Estudios de Gravimetría y Geodesia en el volcán Concepción, Nicaragua

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¿Por qué nos debe importar el volcán Concepción?

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- Es el volcán más difícil de ser evacuado en Nicaragua.
- En las últimas décadas su actividad es pequeña a moderada, pero su registro estratigráfico revela episodios de extrema violencia explosiva.

Objetivos de esta Investigación

- **Estudiar la estructura del edificio volcánico y sus alrededores a través de mediciones de gravedad relativas.**

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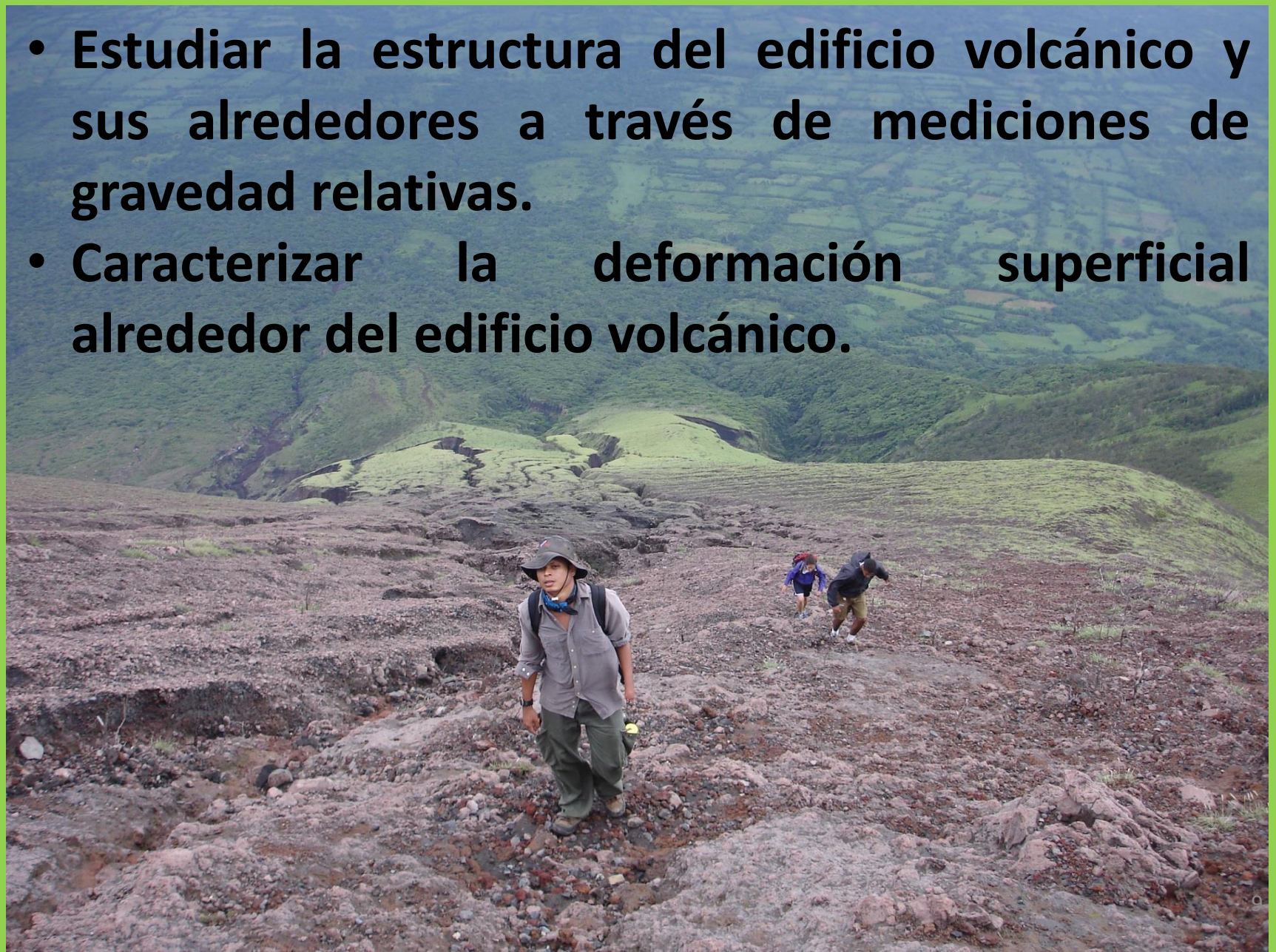
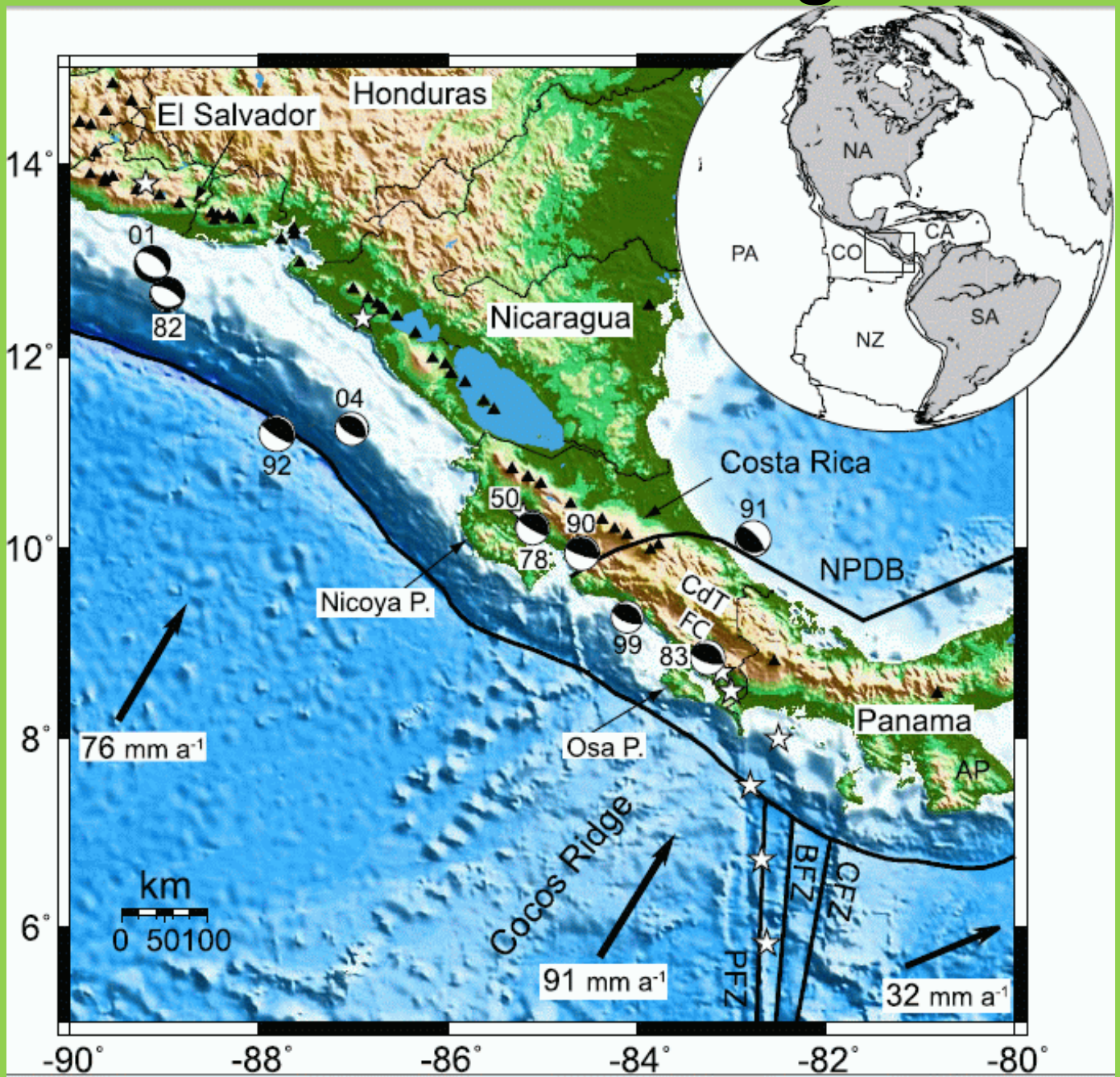
- **Caracterizar la deformación superficial alrededor del edificio volcánico.**

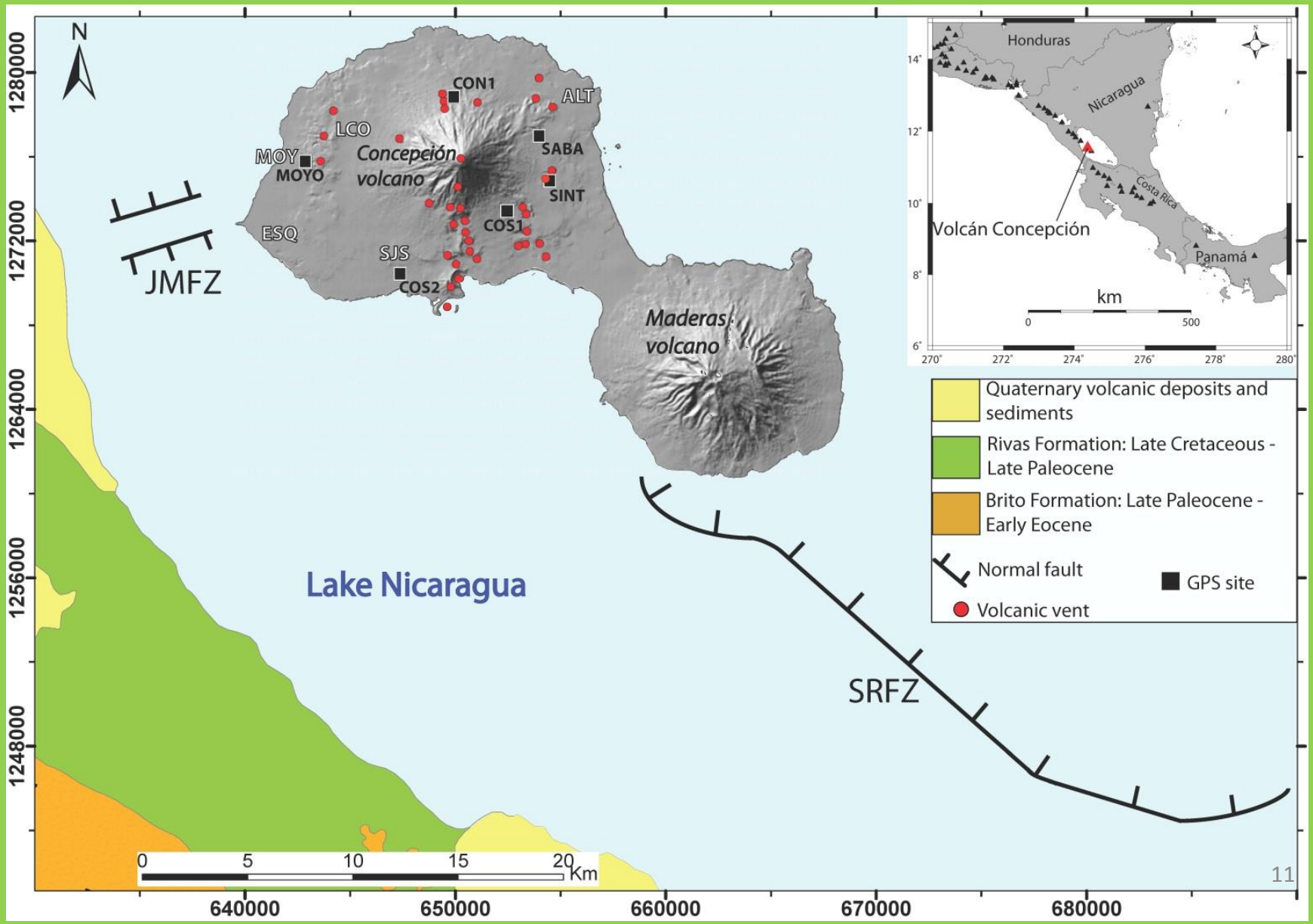


Marco Tectónico Regional

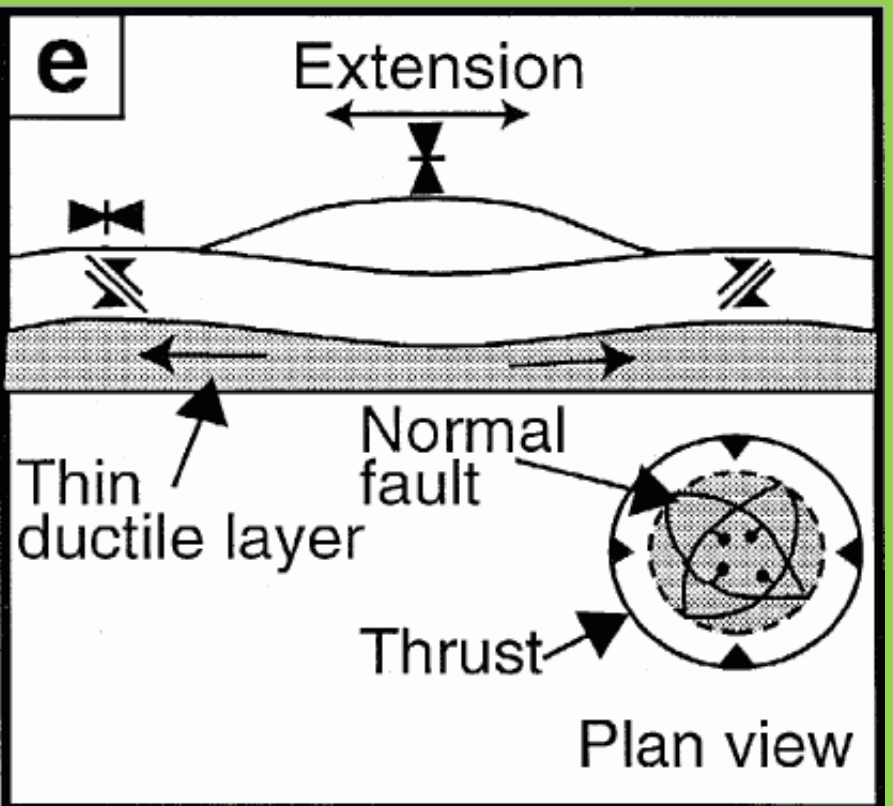


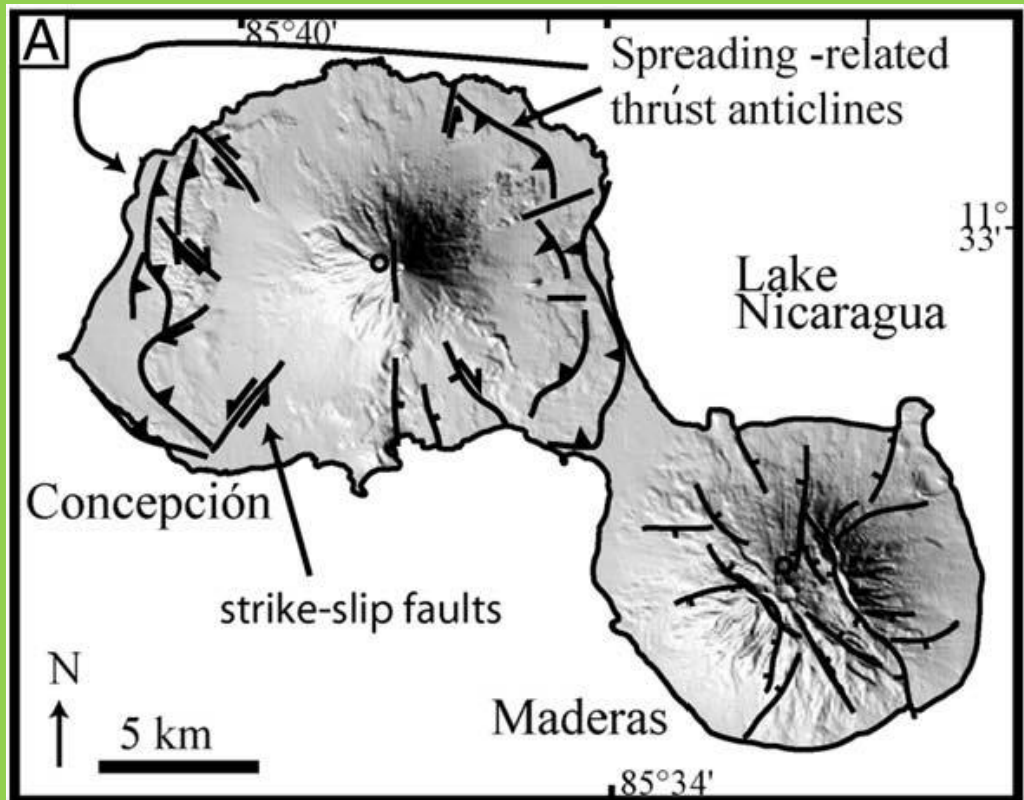
From La Femina et al., 2009

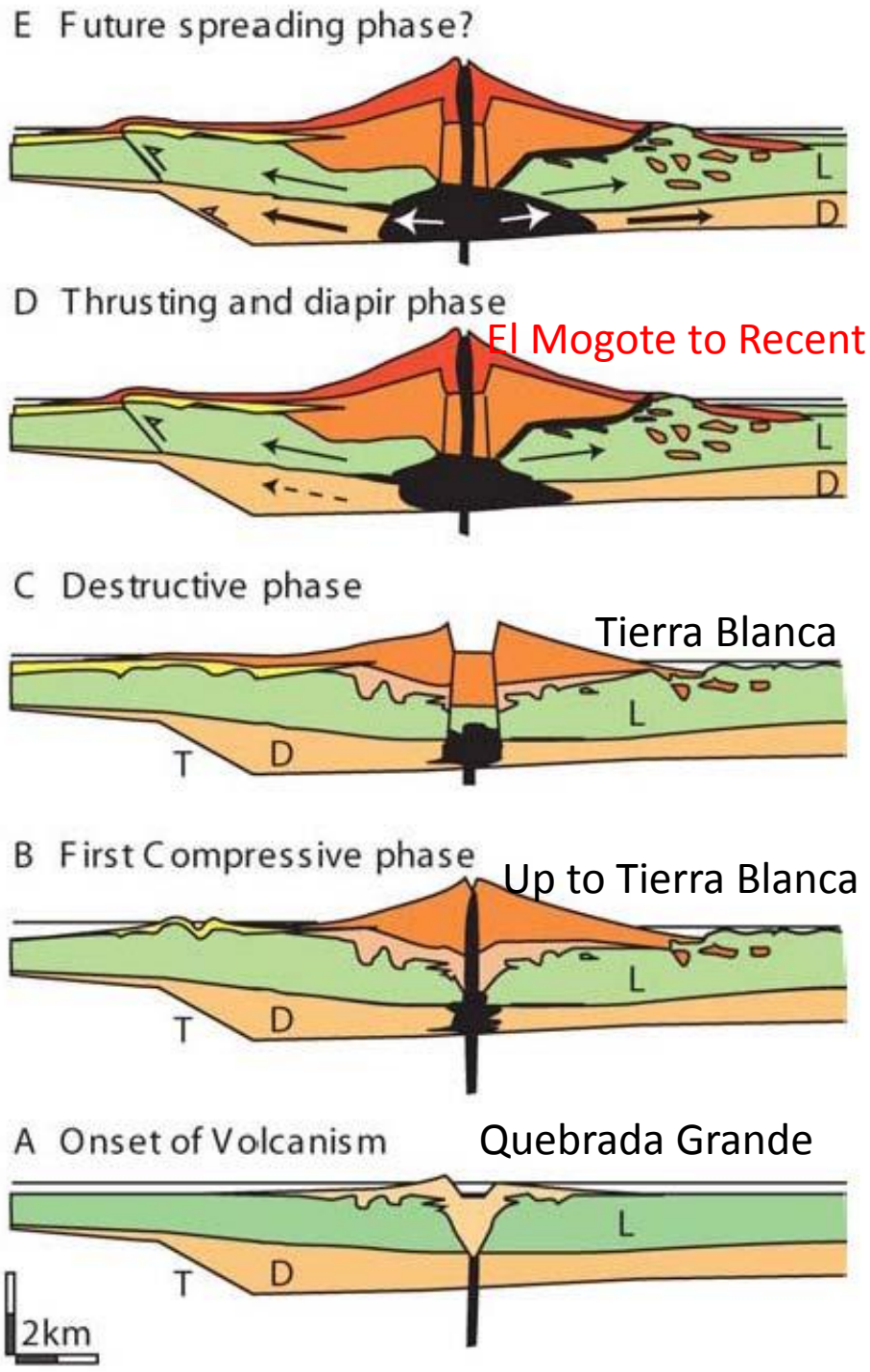
Simplificación de la Geología



Modelo Simplificado de Expansión Gravitacional Propuesto para el Volcán Concepción por otros autores, e.g., Borgia et al., 2000; Borgia and van Wyk de Vries, 2003; Delcamp et al., 2008, etc…







Evolución magmática y estructural del volcán Concepción de acuerdo a Borgia & van Wyk de Vries, 2003.

¿Está el volcán Concepción verdaderamente expandiendose por la acción de la gravedad?

Campañas gravimétricas entre el 2007 & 2010

La Sabana

San José del Sur

Urbaite

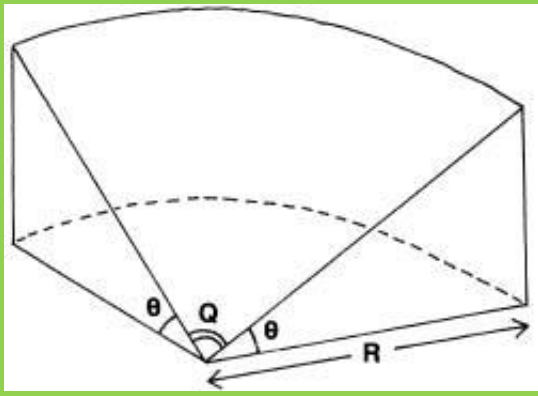
Se usó un Burris B38. Errores de cierre fueron < 1mGal.

Tratamiento de los datos de Gravedad

- Se utilizó el método estándar el cual consiste corregir los datos crudos por efectos de la marea de la Tierra sólida (SET), deriva instrumental, latitud geográfica, aire libre, la plancha de Bouguer, la capa terrestre esférica, y la topografía del terreno.
- La corrección topográfica se hizo en 3 etápas: cercana (53.3 m), intermedia (>53.3 m – 9903 m), y lejana (>9903 m).

Corrección Topográfica

- 1) La corrección topográfica interna se hizo hasta la zona C de Hammer (53.3 m, Hammer (1939)) usando el método del cuarto de cuña mejorado por (Nowell, 1999):

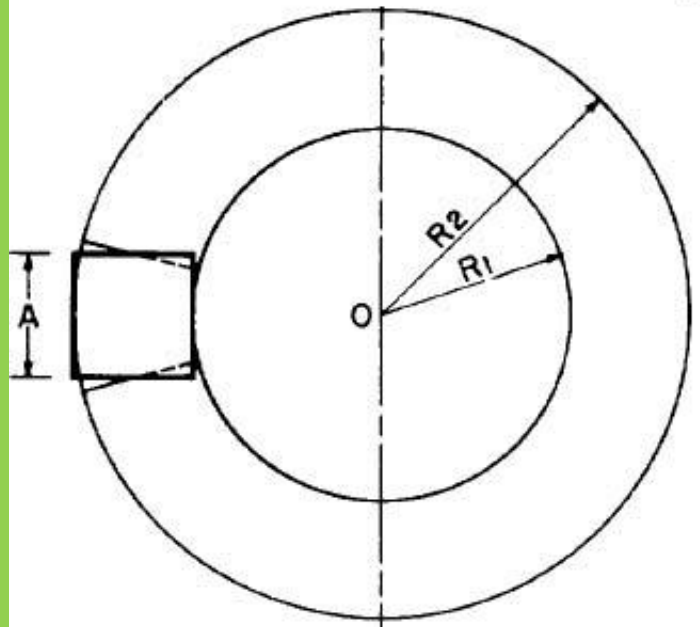


$$g = 2\pi G\rho R(1 - \cos\theta)$$

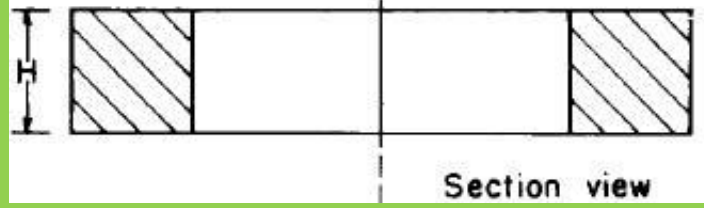
Corrección Topográfica, *cont…*

- 2) La corrección topográfica intermedia se llevó a cabo de la zona D de Hammer (>53.3 m, Hammer (1939)) hasta el radio externo de la zona K de Hammer utilizando el método de Kane (1962), el cual representa los prismas topográficos como anillos anulares.

$$g = \frac{GDA(1.26A + \sqrt{(R - 0.63A)^2 + H^2} - \sqrt{(R + 0.63A)^2 + H^2})}{1.26R}$$



Plan view



Section view

g: atracción gravitatoria.
G: constante gravitacional.
D: densidad del terreno.
A: longitud horizonatl de un lado del prisma.
R: distancia entre la estación de gravedad y al centro del prisma topográfico.
H: altura del prisma o anillo.

Corrección Topográfica, *cont…*

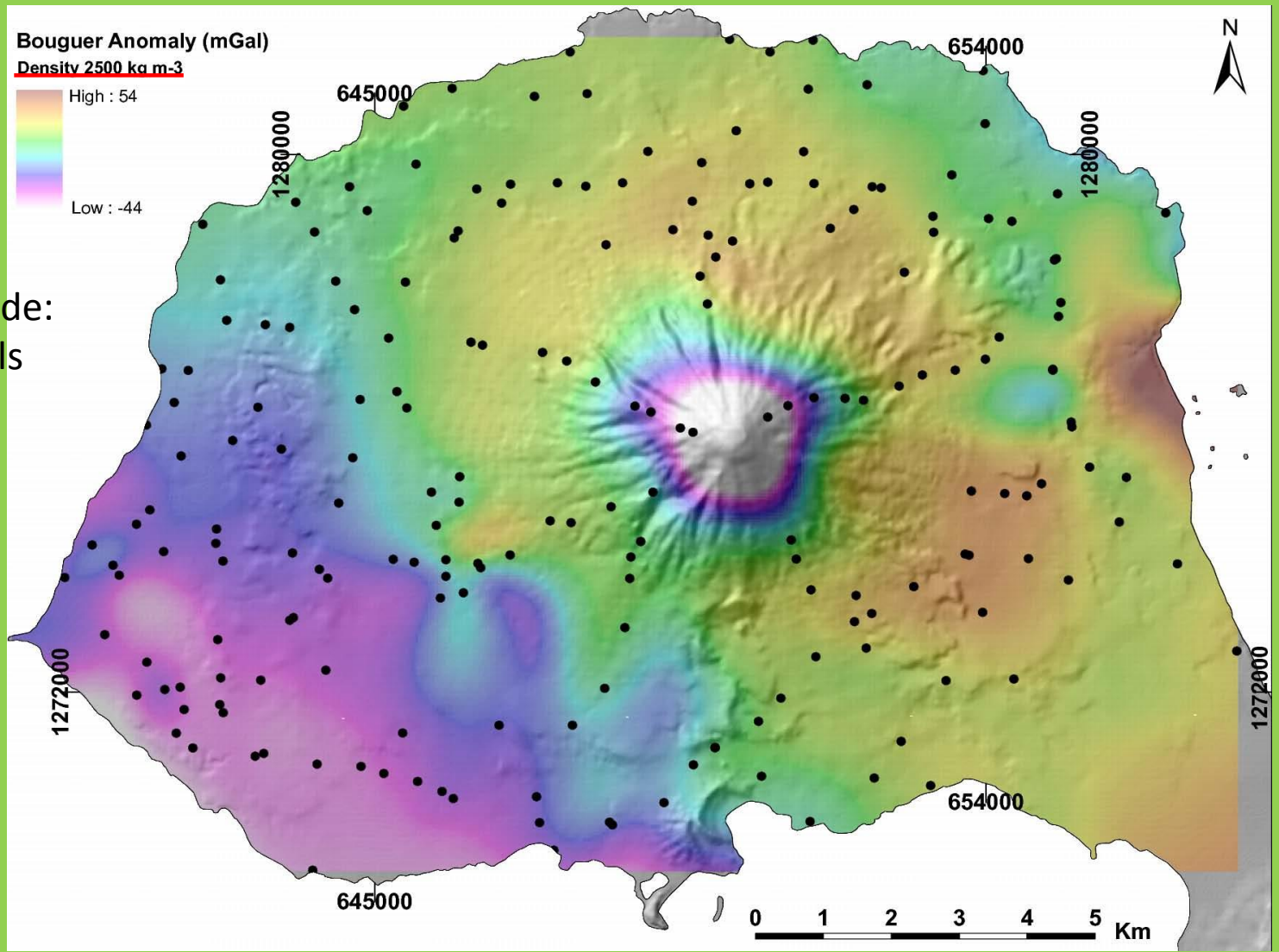
- 3) La corrección topográfica lejana se llevó a cabo para distancias mayores a la la zona K de Hammer (>9903 m, Hammer (1939)). Para esto se utilizó la aproximación de la línea de masa vertical descrita por Blais y Ferland (1984):

$$g = G(rho)s(1/d - 1/d')$$

G: constante gravitacional.
rho: densidad del terreno.
s: área de la sección transversal.
d: distancia horizontal entre
la estación de gravedad y
el centro del prisma.
d´: distancia entre la estación
y la parte superior del prisma .

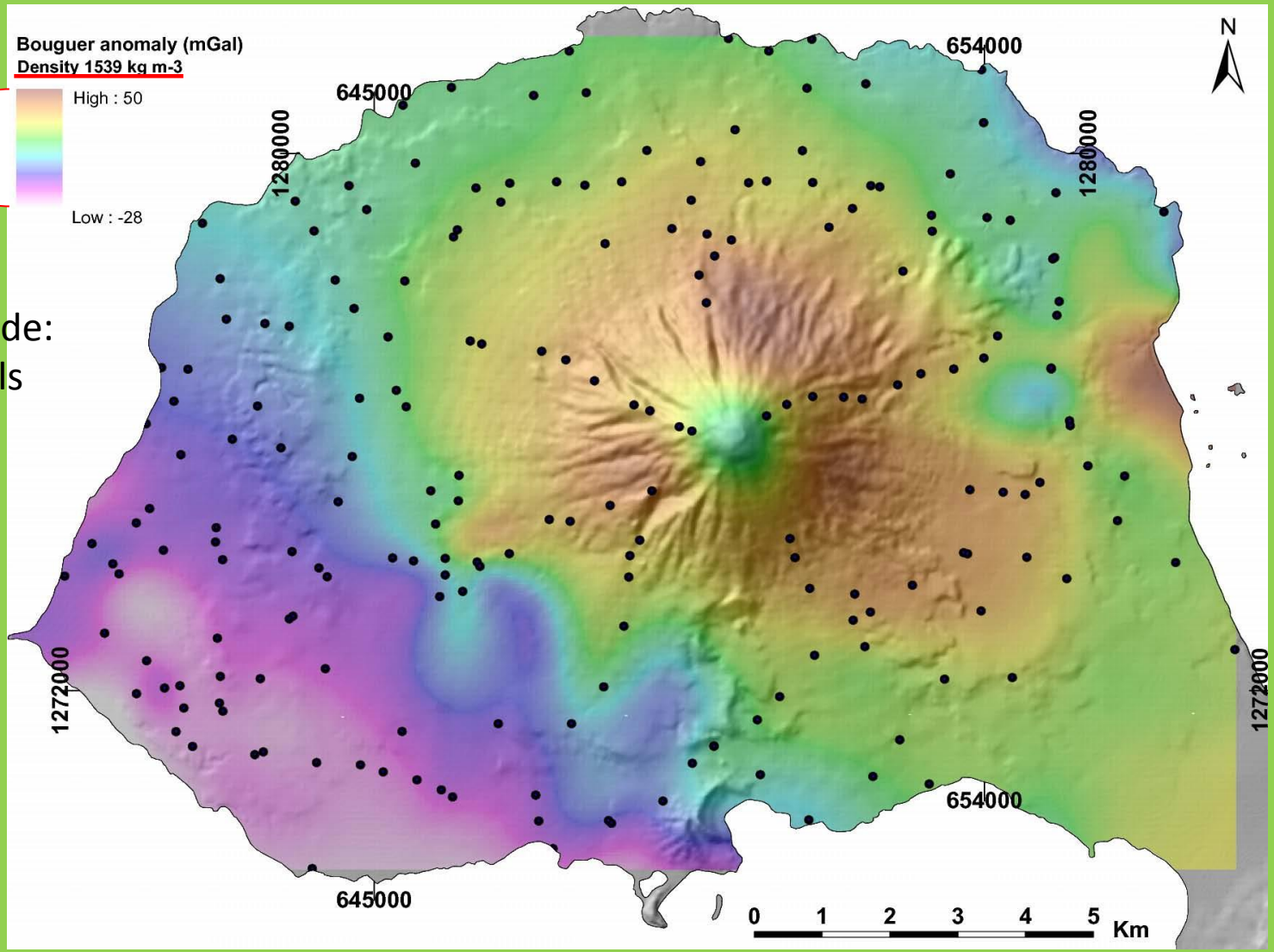
What is the bulk average density of Concepción?

Previous studies assumptions, and Bouguer anomaly map



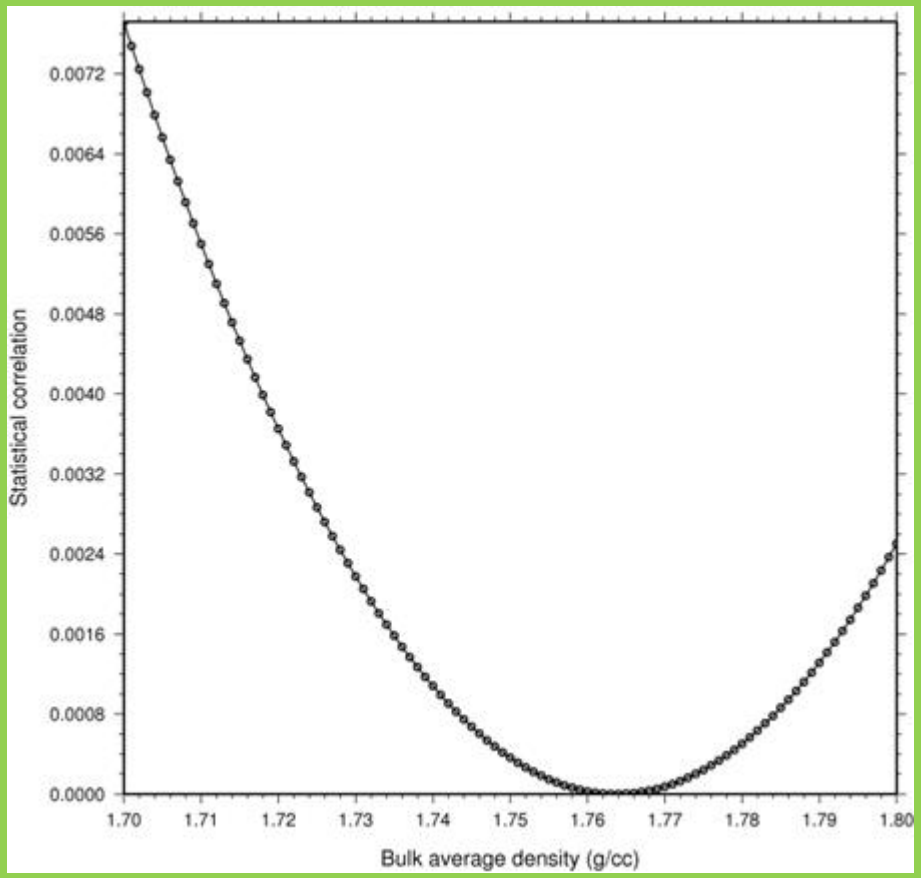
Amplitude:
94 mGals

Density by Nettleton's & Parasnis'methods, Bouguer anomaly map



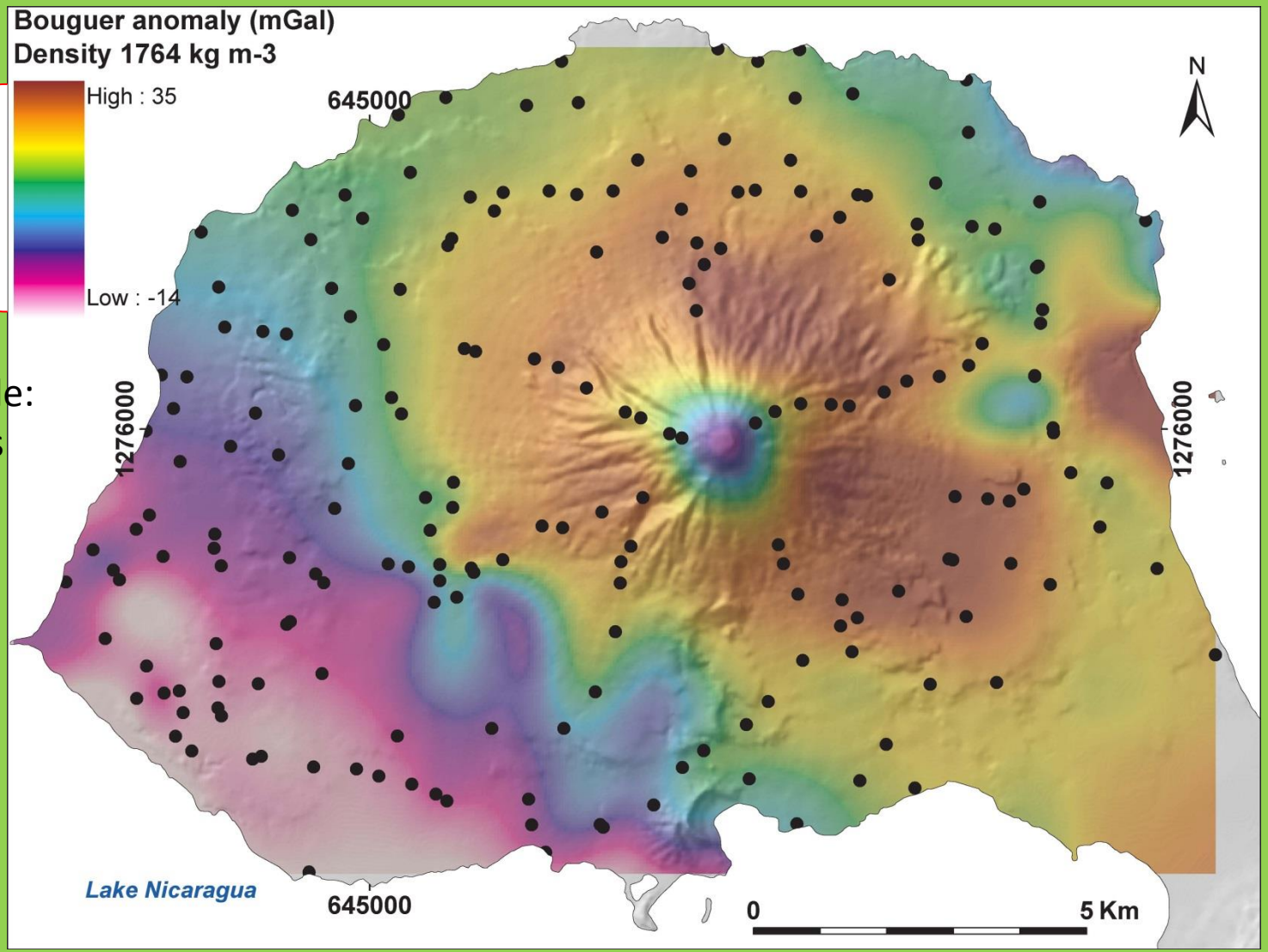
Amplitude:
78 mGals

Results: Gravity – Bulk average volcano density from this study

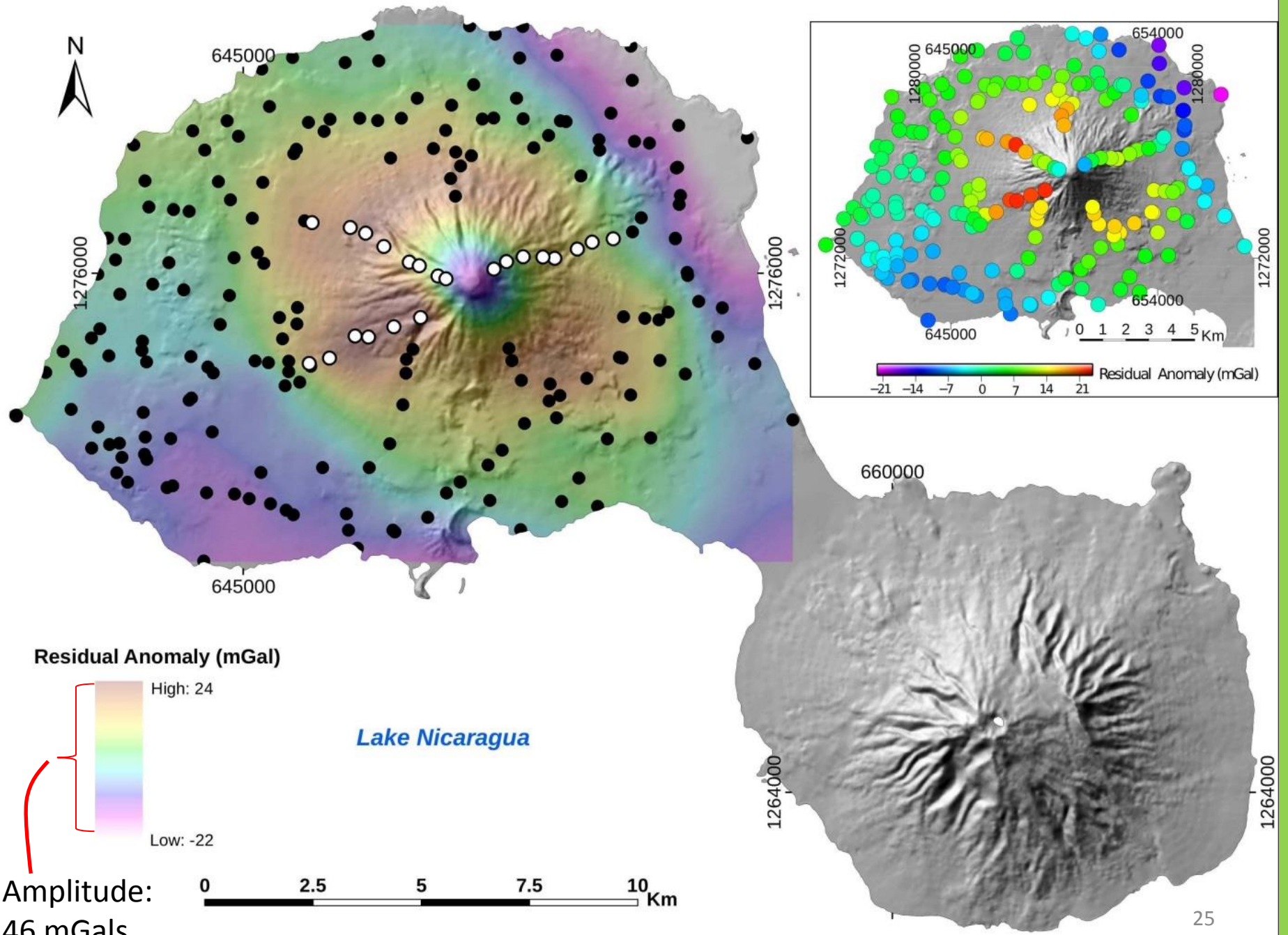


Extending Parasnis' method to 2-D.
Best value is 1764 ± 111 kg m^{-3}

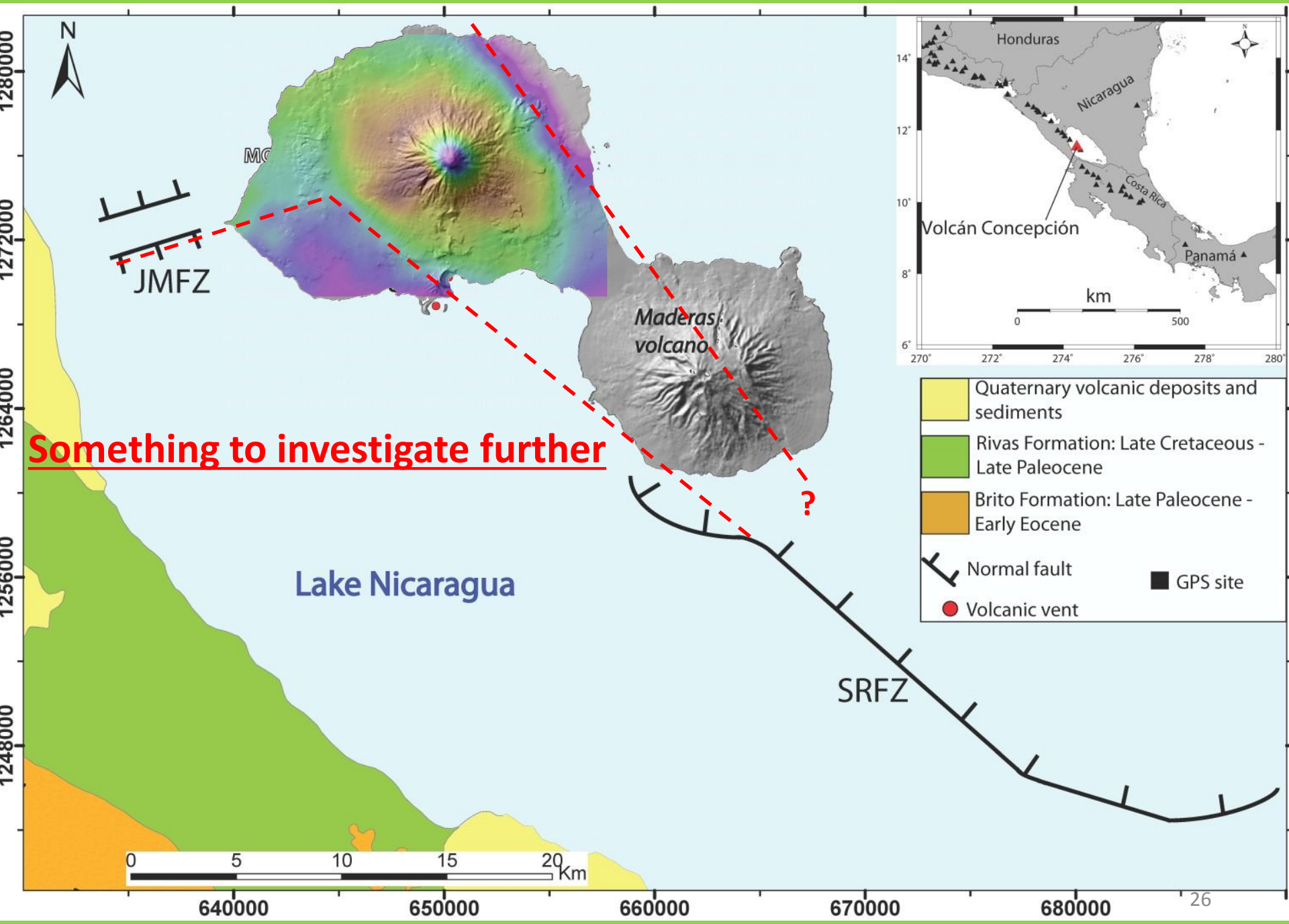
Density from this study



Amplitude:
49 mGals



Amplitude:
46 mGals



Something to investigate further

3-D inversion of gravity data with GROWTH2.0

- GROWTH2.0 (Camacho et al., 2011) is a non-linear inversion model to look for the geometrical properties of the anomalous bodies that best fit the gravity observations.
- Density contrast range is given by the user.
- The 3-D subsurface is initially divided up into small prismatic bodies that may grow during the inversion.
- The gravity data can be unevenly spaced.

Results of the 3-D inversion

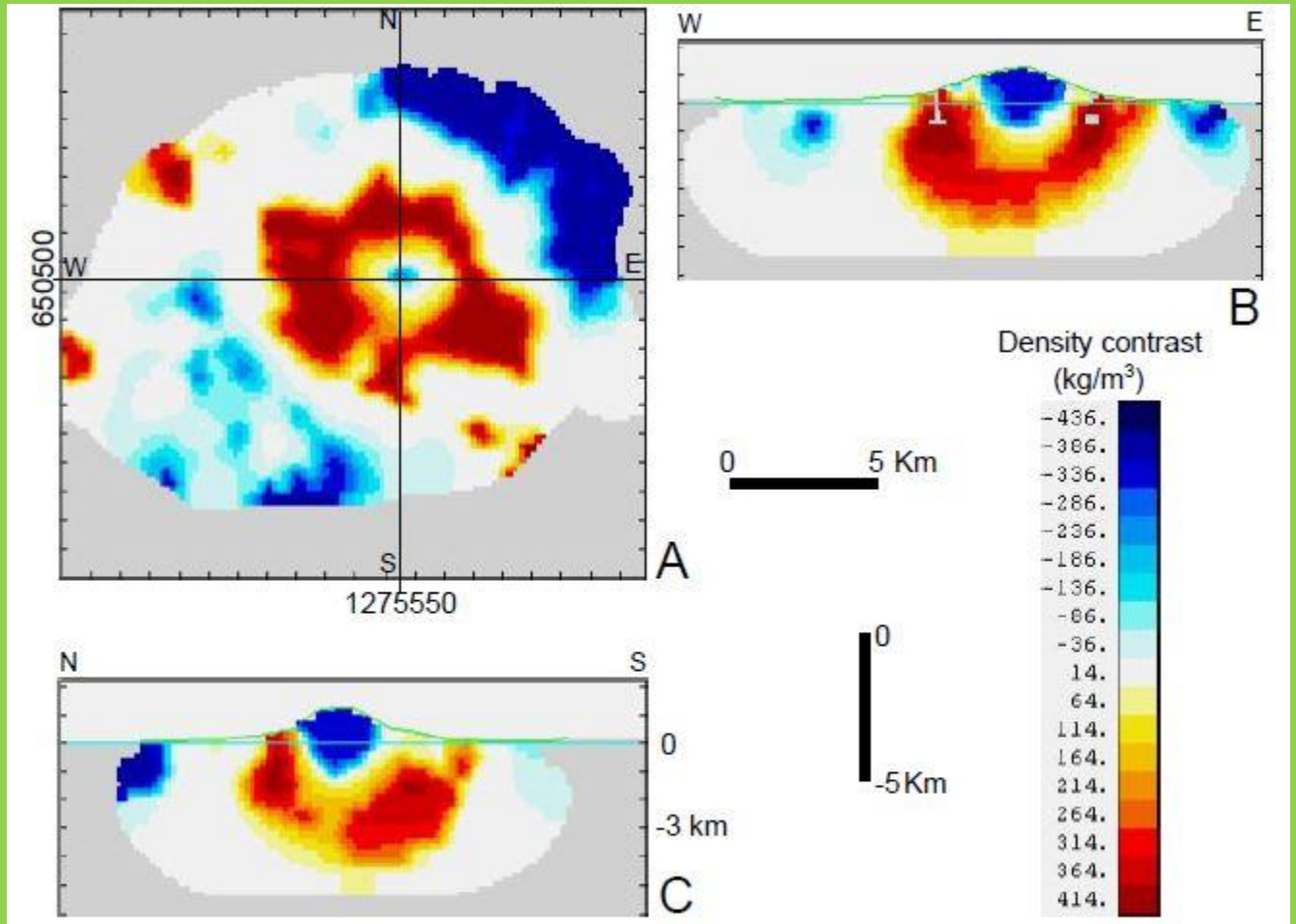


Figure 2.3. 3-D inversion of the gravity data shown in Figure 2.2 using the GROWTH2.0 model developed by Camacho et al., (2011). The input parameters used in the modeling correspond to the first set of parameters summarized in Table 2.1. (A) Structural density map at 1 km depth (-1000 m) of Concepción volcano and its surroundings. (B) East-West cross-section of structural density map. (C) North-South cross-section of structural density map.

Results of the 3-D inversion, *cont.*

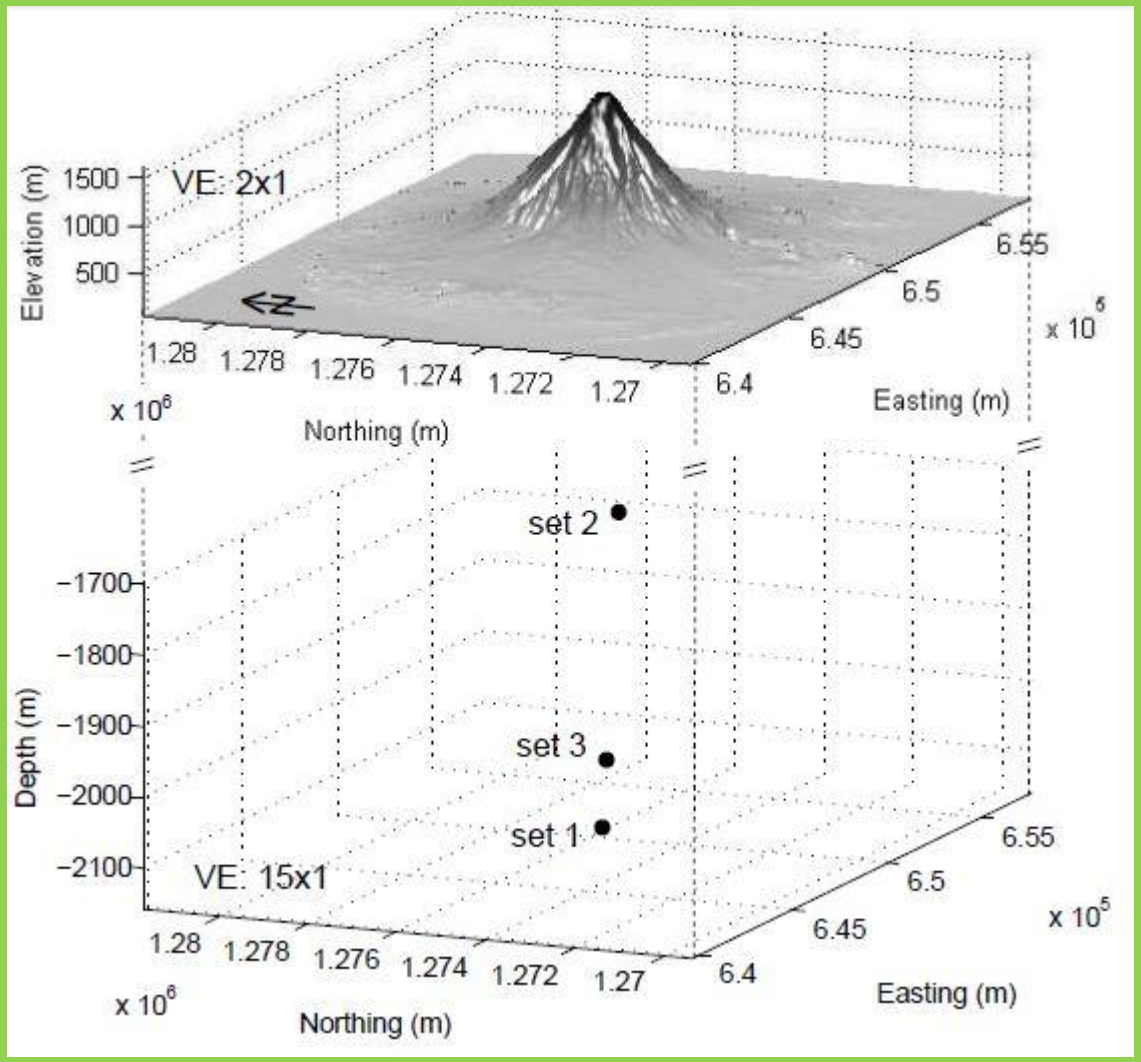
Table 2.2. List of output parameters from GROWTH2.0 (Camacho et al., 2011) using as input the data shown in Table 2.1.

Set	Model fitted DC[a] (kg/m^3)	Balance factor, λ[b]	Auto-correlation[c]	TA mass[d] (x 10^{14} kg)
1	-440 – 410	36	-0.05	1.16
2	-440 – 410	44	0.05	1.02
3	-370 – 310	36	-0.05	1.16

Location of center of total anomalous mass[e]			
Set	Easting (m) (m)	Northing (m) (m)	Depth (m)
1	650900	1276129	-2159
2	650010	1275368	-1697
3	650600	1275880	-2057

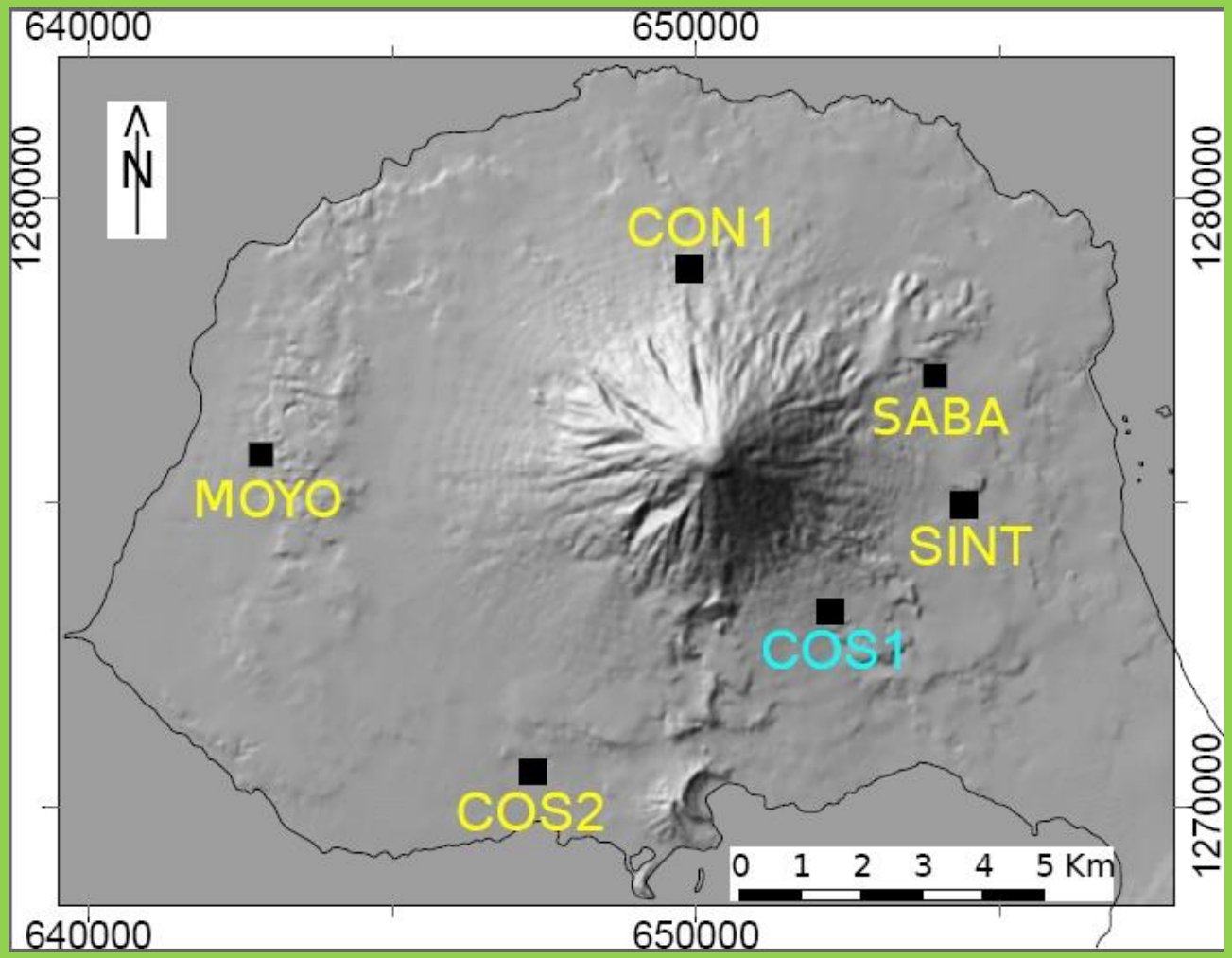
[a]Density contrast range fitted by the model.
[b]Optimal value of the balance factor found by the model.
[c]See text for explanation.
[d]Total Anomalous mass, i.e., cumulative of excess and deficit masses.
[e]The center of mass is virtually located below the volcano whose crater location is at 650500 (Easting), and 1275550 (Northing), see Figure 2.4.

Results of the 3-D inversion, *cont.*

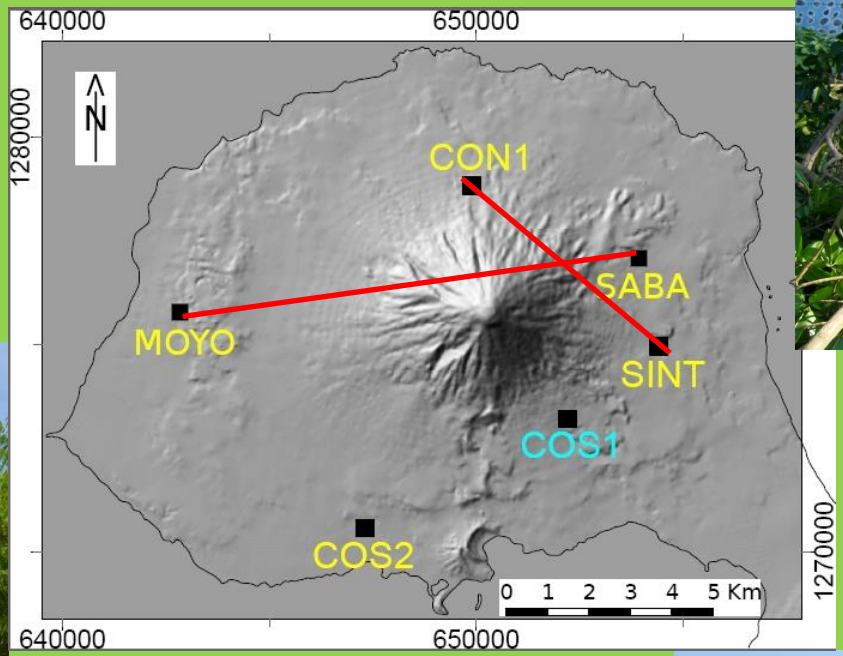


Solid circles represents the location center of anomalous mass obtained from GROWTH2.0, it is confined between 1.7 to 2.2 km depth. The total anomalous mass across the study area is ~$1x10^{14}$ Kg, total volcano mass is ~$0.4x10^{14}$ Kg.

Let’s switch to GPS data now



GPS measurements



Sintiope

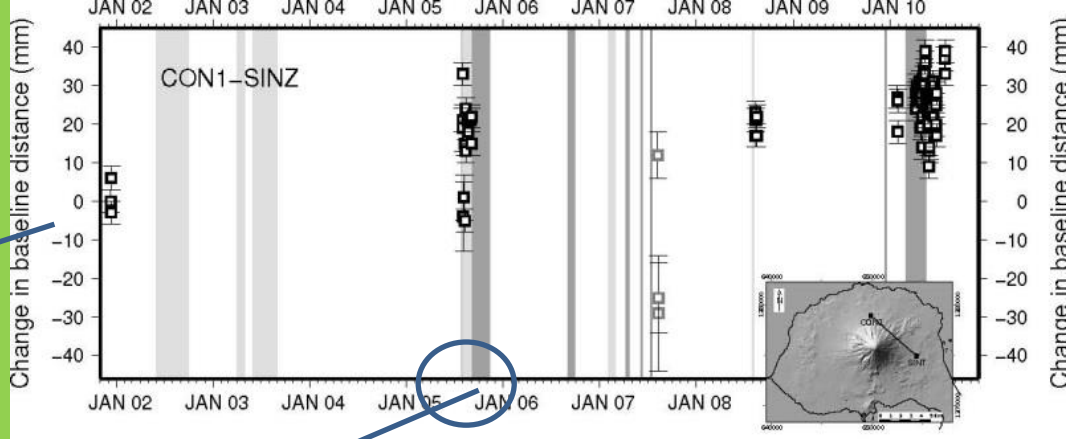
San José del Sur

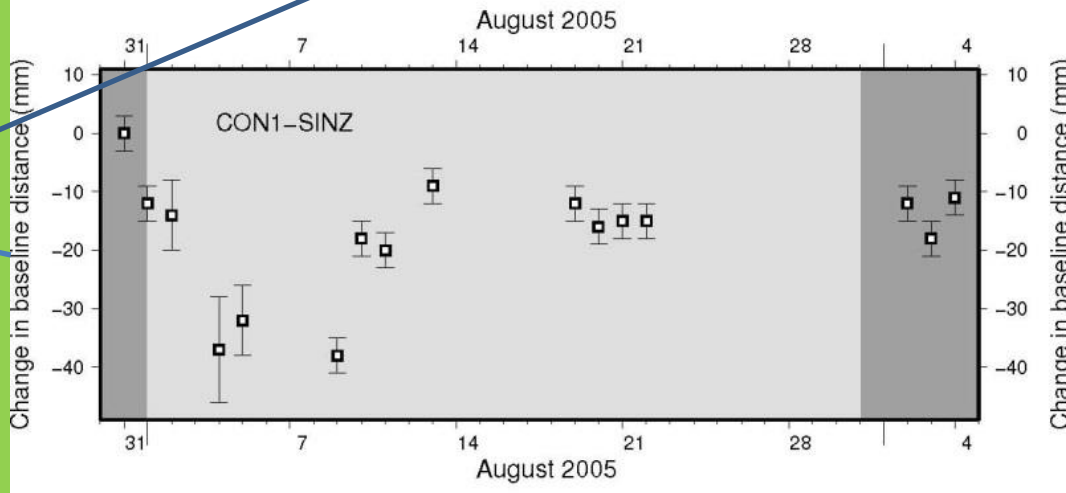
Results: Change in baseline length from GPS

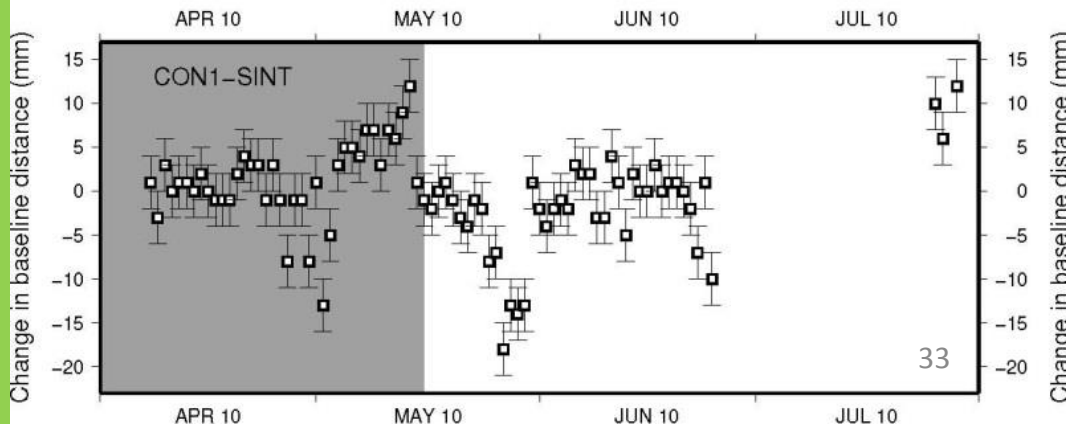
Longest time series, 8.6 yr. No significant change in average

Zoom of 2005 campaign. Main shock on August 3 was Mw 6.3 Scattering during a single campaign can be up to 4 cm, which seems to be non-random

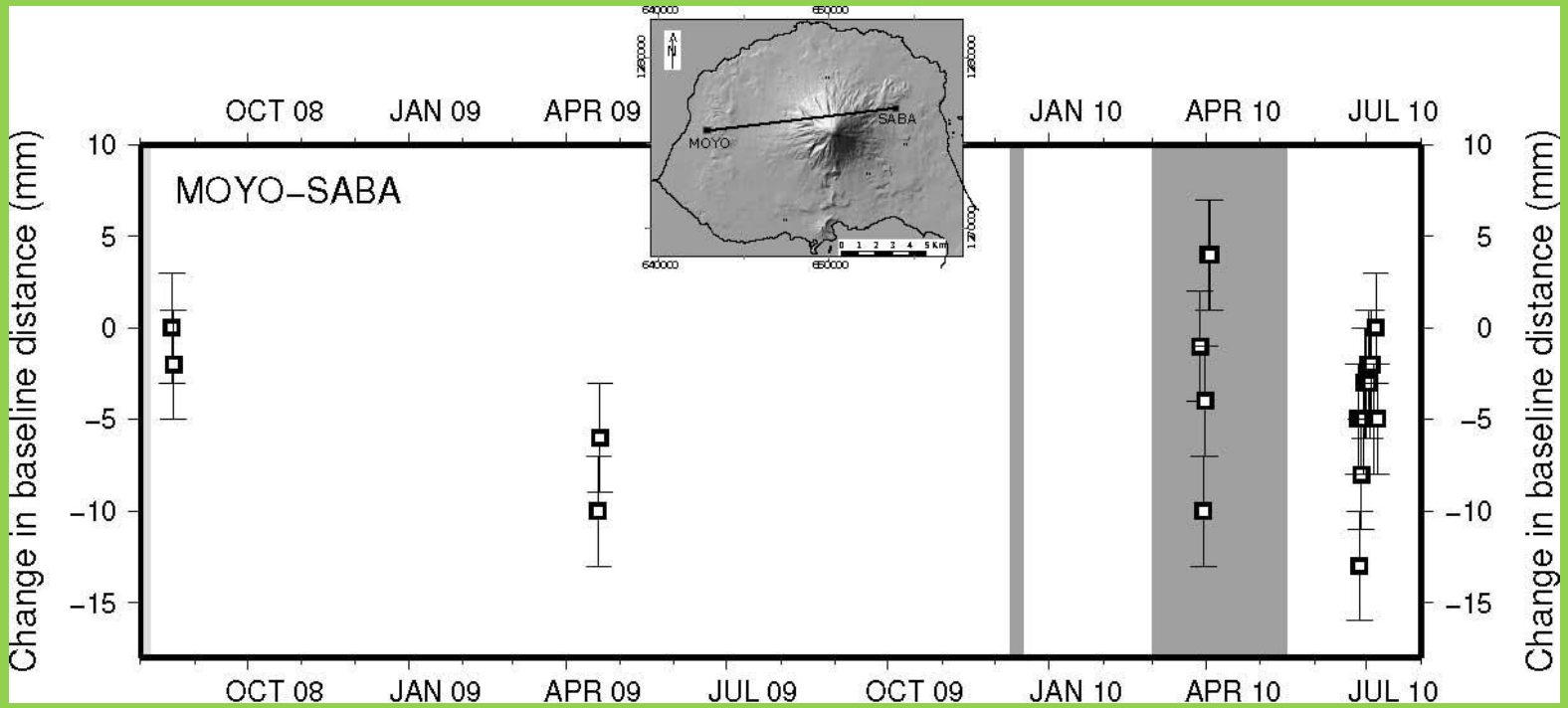
Zoom of 2010 campaign. More analysis later.







Results: MOYO-SABA baseline changes



Conclusions

- The average bulk density of Concepción volcano is much lower than previously thought, 1764 ± 111 kg/m^3, comparable to unconsolidated sediments.
- The upper part of the cone is composed of lighter material than the lower part.
- A possible normal fault was found NE of the volcano running parallel to the subduction zone, which may be related to regional tectonics, important for seismic hazards.
- No evidence of continuous gravitational spreading (previously proposed to be ~2-2.5 cm/yr), but it could be episodic.
- Scattering in the GPS baseline changes seems to be related to recoverable deformation and may be as large as 4 cm in a matter of days to weeks during volcanic activity.

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¡ GRACIAS !
2010/04/15 15:46