Meteorite Fall at Pueblito de Allende, Chihuahua, Mexico: Preliminary Information

Abstract. *Specimens from the meteorite fall at 1:05 a.m., on 8 February 1969 at Pueblito de Allende, Chihuahua, Mexico, have been recovered. The meteorite is a chondrite (C3 and C4) with both opaque and microcrystalline matrices. Specimens were brought to a low background gamma counter less than 4½ days after the fall, and gamma rays from short-lived isotopes have been observed.*

An intensely bright, blue-white bolide was observed over Chihuahua, Mexico, in the early morning of 8 February 1969. The light from this object was observed as far north as southern Arizona, was very bright over Chihuahua City, and was seen and heard in many small cities and villages to the south. The bolide broke into many pieces in the air near the town of Pueblito de Allende (a village approximately 30 km east of Hidalgo del Parral) at approximately 1:05 a.m. Telephone calls to the offices of the *Correo del Parral* on the morning of 10 February revealed that a number of fragments had been recovered soon after the fall. One of us (E.A.K.) departed for the site immediately.

Thirteen fragments of the meteorite from three different localities were obtained during a 1-day reconnaissance of the area of the fall. The total weight obtained was 6784 g as follows: 4180 g were found 1 km north of San Juan; 167, 135, and 89 g were found at Pueblito de Allende; 1259, 782, 44, 34, 25, 22, 18, 17, and 12 g were found at Rancho Blanco. The specimen from near San Juan is approximately 75 percent of a single subrounded stone that was completely covered with fusion crust. The 1259-g specimen from Rancho Blanco is a complete, slightly elongate, rounded individual covered with fusion crust. All other specimens are fragments of larger individuals, but most have fusion crust on at least one surface. Eight other specimens were seen but not obtained; these had an estimated combined weight of 20 kg. The fusion crust is commonly 1 mm or less in thickness, black or very dark grey, and slightly to highly vitreous.

Two small pit craters were observed. One of these was approximately 4 m from the southernmost corner of the post office in Pueblito de Allende, but had been trampled and generally deformed. This was reported to be the site where a rounded stone weighing approximately 12 to 15 kg had fallen. The site north of San Juan that produced the 4180-g fragment still contained an unaltered pit crater approximately 12 cm deep and 20 cm wide. This was clearly a penetration pit crater, which indicates a very low terminal velocity for the meteorite. There were no reports of craters that might be explosion craters. The reports of the trajectory from local observers were contradictory, and establishing the approximate path of the bolide will probably have to wait until a large number of observers can be interviewed.

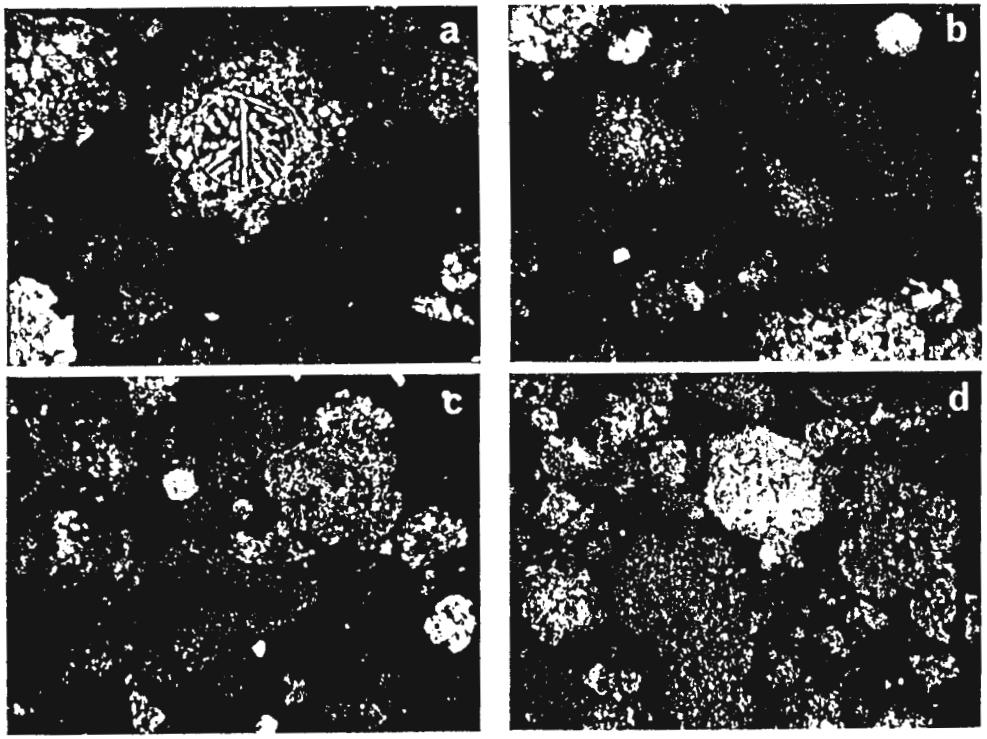

Fig. 1. Typical textures in the Pueblito de Allende meteorite. (a–c) Standard thickness petrographic sections showing much opaque matrix with a lesser amount of microcrystalline matrix. (d) More microcrystalline matrix, but still showing a significant amount of opaque area (section thickness is approximately 0.01 mm). Chondrules are well to sharply defined. All photographs were taken in plain light and at the same magnification. The length of each field of view is approximately 5 mm.

In hand specimens, the meteorite appears homogeneous from piece to piece, dark grey, with many obvious chondrules averaging approximately 2 mm in diameter but ranging to as much as 13 mm. Most specimens are hard and not readily friable except where badly fractured by impact or subsequent handling. On fractured surfaces, approximately 60 percent of the chondrules are broken through, but the remainder have nicely preserved hemispherical surfaces. The general appearance is similar to Mokoia or Vigarano, but the color is slightly lighter grey. The bulk density measured by air-comparison pycnometry is 3.67 g/cm^3.

Petrographic thin and polished sections show less than 1 percent metal and an estimated overall average of 60 percent chondrules and 40 percent matrix. In standard thickness sections, much of the matrix is opaque (Fig. 1, a–c) with some transparent microcrystalline matrix. However, in sections 0.01 mm thick (Fig. 1d) a much greater proportion of the matrix can be seen to be microcrystalline. X-ray diffraction patterns from bulk samples and nonmagnetic fractions have well-defined narrow olivine peaks, indicating relatively homogeneous olivine composition. Clinopyroxene is abundant, and there is a small amount of turbid glass. Chondrules are mostly well-defined to sharply defined. Pueblito de Allende would seem to best fit petrologic type 4 but seems to have many affinities for type 3 also (*1*). Detailed petrographic and mineralogic description is now in progress, and will be the subject of a later paper which should resolve this question.

Preliminary analytical information (Table 1) is sufficient to establish that Pueblito de Allende is a C group chondrite (*1*) based on the possible values of the ratio of metallic iron to total iron and of total iron to silica. The petrographic and chemical data now available indicate that the specimen should be classified as a C4 or C3.

One of the prime objectives of obtaining portions of this fall was to return suitable specimens to the Lunar Receiving Laboratory Radiation Counting Facility for total gamma and gamma-gamma coincidence spectrometry as quickly as possible in order to make analyses for isotopes with short half-lives (*2*). The 4180-g specimen was introduced into the gamma counter, and data was taken at 6:16 a.m. on 12 February, an elapsed time from fall to counter of approximately 101 hours. The other two large specimens (1259 and 782 g) are also being counted.

Table. 1. Chemical analyses of the Pueblito de Allende meteorite.

Oxide or element	Optical emission spectrograph * (wt %)	Atomic absorption † (wt %)	Spectrophotometric ‡ (wt %)
SiO_2	31.0		33.35
MgO	21.3	20.7	
FeO (total Fe)	31.9		28.9
Al_2O_3	2.9		3.75§
CaO	2.8	2.35	
Na_2O	0.60		
K_2O	0.01	0.093	
TiO_2	0.17		
MnO	0.14		
Ni	1.40		
Cr	0.32		
C	0.27¶		
N	0.007¶		
	0.0055¶		
Co	0.79		
Zr	0.0036		
B	0.010‖		
Cu	0.008		

* Monitored with W-I and a synthetic dunite standard; analyst: R. Martin. † Analysts: J. Allen and P. Johnson. ‡ Analysts: D. Bennett and P. Johnson. § Probably high due to iron interference. ¶ By combustion and chromatographic detection; analyst: C. Moore. ‖ Sample was prepared by grinding in a boron nitride mortar, but standards did not show contamination.

We believe that we have identified the following isotopes: U (Bi^{214}), Th (Tl^{208}), K^{40}, Al^{26}, Co^{60}, Na^{22}, Mn^{54}, and Na^{24} (half life = 15.0 hours). In addition, the following isotopes are tentatively identified: Be^7, Mn^{52} (half life = 5.7 days), Co^{56}, and Cr^{51}. Several peaks appear in the spectra that have not yet been identified. Data collection and evaluation is continuing in order to confirm the identification of the above isotopes and to obtain less complex spectra after the decay of the short-lived isotopes. A detailed evaluation of the gamma spectra from this meteorite is the subject of continuing work and will be reported later.

The counting of samples of short terrestrial age such as Pueblito de Allende is an excellent rehearsal for the Lunar Receiving Laboratory Radiation Counting Facility, because it is probable that many of the same isotop
present in the samples to
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The size of the total f
Pueblito de Allende is an
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came from obvious places, su
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and these specimens collectiv
approximately 27 kg. Based
graphic distribution of finds,
mated that the area of the f
at least 150 km^2, and it is
to expect that many more
will be recovered from su
desert areas.

E. A.
E.
K. A. R

Lunar Receiving Laboratory
NASA Manned Spacecraft
Houston, Texas

J. S

Oak Ridge National Laborato
Oak Ridge, Tennessee

References and Notes

1. W. R. Van Schmus and J. A. W
Cosmochim. Acta 31, 747 (19
2. Rapid recovery of specimens a
not have been possible without
operation from local authorities an
Ruben Rocha Chavez, editor of
Parral, was very helpful in locatin
falls and persons who had frag
nicipal President of Hidalgo del
Franco, extended every official
gave considerable support to eff
new specimens. Ing. Manuel Gon
special thanks for his hospitality
guiding, interpreting, and helpin
quisition of specimens. Dr. Carl
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18 February 1969

Evaporation Retarded by M

Abstract. *The reduction in t
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I thank Professors A. T. Price and A. A. Ashour for helpful discussions. This investigation is a preliminary contribution to the Nigerian Upper Mantle Programme.

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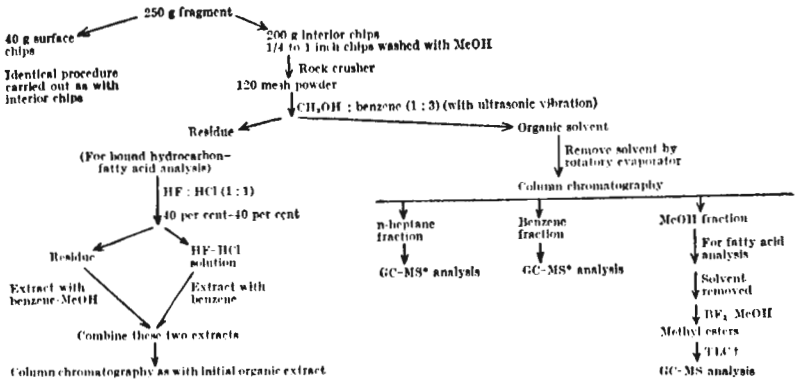
Organic Analysis on the Pueblito de Allende Meteorite

ON February 8, 1969, a meteorite fell near Pueblito de Allende, Chihuahua, Mexico. An elemental analysis of fragments, collected shortly afterwards, was published on February 28, 1969[1], and showed that it contained approximately 0·3 per cent carbon. In the meantime, samples of the meteorite were collected by one of us (B. R. S.). We now report the analysis for certain organic constituents in that sample which was collected on February 15, 1969. The carbon content of the sample used in these studies was approximately 0·35 per cent.

Dual analyses were performed between March 1 and March 10, 1969. The sample used was approximately egg-shaped, weighing 2·5 kg in total with a fusion crust over its entire surface.

The surface of a 250 g portion, on which the analysis was to be performed, was removed to a depth of about 0·25 inch, including all of the fusion crust and an approximately equivalent thickness of the fresh break which represented one surface. This operation, and all succeeding operations, were carried out in a clean cabinet through which a filtered air stream was continuously passing. The chips and centre piece were analysed separately, according to the following flow sheet.



* GC-MS = Gas chromatography and mass spectrometry. † TLC = Thin layer chromatography.

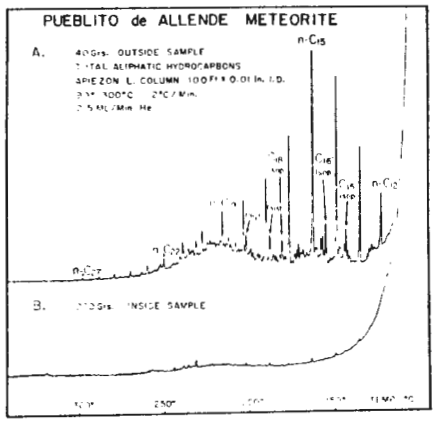


Fig. 1. Gas chromatogram of total aliphatic hydrocarbons from extractable organic material. Aerograph model 204 gas chromatograph equipped with a flame ionization detector. About 1/10 of the *n*-heptane eluate was injected in each case. *A*, 0·5 p.p.m. of hydrocarbons were detected in outside sample; *B*, 0·001 p.p.m. of hydrocarbons were detected in interior sample.

The extractable organic compounds are shown in the chromatograms in Figs. 1, 2 and 3. In each case, the *A* chromatogram represents the analysis of the surface chips and the *B* chromatogram represents the analysis of the interior of the sample. The surface chips in all three cases contained between 0·1 and 0·5 p.p.m., as indicated specifically in the figures, while the interior contained 0·001 to 0·002 p.p.m. as indicated. The identity of each peak was obtained by combined gas chromatography–mass spectrometry. All mass spectra were taken by a combination of an Aerograph 204 gas chromatograph and an AEI MS-12 mass spectrometer. The chromatogram of the organic extract obtained from HF–HCl dissolution revealed no organic material at all. The amounts of solvent soluble organic matter found in the interior portions are several orders of magnitude smaller than that reported[2–4] for other carbonaceous meteorites. A limit of 0·1 part per billion of possible indigenous organic matter is indicated.

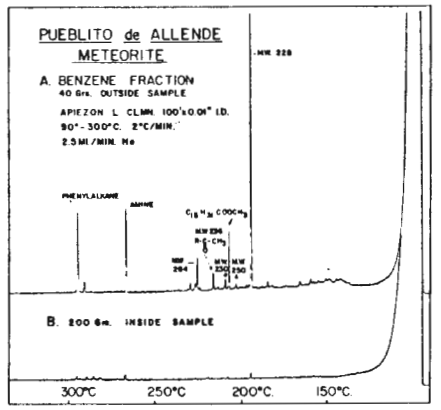


Fig. 2. Gas chromatogram of total benzene fraction from extractable organic material. *A*, 0·2 p.p.m. of organic compounds were found in outside sample; *B*, 0·002 p.p.m. of organic compounds were found in interior sample.

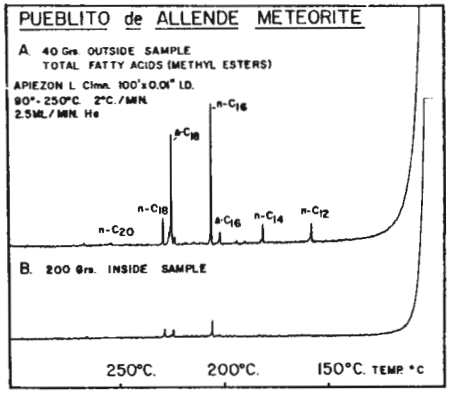


Fig. 3. Gas chromatogram of total fatty acids (methyl esters) from extractable organic material. *A*, 0·1 p.p.m. of fatty acids were detected in outside sample; *B*, 0·001 p.p.m. of fatty acids were detected in interior sample.

It is clear that the organic material found in the surface layer of this meteorite is of biological origin and cannot be other than terrestrial contamination acquired even in the short period of time available to the meteorite, namely, between its fall on February 8, 1969, and its collection on February 15, 1969. The speed with which this contamination was acquired, and the diversity of the material contained in that contamination, make doubtful any interpretation of such organic materials that have been found in meteorites of unknown, or at least considerably longer, terrestrial history[2,4]. The presence of the monounsaturated C_{18} fatty acid in the Pueblito de Allende meteorite is additional confirmation of recent contamination. Such unsaturation has not been found in the Pre-Cambrian rocks[5]. Furthermore, this exercise in analysis of rocks recently acquired on Earth makes all the more clear the need for the extreme precautions that are being taken in preserving the returned lunar sample.

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Recent Geological Investigations in the Irish Sea

AN area of Carboniferous rocks between the Isl and Anglesey has been found during a recent s and geophysical survey by the Institute of G Sciences in the north-east Irish Sea. Echo sounds from this area indicate a notably uneven sea b locally has a relief of up to about 40 feet and consists of outcrops of solid rock surrounded by clay or gravel. Rock samples were recovered with corer at fifteen localities and it seems likely that cored from outcrops rather than from boulders i clay. The samples have been identified as foll Fig. 1 for localities): three cores of Manx Slates the Isle of Man), three cores of rocks from the M plex (close to Anglesey), four cores of Carb (Westphalian) mudstones and siltstones, one cor vician mudstone, and four cores of mudstone and of undetermined age. These have yielded no Carb spores but are currently being examined for a microfauna. They may be of Lower Palaeozoic

At two other localities cores were obtained of Permo-Triassic aspect. It is possible that these were cored from large boulders in boulder clay, equally likely that they came from outcrops of s

The palynological examination of twelve sam been completed. The character of the residues has permitted the samples to be readily separated main groups. The southern group of eight sa was composed of finely digested carbonaceous mat small carbonaceous rods. From one of the sampl group three chitinozoans were recovered which h identified as ? *Cyathochitina campanulaeformis* and *C. calix* Eisenack and are taken to ind Ordovician age. The latter species, which has n recorded from sediments younger in age than Ca was recorded by Jenkins[1] from the basal Hope Shropshire which are of lower Llanvirn (*D. bifid* age.

The northern group of samples differs marke those of the southern area in possessing large q of well preserved plant debris and large num miospores. Representatives of the genus *Lycosp* dominant microfloral element in all four sampl monly made up more than 80 per cent of the tot blage. Of the less frequent forms recorded, the are of stratigraphical significance: *Baisdrickia* (Ibrahim) Schopf, Wilson and Bentall, *Dictyotr ticulatus* (Ibrahim) Schopf, Wilson and Bentall, *D*