relations between the variables involved in both infrared and radar measurements, however, make it difficult to draw firm conclusions regarding the exact cause of Tycho's anomalous thermal behavior. It may be that difference in surface roughness alone could account for all observations (*8*). It is also possible that other thermal anomalies on the lunar surface have entirely different causes. This problem is discussed at greater length elsewhere (*9*).

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7 November 1966

Martian Relief and the Coming Opposition

Abstract. *Ground-based observations of Martian relief may be possible when the Earth-Mars geometry is optimum and the observing conditions are near perfect. There is some evidence that detectable relief is present. Ground-based observations of Martian relief during the coming opposition will be optimum between 1 February and 1 March and between 1 June and 15 August 1967.*

Because of the difficulty of resolving Martian surface features from Earth and because of the small area covered by the Mariner IV photos our present knowledge of Martian relief is very meager. Consequently further study of Martian relief is needed. The possibility of observing relief during the coming opposition is presented in this report.

The first observer reporting Martian relief was Mellish who used the 40-inch (1 meter) refracting telescope of the Yerkes Observatory during the February 1916 Mars opposition to observe what he interpreted as Martian craters. He asserted that between 1 November and 15 December 1915, he saw Martian craters on several occasions, his best views of the craters being on 13 November 1915, shortly after sunrise (*1*). "Using a power of 1100, I saw many small craters and one large one. The latter, estimated to be 200 miles (300 km) in diameter, was in Martian latitude about −50°; north of it were many bright-rimmed small craters" (*2*). Mellish estimated the depth of the large crater at three to four miles (4 to 6 km).

Since his 1915 observations, Mellish has shown his records to many Mars observers including E. E. Barnard whose records of the 1892–93 opposition showed some of Mellish's craters as dark spots (*1*). Similar observations of dark spots by Antoniadi, Lyot, Dollfus, and notably Focas at Pic du Midi show that with good seeing the maria, canali, and oases appear composed of dark spots many of which are nearly circular and thus may possibly be craters (*3*).

Crater counts for Moon and Mars by Hartmann (1966) suggest that very large craters, comparable to lunar mare basins, may exist (*4*). Hartmann's work also suggests appreciable erosion. Relief is therefore probably not greater than that on the moon. However, relief may be widespread. This is implicit in the work of Katterfeld (*5*) and Binder (*6*) which shows that Mars may have a tectonic grid. Admittedly these observations have only recently come to light because of the Mariner IV results, but there is now new interest in the possibility of telescopic detection of Martian relief.

Mellish's observations were made at quadrature of an unfavorable opposition with a 40-inch (102 cm) aperture. Such an aperture (40 inches or larger) should permit detection of large Martian craters when the Earth-Mars geometry is optimum and seeing is nearly perfect. Why then is relief on Mars not generally reported? There are two reasons: (i) perfect atmospheric conditions for large apertures are extremely rare, and (ii) most Mars observations are made near opposition when the visibility of relief is minimum.

The use of telescope time may be optimized by calculating the relative angular size of the shadow of an arbitrary Martian prominence as a function of time. The visibility of the prominence is judged by the angle subtended at the earth by its shadow.

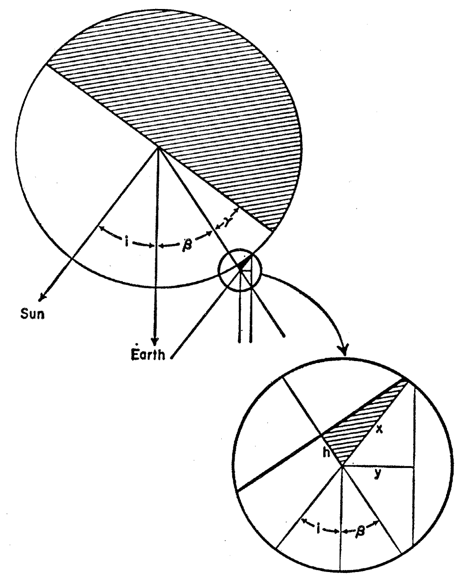

Fig. 1. Geometry for determining the angle subtended by the shadow of an arbitrary Martian prominence seen from Earth.

Consider a prominence of height h above the Martian surface (Fig. 1). The prominence will cast a shadow only if its slope away from the sun is greater than $90°-(i+\beta)$, which is γ. Therefore, the smaller the slope, the closer it must be to the terminator to be visible. In the limiting case a very small slope will be observable only as an indentation of the terminator.

If the prominence is close enough to the terminator to cast a shadow then it will cast a shadow of length x

$$x = h \sec (i + \beta)$$

The same shadow as seen from earth will have an apparent linear length y

$$y = x \sin i.$$

If the Earth-Mars distance is R, then the angle subtended at the earth by the shadow will be

$$\alpha = \frac{y}{R} = \frac{h}{R} \sec(i + \beta) \sin i$$
$$= h \csc \gamma \left(\frac{\sin i}{R}\right)$$

The relative visibility of the prominence's shadow may be defined in terms of the positions of Mars and Earth as

$$r = \alpha/(h \csc \gamma) = (\sin i)/R$$

Thus by calculating r for various dates and plotting r against time, we may find the best times to observe Martian craters (Fig. 2) (*7*). The epoch of maximum subtended angle is found by differentiating α with respect to time and set the result equal to zero, giving $dR/R = \cot i \, di$. From the *American Ephemeris* (*8*) we may obtain *i*, *di*, *R*, and *dR* tabulated for various dates. Then by substituting we obtain the time when any shadow, as seen from Earth, subtends its maximum angle. We find that this occurs on February 25.3 (Universal Time). A second such occurrence, after opposition, is on June 11.1.

Around the two periods of optimum visibility there occur intervals of "good" visibility, defined by $r > 0.7\ r$ (second maximum). For the coming opposition these intervals are from February 1.7 to March 15.0 and from May 9.2 to September 3.0, 1967.

Up to this point we have considered only the Earth-Mars geometry as a criterion for visibility of Martian relief. However, there are certain complicating factors that should also be considered. Among these are light scattering and contrast vitiation by the Martian atmosphere. The scattering and contrast vitiation will be proportional to the Martian air mass along the line of sight, or sec β, where β is the zenith distance of Earth as seen from the top of the prominence. For β we may substitute $90° - (i + \gamma)$. Then atmospheric contrast vitiation will be proportional to $\sec\,[90° - (i + \gamma)]$, which is csc $(i + \gamma)$. The subtended angle of the shadow α is also proportional to csc γ. Therefore, for any value of *i* the reduced contrast with decreasing γ just balances the increase in visibility due to shadow length. The decreasing contrast with decreasing *i*, however, makes it clear that observations made near opposition are not likely to succeed.

Another complicating factor is the frequent presence of morning haze along the sunrise terminator and the less-frequent evening haze along the sunset terminator. Both the morning and evening haze can be avoided by observing well away from opposition. Also the greater frequency of morning haze favors observations made before opposition.

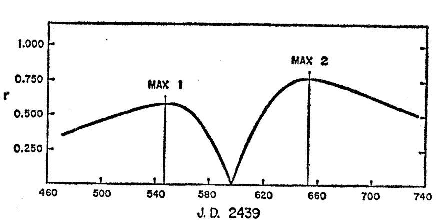

Fig. 2. Relative visibility of shadow relief *r* plotted against Julian Date. Maximum relative visibility before opposition occurs at J. D. 2,439,546.8 which is February 25.3, 1967. Similarly, maximum relative visibility occurs at J. D. 2,439,652.6, June 11.1.

With all these factors considered, probably the best times for observing Martian relief during the coming opposition will be between 1 February and 1 March and between 1 June and 15 August 1967.

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Aldolase Reaction with Sugar Diphosphates

Abstract. *Xylulose-, fructose-, and octulose-diphosphates are substrates for rabbit muscle aldolase with essentially identical* K_m *values, but they are cleaved at different rates. After treatment with carboxypeptidase, chymotrypsin, or subtilisin, aldolase cleaves all of these substrates at the same (deceased) rate; the modified aldolase preparations are also equally impaired in their ability to catalyze the detritiation of specifically labeled dihydroxyacetone phosphate. These results suggest that aldolase exhibits "induced fit," in which the rate of cleavage is determined by the distance between the sites on the protein to which the two phosphate groups of a substrate are bound. The activity of the modified aldolases is limited by a step involving making or breaking a carbon-hydrogen bond.*

Rabbit muscle aldolase cleaves fructose-1,6-diphosphate (FDP) or several analogs reversibly to dihydroxyacetone phosphate (DHAP) and glyceraldehyde-3-phosphate or corresponding aldehydes (*1*). In the absence of an aldehyde, aldolase catalyzes a stereospecific exchange of one hydrogen atom of DHAP with the hydrogen of water (*2*). Drechsler *et al.* (*3*) showed that the cleavage of FDP is reduced to about 5 percent of the original rate when aldolase is treated with carboxypeptidase, and Rutter *et al.* (*4*) showed a simultaneous decrease in the rate of liberation of tritium from labeled DHAP to about 0.1 percent. These effects of carboxypeptidase treatment were interpreted by Rose *et al.* (*5*) to be caused by an alteration in the ability of aldolase to catalyze the partial reaction in which the carbon-hydrogen bond of DHAP is made or broken; this step becomes rate-limiting after carboxypeptidase treatment.

Among the many aldehydes that can replace glyceraldehyde-3-phosphate in the condensation reaction are glycolaldehyde phosphate and ribose-5-phosphate, which produce xylulose-1, 5-diphosphate (XDP) and an octulose-1,8-diphosphate (ODP), respectively. Xylulose-diphosphate and ODP were synthesized by aldolase with either FDP (plus triose phosphate isomerase) or DHAP with glycolaldehyde phosphate and ribose-5-phosphate. The condensation products were purified by chromatography on columns of Dowex-1 formate according to the procedure of Bartlett (*6*). The fractions containing substances that gave a positive reaction for a substrate in the spectrophotometric assay with aldolase, glycerophosphate dehydrogenase, and reduced diphosphopyridine nucleotide (DPNH) were pooled and freed from the ammonium formate buffer by passage through a column of Dowex-50-H^+ followed by extraction with ether. The sugar components were identified as pentose by the reaction with orcinol (*7*) or octulose by the reaction with cysteine and H_2SO_4 (*8*). Purity of the sugar diphosphate was established by the presence of two organic phosphate groups per potential DHAP in the spectrophotometric assay.

The longer and shorter analogs were compared with FDP as substrates for aldolase by determination of K_m and V_{max} values (*9*). Contrary to expectation, the data of Table 1 show that the distance between phosphate groups makes no significant difference in the binding of the three substrates