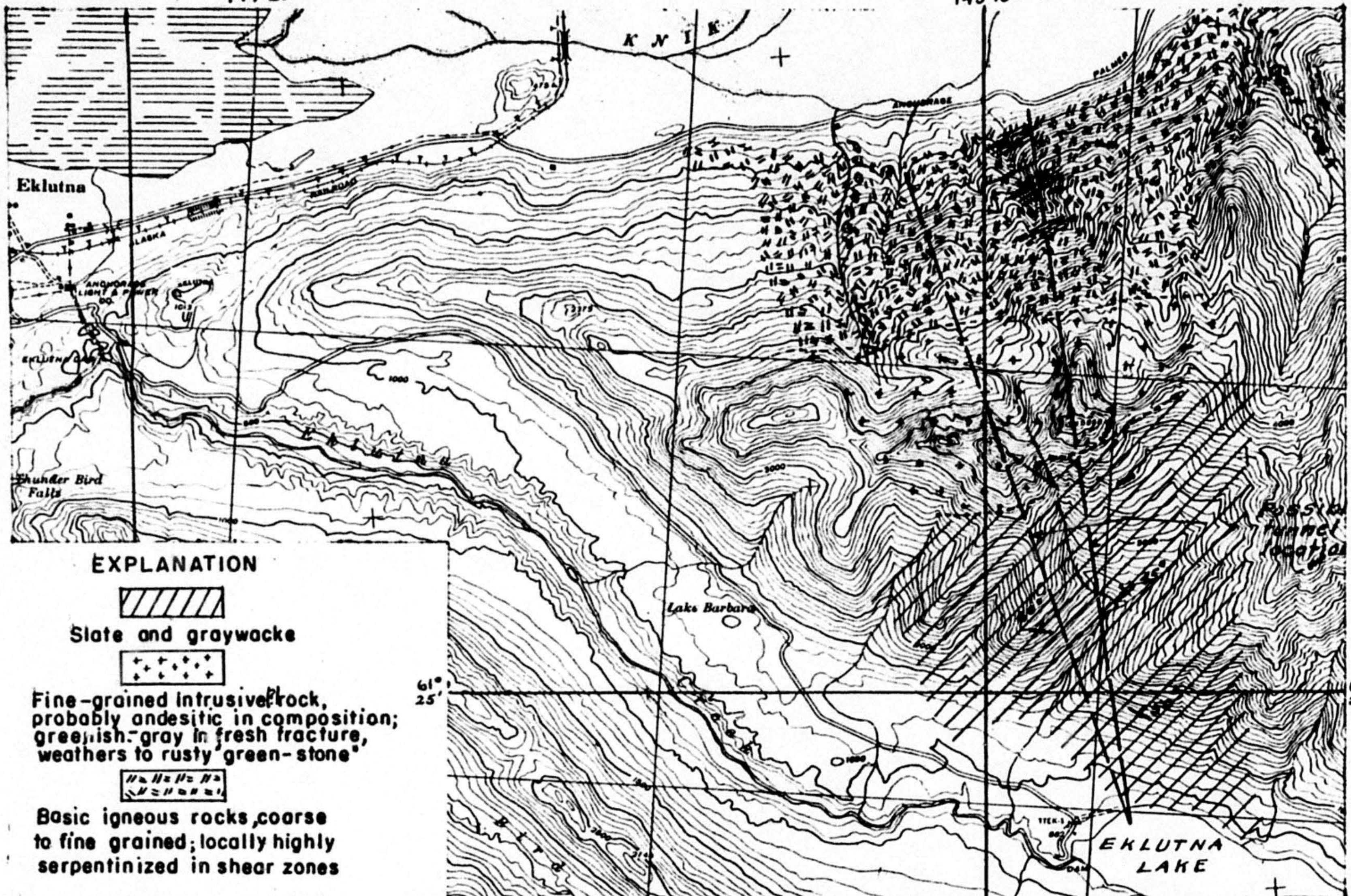
The results of this investigation indicate that a tunnel from Eklutna Lake northwestward to the valley of the Knik River would encounter three general classes of bedrock; namely, interbedded slate and graywacke which crops out on the south slope of the intervening ridge, a fine-grained intrusive rock, probably andesitic in composition, found along the crest, and a variety of basic intrusive rocks, locally highly sheared and serpentinized outcropping on the north slope.

No evidence was found to indicate that the slate-graywacke series would present serious obstacles to tunnel building. The railroad tunnels on the Whittier branch of the Alaska Railroad, driven through slate and graywacke very similar in character, to that encountered at Eklutna required very little timbering. The andesitic rock is extremely hard and tough in fresh exposures along the crest of the ridge and should stand well unless weakened by faults or chemical alteration. The basic rocks on the north slope also stand well in fresh exposures, as shown in numerous cuts along the highway, but appear to be particularly susceptible to chemical alteration along shear zones.

The region as a whole has been subjected to strong deformative stresses, as shown by the numerous sheared and complexly folded zones. The effects of this deformation may be expected in all types of rock at tunnel depth in the form of joints, faults, and shear zones.

This investigation revealed no unusual geologic conditions that would seem to make the construction of the proposed tunnel unfeasible or excessively costly. The maximum depth of cover would be about 4,000 feet, which is well within the critical depth of sound rock of the types involved. The construction of certain section of the tunnel would be rendered more difficult and expensive by intense shearing and chemical alteration, but these conditions probably would affect only a relatively small proportion of its length.

Available geologic evidence indicates little choice between the two alternate routes shown on the map. The eastern route obviously would pass through the largest observed and altered zones. Although no bedrock was found on the slope above the portal of the western route, the position and trend of shear zones on either side strongly suggest that they would be encountered along this route also.




Fault

Shear zone

Strike and dip of foliation and bedding

## MAP SHOWING GEOLOGY ALONG POSSIBLE ROUTES OF TUNNEL FOR PROPOSED EKLUTNA LAKE HYDROELECTRIC POWER DEVELOPMENT

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 Miles

Base: Eklutna quadrangle
Corps of Engineers U.S. Army
1942

Contour interval 100 feet

Geology by F. F. Barnes
June 1947