Note on a chrome and two manganese garnets from India.

By G. G. K. Sastri, M.Sc., D.Sc.

Director of Geology and Mining, Government of Gujarat, Ahmedabad 16, India.

[Taken as read 28 March 1963.]

Summary. Mineralogic data on a chrome garnet, a spessartine, and a spandite from India are presented. The chrome garnet, named *hanléite* by Fermor, carries 89·7 % uvarovite, and is not a distinct mineral. The end-member compositions of the manganese garnets, recast from their chemical analyses, lend support to the existence of *calderite* and *blythite* as garnet end-members.

WHILE engaged in studies on the mineralogy and paragenesis of some Indian garnets, a chrome garnet and two manganese garnets, a spessartine and a spandite, were investigated by the writer. The data are presented here, as they appear to be of interest.

The *chrome garnet* is described as having been collected from near Hanle monastery in Kashmir. It occurs in thin seams in association with chromite, and is made up of minute emerald green dodecahedral crystals. Under the microscope, the garnet has a pale green colour, some grains being anisotropic. Its physical properties are: n 1·840± 0·005, a 11·999±0·005 Å.

Fermor (1952) quotes Mallet for his observation that the mineral, though resembling uvarovite, is different from it. He also quotes an old analysis of the mineral by Tween: SiO_2 41·2, Cr_2O_3 33·5, Al_2O_3, Fe_2O_3, and MgO 24·2, H_2O 1·1 %. By present-day standards, the analysis is unacceptable, and Mallet himself did not think it worthwhile to include it in his *Manual of Geology* (1887, p. 91) and commented that the amount of material that could be devoted to an analysis was not sufficient for a trustworthy result. Surprisingly, Fermor (op. cit.) utilized this analysis, and taking note of the high Cr_2O_3 content and the absence of calcium, proposed the new name, hanléite, for this alleged iron and magnesium garnet.

The analysis quoted does not appear reliable, particularly from the way some of the oxides are grouped together. The high percentage of

Cr_2O_3 is likely to be due to the presence of chromite in the analysed material. Unfortunately, the writer too could not obtain enough material for a complete analysis. The Cr_2O_3 was determined by A. Purushottam as 27·26 % (which would correspond to 89·7 % uvarovite), and he also confirmed the presence of an appreciable percentage of calcium qualitatively. The refractive index and cell-size closely match those of synthetic uvarovite; in view of the marked reduction in the cell-dimensions of grossular occasioned by substitution of Mg or Fe″ for Ca, it is improbable that the mineral contains any appreciable amount of MgO or FeO. It follows that Fermor's hanléite is merely uvarovite.

The *spessartine* is from the West Tirodi manganese mine in Madhya Pradesh and is in the Geological Survey of India collections. It shows coarsely crystalline, orange-yellow aggregates of spessartine associated with rhodonite. In thin sections, the garnet is yellow in colour and isotropic. The grains are fractured, and carry inclusions of microcline, sodic plagioclase, biotite, quartz, and ore.

A concentrate of the garnet for chemical analysis was obtained using the Franz Isodynamic Separator and a centrifuge. This was finally checked under the microscope to ensure absolute purity. The physical properties and chemical composition of the spessartine are presented in table I. In the calculation of the composition of the garnet in terms of the common end-members, Al_2O_3 was not adequate to satisfy the entire MnO to form spessartine, and part of the MnO was calculated as calderite ($Mn_3Fe^{\cdots}_2Si_3O_{12}$).

Calderite is the name originally given by Piddington (1851, p. 148) to what he considered a rock from Kut-Kumsandy in Bihar, India. Fermor (1909, p. 184) recalculated the analysis, assuming the material to be a mixture of 76·97 % garnet and 21·07 % quartz, the garnet itself containing 52·76 % calderite and 19·50 % skiagite ($Fe^{\cdots}_3Fe^{\cdots}_2Si_3O_{12}$). Another garnet from Chargaon, Madhya Pradesh, India, is said to contain calderite and blythite ($Mn^{\cdots}_3Mn^{\cdots}_2Si_3O_{12}$), (Fermor, 1934, p. 340). Vermaas (1951) reported two garnets containing 54 and 35 % of calderite by weight from Southwest Africa.

The specimen under study is reported to be from the Gondite Series of rocks, representing metamorphosed manganiferous sediments, the typical gondite consisting wholly of spessartine and quartz (Fermor, 1909, p. 325).

The *spandite* is from the Kodur quarry in Andhra Pradesh. Fermor (1909, p. 163) used the term spandite for a garnet composed mainly of

TABLE I. Composition and physical properties of Indian garnets.
G. G. K. Sastri, analyst.

	1.	2.
SiO_2 ...	34·85	34·18
TiO_2 ...	0·41	0·41
Al_2O_3 ...	15·70	4·73
Fe_2O_3 ...	8·05	22·96
Mn_2O_3 ...	—	Present
FeO ...	0·18	—
MnO ...	39·45	10·00*
MgO ...	nil	nil
CaO ...	1·95	27·55
H_2O ...	n.d.	n.d.
Total ...	100·59	99·83

	1*a*.		2*a*.	
Si ...	2·932	2·957	2·890	2·915
Ti ...	0·025		0·025	
Al ...	1·554	2·059	0·467	3·000
$Fe^{\cdots}$ ...	0·505		1·460	
$Mn^{\cdots}$ ...	—		0·173	
$Fe^{\cdot\cdot}$ ...	0·015	2·998	—	3·021
$Mn^{\cdot\cdot}$ ...	2·806		0·531	
Mg ...	nil		nil	
Ca ...	0·177		2·490	

Sp. gr. (Obs.)	4·178†	3·749†
Sp. gr. (Calc.)	4·220	3·882
a, Å	11·683‡	11·982‡
n	1·835‖	1·870‖

	1*b*.	2*b*.
Spessartine	75·72 mol %	13·02
Andradite	5·93	73·16
Calderite	17·85	—
Grossular	—	8·86
Blythite	—	4·96
Almandine	0·50	—

* Total Mn as MnO; qualitative tests show that Mn_2O_3 is present.
† ±0·005.
‡ ±0·005 Å.
‖ ±0·005.

1. Spessartine, West Tirodi mine, Madhya Pradesh. Colour orange yellow.
2. Spandite, Kodur quarry, Andhra Pradesh. Colour bright red.
1*a*, 2*a*. Atomic ratios per 12 oxygen.
1*b*, 2*b*. Molecular proportions of garnet end-members.

the spessartine and andradite end-members. The specimen under study is an aggregate of dodecahedral or trapezohedral crystals of garnet, bright red in colour and 1·5 to 2 mm in diameter, cemented by secondary manganese ores.

The solution of the sample in sulphuric and hydrofluoric acids was purplish, approximately the colour of permanganate, indicating the presence of a higher oxide of manganese in the garnet. The physical properties and chemical composition of the spandite are presented in table I. The Al and $Fe^{\cdots}$ are insufficient to balance all the Ca and Mn if the latter is wholly divalent, and in view of the evidence for the presence of $Mn^{\cdots}$, part of the MnO has been reckoned as Mn_2O_3, building up blythite ($Mn_3^{\cdot\cdot}$ $Mn_2^{\cdots}$ Si_3O_{12}).

Other spandites reported are the one containing calderite and skiagite from India (Fermor, 1934, p. 340) and another from Sweden (Lee, 1958, p. 210).

The garnet under study is possibly formed by the metamorphism of calcareous sediments containing manganese as an impurity. The rock is reported to occur as lenses and bands in highly weathered quartzo-feldspathic gneisses of the Khondalitic suite of rocks in close association with metamorphosed calcareous rocks. Fermor (1909, p. 250) grouped the manganiferous rocks under the Kodurite Series; a typical kodurite, according to him, is composed of potash feldspar, spandite, and apatite, with or without pyroxene. He considered the rocks to form an igneous suite with a pronounced enrichment in manganese.

Cross (1914) was the first to disagree with Fermor on the origin of these rocks. Many later workers, on field evidence, regard kodurite as a hybrid rock formed by the assimilation of manganiferous metasediments by a potash-rich granite.

It is of interest to note that Rankama and Sahama (1950, p. 645) mention that trivalent manganese is rare in igneous rocks. The chemical composition of the garnet under study, suspected to contain Mn_2O_3, lends support to the genesis of the kodurites by reconstitution of manganiferous sediments, perhaps induced by the influx of a granite.

Acknowledgements. Dr. A. P. Subramaniam suggested the investigation and read this note, for which the writer is thankful. Thanks are also due to Dr. A. Puru shottam for help and co-operation during the chemical analysis of the specimens and to Mr. Daniel Barker and Miss Bela Csejtey of Princeton University for determining the cell sizes of the uvarovite and the manganese garnets respectively.

References.

Cross (W.), 1914. Journ. Geol., vol. 22, p. 791.
Fermor (L. L.), 1909. Geol. Surv. India Mem., vol. 37, p. 183.
—— 1934. Records Geol. Surv. India., vol. 68, p. 337.
—— 1952. Geol. Mag., vol. 89, p. 145.
Lee (D. E.), 1958. Amer. Min., vol. 43, p. 208.
Mallet (F. R.), 1887. A manual of the geology of India; pt. IV—Mineralogy: Government of India, Calcutta.
Piddington (H.), 1851. Journ. Asiatic Soc. Bengal, vol. 19, p. 145.
Rankama (K.) and Sahama (T. G.), 1950. Geochemistry: Univ. Chicago Press, Chicago.
Vermaas (F. H. S.), 1952. Min. Mag., vol. 29, p. 946.