LETTERS TO NATURE

PHYSICAL SCIENCES

Post-Occultation Reception of Lunar Ship America Radio Transmission

THE reception of radio signals from the orbiting lunar spaceship America after its occultation behind the lunar limb is a confirmation of results reported for the Apollo 15 ship Endeavour¹. Similar observations arranged with the lunar command module during the Apollo 16 mission were unsuccessful because transmissions from the command module did not occur while the Moon was above our horizon.

The transmitter used for communication between the lunar command module and the lunar landing party was turned on almost continuously during a period of lunar orbiting between 1755 GMT, December 14, and 0400 GMT, December 15, 1972. The frequency of this transmission was 259.7 MHz with an audio signal at times impressed on the carrier. This transmission was intercepted by a special receiver attached to the 150-foot radio telescope of the US Air Force Cambridge Research Laboratory. This instrument is located at Sagamore Hill near Hamilton, Massachusetts, USA (latitude 42° 37' 55.6" N; longitude 70° 49' 04.5" W).

The spacecraft transmitted during most of the time the Moon was above the local horizon. Post-occultation signals were received when the Moon was near the local zenith. This high lunar altitude facilitated the reception and the signal strengths were much greater than on previous flights.

Occultation of the signal occurred at 0143:36 GMT, December 15, 1972. The signal did not immediately go to a zero level; it seemed to go to zero at approximately 0144:02 GMT and reappeared at 0144:12 GMT, persisted for 52 s, and finally disappeared at 0145:04 GMT. This behaviour indicates a dependence of the post-occultation signal on the exact topography of the lunar surface beneath the spacecraft.

Because the altitude of the Moon was higher than on previous flights, our signal strength was correspondingly greater, and we observed the Fresnel patterns that characteristically accompany occultation. When the signal reappeared, its level was approximately 20 db above noise (as shown by digital voltage recordings). The pen-recorded chart appears in Fig. 1. The AM and FM magnetic tapes and digital sampling of receiver output voltage provide alternative records, and an oscilloscope gave visual and photographic reception.

Fig. 1 Record of receiver response (1 division = 10 s).

The height of the America's orbit above the lunar surface was about 96 km at the time of occultation and was reasonably uniform thereafter. The occultation of the Moon ship occurred during 154° of its orbit relative to the lunar centre. During the elapsed time between the occultation and the disappearance

of the signal, the ship traversed about 134 km of the lunar surface. The actual path of the signal was about 6 km less than this figure because the orbit of the ship was inclined to the line of sight to the Earth.

The surface distance traversed between the time of occultation and the time of disappearance of the signal projected on the signal path to the Earth is about 97 km. The effects of libration were insignificant.

Other results from this experiment, such as the possible significance of signals received during the other two occultations, are awaiting further reduction of the data.

Several possibilities for explaining such results have been considered¹⁻³, including refracted waves through the limb of the Moon or lunar surface waves. The immediate continuation of the signal after occultation favours the surface-wave explanation.

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¹ Salisbury, W. W., and Fernald, D. L., *Nature*, **234**, 95 (1971).

² Salisbury, W. W., in *Proceedings of the Conference on Electromagnetic Exploration of the Moon* (Ames Research Center, 1970).

³ Salisbury, W. W., *Nature*, **211**, 950 (1966).

Cariaco Trench: Oxidation of Organic Matter and Residence Time of Anoxic Water

THE Cariaco Trench is located on the Caribbean shelf of Venezuela and has a maximum depth of 1,400 m. The surrounding shelf is nowhere deeper than 150 m, thus separating the deep water of the trench from that of the Caribbean. The deep water of the trench is devoid of dissolved oxygen¹. Between the sill depth and 500 m both temperature and salinity decrease, resulting in a slight increase in density which stabilizes the water column somewhat precariously. Below 500 m the water is uniform and well mixed. Such anoxic basins are critically dependent on the balance between supply of organic matter and renewal of the deep water. Although the sediments indicate that at least the deep part of the basin has been permanently anoxic for thousands of years² the relatively small density gradient may facilitate renewal of the deep water on a much shorter time scale. Estimates of the residence time vary between 100 and 2,000 yr (refs. 1,3). Data resulting from a cruise of RV Atlantis II in July 1971 provide a way of assessing the