

MARBLE RESOURCES OF KETCHIKAN AND WRANGELL DISTRICTS.

By ERNEST F. BURCHARD.

INVESTIGATION.

Studies of the marbles and other structural materials of southeastern Alaska were first made by F. E. and C. W. Wright in 1905 and by C. W. Wright in 1906, the results being published in Survey bulletins in 1906, 1907, and 1908.¹ Between 1908 and 1912 nothing was added to the reports on the subject.

In the autumn of 1912 the writer made a brief examination of the marble areas on Prince of Wales, Kosciusko, Marble, Orr, Tuxekan, Heceta, Ham, and Revillagigedo islands, and of the gypsum mine on Chichagof Island. This work occupied the interval between September 13, when a trip westward from Wrangell was begun, to October 12, when work was closed at Ketchikan. All the marble deposits that were producing and all that were being actively prospected except one on the west coast of Dall Island were visited, besides a number of known and hitherto undescribed areas of some promise. This paper discusses merely the economic features of the deposits. The petrologic character of the intrusive and metamorphic rocks associated with the marble deposits was determined by J. B. Mertie, of the United States Geological Survey, and the writer herewith expresses his appreciation for this service.

DISTRIBUTION OF THE MARBLE.

Beds of marble occur in places along the mainland in the Ketchikan and Wrangell districts and on many of the islands of the Alexander Archipelago, including Prince of Wales Island, Kosciusko Island, Dall Island, Revillagigedo Island, and several smaller islands mainly in Davidson Inlet on the west side of Prince of Wales Island. The principal developments that have taken place thus far are in the

¹ Wright, F. E. and C. W., Economic developments in southeastern Alaska: U. S. Geol. Survey Bull. 259, p. 68, 1905; The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, pp. 191-198, 1908.

Wright, C. W., Nonmetallic deposits of southeastern Alaska: U. S. Geol. Survey Bull. 284, pp. 55-57, 1906; Nonmetalliferous mineral resources of southeastern Alaska: U. S. Geol. Survey Bull. 314, pp. 73-77, 1907; The building stones and materials of southeastern Alaska: U. S. Geol. Survey Bull. 345, pp. 116-122, 1908.

northwestern and southeastern parts of Prince of Wales Island, on Marble Island in Davidson Inlet, and on Ham Island near the southeast point of Wrangell Island. The relations of all these localities are shown on Plate II and on the maps accompanying Survey Bulletin 347. The most detailed maps showing the geographic relations are the charts issued by the Coast and Geodetic Survey. Charts Nos. 8150 and 8200 show Ham Island southeast of Wrangell and the northwestern part of Prince of Wales Island and the neighboring islands; and chart No. 8100 shows Revillagigedo Island near Ketchikan and the southeastern portion of Prince of Wales Island. Both charts are on the scale of 1 : 200,000, or approximately 3 miles to 1 inch.

TOPOGRAPHIC AND COMMERCIAL RELATIONS.

The mainland of southeastern Alaska and the islands of Alexander Archipelago are generally mountainous. There is little level land either as upland area or along the shores. Along much of the coast line the hills and mountains rise abruptly, and the dense forest growth extending down to the level of high tide overhangs the steep banks. The islands are separated by an intricate system of deep waterways and fiords, known locally as straits, canals, channels, passages, sounds, inlets, bays, coves, and arms, some of which reach far inland. The topography is so rough that only in favored localities and at great expense can wagon roads or short tram railroads be constructed. The waterways are therefore of great value as affording routes of communication between different portions of the region and between the region and the Pacific coast ports of the United States. Indeed, were it not for water transportation the mining and quarrying industries in southeastern Alaska could scarcely have been developed.

Many of the marble beds are directly on the shores of sheltered bays, some of which are deep enough to afford anchorage or wharfage for ocean-going freight vessels. Some, however, are located on deposits a mile or more from the shore and at considerable altitudes. Naturally the deposits most convenient of access will be first developed.

The deposits are in general thickly overgrown with small to medium sized timber and dense underbrush and, as a rule, have a soil cover of decayed wood, moss, and mold from a few inches to 3 or 4 feet thick, but thicker in places in crevices in the rock. The timber consists of hemlock, spruce, and cedar, having in most places a maximum diameter of 4 feet, though exceptionally in the southern part of the area they may reach 6 feet. The following paragraph, by Wright, on the growth of vegetation is of interest here:¹

The luxuriant growth of vegetation along the coast of southeastern Alaska may well be compared with that of a tropical region. This is caused by the moist and

¹ Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, p. 31, 1908.

temperate climate and the long summer days at this high altitude. At elevations below 1,500 feet bushes, ferns, and tall grasses grow profusely, especially in the valleys and gulches. These form in places a dense and almost impassable undergrowth and are a great hindrance to the prospector. Among the most common of these shrubs are the thorny devil's club, the salmonberry, the elderberry, the huckleberry, the high-bush cranberry, various willows, the black alder, and the white alder, the latter forming thickets along the streams and mud flats.

GEOLOGIC RELATIONS.

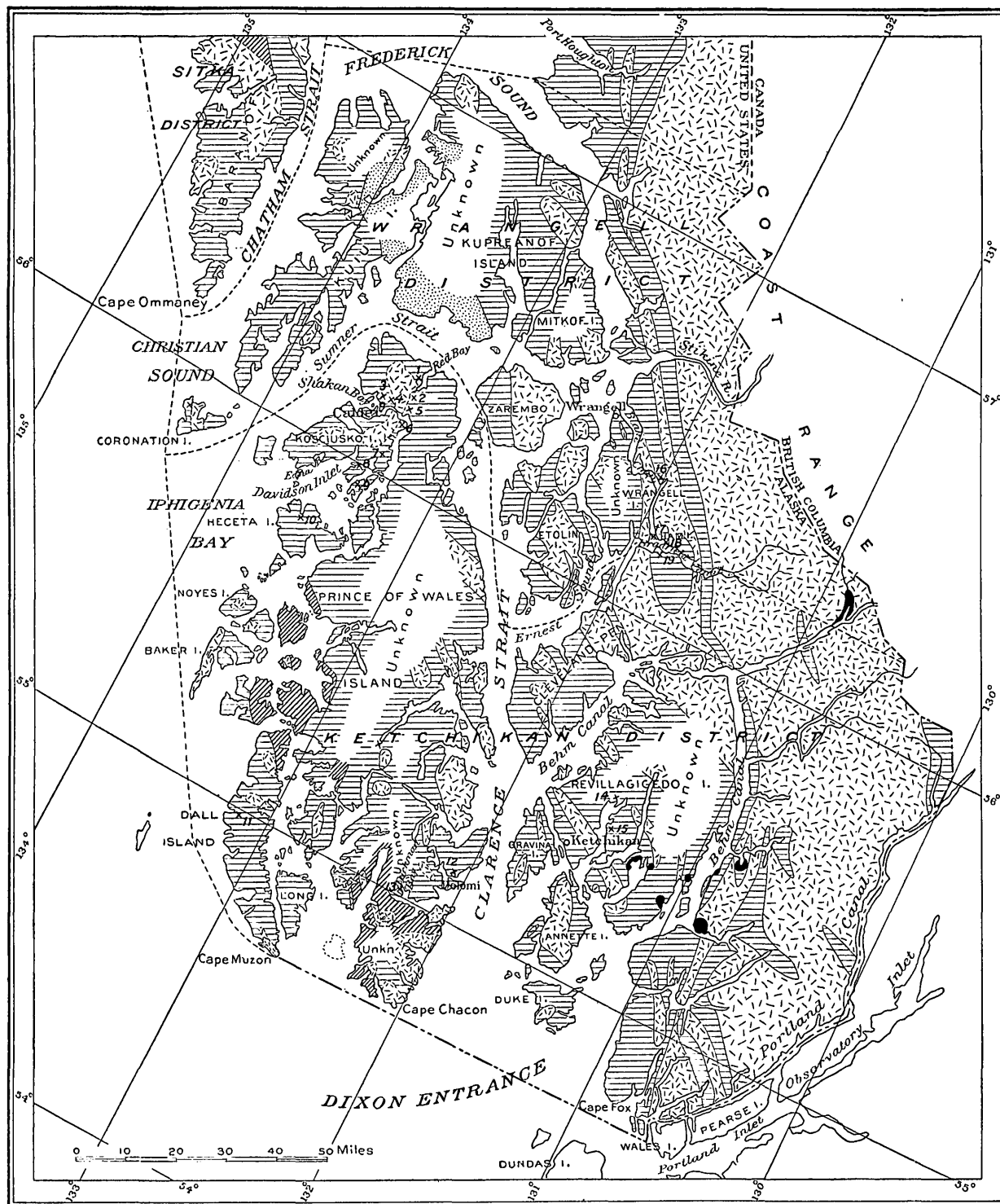
Most of the marble beds noted appear to be portions of extensive belts of limestone that have been metamorphosed at or near the contact of an intrusive mass of granodiorite. Both the limestone and the marble are cut in many places by thin dikes, principally of diabase, basalt, and andesite, all more or less altered and containing secondary calcite, and are interstratified with graywackes, schists, and tuffs. Both the limestone and the marble are generally much fractured and jointed, the marble in places showing joints open to considerable depths. The limestone beds associated with the marble deposits are of Paleozoic age and at a few places, notably in northern Prince of Wales Island and vicinity, are probably Lower to Middle Devonian.

TYPES AVAILABLE.

Several types of marble are available in southeastern Alaska. Probably the most common, and the only one which thus far has been exploited commercially, is a finely crystalline white to bluish-gray marble with gray to dark-bluish veins and clouded areas. Other crystalline marbles which give promise of being developed successfully show handsome contrasting "verde antique" effects and other striking combinations of color, such as green and pink, black and white, and white and yellow. The green color appears to be due to chloritic material and possibly to epidote, the bluish and black veins possibly to graphite, and the pink and yellow shades to iron oxide. Certain marble deposits give promise of affording statuary material. Some dense noncrystalline limestones have attractive colors of pink and chocolate mottled, gray, blue, and black and are susceptible of receiving a high polish.

QUARRIES AND PROSPECTS.

In the following pages the marble quarries and prospects are grouped geographically and are described as nearly as possible in the order in which they are numbered on the map (Pl. II). All the quarries and prospects that have made shipments of marble from Alaska are described, but a few claims located in the Ketchikan, Wrangell, and Juneau districts that have not been investigated by the Survey are omitted.




LEGEND STRATIFIED ROCKS



Recent
basaltic lavas and tuffs



Tertiary
including sandstone,
conglomerates, and
rhyolitic lavas and tuffs


Mesozoic
including graywackes,
slates, conglomerates, and
andesitic lavas and tuffs


Paleozoic
including limestones, schists,
phyllites, and greenstone
lavas and tuffs

INTRUSIVE ROCKS


Granite, granodiorite,
and diorite


Marble quarry
or prospect

MARBLE QUARRIES AND PROSPECTS

1. Woodbridge and Lowery claims on Red Bay
2. Vermont Marble Co. claims south of Red Bay
3. Alaska Marble Co. quarry at Calder
4. Marble bluff north of Dry Pass
5. El Capitan Marble Co. quarry, north of Dry Pass
6. Claims south of Dry Pass
7. Vermont Marble Co. claims near Pyramid Peak
8. Vermont Marble Co. quarries, Marble Island
9. Mission Marble Works quarries, Orr and Marble islands
10. Waters claims, Hecata Island
11. St. Augustine, Euris, and Marble Heart claims, Dall Island
12. Claims near Dolomi
13. Alaska-Shamrock Marble Co. claims, Dickman Bay
14. Claims at Head of George Inlet
15. Claims on east side George Inlet
16. Spaulding claims, on Blake Channel
17. Vermont Marble Co. claims, Ham Island
18. Vermont Marble Co. claims, mainland east of Ham Island
19. Vermont Marble Co. claims, mainland southeast of Ham Island

GEOLOGIC RECONNAISSANCE MAP OF A PORTION OF SOUTHEASTERN ALASKA.

NORTHERN PRINCE OF WALES AND ADJOINING ISLANDS.

RED BAY.

The calcareous rocks exposed along the shore of Sumner Strait at the north end of Prince of Wales Island are mainly fine-grained to dense bluish-gray limestone. Marble appears on the west shore of Red Bay about $2\frac{1}{2}$ miles from the mouth, near the head of the bay, and beyond in the vicinity of Red Bay Mountain.

The marble on the west shore of Red Bay (No. 1, Pl. II) is fine grained and is mostly light colored, showing white, faintly to strongly clouded gray, and grayish-blue shades. The part exposed at the surface is rather soft. The beds are cut by several dikes of meta-dabase, most of which are only a few inches thick, though one measuring 4 to 6 feet was noted. Thin irregular stringers from some of these dikes penetrate the marble in all directions. The marble exposed on the beach is jointed and, where weathered, shows slightly schistose planes that strike north-northeast. One bed of partly metamorphosed dark-bluish limestone, much fractured and having the seams filled with calcite, was noted interbedded with the marble.

Claims aggregating 80 acres extending about half a mile parallel to the beach and one-fourth mile inland, have been located on this deposit by Woodbridge & Lowery, who formerly located marble claims on Ham Island. Some prospecting has been done on the beach by hand and by blasting with black powder, and back of the beach, within the woods, the soil has been stripped and the surface of the marble bared in several pits and trenches, some of which are 140 feet long. The cover is 2 to 4 feet or more thick.

On the west shore of Red Bay, about three-fourths of a mile south of the Woodbridge & Lowery claims and separated from them by a body of dark intrusive rock, is an exposure of fine-grained light-gray to dark-gray marble. Samples from an exposure in the woods about 500 feet back from the beach and 60 to 80 feet above high-tide level are mottled. The weathered marble on the beach is very soft and appears slightly schistose, with the gray veins parallel to the schistosity.

Near the head of Red Bay, and between Red Bay Mountain and the head of a small lake about $1\frac{1}{2}$ miles long which lies south of the bay, there are deposits of marble (No. 2) on which the Vermont Marble Co. has located claims. It is probable that this belt of marble extends southwestward nearly if not quite all the way to Dry Pass. The mass of marble opened at Calder has been traced a mile or more northeast from Dry Pass.

MINERAL RESOURCES OF ALASKA, 1912.

SHAKAN BAY.

stone beds border the northeast shore of Shakan Bay. This is well exposed in the entrance to Dry Pass which are Indian graveyards. This marble is of Tertiary age¹ and to have been altered by the contact of the granite which lies adjacent to it on the southeast. The beds are from 50 to 100 feet or more wide were located along the shore by the Alaska Marble Co., after some prospecting and drilling to ascertain the extent of the deposit. A quarry (No. 3) has been opened about 100 feet on the hillside above its mouth, and an adit has been quarried to a depth of 20 feet below the surface.

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Three distinct varieties of marble are found—pure white, blue-veined with white background, and light blue, often having a mottled appearance. The pure white, which has a finely crystalline texture, is the most valuable. All of the marble is free from silica and flint beds common in most quarries, and though thin seams of pyrite were observed they do not occur in a quantity detrimental to the stone. The following chemical analysis of the white marble was made by E. F. Lass for the Alaska Marble Co.:

Chemical analysis of white marble from Marble Creek, Prince of Wales Island, Alaska.

Insoluble matter.....	0
Oxide of iron (Fe_2O_3).....	Slight trace.
Sulphuric anhydride (SO_3).....	Trace.
Lime (CaO).....	55.59
Magnesia (MgO).....	.30
Carbon dioxide (CO_2).....	43.67
Undetermined.....	.44
Total.....	100.00
Calcium carbonate (CaCO_3).....	99.26

A qualitative test for magnesia in a sample collected by the writers was made by Dr. George Steiger, of the United States Geological Survey, who reports a content of less than 1 per cent.

To determine the crushing strength of the stone the Alaska Marble Co. submitted samples to N. H. Winchell, State geologist of Minnesota, who reports an average strength of 10,521 pounds per square inch, a strength ample for all building purposes. Though not equal to the best Italian grades, this marble is better than most American marbles and in the market will compete on at least equal terms with the product of Vermont, Georgia, and Tennessee.

A thin dike of metabasalt at this quarry was noted to contain much pyrite and a streak of pyrrhotite.

Experience in quarrying this marble seems to have shown that the whiter varieties are softer than the veined or clouded varieties.

Those in which the rock is too soft for commercial purposes are not quarried, even in the depths of the quarry. The marble beds are fractured and as yet the fractures have not been found to enlarge with depth. A vertical hole is reported to have been drilled 175 feet below the present bottom of the quarry. More holes were drilled in the southeast and southwest for distances of about 200 feet at an angle of 45° to the horizontal. All these cores are reported to have shown no pyrite.

Marble is made from this quarry each year from December 1st to March 1st, as has been done since December, 1909.

The work is done mostly to a sawing and polishing.

When it was prepared for interior use.

It is also made to Spokane and other points.

The passing into other hands.

The output of this quarry is

said to have been one cause for the closing of the quarry, but it is probable that another was the failure to find sufficiently hard stone within the depths quarried. According to recent reports it is planned to reopen this quarry in the spring of 1913. All the equipment has been kept in good condition.

DRY PASS.

The marble area extends eastward from Calder about 2 miles along the north side of Dry Pass to a small shallow cove known as Winter Harbor, just east of the shallowest part of Dry Pass, where it terminates against a mass of gray granite. The marble in this vicinity is white to light grayish blue in color and is very coarsely crystalline near the contact with the granite. On the surface it is not very hard and is easily disintegrated to sand by water running down the slopes. On the northeast shore of the small cove the marble forms low cliffs, over one of which, at the north end of the cove, falls a small mountain stream. One-half mile above the mouth of this creek a cliff of gray, coarsely crystalline marble (No. 4) 100 feet high surmounts a talus slope about 200 feet high, which extends from the creek to the cliff. The top of the marble cliff is probably 500 feet above sea level. The general trend of the ridge is N. 60° E., and the marble mass may be continuous with the deposits located by the Vermont Marble Co. south of Red Bay. Between Winter Harbor and Shakan Bay the marble beds are cut by several dikes and are intruded by small areas of basaltic rock.

On the north side of Dry Pass, about 2½ miles east of Winter Harbor, on the east side of the granite mass just mentioned, marble beds (No. 5) form the surface rocks for a mile or more. Ten marble claims located here were sold to the El Capitan Marble Co. in 1903. In 1904 a small quarry pit 12 feet deep was opened near tidewater by channeling and gadding machines, and three gangsaws operated by steam power were installed. A small quantity of marble was shipped to Seattle. Operations were suspended at the close of 1904 and have not been resumed, although the property has been cared for and it is rumored that the quarry will be reopened in 1913.

The marble exposed in the El Capitan quarry, though not very firm, is of slightly coarser texture and shows more contrast than the marble at Calder. It is white with faint gray veins and cloudy areas. The exposures near the beach are badly fractured. In one set of fractures, which strikes N. 60° E., nearly all the openings are filled with quartz, which stands out in relief on the weathered surfaces. These quartz seams are nearly vertical and are spaced from 3 or 4 inches up to many feet apart. A small geode of quartz crystals was noted in the marble exposed in the wall of the quarry pit. The

presence of siliceous material in the marble may render the stone slightly difficult to saw uniformly. Several metadiabase dikes cut the marble beds. Near the quarry one which is much jointed and has been faulted and deformed ranges from 12 to 18 inches in thickness, strikes N. 40° E., and dips steeply southeast. Wright considers that the dikes were intruded and later disturbed, all, however, prior to the metamorphism of the limestone beds.

In the bluffs northeast of the El Capitan quarry at 200 to 400 feet above sea level are exposures of medium-grained bluish-gray marble which has been prospected by pits and trenches, and about one-half mile above the mouth of a small creek that empties near the sawing plant are exposures of very fine grained white marble, all of which are included within the El Capitan group of claims.

KOSCIUSKO ISLAND.

On Kosciusko Island, on the opposite side of the channel from the El Capitan marble claims, are exposures of marble (No. 6), most of which is grayish although some is nearly white. This marble is rather fine grained and is cut by fractures filled by siliceous seams like those on the El Capitan property. These seams are one-sixteenth to one-fourth inch thick, are spaced from 4 inches up to 4 feet apart, strike N. 50° E., and are nearly vertical. Toward the east and south along this shore of Kosciusko Island the marble gradually changes into less metamorphosed limestone. At Aneskett Point the rock is a dense fine-grained limestone, much fractured and seamed with calcite.

In the western part of Kosciusko Island, between the southwest base of Pyramid Peak and the head of Token Bay, three claims of 160 acres each (No. 7) have been located by the Vermont Marble Co. This marble lies just south of the granitic mass that has produced the metamorphism of the marble deposits of Calder and the El Capitan claim farther north. The deposit is exposed for about 200 feet in a steeply sloping bluff 20 to 30 feet high on the left bank of a small mountain creek that flows southwest into Token Bay about one-half mile distant. At the lower end of the exposure the marble is dark bluish gray and fine grained, but the greater part of the deposit is medium grained and white and is thinly veined with dark-gray or yellowish seams. On the exposed face the marble is very soft, almost saccharoidal, and it was difficult to obtain a sample firm enough to be carried away. The beds are cut by numerous joint planes. Prospecting has been done by blasting and by core drilling nearly at right angles to the face, which seems to represent a steep dip slope. The prospects are located about 200 feet above sea level. To transport the marble to tidewater it would be necessary to build one-half to three-fourths of a mile of tramway through some rather rough country.

On the southwest shore of Kosciusko Island northeast of Edna Bay outcrops of dull to dark gray limestone alternate with narrow areas of graywacke for 2 miles or more. The limestone is cut by basaltic dikes and is everywhere badly cracked and at the contact with some dikes is locally metamorphosed to marble. The marble thus produced is probably not of uniform quality nor of sufficient extent to be of commercial value. About 2 miles northeast of Edna Bay a small area of red and white mottled limestone was noted.

MARBLE AND ORR ISLANDS.

GENERAL FEATURES.

The most extensive developments of marble in southeastern Alaska are in the northwestern part of Marble Island, one of the larger islands in Davidson Inlet, on which marble was first discovered in 1899. Quarrying has also been begun on Orr Island, just across the narrow inlet from Marble Island.

Marble Island extends about 3 miles from east to west and about 4 miles from north to south. Its surface is densely wooded and is generally of moderate relief, the highest point noted by the Coast and Geodetic Survey being 1,528 feet above sea level. According to the mapping of the Wrights¹ the rocks of both Marble and Orr islands are classified as limestone and other sedimentary rocks, together with schists and volcanic tuffs, all of Paleozoic age. Much of the limestone in this area has been metamorphosed to a high-grade marble.

VERMONT MARBLE CO.'S CLAIMS.

Certain marble claims that were located in the northwestern part of Marble Island in 1903 have been purchased by the Vermont Marble Co., which has opened a large quarry (No. 8) and built a small village named Token. The total area held by the company aggregates 703,246 acres, according to the plat of mineral survey No. 927, made by L. D. Ryus, deputy mineral surveyor, of Ketchikan.

Blue limestone.—The marble in the quarry is massive and has yielded no fossils except crinoid buttons, but it overlies thin-bedded dark-blue limestone which has yielded fossils of probable Middle Devonian age, consisting of *Favosites* and *Spirifer* (?), as determined by Edwin Kirk, of the United States Geological Survey.

Southwest from the Token wharf, along the shore of the island, an alternation of limestone beds, intrusive rocks, and marbles occurs, but around the cove in which the wharf is situated the dark-blue limestone outcrops and has been stripped over an area about 50 feet square preparatory to quarrying sample blocks. The rock is fine grained and dense but is much fractured and jointed, the openings

¹ Wright, F. E. and C. W., op. cit., Pl. I.

having been cemented with white calcite. The beds range from 1 foot or less to 3 feet in thickness, but on weathering separate into thin layers $1\frac{1}{2}$ to 5 inches thick. The joints separate the rock in places into small blocks only 1 inch to 3 or 4 inches on an edge. The material is reported to take a fine dark polish. The rock is very brittle and breaks easily, not only along the calcite-filled joint cracks but also along the laminations parallel to the bedding planes. Probably most of the surface material will have to be rejected, but with depth the joint cracks may become fewer and the rock stronger. The white calcite streaks that intersect the dark surface produce very attractive effects in the polished stone.

The overburden consists of forest growth and decayed wood and mold $1\frac{1}{2}$ to 3 feet thick. The rocks dip 38° – 40° NE., and the edges of their tilted beds have been cut by solution into a very irregular surface. The tramway from the wharf to the marble quarry passes the opening on the blue limestone, so that the material can be handled with a minimum of expense.

White and veined marble.—Eastward from Tokeen the blue limestone passes beneath the deposit of marble, which extends to and probably far beyond a small bight on the north side of Marble Island, 400 feet from the quarry. The belt of marble and blue limestone is probably 2,500 feet or more in width, and it extends southeastward into the interior of the island for a much greater distance—possibly entirely across to Orr Inlet. The color of the marble ranges from nearly white with dark-gray and black veins to light-gray to grayish-blue shades. The grain is medium fine and fairly uniform. The marble takes a good polish and is said to resemble certain grades of Italian marble. Iron pyrites grains are exceptionally present. The marble having dark veins on white background is very much in demand at present for interior decoration. Blocks are sawed into slabs, which may be matched so as to form certain nearly symmetrical patterns. They have been used in a number of buildings. (See pp. 76–77.)

The marble appears to be wholly metamorphosed. The material is massive and shows no indication of its original bedding, but it is much jointed and fractured and within 10 to 20 feet of the surface is rather soft. The joint planes cut the deposit at many angles but may perhaps be referred to several systems, the two principal ones striking about N. 50° E. and N. 40° W. The dips of the joint planes are likewise at many angles, and the spacing of the joints is variable, ranging from a few inches to 10 feet or more. In places parallel joints, or "headings," are rather close together, rendering it impossible to obtain blocks large enough for shipment, but in other places blocks 4 by 4 by 10 feet free from cracks may easily be obtained. Wedge-shaped blocks that are completely separated from the sur-

rounding mass by smooth joint planes are occasionally encountered in quarrying. Near the northeast side of the main quarry the marble is cut by a dike of altered andesite porphyry, 8 to 16 inches thick, containing much pyrite and dipping 17°-25° NE.

The jointed structure of the marble is the most serious hindrance to its profitable exploitation. It is to be expected that joint cracks should be present at the surface and that surface water should descend along these cracks, enlarging them, softening the marble, and oxidizing it to a faint yellowish hue, but, according to experience in many other regions, it might be expected that at depths of 40 to 60 feet the joint cracks would disappear and the marble become solid. So far as quarried (60 feet), however, it still shows joint cracks in places.

Quarries.—The main quarry operated by the Vermont Marble Co. on Marble Island in 1912 is situated about 900 feet northeast of the shore of the small cove at the northwest corner of the island, at an altitude of about 15 feet above the wharf. In places bare knobs of marble are exposed in the vicinity of the quarry, but the surface of the marble, which is very irregular as a result of solution and running water, is generally covered by 1½ to 3 feet of decayed wood and mold. In places the roots of trees have followed the crevices in the rock to depths of 5 or 6 feet. Trees and stumps are removed by derricks and the soft mold by hand. The first small opening was abandoned at a depth of about 20 feet on account of several joint cracks 1 to 6 inches or more apart in the northwest end of the cut. These joints dip steeply toward the north, and the quarrying was shifted far enough northwest to avoid them for a time. This dip, however, brings them back into the quarried area at a depth of about 50 feet, and at 60 feet they are apparently about as numerous as at the surface.

In September, 1912, the top of the opening of the quarry measured roughly 90 by 100 feet, and the depth ranged from 10 to 60 feet. About one-half of the area had been quarried to the maximum depth. Methods of quarrying commonly in use at well-known marble quarries in the Eastern States are employed. The equipment in the main quarry consists of the necessary drills, seven Sullivan single channeling machines, four gadders, and pumps, all operated by steam power generated by a 125-horsepower boiler near the quarry, and a complete machine shop.

The blocks of marble are lifted from the quarry by a 25-ton derrick and are carried to the wharf on flat cars running on a standard-gage track. The loaded cars move by gravity and are drawn back to the quarry by a 7⁄8-inch steel cable. Waste rock is also trammed down to the wharf and dumped into the water alongside the pier. Deep water is reached by a pier about 150 feet long. A 25-ton stiff-leg derrick for unloading cars and loading marble on boats is operated by a small steam boiler on the shore near the wharf.

In September, 1912, a space of $1\frac{1}{2}$ acres about 375 feet southeast of the main quarry was being cleared for a new quarry. The highest knobs of marble rise here to about 35 feet above the level of the wharf. The marble at this new opening is chiefly white with bluish-gray veins and clouds similar to that already being quarried but apparently contains areas of more handsomely veined stone. One dike of meta-andesite $1\frac{1}{2}$ to 2 feet thick, striking N. 35° W. and dipping 78° SW., was noted. A large derrick is used for stripping.

About 60 men were employed in connection with this plant in 1912. The men live in sanitary and comfortable dormitories, eat excellent fare at a commodious mess hall, and enjoy such generally favorable conditions under which to work that they show a high degree of efficiency. Quarrying is carried on for eight or more months during the year. The winters are not severe, and operations may be carried on throughout most of the year as soon as pipes from a reservoir are laid underground so that there shall be no danger of interruptions by freezing of the water supply.

Products.—Rough blocks 4 by 4 by 6 feet to 4 by 4 by 10 feet are shipped by freight steamers to the mill of the Vermont Marble Co. at Tacoma, Wash., where they are sawed, polished, turned, or planed, for interior decorative purposes. To save freight only perfect blocks are shipped, necessitating the wasting of considerable material. According to the absence or presence of joints the proportion of waste marble quarried may vary between 10 and 75 per cent. The marble for a foot or more on each side of most fractures is discolored and must be cut away. If a fracture crosses the block diagonally or near the middle, it may render the whole block worthless. If cheap power were available it might prove an economy to operate a small sawing plant at Tokeen in order to work the waste marble into slabs.

Other prospects.—The Vermont Marble Co. has prospected claims about 1 mile and $1\frac{1}{2}$ miles southwest of Tokeen. At one point a white marble is exposed in a small hillside quarry from which, it is reported, marble was obtained many years ago for making tombstones. The surface marble here has been softened by long exposure to atmospheric agencies, and none from any considerable depth was available.

At a second place several variegated marbles have been exposed by prospect pits. The most characteristic varieties are colored light to dark green, bluish, mottled light pink, and brownish gray. The mottled character is due to the presence of chert veins and nodules. The green varieties are veined with grayish green, darker than the body of the rock. The rock is massive and jointed and is cut by a thin dike of meta-andesite striking N. 40° W. The deposit was prospected by three or four drill holes, 60 to 94 feet deep, which showed that the green stone changed to gray or bluish within 15 to

25 feet from the surface. A small area was next stripped by hand and two or three shallow pits were opened by a channeling machine in the hope of developing a supply of desirable green marble. A wooden track on an incline was built from the test pits a short distance down to the water in order to get out a few sample blocks of stone, but the operations have been discontinued on account of the scarcity of stone of uniformly strong green color.

Between these two prospects there is a beach about 1,600 feet in length, along the greater part of which marble beds are exposed. The marble is veined and is white to grayish in color. It is cut by several meta-diorite dikes 8 inches to 2½ feet thick, some of which are broken and distorted. One dike noted had been faulted and offset horizontally a few feet, but the marble which filled the space between the broken ends of the dike showed only a flowage structure without a definite fault plane. The intrusion of the dike and the deformation of the beds through which it passes probably preceded the metamorphism that produced the marble.

Limestone, alternating with graywacke, the former slightly metamorphosed in places but generally a fine-grained bluish rock much fractured and seamed with calcite, forms the coast line around most of the west and south sides of Marble Island. A considerable area of true marble, however, occurs along the middle of the east side of the island and on the west side of Orr Island, which is separated by a narrow channel from Marble Island.

MISSION MARBLE WORKS.

A group of claims lying on both Marble and Orr islands and crossing the channel between them is under development by the Mission Marble Works, of San Francisco, Cal. On Marble Island the rock is nearly white and grayish blue. The light-colored marble lies south of the blue marble and apparently overlies it, although the stratigraphic relations of the two varieties are not wholly clear. A small bluff of white marble is exposed at the water's edge almost directly opposite the quarry on Orr Island. This marble is massive and of medium grain for 15 to 20 feet above the water. Higher up the slope the weathered surface shows thick layers, and the grain is somewhat finer. Only a small amount of prospecting has been done here.

The blue marble outcrops in a low swampy tract along the shore about one-half mile northeast of the bluff of white marble. It is dense, hard, and fine grained and shows white calcite streaks along bedding and joint planes. It appears to be more nearly a true marble than the thin-bedded blue limestone at Token, which it nevertheless resembles somewhat in character. Weathering has accentuated the bedded character of the rock along exposed edges.

The dip of these beds is steep toward the northwest. A little prospecting and sampling have been done on this deposit in the way of assessment work.

On the Orr Island portion of the property (No. 9) considerable prospecting and development have been done, affording better opportunity for inspection than on Marble Island. The timber has been cleared along the water front and a space about 50 feet square has been stripped and opened for quarrying about 25 feet above high tide. The overburden is similar to that at the quarries of the Vermont Marble Co. (p. 62). The surface of the marble is much furrowed and pitted by solution, and joints and fractures are numerous, being spaced from a few inches to several feet apart, but they seem to close up and to become fewer even in the little depth penetrated by the quarry. The marble exposed is of medium grain, cream-colored to bluish white, veined with dark gray, and in places shows mottled effects. Near the surface the veins producing the mottling are oxidized to a brownish color. The appearance of the mottled stone suggests that it may have been derived from a conglomerate. Both the veined and the mottled types of stone are handsome in the rough and give promise of showing up finely when polished. The marble in the north side of the quarry is cut by a dike of andesite, somewhat altered and containing considerable pyrite. For most of its length the thickness of this dike ranges from 2 to 6 feet, but it thins abruptly and terminates in a few irregular branching veins only a fraction of an inch in thickness. This dike strikes about S. 30° E. and dips steeply northeast. A similar and approximately parallel dike was recognized at a prospect about 100 feet northeast of the quarry.

When visited in September, 1912, the quarry had been opened to a depth of about 11 feet only, and for the most part the surface rock had not yet been removed. Two drills and two channelers, both of the Ingersoll type, were in operation and six or seven 10-ton blocks of marble from the second bench of the quarry were ready for shipment. The first consignment of blocks from this quarry reached San Francisco in February, 1913. The quarry is equipped with hand-power derricks capable of lifting blocks weighing 10 to 15 tons. The marble will have to be carried by scows from the quarry southward about 1 mile and transferred to freighters in deep water. Marble outcrops at intervals for several hundred feet along a low bluff parallel to the beach and has been shown to underlie the whole group of claims, but its depth and soundness have not been demonstrated by the drill.

SEA OTTER SOUND AND DAVIDSON INLET.

In order to verify several reported occurrences of marble on Tuxekan, Heceta, and smaller neighboring islands a trip was made around practically all the remaining shores of Sea Otter Sound and Davidson Inlet, as well as into Tuxekan Passage and Tonowek Bay. The calcareous rocks bordering these shores proved to be for the most part nonmetamorphosed limestone, principally of the gray or blue fine-grained brittle type, with fractures filled with calcite. Near the middle of the north side of Heceta Island (No. 10) an exception to this type of limestone was noted in the occurrence of a limestone colored pink, chocolate, green, and white, with mottled effects. The stone is fine grained, hard, and dense and should take an excellent polish. It has been somewhat fractured and recemented with calcite, but it is not metamorphosed, and it yielded a few fossils, among which were recognized *Conchidium* and a pentameroid(?). These forms, according to Edwin Kirk, are not much younger nor a great deal older than Lower to Middle Devonian. This limestone outcrops at the head of a small bay and was traced inland for about 300 yards and to an altitude of 50 feet or more above high tide. In places the colors are much paler, but the mottled character persists and much stone is attractively colored. An area of graywacke borders this limestone on the west and north. Claims have been located on this mottled limestone by W. C. Waters. No marble was found on any of the smaller islands within this area, although trips were made to Cap, Hoot, Owl, Eagle, Whitecliff, and Green islands.

DALL ISLAND.

Samples of marble obtained near Waterfall Bay (No. 11), on the west coast of Dall Island, were seen by the writer at Ketchikan. He had no opportunity to visit the locality but found the samples to be of much merit. The principal colors are white, pink, gray, and blue. The white and pink varieties are very handsome, the pink occurring in various delicate shades and in areas mottled with white. Green marble is reported to occur but has not been much prospected. The white and pink varieties appear to have been wholly metamorphosed, but the gray and blue varieties appear to possess the characteristics of little-altered limestone. The grain of all the samples is fine, that of the gray and blue varieties being exceedingly fine. In the lighter-colored varieties calcite crystals larger than the average are exceptionally present, but in general the texture is uniform and thin pieces of the stone are as translucent as alabaster. This marble takes a very high polish.

The marble deposits are reported by M. D. Ickis, of Ketchikan, to lie about the head of Waterfall Bay, about the middle of the west

coast of Dall Island. Twenty claims in all, totaling 400 acres, have been located under the names Eurus, Marble Heart, St. Augustine, and Marble Bay groups. Openings have been made about 300 feet above tide level and about 1,000 feet from the beach. The geology of the western part of Dall Island has not been mapped by the Survey, but Mr. Ickis reports that the rocks in the vicinity of Waterfall Bay consist of limestone, marble, schist, and granitic rocks. On the east coast of the island, within $7\frac{1}{2}$ miles of Waterfall Bay, the country rock is shown to be greenstone lava flows interstratified with volcanic tuffs and black slate, bordered both to the north and south by Paleozoic sedimentary and eruptive rocks.¹ A few dikes of "trap" rock 1 foot to 4 feet wide are reported to cut the blue marble beds. The rock is probably much jointed, as many of the samples shown to the writer displayed one or more smooth joint faces. Blocks of the pink marble only 2 to 3 inches wide have been produced by parallel joints. It is reported that enough marble is available in these claims to warrant development and that several thousands of dollars have been expended in prospecting.

SOUTHEASTERN PRINCE OF WALES ISLAND.

DOLOMI.

Certain marble deposits (No. 12), on the east side of Prince of Wales Island in the vicinity of Dolomi were described by the Wright brothers,² and as no new work has been done on the claims they were not visited by the writer. The notes as originally published are given below:

The properties of the American Coral Marble Co. are located at two localities—(1) at the head of North Arm, where 12 claims have been located along the north shore of the inlet, and (2) at the north entrance to Johnson Inlet, where the company has several claims extending from Dolomi eastward to Clarence Strait. The principal developments have been made at the North Arm property, and at this point a post office named Baldwin has been established. Active work at this locality began in 1904, and the marble deposits were prospected during that year. In 1905 a wharf was built, machinery installed, and buildings erected preparatory to quarrying the marble. During 1906, however, practically no work was done, and all of the machinery was removed in 1907. At the Dolomi property a small quarry was started on the hillside, at a point a quarter of a mile northeast of Dolomi post office and a few hundred feet from tidewater on the Clarence Strait side, and buildings were erected. No operations were in progress at these localities during 1907 [nor in 1912—E. F. B.].

The deposits at North Arm and at Dolomi consist of marble beds interstratified with chloritic and calcareous schists, striking northwest with steep dips, usually southwest. The surrounding area is mantled by a dense growth of vegetation, and the limits of the deposits have not been definitely determined, though where the marble is exposed it is much fractured, variable in color and composition, and intersected by a few narrow dikes of diabase. The fracture planes were probably formed principally during the period of tilting and folding of the beds and existed before erosion exposed the

¹ U. S. Geol. Survey Bull. 347, Pl. I.

² Wright, F. E. and C. W., op. cit., pp. 196-197.

present surface outcrops. Since that time weathering has accentuated and to some extent increased the number of fracture planes, and it seems probable, however, that in depth these planes, although potentially present as lines of weakness, will become less numerous and will not interfere greatly in quarrying.

Although some parts of the deposits consist of pure-white fine-grained marble of excellent quality, other parts are poorly colored, coarse grained, and of little commercial value, and it will probably be difficult to obtain large quantities of uniform grade. The better grade is reported to give the following analysis: Calcium carbonate, 94 per cent; alumina, 3.9 per cent; silica, 1.4 per cent; magnesia, 0.7 per cent. Pyrite is also present in small amounts, occurring in thin seams and finely disseminated in some of the marble.

DICKMAN BAY.

Location.—An area of particular interest on account of the large variety of marble which it affords is situated in southeastern Prince of Wales Island in the peninsula between Dickman Bay (so named on Coast and Geodetic Survey chart No. 8100) and the unnamed narrow inlet to the northward, here designated Shamrock Inlet. Dickman Bay is an extension of West Arm of Moira Sound, and the area lies 11 to 12 miles southwest of Dolomi. Twelve claims of approximately 20 acres each (No. 13) have been located here by Francis Clarno, of Portland, Oreg., and others, and are being developed by them under the name Alaska-Shamrock Marble Co.

Relations and character of the marble.—The marble occurs in beds of varying thickness which strike N. 30°–40° W. and dip steeply southwest. The marbles are interstratified with graywacke and schistose beds and are intersected by dikes of diabase and basaltic rock. A small area of dark-gray granitic rock is exposed at the southeast point of the peninsula and appears to border the marble mass on the southwest. The marble is more or less schistose in places, especially near the contacts of schistose beds, and it is banded locally near the contacts of dikes by the interlamination of marble and dike rock, the laminæ ranging from less than 1 inch to several inches in thickness. Ledges of marble 50 to 75 feet wide alternate with areas of graywacke 50 to 1,000 feet across and have been traced in the direction of the strike for a mile or more. The surface exposures show more or less jointing and fracturing of the beds.

The surface of the peninsula north of Dickman Bay is rough and wooded. The banks generally rise abruptly from deep water, and the highest marble ledges reach an altitude of 350 to 500 feet above sea level at a few hundred feet from the shore.

Generally the marble on the Alaska-Shamrock claims is of fine grain, although in a few places a little coarsely crystalline material was noted. A large number of samples sent from the prospects to Portland, Oreg., have been polished and have revealed a large variety of colors in a great many combinations. As a rule the rocks take a good polish. Where the marble is strongly veined, or schistose,

the veins which produce the beautiful effects in the marble do not take so uniform a polish as the calcite portions of the stone. The differences in the polish are due to the presence in the veins of minerals, such as quartz, mica, and chloritic materials, of varying degrees of hardness, and are not noticeable unless the light falls on the surface at an angle.

Certain of the varieties of marble obtained here, according to color combinations, are white with golden-yellow veining; grays of various shades; gray, veined and mottled with white, pink, and yellow; pale green, grass-green, green with black and white, green with pink and white, black and white, plain black, and other combinations. In thin sections the green color appears to be due to chloritic material and possibly to some epidote. Among the trade names adopted by the company to designate some of the more striking varieties of the marble are "white and gold," "Confederate gray," "moss-agate green," "raven-black," and "jewel marble." The last is a veined or mottled stone generally showing strong contrasts between dark green, white, and pink and having a few pink calcite crystals either isolated or in bunches. The color of these calcite crystals, which suggests that of garnet, is due to the presence of disseminated fine grains of hematite.

Prospects.—Three or four openings have been made on marble beds that outcrop on the shore of Shamrock Inlet. At the prospect nearest the southeast point of the peninsula work was in progress in October, 1912. A small clearing had been made, several houses and a machine shop had been built, and blocks were being detached from a ledge of marble banded with dark-gray and white veins. The marble is brittle and somewhat schistose and splits readily along the laminations. On weathered surfaces the harder portions of the rock stand in relief above the more calcareous portions. A hand derrick was used here in clearing away stumps and raising blocks of marble.

Northeastward along the shore of the inlet other openings disclose alternations of light-colored and blue marble. One opening is in beds of very fine grained cream-colored marble slightly veined with yellow. At this place the beds are exposed for about 100 feet horizontally and 30 to 40 feet vertically. The strike is N. 75° W. and the beds stand nearly vertical. The surface of the beds is rough and fractured with deep crevices produced by solution, and the mass is cut by a basaltic dike which has been faulted and twisted since its intrusion into the marble. Where badly fractured the beds will have to be quarried deeply in order to ascertain the possibility of obtaining adequate-sized blocks.

Two of the most interesting prospects are on a ridge extending northwest from the settlement, in the direction of the strike of the rocks. The marble ledge that has been opened is 70 to 75 feet wide

between two dikes that have weathered more slowly than the calcareous mass and that form walls on either side of it. At the upper opening, about 800 feet from the shore and 350 to 400 feet above tidewater, the marble is principally green. The beds are exposed for about 150 feet along the strike. The green color appears to become paler toward the northwest, although small patches of stone among the paler areas are fully as deep a green as any in the deposit. The deeper shades of green seem also to occur nearest the top or surface edges of the beds. Prospecting with a core drill is recommended if more definite knowledge is desired regarding the continuation of green shades in depth. The rock here is not so badly fractured at the surface as along the shore, and it is possible to get out some very good sized blocks without quarrying deeply. A 1-ton block, which was moved on skids down the trail to the beach, has already been shipped to Portland, Oreg. Another opening on this same ledge was noted about 600 feet from the beach and about 200 feet above water. The beds here are banded with dark blue or gray and white near the southwest wall, but the blue bands change to dark green near the middle of the ledge. A small mass of garnet-colored calcite was noted in the rock at this place.

At these various prospects a vigorous growth of timber has had to be cleared away, and a cover ranging from a few inches of moss on the exposed places to soil 6 or 7 feet thick in the crevices and hollows in the rock has had to be stripped off.

Other prospects of the Alaska-Shamrock Marble Co. are situated on this peninsula on the north shore of Dickman Bay and extend up a small bight about three-fourths of a mile from the extremity of the peninsula. The dip and strike and the position of the beds exposed here indicate that they are probably continuations of the ledges exposed near Shamrock Inlet. Diabase dikes have intruded the beds in this locality, and the surface exposures of the stone show much jointing and fracturing. The marble occurs in various shades of white, bluish gray, and green. In polished samples some of the green marble compares favorably with the "verde antique" types produced in the United States. The beds are exposed in bold cliffs on both sides of the small cove and they also form its floor and extend inland beyond the head of the cove. This area was the first one to be prospected by the Alaska Shamrock Marble Co. The prospecting has been done mainly by hand drilling and loosening blocks with black powder. Considerable material has been shipped to Portland for exhibition. Another possible resource of this company is the gray granite that outcrops on the shore of Dickman Bay between the two marble localities.

Though much of the marble available here is of great beauty when finished, the structural conditions suggest the necessity of consider-

able waste in quarrying and in finishing. Much more prospecting and development work must be done in order to ascertain whether or not the properties can be exploited on a commercial basis.

All the properties are situated most favorably for shipping quarry products. Deep water extends practically to the shore line, except in the small cove, and both Dickman Bay and Shamrock Inlet afford roomy and sheltered harbors.

REVILLAGIGEDO ISLAND.

Prospecting for marble on Revillagigedo Island has been carried on at intervals for about 10 years. Little of importance has been done, however, since the survey of the Ketchikan district by F. E. and C. W. Wright, who noted the important features of the marble deposits on this island as follows:¹

A well-defined limestone belt traverses the eastern portion of Revillagigedo Island in a northwesterly direction and is exposed in Thorne Arm, Carroll Inlet, and George Inlet. * * * Its widest development is on the north side of George Inlet, near the head, where marble claims known as the Bawden group were located in 1904 (No. 14). The deposit is included in the crystalline schist near the contact with the less-altered slates to the southwest. The marble beds range from 10 to 20 feet in width and are separated by strata of calcareous schist. Their strike is northwest and their dip northeast. The marble is exposed in cliffs near tidewater and is of good quality, being relatively free from fracture and joint cracks, finely crystalline, and from white to gray in color. No large developments have been started on this property.

In Carroll Inlet to the southeast claims have also been located on the same belt, but at this locality the deposit is not so extensive as in George Inlet.

In addition to these claims two groups were noted by the writer in October, 1912, on the east side of George Inlet. One (No. 15) lies 6 to 7 miles due north of the point where George Inlet and Carroll Inlet coalesce, and the other about 2½ miles farther north. Only the shore exposures were visible at these places and no prospects could be found. The rock exposed consists of gray to whitish, medium fine grained schistose marble, interstratified with and intersected by dikes of mica dacite. Nearly as much dike rock as marble is exposed on the beach at the southern locality. All the beach exposures of marble are very soft and saccharoidal, almost too soft to yield a hand specimen. The beds dip about 30° a little north of west. So far as these exposures indicate, little if any commercially valuable marble is present at either place.

HAM ISLAND AND VICINITY.

LOCATION AND GEOLOGIC RELATIONS.

Ham Island lies in Blake Channel at its junction with Bradfield Canal about 25 miles southeast of Wrangell. It is about 1½ miles long and is composed largely of crystalline limestone interstratified

¹ Wright, F. E. and C. W., op. cit., pp. 197-198.

with beds of calcareous schist. These beds strike N. 35° W. and fall in line with a long lens or belt of crystalline limestone, which begins on the mainland 2 miles southeast of Ham Island and is continued on the mainland about 10 miles to the northwest. According to the Wrights,¹ the metamorphism of the limestone to marble has probably been caused by the intrusion of wide belts of granite both on the mainland and on Wrangell Island.

HAM ISLAND.

The marble beds have been extensively tested on Ham Island, and deposits have been prospected and claims located on the mainland north, east, and southeast of Ham Island. In the northern part of Ham Island (No. 17) the greater part of the marble available is coarse grained and varies in color from light grayish blue to dark gray, but some of it is nearly white. A little fine-grained marble, mostly white, lies in the southeast portion of the island. Two groups of claims on Ham Island, owned originally by Woodbridge & Lowery and by Mr. Miller, have recently been purchased by the Vermont Marble Co. but are not under development by that company. Although the strata have been crumpled and folded and are slightly schistose in places, the stone generally seems sound and the rock is not so badly checked and fractured as in certain other marble areas in southeastern Alaska. Several systems of joint planes intersect the beds, but the joints are spaced widely enough not to interfere greatly with quarrying. The marble occurs in beds of varying thickness, generally 2 to 4 feet or more, that strike northward and dip at an angle of 50° or more toward the east. In the eastern part of the island, south of the middle, the presence of some beds of fine-grained white marble, 20 feet thick, alternating with coarser crystalline marble, has been shown by the core drill. In some places the presence of many veins and nodules of quartz and chert in the white marble has been shown by drilling perpendicular to the bedding, and it is feared that these may present a serious obstacle to the utilization of these beds. The quartz veins are generally from a fraction of an inch to a few inches in thickness, though at least one vein a foot thick has been noted.

MAINLAND NEAR HAM ISLAND.

On the mainland in the vicinity of Ham Island the Vermont Marble Co. holds two claims of 160 acres each about 1 mile east of Ham Island on the north side of Bradfield Canal (No. 18), and two claims 1½ miles southeast of Ham Island on the south side of Bradfield Canal (No. 19). Neither of these properties has been developed.

¹Wright, F. E. and C. W., op. cit., p. 198.

The occurrence of marble on the mainland northeast of Blake Channel is reported by Frank Spaulding, of Wrangell, who holds five claims of 20 acres each. The deposit is reported to lie southeast of Ahrens Creek (No. 16) and to extend back 2,000 feet from the beach and 300 feet above water level. The marble is reported to be coarsely crystalline, a trifle less coarse than the average of the Ham Island stone, and to comprise both gray and white varieties.

COMMERCIAL CONSIDERATIONS.

DEFINITION OF MARBLE.

Technically, marble is a rock consisting chiefly of crystalline particles of calcite or of dolomite or of both. Commercially, marble includes a wide variety of other rocks that are susceptible of receiving a good polish and are suitable for ornamental work. Dale¹ describes among the commercial marbles of Vermont a serpentine and a chrome-mica schist, and it is interesting to note that some of the most handsome polished samples of marble produced recently in Alaska owe their distinctive banding and coloring to their schistose character.

FACTORS CONTROLLING VALUE.

The value of a marble deposit in southeastern Alaska can not be judged by small surface samples alone, although tests of such samples may be of considerable importance. The character of the deposit as a whole must be considered, or at least so much of it as will be required for a quarry, as well as extent, color, lack of objectionable impurities such as silica, pyrite, argillaceous and organic matter, soundness, absence of fractures or joint planes and of intersecting dikes, facility of quarrying and loading on vessels, distance and freight rates to markets, and competition.

The features that probably will cause the most serious hindrance to profitable quarrying in southeastern Alaska are the fracturing and jointing of the beds. Observations have shown that this is very prevalent at the surface in this region, and such experience in quarrying as has been had has shown that the cracks extend 60 feet or more below the surface. It is, of course, possible that at greater depths sounder stone will be found, but it is not profitable to be obliged to reject a large percentage of waste simply because the percentage of available blocks of the requisite size is limited by the structure of the deposit. The excessive moisture and the influence of the dense vegetation in this region has softened the surface marble, in places to surprising depths as compared with other well-known regions.

The practical judgment of a competent marble quarryman is necessary to decide many of the questions relating to the availability

¹ Dale, T. N., The commercial marbles of western Vermont: U. S. Geol. Survey Bull. 521, pp. 49-50, 1912.

of the stone. Cross trenching, a common form of prospecting to determine the surface extent of a marble deposit, must be supplemented in southeastern Alaska by the core drill. A careful study should be made at the surface of the directions or strikes of the various systems of joints, their minimum, maximum, and average spacing, the direction and angle of their dip, and the nature of the fracturing that is not related to the systematic jointing. A sufficient number of holes should then be drilled to such depth and in such directions that a definite idea may be obtained as to the character of the beds below the surface, especially in relation to fracturing and jointing and the hardness of the marble.

Tests of the cores, including chemical analyses, measurement of size of grain, absorption, porosity, compressive strength, and polish are all of great value, but satisfactory tests for strength and polish may not be practicable unless the core is of a diameter of 2 inches or more.

LOCAL SAWING PLANTS.

Thus far the products of Alaska marble quarries have been confined practically to marble for interior finishing (see p. 76), and, as already mentioned, the percentage of waste in quarrying is necessarily great because it does not pay to ship blocks that can not be almost entirely sawed into large and perfect slabs for polishing. If the marble is of suitable character for exterior construction (and much of it appears to be suitable for such purposes), local sawing plants might produce much dimension marble from blocks that would otherwise be rejected. Small polishing plants might also utilize much of the waste marble by working it up into the smaller slabs required for base boards, tiles, plumbing fixtures, moldings, and the like. A small sawing plant was installed at one quarry, but operations were soon discontinued and no figures are available as to the relative costs of operation in southeastern Alaska and on Puget Sound; it is understood, however, that the high cost of coal in this part of Alaska makes manufacturing generally rather expensive. Moreover, the Puget Sound cities are supplied with relatively cheap electric power.

WATER POWER AND ELECTRICITY.

In southeastern Alaska electricity is generated by water power at seven or more places.¹ It is reported that abundant water power is available on Kosciusko Island near Holbrook, less than 4 miles from the marble quarries on Marble Island. To deliver electric power to Marble and Orr islands a cable would have to be laid across a channel measuring, according to the Coast and Geodetic Survey charts, about

¹ Hoyt, J. C., A water-power reconnaissance in southeastern Alaska: U. S. Geol. Survey Bull. 442, pp. 147-157, 1910. See also Engineering News, pp. 551-553, 1910.

3,400 feet in width and 120 feet in depth; or else a line several miles longer would have to be built around the head of Tokeen Bay. In southeast Prince of Wales Island and on Revillagigedo Island the appearance of certain mountain streams and waterfalls suggests the possibility of power not yet utilized. It should be stated, however, that none of these streams were studied with reference to their source of supply, and that unless fed from natural reservoirs such streams can not always be relied on to furnish power throughout the year.

TRANSPORTATION.

As already mentioned all the properties thus far developed and a great many undeveloped deposits are situated either close to or directly on deep water. At present marble in rough blocks is carried by freight steamers to Tacoma, Portland, and San Francisco. Freight rates have been much reduced in the last few years through competition and are reported to be moderate at present.

COMPETITION.

Considerable marble is still shipped to the Pacific coast from quarries in the eastern United States, mainly Vermont and Tennessee, and some is imported from Italy. The Alaska product is, however, increasing, and it is reported that there is a market for all of it that can be produced. In the western half of the United States marble quarries and prospects have been opened in Stevens County, Wash., Josephine County, Oreg., Inyo and Tuolumne counties, Cal., Cochise County, Ariz., Otero County, N. Mex., White Pine County, Nev., Beaver County, Utah, and Gunnison County, Colo. Only the product of the California and Colorado quarries has been of commercial importance thus far.

In British Columbia large deposits of marble are known along the sounds, on the coast, and in the interior. Among those on Vancouver Island are deposits on Nootka Sound and at Beaver Cove. The deposit on Nootka Sound was once quarried but is reported not to have been operated since 1909. On Malaspina Inlet two small deposits have been noted, one of which is of white marble and the other of gray and white marble, mixed with serpentine.

The principal marble quarry in the province is that of the Canadian Marble & Granite Co., on the Canadian Pacific Railway between Lardo and Trout Lake. This quarry is equipped with finishing works and supplies the greater part of the marble used in British Columbia. White marble is reported near the town of Wycliffe, on the Kimberly branch of the Canadian Pacific Railway, and dolomitic marble of various colors in the Rocky Mountain region on the slopes of Mount Ogden 2 miles from the mouth of Yoho River.

It is not likely that during the maintenance of the present tariff on marble much of the Canadian product can be sold profitably within the United States, nor can the Alaskan product be delivered in Canada, although it must pass through Canadian waters en route to the United States.

PRODUCTION.

The first production of marble recorded by the Survey was made in 1901 by the Alaska Marble Co. from the quarry at Calder, the first shipment to the United States having been made in 1902. For the years 1902 and 1903 no production was reported, but beginning with 1904 the production has steadily increased year by year. It is not possible to give the statistics of production by years, for in only one year were there more than two reporting producers, and it is the Survey's custom to conceal all production not reported by three or more producers. In all, however, from 1901 to 1912 five producers have reported total shipments of unfinished marble to the United States of an approximate value of \$400,000. Not included in this total is a small output of marble used locally for tombstones and monuments.

USES.

Small quantities of marble have been shipped to the United States from the quarries of the Alaska, El Capitan, Mission, and Alaska-Shamrock companies, but by far the greater part of the output has come thus far from the quarry of the Vermont Marble Co. on Marble Island. The product of this quarry is shipped to the electrically driven mill owned by the company at Tacoma, Wash., where the rough blocks are sawed into smaller blocks for turning and planing and into slabs three-quarters of an inch to 1 inch thick for polishing. The slabs and sawed blocks are worked up into wainscotings, ceilings, floor tiles, moldings, fixtures, rails, balustrades, and a variety of forms for interior finish and decoration. The market for these products comprises the cities of the Pacific coast States and extends as far eastward as Salt Lake City.

In the following important buildings marble from Tokeen, Alaska, is reported to have been used in interior work:

Buildings having interior decorations of Alaska marble.

SEATTLE, WASH.

Hoge Building.
Lyons Building.
Haight Building.
L. C. Smith Building.
Bank of California Building.
McCormick Hotel.

TACOMA, WASH.

National Realty Building.
Perkins Building.
Tacoma Building.

BELLINGHAM, WASH.

United States Post Office.

NORTH YAKIMA, WASH.

United States Post Office.

VANCOUVER, B. C.

Pacific Building.

Rogers Building.

PORTLAND, OREG.

Spaulding Building.

Wilcox Building.

Yeon Building.

Selling Building.

Littman-Wolfe Building.

Oregon Journal Building.

Multnomah Hotel.

SAN FRANCISCO, CAL.

Odd Fellows Building.

Sharon Estate Building.

OAKLAND, CAL.

Bankers Investment Building.

Realty Syndicate Building.

SACRAMENTO, CAL.

Forum Building.

LOS ANGELES, CAL.

Los Angeles Investment Building.

Title Insurance and Trust Building.

Van Nuys Building.

SAN DIEGO, CAL.

Spreckels Theater.

United States Post Office.

PRESIDIO, CAL.

United States General Hospital.

BOISE, IDAHO.

State Capitol.

Gem Building.

MOSCOW, IDAHO.

United States Post Office.

LEWISTON, IDAHO.

United States Post Office.

SALT LAKE CITY, UTAH.

Walker Building.

National City Bank Building.

Empress Theater.

It is also reported that this marble was used in the exterior trim in the front of the Merrill Apartments at Seattle, Wash., but that no effort has been made as yet to push the use of the stone for such purposes.

A small quantity of Alaska marble is used locally for monuments, for which it is said to be entirely suitable. A handsome altar in St. Philip's Episcopal Church in Wrangell was fashioned (except the cross) from white marble obtained from Ham Island, Calder, and Tokeen, Alaska. The body of the altar has received a hone finish; the cross, which is of polished Italian marble, is mounted on a base of polished marble from Tokeen. There is apparently no essential difference between these pieces of Italian and Alaskan marble.