Fig. 3. Some venusian sinuous rilles are associated with coronae. Corona volcanism may have provided required conditions for the sinuous rille formation (high discharge, high temperature, low viscosity, etc.).

channels. However, incision was caused by the long flow duration and high temperatures of eruption, along with relatively large discharge rates, possibly assisted by a low viscosity of the channel-forming lava. Channel narrowing and levee formation suggest relatively fast cooling. The venusian channels could have had a similar sequence of formation including rapid cooling.

Lava types. Assuming the substrate is typical tholeiitic lava, the flowing lavas' temperatures have to be higher than the melting temperature of the substrate. The flow should have a low viscosity to cause turbulence and keep a high Raynolds number to sustain efficient thermal erosion. The returned Apollo samples indicate that the lunar lava was enriched in Fe and Ti and had relatively low viscosities and high eruption temperatures [6]. Venera landers reported tholeiitic basalt and alkaline basalt for the composition of plains material. However, none of the landers landed close to venusian sinuous rilles. So the chemical composition of sinuous rille-forming lava remains uncertain. A potential clue comes from geologic associations. The channels are often associated with the coronae [7], which are hypothesized to be related to mantle plume activity. The channel-forming lava may be mantle-derived magmas, e.g., alkaline basalt, picrite, komatiite [2]. They have low viscosities at their melting temperatures, and, since the eruption temperature of these lavas is so high, thermal erosion can be very efficient. Some of the channels' great depths (approximately a few hundred meters deep) may thereby be explained. Because high-temperature lava tends to cool rapidly, the channel narrows, shallows, and terminates over a relatively short distance.

Eruption Conditions: Determining eruption conditions also provides insights to estimate lava composition. Assuming a channel is formed mostly by thermal erosion, the channel's length and longitudinal profile are functions of lava properties. The depth profiles of the channels are measured by radar foreshortening methods and stereo images. Eruption conditions of channel forming lava can be estimated by the methods developed by Hulme [5].

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N93-14338

RADIATION PRESSURE: A POSSIBLE CAUSE FOR THE SUPERROTATION OF THE VENUSIAN ATMOSPHERE.

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The superrotation of the venusian atmosphere relative to the planet's surface has long been known. Yet the process by which this vigorous circulation is maintained is poorly understood [1]. The purpose of this report is to show that a mechanism by which the solar radiation interacts with the cloudy atmosphere of Venus could be the principle cause of the superrotation. Radiation pressure is the term used to describe the result of the transfer of momentum from a photon to matter that occurs when a photon interacts with matter by the known processes of absorption, scattering, or reflection.

The simple rotor radiometer (Fig. 1) can be used to demonstrate radiation pressure. It is useful to review this classic demonstration as the proposed mechanism is so closely related to it. It is known that the absorbing surface of the asymmetrical rotor begins to turn toward the radiation when a radiation source is placed before the apparatus. A specific configuration of this system (Fig. 2) aids in the explanation of this rotation. The radiation interacts differently with the different vane surfaces. When a photon strikes the absorbing surface and is absorbed, its momentum is transferred to the vane. When a photon strikes the reflecting surface of the opposite vane, its momentum is transferred to the vane twice in the reflection process.

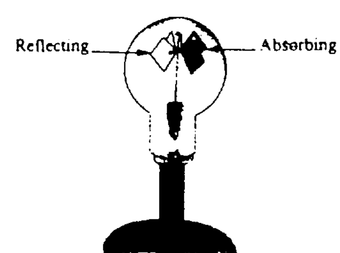

Fig. 1.

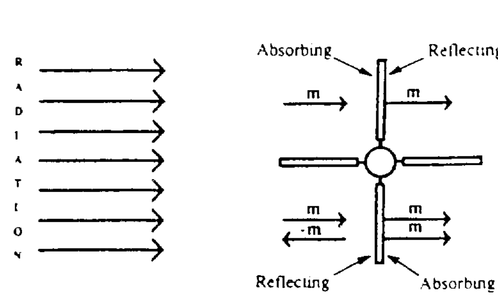

Fig. 2.

To understand the reflection process it is convenient to divide it into two steps. In the first step the photon is stopped (absorbed) by the reflecting surface and the photon's momentum is transferred to the vane. In the second step a photon is immediately emitted from the reflecting surface of the vane. By the principle of equal but opposite reaction a momentum equal to that of the emitted photon must be transferred to the vane during this second step. Therefore, it can be seen that the rotor must rotate so that the absorbing surface turns toward the radiation when opposite vanes are equally illuminated and equal in surface area.

It has been long known that Venus has a high albedo due to the scattering (similar to the reflection process) of solar radiation by the cloud droplets in its atmosphere. The radiation not scattered, but intercepted by the planet and its atmosphere, is mainly absorbed within the cloud layers. Therefore, momentum (equal, more or less, to that of the solar radiation intercepted) is continually transferred to the venusian atmosphere. An atmospheric system is different from the radiometer in that it presents a symmetrical surface (same radiation-matter interaction) toward the solar radiation at its morning and evening limbs (Fig. 3). If the cross-sectional areas at both limbs were equal as illustrated, the momentum transfer at the morning limb would decelerate the atmosphere's rotation while at the evening limb the same transfer would accelerate the rotation an equal amount. The net result of this is that the overall rate of rotation would be unchanged.

Such a symmetrical configuration is not likely since the atmosphere must be warmed as it rotates across the planet's day hemisphere and cooled as it rotates across the planet's night hemisphere. This warming and cooling must result in a formation of an asymmetrical configuration (Fig. 4). It is apparent that the momentum transfer at the evening limb must be greater than that at the morning limb because the atmosphere's greater cross section at the evening limb intercepts a greater amount of solar radiation. It should be noted that very little of the solar radiation is transmitted through the cloud layers, especially at or near the limbs where the atmospheric path length of the radiation is long. This net momentum transfer must be continually added to the angular momentum of the atmospheric system at the same time angular momentum is continually removed from the atmosphere by the frictional drag imposed on the atmosphere by the slowly rotating planet's surface. This completes the description of this mechanism.

There is great pressure to quantify the mechanism just introduced in an effort to evaluate its potential effectiveness. This pressure is resisted for the following reason. What physics professor would demonstrate the existence of radiation pressure and make the success or failure of the demonstration dependent upon the ability to predict the expected rate of rotation of an unknown apparatus? It is enough that the rotor turns in the direction predicted when the radiation source is set before the apparatus.

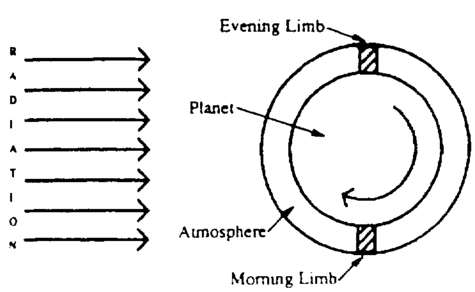

Fig. 3. Atmosphere not to scale.

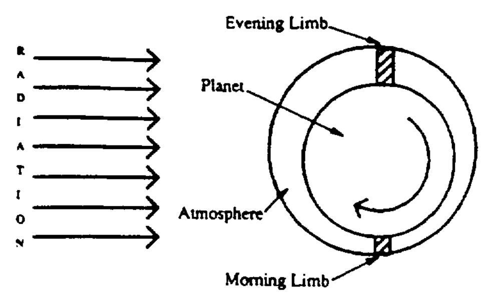

Fig. 4. Atmosphere not to scale.

It should be enough that the qualitative details of the known superrotation of the venusian atmosphere are entirely consistent with the simple radiation pressure mechanism presented for this mechanism to receive serious consideration. An analysis of the frictional drag expected for the nearly laminar flow found beneath the cloud deck is much beyond my talent, to say nothing about the frictional coupling that exists in the turbulent cloud layer. It is possible that the mechanism might be tested if such frictional effects were reasonably well known.

The mechanism does suggest a possible phenomenon other than superrotation. The acceleration and deceleration that occur at the evening and morning limbs must compress the rotating atmosphere at some morning location and rarefy it at some afternoon location. A more detailed analysis of the expected atmospheric tides due to this mechanism is the subject of a nearly completed separate work.

A simple mechanism involving the phenomenon known as radiation pressure has been proposed to explain the superrotation of the venusian atmosphere. According to basic principles of physics it cannot be denied that the process must be active. It has been shown that support of the proposed mechanism by predictive, quantitative calculations is not presently possible because critical properties of the real system are unknown, or at best, poorly known. The possibility of atmospheric tides that, if observed, would be consistent with the mechanism has been noted. It should also be noted that the solar wind might replace the solar radiation in a similar mechanism. This has not been considered because the physics of the solar wind as it encounters a planet in its path is beyond my abilities.

Reference: [1] Belton M. J. S. et al. (1991) *Science, 253,* 1531–1536. (This article not only reports results from the Galileo venusian encounter, but also is a review of the superrotation phenomenon and is extensively referenced.)

N93-14339

LARGE-VOLUME LAVA FLOW FIELDS ON VENUS: DIMENSIONS AND MORPHOLOGY. M. G. Lancaster[1], J. E. Guest[1], K. M. Roberts[2], and J. W. Head[2], [1]University of London Observatory, University College London, London NW7 2QS, UK, [2]Department of Geological Sciences, Brown University, Providence RI 02912, USA.

Of all the volcanic features identified in Magellan images, by far the most extensive and areally important are lava flow fields. Neglecting the widespread lava plains themselves, practically every C1-MIDR produced so far contains several or many discrete lava flow fields. These range in size from a few hundred square kilometers in area (like those fields associated with small volcanic edifices for example), through all sizes up to several hundred thousand