

cloud. Cometary chemistry is very similar to that of interstellar gas but fortunately comets are closer. The interaction between the plasma in the cometary coma and the high speed magnetoplasma of the solar wind poses exciting physical problems. Comets are also probably in the form of the original condensate from the pre-Solar System nebula and as such furnish an outstanding clue in cosmogony.

Halley's comet was visible to the naked eye over a four month period at its 1910 apparition. The nuclear region was several thousand kilometres in diameter but on 18 May, 1910, when Halley transited the Sun, no solid nucleus was observed against the solar disk indicating that, if this existed, it must be less than 50 km across. The coma was about 3×10^7 km in diameter during the postperihelion phase, and had a continuous background spectrum with superimposed CN and C₂ lines. Transient phenomena were observed in the inner coma regions. Halley is a very dusty comet and also has non-gravitational effects acting on its nucleus leading to a lengthening of the orbital period by about 4.1 d per apparition.

The main scientific objectives of the fly-by are to image the nucleus, to find its size, shape, rotation period and colour, to determine the nature of the multiple condensations seen in 1910, to determine the abundance and spatial distribution of neutral molecules, radicals and charged particles in the coma and tail, to investigate the shockwave interaction between the cometary plasma and the solar wind, to measure the spatial density and size distribution of the emitted dust particles and to investigate the time variation of the coma's structure and brightness.

Opportunities for ballistic missions to Halley have been studied by Robert W. Farquhar and William H. Wooden II (NASA Goddard Space Flight Centre) and have been recently reported in NASA Publication No. X-580-77-46. At a fly-by speed of 60 km s⁻¹ the spacecraft will pass through the inner and outer coma in 14 and 18 min respectively. The miss distance from the nucleus would be about 2,000 km. The spacecraft could approach closer to the nucleus with onboard navigation but previous visual observations indicate that Halley has multiple nuclear condensations and it would be difficult to know which one to pick when the spacecraft is a considerable distance from the comet. At perihelion Halley is about 0.59 a.u. from the Sun. Perihelion passage occurs on 10 February, 1986 and most investigating spacecraft plan to visit Halley within a period of about 60 d either side of this date.

The Warsaw-Moscow soil structure project

from I. J. Smalley

A JOINT programme to provide a set of soil structure standards for use in engineering geology and soil mechanics has been under way for five years at the Universities of Warsaw and Moscow and is now nearing completion. The first applications of the scanning electron microscope (SEM) to soil structure studies were made in the late 1960s and in 1971 a project was initiated by B. Grabowska-Olszewska of the Warsaw University Engineering Geology Institute and V. Osipov and V. Sokolov of Moscow University with the aim of providing a complete range of reference structures from clay sediments of different ages and from different sedimentary environments.

The scanning electron microscope has not proved as effective a tool in the investigation of soil structures as was hoped when studies began and much of the earlier enthusiasm is now waning. There is, however, a growing emphasis in engineering geology and soil mechanics on the study of earth materials in some detail and Attewell and Farmer (*Principles of Engineering Geology*, Arnold, 1976) and J. K. Mitchell (*Fundamentals of Soil Behaviour*, Wiley, 1976) in their new books both present extensive sets of soil microstructures, but they are essentially illustrations; the relating of soil structure to engineering properties has not been achieved. A set of standard structures with related properties may help in the making of this necessary connection.

The Warsaw-Moscow project has been hampered by the lack of SEM facilities in Poland and the USSR and most of the structural photographs were obtained using the American

built 'Cwik-Scan' 106A SEM of Moscow University. Samples were taken from Poland and the European USSR and all geological areas are represented from Proterozoic to Holocene. The programme involved the examination and testing of 86 samples of eluvial, hydrothermal, marine, lacustrine, alluvial, glacial and glacial-lacustrine origins. Five structural elements were identified: primary clay particles, micro-aggregates, aggregates, grains and inclusions of microfauna, microflora and microcrystals of salts and ore minerals. The structural data, usually presented as 5000× and 500× photographs, is supplemented by a range of property measurements including specific gravity, water content, density of wet soil, porosity, specific surface, liquid limit, plastic limit, uni-axial and pure shear strengths and it is the relation of this set of mechanical data to the structural representations which makes the project so valuable.

E. M. Sergeev (Moscow) and W. C. Kowalsky (Warsaw) have editorial attachment and various western investigators have been involved; in particular David Krinsley of Arizona State University, doyen of the SEM sand gazers, has recently been in Warsaw helping with the final stages of the project; and R. Pusch of Lulea University has been giving encouragement. The 1973 Gothenburg Engineering Soil Structure Symposium organised by Pusch revealed the disorder and confusion in the field; perhaps the Warsaw-Moscow project will provide a necessary foundation for future studies.

I. J. Smalley is a lecturer in the Department of Civil Engineering at the University of Leeds.

Rendezvous with Halley

Farquhar and Wooden put forward four possible missions. The first is a dual launch around 4 July, 1958 of the spacecraft using a single Space Shuttle, one planned to intercept Halley 63 d before perihelion (at 1.37 a.u.) the other 39 d after perihelion (at 1.00 a.u.). One approaches Halley from the sunward side the other from the anti-Sun direction. The second scenario again uses the Shuttle to launch two spacecraft, this time on 10 March, 1985. One intercepts Halley 58 d before perihelion passage, the other flies off to intercept two other comets, Giacobini-Zinner on 11 September, 1985 and

Borelly on 25 December, 1987 these interceptions taking place at 1.03 and 1.36 a.u. respectively. The third launches the spacecrafts at Halley in a trajectory that returns to Earth after passing the comet. They then swing past the Earth and are retargeted on Borelly to fly-by in January, 1988 or comet Tempel-2 in September, 1988. The final proposed mission has a dual launch in August, 1985, with both spacecraft encountering Halley at the same time, one passing the nucleus on the sunward side at a distance of about 2,000 km and the other moving through the tail about 30,000 km behind the nucleus.