64 PHYSICAL PROPERTIES OF DROPLET CHONDRULES.

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Much research into the chemical and mineralogical constitution of chondrules has been undertaken, but very little has been done to determine constraints on their origin from purely physical properties. We have separated droplet chondrules (identified by their near spherical form and generally smooth surfaces) from three relatively friable chondritic meteorites - Bjurböle (L4), Chainpur (LL3) and Allegan (H4). Individual chondrules were examined with apparatus incorporating two orthogonal binocular microscopes, and their three major axes measured. Maximum chondrule diameters ranged from 0.4 to 2.2mm in Bjurböle, 0.4 to 2.4mm in Chainpur and 0.15 to 2.75mm in Allegan. Histograms of the size distributions are negatively skewed, exhibiting a rapid rise from the smallest diameters to a well-defined peak. A sharp drop from this is followed by a more gradual decrease in number with increasing diameter. In Bjurböle the distribution peak lies between 0.8 and 1.2mm, and in Chainpur at 0.6 to 1.0mm. However, in Allegan we found many smaller chondrules and the distribution peaked at 0.35-0.75mm.

When phi values ($-\log_2$ diameter (mm)) are used in the construction of size distribution histograms the distributions become more symmetrical, indicating a log-normal distribution of chondrule sizes. Cumulative weight per cent plots of chondrule sizes for each meteorite were found not to conform to Rosin's law.

Various analyses were performed to determine the shape of chondrules in the three suites. In all cases the chondrules were found to depart from sphericity by small amounts and in a random fashion. In fact the shape properties of the three chondrule suites were remarkably similar.

After a careful consideration of the proposed chondrule forming mechanisms and the implications of our results it is our opinion that the melting of nebula dust-ball agglomerates by some high-energy event was the most probable chondrule-forming process.

65 A DISAGGREGATION AND THIN SECTION ANALYSIS OF THE SIZE AND MASS DISTRIBUTION OF THE CHONDRULES IN THE BJURBOLE AND CHAINPUR METEORITES

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This paper presents the results of a disaggregation and thin section analysis of the chondrule size distribution in the friable meteorite Bjurböle. Martin and Mills (EPSL 33, 239; 1976) imply that thin-section studies are not valid in this field and the meteorite disaggregation is required. However it was found that the size distributions of the chondrules obtained by these two techniques agreed within experimental error thus indicating that thin sections can be used to obtain accurate values for the chondrule size distribution. The chondrules were found to have a median diameter of 0.80 ± 0.01 mm, a mean density of 3.258 ± 0.008 g cm^{-3}, and a median mass of 8.7×10^{-4} g. The lower limit of the chondrule diameter was 0.25 ± 0.01 mm the largest chondrule having a diameter of 3.67 mm. Martin and Mills found a lower size limit of 0.4 mm.

Both the disaggregation and thin section chondrules had size distributions which obeyed Rosin's Law.

The size distribution of the chondrules revealed by a thin section of the meteorite Chainpur, was found within experimental error, to agree with the Bjurböle results.

66 COSMIC SPHERULES AS ROUNDED BODIES IN SPACE*

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SEM photography of many 'stony' and 'iron' type spherules (from Atlantic and Pacific surface red clay) show features which suggest the aligned flight through the atmosphere, at grazing incidence, of a body that was already round in space. Some spherules show fusion only on one hemisphere, and others show no fusion anywhere. If fusion occurs it is only superficial. Often the crust is "brushed", indicating flow in aligned flight. We believe that cosmic spherules are micrometeorites, possibly from a cometary source.

Comparison (SEM and Xray diffraction) of the stony spherules with the fusion crusts of ordinary and carbonaceous chondrites reveal marked differences. The surface texture of the meteorite is very smooth and the fayalite content of the myriads of tiny olivine crystals in the crust is about 50% less than that occurring in its interior. In contrast, the texture of the spherules is very crystalline and the fayalite content of their olivine agrees well with that for the interior of the ordinary chondrites. Also the magnetite lattice parameter in fusion crusts is greater than the parameter in the stony spherules.

* Preliminary report Nature 266 515-517 (1977).

67 MINERALOGY, PETROLOGY, AND CHEMISTRY OF THE ITAPICURU MIRIM, MACAU, AND SANTA BARBARA CHONDRITES.

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As part of a comprehensive research program on Brazilian stone meteorites, we present here the results of mineralogical, petrological and chemical studies of three previously only poorly described meteorites, Itapicuru Mirim (Maranhão), Macau (Rio Grande do Norte), and Santa Barbara (Rio Grande do Sul).

IN: Annual Meeting of the Meteoritical Society, 40, 1977, Cambridge

Itapicuru Mirim (fall, March 1879) consists of major olivine ($Fa_{18.8}$), orthopyroxene ($Fs_{16.8}$), metallic nickel-iron; minor plagioclase ($Or_{5.3}$ $Ab_{81.7}$ $An_{13.0}$), troilite; and accessory diopside ($En_{49.2}Fs_{7.0}$ $Wo_{43.8}$), chromite ($Uv_{6.3}Cm_{80.3}Hc_{2.9}Sp_{10.5}$), native copper, and whitlockite. Mineral and bulk composition (35.61 SiO_2, 0.11 TiO_2, 2.05 Al_2O_3, 0.53 Cr_2O_3, 9.44 FeO, 0.32 MnO, 22.31 MgO, 1.63 CaO, 0.79 Na_2O, 0.09 K_2O, 0.24 P_2O_5, 0.90 H_2O^+, 0.11 H_2O^-, 19.09 Fe, 1.93 Ni 0.05 Co, 4.96 FeS, 100.16 Total) and texture indicate H5 classification.

Macau (fall, Nov. 11, 1836) consists of major olivine ($Fa_{19.0}$), orthopyroxene ($Fs_{17.4}$), metallic nickel-iron; minor plagioclase ($Or_{5.4}Ab_{82.1}An_{12.5}$), troilite; and accessory Ca-rich clinopyroxene, chromite ($Uv_{5.8}Cm_{80.7}Hc_{1.6}Sp_{11.9}$), and hydrous ferric oxide of terrestrial origin. Mineral and bulk composition (36.26 SiO_2, 0.11 TiO_2, 2.02 Al_2O_3, 0.52 Cr_2O_3, 6.19 Fe_2O_3, 8.83 FeO, 0.32 MnO, 22.74 MgO, 1.65 CaO, 0.84 Na_2O, 0.09 K_2O, 0.26 P_2O_5, 1.42 H_2O^+, 0.10 H_2O^-, 12.07 Fe, 1.68 Ni, 0.06 Co, 4.74 FeS, 99.90 Total) and texture indicate H5 classification.

Santa Barbara (fall, Sept. 26, 1873) consists of major olivine ($Fa_{24.6}$), orthopyroxene ($Fs_{20.6}$), metallic nickel-iron; minor plagioclase ($Or_{5.2}Ab_{84.8}$ $An_{10.0}$), low-Ca clinopyroxene; and accessory high-Ca clinopyroxene ($En_{51.3}Fs_{10.4}Wo_{38.3}$), chromite ($Uv_{5.6}$ $Cm_{81.9}Pc_{1.1}Sp_{11.4}$), devitrified and turbid glass. Mineral composition indicates L group classification, and textural and mineralogical evidence (abundant twinned low-Ca plagioclase; turbid glass; microcrystalline groundmass with no evidence for extensive recrystallization) suggest petrologic group 4.

* Speaker

68 THE HICKIWAN, ARIZONA, CHONDRITE: AN ORIENTED STONE

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The Hickiwan meteorite was discovered on March 23, 1974 seven kilometers east of Hickiwan, Pima County, Arizona (112°24'32" W., 32°21'30" N.) by one of us (JEW). It was noticed because of its dark-brown color contrasting with the light granite grus of the pediment. The single stone is a well-oriented specimen with the shape of a flattened cone 15 cm in diameter and 6 cm in height, weighing 1,928g.

A study of the texture, mineral content and mineral composition was made using microscopic and electron microprobe techniques. Chondrules are readily discernible, although some intergrowth with the matrix has occurred. The matrix is a fine grained and somewhat recrystallized. Plagioclase occurs as small interstitial grains, and polysynthetically twinned clinopyroxene is present in minor amounts. Both olivine (Fa 19.4) and pyroxene (Fs 17.2) are homogeneous (%MD for FeO is 1.1 and 1.3 %, respectively) as determined by microprobe analyses. Thus, Hickiwan is placed into petrologic group 5. A modal analysis yields (in weight percent) 14.0 % metal, 3.8 % hydrated iron oxides of terrestrial origin, 4.9 % troilite, 67.1 % olivine and pyroxene, 0.8 % chromite and 0.1 % ilmenite. Calculating hydrated iron oxide as metal, the mode is very close to the average for H-group chondrites. Thus, the Hickiwan stone is classified as an H5 chondrite.

* Speaker

Isotope Anomalies 2

ROOM A

Tuesday afternoon

69 SUPERNOVAE, GRAINS AND THE ORIGIN OF THE SOLAR SYSTEM

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The discovery by Lee, Papanasstassiou and Wasserburg[1] that ^{26}Al ($\tau_{1/2} = 7 \times 10^5$ yr) was present when the solar system formed led to the realization that a nucleosynthetic event took place within a few million years of the condensation of objects in the solar system. In this work it is argued that the simplest self-consistent such event is a supernova. In addition to describing the detailed nucleosynthetic ejecta from such a supernova, the possible grain ejecta are also described. In particular, following the work of Lattimer, Schramm and Grossman[2] it is shown that the grain condensation sequences in supernova may help explain the relative magnitude of Clayton et al.'s[3] ^{16}O anomaly in various mineral species as well as many other effects. Not only is the composition of these grains discussed but also the chances of their formation and survival. If a supernova did occur, then the hydrodynamic shocks from such an event may have had a causal relationship to the contraction and formation of the solar system. This possibility is illustrated with some selected hydrodynamic models as is the possibility of mixing at the proto-solar-cloud-supernova ejecta interface. Finally the relationship between the 10^8 yr r-process-xenon timescale and the 10^6 yr ^{26}Al timescale is discussed and related to the standard density wave model of star formation.

[1]T. Lee, D. Papanastassiou and G. J. Wasserburg, 1976, Ap. J. 211, L107.
[2]J. Lattimer, D. N. Schramm and L. Grossman, 1977, Ap. J., submitted.
[3]R. N. Clayton, L. Grossman and T. K. Mayeda, 1973, Science , 485.

70 CONDENSATION IN SUPERNOVA EJECTA

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Pre-supernova stars are thought to consist of concentric spherical shells, containing unburned fuel in the outermost zone and products of static H-, He-, C-, O- and Si-burning in progressively deeper interior zones. Supernova detonation causes explosive burning of the matter in each zone and its ejection from the star. The gaseous ejecta may expand and cool to condensation temperatures before appreciable mixing occurs between adjacent zones. Because each zone has a different elemental and isotopic composition, the condensation sequence and isotopic compositions of condensates are different in each. Full equilibrium condensation calculations have been carried out for compositions representative of the various zones, taking into account the pressure decrease due to adiabatic expansion and condensation and variations in the C/O ratio and initial total pressure. Explosive H- and He-burning zones have similar compositions and condensation sequences. They resemble the familiar solar sequences but are displaced to higher temperatures relative to them at the same total pressure and C/O ratio. This is due to the absence of H which, in solar cases, dilutes the partial pressures of other elements and, at C/O < 1, binds available O in the stable molecule H_2O. In the explosive C-burning zone, the Ca/Al ratio is much less than the solar ratio. Al condenses mostly