to transmit 100-kw signals, and the total temperature of the noise within the system was lowered to 37°K.

Two types of experiments were performed. In one, the total power of the echo was measured by means of radiometer techniques. In the other, the autocorrelation approach was used to analyze this power into its frequency spectrum (*2*).

Over 65 hours of signal integration is represented in Fig. 1, covering a full 360 degrees of Martian longitude. A pure sine wave was transmitted, but because of the Doppler effect that results from the planet's rotation, the echo spans a frequency interval of 7.6 kc. Most of the power is contained in a band of only 450 cy/sec; this corresponds to reflections from a disk about 250 miles wide on the surface of Mars. Thus, the sub-earth points stand out as small areas of highlight—that is, areas showing more light than the surroundings. Venus shows a similar area of highlight, but it is larger in proportion to its size and speed of rotation. Mars is somewhat smoother than Venus in this sense.

Each transmission cycle lasted about 11 minutes, the time required for a radar signal to get to Mars and back. This was followed by a receiving cycle of the same length. In this way, each successive transmission cycle illuminated an area about 200 miles farther westward at about 13 degrees north latitude on Mars. Throughout the nights of the experiment, each 250-mile disk was illuminated about 12 times. The average power of the signal from each of these areas defines a map of radar "brightness" (Fig. 2) for the 13-degree parallel. Since echo power was measured through a predetection filter with a bandwidth of 400 cy/sec, dark areas may be due either to lower reflectivity, or to rougher areas which spread the signal beyond the filter passband. It is interesting to note that the region of Syrtis Major appears light to radar but dark to visual observations. The experimentally determined standard deviation of the observations is marked on the curve. It was measured without signal input to the receiver. An average reflectance of 3.2 percent is obtained by averaging all of these data together.

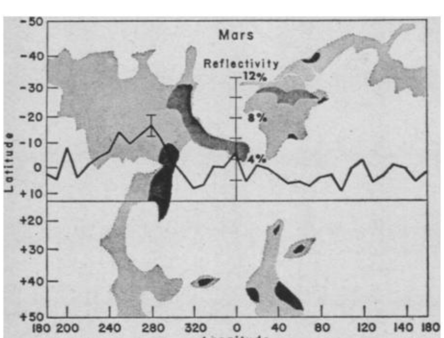


Fig. 2. A radar map of Mars, with some of the visible features of the planet shown in the background. Syrtis Major is the area at 290° longitude, in the equatorial region.

Mars is a very difficult radar target because of its great distance from Earth and rapid rate of rotation. During future oppositions, when radar technology is more advanced and Mars comes much closer to us than the 100,000,000 km (62,400,000 miles) this year, it will be possible to obtain data for much more detailed maps.

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**References and Notes**

1. R. M. Goldstein and R. L. Carpenter, *Science* **139**, 910 (1963).
2. The equipment which was used to accomplish this will be described in detail in a Jet Propulsion Laboratory report, now in preparation.

1 July 1963

## Relative Dating of Arlington Springs Man

Abstract. *Relative dating tests confirm the antiquity of the Arlington Springs human femur.*

In 1959 P. C. Orr discovered two human femurs at a depth of 11 m (37 ft) in Quarternary sediment exposed at Arlington Canyon, Santa Barbara, California. The discovery was investigated by a team of geologists and archeologists in 1960 (*1*), and further work at the site resulted in datable carbonaceous material being found adjacent to the human bones. A sample collected by Orr, W. Farrand, and W. S. Broecker was dated by Broecker at the Lamont Geological Laboratory as 10,000 ± 200 years old (*2*).

If it is assumed that the human bones are not part of a burial from a higher surface, they represent one of the very few Pleistocene men of the Americas. At the suggestion of W. F. Libby, a sample of one of the femurs was sent to us in London for tests of relative datings. My assistant, Mrs. E. Gardiner, made a radiometric assay of the sample as means of assessing its uranium content. The sample was then submitted to the Government Chemist's Laboratory, where R. G. Cooper determined the fluorine and phosphate contents, and E. J. Johnson the nitrogen content (Table 1).

Table 1. Analyses of early human bones from North and Central America. The italic lines indicate bone source.

| F (%) | $\frac{\%F}{\%P_2O_5} \times 100$ | $e.U_3O_8$ (ppm) | N (%) |
|---|---|---|---|
| | *Arlington Springs, Calif.* | | |
| 1.2 | 3.6 | 28 | 0.23 |
| | *Tepexpan, Mexico* | | |
| 2.0 | 6.8 | 1 | 0.06 |
| | *Midland, Texas* | | |
| 0.8 | 10.4 | 13 | 0.03 |
| | *Lagow, Texas* | | |
| 0.2 | 0.6 | 3 | 1.2 |
| | *Natchez, Mississippi* | | |
| 0.9 | 3.4 | | 1.4 |
| | *Compare: Modern bones* | | |
| <0.1 | 0.1 | <1 | ~4.0 |
| | Camelops, *Lagow* | | |
| ~1.5 | | 36 | 0.5 |
| | Mylodon, *Natchez* | | |
| 1.0 | 4.9 | | 1.6 |

Although no other bones from the same, or from earlier and later, levels have yet been sent for analysis as controls, the ratio of fluoride to phosphate and the uranium content are both high enough, and the nitrogen content low enough, to be reassuring in regard to the high antiquity of the bone in question. Series of bone samples from comparable sites in North and Central America have already been assayed for F, U, and N (*3*), and when the composition of the Arlington Springs bone is considered in the light of these results, there is no reasonable doubt that it is "fossil" rather than subfossil, and unquestionably it is not a recent intrusive burial. For present purposes the results summarized in Table 1 are sufficiently significant.

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**References and Notes**

1. P. C. Orr, *Bull. Geol. Soc. Am.* **71**, 1113 (1960).
2. ———, *Science* **135**, 219 (1962).
3. K. P. Oakley and W. W. Howells, *Am. Antiquity* **26**, 543 (1961); K. P. Oakley and A. E. Rixon, *ibid.* **24**, 186 (1958).

1 August 1963