Garnet deposits near Wrangell Southeastern Alaska

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GARNET DEPOSITS NEAR WRANGELL SOUTHEASTERN ALASKA

By C. T. Bressler

ABSTRACT

Almandite garnet crystals occur disseminated in schist 7½ miles north of Wrangell on the east side of the Stikine River, in a region of high relief and rugged mountains covered with rain forest.

The schists are part of the Wrangell-Revillagigedo belt of regionally metamorphosed rocks that flank the west margin of the Coast Range batholith. Intrusion of an outlying stock of quartz diorite has induced the formation of sizable garnet deposits adjacent to the contact.

Five claims, several prospects, and one adit are in the area. Production of abrasive garnet has been small and intermittent; there has been no production for the past 25 years.

Laboratory examination of Wrangell garnets indicates that they are excellent for use as an abrasive.

INTRODUCTION

The deposits of almandite garnet, occurring in schists near the east side of the mouth of the Stikine River, southeastern Alaska, have supplied for more than five decades the renowned "Fort Wrangell" garnet crystals displayed in many musuems and mineral collections. The deposits are less well known as a source of abrasive garnet, yet they have been mined intermittently for that purpose since before 1910. Prior to 1946 no detailed study of the garnet deposits had been made. In the summer of 1946, the United States Geological Survey made investigations of the deposits, which are described in this report. A generalized geologic map of Wrangell and vicinity was prepared, modified after the maps of the Wrights [1] and Buddington and Chapin.[2] In addition, detailed geologic maps of the principal garnet deposits and of the adit at the garnet mine were prepared.

HISTORY AND PRODUCTION

The date of actual discovery of the garnet deposits is unknown, but gold seekers working the bars of the Stikine River as early as 1862, probably knew of their existence. J. D. Dana,[3] probably the

[1] Wright, F. E., and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, 1906.

[2] Buddington, A. F., and Chapin, Theodore, Geology and mineral deposits of southeastern Alaska: U. S. Geol. Survey Bull. 800, 1929.

[3] Dana, J. D., System of Mineralogy, 6th ed., 1892. Analysis of garnet from Wrangell cited on p. 442.

first to record the presence of garnet crystals on the Stikine River, published an analysis of the crystals by A. F. Kountze. F. E. and C. W. Wright[4] mentioned the presence of garnets along the Stikine River in the course of their investigations of the Wrangell mining district, and Knopf[5] states that a small amount of garnet was produced from the Wrangell district in 1910. In 1912, the Alaska Garnet Mining & Manufacturing Co. applied for a patent on two claims covering the most promising garnet area. The same year, J. L. McPherson, civil engineer of Seattle, Wash., made a location map for United States Mineral Survey 951 embracing the garnet claims, which were at that time a portion of the unsurveyed Public Domain in the Wrangell mining district.

In 1922, the Alaska Garnet Mining & Manufacturing Co. gave a short-term lease to a small company that operated for the period of the lease. The quantity of garnets produced by the two companies is unknown, but it is probably small, as the literature contains only a few indefinite statements concerning production.

PREVIOUS WORK

The most comprehensive previous study of the garnet-bearing schists on the Stikine River is that made by Buddington[6] in 1922 while he was engaged in investigations of the mineral deposits of the Wrangell mining district. A topographic map of the district from Eastern Passage east to the Canadian Boundary was prepared by the International Boundary Commission in 1904–5. This survey constituted the first effort at accurate mapping in the Wrangell district.

FIELD WORK AND ACKNOWLEDGMENTS

The field work that provided the data for this report began June 26 and ended August 5, 1946. Detailed mapping of the garnet deposits by plane table and telescopic alidade was carried out on a scale of 1 inch to 200 feet. Contiguous areas, embracing approximately 4 square miles, were mapped in less detail on the same scale. Tri-lens aerial photographs and United States Coast and Geodetic Survey nine-lens composite photographs were of great value despite the heavy timber and great relief. The entrance to the adit at the garnet mine, which had caved in approximately 25 years before, according to local sources of information, was reopened with considerable difficulty in order to map the underground workings.

[4] Wright, F. E. and C. W., op. cit., p. 92.

[5] Knopf, Adolph, Mining in southeastern Alaska: U. S. Geol. Surv. Bull. 480-D, p. 42, 1911.

[6] Buddington, A. F., Mineral deposits of the Wrangell district, Alaska: U. S. Geol. Surv. Bull. 739, pp. 51–75, 1922.

The writer was aided greatly in the examination of the deposits by William T. Holser. Wayne L. Swift also served efficiently in camp and in the field.

Numerous courtesies and helpful cooperation by the citizens of Wrangell aided the investigation, and the work was facilitated especially by Bert and Ingvald Nore, H. R. McKibben, Neil Grant, and by Richard J. Suratt, the United States Commissioner.

GEOGRAPHY

LOCATION AND ACCESSIBILITY

The garnet deposits are on the east bank near the mouth of the Stikine River, 7½ miles north of Wrangell, the principal town and supply point in the Wrangell mining district. (See pl. 7.) Wrangell is served regularly by coastwise steamships carrying passengers and freight between Seattle or British Columbia and points in Alaska. Specially constructed shallow draft, high-powered boats ply the Stikine River twice a week between Wrangell and Telegraph Creek, British Columbia. These boats can stop at the garnet deposits only at high tide because of the shallow, shifting, and anastomosing channels of the muddy lower reaches of the Stikine River. Daily air service is maintained, weather permitting, between Wrangell and Juneau.

TOPOGRAPHY

The principal garnet deposits lie 750 feet east of the Stikine River in a steep narrow valley, 1½ miles long, which is bordered by precipitous ridges rising from sea level to 3,010 feet, the summit of Garnet Mountain. Two forks of Garnet Creek, both of which traverse the garnet deposits, rise from snow fields on Garnet Mountain and flow over a series of cascades and waterfalls to join at a point 600 feet east of the Stikine River. Great relief and steep-walled valleys are typical of both the mainland portion of the Wrangell district and its contiguous islands.

Dense stands of timber cover all but the steepest slopes up to timber line, which is about 2,500 feet above sea level. The undergrowth, consisting mainly of huckleberry bushes, alder, and devil's club, is extremely thick and in many places, particularly on old avalanche scars, nearly impenetrable. Heather and lichens are the dominant vegetation between timber line and the permanent snow fields.

CLIMATE

Climatic records at Wrangell show that the district has relatively mild winters at the lower altitudes, with temperatures usually above zero, and cool summers with temperatures rarely above 80° F. About

60 percent of the mean annual precipitation of 78 inches occurs between the first of September and the last of January. Most of the precipitation is in the form of rain below an altitude of 500 feet.

GEOLOGY

GENERAL FEATURES

The Wrangell garnet deposits lie within the Wrangell-Revillagigedo belt of metamorphic rocks which comprise a complex assemblage of schists, phyllites, and slates that form the western flank of the Coast Range. The trend of this belt is, in general, parallel to the northwesterly trend of the range, and the rocks dip to the northeast. Intricate and locally highly contorted folds are superimposed on the uniformly trending structures, a condition that makes difficult the determination of the origin and age of these rocks.

Intruded into this metamorphic complex is the Coast Range batholith of probable Jurassic age. The batholith forms the backbone of the Coast Range and is its dominant geologic feature for more than 1,100 miles along the coast from southern British Columbia northward beyond latitude 60° N. Numerous peripheral and outlying stocks, dikes, and bosses are thought generally to be genetically related to the batholith. Buddington,[7] after studying many portions of the batholith in southeastern Alaska, concluded that the core is granodioritic in composition and that the western margin is quartz diorite, whereas the eastern margin is dominantly quartz monzonite. Locally there are many variations in composition ranging from granite to diorite and more basic types.

Metamorphic and late magmatic effects associated with these large and small intrusions are widespread, pronounced, and varied. Bed-by-bed injection gneiss, aplite, and pegmatite are conspicuous, particularly near intrusive contacts.

As valley sides have been oversteepened by glaciers, the marks of avalanches are fairly common features. Between the two main forks of Garnet Creek at an altitude of 500 feet is a large area of landslide debris containing blocks of rock up to 50 feet in length.

The rocks are faulted, but faults are not prominent within the map area. Most of the observed faults appeared to be small and were so poorly exposed that the direction of movement was not determined.

METAMORPHIC ROCKS

DISTRIBUTION AND CHARACTER

Schists, representative of the Wrangell-Revillagigedo metamorphic complex, crop out prominently for more than 800 feet in the lower

[7] Buddington, A. F., op. cit., pp. 178–179.

part of the valley of Garnet Creek. (See pl. 8.) Quartz diorite intrusions fringe on three sides the several schist facies that crop out in the map area. The fourth side is obscured by the Stikine River. Similar schists are exposed south of the intrusive rocks shown on plate 8, and on Sergief Island. (See pl. 7.) Contacts between the schist and the quartz diorite are characterized by a zone of aplitic bed-by-bed injection gneiss, which generally is gradational. Locally, however, the contact is fairly sharp, as along the main fork of Garnet Creek (pl. 8) where at several points the contact zone is very narrow or missing.

Within the areas of quartz diorite are masses of large blocks of unassimilated schist. Some smaller blocks are present as xenoliths and inclusions that were probably caught up by the invading magma.

The metamorphic rocks of the garnet area are predominantly crystalline quartz-biotite schist with some interbedded quartzite and quartz schist. Other metamorphic rock types, including black slaty phyllite, schistose greenstone, and crystalline limestone, crop out near the garnet area.

The more quartzose facies of the fine- to medium-grained schists commonly exhibits a gneissic structure owing to alternating layers of contrasting minerals. The fine-grained, less-quartzose schist facies is often highly contorted and does not show the conspicuous alternation of quartz and mica.

The mineral constituents, with the exception of the garnets, are not conspicuous for their size. The garnets are commonly less than 6 millimeters in diameter, although specimens with diameters in excess of 25 millimeters have been noted. The other minerals of the metamorphic rocks are commonly less than 1 millimeter in size.

In thin section, the schists exhibit variations in composition, texture, and structure. Quartz, biotite, garnet, muscovite, graphite, and orthoclase are identified in the schists in the garnet-bearing area. In thin sections of quartzite and quartz schist, the structure is usually a granulose aggregate of equidimensional, recrystallized quartz grains. Rudimentary schistosity is present locally where biotite flakes impart a poorly developed parallel alinement between the quartz grains. The recrystallized quartz grains show elongation only to a very minor extent. Where this occurs, the quartz is usually introduced into the body of the rock along the schistosity as quartz veinlets, or as small apophyses of aplite or injection gneiss.

In thin sections containing large amounts of biotite and muscovite, flakes of these minerals commonly define highly contorted microfolds, and the rocks are characteristically schistose. In this facies belongs the larger part of the garnetiferous quartz-biotite schists found in the garnet area and throughout the northeastern portion of the Wrangel-Revillagigedo belt of metamorphic rocks.

It is apparent from studies of thin sections that some of the schists in the garnet area have been subjected to at least two periods of metamorphism. The earlier of these, and the one which produced the schists, phyllites, and slates of the Wrangell-Revillagigedo metamorphic complex, was of the dynamothermal type of metamorphism on a regional scale. Thin sections of the regional garnetiferous quartz-biotite schist facies show the small garnets to be fairly idioblastic and to contain relatively few inclusions. Where the garnet is in contact with mica flakes, the latter have been spread apart by the growth of the garnet.

The idioblastic garnet crystals in the schists adjacent to the quartz diorite contact are generally of much larger size and contain innumerable inclusions. Most of the garnet metacrysts in the quartz-rich biotite schist show little or no spreading of the enclosing schist, and only in the graphite-rich schist facies is there any apparent spreading by garnet growth. Because large garnets, commonly containing inclusions and showing no spreading of the micas, are found only adjacent to the intrusive igneous contacts, they are believed to be the result of contact metamorphism caused by the intrusion of the quartz diorite.

STRUCTURE

In the vicinity of the garnet deposits the attitude of the schists conforms to the regional pattern. Local variations in strike and dip reflect minor folds. Only two small well-defined folds are exposed in the map area; one at the garnet mine and one at a point on the Stikine River bank between Garnet Creek and Green Point.

Fracture cleavage is displayed in the schists. It is seen best in the garnet-mine adit where its strike is parallel to the schistosity and its dip is to the south.

AGE

Little evidence was found within or adjacent to the garnet area by which the age of the schists could be ascertained. The only evidence of age relationship in the garnet area is that of the quartz diorite, generally regarded as Jurassic age, which intruded the Wrangell-Revillagigedo schists.

The Wrights[8] believed that the greater part of the metamorphic rocks were of Carboniferous age, and that part of the formations might include rocks of Triassic age. Buddington[9] concurs with the Wrights in assigning these rocks to the late Paleozoic and early

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[8] Wright, F. E., and C. W., op. cit., p. 56.

[9] Buddington, A. F., The Geology and mineral deposits of southeastern Alaska: U. S. Geol. Surv. Bull. 800, p. 74, 1929.

Mesozoic. However, he believes that some of the rocks may be as old as Devonian, whereas others may be as young as Cretaceous.

IGNEOUS ROCKS

DISTRIBUTION AND CHARACTER

Most of the igneous rocks exposed near the garnet deposits are tongues of a large quartz diorite stock, and it is likely that the body of schist near the garnet mine may represent a roof pendant in this quartz diorite stock. The quartz diorite which forms the ridge southwest of Garnet Creek is only a few hundred feet wide at the Stikine River but widens to the southeast where it joins the main body of the stock. The main body of the stock trends southeastward from Point Rothsay in a broad band roughly parallel to the eastern side of Eastern Passage.

Fine- to medium-grained gray quartz diorite predominates within the stock. Variations to granodiorite occur locally, but the difference between the two types is so slight that no distinction has been made on the map. The variations in composition probably resulted from differing physico-chemical conditions in the country rocks intruded by the stock. Porphyritic textures and gneissic structures are comparatively uncommon in the quartz diorite near the garnet-mine area. At some localities, blocks of schist were incompletely assimilated by the magma and relict structures give the rock a gneissoid appearance.

In most hand specimens of the quartz diorite, biotite and hornblende are readily distinguishable. The biotite commonly gives the appearance of chunky plates, whereas the hornblende appears as black prismatic crystals. In thin section its texture is seen to be hypidiomorphic granular. Locally the quartz diorite is porphyritic. The average grain size is slightly greater than 1 millimeter, but occasionally phenocrysts of biotite and hornblende as much as 3 millimeters in length are present. Less common are phenocrysts of plagioclase feldspar up to 2.8 millimeters in length.

The approximate modal composition of six representative specimens of quartz diorite from the garnet-mine area is given below.

Andesine (Ab_{60}–An_{40} to Ab_{64}–An_{34})	53	Clinozoisite	1.0
Orthoclase	3	Garnet	.5
Quartz	17	Pyrite	Trace
Biotite	14	Zircon, apatite	Trace
Hornblende	7		
Kaolin	3		100.00
Sericite (muscovite)	1.5		

Some large plagioclase crystals, apparently older than most of the other minerals, display conspicuous zoning. The zoned plagioclase crystals are generally larger than those showing no zonal structure.

All biotite crystals are deeply pleochroic, the color varying from a very pale yellow to an intense deep red brown. The biotite commonly shows large pleochroic halos surrounding zircon inclusions. The hornblende, in contrast to the biotite, displays a prismatic shape in which the length greatly exceeds the width. Neither biotite nor hornblende shows any alteration. In several specimens the larger grains of feldspars showed alteration to kaolin and sericite. Garnet is conspicuous as an accessory mineral in some specimens of the quartz diorite. Pyrite is locally abundant and appears to be one of the latest minerals for it is seen constricted between the boundaries of other minerals, notably quartz.

A few pegmatite and aplite dikes crop out within the garnet-mine area. Two dikes of pegmatite crop out on the south side of the north fork of Garnet Creek about 600 feet from the forks. This rock is coarse-grained and blocky and in color is white to yellowish white. Plagioclase and quartz are the dominant minerals, together making up 95 percent of the rock; the remainder is biotite. The biotite occurs in small books about 12 millimeters in diameter. The average grain size of the rock as a whole is about 12 millimeters.

Aplite is less easily recognized, for at many points it grades into bed-by-bed injection gneiss. It has no characteristic place of occurrence but is found near most of the borders of areas of intrusive rocks. It is a fine-grained, sugary white rock often containing stringers of biotite.

STRUCTURE

The structure of the igneous rocks is generally massive. Locally, a gneissic structure is apparent in the quartz diorite although in general it seems to be less prevalent than in most of the Coast Range intrusives.[10] Jointing is fairly prominent, consisting of both open joints and joints filled with aplite. The main trends of jointing are northward and eastward.

AGE

The age of the quartz diorite, as determined from contact relations outside the garnet-mine area,[11] is probably Upper Jurassic or Lower Cretaceous. Within the garnet area the only evidence for age determination is its intrusion into the schists of lower Mesozoic or pre-Mesozoic age.

GARNET DEPOSITS

LOCATION, SIZE, AND GRADE

The garnet crystals, disseminated through the quartz-biotite schist, attain a size and concentration worthy of economic consideration only

[10] Buddington, A. F., Geology and mineral deposits of southeastern Alaska: U. S. Geol. Surv. Bull. 800, p. 231, 1929.

[11] Buddington, A. F., op. cit., pp. 252, 253.

at Garnet Creek. Five garnet claims, all belonging to the Alaska Garnet Mining and Manufacturing Co. have been located within the valley of Garnet Creek. The largest concentration of garnets is in the two patented claims Ruby No. 1 and Ruby No. 2. These claims are near the mouth of Garnet Creek, which traverses both of them. (See pl. 8.)

The deposits, as delimited on the map, roughly form a narrow isosceles triangle extending approximately 450 feet southeast from an apex at the confluence of the two forks of Garnet Creek. (See pl. 8.) The maximum width of the rich garnet-bearing zone is about 250 feet. A vertical profile across the low ridge at any point between the two forks of Garnet Creek is roughly triangular. The shape of the body of rock enclosing the deposits of highest grade is thus a rough tapering triangular prism. Above a horizontal datum plane at the level of the forks of Garnet Creek, this body of rock is estimated to have a volume of more than 2,810,000 cubic feet.

Two samples, representative of the garnet-bearing schist between the two forks of Garnet Creek, gave 4.85 and 9.26 percent of garnet by weight. (See pl. 8.) A comparison between barren schist and the two garnet-bearing schist samples is shown below:

	Percent of garnet	Calculated specific gravity of schist	Volume (cubic feet per ton)	Weight of garnet (pounds per ton)
Schist (barren)	0	2.65	12.1	0
Schist (sample 1)	4.85	2.72	11.78	97.0
Schist (sample 2)	9.26	2.78	11.5	185.2

The deposits probably will average at least 5 percent of commercial garnet, possibly more. Miss Anna E. Durkee,[12] secretary of the Alaska Garnet Mining & Manufacturing Co., states that W. C. Hall, mining engineer, sampled the deposits in 1922 and calculated that a ton of garnet-bearing schist contained 112.5 pounds of garnet.

If it is assumed that 11.8 cubic feet of schist containing 5 percent of garnet weighs 1 ton, then 2,810,000 cubic feet of the garnet-bearing schist will weigh 238,136 tons and will yield 11,907 tons of garnet.

If garnet-bearing schist of the same tenor extends 20 feet below the assumed datum plane, then a further volume of 1,125,000 cubic feet, equivalent to 95,339 tons, is added; this increases the total to 333,475 tons of schist or 16,674 tons of garnet.

MINE DESCRIPTION

The adit of the garnet mine is located on the Ruby No. 1 claim on Garnet Creek, 265 feet southeast of the forks. (See pl. 8.) It is easily accessible by trail from the Stikine River.

[12] Personal communication, June 4, 1947.

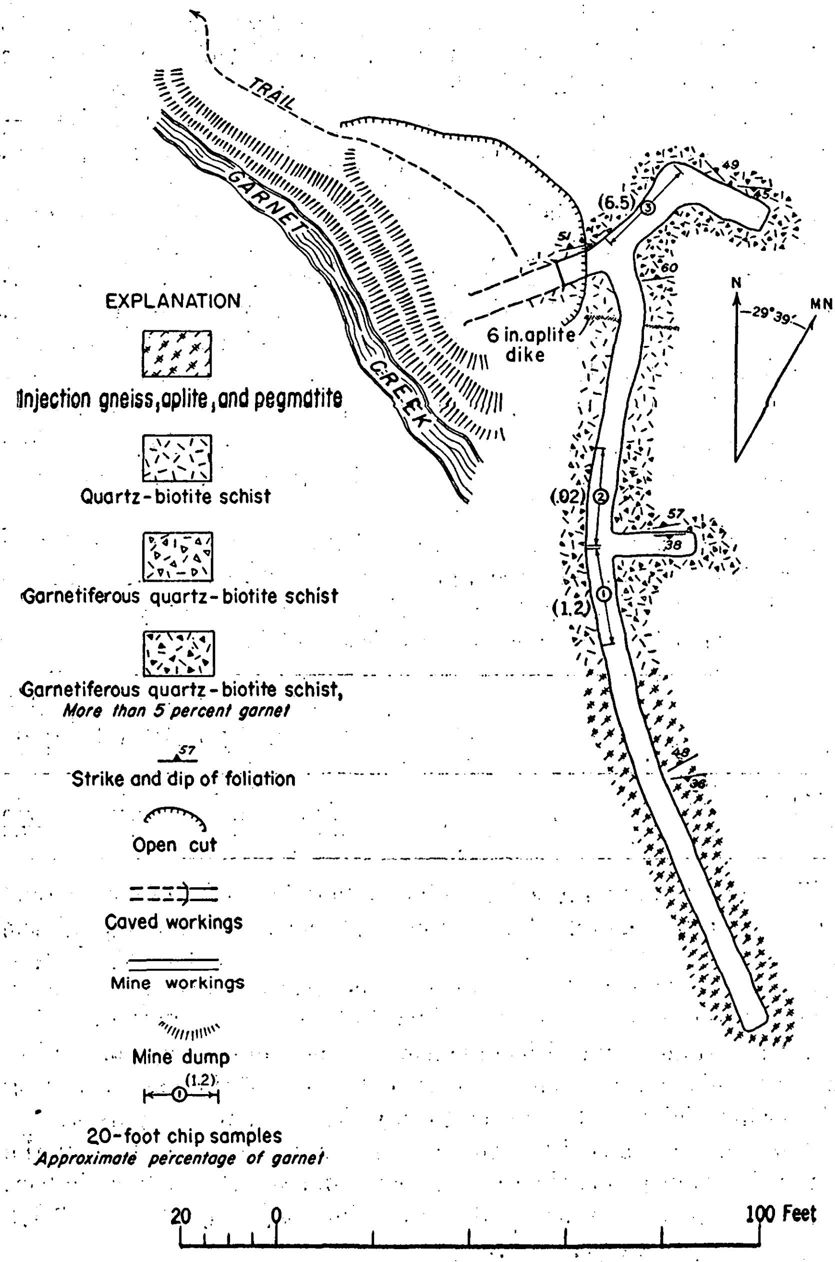

FIGURE 21.—Tunnel map of the Wrangell garnet mine.

The underground workings consist of about 260 feet of drifts. The main drift explores the deposits for 30 feet northeastward from the present entrance; then turns to the southeast for 25 feet. Another drift, from a point 10 feet inside the main drift, extends for 162 feet in a southerly direction. It crosscuts schist with minor amounts of bed-by-bed injection gneiss for about 80 feet, beyond which the proportion of injection gneiss increases markedly to the end of the drift. About 55 feet south of the mouth of this drift, a short drift, 17 feet long, explores the schist eastward and parallel to the schistosity.

Three chip samples taken along the west wall of the main and south drifts showed the northern part of the workings to contain an appreciably higher percentage of garnet than the remainder. (See fig. 21.) The samples of garnet-bearing schist were disaggregated, with due care to avoid crushing the garnet, and the percentage of garnet by weight was calculated. A cut-off size of 6 millimeters (¼ inch) was used, as garnets below this size have no commercial value, and most manufacturers of garnet products screen out everything below 13 millimeters (½ inch). This cut-off size was used in the calculation of the reserves of the deposits.

Samples 1, 2, and 3 contained 2.1, 0.2, and 6.5 percent of garnet, respectively. As chip sampling in such deposits offers relatively inaccurate results, it is likely that samples 1 and 2 may actually be of higher grade than is indicated by the figures. Sample 3 conforms more closely to the results of the two representative garnet-bearing surface samples.

CLASSIFICATION AND GENESIS

The slates, phyllites, and schists that comprise the Wrangell-Revillagigedo belt of metamorphic rocks were formed by regional dynamothermal metamorphism. Contact metamorphism caused by intrusions of igneous rocks into this metamorphic series, as seen in the garnet mine area, induced the formation of large garnets in the schist. The deposits are thus classified as contact metamorphic.

MINERALOGY

These garnets have been classified by Dana [13] and others as almandite. The crystals range in diameter up to 44 millimeters. All the garnets have external crystallization and generally show both dodecahedron and trapezohedron faces. As Pabst [14] has pointed out, the dodecahedron becomes more prominent with increase in size of the crystal. Measurement of the specific gravity of several garnets showed the value 4.1 to be constant for crystals of all sizes, and any

[13] Dana, J. D., System of Mineralogy, 6th ed., p. 442, 1892.

[14] Pabst, Adolph, Large and small garnets from Fort Wrangell, Alaska: Am. Min., Vol. 28, pp. 233–245, 1943.

slight variation commonly affects only the second or third decimal place. The hardness, based on Moh's scale, is approximately 7.5. The color is deep red.

Some of the larger crystals display a parting or lamination that generally is parallel to the plane of schistosity, and experiments showed that crystals embedded in schist would fracture parallel to the schistosity. Experiments conducted to determine the manner of fracture showed that the crystal fragments are equidimensional with sharp angular edges, even when crushed to pass through a 230-mesh sieve.

The garnets generally show no alteration, but many crystals, particularly those displaying parting, show oxidation of part of the iron to limonite along the planes of parting and within the internal fractures.

The crystals have no value as gems, for all contain internal fractures. Thin sections show that the garnet crystals contain many inclusions of quartz. No zoning was seen in garnets found in the quartz diorite or in the garnet schist.

Myers and Anderson [15] give requirements for abrasive garnet, and the Wrangell garnets have physical properties analogous to the commercial garnets from New Hampshire, which are the acknowledged standards for the abrasive-garnet industry.

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[15] Myers, W. M., and Anderson, C. O., Garnet—Its mining, milling, and utilization: U. S. Bur. Mines Bull. 256, 1925.

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