and repetitious at times, but this detracts little from a very human account of very human beings.

The journal has been most attractively produced, the type is clear, the sketches well reproduced, and the whole book, with its wide margins, has a clean, uncluttered look about it.

JIM LOTZ

GEOLOGIC MAP AND SECTIONS OF THE KEPLER REGION OF THE MOON. By R. J. HACKMAN. Map I-356 (LAC-57). *Washington, D.C.: U.S. Geological Survey. 1962. 41¾ x 35¾ inches. $1.00.*

The prospect of sending human explorers to the moon has given tremendous impetus to efforts to interpret the "geology" of its surface preliminary to field operations there. Interest in the moon was renewed after World War II, has accelerated rapidly in the last 5 years with the evolution of space vehicles, and has been further stimulated by competition with the USSR. American geologists have actively studied the moon since 1846, when J. D. Dana discussed its "volcanoes". G. K. Gilbert presented an interpretation of its features in 1893. Several geological studies have appeared since then, but Dr. Hackman has produced the first geological map of a part of the surface of the moon.

A geographic co-ordinate system similar to that used on earth was established for the moon in 1935, with a north-south axis that is inclined 1.5° to the plane of its orbit. In this map series the longitude co-ordinates are measured east (right) and west (left) of the centre of the moon (zero longitude) as seen from the earth, contrary to astronomical tradition and latitude is measured north and south from the equator at zero libration. Most of the maria, the dark, relatively smooth lowlands, are in the northern hemisphere and especially in the northwest quadrant. The Kepler region is in this quadrant and extends 16° north of the equator from 30° to 50° west longitude, or from about one-half to three-quarters of the distance from the zero meridian to the west side as seen on the disk of the moon, and covers an area about 380 statute miles long (east-west) and 300 miles wide (north-south). Most lunar atlases show north at the bottom, because the moon appears inverted in astronomic telescopes. The conventional Cartesian grid used in charts of the disk of the moon is not used by Hackman, as it is impractical for indicating locations on a sphere.

The Kepler region is part of the mare called Oceanus Procellarum. The western half of the map area is a plain with a few long northwest-trending ridges in the southwestern corner. The spectacular rayed crater Kepler, about 18 miles in diameter, is just southeast of the centre of the map. The non-rayed crater Encke of slightly smaller dimensions is about 55 miles south-southeast of Kepler. The floor of the mare forming the east half of the map contains many short ridges in echelon, mostly trending north-northeast. A cluster of low domes each from 5 to 15 miles in diameter lies in the northeast corner. Generalized contours with an interval of 300 metres and a probable error of 100 metres indicate the relief, with the zero altitude contour appearing in the northwest and the 900-metre contour in the southwest. The altitude of the mare rises to about 3000 metres in the east side of the area. The rim of the crater Kepler rises from the plain at 2600 metres to a maximum altitude of 3700 metres. The lowest area in the crater is about 900 metres, giving a relief of 2800 metres or about 9000 feet inside the crater and roughly 3500 feet outside of it. Most of the ridges and domes scattered over the map have less than 300 metres relief. The lack of any equivalent of our oceans that provide a world-wide altitude datum makes regional integration of altitudes on the moon a complex problem.

The interpretation of the lunar surface from photographic and visual observations is only a special case of the interpretation of terrestrial aerial photographs that has been practised systematically since World War II with increasing refinement. In many areas on earth, though not everywhere, rock types can be identified by photographic tones (shades of grey) or colour, relief forms, and drainage pattern, and many geologic structures can be delineated and stratigraphic sequences can be described. The accuracy of interpretation increases with knowledge of rock types gained by field observation, and with the quality of the photographs. The student of the lunar surface has yet to have help from field observations, he must rely on radiotelescope and radar techniques to support optical studies.

The quality of lunar photographs and visual observations is the weakest point in interpretation. The limitations are imposed by terrestrial atmospheric disturbances and not by the quality of telescope optics. The smallest object that can be recorded in the best photographs is about 2500 feet across, and the smallest that can be seen under the best conditions is about 600 feet across. A linear feature the size of the Connecticut, Ohio, Missouri, or Saskatchewan rivers would not be visible in lunar photographs, but might be glimpsed intermittently by an observer watching through a telescope under ideal conditions. Hence the details observed compare with those in the better televised photographs of the earth sent back by weather satellites; geologists would regard terrestrial aerial photographs with such limited detail as utterly useless.

The smoothness or roughness of the lunar surface, knowledge of which is vital for the landing of any kind of vehicle, must still be inferred from studies of its polarizing effect on light, and its reflectance of light of specific wave-lengths.

Resolution of detail is only one problem confronting the earth-bound selenologist. Terrestrial photo interpretation relies very heavily on the study of stereoscopic images and measurements of photographs that were taken from stations above the object having an angular separation of 20° to 30°. Photographs of the moon taken simultaneously from opposite sides of the earth are separated by only about 1.75° and do not give a useful stereo-image. Photographs taken at extreme librations of the moon, when adjusted in scale, make stereoscopic models that are useful but still have only half the angular separation desirable for good parallactic measurement. Libration also makes it possible to see slightly more than one-half of the surface of the moon, the additional parts being 6.5 degrees beyond the poles (undoubtedly the lunar regions of greatest interest to readers of *Arctic!*) Relief of 1000 feet or more can be seen in the best stereophotographs. A great amount of qualitative information on smaller relief features, down to only 10 feet high, is obtained by studying their shadows under different directions and intensities of illumination. The problems of mapping these surface forms are discussed in papers by Hackman[1] and Shoemaker[2].

On the basis of tonal differences and topographic situation and characteristics the following "geological" materials are delineated: regional material, crater rim material, crater floor material, mare material, dome material, slope material, and ray material. The descriptions of the appearance of these materials in the legend are carefully separated from the interpretations of their nature (mostly crushed rock with large blocks; volcanic flows in maria and domes; and partly sorted fragments in slope material). Relative ages of various features are based on the relative amounts of erosion by meteoric and possibly cosmic ray bombardment, on the superposition of craters on older craters, and discontinuities in topography. Materials of four ages have been outlined: the youngest materials belong to the Copernican system and include the large rayed craters, some of which are visible to the naked eye. The next to youngest unit is the Eratosthenian system that includes relatively fresh craters without rays and that is overlapped by rays of younger craters. The next oldest unit, the Procellarian system, includes the material of maria and domes. The oldest unit, the Imbrian system, has rough topography and older dissected craters with numerous small craters superimposed on them; some of these craters are flooded with mare material (of Procellarian age).

The map of the moon and of the Kepler region especially, has much of interest to the geologist studying the larger problems of tectonics. Numerous fault systems, anticlines, and structural depressions have been interpreted, and regional patterns are evident. The larger craters are not perfectly circular, but polygonal in form, resembling explosion craters in rocks that have preexisting fracture systems.

The Kepler region map covers an area similar in size to the Columbia Plateau of Washington and Oregon. The anticlinal folds in the southwest of the Kepler region compare in relief and length with the system of anticlinal ridges in Washington that includes the Horse Heaven Hills, Rattlesnake Hills, and Saddle Mountains. The topography of the mare resembles the Columbia Plateau without its dissection by rivers, except for a sinuous rille (valley) 50 miles long in the northwest corner of the Kepler area. The craters do not resemble volcanic cones, but rather explosion craters in which a relatively low rim surrounds a depression. A crater the size of Meteor Crater in Arizona might appear as a very small feature on the Kepler map but is about the smallest that could be shown and might easily have been missed. The Chubb Crater in northern Quebec, 2 miles across, would appear as a small feature. A score of craters in the Kepler region have the diameter of Crater Lake, Oregon. The largest craters in the area, Kepler and Encke, have dimensions of the same order of magnitude as Mt. Rainier National Park, the city of Los Angeles, or Lake Simcoe, Ontario. Some "islands" or inliers of older material seem to project through the mare material as older rocks project through the lavas of the Columbia Plateau in northeastern Oregon.

Dr. Hackman has made full use of the data available to him through telescopic and radiotelescopic techniques in preparing his map of the Kepler region. The best observations of the moon are very inferior in quality to corresponding observations of the earth, and substantial revisions may be expected when better photographs from satellites become available. Further substantial improvements in interpretation will be possible when field data are sent back by robots and subsequent human explorers.

The lay reader interested in Dr. Hackman's map of the Kepler region will appreciate references 3, 4 and 5.

J. A. Elson

[1]Hackman, R. J. 1961. Photointerpretation of the lunar surface. Photogrammetric Eng. 27:377-86.

[2]Shoemaker, E. M. 1962. Explorations of the Moon's surface. Am. Scientist 50:99-130.

[3]Fiedler, Gilbert. 1961. Structure of the moon's surface. London: Pergamon Press, 266 pp.

[4]Hackman, R. J., and A. C. Mason. 1961. Engineer special study of the surface of the moon. U.S. Geological Survey, Misc. Geol. Invest. Map I-351 (Three maps showing physiographic divisions, generalized photogeology, and lunar rays, and a descriptive table.)

[5]Markov, A. V., *ed.* 1960. The Moon, a Russian view. (Nine articles on various aspects of the physical features of the moon by Russian workers.) Chicago: Univ. of Chicago Press, 391 pp. (1961 translation by Royer and Roger, Inc.)

NEW INDUSTRIAL TOWNS ON CANADA'S RESOURCE FRONTIER. By Ira M. Robinson. *Chicago: The University of Chicago. 1962. (Program of Education and Research in Planning, Research Paper No. 4; Department of Geography, Research Paper No. 73). $4.00.*

Mr. Robinson's thesis is that because Canada's economic growth is stimulated by resource development on or beyond the frontier, the boom town in the bush is a recurrent and important feature of the Canadian scene and economy. His particular interest lies in the problems of town planning, but he also pays attention to local geography, town administration, inter-town relations, and