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Investigación de una Muestra Meteorítica Amazónica a través de Técnicas Analíticas

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Presentamos el estudio de una muestra meteoritica descubierta en la Amazonía peruana. De acuerdo con el análisis realizado por diferentes técnicas físicas llevadas cabo en un fragmento de este meteorito, éste pertenece a las condritas ordinarias. Específicamente, hemos utilizado la espectroscopía de transmisión Mössbauer y la fluorescencia de rayos X por energía dispersiva. Los resultados con estas técnicas muestran que las muestras tienen cantidades relativamente grandes de Si, Al y Fe. Asimismo, dado que la espectroscopía de transmisión Mössbauer es una técnica isotópicamente más selectiva, hemos observado la presencia de sitios magnéticos asignados a las fases de taenita (Fe,Ni) y troilita (Fe,S). También se encontró la presencia de tres dobletes paramagnéticos asignados a Fe^{2+}: uno asociado con olivino $(Fe,Mg)_2SiO_4$, otro, a piroxeno $(Fe,Mg)SiO_3$; y tercer doblete, a un sitio Fe^{3+}.
Palabras claves: condritas, fluorescencia de rayos X por energía dispersiva, espectroscopia de transmisión Mössbauer.

A Study about a Amazonian Meteoritic Specimen by Analytical Techniques

Herein, it is introduced the analysis of a meteoritic specimen discovered in the Peruvian Amazonia. According to the analysis by different physical techniques carried onto a fragment of it, this meteorite belongs to the ordinary chondrites. Specifically, we have used transmission Mössbauer spectroscopy and energy dispersive X-ray fluorescence.The results with these techniques show that the samples have relatively large amounts of Si, Al and Fe. Likewise, since transmission Mössbauer spectroscopy is an isotopically more selective technique, we have observed the presence of magnetic sites assigned to the taenite (Fe,Ni) and troilite (Fe,S) phases. We also realized the presence of three paramagnetic doublets assigned to Fe^{2+}: one associated with olivine $(Fe,Mg)_2SiO_4$;other, to pyroxene $(Fe,Mg)SiO_3$; and third doublet, to one Fe^{3+} site.
Palabras claves: chondrites, energy dispersive X-ray fluorescence, transmission Mössbauer spectroscopy.

1. Introduction

In continuing our investigations about the fall of meteorites occurred in Peru [1–3], we have incidentally obtained an alleged meteorological sample, which was found in the Madre de Dios Region, in the Peruvian Amazonia. Thus, we must also point out that trading and smuggling of meteorites have already been initiated in the Republic of Peru.

We have subjected the corresponding meteoritic sample to energy dispersive X-ray fluorescence (EDXRF) and to transmission Mössbauer spectroscopy (TMS). The former was used to determine its elemental composition and the latter, to determine its chemical and phase composition. TMS is a technique useful to study meteorites and especially chondrites, because it is an isotopically selective technique.

Ordinary chondrites normally contain metal phases (FeNiCo alloys), troilite (FeS), olivine $[(Mg,Fe^{2+})_2SiO_4]$, augite $(NaCa)(Mg,Fe,Al)(Al,Si)_2O_6$ and sometimes iron oxides like ferric oxide or hydrated oxides – from now on, augite will be called pyroxene because it is the most frequent pyroxene. Besides, ordinary chondrites can be classified into three groups: H, L and LL. These groups are cha-

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racterized by a different total content of iron and nickel. The contents by weight of metallic iron in these chondrite groups are, respectively, 15-19 % (H), 4-10 % (L) and 1-3 % (LL) [4]. In our results, we detected the presence of troilite and taenite in ordinary chondrite; we determined its percentage as well as differentiate its main metallic phases..

2. Materials and Methods

The owner of the meteorite provided us with a small fragment, which was yellowish-gray. Shortly after the receipt,we convey the small fragment toward the Soil Analysis Laboratory of the UNMSM (SAL) to verify its authenticity by carrying out the corresponding tests and analyses. In the SAL, the fragment provided to us was ground in an agate mortar; afterwards, we obtained a fine 160 μm mesh powder of approximately 180 mg.

In Fig. 1, we observe a photograph of the meteoritic specimen; the picture was sent to us by the possessor of the meteorite in 2016. The total specimen weighs about 5 kg and has both a granular aspect and a size about 20 cm. On the surface, it shows gaps and spherical parts; striation is notorius. Probably, in crossing the earth's atmosphere, due to high pressures and temperatures, it was deformed by burning [7–11].

Figure 1: Photograph of the meteoritic specimen. On the bottom left,we observe circular formations, which are possibly provoked bythe high pressures and temperatures when it impacted into the Earth.

2.1. Energy dispersive X-ray fluorescence (EDXRF)

In order to obtain the elemental composition, we used a portable EDFRX AMPTEK instrument, which uses an X-ray tube with a silver cathode operating at 30 kV and about 30 μA.

Figure 2 shows the corresponding experimental spectrum, wherein we have identified the characteristic X-ray peaks of the elements present in the sample. We have also detected the characteristic x-rays of argon from the air and the dispersed X-rays of gold from the source we used. In addition to the experimental spectrum, Figure 2 shows a blue color curve that corresponds to the theoretical simulation of the spectrum, on which the quantitative interpretation of the spectrum is based.

Likewise, Table 1 shows the quantitative elemental composition of the sample expressed in terms of the relative mass percent composition of elements having an atomic number equal and greater than 13. If the sample had lighter elements such as magnesium, sodium, boron or beryllium, they would be unnoticed unless additional information is available. The uncertainty estimated in these measurements of the elemental concentration is about 10 %.

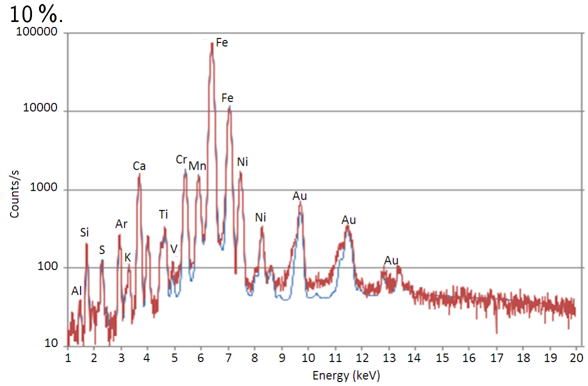

Figure 2: In a semilogarithmicplot, the EDFRX experimental spectrum of themeteoritic sample from the Peruvian Amazonia.

Table 0: Mass percent composition of the meteoritic sample from the Peruvian Amazonia.

Compound	%	Element	%
Al_2O_3	16.50	Al	8.733
SiO_2	41.82	Si	19.548
Fe_2O_3	24.18	Fe	16.912
CaO	2.65	Ca	1.894
CuO	0.01	Cu	0.008
K_2O	2.94	K	2.441
SO_2	4.76	S	2.382
TiO_2	0.20	Ti	0.120
Cr_2O_3	0.89	Cr	0.609
MnO	0.45	Mn	0.349
Ni_2O_3	0.61	Ni	0.433
V_2O_3	0.01	V	0.007
Subtotal	95.02	Subtotal	53.436
Others	4.98	Others	46.564
Total	100.00	**Total**	100.00

2.2. ^{57}Fe transmission Mössbauer spectroscopy (TMS)

This technique is useful to obtain detailed information about mineral phases that contain iron. Thus, we placed 180 mg of the sample inside of a sample holder of 1.7 cm internal diameter. Afterwards,we subjected it to gamma radiation of 14.413 keV from a radioactive ^{57}Co source in an Rh matrix. As usual, aconventional spectrometer was utilized; it has a sinusoidal velocity modulation signal and 1024 channels. The Mössbauer spectrum at room temperature of the sample was collected at the LAS. This spectrum was analyzed by using the Normos program invented by R. A. Brand in its crystalline sites version (Normos Site) [5].

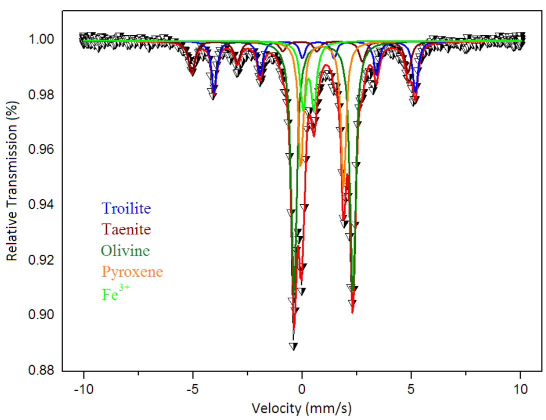

Figure 3: Mössbauer spectrum of the meteoritic sample From the Peruvian Amazonia taken at room temperature.

Table 2: Hyperfine parameters of the meteoritic sample.

Carancas				
Mineral Phases	ISO (mm/s)	QUA (mm/s)	B_{hf} (T)	A (%)
Kamacite/Taenite	-0.110	0.00	33.67	11.712
Troilite	0.648	-0.16	31.38	15.918
Olivine	1.036	2.95	40.580	
Pyroxene	1.035	2.18		21.012
Fe^{3+}	0.223	0.458		10.777

3. Discussion and Results

The analysis by EDFRX of the sample showed the presence of the following oxides: Al_2O_3, SiO_2, SO_2,CuO, K_2O, CaO, TiO_2, Cr_2O_3, MnO, Fe_2O_3, Ni_2O_3 and V_2O (see Table 1). We notice as follows: high concentrations of Si>Fehigh concentrations of Al, intermediate concentrations such as S>K>Ca, minor concentrations of Cr>Ni>Mn>Ti. Cupper and vanadium are practically scarce. As shown in Figure 3, the spectrum taken at RT was fitted by two magnetic sextets and by three doublets paramagnetic. The two sextets were respectively assigned to troilite (FeS) and the FeNi phase known as kamacite; meanwhile, two of the doublets were assigned to paramagnetic Fe^{2+} doublets (the one associated to olivine $(Fe,Mg)_2SiO_4$ and the other to pyroxene $(NaCa)(Mg,Fe,Al)(Al,Si)_2O_6$ The third doublet was assigned to one Fe^{3+} site. Consequently, Table 2 shows the respective hyperfine parameters of the different mineral phases found in the meteoritic sample taken at room temperature. The iron minerals with higher concentrations, identified in the TMS spectrum, agree with those from the EDFRX spectrum. This because 0.6 % Ni observed would correspond to the metal phase of the kamacite observed by TMS. Besides, 24.18 % Fe would be distributed in all phases given by the areas; the high percentage of Si is distributed between the paramagnetic phases of olivine and pyroxene. By using aforementioned techniques, the results show a correlation.

4. Conclusions

Through the analysis by EDFRX, we have identified the presence of the following compounds: Al_2O_3, SiO_2 and Fe_2O_3 in relatively high concentrations. Likewise, the analysis by TMS at room temperature allowed us the observation of magnetic and paramagnetic phases, some of which are super imposed on others. The FeNi phases can be related to kamacite, that is, we have found metallic phases corresponding to a meteoritic sample. Therefore, the investigated sample can be classified as a meteorite belonging to the ordinary chondrites.

Acknowledgments

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