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Can terrestrial impact craters cause changes in the geoid undulation? A case study

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Abstract

In this abstract the hypothesis that impact craters may cause changes in the geoid undulation on Earth is tested. The Vargeão Dome crater in Brazil has been chosen as the case study. The geoid undulation *N* has been calculated in 315 points spread over the region and no variation due to the presence of the crater has been noted.

1. Introduction

On solid planetary bodies, impact cratering is currently being referred as the most important resurfacing and land forming process. In planets such as Mars, craters can be easily identified by visual analysis performed on remotely sensed data. On Earth, a number of resurfacing processes take part. Hence, the impact craters can be erased or masked by erosional and depositional processes or land cover. Much effort has been done to detect impact craters on Earth. There is a broad field of research on the subject comprising, among others, the analysis of optical [1] and microwave [2] remote sensing data, digital elevation models [3] and global gravitational models [4]. Despite that, only a few 188 (http://passc.net/EarthImpactDatabase) confirmed impact craters on our planet have been reported. In this abstract, we investigate if an impact crater can cause changes in the geoid undulation. If that hypothesis is confirmed, then geoid undulation models can be an alternative method for searching for candidates of impact craters on Earth.

2. Setting

Up to date, seven impact craters have been confirmed [5] in Brazil, which are Araguainha Dome, Serra da Cangalha, Riachão, Vargeão Dome, Vista Alegre, Cerro Jarau and Santa Marta. In this abstract, we have chosen to study the geoid undulation in Vargeão Dome crater. Vargeão Dome is a circular feature located in the Santa Catarina state, Southern Brazil, formed in Cretaceous volcanic rocks of the Serra Geral Formation. This unit comprises mainly continental flood basalts and subsidiary intermediate and acidic volcanic rocks whose emplacement are related to the rifting of Gondwana and the formation of the South Atlantic Ocean [6]. The crater has the center coordinates 26°47’S and 52°10’W (SIRGAS2000 reference frame), its diameter is ~12 km and its age is ~123 Ma.

3. The geoid undulation

The geoid is the equipotential surface of the Earth’s gravity field, which best fits, in a least square sense, the global mean sea level. It is a surface that defines zero elevation for orthometric heights measurements. The orthometric height H is the distance along the plumb line between the geoid and the point on the Earth’s surface. The distance between the geoid and the reference ellipsoid is the geoid undulation N. N can be obtained by field gravity measurements or, as an alternative, by the difference between ellipsoidal heights h and orthometric heights: $N = h - H$. The ellipsoidal height h is the distance measured from the reference ellipsoid to the point on the surface of the Earth. The geoid is a smooth but highly irregular surface whose shape results from the uneven distribution of mass within and on the surface of the Earth. Consequently, the geoid undulation also varies according to the mass distribution inside the Earth’s crust.

3.1 Brazilian undulation model

The Brazilian undulation model is named MAPGEO2010 and has a grid resolution of 5’ in latitude and longitude. It was estimated by using more than 928,000 terrestrial gravimetric points for the South America. The procedures for the determination of the model can be found on http://www.ibge.gov.br/english/geociencias/geodesia/calculo_do_modelo.shtm. The mean accuracy of the model is ± 0.32 m. The lowest accuracy occurs in the North and Northwest regions of the country where it can reach up to ± 0.50 m.

4. Results

Our assumption is that the impact crater produced by a planetary body may alter the mass distribution immediately below Earths' surface and force the geoid undulation to change. We have used MAPGEO2010 to calculate the geoid undulation in 315 points spread over the Vargeão Dome crater. The points were placed in a grid with 30" of resolution in latitude and longitude. The adopted reference frame was the Brazilian SIRGAS2000. Fig. 1 shows a map of the region. The background image is a Landsat-7 scene, composite bands 3 (B), 4 (G) and 5 (R). From the points with *N* values, we have calculated contour lines with a vertical distance of 0.05 m. In Fig. 1, the *N* values are positive over the region meaning that the geoid lies above the ellipsoid surface there. By analyzing the contour lines, one can see that there is a Southeast trend of increasing values and no changes in the geoid undulation due to the presence of the crater are noted.

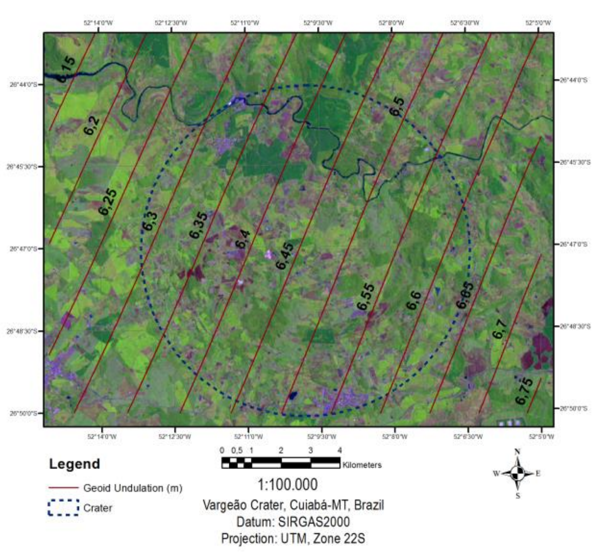

Figure 1: Geoid undulation in Vargeão crater.

5. Conclusion

After analyzing the contour lines made up of 315 points of geoid undulation values in the region of Vargeão crater, as shown in Fig. 1, the hypothesis that an impact crater may change the geoid undulation could not be confirmed. In the data shown in Fig. 1 the geoid undulation has not been affected by the presence of the impact feature. On the other hand, the hypothesis cannot be discarded yet. The Brazilian model has a poor 5' by 5' resolution in latitude and longitude, which roughly corresponds to an area of ~9.25 km by 9.25 km. As the crater has a diameter of ~12 km, most of the *N* values were obtained by interpolation (carried out by the MAPGEO2010 itself). Thus, we are going to perform another test with a much larger structure, the Araguainha impact crater, whose diameter is ~40 km. In addition, we are going to test the EGM2008 global gravity field model.

References

[1] Zumpreskel, H. and Bischoff, L.: Remote sensing and GIS analysis of the Strangways impact structure, Northern territory, Australian Journal of Earth Sciences, Vol. 52, pp. 621-630, 2005.

[2] Chiarro, A. et al.: ERS Synthetic Aperture Radar imaging of impact craters, ERSA Publication Division, 2003.

[3] Krogli, S.O., et al.: Automatic detection of circular depressions in digital elevation data in the search for potential Norwegian impact structures, Norwegian Journal of Geology, Vol. 87, pp. 157-166, 2007.

[4] Kalvoda, J. et al.: Mass distribution of Earth landforms determined by aspects of the geopotential as computed from the global gravity field model EGM2008, AUC Geographica, Vol. 48, pp. 17-25, 2013.

[5] Crósta, A.P. and Vasconcelos, M.A.R.: Update on the current knowledge of the Brazilian impact craters, Lunar and Planetary Science Conference, March 2013, The Woodlands, USA, 2013.

[6] Crósta, A.P. et al.: Geology and impact features of Vargeão dome, southern Brazil, Meteoritics and Planetary Science, Vol. 47, pp. 51-71, 2012.