

resolution between adjacent reflexions, can be obtained even at depths down to 5,000–6,000 ft.

A paper on instrumental distortion and the seismic record, by N. A. Anstey, attracted considerable interest. Taking a standard seismic input pulse—the Ricker velocity wavelet—Anstey has determined the various distortions of this pulse which arise due to filtering, automatic gain control, and high-amplitude effects in reflexion amplifiers. These distortions may affect the relative amplitudes, the shapes of the pulses, and the arrival times. Clearly, in the attempts which are now being made to use the reflexion method to the utmost limits of its resolving power, these instrumental effects must be fully understood, and in this respect Anstey's work is a most valuable contribution.

Out of the remaining twenty-three papers presented at the meeting, almost half dealt with the detailed mathematical and geometrical problems involved in the interpretation of geophysical results. Of these, the papers by F. Veyretout, M. Rimbaut, and by J. Schoeffler and L. N. Nardon were concerned with seismic reflexion problems; those by L. H. Tarrant and by S. Wyrobek dealt with refraction interpretation; those by A. H. Kleijn and by K. Helbig investigated the effects of seismic anisotropy; while A. Lundbak, C. Monnet, A. Hahn and T. Knight gave papers on gravity and/or magnetic interpretation.

Considerable interest was attracted by three papers presenting the results of gravity determinations: the first, by F. A. Vening Meinesz and A. P. Collette, reported a regional gravity survey of the North Sea carried out by means of an underwater gravity-meter, with the co-operation of the Royal Netherlands Navy; another, by G. P. Woollard, W. E. Bonini and J. C. Rose, gave the latest results in their programme for the establishment of a world-wide network of gravity bases; and the third, by Rose and Woollard, described the measurements carried out from end to end of the North American continent with quartz gravity pendulums, with the object of establishing a gravity calibration baseline. Three papers dealt with seismic field-research: two of these, by T. Gaskell and by M. Pieuchet and H. Richard, were concerned with the efficiency of the customary source, that is, explosives either in a shot-hole or on the surface; and in the other, R. G. Mason described investigations of surface waves near the less commonly used alternative source, namely, a dropped weight. Actual field-surveys for mineral resources were the subject of two papers, one by M. Guerrier and A. Rogier on the Lorraine coal-basin, and one by R. Cassinis on exploration for sulphur limestone in Sicily.

The remaining four papers serve to illustrate the diversity of topics at the meeting. W. Domzalski dealt with problems of very shallow refraction work for civil and mining engineering purposes. F. Sumi treated some of the refinements of the electrical earth-resistivity method. Some novel ideas on the possible turning to advantage of seismic noise in prospecting were expounded by M. Matschinski. Lastly, very precise hydrostatic levelling for foundation problems was described by O. Meisser.

The meeting ended with a showing of the British Petroleum Company's film, "The New Explorers". Despite the many counter-attractions of London, attendance at the technical meetings was consistently high, showing that the meeting was most successful in furthering the interchange of geophysical knowledge and ideas.

L. H. TARRANT

STRUCTURE OF SEMI- AND NON-CRYSTALLINE MATERIALS

THE autumn conference of the X-ray Analysis Group of the Institute of Physics was held in London at the Institution of Civil Engineers during November 18–19, the topic for discussion being "Semi- and Non-Crystalline Materials". In her opening paper, on the mechanism of crystallite growth in carbons, Dr. R. E. Franklin reviewed her work on the structure of graphitic and non-graphitic carbons. The latter can be further classified into graphitizing and non-graphitizing carbons according to whether crystallite growth can be induced by heat-treatment or not. From this fact, and from the nature of order produced during growth, certain conclusions about the mechanism of crystallite growth can be drawn, in particular when the graphitic sheets grow by the addition of edge groups and when growth is normal to the plane of the sheets. In discussing this paper, Dr. G. E. Bacon described his own work on radiation damage in crystalline graphite, where the order destroyed by irradiation can be completely restored by heat-treatment.

Dr. R. Diamond gave an account of a new theoretical method which he has developed for the interpretation of amorphous scattering curves, and which he has applied to the composition of various coals. Exact theoretical curves for the X-ray scattering from perfect condensed aromatic ring systems of various sizes were first calculated on the EDSAC digital computer. A linear combination of such curves was then fitted to each of the observed experimental intensity curves by the method of least squares, and from the coefficients in the combination histograms were obtained showing the proportions of the various ring systems present. This matrix method is to some extent analogous to the process of Fourier inversion; in cases such as this one, where all the possibly existing components are known, it avoids the difficulties due to cut-off and to the inaccuracies in the experimental curves at high values of $(\sin \theta)/\lambda$. The method has been applied by Dr. Diamond to a study of vacuum carbonization of coal, where the effects of polymerization and evaporation have been clearly shown. Dr. L. Cartz has used the same method on the vitrain series of coals and on ethylene diamine extracts of coals, and has derived histograms of molecular sizes, matching being carried out in the region of the (11) band. Discrepancies occurring between theoretical and experimental curves in the region of the (10) band can be explained as due to the (00l), that is, to intermolecular effects. Replying to questions by Dr. Stadler, Drs. Diamond and Cartz stated that they have also examined quinone extracts in which experimental and calculated curves do not agree; a chemical change during extraction is thought to have taken place.

Prof. R. W. Douglas reviewed some of the experimental work on the structure and physical properties of glass. The principal X-ray work in the subject, that of Warren and his associates on silica, and on soda-silica and boric oxide glasses has led to a concept of network-forming atoms and network-modifying atoms. The rather anomalous physical properties of boric oxide and sodium borate glasses have to some extent been explained by recent infra-red absorption measurements on these materials which have given important information on the bonds present. The

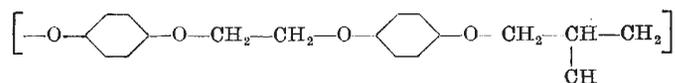
X-ray results have indicated the liquid-like structure of glasses, and, on the whole, their behaviour fits well into this pattern; much research, however, is still needed into the long-range order of glasses.

Dr. R. L. Gordon described X-ray measurements made by himself and his colleagues which indicate the presence of a disturbed layer, effectively about 1000 Å. thick, existing at the surface of finely ground quartz particles which could be partly removed by etching, particles of diameter less than about 0.5 μ apparently not containing any perfectly crystalline material. This conclusion was not universally accepted in the subsequent discussion, which, however, failed to produce an alternative explanation of Dr. Gordon's X-ray results; these were supported by other measurements such as differential thermal analyses. In discussing the papers on glasses and on quartz, Dr. A. E. J. Vickers described the difficulty of producing commercially truly isotropic fused silica.

Dr. W. May next gave an account of special X-ray diffraction techniques developed for obtaining patterns of liquid systems. His apparatus consists of a cylindrical powder-camera on the axis of which a free jet of liquid serves as specimen. The camera is kept filled with helium so that the pattern is practically free of unwanted scattering. The liquid is circulated by a pumping unit of the 'closed' type needing little attention, and interlocking safety devices between the X-ray unit and the pumping unit safeguard the operation of both. Provision has been made for working temperatures between 0° C. and 80° C.

Mme. J. Longuet-Escard described the work which she has carried out with J. Mering on colloidal nickel hydroxide. In settling from a fresh suspension, very small crystals of nickel hydroxide tend to stick together by their (001) faces. In this coagulation the ionic double layer of the surface is imprisoned, and non-rational (00*l*) reflexions are produced. The abnormal spacing (that is, the thickness of the imprisoned ionic layer) cannot be calculated from Hendricks's and Teller's formula, since its distribution in the stacking process does not follow a law of constant probability. The spacing can be determined directly by a Fourier transformation of the (00*l*) intensity distribution. The thicknesses thus measured were found to depend upon the nature of the anion and the state of hydration of the double layer. In the case of a chloride ion, spacings more than three times the normal spacing of nickel hydroxide (4.60 Å.) have been found.

The final session of the conference was devoted to a discussion of non-biological fibres. Dr. L. Brown described preliminary crystallographic investigations on a polymer of repeating unit:



which may be prepared from 4,4'-dihydroxydiphenoxyethane and epichlorhydrin in the presence of sodium hydroxide. In the crystal the molecule is found to be twisted, probably S-shaped with the planes of the benzene rings at an angle to the chain axis. The crystallographic repeat is probably two molecular units, arranged around a two-fold screw axis. The symmetry is monoclinic with two chains (that is, four residues) in the unit cell. The inter-

esting point about this structure is that the *b* (chain) axis extends reversibly from 27.6 Å. to 29 Å. on stretching, with only slight changes occurring in the diffraction pattern. Under suitable conditions the molecules may be drawn out to a straight form with a repeat of 16 or 32 Å., but they do not appear capable of crystallizing in this form.

Dr. E. R. Howells next presented the results of X-ray examinations carried out by Mr. C. W. Bunn and himself on straight-chain fluorocarbons, particularly on 'Fluon', polytetrafluoroethylene. The fluorocarbon chains, both in 'Fluon' and in perfluorocetane, C₁₄F₃₄, were found to have a helical configuration with six turns in the repeat unit of thirteen (CF₂) groups. On account of the relatively large van der Waals radius of 2.7 Å. of fluorine, the cross-section of the fluorocarbon chain is very nearly circular, and it should therefore be easy for chain segments to rotate about their own axes. This rotation probably accounts for the remarkable room-temperature transition which occurs in 'Fluon' some 300 deg. below the melting point; as Mr. Bunn pointed out in a reply to a question, the rotation may also be the explanation of the remarkably low coefficient of friction of the polymer: the cylindrical molecules may be acting as roller bearings.

Dr. A. Keller has been studying orientation phenomena in synthetic crystalline polymers, where the crystallites do not appear in a haphazard way, but form sub-microscopic fibrous aggregates. These fibrils themselves can build up larger structures, the spherulites, within which they are essentially radially disposed. Thus a polymer which is macroscopically unoriented is in fact composed of minute oriented regions which arise spontaneously from melt or solution. Dr. Keller has studied the orientation of the unit cell within these regions by means of a micro X-ray technique and found it to be such as to result in a predominantly perpendicular disposition of the chains with respect to the radii of the spherulites. In certain special cases the X-ray results have been correlated with birefringence measurements. The existence of these spontaneously oriented regions can manifest itself when a crystalline or crystallizing polymer is artificially oriented. A number of uniaxial orientations were observed which are unusual since the molecular chains are oriented preferentially in directions other than that of the external orienting influence. While this is unexpected from simple molecular considerations, Dr. Keller showed that the anomaly is only apparent and that the actual orientations fit in well with his picture. Prof. J. D. Bernal pointed to a possible similarity between Dr. Keller's spherulites and those observed, although of a much larger size, by Dr. Conmar Robinson in solutions of synthetic poly- γ -benzyl-L-glutamate.

In a short contribution, Dr. K. Dornberger-Schiff gave examples of the type of misalignment and 'mistakes' occurring in semi-crystalline material in which only a two-dimensional periodicity is retained. Such structures are best treated by considering the planar symmetry of the two-dimensionally ordered regions rather than by space-group theory. Important examples of the type of treatment suggested by her are afforded by certain fibrous minerals, notably chrysolite, halloysite and garnierite, which Dr. E. J. W. Whittaker has been examining. He has found that, while these minerals do not possess crystal lattices of the ordinary kind, their structures can be described in terms of cylindrical lattices. He defined a cylin-

drical lattice as a set of congruent two-dimensional lattices inscribed on a set of cylindrically curved surfaces and mutually ordered with respect to the cylinder axis, there being equal and uniform normal spacings between each successive pair of such surfaces; he then developed a classification of such lattices which is a cylindrical analogue of ordinary space-group theory.

Dr. D. E. Corbridge reported on his structure analysis of the fibrous 'Kurrol' salts, which are long-chain metaphosphates; they are insoluble and exhibit colloidal behaviour. In the case of rubidium metaphosphate, the unit cell is monoclinic and contains continuous chains of composition $(\text{PO}_3)_n^{n(-)}$ spiralling around the screw axes with a repeat pattern every two PO_3 units; similar structures have been found for the potassium and caesium salts. Dr. Corbridge pointed out some interesting structural resemblances between the metaphosphate chain and long-chain anions found in certain silicate minerals which also form helical structures.

An interesting and stimulating evening discourse was delivered during the conference by Prof. A. R. Ubbelohde, whose subject was "Crystallography and the Phase Rule". The next conference of the Group will be held jointly with the Low Temperature Group of the Physical Society; it will take place in Oxford during April 11-13 and will be devoted to low-temperature crystallography. U. W. ARNDT

DENSITY OF THE LUNAR ATMOSPHERE

SOME of the values of the density of the Moon's atmosphere obtained by observers in the U.S.S.R. are discussed by E. J. Öpik, of the Observatory, Armagh, in a paper in the *Irish Astronomical Journal* (3; March 1955). The Russian workers determined the relative polarization of the diffuse light of the sky near the horns of the lunar crescent and they arrived at a value approximately 0.5×10^{-4} of the terrestrial atmosphere, but A. Dollfus in 1952 found a value 10^{-9} for the upper limit (*C.R. Acad. Sci., Paris*, 234, 2046; 1952). J. N. Lipskij carried out a detailed investigation and arrived at a value of the order 10^{-4} (*Pub. Sternberg Astro. Inst., Moscow*, 22, 66; 1953), but Öpik's examination of the matter shows that the values obtained by the Russian observers must be far too big.

In his investigations, Öpik completely ignores any possible absorption by the hypothetical lunar atmosphere, which is too thin to cause absorption effects, and hence the surface brightness in a given direction will be proportional to the intensity of illumination and to the illuminated air mass per unit cross-section along the line of sight. On this assumption, he shows that the surface brightness of the earth-shine at quarter phase is at least thirteen times as great as that of a vertical column of the lunar atmosphere illuminated by the Sun, and this result is used to determine the upper limit to the mass of the lunar atmosphere. It seems highly probable that any lunar atmosphere (if such exists) will be practically free of dust, and Raleigh scattering of light by the gas molecules prevails. It is assumed that the scattering power of the lunar atmosphere is about the same as that over high mountain tops, such as Mount Whitney (4,420 m. above sea-level), and C. G.

Abbot's observations on Mount Whitney (*Ann. Astrophys. Smithsonian Inst.*, 3, 145; 1913) showed that the surface brightness of a sunlit atmosphere at sea-level, but of a degree of purity equal to that on Mount Whitney, is 8.02×10^{-7} . The surface brightness of the earth-shine, measured by Öpik in 1924 and by Danjon in 1936, is about 25.84 mag., from which it is easily found that the surface brightness of earth-shine is 4.61×10^{-11} . The ratio of the lunar to the terrestrial atmospheric masses in vertical columns of unit cross-section is therefore less than $4.61 \times 10^{-11}/13 \times 8.02 \times 10^{-7}$ —that is, less than 4.42×10^{-6} —making use of Öpik's figure thirteen, as already explained earlier.

It appears from this investigation that the mass of the lunar atmosphere is less than 1/226,000 of the terrestrial, and with the smaller gravity on the Moon, the pressure and density of the lunar atmosphere cannot be more than one part in 1.3 millions of those of the terrestrial atmosphere.

INSECTICIDES AND THE BALANCE OF ANIMAL POPULATIONS

DR. H. E. HINTON, of the Zoology Department, University of Bristol, has recently directed attention to the dangers involved in the indiscriminate use of insecticides (*Sci. Prog.*, 43, No. 192; October 1955).

Much has been written on the kinds of direct injury that can be done to crops and other useful plants by insecticides, while individuals using poisons are materially concerned with any damage they may do to farm animals, crops and ornamental plants. They are not always as interested in the damage they may do to wild animals and birds, and they occasionally tend to dismiss injuries to their operatives as unavoidable occupational hazards. For example, in Argentina the incidence of dermatitis in workers exposed to BHC was once as high as 25 per cent. Fish are said to be as sensitive to DDT as insects; but the possibility of producing damaging concentrations in water as the result of normal control operations is slight.

In 1952 many instances of death or serious injury following the use of DDT, BHC and other chlorinated hydrocarbons had been reported. The chlorinated compounds which are fat-soluble and chemically stable tend to accumulate in the fatty tissue; this explains why animals with a large amount of fat tend to be less susceptible to acute poisoning than under-nourished ones. It has been shown that, in mammals, accumulation occurs at all ordinary levels of intake, and rats may accumulate DDT in the fat body until there may be as much as thirty times the level of intake. More DDT may accumulate in the fat body than is required for a lethal intravenous dose without the mammal showing any obvious signs of poisoning. Elimination occurs slowly; but sudden starvation may release enough DDT to affect the animal seriously. It is also known that there are great seasonal differences in the susceptibility of insects to chlorinated compounds, and there is good evidence that these seasonal differences are related to the amount of depot fat present. Many investigators believe DDT should not be used on dairy cattle and animals that are to be eaten because it accumulates in the milk and fatty tissues.