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 approxi-

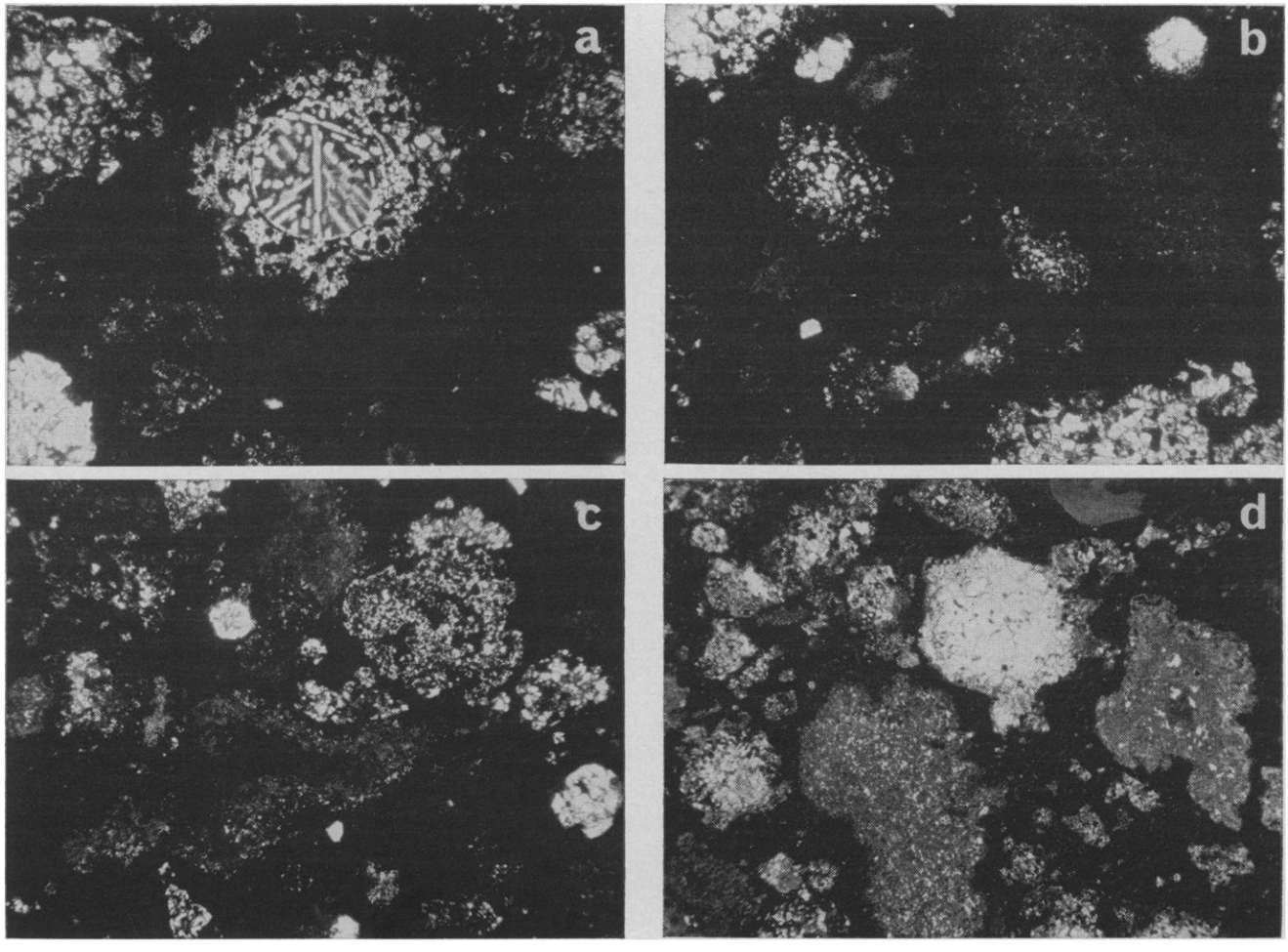

Fig. 1. Typical textures in the Pueblito de Allende meteorite. (a–c) Standard thickness petrographic sections showing much opaque matrix with a lesser amount of microcrystalline matrix. (d) More microcrystalline matrix, but still showing a significant amount of opaque area (section thickness is approximately 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.

mately 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.

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 pyncnometry 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-1 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 isotopes will be present in the samples to be returned from the moon by the Apollo project.

The size of the total fall around Pueblito de Allende is an interesting subject for speculation. All of the specimens recovered prior to 11 February came from obvious places, such as small towns, roads, and very close to houses, and these specimens collectively weighed approximately 27 kg. Based on the geographic distribution of finds, it is estimated that the area of the fall covered at least 150 km^2, and it is reasonable to expect that many more specimens will be recovered from surrounding desert areas.

E. A. KING, JR.
E. SCHONFELD
K. A. RICHARDSON
Lunar Receiving Laboratory, NASA Manned Spacecraft Center, Houston, Texas

J. S. ELDRIDGE
Oak Ridge National Laboratory, Oak Ridge, Tennessee

References and Notes

1. W. R. Van Schmus and J. A. Wood, *Geochim. Cosmochim. Acta* **31**, 747 (1967).
2. Rapid recovery of specimens and data would not have been possible without excellent cooperation from local authorities and individuals. Ruben Rocha Chavez, editor of *Correo del Parral*, was very helpful in locating the sites of falls and persons who had fragments. The Municipal President of Hidalgo del Parral, Carlos Franco, extended every official courtesy and gave considerable support to efforts to obtain new specimens. Ing. Manuel Gomez deserves special thanks for his hospitality and help in guiding, interpreting, and helping in the acquisition of specimens. Dr. Carleton Moore's rapid response in providing analyses for carbon and nitrogen is very much appreciated.

18 February 1969

Evaporation Retarded by Monolayers

Abstract. *The reduction in the steady-state rate of evaporation of water by hexadecanol monolayers depends only on the air velocity above the surface and is independent of the absolute rate of evaporation up to air velocities of 40 centimeters per second. This indicates that the monolayer does not affect the vaporization step but increases the size of the diffusion boundary layer. The mechanism (the creation of a surface pressure gradient in the monolayer which reduces the net stress on the surface by the air) is discussed.*

The reduction in the rate of evaporation of liquids by monolayers is of theoretical as well as practical interest (*1*). In discussion of the role of the monolayer, it is useful to consider the