Geodynamic constraints of Canarian volcanism

Joan Marti and Adelina Geyer
Group of Volcanology, SIMGEO (UB-CSIC)
Institute of Earth Sciences Jaume Almera, CSIC
Barcelona, Spain

OBJECTIVES

- We propose to investigate the relationship between tectonism and volcanism in the Canary Islands froma regional to a local scale, trying to characterise the structural controls on magma evolution and eruption.

- We will develop a set of numerical and experimental models to investigate the influence of the stress field on the distribution of volcanism in the studies area at different scales

- In this contribution we investigate the geodynamic framework of Canarian volcanism, developing a 2D finite element model of the current distribution of regional stresses.

- We discuss the structural controls of the Canarian volcanism, and propose that understanding the interplay between volcanism and geodynamics is an effective way to forecast future volcanic activity.

METHODOLOGY

- the computational domain considered comprises between the 18N and 44N parallel and the 50W and 2E meridian

- The numerical procedure is based on the finite element technique, with 2-D linear elastic elements in a plane stress approximation

- We have modelled the area as a mosaic of poorly deformable zones (“blocks”) (Fig.2 I-VII), separated by highly deformable narrow “decoupling zones”, where most deformation is accommodated

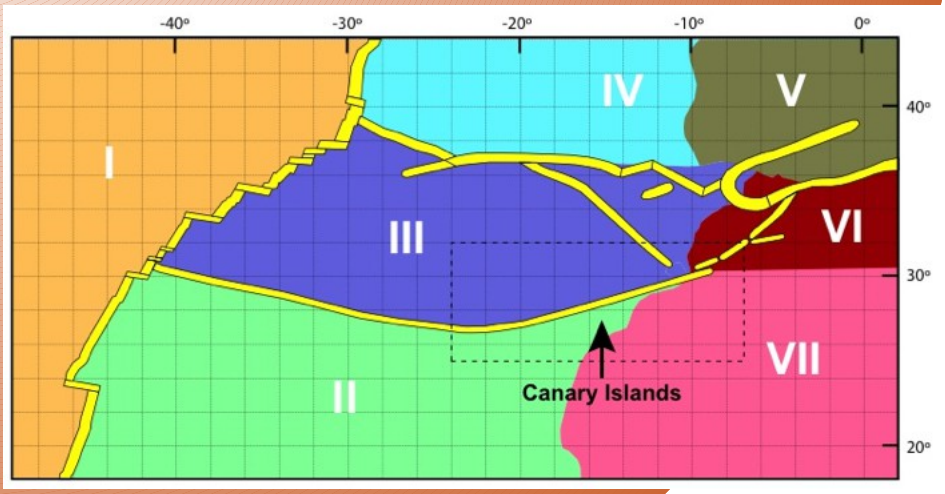
- The nature (compressional, extensional or transcurrent) and geometry of the ``decoupling zones'' have been extracted from previous studies describing the kinematics and neotectonics of the area

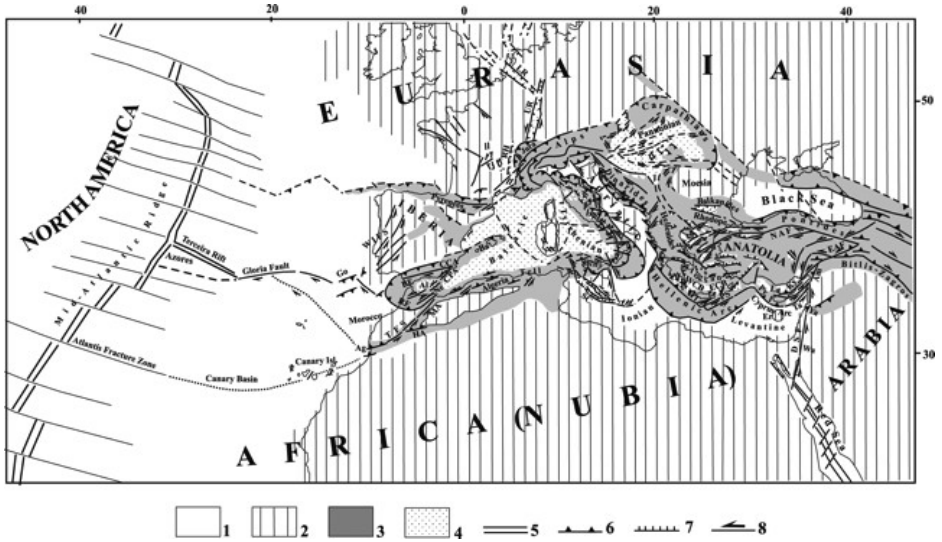
- To be able to introduce all input data in COMSOL Multiphysics software we have transformed the available information given in geographic coordinates into a Cartesian x-y coordinate system with meters and not degrees as measurement units. For this we have applied a Lambert Conformal Conic projection (LCC) with horizontal datum WGS84 .

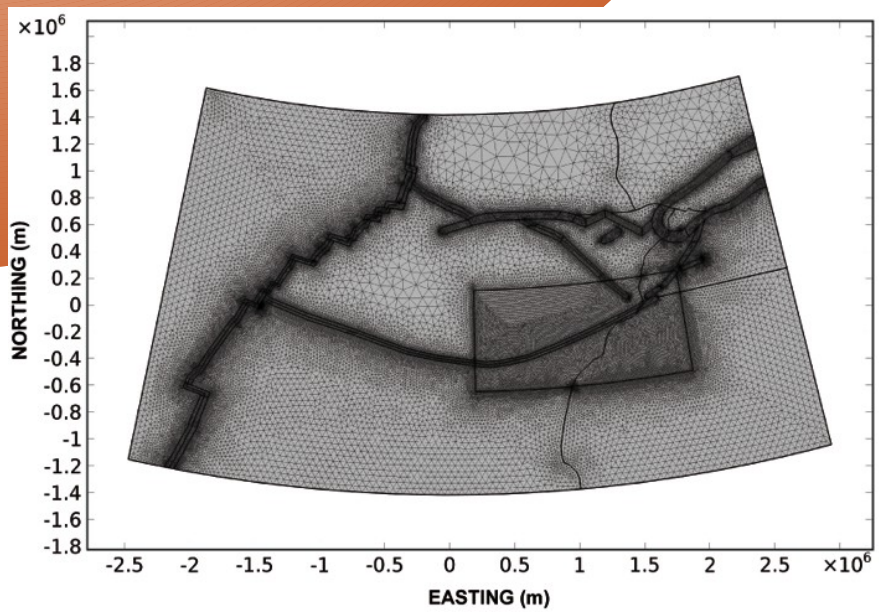
- The area of Figure 1 once projected in LCC is imported in COMSOL and meshed with triangular elements. The grid adopted involves around 112,000 triangles. The size and density of triangles have been chosen on the basis of the complexity of the local tectonic pattern to be reproduced

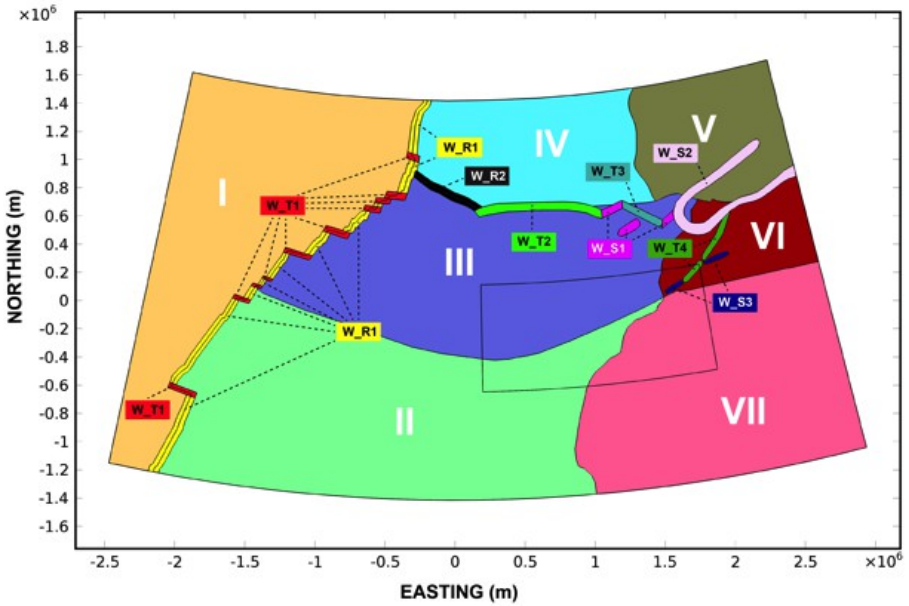
- Each block (Fig. 2 and Fig. 6 I-VII) is characterised by two constants, the Poisson's ratio and the parameter M = E h, where E is the Young's modulus and h is the thickness of the mechanical lithosphere , that in our approximation is the part of the plate that sustains the stresses induced by tectonic forces

METHODOLOGY

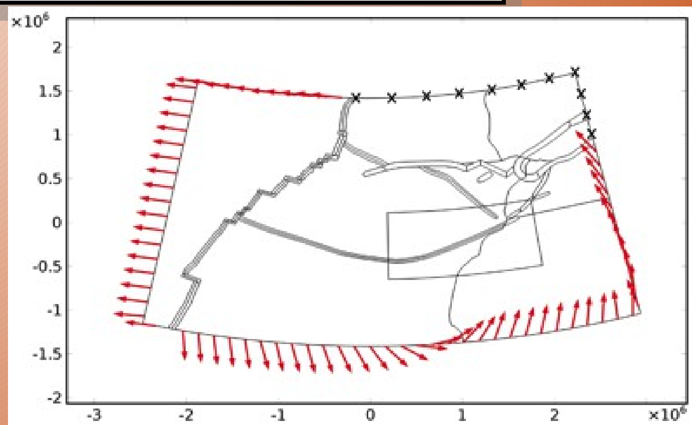


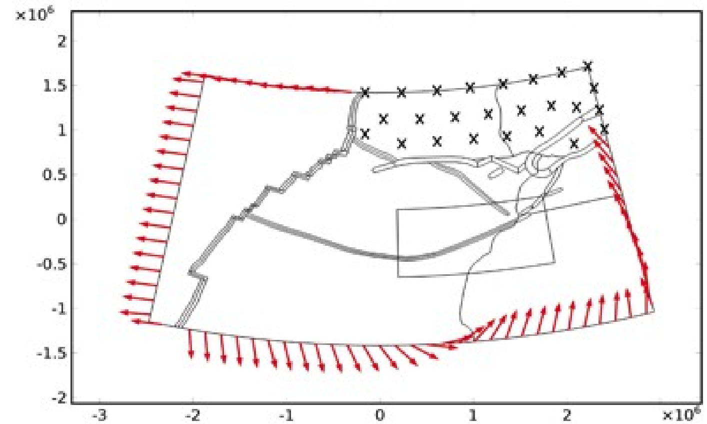


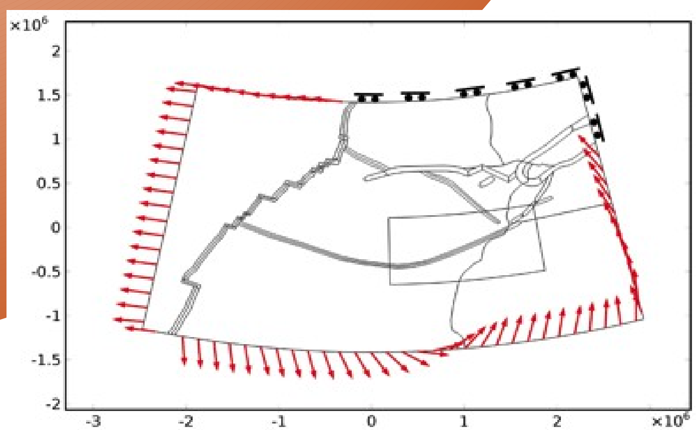


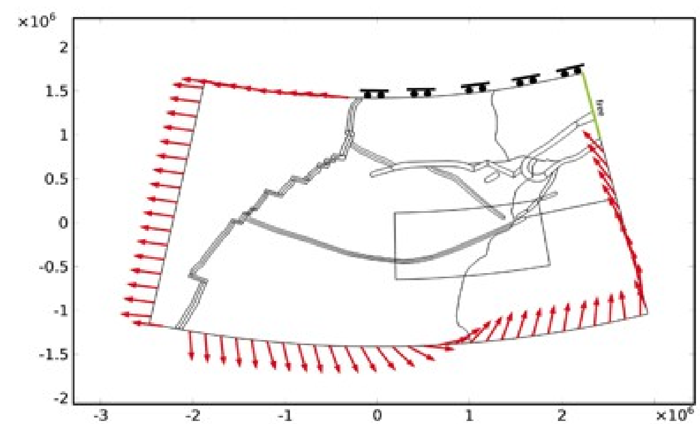


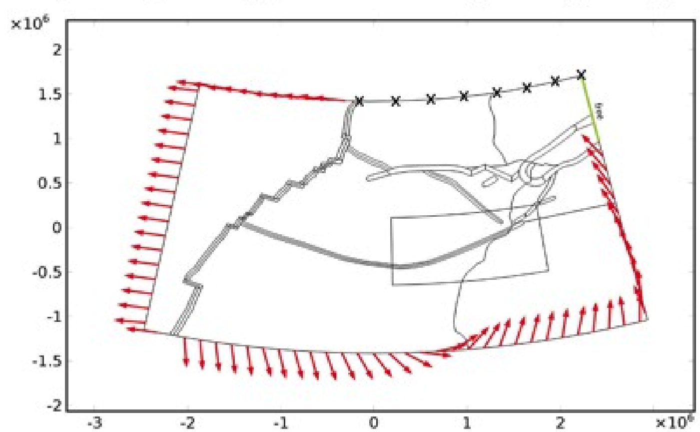
BOUNDARY CONDITIONS





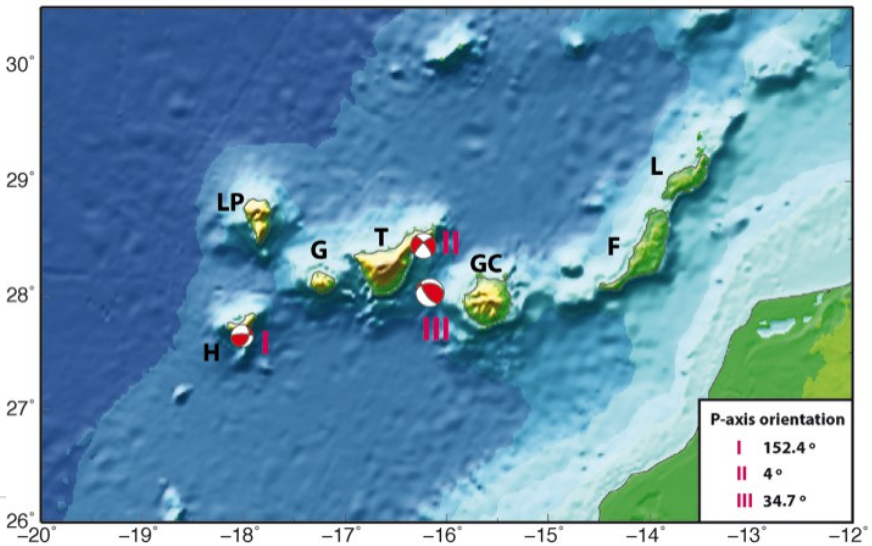


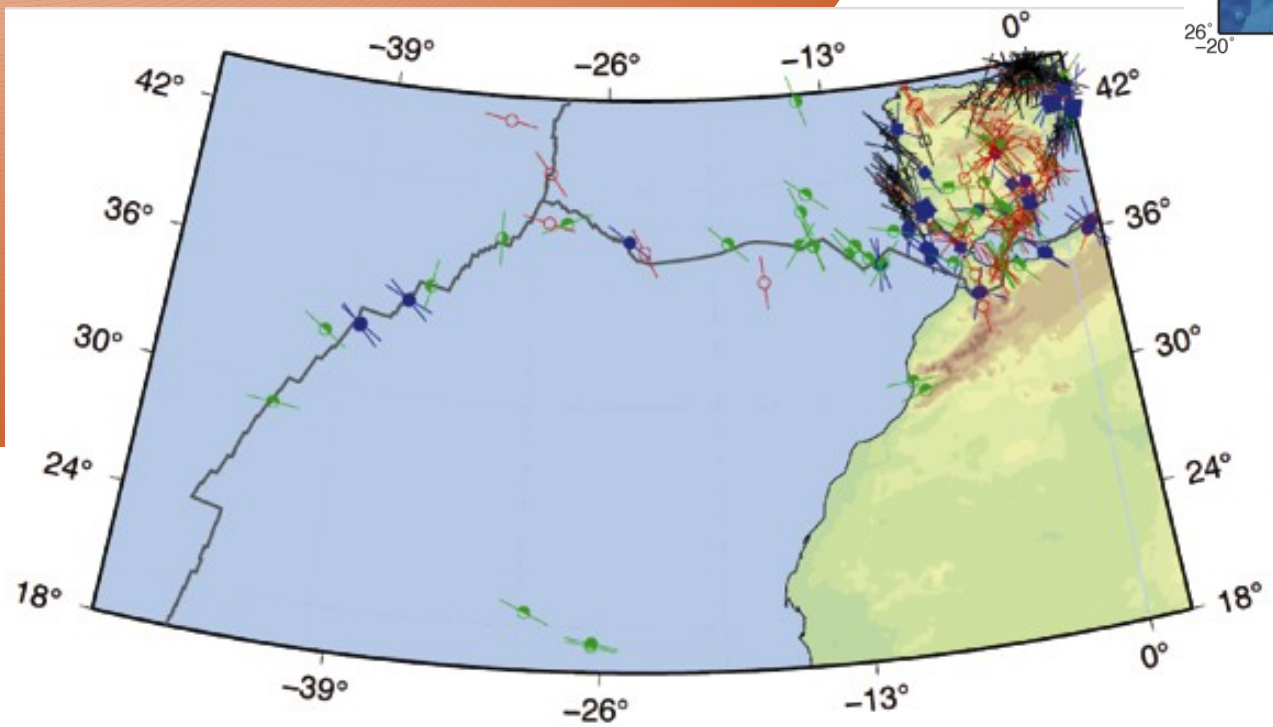


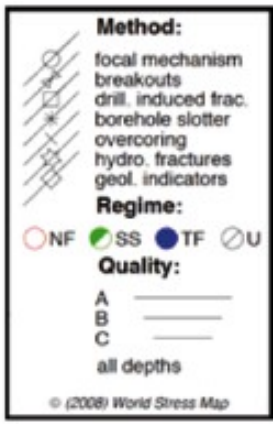


RESULTS

comparing results with reals data for model validation







Section of the WSM for the area under study. Illustrated in the map are the directions of the maximum horizontal compressive stress σ_{Hmax} . Data included in the map are of A to C quality, i.e. the error is ±15-25°.

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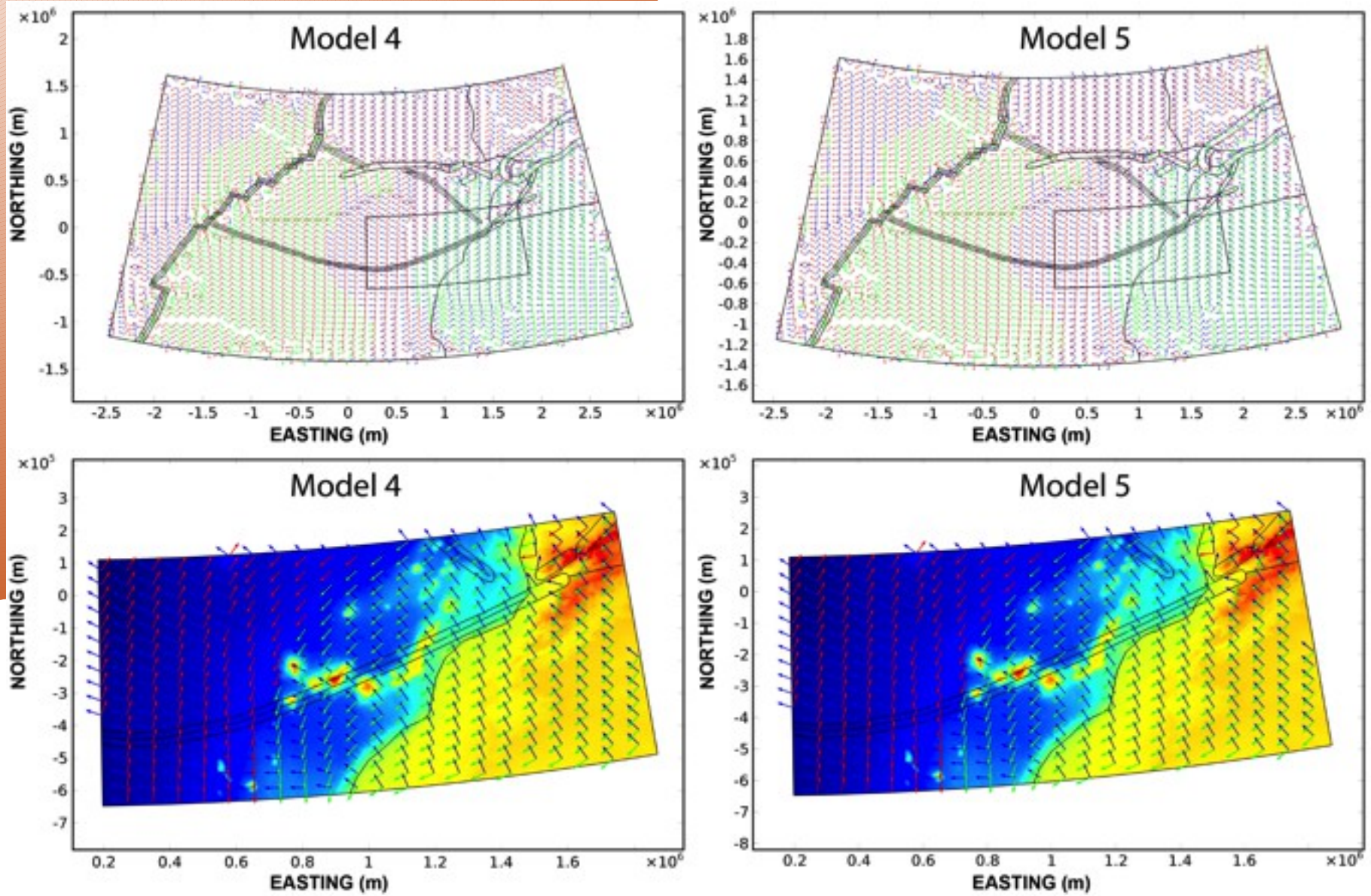
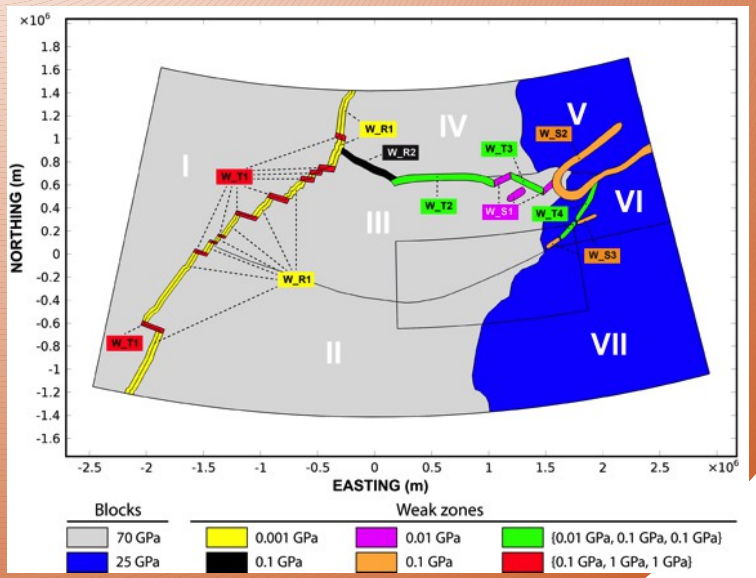
RESULTS

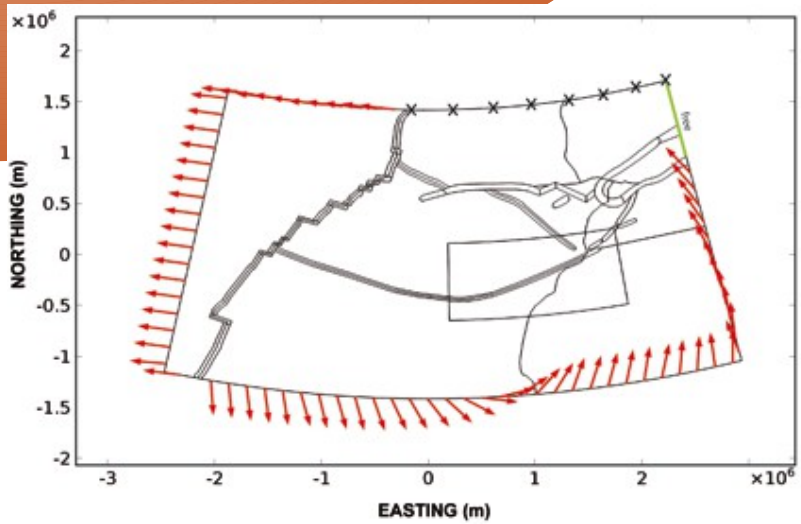

Model 4
Model 5
Model 4
Model 5
NORTHING (m)
EASTING (m)
×10⁶
×10⁵
Thrust
Strike-slip
Normal
σ1
σ2
σ3

RESULTS

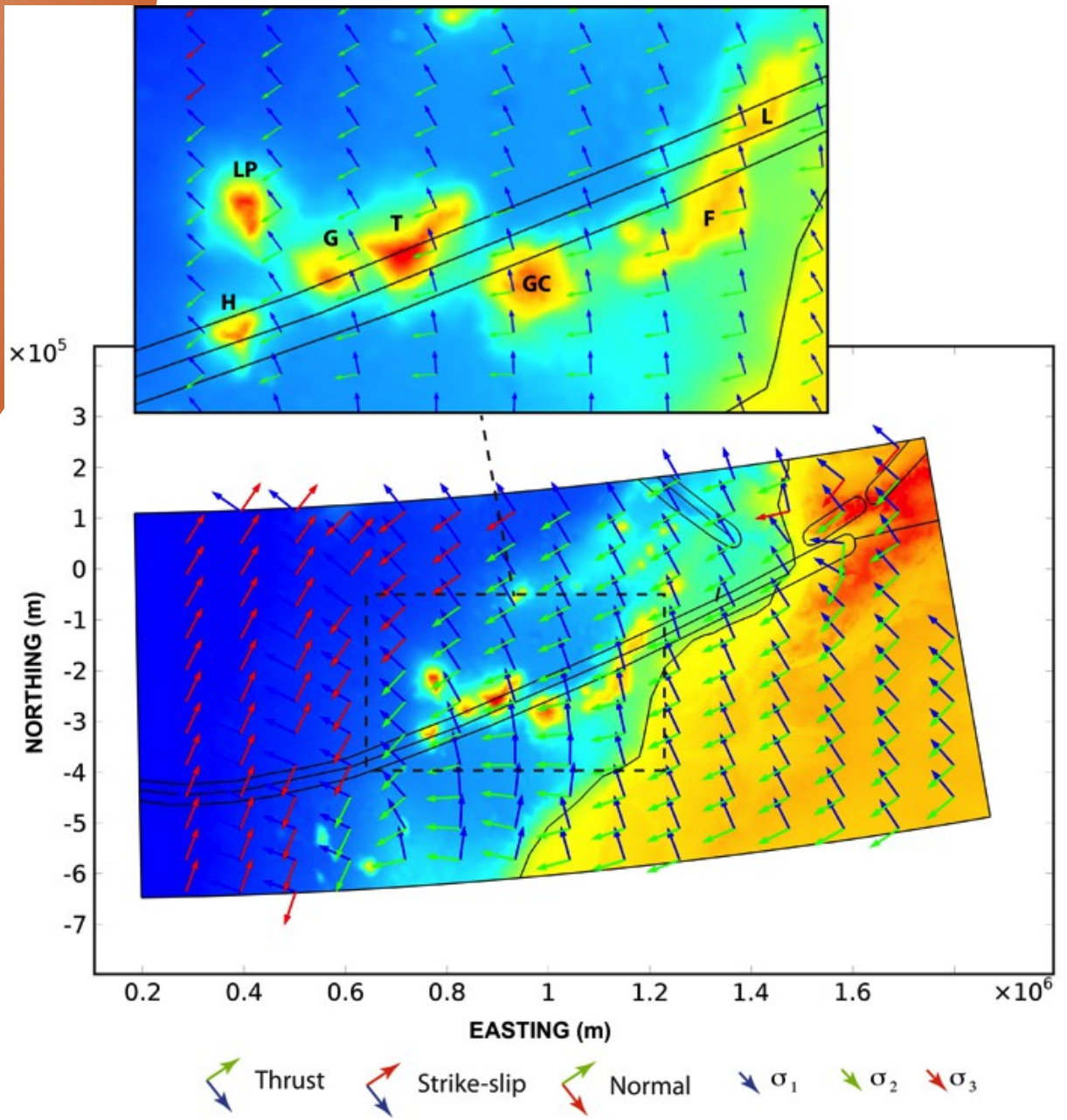
The final model



Computational domain and material properties of the final model



Boundary conditions of the final model



CONCLUDING REMARKS

- What we have shown is a 2D model of the geodynamic framework of the Canaries, which is the first step in the construction of a 3D model. The methodology developed here will be easily applicable to other active volcanic areas.

- Comparing the model obtained with the existing stress data and distribution of recent volcanism, we observe a perfect coherence between predicted results and geological and geophysical evidence.

- Applying this model to the El Hierro eruption it shows a perfect coincidence with the tectonic controls exerted on magma migration during unrest and the eruption site. A similar coincidence can be deduced for the Teneguía eruption (October 1971) in the island of La Palma.

- In conclusion, the model (and, in general, similar models for other areas) helps to identify the areas with a highest volcanic susceptibility (highest probability of vent opening), and may be used to forecast the sites of future eruptions