RADAR MAPPING OF THE MOON AT 162 MHz

J. E. B. PONSONBY, I. MORISON, A. R. BIRKS, and J. K. LANDON
Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire, England

Abstract. The result of Lunar radar mapping observations are presented, which were made at Jodrell Bank in January and February 1970 at 162.4 MHz in the depolarized return. The Maps show that most of the depolarized return comes from the highland regions. No significant return has been detected from the Maria. Certain isolated features are particularly prominent, notably the craters Tycho and Theophilus which appear almost equally intense, also the areas around Werner and Fourier. Various other features can be identified with less reliability. These results are discussed in qualitative terms.

The Moon has been observed at Jodrell Bank with an essentially continuous wave (cw) radar operating at 162.4 MHz ($\lambda = 1.85$ m). A circularly polarized wave was used

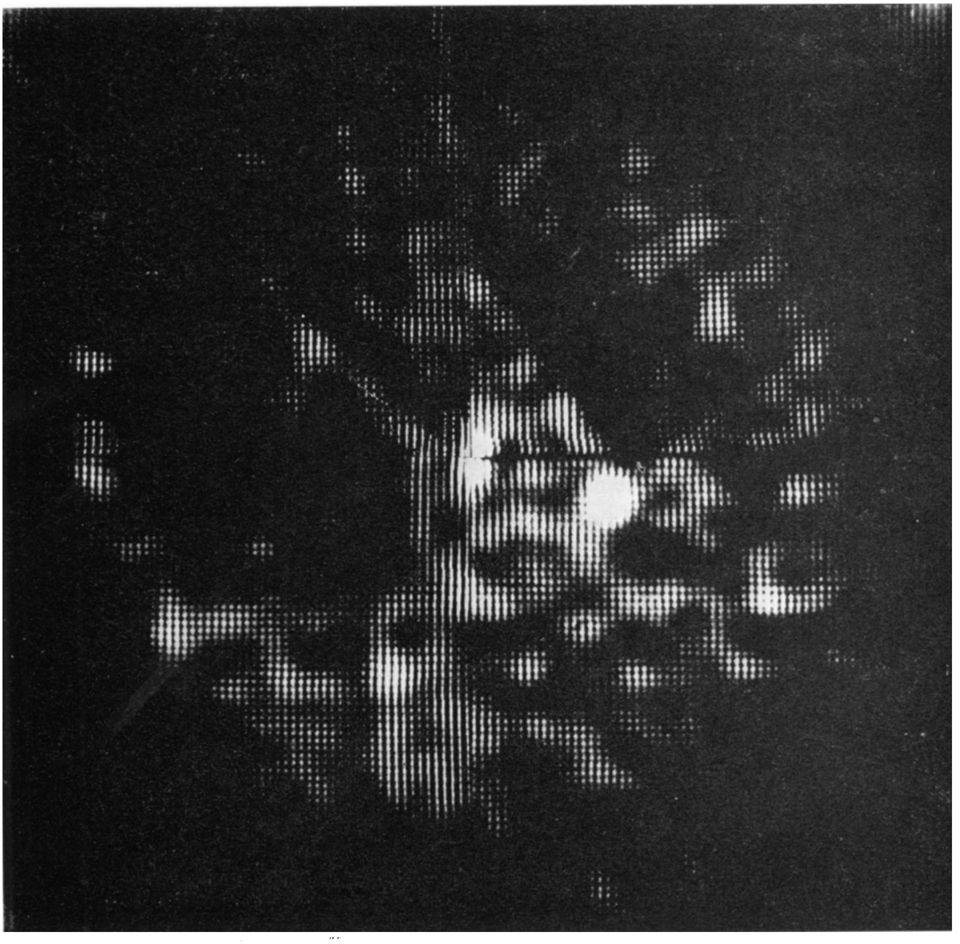

Fig. 1. Moon seen by 162.4 MHz radar with 1.25 arc min. resolution in January 1970.

Urey and Runcorn (eds.), The Moon, 68–71. *All Rights Reserved.*

to illuminate the Moon, and the component of the reflected signal having the non-specular sense of circular polarization was received and used to make images of the lunar disk.

In this paper we present the results of two independent observations made in January and February 1970. A preliminary map at 2 arc min resolution obtained from some of the January data was presented at the XIV General Assembly of IAU at Brighton (Ponsonby, 1970). Here we present a final map at 1.25 arc min resolution from the January data and one at 2 arc min resolution from the February observations. These are shown in Figures 1 and 2 respectively. North is at the top in both cases so that the disc is seen as it is in the sky in the northern hemisphere.

Two-dimensional mapping has been achieved using the Aperture Synthesis method first described by Thomson (1965) and later by Thomson and Ponsonby (1968) and Hagfors *et al.* (1968). This method is distinct from the better known range-doppler

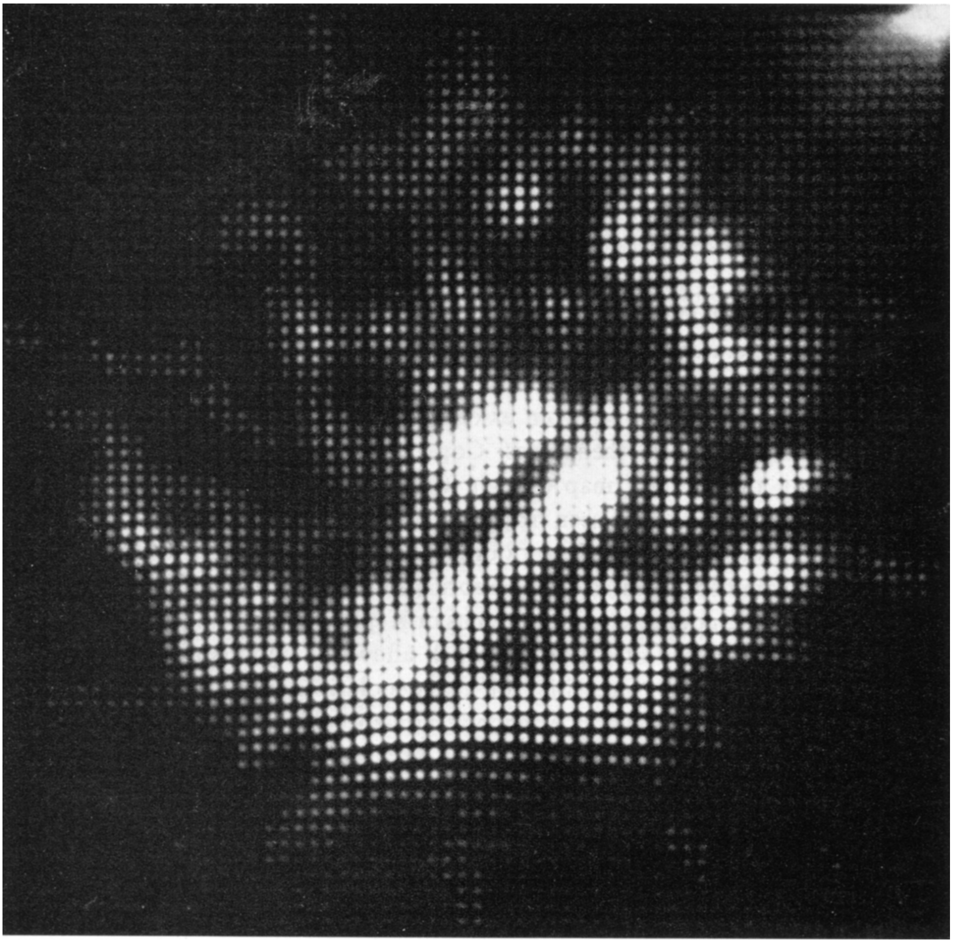

Fig. 2. Moon seen by 162.4 MHz radar with 2 arc min resolution in February, 1970.

https://doi.org/10.1017/S0074180900097436 Published online by Cambridge University Press

mapping technique, and has the advantage of enabling the whole face of the Moon to be mapped simultaneously without ambiguity using a relatively modest radar system.

The present observations have been made using a 1 kW transmitter with a single 50 ft diam. dish having a 7° beamwidth.

The method relies upon the differential doppler shifts caused by the Moon's librations; the peculiar circumstances of the Moon's librations allow the method to be used on two or three favourable days each month. About 12 hr of observations are necessary for a complete map; the total change of Lunar aspect during this period, typically 2° in selenographic coordinates, limits the attainable resolution to about 1 minute of arc. This resolution is equal to what could be achieved directly had one an aerial about 6 km in diam.

At the times of the observations, the mean selenographic coordinates of the disc centre were;

in January 1970, $l = +4\overset{\circ}{.}5$, $b = -6°$;

in February 1970, $l = +6\overset{\circ}{.}1$, $b = -6°$.

The bright region at the centre of the maps is due to an instrumental malfunction which more seriously effected the February results.

The broad features appear the same on both maps. Thus the highland regions appear bright whilst no significant return has been detected from the extended maria. The dark areas on the left hand sides correspond to maria Imbrium, Procellarum, Nubium and Humorum. On the right hand side Serenitatis and Tranquillitatis form the main dark area, whilst there are isolated dark areas at the position of Crisium, Fecunditatis and Nectaris.

Individual features are best seen on the 1.25 arc. min January map. The most prominent are the craters Tycho and Theophilus which appear almost equally bright. Comparable though lesser returns are seen from the regions of the craters Werner and Fourier. These appear to come from extended areas and are not necessarily to be associated with the craters themselves. Copernicus can be definitely identified in Procellarum on the January map though it appears considerably less bright than Tycho. A comparable return is seen from the region of Proclus. The crater Langrenus coincides with a still weaker bright spot on the January map but surprisingly appears as one of the prominent features on the February map. This may be due to a random fluctuation. We have not detected Aristarchus or Kepler.

We know of no theory of scattering which allows quantitative deductions to be made from the observed intensities of the depolarized return. The depolarized scattering mechanism is however essentially non-specular and one can say that its occurence must be associated with structure on a scale comparable with the wavelength. This structure may be on the surface or be buried at a depth of some meters. Qualitative interpretation of our results can be based on this notion.

That Tycho would appear as a prominent feature was expected from earlier reports that it has appeared unusually bright to radar at short wavelengths. The intense return from Theophilus was not so anticipated. On the map obtained by Hagfors *et al.* (1968) for instance, at $\lambda = 23$ cm using effectively the same mapping technique, Tycho is extremely conspicuous, whilst Theophilus is not prominent at all. Together with Copernicus however, which appears much less intensely at our wavelength, both are rayed craters believed to be of relatively recent origin. We interpret the change in behaviour of Theophilus as indicating a lack of structure on the scale of the shorter wavelength. This view is consistent with the smoother appearance of Copernicus compared to Tycho on the scale of the high resolution photographs taken by the Orbiter space craft. Unfortunately there are no high resolution pictures available of Theophilus. If there were, we suppose they would reveal a degree of roughness intermediate between that seen in Tycho and Copernicus.

References

Hagfors, T., Nanni, B., and Stone, K.: 1968, *Radio Sci.* **3** (*New Series*), 491.

Ponsonby, J. E. B.: 1970 'Mapping of the Moon by Continuous Wave Radar at 162 MHz', presented at XIV General Assembly IAU, Brighton 1970.

Thomson, J. H.: 1965, 'Talk Given at the Symposium on Planetary Atmospheres and Surfaces', Dorado, Puerto Rico.

Thomson, J. H. and Ponsonby, J. E. B.: 1968, *Proc. Roy. Soc. A.* **303**, 477.