EPSC Abstracts
Vol. 6, EPSC-DPS2011-820, 2011
EPSC-DPS Joint Meeting 2011

Monte Carlo simulations of the interaction between volcanic resurfacing and cratering on Venus

I. Romeo
Departamento de Geodinámica. Universidad Complutense de Madrid, Spain (iromeobr@geo.ucm.es / Fax: +34-913464845)

Abstract

The interaction between volcanic resurfacing and impact cratering on Venus has been evaluated for different proposed geological evolutions of the planet. The models generate conic volcanic units and impact craters randomly in space and time over a sphere. The process of impact crater burial or volcanic partial modification is reproduced using a 3D approach, the geometry of each unit in the model is a flat cone with an edge angle of 0.5 degrees. The sizes of volcanic flows in the models were generated using the frequency–size distribution of volcanic units measured on Venus. A non-homogeneous spatial generation of volcanic units was included in the models reproducing the Beta–Alta–Themis volcanic anomaly. The final number of modified craters and randomness of the crater population measured by pair-correlation statistics were used to evaluate the success of the models, comparing the results from our simulations with Venus observations. The modified crater frequency-size distribution and the frequency of distances from craters and modified craters to the center of the BAT anomaly were also obtained form the models and compared with Venus. A catastrophic evolution is the only solution that fits Venus observations. Evolutionary models cannot reproduce all the characteristics of the crater population.

1. Introduction

The geologic evolution of Venus is still a controversial topic since high-resolution radar images obtained by the Magellan mission revealed a low global number of craters [9], with a spatial distribution that cannot be distinguished from a uniformly random distribution, and a small fraction of modified craters. These observations were interpreted as caused by a catastrophic event followed by a decay of the volcanic activity [13,14] or an equilibrium steady-state evolution where the low number of craters is maintained through small-scale time-transgressive resurfacing events [7,10].

A wide variety of Monte Carlo simulations of the interaction between volcanic resurfacing and cratering on Venus has been performed. [10] used equal-sized volcanic units produced at constant generation rates without considering modified craters. [13] also used equal-sized volcanic units produced periodically at a constant time rate during the resurfacing process but added an estimation of the number of modified craters. [14] performed Monte Carlo simulations of different equilibrium resurfacing evolutions. Several models had equal-area volcanic units at constant intervals, and one model used the frequency–diameter distribution of volcanoes produced at constant intervals. A more realistic 3D approach for crater modification was achieved by [4] using a topographic grid, generating the volcanic units at constant rates. [7] studied the randomness of the Venusian crater population through the nearest neighbor analysis, demonstrating that it can be reproduced both by a catastrophic resurfacing event and also by more evolutionary models with different ages of generation of the volcanic plains, but this study did not take into account the number of modified craters. [8] modeled catastrophic and equilibrium resurfacing, estimating the number of modified crated using a 2D approach, concluding that very large plain units are incompatible with equilibrium resurfacing. [3] developed Monte Carlo simulations for equilibrium resurfacing using variable rates of volcanic activity with a decay in the size of the volcanic units, but with a fixed unit size for a given age in the model. [1,2] performed Monte Carlo simulations with a simple 2D approach for crater modification and resurfacing areas are constant along the models. [12] reproduced volcanic resurfacing using the measured frequency-area distribution of volcanic units mapped on Venus [11] and their models included a non-homogeneous spatial generation of volcanic units reproducing the Beta–Alta–Themis volcanic anomaly [6].

2. Improvements in the models

Since the previous version of our models [12] several improvements has been included. Our 3D approach for crater modification allows us to reproduce not only the location of the modified craters but also their frequency-size distribution. Three new characteristics of the crater population were obtained from our models and were compared with Venus observations: (1) the frecuency-size distribution of modified craters, (2) the frecuency of distances to BAT anomaly of craters and (3) the frecuency of distances to BAT anomaly of modified craters.

We also considered more complex geological evolutions than in previous models: (1) the posibility of restricting the maximum size of volcanic unit that can be generated at the end of the model, (2) the generation of the BAT anomaly only at the end of the model, (3) evolutionary models with a recent volcanic event (not completely catastrophic) and (4) evolutionary models with final decay of the volcanic activity.

3. Preliminary results

None of the evolutionary models can reproduce our new observations of the characteristics of the Venusian crater population. The distribution of craters of all the evolutionary models necessarily generate a significant lack of craters in the BAT anomaly area, which is not observed on Venus. The only solution that satisfied all the observations is the catastrophic evolution previously proposed by [13,14,5].

References

[1] Bjonnes, E.E., Hansen, V.L., James, B., Swenson, J.B., Equilibrium resurfacing of Venus: Results from new Monte Carlo modeling and implications for Venus surface histories, Icarus, doi:10.1016/j.icarus.2011.03.033, 2011.

[2] Bjonnes, E.E., Hansen, V.L., Swenson, J.B., Results of equilibrium resurfacing Monte Carlo models on Venus. In: Proceedings of the 39th LPSC, #2410, 2008.

[3] Bond, T.M., Warner, M.R., Dating Venus: statistical models of magmatic activity and impact cratering. In: Proceedings of the 37th LPSC, #1957, 2006.

[4] Bullock, M.A., Grinspoon, D.H., Head, J.W., Venus resurfacing rates: constraints provided by 3-D Monte Carlo simulations, Geophysical Research Letters, Vol. 20, pp. 2147–2152, 1993.

[5] Collins, G.C., Head, J.W., Basilevsky, A.T., Ivanov, M.A., Evidence for rapid regional plains emplacement on Venus from the population of volcanically embayed impact craters, Journal of Geophysical Research, Vol. 104 (E10), pp. 24121–24139, 1999.

[6] Crumpler, L.S., Aubele, J.C., Senske, D.A., Keddie, S.T., Magee, K.P., Head, J.W..: Volcanoes and centers of volcanism on Venus. In Venus II (eds: Bougher, S.W., Hunten, D.M., Phillips, R.J.) pp. 697-756, University of Arizona Press, 1997.

[7] Hauck, S.A., Phillips, R.J., Price, M.H., Venus; crater distribution and plains resurfacing models, Journal of Geophysical Research, Vol. 103 (E6), pp. 13635–13642, 1998.

[8] Kreslavsky, M.A., Venus cratering record: constraints on resurfacing history, Lunar and Planetary Science 27, pp. 697–698, 1996.

[9] McKinnon, W.B., Zahnle, K., Ivanov, B.A., Melosh, H.J.: Cratering on Venus: modeling and observation. In Venus II (eds. Bougher, W., Hunten, D.M., Phillips, R.J.) pp. 969–1014, University of Arizona Press, 1997.

[10] Phillips, R.J., Raubertas, R.F., Arvidson, R.E., Sarkar, I.C., Herrick, R.R., Izenberg, N., Grimm, R.E., Impact craters and Venus resurfacing history, Journal of Geophysical Research, Vol. 97, pp. 15923–15948., 1992.

[11] Romeo, I., Turcotte, D.L.: The frequency–area distribution of volcanic units on Venus: implications for planetary resurfacing, Icarus, Vol. 203, pp. 13–19, 2009.

[12] Romeo, I. and Turcotte, D.L.: Resurfacing on Venus, Planetary and Space Science, Vol. 58, pp.1374–1380, 2010.

[13] Schaber, G.G., Strom, R.G., Moore, H.J., Soderblom, L.A., Kirk, R.L., Dawson, D.J., Gaddis, L.R., Boyce, J.M., Russell, J., Geology and distribution of impact craters on Venus: what are they telling us?, Journal of Geophysical Research, Vol. 97, pp. 13256–13301, 1992.

[14] Strom, R.G., Schaber, G.G., Dawson, D.D., The global resurfacing of Venus, Journal Geophysical Research, Vol. 99 (E5), pp. 10899–10926, 1994.