

# Erlianite, a new vanadium- and iron-bearing silicate mineral

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**ABSTRACT.** Erlianite was found in the Harhada iron deposit along the Jining-Erlian railway, Inner Mongolia Autonomous Region, People's Republic of China. The occurrence formed at a high pressure and low temperature and the mineral occurs sparingly, mainly on fracture surfaces on which there is evidence of movement. It is associated with quartz, magnetite, siderite, albite, stilpnomelane, minnesotaite, deerite, etc.

Erlianite is black with a brownish streak, silky lustre and occur as fibres, flakes, and lath-like aggregates. The grain size is 1-2 cm. It is not fluorescent.  $H = 3.7$ ,  $D = 3.11$ . Cleavages on  $\{001\}$  and  $\{100\}$  are perfect; orthorhombic  $Pm\bar{m}n$  or  $Pm2_1n$  with  $a = 23.20$ ,  $b = 9.20$ ,  $c = 13.18$ , Å and  $Z = 1$ . Strongest lines are 11.5(100)(200, 101), 3.05(50)(223,130), 2.89(60)(603,800,231,621), 2.61(60)(523,105,332,224), 2.52(50)(901,115,033,531), and 1.560(50)(12.0.5,14.2.0). Biaxial negative with  $\alpha = 1.667$ ,  $\beta = 1.674$ ,  $\gamma = 1.679$ ,  $2V = 56-59^\circ$ . Analysis gave  $SiO_2$  38.80,  $FeO$  26.67,  $Fe_2O_3$  21.26,  $V_2O_5$  1.15,  $MgO$  1.00,  $CaO$  0.83,  $MnO$  0.55,  $P_2O_5$  0.051,  $K_2O$  0.079,  $Na_2O$  0.09,  $Al_2O_3$  0.19,  $TiO_2$  0.38,  $H_2O^+$  7.65,  $H_2O^-$  0.90, total 99.60%, leading to  $(Fe_{9.96}^{2+}Fe_{3.19}^{3+}Mg_{1.33}Mn_{0.42})_{\Sigma 23.90}(Fe_{11.32}^{3+}V_{0.68})_{\Sigma 12}(Si_{34.73}Ti_{0.26}Al_{0.20}Fe_{3.81}^{3+})_{\Sigma 36}O_{90}(OH)_4$  (one unit cell content for  $O = 138$ ).

The sample of the new mineral was discovered in 1977 during an investigation of an iron deposit which has been named 'M14'. The methods used for studying this mineral included optical microscopy, X-ray powder diffraction, selected area electron diffraction analysis, wet chemical analysis, DTA, TGA, infra-red absorption and Mosbauer spectroscopy.

**KEYWORDS:** erlianite, new mineral, iron deposits, iron silicates, China.

THE iron deposit lies in the south of an area of folded strata on the side of the Inner Mongolia Geosyncline. The rocks represent an underthrust zone of the Inner Mongolia shield in the North China platform. The folding is intense and complex, and faulting is also well developed in the area (Qi Sijing *et al.*, 1979). Lithologically, the rocks form part of a metamorphosed marine volcanic-sedimentary sequence of early Palaeozoic age. The lower 680 metres of the ore formation is a mixed accumulation of spilite, spilitic tuff and carbonatite, metamorphosed to form chlorite schist, with

schistosity well-defined and microfolding clearly marked by white carbonate veins. The upper 266 metres of the ore formation was originally siliceous sedimentary rock with volcanic ash and clay but, as a result of low-grade metamorphism, is now represented by fine-grained quartzite and sericite-chlorite-quartz gneiss. The ore itself consists mainly of magnetite.

Erlianite was found in a fractured zone intersected by drill-hole ZK 1412 at locality M14 of Harhada ore area. The samples collected came from the metamorphosed sedimentary and volcanic pile referred to above as forming the upper part of the ore formation. The mineral is associated with minnesotaite, stilpnomelane, quartz, magnetite, siderite, albite, and other minerals. Its distribution is closely related to structural features, and it has often developed with red-brown stilpnomelane and dark-brown minnesotaite on planes of dislocation formed by shearing.

**Physical and optical properties.** Erlianite is orthorhombic. Single crystals occur as fibres or flakes. Aggregates are lath-like, and may show an imbricate structure when they have been deformed by stress. Grains of the mineral are black and opaque, with a silky lustre and brownish streak. When powdered they are brownish black. Usually, the size of the crystal aggregates is 1-2 cm. The mineral is not fluorescent; it has two perfect cleavages, on  $\{001\}$  and  $\{100\}$ .

The specific gravity of the mineral was determined by measurement of volume and weight in air. The volume was determined by measuring the displacement of liquid in a thin tube by immersion of the sample. The measured specific gravity is 3.11. The hardness of the mineral, 3.7, was obtained by using a sclerometer.

In thin section the mineral is brown with moderate relief. The measured refractive indices are:  $\alpha = 1.667$ ,  $\beta = 1.674$ ,  $\gamma = 1.679$ . The orientations are  $X = b$ ,  $Y = c$ ,  $Z = a$ . It is slightly pleochroic with Y and Z dark brown and X light brown. The absorption relation is:  $Z \approx Y > X$ . It has weak

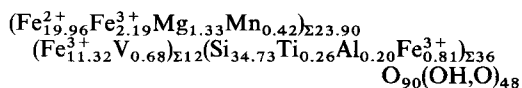
TABLE I. Chemical analysis of erlianite

Oxide	Wt. %	Oxide	Wt. %
SiO <sub>2</sub>	38.80	K <sub>2</sub> O	0.079
FeO	26.67	Na <sub>2</sub> O	0.09
Fe <sub>2</sub> O <sub>3</sub>	21.26	Al <sub>2</sub> O <sub>3</sub>	0.19
V <sub>2</sub> O <sub>5</sub>	1.15	TiO <sub>2</sub>	0.38
MgO	1.00	H <sub>2</sub> O <sup>+</sup>	7.65
CaO	0.83	H <sub>2</sub> O <sup>-</sup>	0.90
MnO	0.55	Total	99.60
P <sub>2</sub> O <sub>5</sub>	0.051		

dispersion with  $r < V$  and may have either positive or negative elongation; most elongate sections show parallel extinction, though extinction angles up to 29° were measured. The mineral is optically negative and has  $2V = 56-59^\circ$ .

**Chemistry.** The mineral is soluble in dilute hydrochloric acid. Employing colorimetric microanalysis, we obtained the composition of the mineral, which is given in Table I. A comparison between electron probe microanalysis (EPMA) and colorimetric microanalysis (CMA) for erlianite is shown in Table II; it can be seen that the results for the two methods are sufficiently close to indicate that the specimens used in CMA are not contaminated.

According to the chemical analysis results, the cell dimensions (see later) and the density (3.11) of the mineral, assuming K, Na, Ca, P, and H<sup>-</sup> to be minor contaminants or interlayer elements, and disregarding them for this purpose, we have obtained the following provisional empirical formula:



(one unit cell content for O = 138).

TABLE II. A comparison between EPMA and CMA for erlianite

	Element (wt. %)			
	Fe (total)	Si	V	Mg
EPMA	32.20	21.70	0.49	0.63
CMA	35.60	18.11	0.64	0.60

**Crystallography.** Selected area electron diffraction studies were carried out, giving the unit cell data  $a = 23.2$ ,  $b = 9.2$ ,  $c = 13.2 \text{ \AA}$  and indicating that the space group may be  $Pm\bar{m}n$  or  $Pm2_1n$  (Meng Xianying and Guo Kexin, 1984). So far we have not found a single crystal of erlianite good enough for a single crystal diffraction photograph. Therefore only X-ray powder data could be obtained and are listed in Table III. Initially all diffraction lines were indexed with the dimensions given above. Then using the computer program of the Causs-Newton least squares method, on 26 diffraction lines, we obtained the refined cell dimensions  $a = 23.20 \pm 0.01$ ,  $b = 9.20 \pm 0.01$ , and  $c = 13.18 \pm 0.01 \text{ \AA}$ .

Using refined cell dimensions, all lines have been indexed (except No. 7) as shown in Table III. From the cell dimensions we have obtained the cell volume  $V = 2813 \text{ \AA}^3$ , the unit cell content  $Z = 1$ , and the calculated density  $D_{\text{calc}} = 3.11 \text{ g/cm}^3$ .

**Differential thermal and thermogravimetric analysis.** The results of differential thermal and thermogravimetric analysis are given in fig. 1. It can be seen that the thermogravimetric curve is smooth and that there is no distinct endothermic peak, showing that the water contained in the mineral escaped slowly. The water content may therefore be structural.

When the temperature reached 320, 720, and 940 °C exothermic peaks were produced. A speci-

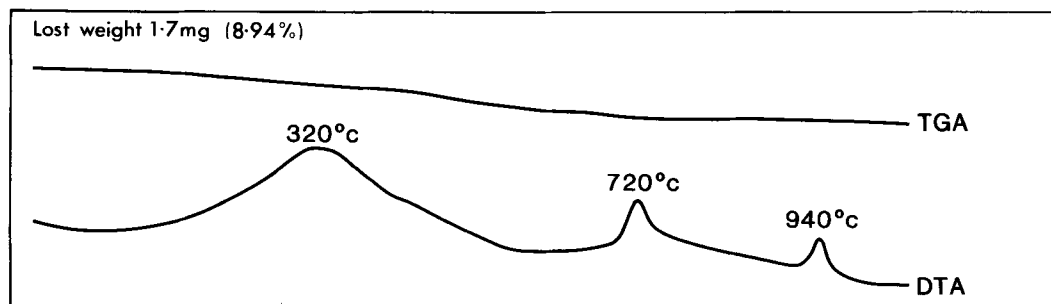


FIG. 1. Differential thermal and thermogravimetric curves of erlianite.

TABLE III. X-ray powder data for erlianite

No.	$I/I_0$	$d$ Å (meas.)	$d$ Å (calc.)	$hkl$	No.	$I/I_0$	$d$ Å (meas.)	$d$ Å (calc.)	$hkl$
1	100	11.5	11.6	200				1.935	335
			11.460	101*				1.933	12.0.0
2	10	6.6	6.59	002*	17	< 10	1.88	1.886	044
3	< 10	5.8	5.8	400*				1.883	007
4	< 10	4.45	4.40	312*				1.882	725
5	10	4.15	4.143	510*				1.880	144*
6	20	3.82	3.820	303*				1.877	107
7†	< 10	3.55						1.876	426
8	50	3.05	3.064	223				1.874	10.2.3
			3.040	130*				1.873	12.1.1
9	60	2.89	2.903	{ 603	18	< 10	1.84	1.841	11.2.2*
				{ 800				1.839	117
			2.893	231*				1.800	{ 251*
			2.888	621	19	20	1.80		{ 933
10	60	2.61	2.621	523					{ 12.2.2*
			2.619	105	20	20	1.72	1.720	{ 816
			2.616	332	21	< 10	1.572	1.573	{ 354
			2.610	224*				1.572	{ 736
11	50	2.52	2.531	324				1.571	{ 10.1.6
			2.530	901					{ 926*
			2.519	115*					{ 337
			2.515	033					{ 14.2.0
			2.512	531	22	50	1.560	1.559	{ 12.0.5*
12	30	2.42	2.432	424	23	< 10	1.425	1.426	338
			2.420	{ 803*				1.425	660*
				{ 614				1.424	16.1.1
			2.412	821	24	< 10	1.419	1.420	409
13	30	2.31	2.320	{ 10.0.0				1.417	953*
				{ 524*					256*
			2.307	433	25	< 10	1.400	1.400	{ 15.0.4
			2.3	040					{ 16.1.2
			2.299	822					{ 946
14	20	2.17	2.178	605	26	< 10	1.352	1.352	{ 464*
			2.177	804					{ 15.3.2
			2.174	341	27	< 10	1.337	1.338	14.4.1
			2.172	042*				1.337	148
			2.162	142				1.336	{ 17.0.2
			2.161	913					{ 529
15	10	2.07	2.071	10.2.0*					
			2.063	705					
16	< 10	1.94	1.941	{ 634					
				{ 516*					

\* These indices were used for refinement of the cell dimensions.

† This line is probably due to a minute inclusion.

Experimental conditions: radiation, Fe-K $\alpha$ ,  $\lambda$  1.93728 Å; camera diameter 57.3 mm;  $I/I_0$  visual; HT 30 kV.

men was heated and kept at these temperatures for 30 minutes before being examined under the optical microscope and analysed by the X-ray powder method. It was found that at 320°C the crystal structure was destroyed and quartz appeared, that at 720°C no new phase was produced, and that at 940°C the specimen was converted to quartz and hematite.

*Infra-red absorption and Mössbauer spectroscopy.* The infra-red absorption spectrum of erlianite is shown in fig. 2 and the results of Mössbauer spectroscopy are listed in Table IV.

*Discussion.* There are certain aspects of the study which are still incomplete. Thus, it is not yet clear in what form water is present, and this needs to be further investigated. Also, the refractive indices

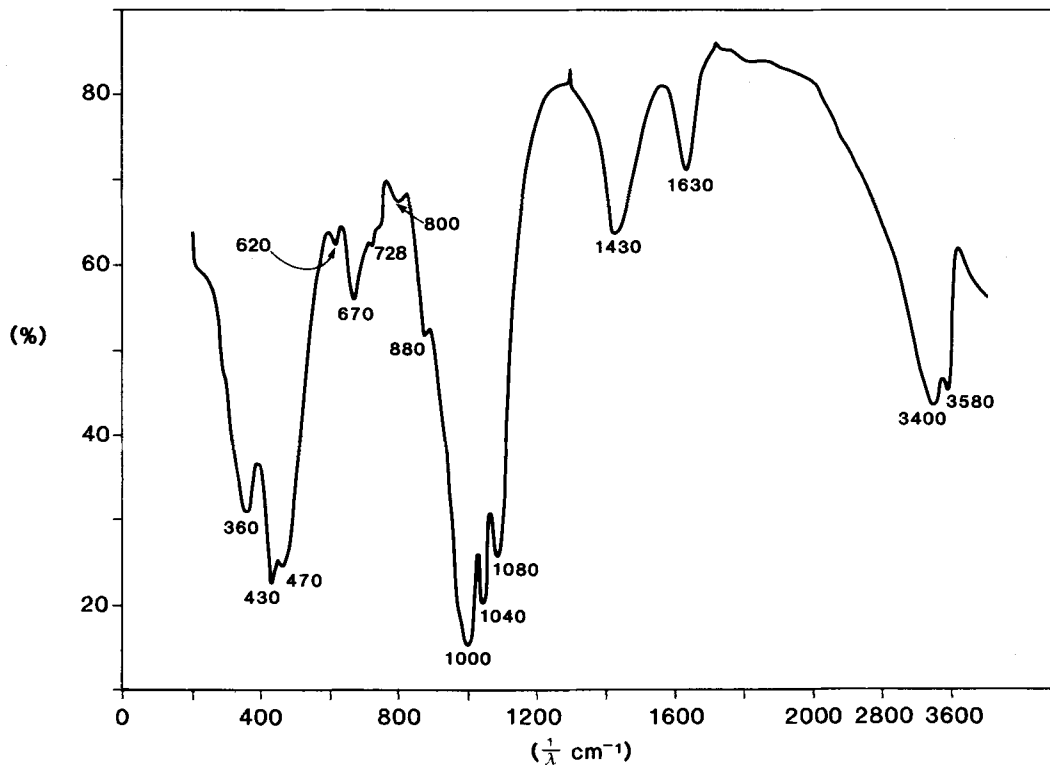


FIG. 2. The infra-red absorption spectrum for erlianite.

TABLE IV. *The results of Mössbauer spectroscopy of erlianite*

Peak	Parameters					
	Isomer shift	Quadrupole splitting	Line width	Fe <sup>3+</sup> /ΣFe	Fe(AA')/ΣFe	Fe <sup>2+</sup> (BB')/ΣFe
Fe CC' peak	0.47	0.67	0.64	0.53	—	—
Fe AA' peak	1.08	2.67	0.24	—	0.16	—
Fe BB' peak	1.05	2.24	0.37	—	—	0.32

of a mineral normally increase with increasing iron content, but decrease with increasing water content. Although erlianite has a very high iron content, its indices are not very high; this may be due to the high water content. Finally, the crystal structure of erlianite has not yet been determined.

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