Geologic Reconnaissance of a Possible Powersite at Takatz Creek, Southeastern Alaska

By JAMES E. CALLAHAN

GEOLOGY OF WATERPOWER SITES IN ALASKA

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A geologic description of a possible powersite on Baranof Island, near Sitka, Alaska

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GEOLOGIC RECONNAISSANCE OF A POSSIBLE POWERSITE AT TAKATZ CREEK, SOUTHEASTERN ALASKA

By JAMES E. CALLAHAN

ABSTRACT

Takatz Creek and Takatz Lake lie in a deep glacial trough on the east coast of Baranof Island, east-northeast of Sitka.

In addition to investigations by the U.S. Geological Survey, the powersite has been examined for possible development by the U.S. Bureau of Reclamation. The Bureau proposes a double-curvature thin arch dam 200 feet downstream from the lake outlet that would raise Takatz Lake from 905 to 1,040 feet. A pressure tunnel 8 feet in diameter and 3,860 feet long would lead to a surface penstock that would start at the 650-foot level and extend about 1,000 feet to a powerhouse on Takatz Bay. A 60-foot-high auxiliary dam or dike is also required to prevent water from flowing through a saddle east of the right abutment.

All the proposed structures and the reservoir site are underlain by competent quartz diorite which is part of a large complex pluton about 10 miles wide centered around Baranof Lake. Zones of closely spaced joints that strike through the main damsite, possibly through the auxiliary damsite, and through the saddle east of the right abutment are possible paths of leakage. Where the tunnel route passes beneath the saddle, it has only about 140 feet of cover, a large part of which is probably loose talus. Pressure tests in two shallow holes drilled by the Bureau of Reclamation at the damsite indicate that the quartz diorite is tight, but additional drilling is required at all three localities.

Waves generated by rockslides or rockfalls into the reservoir appear to be the most significant hazard affecting the powersite.

Construction materials include fluvioglacial material from the area above the head of the lake and from the tidal flat at the head of Takatz Bay, and talus from the deposits near the damsite.

INTRODUCTION

During September 1964, a geologic reconnaissance was made of a possible powersite at Takatz Lake on Baranof Island, southeastern Alaska. The investigation was made at the request of the Branch of Waterpower Classification, U.S. Geological Survey, to aid in the evaluation and classification of federally owned lands for waterpower resources. The writer was assisted by George Kraemer, field assistant. J. B. Dugwyler, Jr., hydraulic engineer, Branch of Waterpower Classification, who had mapped the powersite topographically in 1957, furnished logistic and other support.

PREVIOUS INVESTIGATIONS

J. C. Dort, of the U.S. Forest Service, examined the Takatz Creek powersite in 1922 for the Federal Power Commission. He surveyed the lake, described the damsite, and made discharge measurements at the outlet of the lake (Federal Power Commission and U.S. Forest Service, 1947). Descriptions of the site have been included in various reports and power inventories which have drawn on Dort's work. No more fieldwork was done until 1957, when the Branch of Waterpower Classification, Geological Survey, surveyed the reservoir site and the damsite by planetable and mapped the underwater topography in the lake. During 1956, K. S. Soward of the U.S. Geological Survey visited the lake, but the outlet and the dam axis line were not accessible. From the ridge between the lake and the bay he observed the damsite, the tunnel and penstock routes, and the powerhouse site (K. S. Soward, written commun., June 24, 1960). In July 1964, A. A. Wanek and the writer made a geologic reconnaissance of Kasnyku Lake, about 3 miles north of Takatz Lake, and of Deer Lake, on the east coast and near the south end of Baranof Island (Wanek and Callahan, 1969). The investigation in September 1964 by the writer included an examination of the dam and reservoir site, an auxiliary damsite, and the part of the tunnel route between the lake and the crest of the ridge between the lake and Takatz Bay.

In 1964 the U.S. Bureau of Reclamation, in an inventory of possible powersites in southeastern Alaska, concluded that the Takatz Creek site was the most favorable for furnishing power to the city of Sitka. The proposal was presented to the city in 1965, and the Bureau of Reclamation was requested to conduct feasibility investigations. The field investigation by the Bureau during September and October 1965 included surface geologic mapping of the dam, tunnel, penstock, and powerhouse sites, supplemental topographic surveys, and exploratory drilling. Two holes were drilled into the bedrock at the damsite, one hole was drilled along the penstock route, and one hole was drilled at the powerplant site (U.S. Bureau of Reclamation, unpub. data, 1966).

In addition to specific investigations of the powersite, general geologic mapping in the area was done by F. E. and C. W. Wright (1905, 1908) and C. W. Wright (1907). Their maps were never published in detail, and only sketch maps are in the reports. Knopf (1912) summarized all previous work in addition to his own in a description of the Sitka mining district. More recently, Berg and Hinckley (1963) mapped the north half of Baranof Island at a scale of 1:125,000 and described the rocks in considerable detail. Loney, Pomeroy, Brew, and Muffler (1964) mapped all of Baranof and Kruzof Islands at a scale of 1:250,000 and divided the igneous and metamorphic rocks of the islands into many units. Loney, Brew, and Lanphere (1967) discussed recent lead-alpha and potassium-argon age determinations of plutonic rocks of Baranof and Chichagof Islands and made some inferences about the time and amount of vertical displacement along major faults in the area.

LOCATION AND ACCESSIBILITY

Takatz Lake is about 17 miles east-northeast of Sitka and about 3½ miles west of Chatham Strait (fig. 1). Tidewater at the head of Takatz Bay is about 1 mile from the outlet of Takatz Lake. The nearest permanent settlement to Takatz Lake is Baranof, on Warm Spring Bay about 3½ miles southeast of the lake. Access

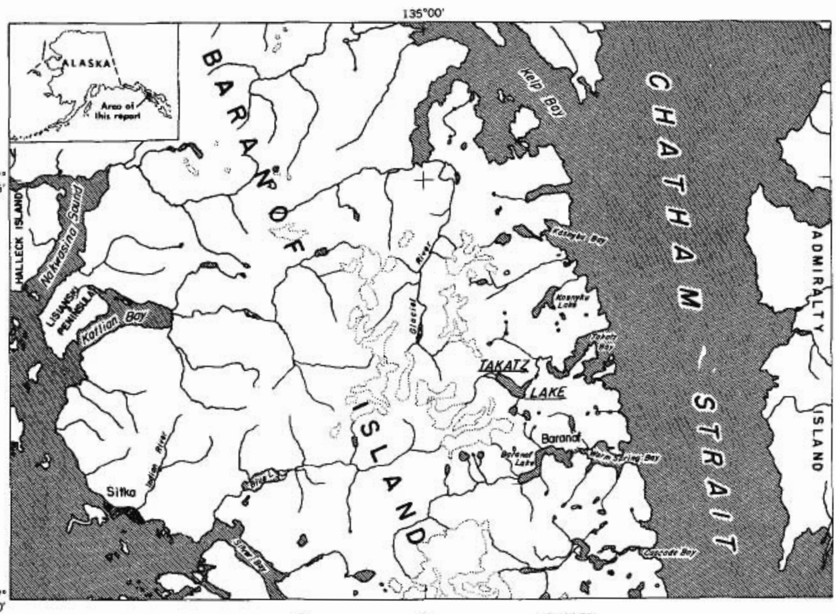

FIGURE 1.—Location of Takatz Lake, southeastern Alaska. Glaciers outlined by dots.

to the lake is by floatplane or helicopter. Bad weather and rugged topography often make flying hazardous. The lake can also be reached on foot from Takatz Bay, but there is no established trail. Foot travel is slow and difficult because of the dense brush and steep slopes.

TOPOGRAPHY AND DRAINAGE

Near Takatz Lake, the east coast of Baranof Island is dissected by many winding, steep-sided glacial troughs. Commonly, the lower ends of the valleys are salt-water embayments and the middle or upper parts contain glacial lakes separated from tidewater by bedrock ridges or lips.

Takatz valley is about 10½ miles long and has a very winding course with an overall northeasterly trend (pl. 1). The lower 3 miles of the valley is occupied by Takatz Bay. The lake is at an altitude of 905 feet. Above the lake, the valley bottom is relatively flat for about 1½ miles, rising from lake level to about 1,100 feet. The gradient increases abruptly above the 1,100-foot level. A glacier about 1½ miles long occupies the upper end of the valley.

The drainage area above the outlet of Takatz Lake is about 10.6 square miles, of which about 2 square miles is covered by glaciers. The lake is fed mainly by the stream flowing from the glacier at the head of the valley. Two cirque lakes, averaging about 2,000 feet in diameter, lie at altitudes of about 1,900 and 2,400 feet in the southern part of the drainage area. The maximum relief in the drainage area is about 3,700 feet.

The area of Takatz Lake is 403 acres. The depth of the lake is 474 feet at its deepest part, which is about midway along the length of the lake.

Takatz Creek flows north-northeast out of the lake for about 300 feet, turns east-northeast, and drops precipitously to a cirque-like basin containing a small pond at an altitude of 595 feet. Below the pond, the creek has an irregular course north and northeast and then east around the north end of the ridge which separates Takatz Lake from Takatz Bay. J. C. Dort (in Federal Power Commission and U.S. Forest Service, 1947) estimated a mean discharge at the lake outlet of 185 cfs (cubic feet per second). Surface water records (U.S. Geological Survey, 1964) for the period 1951–60 at the gaging station at the mouth of Takatz Creek show a mean discharge of 262 cfs. This figure includes the discharge of a large stream from the northwest which flows into Takatz Creek below the outlet. The measured discharge reduced proportionately to the drainage area above the lake outlet is about 160 cfs.

CLIMATE AND VEGETATION

The climate of southeastern Alaska is moderate. The mean annual temperature at Baranof for the period 1951–60 (U.S. Weather Bureau, 1965) was 42.0°F. For the same period, the range in average monthly temperatures was from 32.5°F for January to 52.7°F for August. The highest and lowest temperatures recorded for the period were 77°F and –10°F, respectively. The mean temperature at Takatz Lake is probably lower than at Baranof because of the higher altitude of the lake. The lake was frozen until late July in 1964.

For the period 1951–60, the mean annual precipitation at Baranof was 147.36 inches, with a maximum of 189.20 inches in 1953. The wettest months are October and November, with means of 22.38 and 24.16 inches, respectively. The lowest mean monthly precipitation for the period was 2.97 inches for July.

The lower slopes around Takatz Lake are sparsely forested by spruce and hemlock to an altitude of about 1,500 feet. However, much of the area around the lake is too steep to support timber of any size. The undergrowth consists of dense berry bushes and devilsclub. Low, dense, tangled alder brush commonly covers talus, old landslide scars, and slopes too steep for larger trees.

GEOLOGY

BEDROCK

Takatz Lake is underlain by part of a pluton of quartz diorite about 10 miles wide that is centered around Baranof Lake. The pluton intrudes metamorphosed sedimentary and volcanic rocks of Mesozoic age and contains granodiorite, diorite, and gabbro in addition to quartz diorite. The intrusive rock in most of the outcrops contains numerous inclusions of metamorphic rocks and inclusions or segregations of gneissic diorite or meladiorite.

The quartz diorite at Takatz Lake is inhomogeneous and ranges from fine-grained medium-gray rock containing scattered elongated inclusions of biotite to coarsely crystalline rock of a typically granitic texture. A vaguely defined flow banding is present in some of the rocks. The quartz diorite is locally garnetiferous.

The mineral and chemical compositions of five samples from localities around Takatz Lake are given in table 1. On the basis of mineral composition, the samples are all classified as quartz diorite (tonalite) according to Johannsen's classification (1939, v. 1, p. 141–161). The chemical variation is wide, but the samples fall within the limits of quartz diorites shown by Johannsen (1939, v. 2, p. 385–386).

TABLE 1.—*Mineral and chemical composition, in percent, of five rock samples from the Takatz Creek powersite*

[Chemical analyses by P. L. D. Elmore, S. D. Botts, and Lowell Artis]

	1	2	3	4	5
Mode					
Quartz	8.0	12.3	30.2	11.7	11.9
Plagioclase	60.0	67.9	50.7	71.9	63.2
Hornblende	19.6	8.3	......	7.2	12.4
Biotite	12.4	11.5	19.1	8.2	12.5
Ilmenite	......	......	......	1.0	......
Total	100.0	100.0	100.0	100.0	100.0
Chemical analyses					
SiO_2	70.50	59.90	62.70	61.20	61.20
Al_2O_3	15.10	18.90	17.30	19.70	18.70
Fe_2O_3	.65	.82	2.60	.85	.38
FeO	2.50	3.80	2.50	2.50	3.20
MgO	.80	1.80	1.60	1.40	2.70
CaO	4.00	7.90	6.20	7.00	7.50
Na_2O	3.50	3.90	4.00	4.50	4.40
K_2O	1.10	.32	.65	.30	.54
H_2O^-	.10	.09	.05	.05	.00
H_2O^+	.78	.90	.81	.59	.61
TiO_2	.46	.83	.87	.95	.40
P_2O_5	.32	.41	.55	.55	.32
MnO	.11	.08	.08	.08	.13
CO_2	.10	.08	.11	.15	.11
Total	100.02	99.73	100.02	99.82	100.19

1. Quartz diorite from left abutment of Takatz Creek damsite at an altitude of 1,130 feet. Feldspar, quartz, and hornblende are anhedral; biotite is subhedral. Plagioclase is andesine, zoned from An_{30} at center outward to An_{40}. Crossed twin laminae are common in the feldspar. The quartz has undulatory extinction. The feldspar is partly altered to sericite, and the biotite is partly altered to chlorite. Accessory minerals are ilmenite, apatite, and garnet.
2. Quartz diorite from left abutment of Takatz Creek damsite at an altitude of 955 feet, upstream from alinement of dam. Andesine feldspar in grains as much as 2.5 mm (millimeters) in diameter is subhedral, zoned outward from An_{30} to An_{45}, and complexly twinned, and contains quartz and hornblende inclusions. Biotite and hornblende occur as elongated ragged grains, with some alteration of biotite to chlorite. The quartz is in small anhedral grains interstitial to feldspar and mafic minerals. Accessory ilmenite and apatite occur in scattered grains as much as 0.5 mm in diameter.
3. Quartz diorite from east side of saddle behind right abutment of Takatz Creek damsite at an altitude of approximately 1,100 feet. Andesine feldspar, zoned outward from An_{34} to An_{50}, occurs in subhedral to anhedral grains as much as 1.4 mm in diameter. The feldspar is complexly cross twinned. The quartz is anhedral and clear and has undulatory extinction. Quartz and feldspar occur in very fine aggregates along microscopic fractures. Twin planes in larger feldspar grains are offset along some of the fractures. The thin section includes the contact between quartz diorite and diabase. There is no evidence of alteration of the quartz diorite along the contact. The diabase consists of microlites of calcic plagioclase feldspar in an aphanitic groundmass that contains much disseminated opaque matter, which gives the rock its very dark color.
4. Quartz diorite from north shore of Takatz Lake about 3,500 feet southwest of the outlet. Andesine feldspar (An_{42}–An_{47}) occurs in subhedral to

anhedral grains as much as 3 mm in diameter. The feldspar is cross twinned. Biotite is partly altered to chlorite. The quartz is anhedral and is interstitial to other minerals. Ilmenite occurs in scattered anhedral to subhedral hexagonal grains and in partial skeleton crystals.

5. Quartz diorite from crest of ridge between Takatz Lake and Takatz Bay. Plagioclase feldspar is andesine, and it is strongly zoned outward from An_{46} to An_{24}. The andesine is complexly twinned. The quartz is interstitial and clear and has patchy or undulatory extinction. The biotite is mostly fresh, with only a small percentage altered to chlorite. The hornblende is pale green and only faintly pleochroic.

The quartz diorite near the outlet of Takatz Lake is cut by pegmatite dikes that range from 1 to 5 inches in thickness. The pegmatites are coarsely crystalline and contain mica plates or booklets as much as 1 inch in diameter. Some of the dikes are regular tabular bodies, and others are moderately deformed. A group of approximately parallel pegmatite dikes exposed on the knob on the east side of the outlet (right abutment) has an average strike of N. 45° E. and dips 70° SE.

The gneissic inclusions in the quartz diorite are generally too small to be mapped separately. However, about 3,000 feet west of the outlet on the north side of the lake, strongly banded biotite gneiss crops out for about 200–300 feet along the shoreline. The banding is highly contorted. Locally, the banding is well defined by parallel orientation of biotite flakes.

Radiometric age determinations on five samples from the pluton range from 28.1 to 47.2 million years (Loney and others, 1967). The two samples collected nearest Takatz Lake have potassium-argon ages of 41.1–44.3 million years, indicating that the rocks were emplaced during late Eocene time.

The pluton is surrounded by an aureole of schist, gneiss, amphibolite, and greenschist derived from Permian, Triassic, and Jurassic metamorphic rocks (Loney and others, 1964). The age of metamorphic rocks occurring as inclusions in the pluton is unknown.

UNCONSOLIDATED DEPOSITS

Surficial deposits near Takatz Lake include silt, sand, and gravel of fluvioglacial origin, talus, colluvium, and rockslide debris.

A considerable thickness of fluvioglacial material underlies the flat valley bottom at the head of Takatz Lake. In the delta area immediately above the head of the lake, the material consists of well-sorted clean sand and fine round to subround gravel. The sand and gravel become coarser, more angular, and more poorly sorted upstream.

Small quantities of alluvium occur at the outlet of the lake and above the small pond below the outlet. These deposits are poorly sorted, consisting mainly of reworked talus from the slopes on either side of the outlet along with some interstitial silt and fine sand. According to drill-hole data, the coarse material at the lake outlet is underlain by silty fine sand.

Talus is widespread around Takatz Lake and is forming along the valley walls above and below the lake. The talus is coarse, angular, and fresh. The talus blocks are roughly equidimensional and are as much as 10 feet in diameter. Parts of the talus slopes are overgrown with dense, tangled alder brush, but the material is not stable. Talus occurs in coalescing fans at the outlet of the lake and fills an abandoned outlet channel which extends northeast from the present outlet. Talus also fills the saddle that trends parallel to the lower part of the lake southeast of the outlet.

One recent rockslide mass in the upper valley above the lake was observed on the aerial photographs and confirmed by aerial reconnaissance. The slide extends more than halfway across the valley and covers an area of 20–25 acres. The landslide deposit contains blocks of quartz diorite estimated to be greater than 50 feet in diameter. According to P. D. Wold (written commun., Feb. 1966), the landslide mass has a thickness of about 30 feet. Soil cover around Takatz Lake is thin and limited in area.

STRUCTURE

The major structural element on the east side of Baranof Island is the Chatham Strait fault, which underlies the strait and extends for about 250 miles in a north-south direction. The Chatham Strait fault is believed to be a continuation or segment of the Denali fault of the central Alaska Range (St. Amand, 1957; Twenhofel and Sainsbury, 1958). According to Lathram (1964), 120 miles of right-lateral separation has occurred along the Chatham Strait fault during Tertiary and Quaternary time. Loney, Brew, and Lanphere (1967) postulated an uplift of Baranof Island amounting to several kilometers relative to Admiralty Island on the opposite (east) side of the Chatham Strait fault.

Minor structural features in the Takatz Lake area include joints and possible small faults or shear zones. The majority of the joints fall into three well-defined sets that have the following attitudes: strike N. 45°–60° E., dip 38°–44° SE.; strike N. 35°–45° W., vertical; strike N. 5°–15° E., vertical (fig. 2). Some joint faces are slickensided, but the slickensides have no consistent orientation. They may be the result of local movement on joints due to load adjustments during glaciation or deglaciation of the area.

No evidence of significant faulting was observed. Many linea-

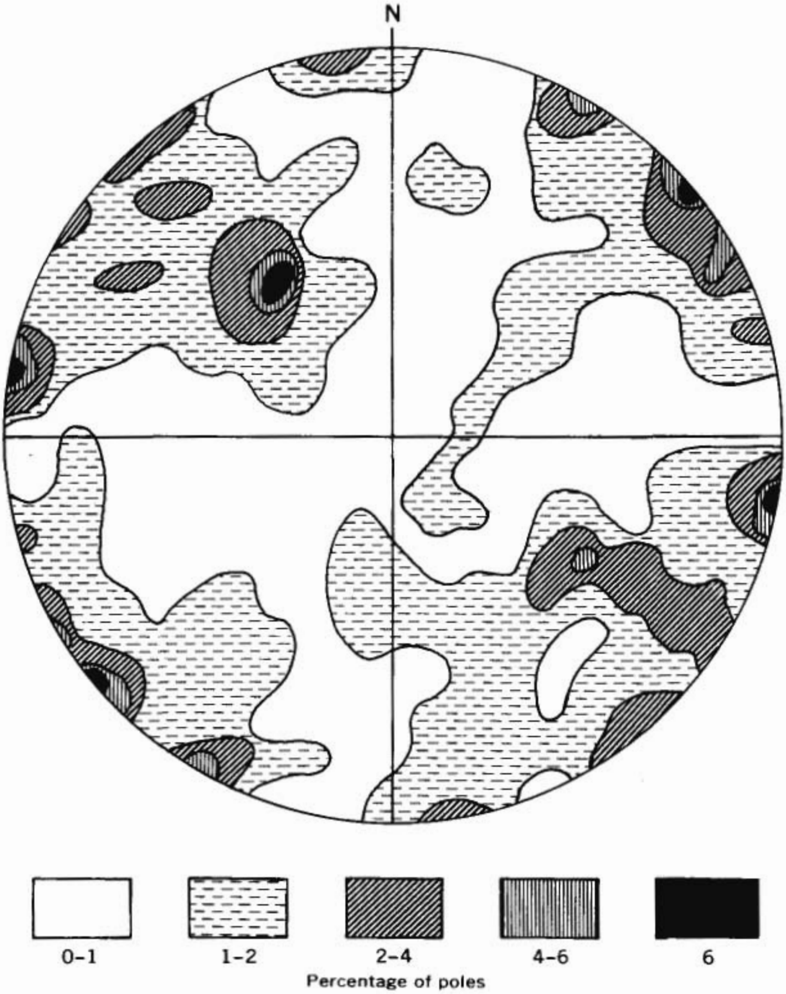

FIGURE 2.—Contour diagram of poles of 136 joints measured in the Takatz Creek powersite area. Poles plotted on lower hemisphere. Contoured on percentage of poles. (Billings, 1954, p. 108–114.)

tions on the aerial photographs can be traced for several thousand feet, but the most persistent ones parallel the northeast-striking joints and probably represent extended single joints or zones of closely spaced joints rather than faults (pl. 1).

EARTHQUAKES

The location of earthquake epicenters along the Chatham Strait–Lynn Canal indicates movement along the Chatham Strait fault within historic time. Ten earthquakes of intensity 5–6 on the modified Mercalli scale have been recorded along the fault between Baranof and the head of Lynn Canal. Earthquakes that appear to be related to the Peril Strait fault, which intersects the Chatham Strait fault about 10 miles north of Takatz Lake, also have occurred. Numerous epicenters are alined along the west coast of Baranof Island. This western line of epicenters extends north and south of Baranof Island and has been the site of moderately severe to very severe earthquakes, including the Yakutat Bay earthquake of 1899 and the Lituya Bay earthquake of 1958 (Heck, 1958, p. 71–78; Davis and Echols, 1962, p. 3).

Takatz Lake is in a seismically active area and lies very near the Chatham Strait fault, which shows evidence of Holocene activity. Dams or other structures near the lake should be designed to withstand earthquakes of maximum severity. Waves capable of overtopping a dam might be generated by earthquake-induced rockslides or rockfalls or by subaqueous landsliding along the delta at the head of the lake. Structures on or near Takatz Bay would be subject to similar hazards, including tsunamis and local waves generated by submarine sliding of the alluvial deposits underlying the tidal flat at the head of the bay.

DEVELOPMENT

J. C. Dort (in Federal Power Commission and U.S. Forest Service, 1947) proposed regulation of Takatz Creek by means of a 75-foot-high dam 400 feet below the outlet of the lake combined with a drawdown tunnel between the damsite and Takatz Bay. Raising the water level more than 75 feet would necessitate an auxiliary dam or dike to prevent water from passing through the saddle behind the right abutment.

The Bureau of Reclamation proposed (P. D. Wold, written commun., Feb. 1966) to raise the water level of Takatz Lake to an altitude of 1,040 feet by means of a thin arch double-curvature dam immediately below the outlet of Takatz Lake. The dam would have a crest chord length of about 450 feet (pl. 1). The reservoir would be drawn down by a tunnel 26 feet below the present water surface, resulting in a usable storage capacity of 88,000 acre-feet. An ungated spillway over the crest of the main dam at an altitude of 1,040 feet is proposed. An auxiliary dam would be necessary to prevent flow of water through the saddle behind the right abutment. The best location would be across the outlet of the small pond midway between the saddle and Takatz Lake. The outlet of the pond flows across a bedrock sill that would make a satisfactory foundation. The saddle itself is filled with large angular talus blocks to an undetermined depth, and it would be uneconomical or impossible to build a dam or dike across it. A double-curvature thin arch dam is proposed for the auxiliary dam, but the site is also well suited for a gravity dam or dike. Locating the spillway on the auxiliary dam was ruled out because of the possible instability of talus slopes in the saddle area.

From an intake about 750 feet south of the dam, the tunnel would extend eastward about 1,200 feet, then northeastward 2,600–2,700 feet to the penstock. As proposed by the Bureau of Reclamation, the tunnel would have an overall length of 3,860 feet. The invert elevation at the intake structure would be 879 feet, and the tunnel portal above the powerplant would be at an altitude of 650 feet. The penstock would be a surface conduit about 1,000 feet long.

DAMSITE

TOPOGRAPHY

The narrowest possible damsite is immediately above the bend in Takatz Creek, about 375 feet from the outlet of the lake, where the stream gradient increases abruptly (pl. 1). However, because of the sharp bend in the channel to the right and the steepness of the cliff downstream, little supporting ground would be available below the right abutment. An alinement about 75–100 feet upstream from the bend would result in more support on the right abutment. An arch dam could be keyed into the right abutment more effectively at this locality. The right abutment is an irregular glaciated bedrock knob. The knob has a relatively gentle upstream slope, but the downstream side is almost vertical. These features reflect the smoothing and quarrying action of the glacier. The slope of the right abutment is about 55° up to an altitude of 1,100 feet. About 1,100 feet southeast of Takatz Creek is a deep saddle behind the right abutment. The saddle trends northeast parallel to Takatz Creek and has a maximum altitude of 1,020 feet. The left abutment is a relatively smooth slope which is continuous with the main valley wall and rises from Takatz Creek at an angle of about 40°.

GEOLOGY

BEDROCK

Quartz diorite is exposed continuously in the right abutment between Takatz Creek and the saddle to the southeast. Scattered outcrops separated by a thin soil cover and heavy brush occur on the left abutment.

The grain size in the quartz diorite at the damsite is variable, ranging from 0.25 mm to 6 or 7 mm. The variations within the quartz diorite are gradational and were not observed to persist in any particular direction. Differences in mineral composition appear slight despite the textural variation.

Inclusions of biotite gneiss are common in the damsite area. The inclusions have sharp contacts with the quartz diorite. The banding is well defined and commonly highly contorted. The mineral composition is similar to that of the quartz diorite.

Pegmatite dikes from 1 to 2 inches thick occur near the top of the right abutment. The dikes strike N. 45° E. and dip 70° SE. and are spaced from 1 foot to several feet apart. Irregular pegmatite bodies 3–5 inches thick were observed several hundred feet northeast of the dam alinement between the abandoned outlet channel and the present Takatz Creek. These dikes are very coarse grained and contain mica plates and booklets as much as 1 inch in diameter.

Neither the dikes and inclusions nor the textural variations in the quartz diorite are likely to cause a significant difference in the foundation properties of the bedrock. The planar structure in gneissic inclusions in the damsite area is not continuous enough to give the rock directional properties such as permeability or lower shear strength parallel to the foliation.

A small linear feature on the aerial photographs trends northeasterly through the outlet area. On the north side of Takatz Creek, the linear feature follows a talus-filled abandoned lake outlet. South of the creek it follows the base of the steep slope of the right abutment into a shallow saddle. K. S. Soward (written commun., June 24, 1960) inferred from his cursory observations and interpretations of the aerial photographs that this might be the trace of a small fault or shear zone. No evidence of faulting was found, but a closely spaced set of vertical joints striking N. 10°–20° E. was observed at the lakeward end of the abandoned outlet.

The total depth in the two holes drilled at the damsite by the Bureau of Reclamation is 70 and 82 feet, and bedrock was reached at depths of 40.4 and 52.8 feet. The rock is quartz diorite which contains gneissic inclusions. Jointing is present in the rock in both holes. Minor slickensiding was noted on joint surfaces of samples taken from one of the holes. The two holes penetrated about 30 feet into bedrock. No water losses occurred during water tests in the bedrock at 50 and 100 pounds per square inch in both holes (P. D. Wold, written commun., Feb. 1966).

UNCONSOLIDATED DEPOSITS

The lower slopes of both abutments are mantled by angular talus. The talus is formed by frost action and by exfoliation from the right abutment. The talus deposits are covered in part by a thin soil layer and vegetation. Talus underlies the channel of Takatz Creek where it has been slightly waterworn, and the interstices between talus blocks are filled or partly filled by fine sand or silt of fluvial origin.

About 25 feet of talus with interstitial silty fine sand was penetrated in both drill holes at the damsite. Silty fine sand underlies the talus to a depth of 40.4 feet in the hole nearest the right abutment and to a depth of 49.9 feet in the hole near the stream channel. The hole near the right abutment penetrated bedrock immediately below the sand. The other hole went through about 3 feet of sand and cobbles before reaching bedrock (P. D. Wold, written commun., Feb. 1966). The left abutment is mostly covered by a thin soil cover and colluvium, but the thickness of the cover probably nowhere exceeds 1 or 2 feet.

AUXILIARY DAMSITE

The auxiliary dam would be across the outlet of the small pond in the gulch behind the right abutment. The left abutment of the damsite is a spur projecting southwestward from the knob forming the right abutment of the main dam. The crest of the spur has a relatively gentle slope as a result of glacial smoothing. The right abutment of the damsite has not been mapped topographically, but the slope is steep as a result of quarrying or plucking by the ice. Quartz diorite is exposed continuously on the right abutment and is mantled by only a thin soil cover on part of the spur forming the left abutment. The location of the steep right-abutment slope is most likely due to a zone of closely spaced joints of the set striking N. 35°–45° W. (fig. 2) which parallels the slope (Flint, 1957, p. 93). The joints would be normal to the axis of the auxiliary dam and might constitute a path for leakage of water beneath the dam.

TUNNEL ROUTES

A number of tunnel routes extending from the east end of the lake to Takatz Bay have been suggested. All the proposed routes, because of the possibility of leakage or weakness in the area of the saddle behind the right abutment, are alined to pass near the high point in the saddle to assure maximum cover. The writer examined only that part of the tunnel route from Takatz Lake to the crest of the ridge between the lake and Takatz Bay. K. S. Soward (written commun., June 24, 1960) examined possible powerplant sites and penstock and tunnel routes along the shore of Takatz Bay and on the ridge. On the basis of more extensive surface investigations and drilling, the Bureau of Reclamation (P. D. Wold, written commun., Feb. 1966) concluded that the tunnel and penstock routes and the powerplant site shown on plate 1 would be the most feasible.

The proposed tunnel route is in quartz diorite which contains gneissic inclusions similar to the rock exposed in the damsite area. The rock has closely spaced jointing, but testing in drill holes at the dam and powerplant sites indicates that the joints are tight at depth. The only area in which serious leakage or water problems might be encountered would be in the part of the tunnel passing beneath the saddle behind the right abutment, which is probably the locus of persistent joints of the northeast-trending set (fig. 2). The amount of bedrock cover in the saddle area is conjectural, but the maximum available cover including the loosely fitted talus deposits is about 140 feet.

K. S. Soward (written commun., June 24, 1960) observed some small faults and shear zones on the ridge through which the tunnel would pass but did not see any significant zones of poor rock.

PENSTOCK ROUTE AND POWERHOUSE SITE

The tunnel alinement chosen by the Bureau of Reclamation is based on the Bureau's assessment of landslide or avalanche possibilities at the proposed penstock and powerhouse (P. D. Wold, written commun., Feb. 1966). The penstock route selected is apparently relatively free of such hazards, although it is closely bounded on the north and the south by snowslide areas.

The top of the penstock is at an altitude of 650 feet. From an altitude of 490–254 feet, the penstock route is over a steep cliff of exposed quartz diorite. Above the top of the cliff, the slope is steep but has a soil cover thick enough to support spruce and hemlock trees. A deposit of fresh angular talus is at the toe of the cliff. The Bureau of Reclamation drilled a 31-foot hole on the penstock route at an altitude of 104.7 feet. The hole penetrated 2.3 feet of organic topsoil resting directly on quartz diorite bedrock similar to bedrock at the damsite (P. D. Wold, written commun., Feb. 1966).

The powerhouse site is near the base of a forested talus slope above Takatz Bay at an altitude of 16 feet. A hole drilled at the powerhouse site penetrated 3.5 feet of topsoil and 13.4 feet of talus with the interstices filled or partly filled. Bedrock is at a depth of 16.9 feet, or about 1 foot below the half-tide level of Takatz Bay. The bedrock is quartz diorite, weakly foliated, containing more strongly foliated gneissic inclusions (P. D. Wold, written commun., Feb. 1966).

RESERVOIR SITE

The reservoir site lies in a glacial valley completely surrounded by steep walls of dense, impermeable intrusive rocks except in the vicinity of the outlet. The rocks are structurally homogeneous and are cut only by minor faulting and joints. The lower slopes on each side of the valley are partly covered by talus to an altitude of 1,400–1,500 feet.

In the area of outcrops the exposed bedrock is medium-grained hornblende biotite or biotite quartz diorite containing numerous inclusions of gneissic rock. The large body of biotite gneiss which crops out on the north shore of the lake has already been described. The foliation in the gneiss at that locality is considerably contorted, but the average trend is about N. 60° E. and the dip is 50° NW.

About 1,100 feet northwest of the damsite behind the left abutment is a cirque basin. The floor of the basin lies about 250 feet below the level of Takatz Lake. P. D. Wold (written commun., Feb. 1966) examined this basin and estimated the flow from it due to seepage to be 1 or 2 cubic feet per second. Considering the apparent tightness of joints in the drill holes and the negligible outflow from the basin, he concluded that raising the water level in Takatz Lake would not result in significant water losses along joints or fractures through the left abutment to the cirque basin.

Rockslides or rockfalls are the only serious hazards affecting the reservoir. In addition to the rockslide already described, a number of potential slide masses of the same order of magnitude are present along the valley walls. None of these are a direct threat to the proposed dam or other works, but they could readily create waves large enough to overtop the dam. The initial raise in the lake level and subsequent fluctuation in the water level due to operations would contribute to slope instability around the reservoir. Considering the recorded seismic activity in the area, waves generated by rockslides or rockfalls should be considered one of the most serious threats to the dam.

CONSTRUCTION MATERIALS

The nearest large source of concrete aggregate is the deposit underlying the fluvioglacial plain at the head of Takatz Lake. The deposit consists of moderately well sorted gravel and sand. The material coarsens and becomes less well sorted upstream. Sufficient coarse and fine aggregate is probably available, but some processing will be required to produce the desired sizes. It would be necessary to move the sand and gravel to the damsite area by barge. Satisfactory natural aggregate might be obtained from deposits underlying the tidal flat at the head of Takatz Bay, but considerable processing would probably be required to remove silt and organic matter. The talus deposits around the lake and in the saddle area are a source of fresh rock suitable for crushing.

SUMMARY AND RECOMMENDATIONS

The damsite is underlain by competent quartz diorite which is homogeneous in its engineering properties. The rock is extensively jointed and fractured, but indications are that the joints and fractures are tight at depth. The channel section of the damsite is underlain by at least 52.8 feet of unconsolidated material. Further exploration should include drilling at an angle toward the center of the valley from the base of each abutment to assure that no deeper channels are present beneath the talus and fluvial deposits of the streambed. The damsite is topographically and geologically well suited for an arch dam. The double-curvature or dome dam proposed by the Bureau of Reclamation would be the most economical with respect to construction materials, an important factor because of the remoteness of the site and the processing and transportation problems in using the local aggregate sources.

Bedrock, under a thin cover of soil and colluvium, underlies the auxiliary damsite over its entire width. The site should be drilled to determine whether the small draw is the locus of closely spaced joints which might be a path for leakage under the dam.

The tunnel, penstock, and powerhouse sites are underlain by competent quartz diorite. A reinforced lining in the tunnel where it crosses beneath the saddle southeast of the right abutment may be necessary because of lack of cover and the presence of persistent closely spaced joints of the northeast-trending set. Drilling or geophysical work should be done to determine how much of the available cover is talus. The penstock and powerplant sites have been located to minimize snow avalanche and rockfall hazards.

The reservoir is not subject to significant water losses. It is subject to the creation of destructive waves caused by rockfalls or rockslides which could result from a combination of steep unstable slopes, water-level fluctuations, and seismic activity. Both dams and any appurtenant works downstream from the dams should be designed to withstand overtopping waves.

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