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Property File
013029 092M 015
Sea Rose

Anthony G Karup
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Bella Coola
British Columbia VOTICO
CANADA

Your reference

Our reference RRH/ke

Date 15 June 1988

Dear Mr Karup

We have recently carried out some analyses on the rhodonite from the Sea Rose Mine that you so kindly donated to the Museum and I thought you would like to know the results.

X-ray diffraction work was carried out on different parts of a banded piece of rough rhodonite and the conclusions are:

X6950F: deep pink massive	rhodonite
X6928F: pale grey-green massive	quartz (chalcedony)
X6927F: brownish-yellow massive	garnet (near spessartine)
X6926F: dull black, metallic aspect	rhodonite

The analysts were J G Francis and S Somogyi

The reason for the X6926F result was puzzling so polished thin sections of black and pink regions of one of the slabs were made and examined under the microscope and by microprobe. The areas which appear black in hand specimen are brown in thin section (30μm thick). The brown areas comprise grains of rhodonite about 3μm across tinted with brown alteration product. The analyses of the black and pink rhodonite are the same, there is no excess Mn or Fe, detectable by the microprobe, in the black rhodonite. So although there is still no obvious cause for the black colouration, we suspect that manganese oxides in quantities too small for the probe to detect are responsible. An analysis of the calcite from a cross-cutting vein indicates that it contains about 9% MnO. The microprobe analyses were carried out by Ms F Wall.

A selection of rough and polished rhodonite from the Sea Rose Mine is now on show in the Geological Museum next to the two cabochons of Yukon material, and they do make a significant addition to the showcase.

You may be interested to know that we have also just analysed a carving of argillite from the Queen Charlotte Islands. It is a panel pipe depicting Haida Indian symbols and we found that its main constituent is pyrophyllite with minor quantities of kaolinite, boehmite, some quartz and feldspar. It came to the Museum in 1868 but was out of public view until now, and as soon as a label is printed it too will be put on show.

With all best wishes

Yours sincerely

Roger Harding

R R Harding

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A G Karup
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Your reference
Our reference RRH/ke
Date 13 June 1989

Dear Mr Karup

Many thanks for the specimen of rhodonite from the Sea Rose Mine. It is a fine display piece showing the colour banding and veining. I apologise for the delay in writing to you but following your letter earlier this year I expected to see you in April and thought you may just have had to postpone your visit.

I have been doing some detailed analysis of the minerals associated with the rhodonite and in addition to the quartz, carbonate and garnet, have identified barytes. This occurs as small grains intergrown with rhodonite or quartz and also as small pockets of crystals.

I would like to present the results of the mineral analyses at an international gem conference in Milan in September and would be grateful if you would permit me to do this. Also if you did have a transparency of the mine or a geological sketch map it would be a great help in setting the scene for the talk if I could borrow them.

Sorry not to have seen you in April, but I hope everything goes well with you, and I hope to hear from you soon.

Yours sincerely

Roger Harding

R R Harding

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A G Karup Esq
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Your reference
Our reference RRH/ke
Date 14 September 1989

Dear Mr Karup

Many thanks for the loan of your photographs; it was interesting to see the situation of the Sea Rose Mine and the means of extracting the rhodonite boulders. Thank you also for the copies of the geological reports which helped with assessing the origin of the rhodonite and possible comparisons elsewhere. They will be useful if I get detailed questions concerning the geology of the west coast.

I enclose a copy of the paper to be presented in Milan and hope it meets with your approval. You will appreciate that I couldn't go into much geological detail, not having visited the area, so I concentrated on the compositional and mineralogical aspects. I hope you find the acknowledgements satisfactory but if not, please let me know.

With all best wishes

Yours sincerely

Roger Harding

R R Harding
Department of Mineralogy

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Rhodonite and argillite from British Columbia, Canada

by

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ABSTRACT

Rhodonite from the Sea Rose Mine, Bella Coola, British Columbia, is being currently mined and used in jewellery. Microprobe and X-ray determinations have been made of the rhodonite and its associated minerals which include quartz, manganoan calcite, spessartine garnet and barytes. Microprobe and X-ray methods have also been applied to black carved argillite from the Queen Charlotte Islands, British Columbia, and have established that the specimen on display in the Geological Museum (British Museum (Natural History)) is composed largely of pyrophyllite.

INTRODUCTION

When the British Museum (Natural History) and the Geological Museum merged in 1985 it brought together two major collections of minerals. The larger of the two in the Mineral Gallery comprised 180 000 specimens and contained particularly fine examples from overseas, while the Geological Museum collection of 70 000 specimens concentrated more on British minerals. Nevertheless there was considerable overlap in species and localities represented. Both have been well-curated and are accessible through registers and card indexes of species, locality, accession date, and donor; there is also a separate index for gems in each collection. To further improve accessibility and to enable more extensive practical use of the collections however it was decided to transfer the specimen data on to computer and at the same time to physically merge the specimens; this is now under way.

In effect this is a stock-taking operation and inevitably in reviewing collections of this size one encounters specimens, especially from the last century, which are appropriate for further investigation by modern analytical techniques. At the same time, material is being continually added to the collection both by purchase and by donation. This paper illustrates these aspects of the 'life' of the collection with two examples from western Canada, a 19th century carving in black argillite and rhodonite from a new mine at Bella Coola.

ARGILLITE

In the Mineral Inventory of the Geological Museum an item was entered on 18th January 1868 as follows: "An Indian pipe 18 1/2" long elaborately carved with grotesque figures, in black slate." (Fig. 1). It was purchased from Messrs Valentine and Co., and in the "Remarks" column appears "probably Mexican workmanship". At some later date not known to us, it was realised that the remarks were in error because on the label accompanying the specimen is typed "Probably from Queen Charlotte Islands".

The Queen Charlotte islands are located off the coast of British Columbia 600-800 km NW of Vancouver (Fig. 2), and until new settlements about 90 years ago, were exclusively occupied by Indians of the Haida tribe. The Haida have been there for centuries if not thousands of years and have developed a remarkable skill in carving. One of the materials they use is the black slate which they call argillite, and a book describing this material and how it is used was written by Drew and Wilson and published in 1980. Carvings in argillite in this style come only from this area so there is no reasonable doubt as to the source of the specimen in the museum.

The two main islands of the Queen Charlottes, Graham Island in the north and Moresby Island are separated by a narrow east-west channel, and the source of the material carved is just north of this channel at a locality appropriately called Slatechuck. This lies about 300 m above sea level in a sequence of sandstones and shales of Cretaceous age (Drew and Wilson 1980, p 43), which were baked and hardened to some degree by volcanic activity in the Tertiary period. The material at Slatechuck is composed of kaolin and carbonaceous matter and is unusual in that quartz and feldspar are absent (op. cit. p 43).

The term argillite is used by geologists to describe an indurated unlaminated mudstone and the material of the carving in the museum is consistent with this broad description. Its precise composition was however not known and in order to obtain the correct information to put on a display label, it was investigated using X-ray diffraction and electron microprobe techniques.

Powder samples from each end of the pipe were examined and at the mouthpiece the X-ray film (X6960F) indicates major pyrophyllite with serpentine and some boehmite and quartz. At the opposite (broad) end, one sample (X6961F) contained pyrophyllite, serpentine and boehmite and another contained these minerals with a trace of carbonate.

From the middle of the pipe a fragment, 8 mm long and polished on one side, was examined in a Hitachi SEM fitted with a Link Systems EDS and computer (Fig. 3). It consists essentially of the aluminium silicate mineral pyrophyllite (dull grey in Fig. 3), and berthierine, an iron-rich serpentine (white). Small amounts of chalcosine (Cu_2S) are also present in the pyrophyllite as grains 1μm or less in diameter (tiny white specks in Fig. 3).

A fractured unpolished surface of argillite was also examined in a Cambridjge Instruments Microscan IX fitted with a multilayer synthetic crystal to determine the nature of the carbonaceous matter. Oxygen and carbon peaks were obtained, and the exact position of the carbon peak was compared with those for standard graphite, for carbonate and for epoxy resin. The argillite carbon peak is intermediate between those for graphite and carbonate, and closest to that for the resin. However, an infrared spectrum of the argillite revealed no evidence of C-H bonds and it is concluded that less than 1% organic carbon is present. The most likely explanation of the data is that the carbon is present in the form of graphite mixed with a little carbonate.

Pyrophyllite, $Al_4(Si_8O_{20})(OH)_4$, has a higher Si/Al ratio and lower OH content than kaolinite, $Al_4(Si_4O_{10})(OH)_8$. In weight percentage terms pyrophyllite has about 65% SiO_2, 28% Al_2O_3 and 6% H_2O. In their book Drew and Wilson (op. cit. p 52) published an old analysis of argillite (the whole rock) which included 46% SiO_2 and 39% Al_2O_3, values closer to those of kaolin than pyrophyllite, and it may well be that the Slatechuck argillite is variable in its composition and mineralogy. However the apparent coincidence of the old analysis with kaolin was not checked by X-ray determination and this bulk composition is also consistent with a pyrophyllite-boehmite (γ-AlO(OH)) mixture, so the presence of kaolin still has to be established.

The results of laboratory experiments suggest that with a SiO_2-Al_2O_3 mixture of kaolinite proportions and water, kaolinite will form at low temperatures and pressures, but at moderate pressures and at 350°C or above, the stable assemblage is pyrophyllite and boehmite. This is consistent with the composition of the museum argillite and the geological evidence of the Slatechuck sediments, which suggests that they underwent baking from volcanoes of Tertiary age.

The argillite has a specific gravity of about 2.6 and a hardness between 2 and 3. Its fracture is conchoidal and carvers like to work it wet with tempered steel files. The finish may be a matt dark grey or a shiny black. In some pieces this may be obtained by prolonged rubbing with thumb and forefinger but others may be stained with graphite stove polish (Sinkankas, 1959 p 571). The presence in the rock of both graphite and chalcosine, although only minor, could only assist in this kind of polishing.

The carvers consider that plates are the easiest objects to make, while the finest and most intricate are the panel pipes. They depict subjects such as whale, raven, bear, eagle and other creatures which inhabit the forests and seas around them.

RHODONITE

The country inland from Bella Coola is rugged and tree-covered, and it was in exposed rocks on the shoreline of one of the many inlets that rhodonite was discovered in 1984. In 1987 Mr A G Karup visited the Geological Museum and after seeing the range of rhodonite on display offered to present specimens from the new discovery (Fig. 4).

The rhodonite extends for 45 m along the shoreline of Rivers Inlet, has a vertical extent of 15 m, and is interbedded with steeply-dipping cherts which strike NW-SE. To date only reconnaissance geological mapping has been carried out in the area. However preliminary conclusions suggest that the association of rhodonite and chert is similar to that found in the Sicker Group rocks of Vancouver Island (Sinkankas, 1976 p 182; A.G. Karup, personal communication). The Sicker Group is possibly 3-4000 m thick and consists of cherts at the base (upper Devonian) extending up through epiclastic sediments (Carboniferous) to bioclastic limestones of lower Permian age at the top. It is not yet clear if the Rivers Inlet rocks are related to Duck Creek Formation cherts near the base of the Sicker Group, or to the Cameron River Formation near the top. The reconnaissance mapping suggests that the cherts and rhodonite are part of a roof pendant in the Coast Range Batholith.

The rhodonite shows considerable variation in colour and texture and it was to describe these as accurately as possible for exhibition purposes that samples were analysed by electron microprobe and X-ray diffraction. The specimens consist of various banded mixtures of pink, black, grey or yellow minerals and these are commonly cut by pink, white or black veins.

X-ray powder films of scrapings of pink and black minerals were made and both showed only the rhodonite pattern. A third film of black material was made and again the pattern obtained showed no significant differences from the pink rhodonite. In polished thin sections the predominant grain size of pink and black material is about 3μm the section being colourless where the specimen is pink, and pale brown where the specimen is black. Microprobe analyses of rhodonite from both colour areas are not significantly different and are grouped in Table 1.

The yellow areas are predominantly garnet, again in granular masses with an average grain size of 3μm; but where there is intergrowth with rhodonite the garnet may assume a skeletal form. It varies somewhat in composition and the range and mean are given in Table 1. To further illustrate the variation in terms of end-members of the garnet solid-solution series, 3 analyses have been selected and calculated according to the procedure proposed by Rickwood (1968).

The dominant end-member component is spessartine and there is a consistent minor content of andradite; grossular, blythite ($Mn_3Mn_2Si_3O_{12}$) and yamatoite ($Mn_3V_2Si_3O_{12}$) components are present in some parts of the rock but not others.

The grey bands in the rhodonite may be quartz or barytes, again very fine-grained. The barytes contain between 1 and 4% SrO, and less than 1% each of Na_2O and SiO_2. Small white or pinkish white pods or veins in the rhodonite consist of calcite or manganoan calcite with up to 11% MnO (equivalent to $(Ca_{0.85}Mn_{0.15})CO_3$).

The rhodonite is extracted by digger and the mine site is known as the Sea Rose Mine (Fig. 5). About 200 tonnes of prime rhodonite have been removed since 1984 and the rate of extraction has increased recently. Some material is of very fine quality and examples of top-grade rhodonite are shown in Fig. 6.

The mean specific gravity of 3 specimens of rhodonite was found to be 3.60, although with different contents of quartz (2.65), carbonate (2.77-2.80), garnet (4.1) and barytes (4.4) considerable variation may be expected. Some pieces are also more porous than others. On the refractometer, polished rhodonite gives a poorly-defined shadow edge at 1.73. The top-grade rhodonite shows a strong absorption spectrum shown schematically in Fig. 7).

Table 1. Electron microprobe analyses of rhodonite and garnet from the Sea Rose Mine, Rivers Inlet, B.C.

	Rhodonite		Garnet	
Wt%	Range	Mean(9)	Range	Mean(6)
MgO	0 - 1.5	0.56	b.d.	b.d.
Al_2O_3	b.d.	b.d.	17.2-20.9	18.90
SiO_2	45.0-49.4	46.48	34.4-36.5	35.42
CaO	5.6- 6.7	6.10	3.4-10.6	6.86
TiO_2	b.d.	b.d.	0 - 0.6	0.29
V_2O_3	b.d.	b.d.	0 - 3.3	0.54
MnO	42.1-48.0	46.21	30.7-39.6	35.52
FeO	0.7- 1.0	0.83	0.5- 3.6	1.54
SrO	0- 0.6	0.39	0- 0.5	0.25
Total		100.57		99.32

Notes: The analyses were obtained using a Hitachi SEM with Link Systems EDS and computer; set at an accelerating voltage of 15kV and specimen current of $1x10^{-9}$ amp. Metal, oxide and silicate standards were used and the limit of detection of an oxide ranges from 0.1-0.4% depending on the mineral. Total Mn and Fe are given as MnO and FeO although there will be small amounts of Mn_2O_3 and Fe_2O_3 in some garnet analyses. b.d. means below detection.

Table 2. Compositions of 3 garnet grains in terms of end-members

Spessartine	73	92	77	$Mn_3Al_2Si_3O_{12}$
Grossular	14	0	8	$Ca_3Al_2Si_3O_{12}$
Andradite	13	6	4	$Ca_3Fe_2Si_3O_{12}$
Blythite	0	2	0	$Mn_3Mn_2Si_3O_{12}$
Yamatoite	0	0	11	$Mn_3V_2Si_3O_{12}$

CONCLUSIONS

The argillite specimen in the Museum consists largely of pyrophyllite with some iron serpentine. The cause of its black colour has not been established but it is likely to be due to small contents of graphite and chalcocite, the latter being described as 'sooty' when fine-grained by Hurlbut and Klein (1977). No iron oxides were found in the rock and the 8.46% peroxide of iron reported in the analysis quoted by Drew and Wilson (1980, p 52) can be accounted for by the iron-rich serpentine berthierine.

The rhodonite is predominantly a fine-grained granular assemblage with variable amounts of quartz, spessartine garnet, barytes and carbonate. Coarser veins of rhodonite and carbonate cut the massive rhodonite and are perhaps evidence of hydrothermal activity and partial reworking of the deposit.

In the context of the Museum collections these specimens are now sufficiently characterised and summaries of the data described above will be stored on computer. Provided resources are adequate the transfer of data to computer and the physical merge of all the specimens in the collections should be complete by 1998.

ACKNOWLEDGEMENTS

A G Karup has been most generous in supplying specimens for study and display in the Museum; I also thank him for pictures and recent geological information. I am grateful to F Greenaway for photographs, to S Somogyi and J G Francis for X-ray data, to G C Jones for infrared work, to C G Jones and A H J Wighton for making polished sections, to Frances Wall for the Microscan IX analyses, and to her and Dr C T Williams for considerable assistance with the Hitachi SEM. I would also like to acknowledge R W Sanderson's part in making the argillite carving fit for exhibition.

REFERENCES

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FIGURE CAPTIONS

Fig. 1 Haida Indian panel pipe carved in argillite (specimen number BM 1985 MI 1533). Photo: F Greenaway.

Fig. 2 Sketch map of coast of British Columbia showing places referred to in the text.

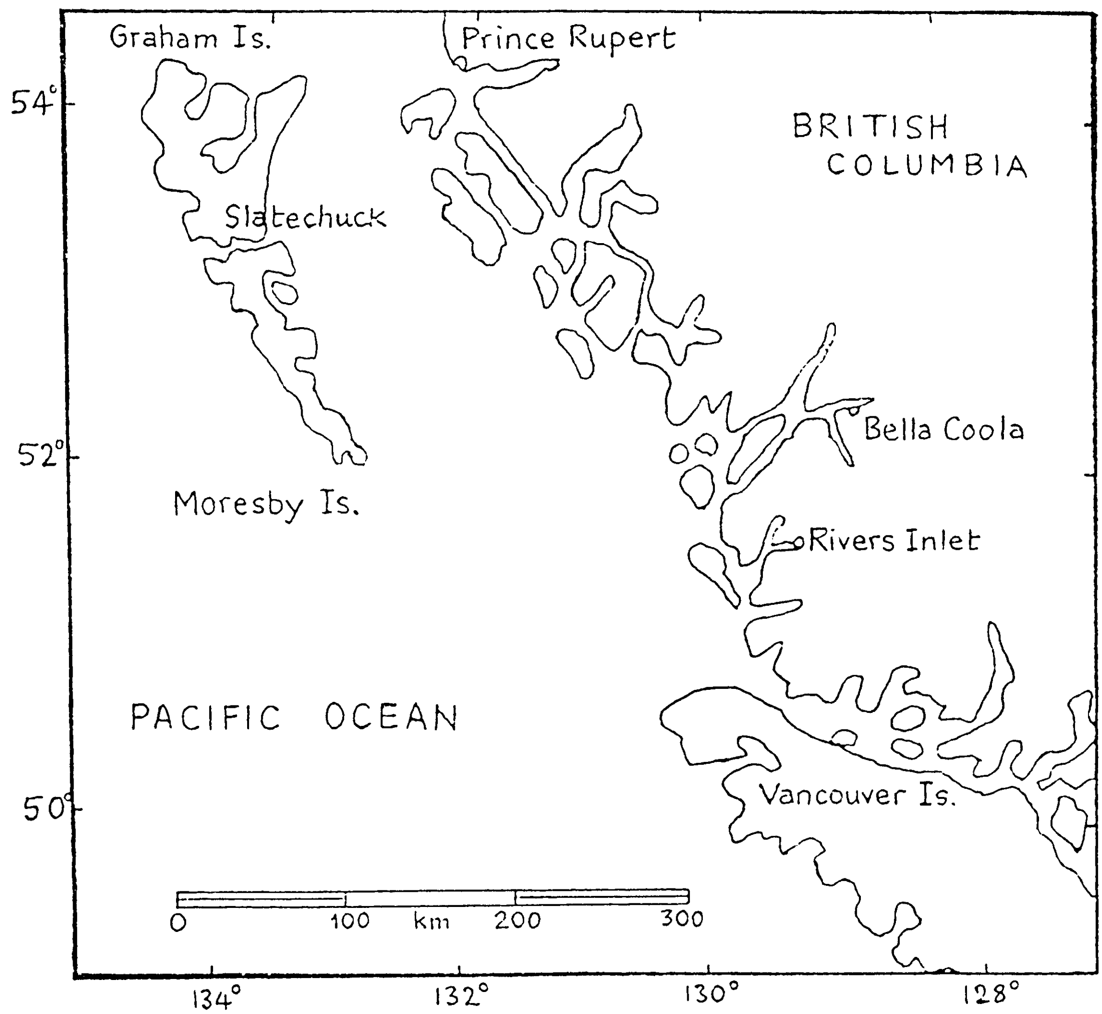
Fig. 3 Fragment of argillite from Haida panel pipe showing incised carved pattern near base and two sets of polishing lines, the curved overlain by the straight (north-south). This is a backscattered electron image (sensitive to atomic number differences in the material) showing pyrophyllite as dull grey with scattered irregularly-shaped grains of berthierine (white).

Fig. 4 Rhodonite from the Sea Rose Mine, Rivers Inlet. A massive, fine-grained mixture of rhodonite, garnet and quartz is cut by veins of pink rhodonite, white carbonate and black rhodonite and manganese oxide. Photo: F. Greenaway.

Fig. 5 Rhodonite at the Sea Rose Mine, Rivers Inlet. Photo: A.G. Karup.

Fig. 6 Earrings of top-grade rhodonite from the Sea Rose Mine. Photo: F. Greenaway.

Fig. 7 Absorption spectrum of top-grade rhodonite in earrings.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Prince Rupert
BRITISH COLUMBIA
54°
Slatechuck
Bella Coola
52°
Moresby Is.
Rivers Inlet
PACIFIC OCEAN
Vancouver Is.
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132°
130°
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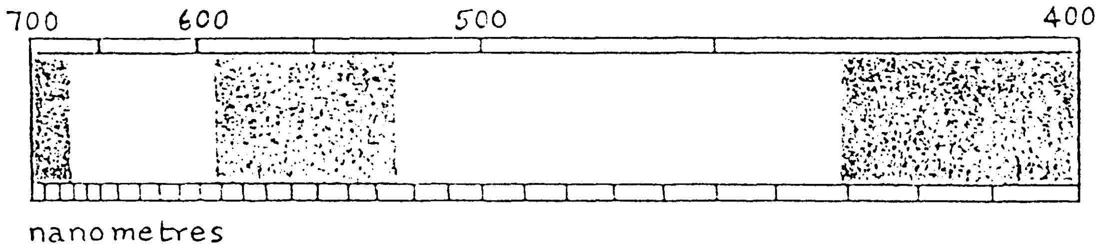

Fig 7.