Gravity data reveals intimate connection between magma plumbing system and tectonics at Cerro Negro

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Introduction

A lack of deep structural data has historically made classifying Cerro Negro and its role in local volcanism difficult. Some argue that Cerro Negro should be considered a long-lived polygenetic cinder cone, others a parasitic cone on Las Pilas-El Hoyo, and others a youthful stratovolcano in the first stages of development.

Gravity data were collected over two field seasons in 2012 and 2013 and when inverted using GROWTH software, rather than a spherical intrusive complex beneath Cerro Negro or Las Pilas, two tabular anomalies trending NW and NE were revealed, bracketing Cerro Negro between them. This studypresents preliminary analysis of this data and the subsequent possible implications for the interaction of tectonics and magma plumbing at Cerro Negro.

Background

First Cerro Negro eruption: 1850; Most recent eruption: 1999
23 eruptions total

Dominant Structural Trends:
Regional: NW Nicaraguan volcanic arc
Local: Rotating blocks along oblique subduction zone promote
NNW trending normal faults
NE trending strike-slip faults

Bouguer Gravity Survey

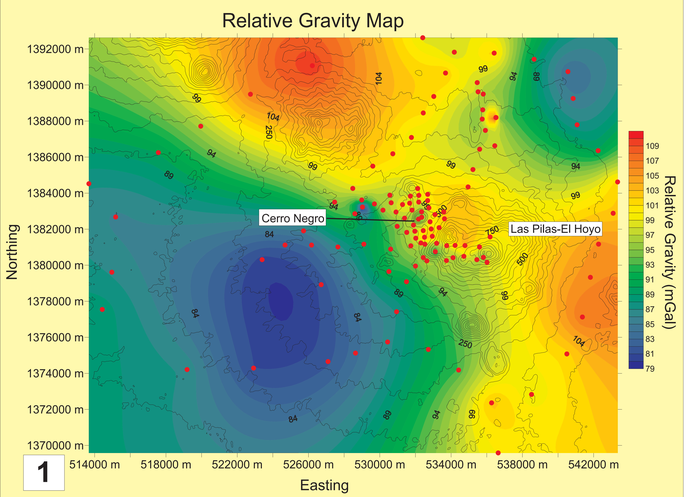
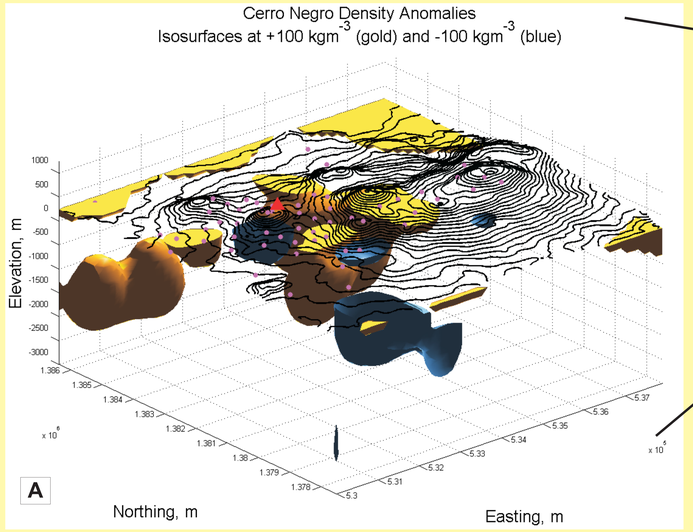
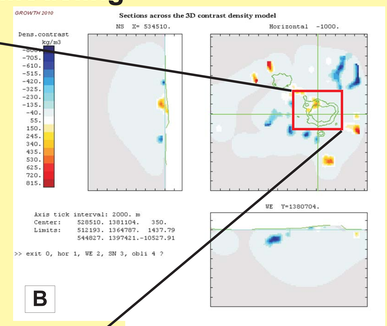


Figure 1: Map of relative gravity data used in inversions. Gravity data has been corrected for free air, Bouguer, Bullard, and terrrain. In total 118 stations (red dots) were measured, covering an area of approximately 660 km^2.

Inversion Results and Forward Modeling





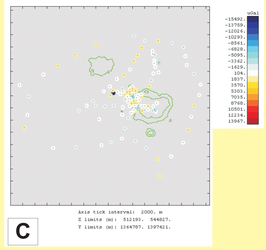


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Figure 2 (above left): Results of inversion of gravity data using GROWTH software (Camacho et al. 2011) **A)** 3-D visualization of density anomalies at Cerro Negro; location of Cerro Negro marked by red triangle, measurement locations by magenta dots. The main positive anomaly at Cerro Negro is composed of two vertical sheets, one trending NW and one trending NE. Small, shallow negative anomalies (volume ~ 2 x 10^7 m^3) correlate with cones and likely reflect either low density pyroclastic materials or topographic effects. **B)** Regional inversion with red box indicating area of 3-D visualization. **C)** Inversion residuals

NE Structural Trends?

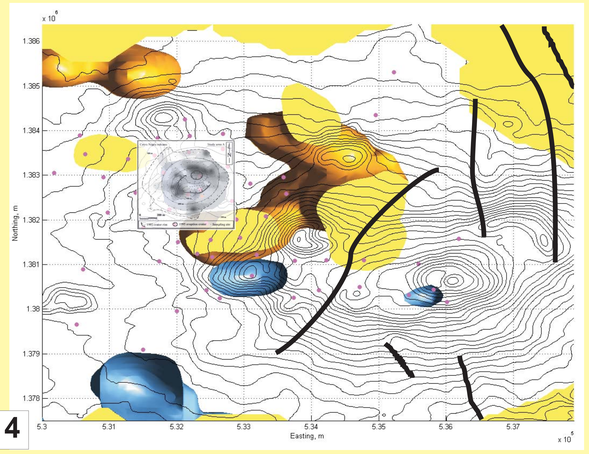

Figure 4 (left): Map view of density anomalies with same isosurfaces as Figure 2, overlaid with fault locations from La Femina et al. (2004), and a CO_2 soil gas study by Salazar et al. (2001). Note: NE trending fault on western flank of Las Pilas-El Hoyo, and NE trend of high CO_2 flux on cone of Cerro Negro.

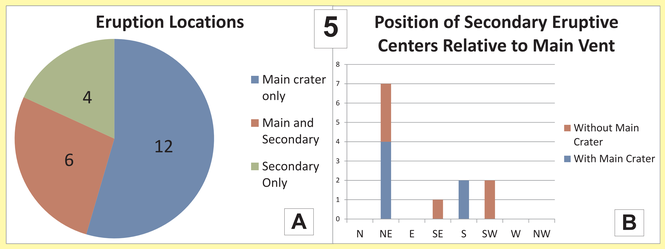

Figure 5 (left):

A) Secondary eruption locations are common at Cerro Negro - nearly half of its eruptions to date have included activity outside the main cone.

B) Over Cerro Negro's history, there have been 7 instances of eruptive activity located NE of the main cone, and 5 located to the S, SW, or SE.

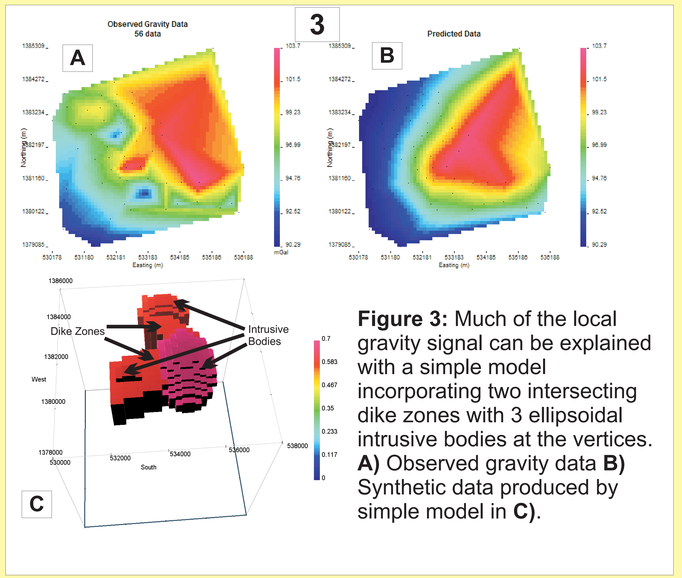

Figure 3: Much of the local gravity signal can be explained with a simple model incorporating two intersecting dike zones with 3 ellipsoidal intrusive bodies at the vertices. **A)** Observed gravity data **B)** Synthetic data produced by simple model in **C)**.

Remaining Questions

Why doesn't the density anomaly follow the NW trends apparent on the surface?

How does the density anomaly relate to the local stress regime?

How, if at all, is this anomaly related to Las Pilas El Hoyo?

How does Cerro Negro maintain such an open system (i.e., Frequent eruptions)?

Is this anomaly a transient feature over the lifespan of the Marabios Range?

Conclusions

Magma source at Cerro Negro consists of two dike zones with localized areas of upwelling

Total volume approximately 7 km^3

Volume of individual intrusive bodies approximately 1 to 4 km^3

Dike zone geometry may explain consistent eruptive activity on NE and S flanks of Cerro Negro

Geometry of magma plumbing center highlights intimate connection between volcanism and tectonics at Cerro Negro

References

La Femina, P.C., Connor, C.B., Hill, B.E., Strauch, W., and Saballos, J.A., 2004, Magma–tectonic interactions in Nicaragua: the 1999 seismic swarm and eruption of Cerro Negro volcano: *Journal of Volcanology and Geothermal Research*, v. 137, no. 1-3, p. 187–199, doi: 10.1016/j.jvolgeores.2004.05.006.

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