QUARTZ-DIOPSIDE-GARNET VEINLETS

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Recently the attention of the writers has been attracted by certain veinlets apparently related to granodioritic intrusives. Two occurrences are discussed, one near Snoqualmie Pass in the Cascade Range of Washington, and the other near Cornucopia, Oregon, on the south eastern border of the Wallowa mountains. These are so similar in textural characteristics and mineral assemblages that their description in a single paper is warranted even though they are separated in time from late Mesozoic to Miocene and in distance by several hundred miles.

Cascade Occurrence

The reconstruction of the Sunset highway across the Cascades of Washington has afforded several excellent exposures along the contact of the Snoqualmie batholith. Some of the best are on the southeastern side of the highway about one mile west of the summit, half way between Lodge Creek and Rockdale Creek. This locality is approximately 65 miles east of Seattle.

Here the contact is irregular and probably represents the top of a stock-like mass. The invaded rock is the Guye formation, which locally is a fine grained quartz biotite schist containing 50 per cent quartz, 40 per cent biotite, 8 per cent oligoclase with minor amounts of magnetite and apatite. Smith and Calkins give the following summary of this formation;

> The age of the Guye is probably Miocene. However, nowhere is the base nor the top exposed and the known extent of the formation is limited to the northwest corner of the Snoqualmie quadrangle. The formation is composed of detrital rocks with some chert and limestone and interbedded basalts. Clearly intrusive into the Guye is the Snoqualmie granodiorite with its age established as late Miocene or post Miocene. Subsequent erosion has furnished excellent exposures of the intrusive contact.[1]

At this locality the granodiorite is light gray in color, coarsely granular in texture and is composed of approximately 55 per cent

[1] Smith, G. O. and Calkins, F. C., *U. S. Geol. Sur., Snoqualmie Folio* No. **139**, 1906, p. 7.

plagioclase, 25 per cent quartz, 10 per cent biotite, 7 per cent orthoclase with minor amounts of magnetite, apatite, zircon and titanite. Plagioclase is zonal with cores approaching an intermediate oligoclase and sheaths ranging in composition from a sodic oligoclase to albite. Biotite is strongly pleochroic, X-pale yellow, Z-deep reddish brown, 2V is less than 2 degrees. The refringence ($N_g=1.690$) indicates an iron rich member of the annite-siderophyllite series.[2]

The quartz-diopside veinlets are conspicuous in the outcrops immediately above the granodiorite. They are irregularly distributed, usually traversing the roof rock vertically although they may have no definite orientation. In general they vary from one quarter to two inches in width and attain a length of a few hundred feet. All the veinlets wider than one half inch show a distinct banded structure, a coarsely crystalline middle zone contrasting with fine grained, brownish gray borders. The central portion contains quartz, diopside and titanite, with minor amounts of apatite and zircon. It has a grain size of about 0.5 mm. and shows a gradual transition into the finer grained outer zones which consist of irregular clusters of leached biotite, quartz, diopside, titanite and a scant amount of magnetite. The average diameter of these segregations is about 0.5 mm. while that of the individual anhedra is but 0.03 mm. The outer fine grained borders of the veinlets are in reality transition zones grading, on the one hand inward toward the coarser central portions and, on the other hand outward into the schist. The larger, more euhedral minerals in the central portion of the veinlets appear to have been formed by the coalescing of the smaller grains. Similar features have been described with regard to recrystallized xenoliths.[3]

A few hundred feet along the highway toward the summit the character of the Guye formation changes from a biotite schist to a metamorphosed basalt. Here the old lava is conspicuously porphyritic with tabular labradorite phenocrysts as much as 4 cm. in length. These crystals, which are severely fractured and contorted, are partially replaced with chlorite and epidote. The groundmass contains small laths of labradorite and shows the same type of alteration.

[2] Winchell, A. N., Elements of Optical Mineralogy, p. 368, **1927.** Part II.

[3] Goodspeed, G. E., *Jour. Geol.*, vol. **35**, no. 7, Nov. 1927. Effects of inclusions in Small Porphyry Dikes at Cornucopia, Oregon.

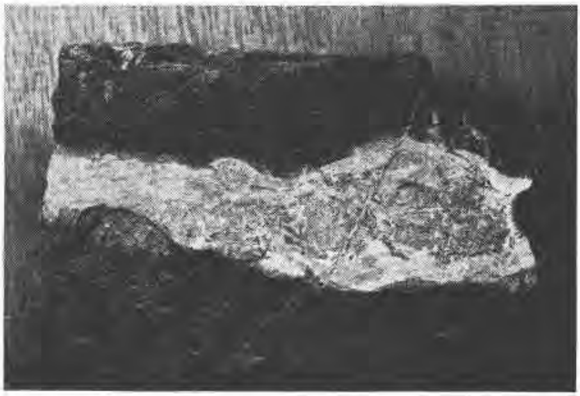

FIG. 1. Garnet-rich veinlet with transitional zones into schist. Cornucopia, Oregon. Natural size.

Where the quartz-diopside veinlets traverse these metamorphosed basic lavas their mineral composition is radically changed. Calcite appears as a late mineral. Garnet becomes noticeable, and in some veinlets may exceed 50 per cent of the mineral composition. With this increase in garnet there is a corresponding decrease in diopside and titanite. The amount of quartz varies from 0–50 per

FIG. 2. A section showing the coarsely crystalline middle zone of clear quartz and dark, euhedral titanite surrounded by diopside. The same minerals appear on the margins of the middle zone but of considerably smaller dimensions. Snoqualmie Pass, Washington. 12×.

cent. In the calcite-rich veinlets it is lacking or not over 5 per cent. In others it equals the amount of garnet.

Structures similar to those of the quartz-diopside veinlets prevail. There are, however, some minor differences such as a coarser central band of diopside in the midst of the quartz and garnet of the middle zone. Another feature peculiar to the garnet veins is a small but definite band of kaolinitic material along the outer margin of the transition zone and the country rock. It persists as an irregular band of fine, cloudy material averaging 0.15 mm. in width wherever the veinlets traverse the basic lavas. It is lacking where they traverse the schist. Another noteworthy feature is the presence of chlorite and pyrite commonly occurring in the upper reaches of the veins several hundred feet above the actual granodiorite contact.

FIG. 3. Section of a garnet-rich veinlet showing later quartz and calcite. Cornucopia, Oregon. 35×.

As previously described, the growing together of smaller individuals to form the larger crystals appears to be an important mechanism of formation. Kaolinitic material and the presence of such minerals as chlorite suggests lower temperature hydrothermal solutions.

Cornucopia Occurrence

The quartz-diopside-garnet veinlets occurring in the vicinity of

Cornucopia, Oregon, are practically identical with those just described. At Cornucopia a late Mesozoic granodioritic batholith invades a series of metamorphic rocks consisting largely of biotite

FIG. 4. Another portion of the garnet phase showing a basal section of quartz surrounded by calcite. Snoqualmie Pass, Washington. 35×.

and hornblende schists. Some of the schists, known locally as greenstones, approach hornfels in megascopic characteristics.

Near Red Mountain, where the veinlets are well shown, the invaded rock is xenoblastic schistose, fine grained (0.07 mm.) and consists chiefly of hornblende and plagioclase with or without biotite. Mafics usually constitute 50 per cent and the quartz and plagioclase 25 per cent each. The plagioclase is oligoclase (An. 25). Distinct alignment of the mafics is evident.

In the vicinity of the Red Mountain contact the granodiorite exhibits a slightly gneissic structure. It is medium grained in texture and in section is seen to be hypautomorphic-granular with elongated clusters of biotite and much finer bands of quartz and feldspar. At the immediate contact the uneven texture is much more accentuated, the finer grained bands of quartz and feldspar composing about 40 per cent. The approximate mineral composition is about 65 per cent albite-oligoclase, 15 per cent quartz, 10 per cent biotite and hornblende and 5 per cent orthoclase, with minor amounts of apatite and zircon. The alteration products, which compose about 5 per cent, include sericite, epidote, chlorite, zoisite and kaolinitic material. At the contact hornblende as well as biotite is present and these minerals constitute about 20 per cent of the rock. The biotite is apparently replacing the hornblende. The outer sodic rims of the plagioclase are very clear as contrasted with the cloudy cores.

The quartz-garnet-diopside veinlets, in general, exhibit the same features as those from the Cascade locality but in the field their contacts appear to be clean cut and sharp. In thin section, however, no line of demarcation is discernible, merely a short transition from the wall rock into the veinlet. Biotite is changed to hornblende at the contact and this, in turn, is changed to diopside. Approaching the contact the feldspar and quartz become increasingly cloudy and indistinguishable, finally merging into a fine "ragged" textural border zone. However, even within the veinlet an alignment, inherited from the schist, is discernible. Coarse crystallization prevails in the middle zone where irregular groups of garnet appear. Coarsely crystalline garnet and diopside also occur in irregular and in transverse veinlets within the main one. The earlier garnet, forming the walls of these veinlets, appears to be somewhat altered along the immediate borders of the cross veinlets.

Conclusions

In his studies of the granitic contacts of the Pyrenees, Lacroix mentions dikes filled with "garnetites" or "epidosites" and classified them as aplitic or pegmatitic dikes.[4] It is doubtful if the term 'dike' could be applied to the veinlets just described as their mechanism is one of replacement rather than fissure filling.

The contact of these veinlets, their texture and the evident aggregation of smaller individuals into larger crystals (an increase in size of about 16 times) indicate an ease of recrystallization which was probably caused by the hot emanations from the granodioritic intrusives. While some calcium and titanium were doubtlessly derived from these emanations, the actual mineral suite of the veinlets was much influenced by the chemical character of the rocks traversed and replaced. As might be expected, garnet and calcite are most abundant in these veinlets, or portions of veinlets, which cut more basic rocks such as altered lavas.

[4] Lacroix, A., Le Granite des Pyrenees et ses phenomens de Contact: *Carte Geologique de France*, tome **10**, no. 64, 1898–1899.

Coarsely crystalline veinlets within the main veinlets may be explained by the filling of shrinkage cracks under lower temperature conditions, which are further evidenced by the kaolinitic borders along these later veinlets. It seems probable that these phenomena were formed by conditions ranging from pyrometasomatism to hydrothermal alteration. Similar conclusions with regard to contact silicates were reached by Agar in his studies of contact metamorphism in the western Adirondacks.[5]

[5] Agar, W. M., *Proc. Am. Phil. Soc.*, vol. **62**, pp. 95–174, 1923, Contact Metamorphism in the Western Adirondacks.

THE PREPARATION OF THALLOUS FORMATE

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Introduction*

Thallous formate is extremely useful in petrographic laboratories because its aqueous solutions are liquids of densities which rise to 3.5 on saturation, properties which make such solutions important both for the separation of minerals of varying density and the determination of densities of individual minerals. The saturated solution is fairly stable, and may be diluted within certain limits; concentration to a density greater than 3.5 may be obtained by saturating at a higher temperature and using the solution at that temperature.[1]

These desirable qualities are offset by the high market price of the compound, and this paper was written at the suggestion of Dr. Sampson to see whether the compound could be prepared in an ordinary laboratory by a comparatively economical process.

The principle of the method finally decided upon is to dissolve metallic thallium in sulphuric acid, and add barium formate, which precipitates barium sulphate and leaves thallous formate. In Miss Vassar's paper[2] on Clerici solution, two methods of preparing thallous carbonate are described, and thallous formate can

* For general information on thallium, see A. V. Petar, Thallium, *U. S. Bur. Mines, Information Circular* **6453**, 1931.

[1] Such hot solutions cannot be used with magnetite and similar minerals, as it was found that the thallous formate was decomposed. H. Vassar found the same thing true with respect to sulphides. (*Am. Min.*, vol. **10**, p. 123, 1925).

[2] *Op. cit.*, p. 124.