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STUDIES OF BRAZILIAN METEORITES X. MINERALOGY AND PETROLOGY OF THE SETE LAGOAS, MINAS GERAIS, CHONDRITE

por
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ABSTRACT

A microscopic and electron microprobe study of the Sete Lagoas chondrite shows that based on the compositions of olivine ($Fa_{19.4}$), orthopyroxene ($Fs_{17.1}$), and chromite, the chondrite belongs to the H-group. A well-developed chondritic texture, combined with slight variations in the compositions of ferromagnesian minerals, as well as the presence of glassy material (particularly in chondrules), suggest that the meteorite belongs to the petrologic class H4.

RESUMO

O estudo microscópico e por microssonda eletrônica do condrito Sete Lagoas mostra que, com base na composição química da olivina ($Fa_{19,4}$), do ortopiroxênio ($Fs_{17,1}$) e da cromita, o meteorito enquadra-se perfeitamente no Grupo H. A textura condrítica bem desenvolvida, a presença de material vítreo (particularmente no interior dos côndrulos), aliadas às pequenas variações químicas dos minerais ferromagnesianos, são sugestivas de que o meteorito pertence à classe petrológica H4.

INTRODUCTION

The Sete Lagoas, State of Minas Gerais, Brazil, chondrite fell on December 15, 1908 (approximate coordinates 19°28'S, 44°13'W). It was observed by only a few witnesses who reported noticing sound effects. Four stones were recovered, weighing a total of 63 grams. The meteorite was listed in the catalogues of Oliveira (1931) and Hey (1966), and Mason (1963) determined the composition of its olivine by optical and X-ray diffraction methods (Fa_{19}). No other mineralogical and petrographic data are available on that stone, and it is therefore the main purpose of the present paper to report on a detailed microscopic and electron microprobe study of the meteorite. A bulk chemical analysis of the chondrite was not made; it would have required approximately 10 grams of material, an excessive amount in view of the very limited material available of this chondrite. This work is part of a systematic study of all Brazilian stone meteorites which we have in progress.

ANALYTICAL PROCEDURES

The texture of the meteorite was studied in transmitted and reflected light, and its constituent phases were analyzed with an electron microprobe. Probe analyses were carried

Table 1

Average compositions and structural formulae of olivine, bronzite, plagioclase, and chromite from the Sete Lagoas, Brazil, chondrite. All data in weight per cent. Number of grains analyzed are shown in parentheses

	Olivine		Bronzite		Plagioclase		Chromite	
	(38)	S.D.	(23)	S.D.	(9)	S.D.	(22)	S.D.
SiO_2	39.4	0.4	56.1	0.6	64.8	0.3	0.04	0.01
TiO_2	n.d.	–	n.d.	–	n.d.	–	2.25	0.23
Al_2O_3	0.08	0.08	0.31	0.18	21.7	0.3	6.0	0.4
Cr_2O_3	n.d.	–	n.d.	–	n.d.	–	55.8	1.0
V_2O_3	n.d.	–	n.d.	–	n.d.	–	0.72	0.04
FeO	18.2	0.5	11.7	0.5	0.72	0.13	30.6	0.8
MnO	0.47	0.04	0.47	0.03	n.d.	–	1.02	0.08
MgO	42.5	0.5	31.2	0.6	0.42	0.12	3.34	0.44
CaO	<0.02	0.03	0.71	0.12	2.61	0.17	n.d.	–
Na_2O	n.d.	–	0.08	0.04	9.8	0.2	n.d.	–
K_2O	n.d.	–	n.d.	–	1.04	0.12	n.d.	–
TOTAL	100.65		100.57		101.09		99.77	
	Number of ions on the basis of							
	0 = 4		0 = 6		0 = 32		0 = 32	
Si	0.998		1.977		11.384		0.011	
Ti	–		–		–		0.481	
Al	0.002		0.013		4.493		2.011	
Cr	–		–		–		12.544	
V	–		–		–		0.164	
Fe	0.386		0.345		0.106		7.276	
Mn	0.010		0.014		–		0.246	
Mg	1.605		1.639		0.110		1.416	
Ca	–		0.027		0.491		–	
Na	–		0.005		3.338		–	
K	–		–		0.233		–	
Z	0.998		1.990		15.877	SUM^{+3}	15.211	
X	2.003		2.030		4.278	SUM^{+2}	8.938	
SUM	3.001		4.020		20.155		24.149	
Fo	80.6	En	81.6	Or	5.7	Uv	5.9	
Fa	19.4	Fs	17.1	Ab	82.2	Cm	78.2	
		Wo	1.3	An	12.1	PCm	3.8	
						Sp	12.2	

S.D. – Standard deviation; n.d. – Not determined

out with an ARL EMX-SM instrument, using an accelerating potencial of 15 keV and a sample current of about 0.02 μAmp. The beam size was ⩽ 1 μm in diameter. Corrections were made for instrumental drift, backgroung, and differential matrix effects, using the method of Bence and Albee (1968). Natural minerals of well-known composition (olivine Marjalahti; augite A-209; andesine AC-362; chromite C53IN8) were used as standards.

TEXTURAL AND MINERALOGICAL DESCRIPTION

Sete Lagoas exhibits a well-developed chondritic texture (Figs. 1A,E), with perfectly round to elongated chondrules ranging in apparent size from 0.1 to 2.0 mm (mean 0.6 mm). Many different textural types of chondrules were observed, including barred, excentro-radial, and porphyritic varieties (Figs. 1B-F). The major minerals of the chondrite are olivine, orthopyroxene, and metallic nickel-iron, and minor troilite and plagioclase and accessory chromite, whitlockite, and glassy material were also observed. A hydrous ferric oxide of terrestrial origin often forms fine rims around metallic nickel-iron.

Olivine is somewhat variable in composition (Table 1, Fig. 2), averaging $Fa_{19.4}$. This average and the range is within the compositional ranges given for the average compositions of olivine from H-group chondrites (Fig. 2, Keil and Fredriksson, 1964, as modified by Fodor *et al.*, 1976). Similarly, orthopyroxene is slightly variable in composition (Table 1, Fig. 2), averaging bronzite ($Fs_{17.1}$) in composition. Its compositional range is also within the ranges given for the average compositions of orthopyroxene from H-group

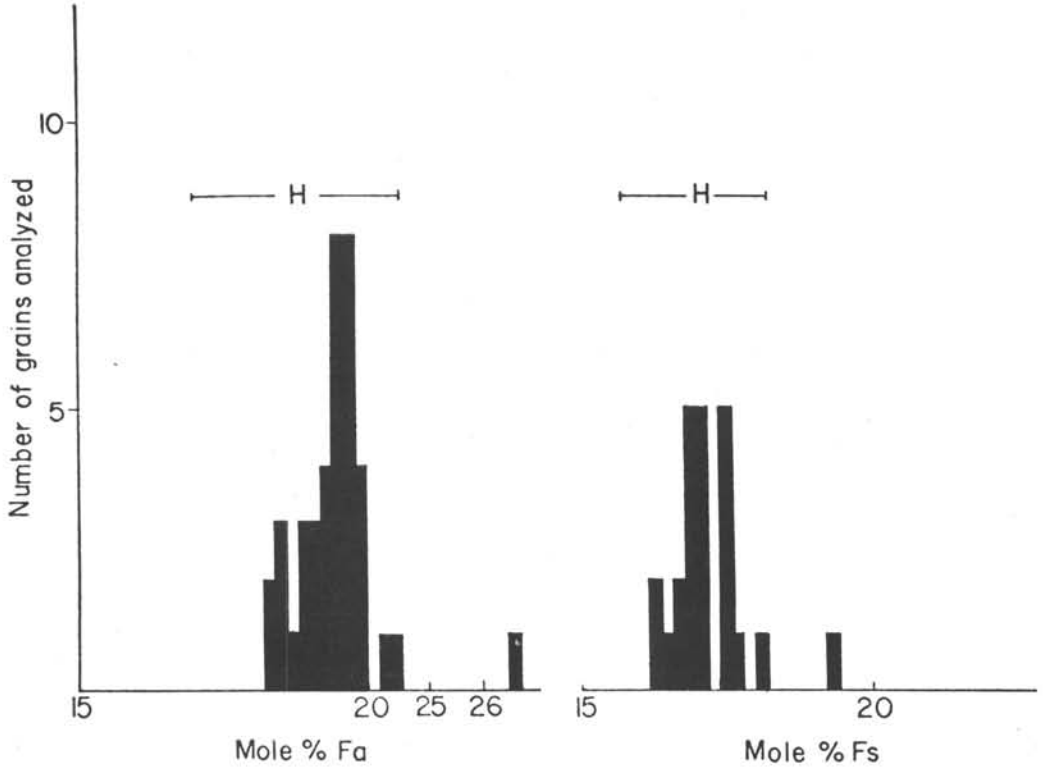

Fig. 2 – Histograms showing the compositions of olivine (Fa; Fe_2SiO_4) and orthopyroxene (Fs; $FeSiO_3$) in the Sete Lagoas chondrite. For comparison, ranges in compositions of olivine and pyroxene in equilibrated H chondrites are given (after Keil and Fredriksson, 1964; as revised by Fodor *et al.*, 1976).

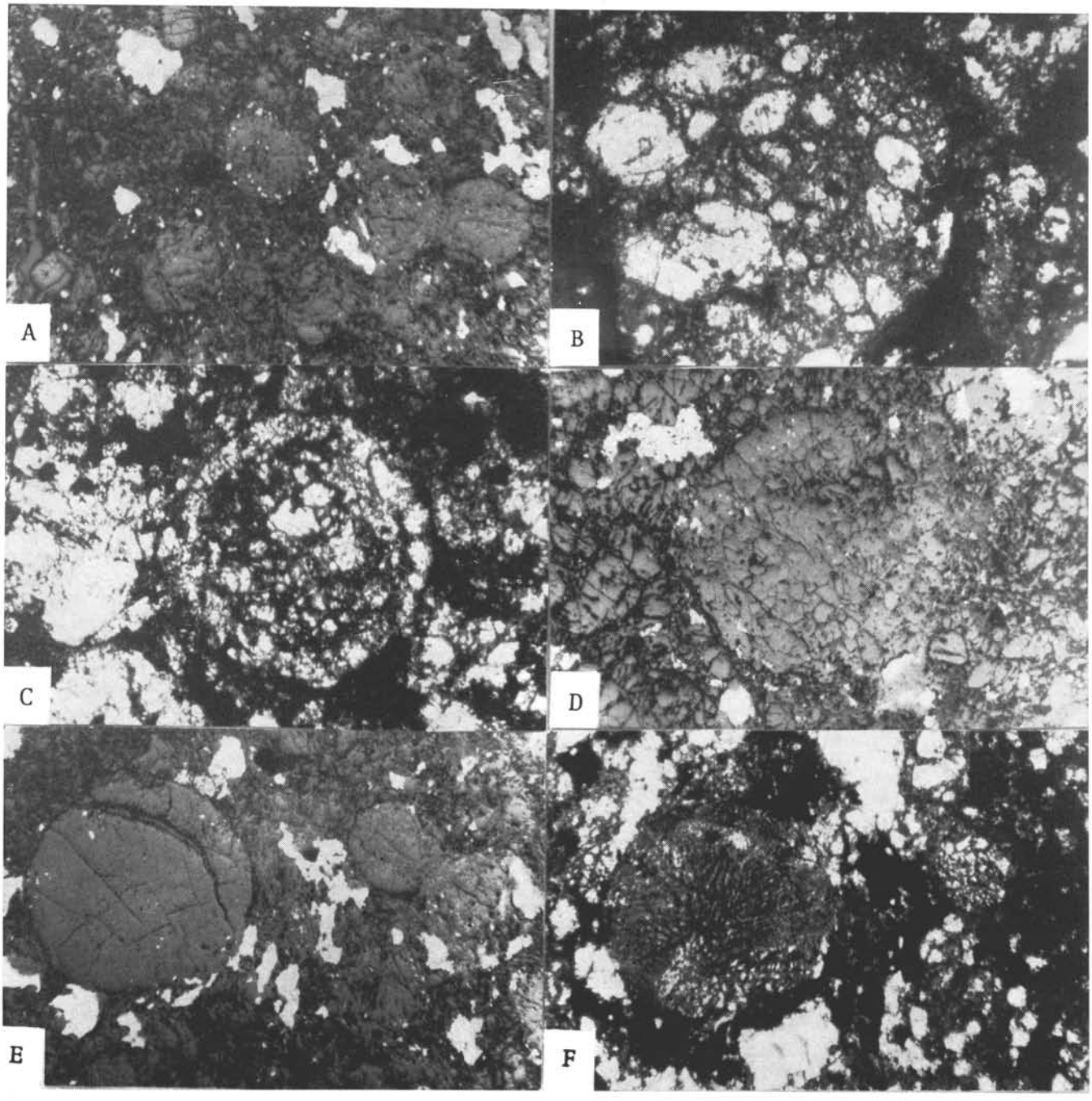

Fig. 1 A – Well-developed chondritic texture in the H4 Sete Lagoas, Minas Gerais, meteorite. Olivine and pyroxene show different shades of gray, metallic nickel-iron is white in color. Reflected light. 32 X.
B – Porphyritic chondrule consisting mainly of subhedral to euhedral olivine crystals embedded in a fine-grained interstitial material. Transmitted, plane polarized light. 80 X.
C – Porphyritic chondrule containing olivine crystals (light gray) in a fine-grained matrix. Transmitted, plane polarized light. 80 X.
D – Same as Fig. 1 C, reflected light. Interstitial material within the chondrule is dark gray in color. 80 X.
E – Relict orthopyroxene chondrule. Reflected light. 32 X.
F – Same as Fig. 1 E, transmitted, plane polarized light. A small porphyritic chondrule can also be seen at the right side. 32 X.

chondrites (Fig. 2; Keil and Fredriksson, 1964, as modified by Fodor *et al.*, 1976). Plagioclase is oligoclase (average $Or_{5.7}$ $Ab_{82.2}$ $An_{12.1}$) in composition and conforms with plagioclase of other H-group chondrites (Van Schmus and Ribbe, 1968). Chromite is an accessory phase, typical in composition of chromite from H-group chondrites (Bunch *et al.*, 1967).

CONCLUSIONS

On the basis of the composition of its constituent phases, particularly olivine, orthopyroxene, chromite and plagioclase, it is concluded that Sete Lagoas is an H-group chondrite. The well-developed chondritic texture, the slight compositional variability of olivine and orthopyroxene, and the presence of interstitial glassy material (particularly in the chondrules), suggest that the meteorite belongs to the petrologic class H4 of Van Schmus and Wood (1967). According to these authors, the petrologic type 4 is characterized by relatively ambiguous features (well-preserved chondrules, microcrystalline matrix, presence of turbid igneous glass, abundant clinopyroxene and nearly uniform compositions of olivine and orthopyroxene) indicating a low degree of recrystallization.

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