VENUS SURFACE INVESTIGATION USING VIRTIS ONBOARD THE ESA/VENUS EXPRESS MISSION. L. L. Marinangeli[1], K. Baines[2], R. Garcia[3], P. Drossart[4], G. Piccioni[5], J. Benkhoff[6], J. Helbert[6], Y. Langevin[7], G.G. Ori[1] , G. Komatsu[1,] and I. C. Pope[1], [1]IRSPS, Univ. D'Annunzio, Viale Pindaro 42, 65127 Pescara, Italy email: luciam@irsps.unich.it, [2]JPL, Pasadena, USA, [3] DGSP-IPGP, Universitè Paris 7, Paris, France, [4] LESIA, Observatoire de Paris, Paris, France, [5] IASF, Rome, Italy, [6]DLR, Berlin, Germany, [7] Universitè Paris Sud, Paris, France.

Instrument description: Venus Express Mission is the first ESA mission to Venus that will be launched in November 2005. In April 2006 after ~150 days of cruise the spacecraft will be inserted into highly elliptical polar orbit around Venus. The observational phase will begin after about one month of commissioning phase. The nominal mission orbital life-time is two Venus sidereal days (~486 Earth days). The scientific goals of Venus Express are related to the global atmospheric circulation and atmosphere chemical composition, the surface-atmosphere physical and chemical interactions, the physics and chemistry of the cloud layer, the thermal balance and role of trace gases in the greenhouse effect, and the plasma environment and its interaction with the solar wind.

Among the scientific payload, there will be a Visible and Infrared Thermal Imaging Spectrometer, VIRTIS-VEX (PIs Giuseppe Piccioni -IASF, Italy and Pierre Drossart - Obs. de Paris, France). VIRTIS is a sophisticated imaging spectrometer (spectral range 0.25 to 5 μm) that combines three unique data channels in one compact instrument. Two of the data channels are committed to spectral mapping and are housed in the Mapper (-M) optical subsystem. The third channel is devoted solely to spectroscopy and is housed in the High resolution (-H) optical subsystem. Both channels may operate simultaneously or separately, depending on the selected observing modes.

VIRTIS will observe the Venusian atmosphere, both on night and day sides and provide a 4-dimensional study of Venus atmosphere (2D imaging + spectral dimension + temporal variations), allowing a sounding at different levels of the atmosphere, from the surface up to the thermosphere.

The Magellan mission unveiled a unique planet but many questions on the geological evolution of Venus are still without answer. VIRTIS investigation will help in solving some mysteries of the recent geological processes characterizing the Venus surface.

Investigation of surface mineralogical composition and chemical weathering: A very little is known about the mineralogical composition of the surface of Venus. Data from the Venera missions show that venusian plains are mainly basaltic in composition. But we don't know in most cases what types of basalts, and , also, if different geological units such as tesserae or steep-sided domes have different petrography. Moreover, the observation on Magellan images of sinuous and long *canali-type* channels suggests unusual lava process occurring on Venus at places and involving very low-viscosity lavas [1,2] which are rare on Earth.

Furthermore, dramatic changes in radar emissivity values observed by Magellan above high relief (> 5000 m above MPR), have been interpreted as due to chemical weathering of the surface basalt operated by the atmosphere at high altitude [3]. The mineral responsible for low emissivity on mountaintops and volcano edifices appears to be the electrical semiconductor pyrite whereas magnetite is thought to characterise the lower altitude [4]. Also, available data suggest that magnetite and hematite may both be stable on the surface probably in solid solution with other oxide minerals [5]. The altitudes at which the magnetite/pyrite phase boundary is encountered vary with the redox state (CO/CO_2 ratio) of the troposphere which is still poorly known [5].

The chemical composition of the lower atmosphere, in particular the CO/CO_2 and COS mixing ratio, is crucial to understand this phenomenon. Radar data cannot provide final clues on the mineral stability under this corrosive condition, but spectral mapping of VIRTIS of the near-surface can help in defining the redox state of the atmosphere and, thus, to identify the surface minerals in equilibrium with the atmosphere.

Surface temperature. VIRTIS can map the temperature of the surface of Venus very accurately. This was demonstrated by Galileo/NIMS [6] and Cassini/VIMS [7]. In addition, there is a distinct option that VIRTIS can derive the emissivity of the surface in 5 distinct atmospheric windows, thus giving the possibility of deriving some surface spectral properties in the 0.85-1.2 -micron range (see figure in [7]).

The surface spectral task is a little more difficult than generally regarded because of multiple surface-cloud reflections which essentially washes out the contrast between high albedo and low albedo parts of the spectrum, but nevertheless some small contrast should still be there which hopefully we can exploit.

Thus, especially over the northern polar area where we are very close to Venus and can get really nice spatial resolution, we should be able to see any hot spots caused by volcanism. And, in addition, we should have a good chance to be able to see contrast variation in the surface material flowing out of the volcano compared to the weathered material that is being covered over.

Searching for recent volcanic activity: Previous studies on NIR spectroscopy of the lower atmosphere composition of Venus [8, 9; 10] suggest carbon monoxide, sulfur dioxide, water vapor and, eventually, methane to be present and variable in space and time. These gases are commonly produced during volcanic eruptions. The NIR window of VIRTIS can detect and map the spectral signature of these chemical species and would allow the identification of recent volcanic eruptions.

Overlapping the thermal and chemical composition of the lower atmosphere to a detailed geological mapping, will provide a comprehensive study of the surface-atmosphere weathering effect and the identification of recent volcanic activity on Venus.

A successful approach of combining atmosphere and surface geology has been done by [11] using SAR Magellan data and Pioneer Venus UV measurements of the lower atmosphere. The authors suggested a very recent volcanic activity on Maat Mons based on the anomalously high concentration of CO_2 and the radar emissivity values of the surface units. Many of the top of the volcano edifices are characterised by low emissivity value [3]. Interestingly, Maat Mons volcano, which reaches ~6000 m of height, does not show such low emissivity at the summit. This has been interpreted as possible evidence for recent volcanic activity which prevented the weathering effect at high altitude [4; 11].

Detection of infrasonic post-seismic or post-volcanic waves: The mechanical coupling between the surface and the atmosphere of Venus is more efficient than on Earth due to the larger atmospheric density near the surface. So, the surface rock displacements due to seismic waves and volcanic eruptions generate pressure waves that propagate vertically in the atmosphere. Such seismic and volcanic events should be occurring rather frequently on an active planet such as Venus. The signal associated to these events will propagate and amplify as pressure waves in the atmosphere of Venus. It will not be attenuated by the CO_2 atmosphere, and will produce temperature variations in the 70-100 km altitude range that could be probed with the CO_2 at 4.3 μm band measured by VIRTIS.

The detection of Rayleigh waves would be possible with the VIRTIS-M channel in its nominal mode, but only the apparent phase velocity and apparent wavelength along the X direction (perpendicular to the spacecraft motion) could be measured due to the high phase velocity of atmospheric Rayleigh waves (~3km/s). However, the high phase velocity of these waves is the best way to separate them from gravity waves and other noise sources. The detection of mesospheric heating associated to quakes implies the repetition of observations on the same region along the same orbit. The measurement of the vibrating modes of the atmosphere could be performed by successive observations of the same line along the X direction during at least 1000 seconds. However, this would imply a new observation mode for VIRTIS-M and additional spacecraft constraints to maintain the pointing of the VIRTIS instrument. The possibility to perform this observation mode is currently under discussion.

Final remarks: Although Venus Express is a mission devoted to atmosphere observation, significant scientific return will be provided by the VIRTIS investigation of Venus surface. Many key issues raised by the analysis of Magellan data on the surface characteristics and recent geological activity can be investigated by VIRTIS providing unique information on surface temperature, mineralogy, chemical weathering, recent volcanic activity and earthquakes occurrence.

Further details on VIRTIS instrument and the Science Team can be found in the web sites http://servirtis.obspm.fr/Venus_Express and http://www.rm.iasf.cnr.it/ias-home/Venus-Express/Venus-Express.htm

Venus Express mission is described at the ESA web site http://sci.esa.int

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