EPSC Abstracts
Vol. 6, EPSC-DPS2011-1167, 2011
EPSC-DPS Joint Meeting 2011

Genetic processes behind calderas formation on Venus through a comparative study with Terrestrial analogues

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Abstract

On the base of remote sensing and terrestrial geological data we have elaborated a hypothesis about the origin of calderas on Venus through a global and a local scale comparison with similar structures on Earth. For the global scale comparison, we categorized the Venusian and the terrestrial volcanic depressions. We extracted for comparison geometric data such as areal dimensions and eccentricity. For the local scale comparison we have selected two cases of study which are comparable in terms of size: Mezrina Patera, on Venus, and Vulsini Complex (Lazio, Italy) on Earth. A geological mapping of the main structural features and deposits has been conducted and a number of specific features, which are interpreted to be related to extrusion of lava and intrusion of magma have been identified in Mezrina Patera. These are: volcano-tectonic depressions, resurgences, lobate deposits, channelized flows (plausible lava flows) and concentric lava domes. The genetic processes behind the formation of the Venusian patera seem to have been influenced from both global and local scale stress fields. Vulsini Complex doesn't show the same evidence, so that the terrestrial volcanic complex appears to have been predominantly influenced by local scale stress fields. While Vulsini Complex is clearly related to explosive volcanism, Mezrina Patera could be connected with a hot spot or mantle plume activity. A deeper analysis of the most recent 1 micron thermal emissivity and surface temperature data, which will be reported in a further pubblication, will allow us to better constrain if Mezrina Patera might be related to recent volcanism.

1. Introduction

Venus is a planet that experienced in the past widespread volcanism [1,2] and it might have recent volcanic activity, based on a recent analysis [3] of data from the VIRTIS instrument on the ESA Venus Express mission.

The work presented here will focus on the following points: A) Analysis of differences between Venusian "caldera" sensu strictu and "corona" formations: Are these structures comparable? B) Global scale comparison between Venusian and terrestrial calderas. C) Local scale comparison between two opportunely chosen calderas (one Venusian vs one terrestrial example). D) Discussion and description of the possible genetic mechanisms which might be responsible for caldera formation processes on Venus, starting from analogue processes on Earth. The present study will continue the analytic research and interpretation work started by other authors [4,5,6,8], trying to evolve our knowledge about Venusian volcanism.

2. Data analysis

2.1 Global scale analysis

For the global scale comparison we used a list of 96 Venusian structures already classified as calderas [7], which we compared to 96 Terrestrial calderas. We used the dimension (semi-major and semi-minor axis) of each sample to calculate its area (here understood as the surface bounded by the caldera topographic rim) and its eccentricity.

2.2 Local scale analysis

We have chosen two caldera structures for the local scale comparison: Mezrina Patera on Venus and Vulsini Complex on Earth. We produced topographic profiles and a volcanological map of associated deposits (Figure 1) for both calderas, and we got useful values of areal extension of these deposits. We also made a structural map of the Venusian caldera. With regard to Mezrina Patera, particular attention was paid to the analysis of the 1 micron relative emissivity data [9] (provided by the VIRTIS instrument), studying the relation between the distribution of these data in the general region surrounding Mezrina Patera and the distribution of

the same data at the site of the Venusian caldera to check possible changes in the concentration of data values. We also took 1 micron emissivity data and surface temperature profiles across Mezrina Patera and compared these profiles with the topography.

3. Conclusions

The global scale analysis showed that Venusian calderas have considerably greater dimensions than terrestrial analogues. The geometrical comparison clarified that there is a bigger percentage of circular calderas on Venus than on Earth, since terrestrial calderas have more variable geometries, varying from circular to very elliptical ones. The geometrical analysis revealed an important common characteristic between Venusian and terrestrial samples: We divided eccentricity of calderas in classes varying from 0% (circular shape) to 100% (completely elliptical shape), and our analysis determined that the eccentricity class between 1% and 30% is completely missing on both planets. The local scale analysis highlighted that Mezrina Patera is characterized by a style of volcanism more effusive compared to Vulsini Complex, which is supported by measurements the areal extent of the deposits associated with the twocalderas, while the results of the VIRTIS data are less clear and we still need to carefully analyze them to complete that part of the study.

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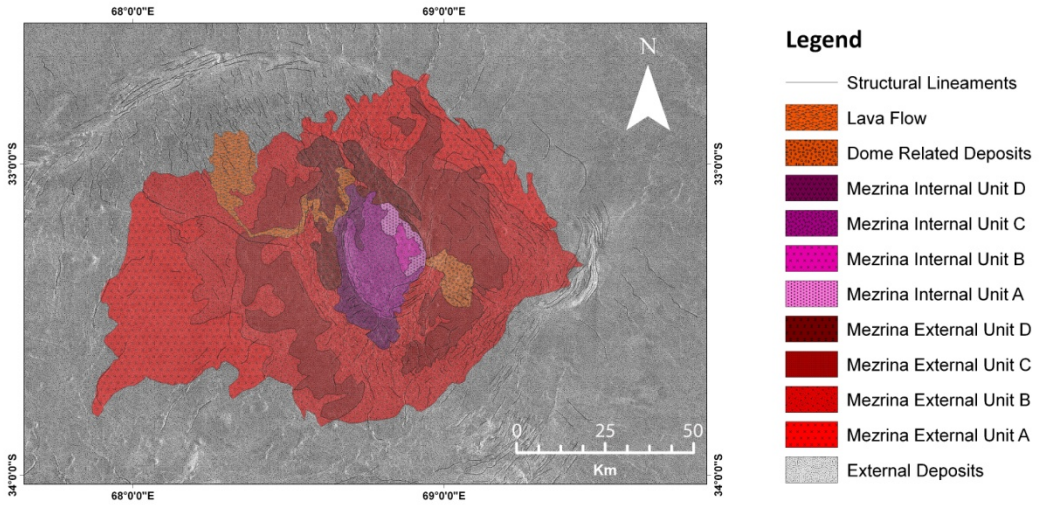

Figure 1 - Map of deposits associated with Mezrina Patera. Deposits marked with the letter "A" indicate the oldest units, while deposits marked with a "D" indicate the youngest ones. The map has been elaborated using a radar Magellan image at 75 m/pixel resolution.