Rhodonite from the Bridge River Assemblage, Downton Creek (NTS 092J/09), Southwestern British Columbia

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KEYWORDS: industrial minerals, rhodonite, sedimentary manganese minerals, chert, rhodochrosite, kutnohorite, cobaltite, gersdorffite, ullmannite, tucekite, replacement mineralization

INTRODUCTION

A new rhodonite occurrence was discovered in the Downton Creek area, about 20 km west of Lillooet (Fig 1). Prospector G. Polischuk of Lillooet made the discovery while carrying out work between 1996 and 1999, under a 1995–1996 Prospector's Grant. Float in Downton Creek was traced to an outcrop in a small unnamed northern tributary, and subsequent staking of two mineral claims, Southern Gem 1 and 2, covered the rhodonite outcrops.

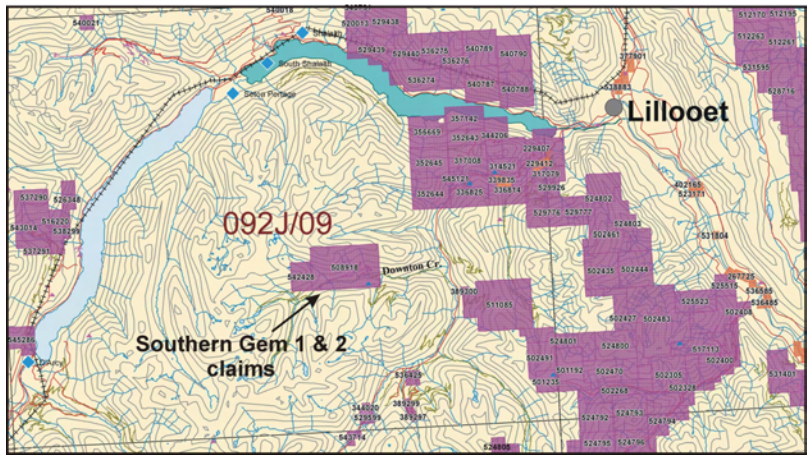

Figure 1. Location of rhodonite occurrence on Downton Creek, near Lilooet.

Samples of Downton Creek rhodonite differ from those studied from similar showings in British Columbia (Nelson *et al.*, 1990; Simandl and Church, 1996; Hora *et al.*, 2005). Hydrothermal replacement of the Downton Creek rhodonite has completely destroyed its original banded structure.

Based upon petrographic textures, it appears that rhodonite grains first recrystallized into automorphic shapes and, during later hydrothermal alteration, were replaced by Mn carbonates and finally quartz. Veinlets rich in Ni-Co-Sb-As sulphides, together with a Bi-Te mineral, indicate a fluid contribution from a source other than the Mn protolith.

ANALYTICAL PROCEDURES

Analytical procedures were similar to those reported in Hora *et al.* (2005). The only difference is that, in order to study the base metal minerals, a beam diameter of approximately 2 µm, an accelerating potential of 20 KeV and a beam current 10 nA was used. Nine new standards were used: marcasite, GaAs, Ni, Co, Mn_3O_4, Ag, Bi_2SO_3, pyrite and stibnite.

GEOLOGY

The Downton Creek rhodonite occurrence is located along the Downton Creek fault in the central Cayoosh Range. It occurs within the Eastern assemblage of the Bridge River Complex (Journeay and Northcote, 1992), which consists primarily of sheared greenstone, serpentinite, chert and fine-grained volcaniclastic rocks (Journeay, 1993).

Rhodonite occurs in slabs of up to 30 cm^2 in association with cherty quartzite and greenstone (G. Polischuk, pers comm, 2006). Quartz veining with arsenopyrite, pyrite and chalcopyrite is common along faults and shear zones that are exposed in logging-road cuts (Polischuk, 1999).

Between the Duffy Lake road and Anderson Lake, the northwest-trending Downton Creek fault marks the boundary between two facies of the Bridge River assemblage, a coherent greenstone-chert argillite in the west and sheared greenstone-chert mélange in the east. The fault cuts the overturned limb of a regional southwest-verging syncline and associated thrust faults in the Downton Creek headwater region (Journeay *et al.*, 1992).

MINERALOGY

The dominant mineral in the samples studied is typically pink rhodonite. Compared to similar samples from Arthur Point, near Bella Coola, it is coarser grained (up to 1 mm) with frequent automorphic-shaped pinacoidal crystals (Fig 2, 3).

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The crystals grow into the cavities, which were later filled with vein quartz (Fig 4, 5). Quartz replaces rhodonite crystals so that, in some samples, only fragments of the original columnal rhodonite crystals remain (Fig 6, 7, 8). The chemical composition of rhodonite is almost pure $MnSiO_3$ (Table 1), except for Ca, which may constitute from 1 to 7 wt. % of the mineral formula (as CaO). Taken together, the remaining elements form less than 1 wt%. Elevated Zn (0.11%) is common in rhodonite associated with chert (Crerar *et al.*, 1982) and correlates positively with FeO.

The second most common mineral in Downton Creek rhodonite samples is quartz, which is the latest hydrothermal mineral, replacing all other mineral phases. Quartz veinlets cut along cleavage and pressure fractures in rhodonite crystals (Fig 4, 5) and display undulatory extinction (Fig 9). Whether the quartz is a product of the transformation of rhodonite to rhodochrosite, or a product of some other hydrothermal event, has not been established.

A relatively common component of the sample is kutnohorite $Ca(Mn, Mg, Fe)(CO_2)_2$ (*see* x-ray diffraction record, Fig 10) which is present as greyish pink aggregates of xenomorphic grains approximately 0.05 mm in diameter (Fig 11, 12). Compared to the kutnohorite from a classical occurrence (Frondel and Bauer, 1955; Trdlička and Ševců, 1968), the Downton Creek samples have lower contents of MgO and FeO (Table 1). Their unusual composition may be explained by formation via replacement of rhodonite.

Veinlets and aggregates of kutnohorite (Fig 11, 12) penetrate into rhodonite along cleavage and boundaries of adjacent crystals. In some samples, kutnohorite is replaced by quartz (Fig 5). Rhodochrosite occurs in veinlets and aggregates up to 100 µm in size (Fig 13, 14), locally with manganocalcite. Both are later than rhodonite, but earlier than kutnohorite and quartz. Relics of manganocalcite and rhodochrosite (Fig 3) within quartz and along rims of rhodonite suggest that rhodonite was originally replaced by both, followed by quartz replacement.

Figure 2. Automorphic rhodonite crystals in quartz-filled vugs, with quartz partially replacing rhodonite; cross-polarized light.

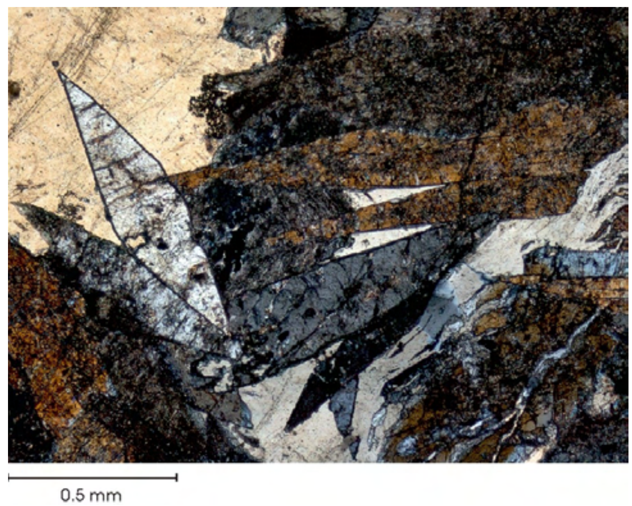

Figure 4. Automorphic crystals of rhodonite (1 mm in size) in quartz filled vug; quartz also penetrates rhodonite along fractures and cleavage planes; cross-polarized light.

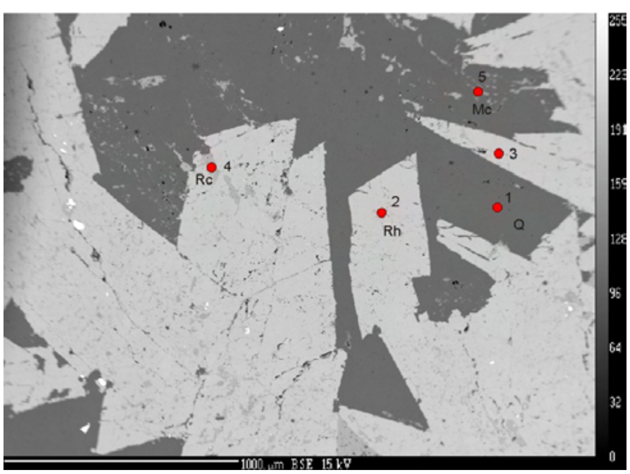

Figure 3. Same as Figure 2, showing rhodonite (Rh) being replaced by rhodochrosite (Rc) and successively by quartz (Q); white grains are ore minerals (sulphides of the niccolite-cobaltite-skutterudite group); back-scattered electron image with location of microprobe tests.

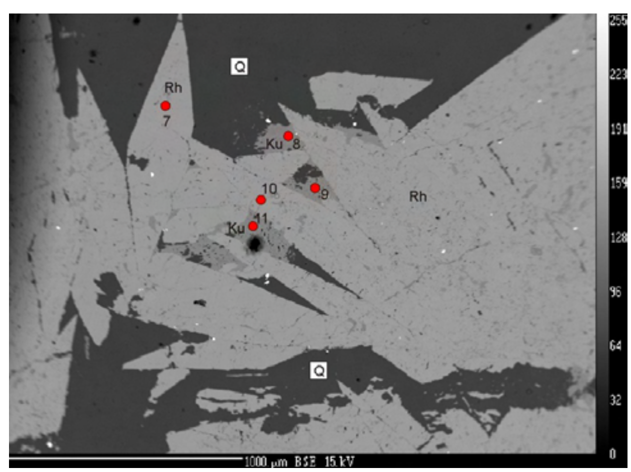

Figure 5. Same as Figure 4, with rhodonite (Rh) being replaced by kutnohorite (Ku); ore minerals (white grains) are irregularly dispersed, mainly in rhodonite; back-scattered electron image with location of microprobe tests.

Cobaltite (CoAsS), gersdorffite (NiAsS), ullmannite (NiSbS) and tucekite ($Ni_9Sb_2S_8$) all occur as tiny grains (up

Figure 6. Skeletal arrangement of rhodonite crystals partially replaced by quartz; cross-polarized light.

Figure 7. Same as Figure 6, in plane-polarized light.

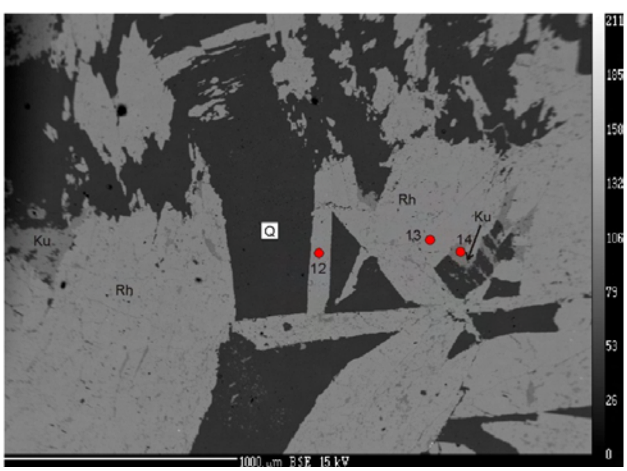

Figure 8. Same as Figures 6 and 7, with quartz (Q) replacing rhodonite (Rh) and kutnohorite (Ku); back-scattered electron image with locations of microprobe tests.

to 2 µm) along fractures in rhodonite and less commonly in quartz (Table 2; Fig 2, 5). Some grains exhibit zoning (Fig 15).

A grey metallic mineral containing 48.69% Bi, 36.58% Te, 2.91% Ni and 0.21% Se could not be identified with certainty due to its tiny grain size (less than 2 µm). Its chemical composition is suggestive of tetradymite affinity.

TABLE 1. SELECTED ANALYSES OF MINERALS FROM DOWNTON CREEK RHODONITE OCCURRENCE.

Element (wt%)	Cobaltite		Gersdorffite		Ullman-ite	Tučekite	
Fe	0.05	0.19	0.09	0.22	0.01	0.85	0.10
Ni	2.49	5.63	35.10	31.00	27.57	48.74	46.34
Co	31.50	28.96	0.20	3.80	0.26	2.15	4.75
Sb	0.17	0.49	3.91	4.50	52.20	22.37	17.11
Mn	0.44	1.89	0.91	0.80	0.57	1.31	2.14
Ag	0.44	0.00	0.00	0.00	0.02	0.00	0.00
Bi	0.00	0.00	0.06	0.00	0.19	0.06	0.00
As	42.21	43.67	41.65	40.08	4.26	0.62	2.73
S	20.48	19.80	18.96	19.39	15.24	24.84	25.82
Total	97.78	100.63	100.88	99.79	100.32	100.94	98.99

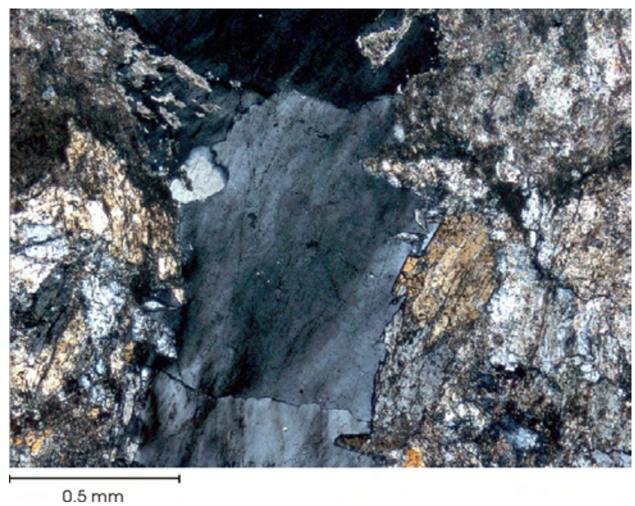

Figure 9. Rhodonite replaced by quartz with undulatory extinction; cross-polarized light.

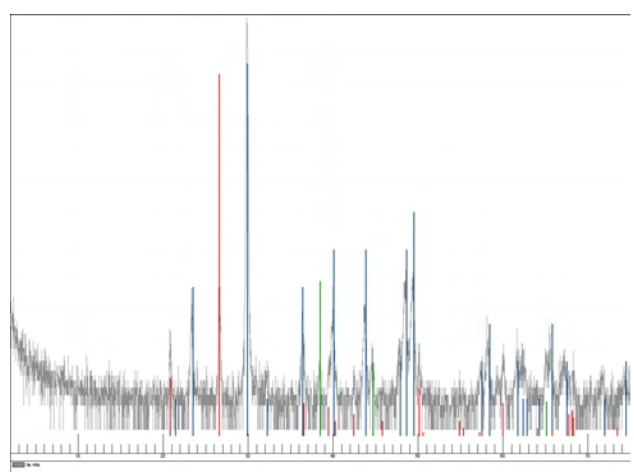

Figure 10. X-ray diffraction record of calcian kutnohorite (blue, kutnohorite; red, quartz; green, alumina holder).

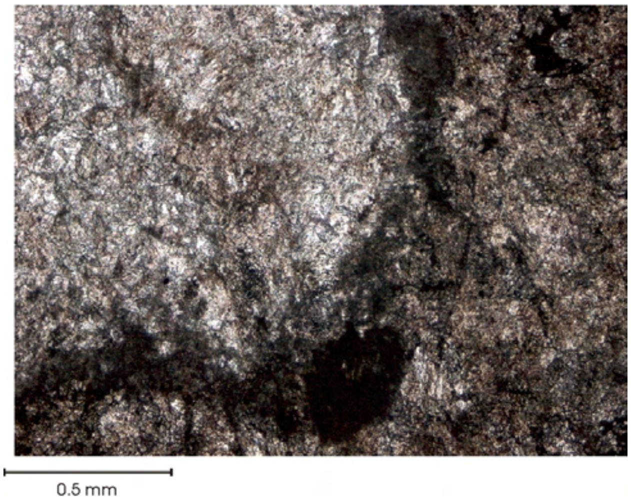

Figure 11. Fine-grained rhodonite (darker) is replaced by rhodochrosite (lighter); boundary between the two is formed by quartz; plane-polarized light.

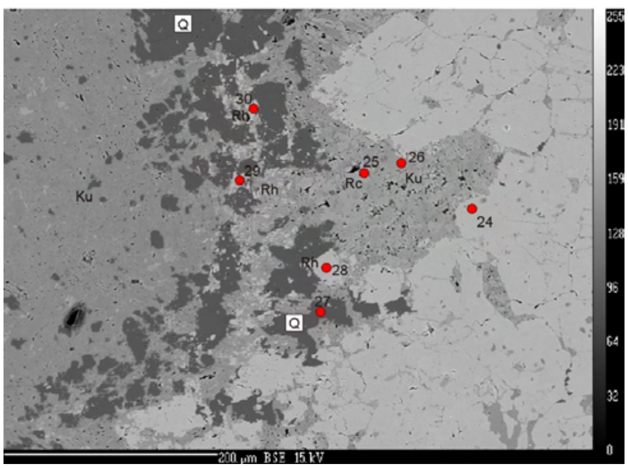

Figure 12. Same view as in Figure 11, showing the manganese carbonates rhodochrosite (Rc) and kutnohorite (Ku) replacing rhodonite (Rh), which results in the silica component being freed from the rhodonite as quartz (Q); back-scattered electron image with location of microprobe tests.

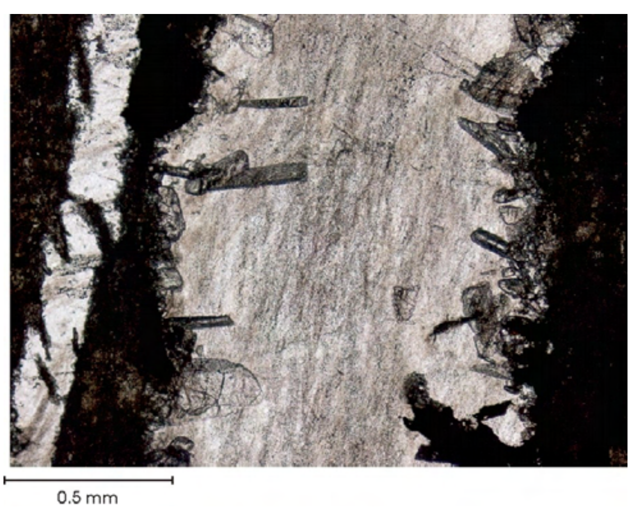

Figure 13. Ladder arrangement of partially replaced rhodonite crystals in a quartz vein; plane polarized light.

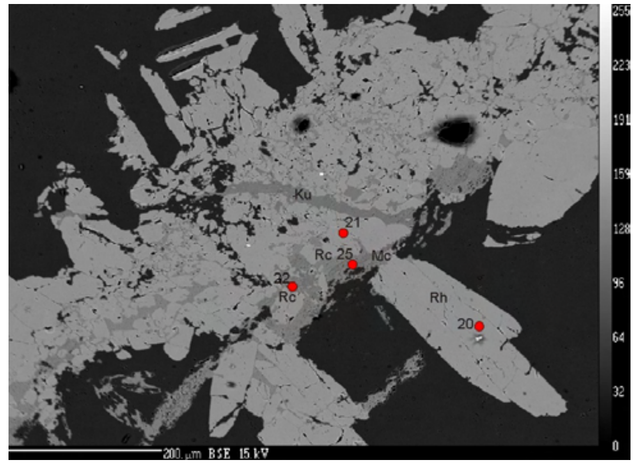

Figure 14. Rhodonite ‘ladder’ arrangement in detail: rhodonite (Rh), rhodochrosite (Rc), kutnohorite (Ku) and Mn calcite (Mc) are replaced by quartz (Q); back-scattered electron image with location of microprobe tests.

SUMMARY

The rhodonite sample from Downton Creek is significantly distinct from material described earlier from Arthur Point. Extensive hydrothermal replacement of the Downton Creek rhodonite has destroyed all original banding within the protolith. Rhodonite was recrystallized into idiomorphic grains, and was subsequently replaced by Mn carbonate and finally by quartz.

The occurrence of Ni-Co-Sb-As minerals together with Bi-Te minerals is unusual in rhodonite deposits. The Bi-Te minerals are common accessory minerals in mesothermal lode gold deposits and are known from the Bridge River camp (Cairnes, 1937). Free gold has also been recovered from the adjacent Raven claims (G. Polischuk, pers comm, 2006). Similar associations of minerals of Ni and Co are known as coproducts of serpentinization, occurring as veins within rodingite rims of serpentinite bodies in both Morocco (Leblanc and Billaud, 1982) and the Italian Alps (Castelli and Rosetti, 1994). The proximity of this rhodonite showing to a major fault and its association with greenstone-serpentine mélange suggest that the Ni-Co minerals were mobilized from the oceanic crust and mantle facies of the Bridge River assemblage.

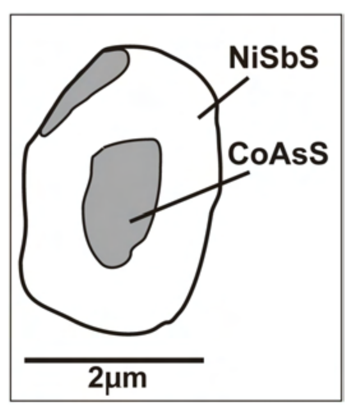

Figure 15. Example of zoning in ore mineral, with cobaltite surrounded by ullmannite.

TABLE 2. SELECTED ANALYSES OF DISSEMINATED ORE MINERALS FROM DOWNTON CREEK RHODONITE OCCURRENCE.

	Rhodonite			Rhodochrosite			Kutnohorite		Mn calcite	
Sample	1	1	2	1	2	2	1	1	1	1
Text figure	3	5	11	3	13	11	5	8	3 (ni)	13
Analyses	2	7	24	4	22	25	8	14	5	18
Oxide (wt%):										
SiO_2	46.97	47.40	46.73	0.08	0.00	0.01	0.00	0.01	0.13	0.03
TiO_2	0.00	0.02	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Al_2O_3	0.02	0.00	0.03	0.00	0.03	0.02	0.00	0.04	0.00	0.01
Cr_2O_3	0.00	0.03	0.00	0.06	0.00	0.00	0.03	0.04	0.12	0.00
FeO	0.60	0.36	0.22	0.06	0.00	0.00	0.00	0.12	0.00	0.10
MgO	0.67	0.22	0.37	0.55	0.49	0.38	0.22	0.24	0.22	0.43
MnO	43.28	43.75	45.48	52.28	50.28	48.60	44.60	46.78	24.26	38.22
CaO	7.17	7.43	7.17	6.24	8.22	9.80	12.69	12.86	36.00	18.99
ZnO	0.11	0.00	0.01	0.00	0.00	0.00	0.00	0.09	0.00	0.00
BaO	0.00	0.00	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Na_2O	0.00	0.00	0.03	0.00	0.01	0.01	0.01	0.00	0.00	0.00
K_2O	0.00	0.02	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.01
Total	98.82	99.23	100.13	59.27	59.06	58.82	57.60	60.18	60.73	57.79

Abbreviation: ni, not included

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