1 in 100,000 or smaller. Future satellites will doubtless broaden the spectrum and one of the more valuable uses that will emerge is undoubtedly data transmission from remote stations such as ocean buoys, where the satellite acts effectively as a communications device. Yet a feeling of forced optimism hung over the meeting.

The question is not, of course, whether earth resources satellites will work but whether scientists will buy the results and get sufficiently excited over them that funding for more and better satellites will be forthcoming. One speaker suggested that all studies of the implications had pointed to "massive financial returns and even larger equivalent benefits in the coming decades". More restraint in claims put forward and less fanciful thinking about remote possibilities might better advance the cause.

In spite of scepticism about some aspects of the subject, one or two speakers and topics particularly command attention. The remarkably diverse interests of Professor A. R. Barringer (Barringer Research Corporation) were in evidence, not for the first time. The depth of his investigations into remote sensing, whether for mineralization or for pollution, was impressive. He, as well as other speakers, spoke in favour of data processing within the satellite, and at present it seems paradoxically as if computing "up there" and the sending down only of useful information may be technically more feasible than trying to pour an undigested data stream back to Earth.

The work of Vickers and Lyon at Stanford came in for considerable attention. Spectral correlation by a small computer in the satellite may make possible differentiation between acidic and basic rocks on the basis of their infrared emission spectra. Data processing, whether on the ground or in the air, is going to be a major problem and undoubtedly a tendency towards numerical and shorthand descriptions will emerge.

It was good to find an awareness among many speakers of the organizational and political implications of earth satellites and a growing belief that an administrative body would eventually have to come into being to take matters on to the international level. Dr K. Stehling of ESSA gave a clear indication of worries that could lie ahead even when dealing with studies of the supposedly international high seas.

EARTH'S CRUST

Glaciation and Heat Flow

from our Geomagnetism Correspondent

CRAIN's suggestion that the observed equality of heat flow over continental and oceanic areas may be more apparent than real (*Earth and Planet. Sci. Lett.*, **4**, 69; 1968) has now received more detailed consideration from Horai (*Earth and Planet. Sci. Lett.*, **6**, 39; 1969). According to Crain, the upper 2,000 metres of the Earth's continental crust should not yet have reached thermal equilibrium following the Wisconsin deglaciation, which he represented as a sudden 10°C rise in temperature 10,000 years ago. Present-day measurements of heat flow on land made at less than 2,000 metres below the Earth's surface could thus be too low by as much as 0.5×10^{-6} calories/cm² s. The true continental heat flow average would thus be higher than the oceanic average in accordance with geochemical predictions.

Horai's contribution has been to take into account not only the Wisconsin glaciation but also the temperature fluctuations which preceded and followed it. The problem here is that assumptions must be made in deriving a model for continental temperature variations before the effect of these variations on heat flow may be determined. Horai has converted Emiliani's curve of the time variation of open sea water temperatures during the Pleistocene (which was based on the vertical variation of the $^{18}\text{O}/^{16}\text{O}$ ratio in pelagic foraminifera in ocean sediments dated by the carbon-14 method) on the assumption that variations in the mean annual land surface temperature were proportional to those in the mean annual open sea temperature. Knowledge of land temperature variations, inferred from pollen analysis, eustatic changes of sea level, loess profiles, advances and recessions of the snow line and "other types of evidence abundant in the literature of Quaternary climatology", was then used to fix the scale. In this way the last temperature maximum (post-Wisconsin) was taken to be 2°C above the current temperature and the last minimum (the Wisconsin glaciation itself) 10°C below it.

Accepting this model, Horai calculates that for a thermal diffusivity of $0.010\text{ cm}^2/\text{s}$ and a thermal conductivity of 5×10^{-3} calories/cm s $^{\circ}\text{C}$, the maximum "error" in a continental heat flow observation due to glacial temperature fluctuations will be only 0.2×10^{-6} calories/cm² s and will occur at a depth of only 500 metres. For diffusivities of $0.005\text{ cm}^2/\text{s}$ and $0.020\text{ cm}^2/\text{s}$ extremes in the range of possible diffusivity values for the upper crust, maximum heat flow errors will be 0.27×10^{-6} calories/cm² s at 350 metres and 0.14×10^{-6} calories/cm² s at 700 metres, respectively. In other words, the maximum disturbances of the heat flow are less than deduced by Crain and occur within the top kilometre of the crust.

If glacial effects decrease continental heat flow by an amount Δq and the standard deviation remains essentially unaltered, an analysis of world heat flow observations shows that at the 99 per cent confidence level continental and oceanic equality is upheld if Δq is less than 0.15×10^{-6} calories/cm² s. If Δq is greater than 0.2×10^{-6} calories/cm² s equality must be rejected at the same confidence level. The likely heat flow "errors" calculated by Horai thus lie in the region where equality is hard to confirm or refute. Bearing in mind the uncertainties in thermal diffusivity, thermal conductivity and the precise form of the temperature fluctuations, and the errors of observation, it will be difficult to establish the validity of glacial effects on heat flow without many detailed and accurate surveys of individual areas.

PULSARS

More about NP 0532

from our Astronomy Correspondent

THE pulsar NP 0532, which Staelin and Reifenstein discovered in the Crab Nebula last October (*Science*, **162**, 1481; 1968), continues to dominate the scene. Fishman, Harnden and Haymes of Rice University have re-examined tapes from an experiment carried out in June 1967 which looked for (and found) gamma rays and hard X-rays from the Crab Nebula, and report the