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MEETING REPORTS

# Lifelike Forms in Meteorites

## Are fossils present in carbonaceous meteorites? The evidence is suggestive but as yet inconclusive.

Harold C. Urey

At a meeting held 1 May 1962 at the New York Academy of Sciences, a group of papers was presented dealing with the organized elements which were observed in carbonaceous chondrites and described by Claus and Nagy and by Nagy, Claus, and Hennessy, and with the hydrocarbon compounds reported by Nagy, Meinschein, and Hennessy. These observations have excited much interest and many comments, some critical and some tolerant, on the findings and interpretations.

A paper by Oro dealt with the nonbiological synthesis of deoxyribose and purines under assumed primitive earth environments from simple compounds of carbon. Berger reported the results of a similar study. He obtained acetone, acetamide, and urea from methane, ammonia, and water upon proton bombardment at a temperature of 77°K. Sidney Fox presented a paper in which he described the preparation of some organic artifacts, which he calls microspheres, from amino acids by heat treatment. He suggested that the organized elements reported in meteorites might indeed be fossilized artifacts of this kind.

Fitch and Anders discussed their observations at Chicago, suggesting that there are two kinds of organized elements. One class, of striking morphology, was definitely of biologic origin, they stated, but had never been seen in slides prepared in Chicago and was exceedingly rare in the slides of the Fordham group. With a single exception, the particles in this class matched in appearance terrestrial contaminants such as ragweed and juniper pollen, unidentified particles in airborne pollen study slides from Brooklyn, and starch grains. Organized elements of the second class, of featureless morphology, were indeed present in the Chicago slides, though in far lower abundance than the 1700 particles per milligram claimed by the Fordham group. However, in contradiction to reports by the Fordham group, these particles lacked all other properties suggestive of a biological origin (*1*). They did not fluoresce in ultraviolet; they dissolved in acids; they had the same density as the principal silicate in the meteorite; and they either did not stain with biological stains or stained atypically, giving no evidence of the deoxyribonucleic acid alleged to be present.

Nagy, Meinschein, and Claus presented evidence in regard to the mineralogical content of the carbonaceous chondrites and the composition of hydrocarbons extracted from these objects, and evidence for the existence of objects of biological origin in the meterorites. Various phases of these papers have previously been presented in the literature. New data were also included.

I served as chairman of the evening conference. The participants were as follows: Edward Anders, University of Chicago; J. D. Bernal, University of London; Rainer Berger, Lockheed California Company; Pierre Bourrelly, Muséum National d'Historie Naturelle de Paris; B. J. Cholnoky, National Institute for Water Research, Pretoria, Republic of South Africa; George Claus, New York University; Frank W. Fitch, University of Chicago; Sidney W. Fox, Florida State University; Douglas J. Hennessy, Fordham; W. G. Meinschein, Esso Research and Engineering Company; Bartholomew Nagy, Fordham; John Oro, University of Houston; C. M. Palmer, Robert Taft Sanitary Engineering Center, Cincinnati; Adolph Papp, University of Vienna; Robert Ross, British Museum (Natural History); Paul Tasch, University of Wichita; Heinz Dombrowski, University of Giessen, Bad Nauheim; Philip Morrison, Cornell; and Brian H. Mason, American Museum of Natural History.

As chairman, I reviewed my contact with the project from the beginning, mentioning my early skepticism in regard to the whole matter and my suggestion that additional experiments on hydrocarbons extracted from the meteorites be made by spectroscopic methods, to supplement the mass spectrographic analyses. In New York, in October 1961, Nagy had shown me chemical and mineralogical data pointing to the possibility that there had been life processes on the meteorite parent body (indications of liquid water, a slightly reducing and somewhat alkaline, aqueous environment). These studies established that the carbonaceous meteorites under study were extraterrestrial objects, unaffected in their interiors by high temperatures during their fall through the earth's atmosphere. Meinschein had shown me the results of mass spectrographic analyses, and of the ultraviolet and infrared spectra that were run at the Esso Research and Engineering Company on samples prepared by the partial separation of saturated and aromatic hydrocarbons and nonhydrocarbon compounds by chromatographic methods on material isolated by the Fordham group. Claus had shown me microscopic examples of what appeared to be fossils isolated from the Orgueil and Ivuna meteorites and had suggested that these had the appearance of microscopic fossils. Nagy, Meinschein, Claus, and Hennessy maintained that the results of the various types of experiments must be considered as a whole in order to evaluate the possibility of extraterrestrial life. Claus maintained that the organized elements had the appearance of microscopic fossils. I had studied microbiologic forms intensively for a number of years as an undergraduate student many years ago. The objects shown me did indeed have the general appearance of biological material. However, I in no way regard myself as an expert in these matters and I had urged that microbiologists and micropaleontologists be consulted in regard to the problem. The meeting in New York was called largely because both Bernal and I had stressed the desirability of consulting additional experts.

Bernal outlined the problem of the

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conference very well, pointing out that we need to know, first, what these objects are, and second, where they come from. He mentioned that they might be contaminations, artifacts—what he called "jokes of nature"—or remnants of indigenous organisms. Cholnoky held that the problem was essentially a biological one and stated firmly that if these are contaminants they do not belong in the classification of starch grains. Also he expressed the view that they are not organic artifacts.

Robert Ross (British Museum) reported on his own observations. The sample in the British Museum is from a complete stone which now is broken up. However, he used sterile instruments to scrape away the surface of the fragments and extracted the sample for study from the interior of the stone after taking this precaution. He found a smaller number of objects than those reported by the New York group. He made density separations and found organized elements of type 1 in the fraction below 1.6 grams per cubic centimeter and also in the fraction between 1.6 and 2.4 grams per cubic centimeter. He found other objects as well, which looked like collapsed spore membranes. In addition, he found two microscopic bodies which he and his colleagues at the British Museum regarded as indigenous and as of biogenic origin. These had a general umbrella or mushroom form. He concluded that other objects were indigenous to the meteorite and stated that they looked like fossil hystrichosphaeres. Ross's discussion was particularly informative and thoughtful.

Fitch pointed out that there were no pollen experts at the meeting and that this was important in view of the work of Anders, Schwartz, and himself on this question. Nagy pointed out that the microscope slides had been shown at a recent meeting at Tucson, Arizona, at which many experts on pollen grains were present, some 80 of whom examined the slides. It was his impression that none of these men advanced valid arguments supporting the view that the objects were pollen grains, though some had made the suggestion. Since the May meeting, measurements by Claus and others on the size of this "pollen grain" of Anders *et al.* have been made at the University of California, San Diego, and the size was found to lie between 15.0 and 15.5 microns, whereas Wodehouse records that ragweed pollen grains vary from approximately 17 to 24 microns in diameter. Whether drying would shrink a pollen grain by this rather substantial amount is difficult to determine, but apparently the measured sizes do not agree. Measurements on other objects of somewhat similar structure range down to 12 microns. A statement in regard to the opinion of Gunnar Erdtman is given in appendix 1. Erdtman admits that there is a superficial resemblance between certain organized elements and pollen grains but insists that the detailed morphologies are different.

Anders reemphasized the discrepancies between the observations of the New York and the Chicago groups. The particles of simple morphology were rarer by more than an order of magnitude than had been reported by Claus and Nagy. In contradiction to previous reports, they seemed to lack all other properties suggestive of a biological origin: fluorescence in ultraviolet and the presence of DNA. All established properties of these particles were consistent with an inorganic composition and origin. The particles of complex morphology were much rarer still; they did not occur in the Chicago samples, they had never been seen in thin section, and it was therefore necessary to establish that they were not merely terrestrial contaminants, to which they bore a strong resemblance.

Tasch said that what he saw on the slide reminded him of dinoflagellates and hystrichosphaeres. He noted that all the discussants might be correct. Some objects, for example, might very well be terrestrial contaminants, others might be Fox's microspheres, and objects in a third category might represent extraterrestrial pelagic protists. He pointed out that these live in water on the earth, and that therefore the difficult question remains of how the parent meteorite body maintained large, or even pond-sized, basins of water, together with the nutrient supply (phosphorus and so on) necessary for pelagic life. Papp pointed out that examples of organized elements had been seen by a number of men in the United States, by Ross in England, by Staplin in Canada, and by Skuja in Sweden. He expressed the view that these organized elements are indeed of biogenic origin and that they are indigenous to the meteorites. He added that the organized elements are not terrestrial forms but resemble such forms. Bourrelly expressed the view that the organized elements are definitely the residue of organisms, but he did not think they were chrysomonads.

Mason urged caution in regard to these conclusions and pointed out that there might well have been contamination by terrestrial organisms during the long period in which these meteorites have been preserved in collections. He stated that the organic compounds in the carbonaceous chondrites are certainly of extraterrestrial origin, but he felt that, so far, the evidence for a biological origin of these compounds is not compelling. Meinschein, in reply, said that many saturated hydrocarbons characteristic of terrestrial sediments had been detected and that aromatic compounds characteristic of those in some terrestrial sediments are present. He stated again that the similarity between the organic material found in terrestrial sediments and in the meteorites was very great and that it would be difficult to contaminate the specimen in any way that would imitate what was observed. (Again, I have consulted specialists in regard to this question; in appendix 2 are excerpts from a letter from Sol Silverman in regard to a paper by Meinschein, Nagy, and Hennessy in which the evidence for these conclusions was presented.) It should be noted that Cloëz (1864) extracted a small amount of organic compounds from the Orgueil meteorite, but not enough to make a detailed study. Since Meinschein *et al.* extracted only 0.5 percent, there is indication that there has not been a large contamination with hydrocarbons during storage in the last century.

My own conclusion from the conference, and from study given to the problems since, does not differ markedly from the tentative conclusion that I reached last October. I have seen specimens in thin sections under the microscope that look to me like the residue of biogenic microspecimens. I do not believe that they could have been introduced mechanically, and I doubt that they could have grown in the locations in which they are found since arrival of the meteorite on earth. Two experienced microbiologists and a mineralogist, who were present when these observations were made, agreed with both these views in regard to the specimens. The objects looked somewhat like pollen grains, to the amateur at least, but they were firmly embedded in the silicate matrix and thus could hardly have been introduced into the meteorite

mechanically, and pollen grains do not grow in such places. These objects from Claus's slides, taken together, make an interesting argument. The first (*a*) is a cross section of an object in a thin section. The object has a wall and spines or protuberances on its surface. It lies in the surface of the thin section and can be seen clearly. The second (*b*) is buried in the minerals below the surface in the thin section and is embedded in the silicate minerals; it can be seen only imperfectly, but it does have protuberances on its surface. The third (*c*) is an object which seems to have broken loose from the matrix but has some minerals sticking to its surface and also has protuberances on its surface. It is in fact the "pollen grain" of Anders *et al.* These three objects look very similar to me (*2*), Claus and Nagy report the diameters to be as follows: *a*, 12.9 microns; *b*, 13.2 to 16.2 microns; and *c*, 14.5 microns (*3*). The first two objects are firmly embedded in the matrix. The third is of biological origin according to all, or nearly all, observers. If such relationships could be confirmed and if other such objects should be observed, there would be a firm basis for a positive conclusion. It may be that other organized elements are mineral artifacts or biological contaminants. It should be noted, however, that in order to reach a positive decision relative to indigenous fossils in these meteorites it is only necessary that we be sure that *some* of these specimens are biogenic in character and indigenous to the meteorites. It should be realized that enthusiastic people may misclassify artifacts of one kind or another, or may mistake a contaminant for an indigenous form; in fact, it would be surprising if this did not occur in such a study. On the other hand, enthusiastic critics also may make mistakes.

It seemed to be the general opinion of all, or at least nearly all, the participants at the conference that further serious study should be given to this question by microbiologists, micropaleontologists, mineralogists, geochemists, and any other scientists who can make a contribution to the solution of this problem. It is doubtful that a conclusion that these compounds and fossil-like objects either are or are not valid evidence for extraterrestrial life can be drawn at the present time, although the evidence for extraterrestrial life is better now than it was before. The opinions expressed by the microbiologists and micropaleontologists are indeed very impressive. If it can be shown that these hydrocarbons and the "organized elements" are the residue of living organisms indigenous to the carbonaceous chondrites, this would be the most interesting and indeed astounding fact of all scientific study in recent years.

At the close of the session the chairman thanked Nagy, Claus, Meinschein, and Hennessy for bringing this subject to the attention of so many scientific groups, and for their great willingness to demonstrate and to discuss all details of the problem with the outstanding specialists in the field.

## Appendix 1

### Summary of a Discussion with Erdtman on Organized Elements in Carbonaceous Chondrites

On 11 May 1962 I was privileged to have a discussion on the above topic with Professor Erdtman, who is director of the Palynological Laboratory of the Swedish Natural Science Research Council, Stockholm. Dr. Erdtman, at a palynological meeting in Tucson, Arizona, the previous month, had the opportunity to examine slides of organized elements in carbonaceous chondrites prepared by Drs. Claus and Nagy. Dr. Erdtman is not willing to exclude the possibility that the organized elements are some kind of spores or sporelike bodies. He emphasizes that, especially in the lower fungi, there is a vast plethora of morphological types, only a few of which have been definitively studied. However, Erdtman emphasized that the organized elements did not resemble any recent or fossil terrestrial pollen or sporelike bodies of which he was aware. He felt that no organic solvents or extraction techniques could have produced the organized elements from pollen grains with which he was familiar. In particular, he felt that the possible identification of the organized element type 5 of Nagy and Claus with pollen of the evening primrose, which was being explored by Dr. H. G. Baker and myself, is untenable.

Dr. Erdtman is one of the world's leading palynologists, and his opinion should carry great weight. That there may be some rare species of fungi which have spores similar to the organized elements is not, I feel, a very significant possibility. If pollen or spore contamination is responsible for the bulk of the organized elements, there should be a direct relation between the most abundant pollen and spore particles and the most abundant organized elements. Dr. Erdtman's analysis shows that no such correlation exists. Therefore, the probability that the bulk of the organized elements in the carbonaceous chondrites are spore or pollen contaminants seems extremely small. [Note modified and approved by Dr. Erdtman. At the time Dr. Erdtman approved this statement, he had not seen the ragweed pollen grain referred to in this paper.—H.C.U.]

CARL SAGAN

## Appendix 2

### Excerpts from Letter of 23 May 1962 to Urey from Silverman

. . . I do not question the reliability of Meinschein's analyses, and I concur with his conclusions that the organic materials identified are comparable with biogenic and sedimentary organic materials on earth. Dr. Rosenfeld read the paper and the above comments represent his views too.

The only remaining question is whether the organic substances analyzed by Meinschein are extraterrestrial materials or . . . terrestrial contaminants. My first thoughts in this regard were to consider the concentrations of extractable bitumens; that is, are these concentrations high enough to rule out a reasonable level of terrestrial contamination? To this end, the concentrations of extractable materials in each of the meteorites were calculated; these are as follows:

| Meteorite | Wt. of sample (g) | Total wt. of extracted materials (g) | Wt. percent of extracted materials |
|---|---|---|---|
| 1-Orgueil | 1.7 | $0.007_1$ | 0.42 |
| 2-Orgueil | 14.5 | $0.075_1$ | 0.52 |
| 1-Murray | 1.9 | $0.001_8$ | 0.07 |
| 2-Murray | 10.2 | $0.006_7$ | 0.07 |
| Holbrook | 1.8 | $0.000_7$ | 0.04 |

It should be noted that these concentrations are maximum values. Although Meinschein has separated sulfur from the extracts, there is no evidence that the extracts are free of other inorganic materials removed by the solvents. Allowing that inorganic contaminants are not present in excess of 10 percent, the figures in the above table indicate that the bitumen content of the Orgueil meteorite is as high as that noted for sedimentary rocks from petroliferous areas and believed to have been saturated with petroleum at one time. Thus, unless this meteorite encountered an unusual level of exposure to bituminous materials during its history on earth, this concentration must be regarded as an unreasonable level of contamination. . . .

If the bitumen concentration of the Holbrook meteorite can be regarded as a reasonable contamination level, then the organic matter in the Murray is in the same class. . . .

I hope that these comments are of some help and thank you for bringing this interesting paper to my attention.

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### Notes

1. The following statement is published at Anders's request, and I have personally made observations bearing on it. I observed a type 1 organized element, as identified by Claus, in water under a microscope, as hydrochloric acid was introduced at the edge of the cover slip by an assistant. These objects have a high refractive index, are yellowish green, and in fact look like beautiful little buttons. The refractive index of the organized element decreased markedly when the acid reached it. The one side cracked a bit, but the object remained and did not change during about 1 hour of steady observation. The residue looked

like an algal cell, though it may have been a silicate residue.

Also, Celeste Engel treated an Orgueil meteorite sample from the Paris Museum with 48 percent hydrofluoric acid at about 80°C in a steam bath for about 8 hours. After a 2-hour and then a 4-hour treatment the hydrofluoric acid was washed from the sample and the sample was examined. After further treatment the remaining "crud" was mounted under a high-power microscope. I saw many outlines with apparently unresolved cell walls of about the sizes of the organized elements. They looked like small pellicles with the interiors destroyed. They were present in very great numbers—some six or ten in one field of the high-power microscope. It should be remembered that methods of preparing samples may make differences in the numbers observed. Also, it is by no means certain that all samples will contain precisely the same numbers. Under sufficiently rigorous conditions it is possible to destroy most varieties of organic matter. Engel worked carefully and secured some evidence of numerous objects in material where only small numbers had been detected previously. In this case the identity of the objects in the residue and of the organized elements was not established.

2. Nagy and Claus maintain that (*a*) and (*c*) are similar to each other but that (*b*) is not similar to the other two. Its spines extend inward from the wall, whereas the protuberances of (*a*) and (*c*) extend outward.
3. The diameters of the bodies were measured from outer wall to outer wall, exclusive of appendages. This is the micropaleontological and palynological convention for defining the size of spiny microorganisms.

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## Forthcoming Events

### September

*25–28.* Electric **Power Systems for Space**, conf., Santa Monica, Calif. (American Rocket Soc., 500 Fifth Ave., New York 36)

*26–27.* Physics of **Failure in Electronics**, Chicago, Ill. (M. E. Goldberg, Armour Research Foundation, Illinois Inst. of Technology, 35 W. 33 St., Chicago 16)

*26–28.* Practice of **Gas Chromatography**, meeting, East Lansing, Mich. (C. G. Harriz, Houdry Process & Chemical Co., Box 427, Marcus Hook, Pa.)

*26–29.* Austrian Soc. of **Biochemistry**, Society for Physiological Chemistry, German Pharmacology Soc., Vienna, Austria. (Secretariat, Vienna Medical Acad., 4 Alserstr, Vienna IX)

*27–28.* **Birth Defects**, symp., Nashville, Tenn. (R. Batson, Vanderbilt Univ. School of Medicine, Nashville)

*27–29.* **Protection of Plants** and Extermination of Pests, symp., Magdeburg, Germany. (Chemische Gesellschaft in der D.D.R., Unter den Linden 68–70, Berlin W.8, Germany)

*27–29.* Society for General **Microbiology**, Reading, England. (SGM, c/o Inst. of Biology, 41 Queen's Gate, London, S.W.7, England)

*28-29.* **Broadcast** Symp., annual, Washington, D.C. (G. C. Wetmore, Collins Radio Co., 1825 Connecticut Ave., NW, Washington 9)

*28–30.* **Medical Psychology**, intern. colloquium, Brussels and Louvain, Belgium. (P. H. Davost, Société de Psychologie Médicale de Langue Française, 2 rue de Rohan, Rennes, France)

*30–5.* American Soc. for **Testing Materials**, Pacific area, Los Angeles, Calif. (Executive Secretary, ASTM, 1916 Race St., Philadelphia 3, Pa.)

*30–6.* Medical **Hydrology and Climatology**, intern. congr., Baden-Baden, Germany. (M. Fontan, c/o Faculté de Médecine, Lille, France)

### October

*1–3.* Association of **Medical Illustrators**, annual, Detroit and Ann Arbor, Mich. (AMI, 1853 W. Polk St., Chicago 12, Ill.)

*1–3.* **Communications**, natl. symp., Utica, N.Y. (J. K. Webb, 489 Van Ellis Rd., Utica)

*1–3.* **Plastics**, intern. congr., Turin, Italy. (Segreteria, Congresso delle Materie Plastiche, Corso Galileo Ferraris 60, Turin)

*1–4.* American **Oil Chemists** Soc., Toronto, Canada (K. F. Mattil, Swift & Co., Packers and Exchange Aves., Chicago 9, Ill.)

*1–4.* **Electroencephalographic** Information, Marseilles, France. (R. Naquet, 23 rue de la Loge, Marseilles 2e)

*1–4.* **Iron and Steel**, intern., Luxembourg. (Secrétariat, c/o Centre National de Recherches Metallurgiques, Abbaye du Val-Benoit, Liége, Belgium)

*1–4.* **Shell Structures**, intern. conf., San Francisco, Calif. (A. C. Scordelis, Dept. of Civil Engineering, Univ. of California, Berkeley 4)

*1–5.* American Soc. of **Tool and Manufacturing Engineers**, Los Angeles, Calif. (R. M. Johnson, 3336 Stinson Blvd., Minneapolis 18, Minn.)

*1–6.* **Food Standards**, conf., Geneva, Switzerland. (Intern. Agency Liaison Branch, Office of the Director General, Food and Agriculture Organization, Viale delle Terme di Caracalla, Rome, Italy)

*1–6.* International **Astronomical** Union, symp. on site testing, Rome, Italy. (D. H. Sadler, c/o Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex, England)

*1–6.* International Soc. of **Photogrammetry**, Milan, Italy. (A. L. Nowicki, c/o Army Map Service, 6009 Massachusetts Ave., NW, Washington, D.C.)

*1–6.* **Malaria**, conf., Manila, Philippines. (World Health Organization, Regional Office for the Western Pacific, P.O. Box 2932, Manila)

*1–10.* International Council for the **Exploration of the Sea**, Copenhagen, Denmark. (ICES, Charlottenlund Slot, Charlottenlund, Denmark)

*2–4.* Advanced **Propulsion** Concepts, Cincinnati, Ohio. (M. M. Slawsky, Air Force Office of Scientific Research, Washington, 25)

*2–4.* **Batteries**, intern. symp., Bournemouth, England. (D. H. Collins, Admiralty Engineering Laboratory, W. Drayton, Middelsex, England)

*2–4.* **Fluid Amplification**, symp., Washington, D.C. (by invitation only). (Public Information Officer, Diamond Ordnance Fuze Laboratories, Room 315, Bldg. 83, Washington 25)

*2–4.* **Physics and Nondestructive Testing**, symp., San Antonio, Tex. (D. L. Black, Southwest Research Inst., Box 2296, San Antonio)

*2–4.* **Space Electronics and Telemetry**, symp., Miami Beach, Fla. (O. A. Hoberg, Marshall Space Flight Center, M-ASTR-I, Bldg. 4487-B, Huntsville, Ala.)

*2–5.* American **Roentgen Ray** Soc., Washington, D.C. (C. A. Good, Mayo Clinic, Rochester, Minn.)

*2–5.* **Animal Care Panel**, annual, Chicago, Ill. (R. J. Flynn, Argonne National Laboratory, Argonne, Ill.)

*2–5.* **Human Engineering**. Annual inst., Stamford, Conn. (J. H. Ely, Dunlap and Associates, 429 Atlantic St., Stamford)

*2–5.* **Prophylactic Medicine and Social Hygiene**, intern. congr., Bad Godesberg, Germany. (Kongressbüro, Postfach 864, Bad Godesberg)

*2–8.* Committee on **Human Genetics**, World Health Organization, Geneva, Switzerland. (WHO, Palais des Nations, Geneva)

*2–9.* **Sanitary Engineers**, seminar, Belgium. (World Health Organization, Regional Committee for Europe, 8 Scherfigsvej, Copenhagen Ø, Denmark)

*3.* **California Acad. of Sciences**, San Francisco. (S. W. Muller, CAS, Golden Gate Park, San Francisco)

*3–5.* International Union for **Applied Ornithology**, Frankfurt am Main, Germany. (S. Pfeifer, Institut für angewandte Vogelkunde, Steinauer Strasse 44, Frankfurt am Main-Fechenheim)

*3–5.* New **Respiratory Disease Viruses**, intern. conf., Bethesda, Md. (C. G. Loosli, Univ. of Southern California School of Medicine, 2025 Zonal Ave., Los Angeles)

*3–6.* **Optical** Soc. of America. Rochester, N.Y. (M. E. Warga, Executive Office, OSA, 1155 16 St., NW, Washington, D.C.)

*4–5.* International Soc. for **Geomechanics**, congr., Salzburg, Austria. (Landesverkehrsamt Salzburg, Mozartplatz 10/1, Salzburg)

*4–5.* International Soc. of **Rock Mechanics**, colloquium, Salzburg, Austria. (ISRM, Franz-Josef-Str. 3, Salzburg)

*4–5.* **Solid Fuels**, conf., Pittsburgh, Pa. (Society of Mining Engineers, Coal Div., 345 E. 47 St., New York 17)

*5–7.* Association of **Cereal Research**, milling conf., Detmold, Germany. (Arbeitsgemeinschaft Getreideforschung, Am Schützenberg 9, Detmold)