Surface expressions of lithosphere removal below the Sierra Nevada de Santa Marta, Colombia

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1. Introduction

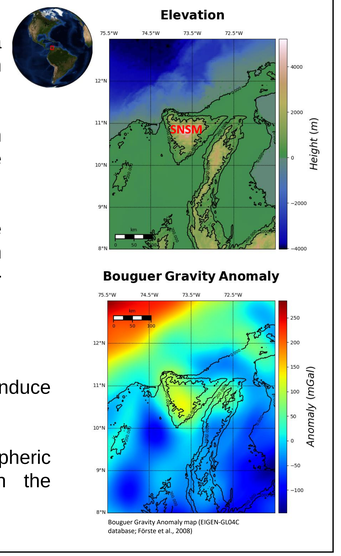
The *Sierra Nevada de Santa Marta* (SNSM) is a mountain in NW South America with maximum height of ±5.8km.

The Bouguer gravity anomaly map in the region shows a maximum value of ± 150mGal over the mountain.

This gravity anomaly can be explained if the region is out of isostatic balance and has a thin crust. However, the cause of the isostatic non-equilibrium of this high mountain is debated.

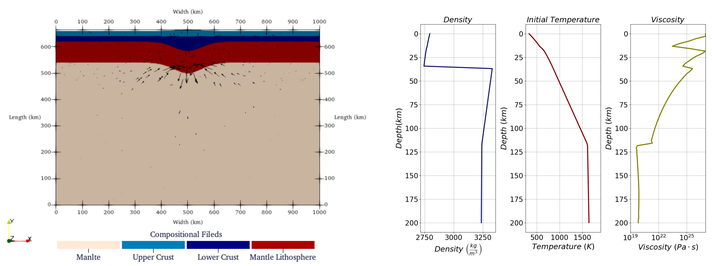
Purpose:

- Determine if lithospheric dripping can induce surface uplift together with crustal thinning.
- Identify if the dynamics caused by lithospheric dripping can hold high topographies in the presence of regional compression.



Bouguer Gravity Anomaly map (EIGEN-GL04C database; Förste et al., 2008)

2. Method



ASPECT 2.2 is used to compute 2D numerical models (Bangerth W. et al., 2020).

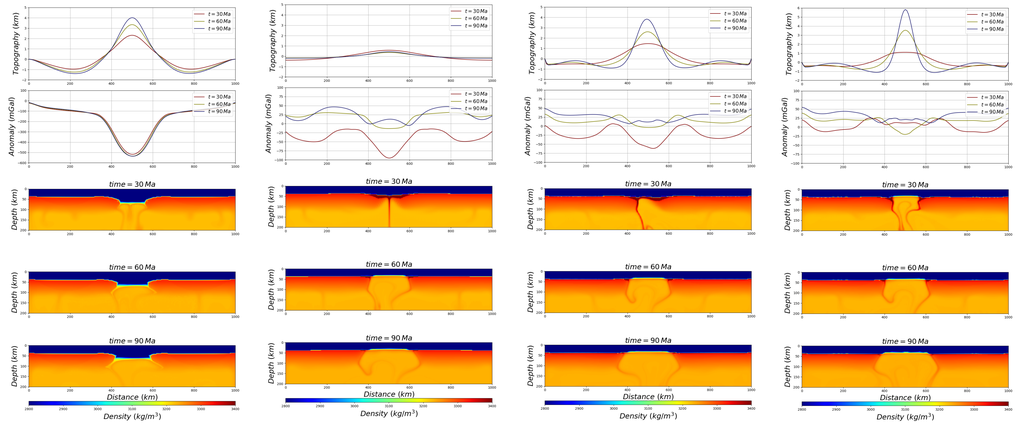
The material parameters and model setup is standard for the lithosphere and upper mantle.

Parameter	Value
Reference specific heat	$1250.0\frac{m^2}{s^2 K}$
Thermal conductivity	$2.25\frac{W}{mK}$
Thermal expansion coefficient	$3.5 \times 10^{-5}\frac{1}{K}$

The region below the mountain has wet rheologies.

	Compositional Field	Reference density ρ (kg/m^3)	Heat production (W/m^3)	Rheology
	Upper crust	2800	1.0×10^{-6}	Wet Quartzite (Gleason and Tullis, 1995)
	Lower crust	2800	0.4×10^{-6}	Dry Maryland diabase (Mackwell et al, 1998)
	Mantle lithosphere	3400	0.0×10^{-6}	Dry Olivine (Karato and Wu, 1993)
	Mantle	3400	0.0×10^{-6}	Wet Olivine (Karato and Wu, 1993)

3. Results

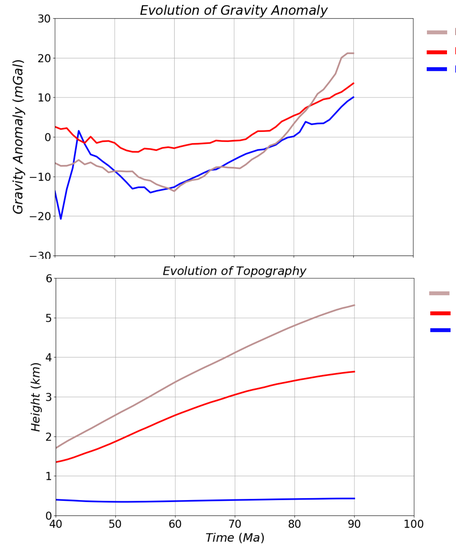


Model 1:
Initially thickened lithosphere (+40km) assuming previous shortening.

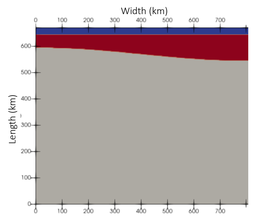
Model 2:
As Model 1 but a phase change to eclogite is added when *T>850K* and *P>1.2GPa*.

Model 3:
As Model 2 but a net compression velocity of 0.1 mm/yr is at the lateral boundaries.

Model 4:
As Model 3 but The lower crust below the mountain is 10x weaker.

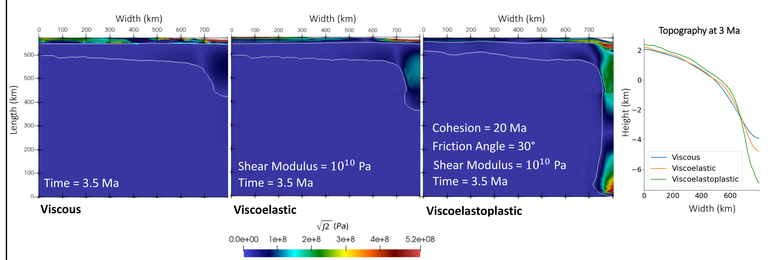


4. Elasticity Tests



	Compositional Field	Density ρ (kg/m^3)	Viscosity (Pa s)
	Crust	2900	1.0×10^{25}
	Mantle lithosphere	3300	1.0×10^{21}
	Mantle	3100	1.0×10^{20}

- Simple tests of elasticity in drip models.
- Models use constant densities and viscosities
- Sinusoidal Raileigh-Taylor instability drip



- When elasticity is present the stresses tend to concentrate above the drip
- In models with elasticity the effective viscosity is lower than the original viscosity, and hence the drip occurs faster

5. Conclusions

- The final magnitude of the gravity anomaly above the mountain is the result of the competing effects of crustal thinning and lithospheric mantle removal.
- Eclogite dripping and the subsequent convection-induced crustal thinning can produce the formation of a mountain out of isostatic equilibrium (without crustal root).
- In the presence of regional compression the mantle dynamics after the drip can hold high topographies out of isostatic balance.
- Elastic effects can speed up the drip dynamics and can localize stresses in the region above the drip (Mountain zone).

Future Work

- Investigate the role of elasticity in this dynamics.
- Evaluate and study the role of tectonics in this specific setting.
- Extend the models to 3D.

6. References

Wolfgang Bangerth, Juliane Dannberg, Rene Gassmoeller, & Timo Heister. (2020). ASPECT v2.2.0. (version v2.2.0). Zenodo. https://doi.org/10.5281/ZENODO.3924604.

Förste, C., Schmidt, R., Stubenvoll, R., Flechtner, F., Meyer, U., König, R., & Loyer, S. (2008). The GeoForschungsZentrum Potsdam/Groupe de Recherche de Geodesie Spatiale satellite-only and combined gravity field models: EIGEN-GL04S1 and EIGEN-GL04C. Journal of Geodesy, 82(6), 331-346.