PREHNITIZATION OF ALBITITE*

K. D. WATSON, *University of California, Los Angeles.*

ABSTRACT

A steeply dipping albitite dike, 25 feet wide, which cuts serpentine is exposed in a quarry about one-half mile west of Gold Bridge in southwestern British Columbia. Prehnite has replaced part of the dike, especially its footwall where a conspicuous white irregular layer averaging 5 feet in width consisting mainly of prehnite has been formed. A comparison of the chemical analysis of this highly altered rock from the footwall (68% prehnite, 31% diopside, 1% leucoxene, epidote, and quartz) with that of less altered rock from the center of the dike (77% albite, 15% prehnite, 4% chlorite, 3% quartz, 1% leuxocene, epidote, etc.) shows principally an increase from 6.32 to 26.34% CaO and decreases from 4.93 to 0.09% Na_2O and from 57.38 to 44.84% SiO_2. It is possible that this metasomatism has been caused by fluids containing lime yielded by the serpentinization of clinopyroxene-bearing peridotite.

INTRODUCTION

Gold Bridge is approximately 100 miles north of Vancouver on the eastern flank of the Coast Mountains in southwestern British Columbia (Fig. 1). A large quarry near Gold Bridge, from which fill was obtained for the Lajoie Dam on the Bridge River, exposes a contact between ser-

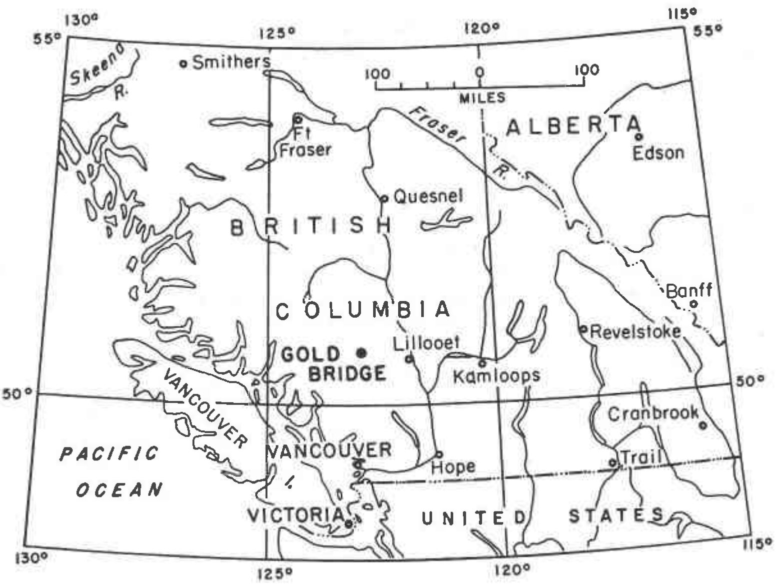

FIG. 1. Index map of southern British Columbia showing position of Gold Bridge.

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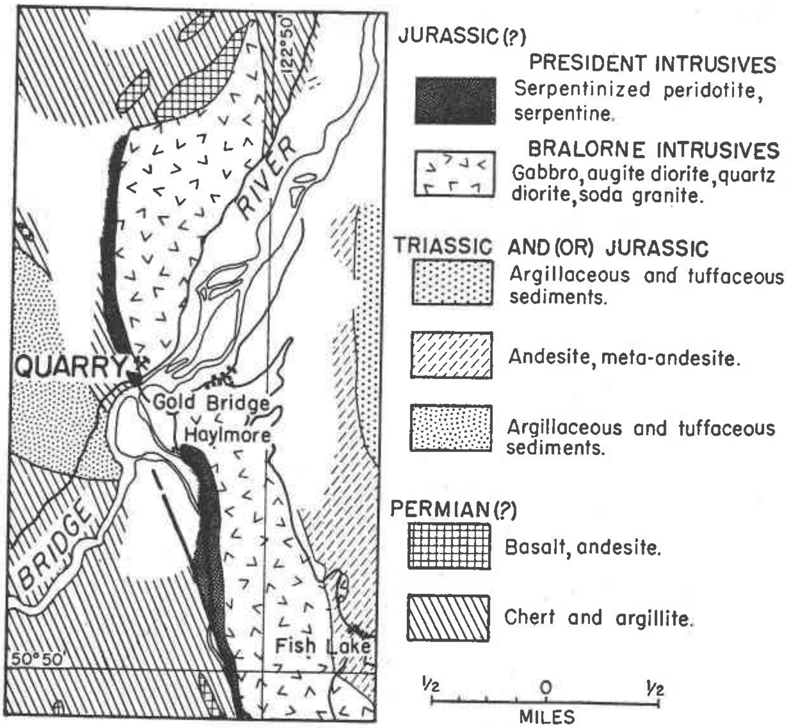

FIG. 2. Geological map of an area in the vicinity of Gold Bridge (after C. E. Cairnes).

pentine of the President intrusives and gabbro of the Bralorne intrusives (Fig. 2). Near this contact, which is at the western end of the quarry, an albitite dike striking about N. 10° E., dipping about 70° E., and having an average width of about 25 feet, intrudes the serpentine (Fig. 3). Much of this dike has been partly replaced by prehnite and large parts of it, especially along its footwall side, have been completely replaced by prehnite and minor diopside.

Albitite

The least altered albitite, which occurs near the center of the dike, is a light gray to light greenish gray, massive, aphanitic rock in which a very few grains of feldspar and chlorite are recognizable with a hand lens. Microscopically, it is seen that the rock is composed mainly of subhedral tabular crystals of albite, 0.1 to 0.3 mm. long, which have a tendency toward parallel orientation in places (Fig. 4). Rarely, albite crystals reach 0.5 mm. in length. The composition of the albite, determined by measurement of three grains by Universal Stage, is An_3, the range in determinations being from An_2 to An_4. Minor constituents of the albitite from the center of the dike are chlorite, quartz, leucoxene, and epidote occurring interstititally to the albite, and prehnite occurring as a replacement of some of the albite and chlorite (Fig. 4). A small amount of a mineral with radial fibrous habit, which may be anthophyllite, accompanies the prehnite locally.

A chemical analysis of the least altered albitite is given in Table 1

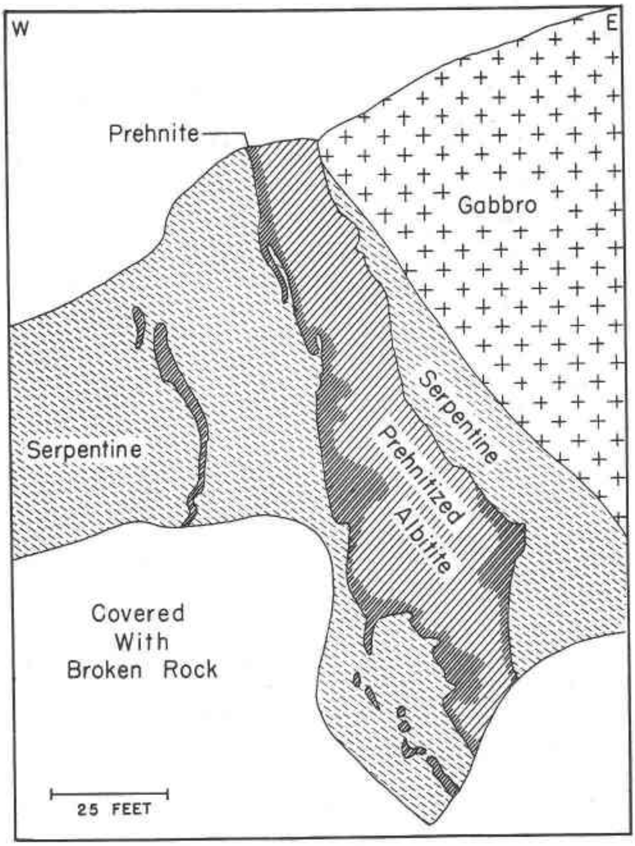

FIG. 3. Section showing geology of the face near the western end of the quarry.

and the mode of the analyzed rock, determined by Rosiwal analyses of five thin sections, is included in the table.

Except for the alteration to prehnite and diopside, this dike is similar to many other albitite and quartz albitite dikes in the Bridge River mining district which have been described by Cairnes (1937, pp. 34–36). In

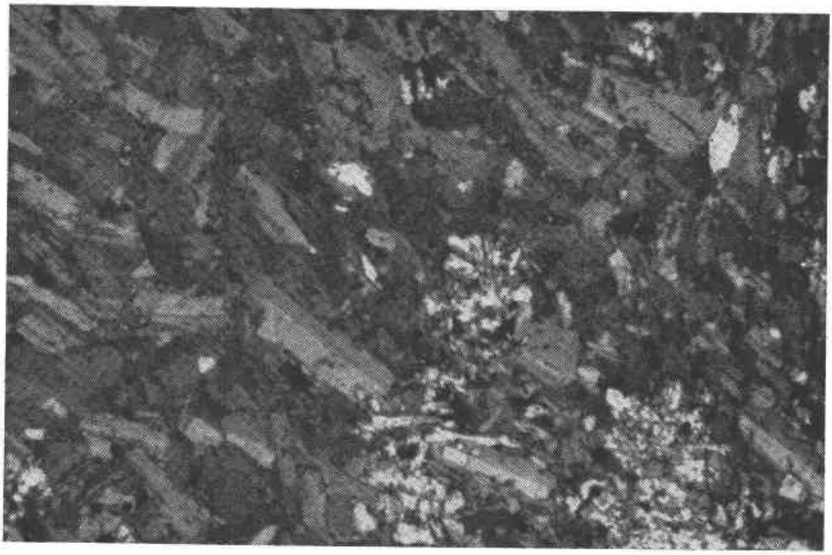

FIG. 4. Albitite showing tendency toward parallel orientation of subhedral tabular crystals of albite. Prehnite (white) has partly replaced albite. Crossed nicols. ×100.

several other places in the district, the President intrusives are intersected by these dikes (Cairnes, 1937, p. 31). A full discussion of the origin of the albitite is beyond the scope of this paper. There is little doubt, however, that because of its abrupt contacts, this dike is intrusive into the serpentine and there is no evidence that it formed by the replacement *in situ* of some pre-existing rock.

PREHNITIZED ALBITITE AND PREHNITE-DIOPSIDE ROCK

The highly altered part of the albitite dike, which is mainly along its footwall contact (Fig. 3), is a conspicuous white rock composed of fine-grained prehnite or prehnite and diopside. The contact between the prehnite rock and the albitite is gradational; indeed, prehnite occurs in appreciable amounts even in the center of the dike. In contrast, the contacts between the massive white prehnite and serpentine are very sharp.

Two irregular and broken, narrow zones of prehnite rock lie several feet west of the main dike (Fig. 3). These are believed to be an offshoot of the main dike and a small parallel dike that have been completely replaced and have been fragmented by shearing movement in the serpentine.

The highly altered albitite is a granoblastic rock of variable mineral composition and texture. Much of it consists of irregular or slightly radiating aggregates of elongate prehnite grains 0.1 to 1.0 mm. in length and of smaller xenoblastic to short prismatic crystals of diopside in lesser amounts. The higher relief and inclined extinction of the diopside make it readily distinguishable from the prehnite in thin section, but it is difficult to see in hand specimen. Commonly, prehnite occurs alone as radiating sheaves 1 to 2 mm. long (Fig. 5). In places, the diopside is idioblastic with long slender prismatic habit. Small quantities of leucoxene, epidote, and quartz are generally present and anthophyllite (?) with radial fibrous habit occurs sporadically. Commonly, the prehnite for one or two inches near the inner edges of the completely replaced albitite contains red dust, probably hematite, that gives the rock a pink color.

A chemical analysis of typical prehnite-diopside rock from the footwall of the dike and a mode based on Rosiwal analyses of five thin sections is given in Table 1.

The properties of the prehnite are:

$G=2.88\pm.02$
$\alpha=1.609, \beta=1.617, \gamma=1.635$; all $\pm.002$
$\gamma-\alpha=0.026$
$(+)\ 2V=68°$ (calculated)
$(+)\ 2V=69°\pm1°$ (U. S. measurement of 6 grains).

Measurements of a grain having wavy extinction—a fairly common characteristic of the prehnite—which gave optic angles of 64°, 61°, and $59\frac{1}{2}°$ in different parts, were not included in the average above. The specific

FIG. 5. Radiating sheaves of prehnite. Crossed nicols. ×90.

TABLE 1

Chemical analyses			Modes			
	Albitite	Prehnite-diopside Rock	Albitite		Prehnite-diopside Rock	
SiO_2	57.38	44.84	Albite	77	Prehnite	68
TiO_2	.44	.29	Prehnite	15	Diopside	31
Al_2O_3	19.96	16.32	Chlorite	4	Leucoxene, Epidote and Quartz	1
Fe_2O_3	.18	.03	Quartz	3		
FeO	5.49	5.40	Leucoxene and Epidote	1		
MnO	.22	.23				
MgO	2.14	3.32				
CaO	6.32	26.34				
Na_2O	4.93	.09	Specific Gravity	2.70 ±.01	Specific Gravity	2.96 ±.01
K_2O	tr	.07				
H_2O+	2.28	3.10				
H_2O-	.26	nil				
P_2O_5	.20	.15	Porosity	0.53% ±.01	Porosity	0.81% ±.01
CO_2	nil	nil				
Total	99.80	100.18				

W. H. HERDSMAN, *Analyst.*

gravity and refractive indices are slightly lower than those recorded for prehnite by Nuffield (1943, p. 62) and by Winchell (1951, p. 360).

The composition of the diopside was difficult to determine exactly because of its small grain size. The refractive indices ($\alpha = 1.690$, $\gamma = 1.715$, both $\pm .002$) and U. S. measurements ($Z \wedge c = 43°$, (+) $2V = 60°$) indicate that the pyroxene is about $\frac{2}{3}$ diopside and $\frac{1}{3}$ hedenbergite (Winchell, 1951, p. 413). This composition corresponds approximately with that calculated from the chemical analysis and mode of the prehnite-diopside rock given in Table 1 and from an appropriate analysis of prehnite selected from Nuffield's data (1943, p. 62).

SERPENTINE AND GABBRO

The serpentine is a greenish black, aphanitic rock cut by closely spaced, curved, slickensided fractures coated with dark green, waxy, serpentine. Most of the rock consists of pseudomorphs after olivine which are composed of magnetite and serpentine with typical mesh structure. Each polygonal area has a rim of radially-arranged, birefringent, serpentine fibers grading inward to a core of weakly birefringent or isotropic serpentine. The rock also contains a small proportion of pseudomorphs after pyroxene which formed irregular grains interstitial to the olivine. Although a few of these pseudomorphs are typical bastite, most of them consist of serpentine flakes and fibers in various orientations. The presence of these two kinds of pseudomorphs suggests that both orthopyroxene and clinopyroxene originally occurred in the rock. Chromite is a minor accessory.

The gabbro is a somewhat brecciated, medium gray, xenomorphic granular rock consisting of about equal amounts of plagioclase and uralitized augite. Its grain size is distinctly variable though it is mostly medium. About one-fourth of the plagioclase (An_{80}) is replaced by sericite and clinozoisite and about one-third of the augite is replaced by actinolite. The gabbro contains a few patches of serpentine which may have formed from olivine.

Chemical Nature of the Metasomatism

The main reasons for concluding that the prehnite-diopside rock has formed by replacement of albitite are:

1. In the partly altered albitite many of the subhedral tabular crystals of albite are irregularly embayed or completely transected by prehnite.
2. Except for the presence of the prehnite and minor diopside the dike is similar to the numerous unaltered albitite and quartz albitite dikes in the district.
3. The prehnite-diopside rock occurs at the margins of the dike and grades into almost normal albitite at the middle.

A comparison of the chemical analyses of slightly altered albitite from the middle of the dike and prehnite-diopside rock from the footwall given in Table 1 shows that the alteration consists principally of great increase of lime from 6.32 to 26.34% and loss of soda. Decrease in silica and alumina and increase in magnesia are also evident.

It is thought that the metasomatism was essentially isovolumetric because of the following observations:

1. The porosities of the slightly altered albitite and of the completely altered rock are not significantly different (Table 1).
2. The albitite adjacent to the highly altered parts of the dike is not closely fractured as it might be if the volume had increased significantly.
3. The highly altered parts of the dike are not closely fractured nor are the parts adjacent to them mashed as they might be if the volume had decreased significantly.

The nature of the change is shown by the following comparison of the standard cells of the rocks.[1]

ALBITITE

$Na_{8.6}\ Ca_{6.1}\ Mg_{2.9}\ Fe_{4.2}\ Mn_{0.2}\ Al_{21.1}\ Ti_{0.3}\ Si_{51.5}\ P_{0.2}[O_{146.4}(OH)_{13.6}]_{160}$

PREHNITE—DIOPSIDE ROCK

$K_{0.1}\ Na_{0.2}\ Ca_{26.9}\ Mg_{4.8}\ Fe_{4.3}\ Mn_{0.2}\ Al_{18.3}\ Ti_{0.2}\ Si_{42.8}\ P_{0.1}\ [O_{140.4}(OH)_{19.6}]_{160}$

TABLE 2. ALBITITE BECOMES PREHNITE-DIOPSIDE ROCK

	By adding	By subtracting
	0.1 ion of K	8.4 ions of Na
	20.8 ions of Ca	2.8 ions of Al
	1.9 ions of Mg	0.1 ion of Ti
	0.1 ion of Fe	8.7 ions of Si
	6.0 ions of H	0.1 ion of P
Total	28.9 cations	20.1 cations
	52 valences	52 valences

POSSIBLE SOURCES OF METASOMATIZING FLUID

Several possible sources of the fluid that brought lime into the albitite may be suggested. The fluid may have been formed, for example, during the uralitization of augite in the nearby basic rocks of the Bralorne intrusives or it may have been derived from the younger bodies of granitic rocks in the area which are described by Cairnes (1937, pp. 37–39). However, it may be significant that bodies of lime-bearing silicate minerals such as grossularite, idocrase, prehnite, diopside, zoisite, and epidote have been formed as veins and as replacements of other rocks *within serpentinized ultramafics* in many parts of the world (see Benson, 1914, pp. 682–687 and 1918, pp. 722–723; Cooper, 1936, pp. 31–34; Flett and Hill, 1912, pp. 115, 143; Graham, 1917, pp. 174–176; Grange, 1927; and Turner, 1933, pp. 269–271. Benson (1918) and Turner refer to many ad-

[1] Barth (1952, p. 82) has found that "In most rocks oxygen makes up about 94 per cent by volume; all cations taken together (silicon and metals) make up less than 6 per cent by volume." He concludes that " . . . it is reasonable to suppose that the mechanism of . . . isovolumetric alterations is that of a migration and exchange of cations in a medium composed of relatively stationary oxygen ions" (1948, p. 50). He has proposed using as a standard of comparison in isovolumetric changes the standard cell which is defined as "a rock volume containing exactly 160 oxygen ions" (1948, p. 51). "The sum of the cations (silicon and metals) associated with this unit is very nearly 100 in all ordinary rock types" (1948, p. 50).

ditional occurrences). Some writers have postulated that lime becomes concentrated in a residual fluid during crystallization of an ultramafic magma. Others have postulated that conversion of clinopyroxene to serpentine in some peridotites would yield lime that may subsequently enter the new lime-bearing silicates.

The latter hypothesis is considered satisfactory to explain the prehnitization of the albitite near Gold Bridge for the following reasons:

1. The rock in which the dike occurs is now completely serpentinized, but it contains possible pseudomorphs of clinopyroxene.
2. A relatively unaltered part of the same ultramafic body contains diopside.[2]
3. The most common varieties of relatively fresh ultramafics in the district are peridotites containing diallage or enstatite or both (Cairnes, 1937, p. 28).
4. The lime content of a sample of serpentinized peridotite from the area is 3.85% but the contents of two samples of serpentine are only 0.22% and 0.30% (Cairnes, 1937, p. 29).[3]

Conclusion

Field and microscopic observations show that the prehnite and diopside have formed by replacement of albitite. It is possible that the lime necessary for this change has been yielded by the serpentinization of clinopyroxene-bearing peridotite.

Acknowledgments

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[2] J. S. Stevenson. Personal communication, February 27, 1950.

[3] Cairnes mentions the presence of carbonate in two of these rocks but its effect on the lime content must be small. The average lherzolite and wehrlite of Daly (1933, p. 20) contain 3.57% and 7.48% of lime respectively.

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