J.Gemm., 1982, XVIII, 1

FERROAXINITE—ANOTHER NEW GEM FROM SRI LANKA

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INTRODUCTION

Foreign visitors from Fa-Hien in the fifth century A.D. to Robert Knox in the seventeenth century through Arabian Nights to contemporary science-fiction author, Arthur C. Clarke, have referred to the abundance of gemstones in Sri Lanka. As one of the productive localities of valuable gemstones its collection extends to many of the rarer minerals. There is every reason to expect still more new findings in this South-East Asian locality.

During his visit to Sri Lanka in October 1980, one of the authors (M.G.) was shown a parcel of rough stones by courtesy of the firm Many Gems, of Colombo, Sri Lanka. The distinct trichroic effect and the preliminary refractive index determination suggested it to be axinite.

Axinite is known as a mineral typically formed under pneumatolytic conditions. Although it has not yet been reported from Sri Lanka, axinite occurs in the Swiss Alps, Dauphiné in France, in the Ural mountain range of U.S.S.R., in Australia, U.S.A. and Tanzania. Since axinite is easily confused with kornerupine, an x-ray powder diffraction photograph was taken to confirm its authenticity. The lines and intensities were similar to the data published by J.C.P.D.S. (1974). Mineralogical and chemical analyses were carried out and the comparison was done in order to introduce this new finding to the gemmological literature. Three axinites from other origins were selected for comparison (Table 1).

TABLE 1

List of axinites referred to in this paper

1 Ferroaxinite, Thissamaharama, Sri Lanka, present work.
2 Ferroaxinite, Bourg d'Oisons, Dauphiné, France, Jobbins *et al.* (1975).
3 Magnesioaxinite, iron-rich, New South Wales, Australia, Vallance, (1966).
4 Magnesioaxinite, Tanzania, Jobbins *et al.* (1975).

ISSN: 0022-1252 XVIII (1) 20 (1982)

TABLE 2

Chemical analyses of axinites

Oxides in wt-%

	1	2	3	4
SiO_2	42.70	42.20	42.39	44.00
TiO_2	nt.fd.	0.03	n.d.	0.03
B_2O_3	nt.fd.	**	5.52	**
Al_2O_3	18.31	17.50	17.10	17.90
Cr_2O_3	nt.fd.	nt.fd.	n.d.	nt.fd.
V_2O_3	nt.fd.	nt.fd.	n.d.	0.13
Fe_2O_3	*	*	1.68	nt.fd.
FeO	10.40	6.10	5.18	nt.fd.
MnO	0.38	3.30	1.38	0.40
MgO	1.40	1.60	4.20	6.90
CaO	19.35	20.10	20.31	21.70
ZnO	nt.fd.	nt.fd.	n.d.	0.06
CoO	nt.fd.	nt.fd.	n.d.	nt.fd.
Na_2O	nt.fd.	0.04	0.06	nt.fd.
K_2O	0.01	0.02	0.03	0.01
$H_2O>105°$	n.d.	n.d.	1.67	n.d.
$H_2O<105°$	n.d.	n.d.	0.31	n.d.
totals	92.55	90.89	99.83	91.13

* the total iron is calculated as FeO

** the presence of boron was confirmed by chemical tests

nt.fd. = not found, n.d. = not detected

Number of ions on the basis of 28 (O)

	1		2		3		4	
B	—		—		1.772		—	
Si	7.997		8.025		7.885		8.012	
Al	4.042		3.923		3.634		3.842	
Fe^{3+}	—	4.042	—	3.927	0.235	3.869	—	3.865
Ti	—		0.004		—		0.004	
V	—		—		—		0.019	
Mg	0.380		0.454		1.165		1.872	
Fe^{2+}	1.621		0.970		0.806		—	
Mn	0.060		0.531		0.217		0.061	
Zn	—	5.949	—	6.070	—	6.265	0.008	6.177
Ca	3.883		4.095		4.049		4.234	
Na	—		0.015		0.021		—	
K	0.005		0.005		0.007		0.002	
Fe-Mn-Mg-ratio	79:3:18		50:27:23		37:10:53		0:3:97	
Authors	1. this paper		2. Jobbins *et al.*, (1975)		3. Vallance, (1966)		4. Jobbins *et al.*, (1975)	

CHEMISTRY

The name axinite is derived from the Greek word *axine* (ἀξίνη), meaning 'axe', in allusion to its acute edged form of triclinic symmetry. It is rather a complex calcium aluminium borosilicate containing ferrous iron, manganese, magnesium and a considerable amount of water. The chemical composition can be formulated as:

$$(Ca, Fe^{2+}, Mn, Mg)_3 Al_2 BO_3 (Si_4O_{12}) OH$$

The proportions of CaO, FeO, MnO and MgO may vary in different axinites. Three end-member compositions are stated, namely *ferroaxinite* (Ca, Fe), *manganoaxinite* (Ca, Mn), and *magnesioaxinite* (Ca, Mg).

The sample from Sri Lanka was analysed by an ARL electron microprobe. Light elements as B, OH could not be detected by this method. The results of this partial analysis are listed in Table 2 together with literature analyses of the comparative stones from Table 1. The total iron is expressed as FeO and the number of ions is calculated on the basis of 28 (O).

The iron content of the Sri Lanka axinite is fairly high compared to the analyses shown by Deer *et al.* (1962) and Jobbins *et al.* (1975). The Fe-Mn-Mg ratios are 78.6 : 2.9 : 18.4—thus the name ferroaxinite is correct.

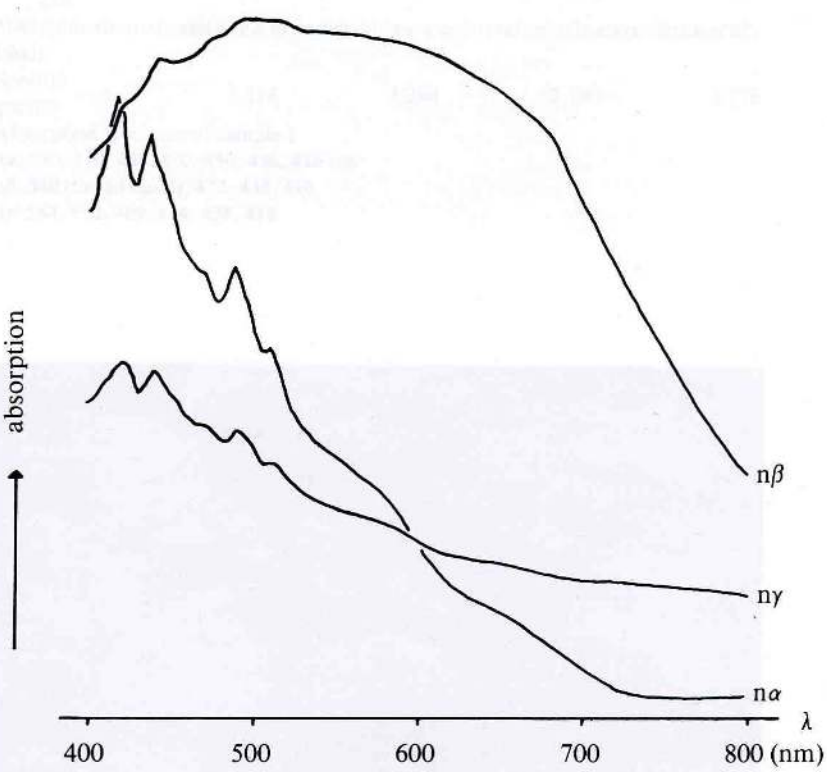
PROPERTIES

The colour of the present Sri Lanka stone and of other pieces of the same origin visually inspected by one author (M.G.) were all of cinnamon brown with differently coloured internal reflections due to pleochroism. The colour is directionally obscured by the strong pleochroism. The strong trichroic colours are: n_α reddish-brown, n_β dark violet, n_γ colourless-yellowish. In magnesioaxinite and manganoaxinite colours like blue and green respectively are reported.

The refractive indices determinations were carried out by using a Krüss ER 60 critical angle refractometer with Na_D light. The angle between the optical axes was measured in immersion on a spindle stage (Steck, 1968). For recording the absorption spectra a Pye-Unicam SP-8 100 spectrophotometer with polarization filter was used. The spectrum is shown in Figure 1.

Specific gravity determination was done by hydrostatic weighing in ethylene dibromide as an immersion liquid. The results of the optical and physical determinations are presented in Table 3,

FIG. 1. *Absorption spectrum of ferroaxinite*



The absorption curves were recorded on a Pye-Unicam SP8-100 spectrophotometer with polarization filter. The unpolarized curve beyond 400 nm shows an absorption band at 376 nm and general absorption in the ultraviolet region below 340 nm.

TABLE 3
Physical constants of axinites

Refractive indices	1	2	3	4
nα	1.675	1.672	1.659	1.656
nβ	1.681	1.679	1.665	1.660
nγ	1.685	1.682	1.668	1.668
Birefringence	0.010	0.010	0.009	0.012
Optical character	Bi−	Bi−	Bi−	Bi+
Axial angle* 2Vx	69.5°	—	—	—
Specific gravity	3.314	3.288	3.190	3.178

*Determination of axial angle in immersion on a universal spindle stage (Steck *et al.*, 1968).

Absorption spectrum of sample 1
nα: 580, 510, **488**, 470, 450, **436**, **416** nm
nβ: **540** (broad band), 472, 438, 416
nγ: 584, 512, 489, 474, **438**, **418**

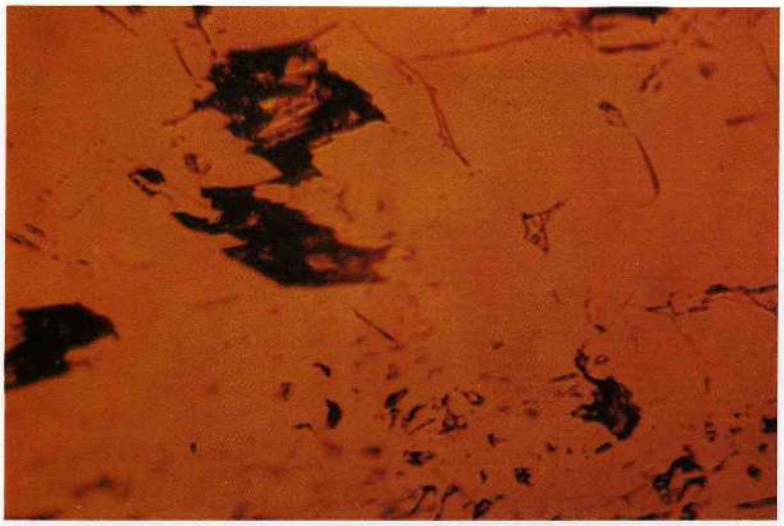


FIG. 2. Two-phase fillings in axinite from Sri Lanka. *(Photo: M. Gunawardene. 60×.)*

FIG. 3. Two-phase fillings in axinite from Brazil. *(Photo: M. Gunawardene. 60 ×.)*

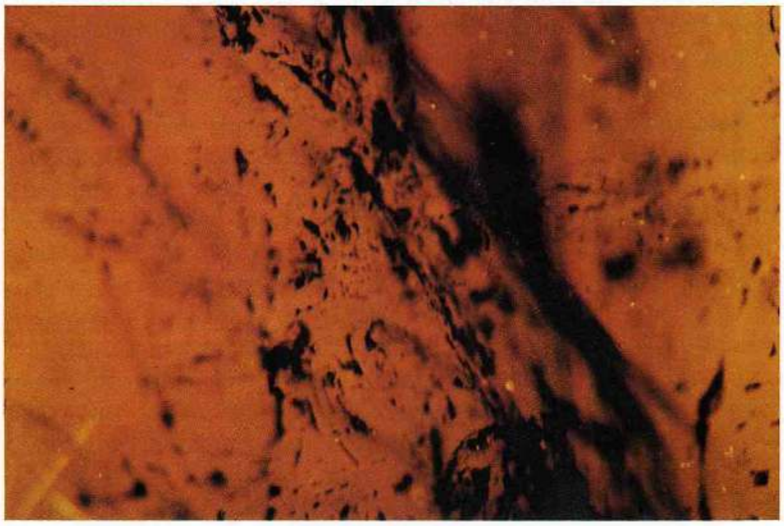


FIG. 4. Black feathers, probably healed fissures in Sri Lanka axinite. *(Photo: M. Gunawardene. 60 ×.)*

together with comparative literature values. The optical character of magnesioaxinite (Table 1, no. 4) is not reported as positive by mistake. The explanation is given by the substitution of Mg for Fe. With increasing Mg content n_β gets small more quickly than n_α and n_γ; in the meantime the axial angle $2V_x$ grows and the optical character turns from negative to positive. It should be stressed (Gübelin, private communication) that apparent discrepancies in gemmological textbooks frequently have their cause in isomorphous replacement, as in this case.

A visual inspection under long- and short-wave ultraviolet radiation showed the stone to be inert in both types of light. Inclusions in axinite from Sri Lanka as well as from Brazil are illustrated in Figures 2 to 4. The aspect of the inclusions is similar from both localities. They mainly consisted of liquid feathers with two-phase fillings reminiscent of the inclusions in tourmaline or topaz. The exact nature of those inclusions was not determined.

Occurrence

Different geological units may be distinguished in the southern part of Sri Lanka. The precambrian Khondalite system (archaic metasediments), the Vijaya gneiss series and their alluvial cover are important with respect to the occurrence of gemstones. These rocks sometimes are intruded by dolerite dykes and pegmatites. Pegmatites frequently bear gemstone quality zircon, beryl, tourmaline, etc. The pegmatite formation (pneumatolytic phase) is often followed by a hydrothermal phase. Under both circumstances the conditions for an axinite formation are physically given. Axinite is formed in contact metamorphic calcareous sediments and less commonly in altered basic rocks, too. The geological frame (Gübelin, 1968; Herath, 1980) allows different interpretations of the type of the present axinite occurrence.

Our stone is reported from the southern part of the island, most probably from Tissamaharama district. In this area pegmatites intruded into the Vijaya gneiss series. On the other hand, the Khondalite complex with its various rock types is not too far away with a possible parent rock. The production of axinite is rather common now and even well developed crystals are found (Gübelin, private communication).

Conclusion

With x-ray powder diffraction we confirmed the suspicion of a new member in Sri Lanka's list of gemstones. The physical properties agree with the range of data in gemmological literature, but the high SG value requires an extension of the recorded range since our sample exceeds the noted upper value for axinite. The reason is most probably the very high iron content of the stone which was confirmed by a microprobe analysis. According to Sanero & Gottardi (1968) this mineral has to be named a Ferroaxinite.

Acknowledgements

Our sincere thanks are due to Dr G. Lenzen, of Deutsche Gemmologische Gesellschaft, and Prof. H. Schwander, Mineralogical Institute, University of Basel, who helped us in realizing this work. Finally we thank the firm Many Gems, of Colombo, Sri Lanka, who kindly allowed us to investigate their material and so to introduce gem axinite to the Isle of gems—Sri Lanka.

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[*Manuscript received 25th June 1981.*]