lower mantle be more viscous than the upper mantle in order to produce the required positive geoid anomalies. This has already been shown to be true for the Earth, where the observed geoid highs over regions of mantle upwelling and regions of mantle downwelling are best explained by the presence of a strong lower mantle [11,12]. The large positive GTRs and the presence of large shield volcanos in certain highland regions on Venus, such as Beta Regio and Eistla Regio, are best explained as areas of mantle upwelling [5,13,14]. The regime of rapid crustal flow predicts crustal thinning over the upwelling. However, the extensive partial melt and ensuing volcanism expected over such regions of mantle may outweigh the effects of crustal thinning on the surface topography and thus also yield postive GTRs [15].

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VENUS GRAVITY: SUMMARY AND COMING EVENTS.

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The first significant dataset to provide local measures of venusian gravity field variations was that acquired from the Pioneer Venus Orbiter (PVO) during the 1979–1981 period. These observations were S-band Doppler radio signals from the orbiting spacecraft received at Earth-based tracking stations. Early reductions of these data were performed using two quite different techniques. Estimates of the classical spherical harmonics were made to various degrees and orders up to 10 [1,2,3]. At that time, solutions of much higher degree and order were very difficult due to computer limitations. These reductions, because of low degree and order, revealed only the most prominent features with poor spatial resolution and very reduced peak amplitudes.

Another reduction technique was the line-of-sight acceleration mapping that had been used successfully for the Moon and Mars. This approach provided much more detail and revealed the high correlation of gravity with topography [4,5,6]. However, this technique does not produce a global field as do the spherical harmonics. It provided a mapping of features from approximately 50°N to 25°S latitude for 360° of longitude. Other shortcomings were that the accelerations were at spacecraft altitude rather than at the surface and were not vertical accelerations; however, the reductions were quick and cheaply accomplished. Other efforts to analyze these data included local area reductions, where surface masses were estimated [7,8,9].

The computer revolution over the past 10 years has allowed new reductions with spherical harmonics. New fields up to degree and order fifty (2600 parameters) have been made [10,11,12]. These fields now provide the best representation for any serious geophysicist doing quantitative modeling. There is now vertical gravity at the surface from a global model that carries all the requirements of dynamical consistency. There is one sizeable concern in that the resolution over the entire planet is not uniform. This is due to the Pioneer orbit, which had a high eccentricity, causing the high latitude regions of Venus to be poorly resolved.

The Magellan (MGN) spacecraft, which went into orbit about Venus in August 1990, has returned Doppler data for gravity field reduction. However, because the high gain antenna was pointed at Venus for SAR mapping, no gravity data were acquired until the antenna was pointed back to Earth. This occurred at spacecraft altitudes higher than 2500 km, greatly reducing local gravity sensitivity. MGN has an eccentricity much smaller than PVO, so there is new information in the polar regions. Present reductions include two MGN circulations (486 days), which reduce uncertainties and produce somewhat better resolution.

During March, April, and May 1992 new low-altitude data have been acquired from both PVO and MGN. PVO periapsis latitude has changed 27°, from 16°N to 11°S. These data will provide better definition in the southern hemisphere, particularly over Artemis. The MGN mission now acquires periapsis gravity data for one orbit out of eight (i.e., foregoes SAR mapping for one orbit/day). Since MGN has an X-band radio signal, the data quality is a factor of 10 better than PVO. Only a small block of MGN data was acquired before its periapsis went into occultation May 16. Solar conjunction and periapsis occultation has also occurred for PVO.

In September of 1992 MGN periapsis will exit occultation and its periapsis altitude will be lowered to approximately 170 km. Periapsis will be visible from Earth for a complete 360° longitude coverage period (243 days). This should be an excellent dataset, having low X-band data noise that in turn can be combined with the PVO dataset.

In December 1992 PVO will exit periapsis occultation and low-altitude data (~150 km) in the southern hemisphere will be acquired for about one month before PVO is lost due to the lack of fuel to maneuver to safe altitudes.

In May 1993 there remains the possibility of aerobraking MGN into a circular orbit, thus allowing global uniform resolution gravity data to be acquired. One hopes that NASA has enough foresight to keep Magellan alive so this is a reality. It is anticipated that if this is done, harmonic solutions to degree and order 60–70 (5000 parameters) will be produced. One could then compare similar features globally, resolve coronae and test many interior structure models.

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DIFFERENT TYPES OF SMALL VOLCANOS ON VENUS.

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One of the studies of volcanic activity on Venus is the comparison of that with the analogous volcanic activity on Earth. The preliminary report of such a comparison and description of a small