ICE AGES

Explained by Continental Drift

from our Structural Geology Correspondent

A SATISFACTORY explanation for the occurrence of the ice ages which have affected the Earth from time to time has so far eluded climatologists, geologists and astronomers alike. It is not surprising, with the growing weight of factual evidence to support continental drift, that a theory for the origin of ice ages with the movement of land-masses as its key has been suggested. This theory, put forward by John C. Crowell and Lawrence A. Frakes (*Amer. J. Sci.*, **268**, 193; 1970), is argued for the Permo-Carboniferous, Palaeozoic glaciation.

Explanations usually advocated for ice ages and stages of ice ages are of two types: those based on extraterrestrial influences, and those based on changes occurring on the Earth itself. Theories based on variations in the energy output of the Sun cannot be substantiated and therefore more attention has been given to theories involving terrestrial change. It can be shown that changes which would cause the mean annual temperature to fall by only a few degrees (3° – 10° C) would be sufficient, by lowering the snowline, to cause an increased albedo effect. This in turn would reduce the amount of heat absorbed by the Earth and so further lower the temperature.

Changes in the distribution of land and sea with reference to the rotational axis of the globe will affect the circulation of the air-ocean system, and therefore the climatic zoning of the Earth and the mean annual temperatures at various points on Earth.

Until recently the past configurations of the continents and oceans have been too little understood to allow a precise evaluation of past climates. Crowell and Frakes use the data from tectonics and palaeomagnetism to suggest that the super-continent of Gondwanaland moved across the south rotational pole during the Palaeozoic. In the Cambrian and Ordovician, what is now North Africa lay above the pole, and the central Sahara region was widely glaciated. South Africa arrived over the pole in the Carboniferous, when the Dwyka tillite was deposited. Eastern Antarctica had moved above the pole by the Permian and was broadly glaciated along with nearby Australia.

For more than 400 million years the South Pole was glaciated, the ice centres shifting as the land masses drifted above the Pole. During this long interval of occasional glaciation, the Gondwanaland super-continent, with Laurasia probably attached, lay in a meridional attitude across the globe. The termination of glaciation in the Permian seems to be associated with the opening of the North Atlantic.

Crowell and Frakes speculate that this emergence from a long glacial period may be a result of a combination of the movement of continental land masses away from the south rotational Pole, together with the changing oceanic and atmospheric circulation from the meridional patterns of the Palaeozoic to a more latitudinal pattern in the Mesozoic.

It seems clear from this work that periods of glaciation, far from being of isolated or rhythmic occurrence, are characteristic of long periods of Earth history. There is no necessity to seek extraterrestrial sources, and the mechanisms Crowell and Frakes suggest would not only explain the Palaeozoic glaciations but also the present Caenozoic Ice Age.

ENGINEERING CERAMICS

Valuable Silicon Nitride

from our Materials Science Correspondent

SILICON nitride is the first pure ceramic to be considered seriously for a critical load-bearing application in rotating machinery. A good deal of development work is in progress in the automotive industry at the moment in the hope of making silicon nitride blades for gas turbines destined for heavy commercial vehicles (for example, N. Penny, *Science Journal*, **6**, No. 4, 54; 1970). The ease of production of high thermal shock resistance makes silicon nitride particularly apposite for this application. As part of the development effort, it is vital to establish how the mechanical properties of the material relate to the mode of preparation, and so the recent work by A. G. Evans and R. W. Davidge (*J. Materials Sci.*, **5**, 314; 1970) is of major importance. They have studied the fracture stress at different temperatures, and the work to fracture of reaction-sintered silicon nitride prepared from material of differing green densities, sintered in various temperature regimes in different atmospheres. Finally, they assessed the influence of oxidation on the hot and cold strengths. These various measurements were related to the ratio of alpha to beta polymorphs, and to pore size distribution.

The first unexpected feature of their results is the small extent of variation of strength with temperature; the total degree of porosity has a much larger influence than does variation of temperature. Once high density is achieved, it is important to control pore size distribution, because the experiments have been analysed to show that the fracture strength is determined by the largest internal pores present, and not by adventitious surface damage. The fracture stress is simply the stress needed to extend the largest pore. Large pores are avoided by sintering below the melting point of silicon throughout. For material of about 80 per cent theoretical density, Evans and Davidge find a strength of ~ 270 MN m^{-2} at room temperature. Fully dense material studied elsewhere has strengths up to 1 GN m^{-2} , and Evans and Davidge have found that this figure is determined by small "structural features" of unknown nature. They point out that to reduce the flaw population of hot-pressed silicon nitride might be expected to increase the strength up to ~ 3 GN m^{-2} . But reaction-sintering is a much simpler and cheaper technique than hot-pressing and their work indicates the degree of improvement that can be expected by perfecting this technique.

Oxidation tests at $1,400^{\circ}$ C on the reaction-sintered material showed that the strength is enhanced so long as the material is continuously maintained above the cristobalite transition at $\sim 250^{\circ}$ C. If it is allowed to fall below this temperature, silica at the surface cracks and the strength falls to slightly less than the unoxidized strength.

INTERSTELLAR MOLECULES

Carbon Monoxide in Space

by our Astronomy Correspondent

THE discovery of microwave radiation from carbon monoxide molecules in interstellar space, announced by the National Radio Astronomy Observatory, brings to four the number of molecular species