The Azores: Triple Junction and a Hot Spot

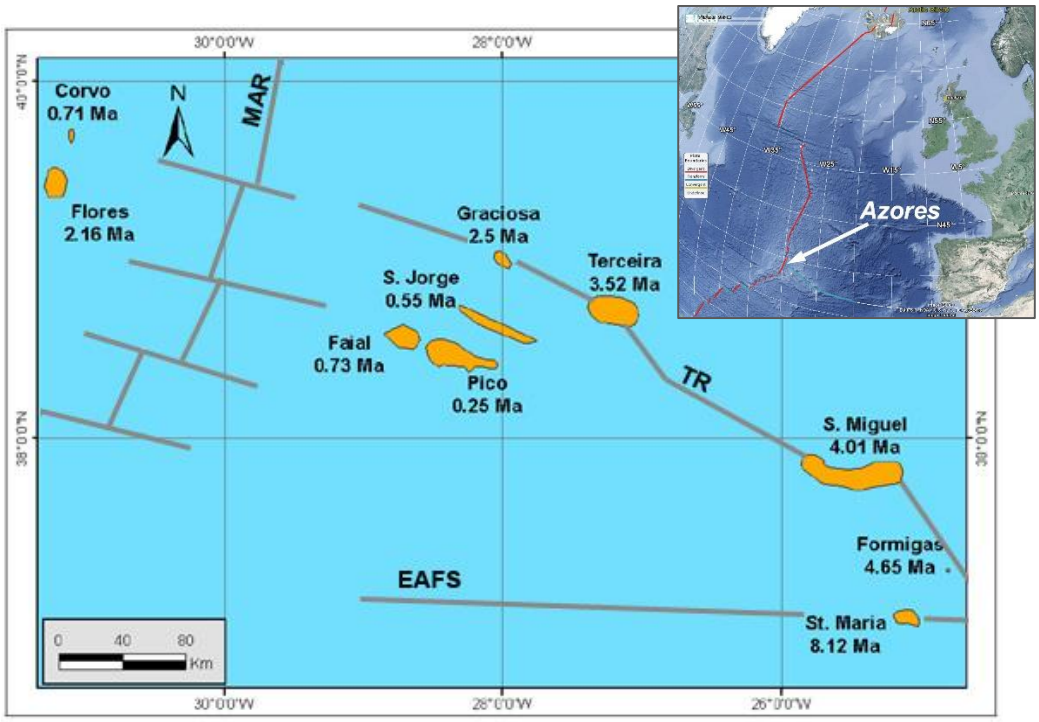

Figure 1: Map based on Quartau (2007), Babtiste et al (2009) and Google Earth, showing the nine islands in the Azores archipelago and the plate boundaries, Mid Atlantic Ridge (MAR) and Terceira Rift (TR) between the Eurasian Plate and the African Plate. The islet Formigas is shown as well.

Geological setting

The Portuguese archipelago Azores in the Atlantic Ocean consists of nine volcanic islands on an intersection of three tectonic plates: The North American plate, the Eurasian plate and the African plate. The islands are located on both sides of the Mid Atlantic Ridge (MAR) and on the east side of it they are on the Terceira Rift (TR) and also south of it on the Azores plateau, see Figure 1 (Quarto 2007).

The formation of the Azores Plateau may have started 36 Ma ago and the area became more active somewhere between 5 and 10 Ma ago. The area is still active with more than 20 volcanic eruptions since 15th century and the last eruption was during 1998 to 2001. The oldest rock on the island is 8.12Ma, see Figure 1 (Quartau, 2007; Babtiste et al, 2009). If putting the age of oldest rock on a map showing coeval lines it seems like the middle of the archipelago around the islands S. Jorge, Faial and Pico is the most active now or at least have been coming more active now than some millions of years before present.

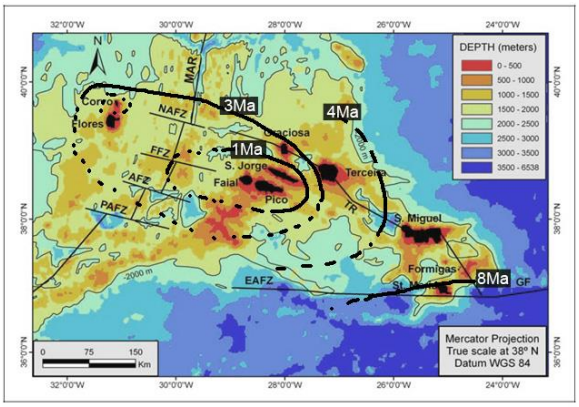

Figure 2: Distribution of oldest rock found in the islands, based on a bathymetry map from Quarto (2007) and data for oldest rock on each island.

The existence of a mantle plume

There has been a debate of the existence of a mantle plume under the archipelago making the hot spot. Most authors assume there is a mantle plume there and perhaps two or two tails of a plum under the middle of the island or one head between Terceira and S. Miquel and another one in the area of S. Jorge, Faial and Pico. The triple junction has been moving from south to north

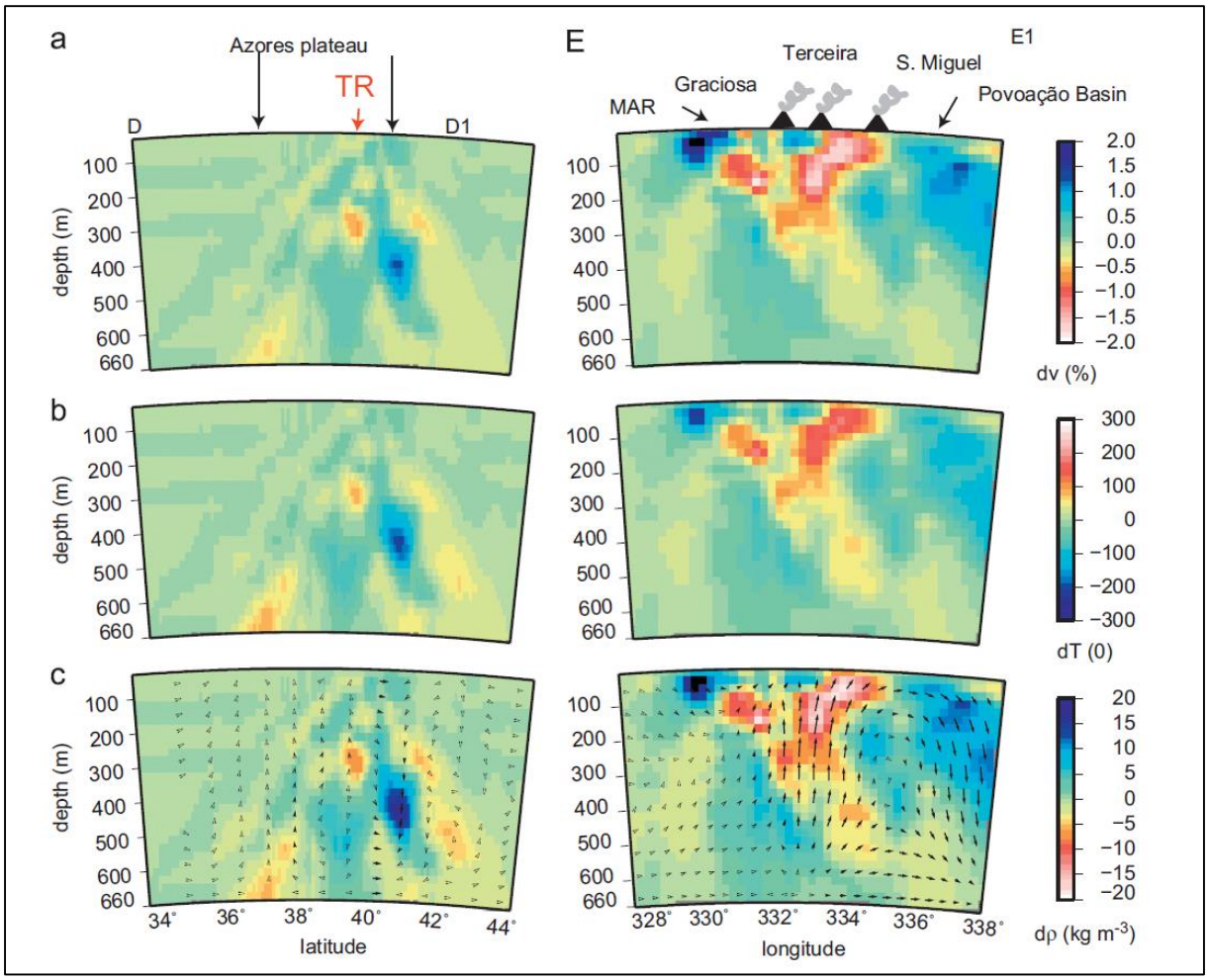

Figure 3: Depth crosssectionsalongtheMAR (left panels) and the Terceira rift bewteen the African Plate and the Eurasian Plate (right panels); (a)tomography model, showing deviation in P wave velocity, indicating different temperature and density; (b) temperature anomalies; (c) density anomalies; the arrows represent the convection driven by the density anomalies. (Adam et al, 2013)

and some authors assume that has to be described with a relative movement of the plates with regard to a mantle plume. Other authors have concluded the movement of the junction is a result of small changes in the relative motion of the three plates (Adam et al, 2013).

Both seismic measurements and chemical studies (based on Uranium-Lead isotope ratios and helium 3 ratio isotopes) are suggesting the existence of a mantle plume. (Adam et al, 2013; Franca et al, 2006 and Babtiste et al, 2009).

Adam et al (2013) suggest two main low shallow (depth < 200km) velocity anomalies. One located under the islands Faial, Pico, S. Jorge, and Graciosa and another located under the area between the Terceira and S. Miguel islands, see Figure 3.

The Terceira rift (TR) and seismicity

The triple junction of Azores is Ridge-Ridge-Ridge junction since all plates are diverging in the junction. The Terceira rift on the north side of the Azores plateau and it is a slow divergent boundaries between the African plate and the Eurasian plate. There has actually been a debate if the Terceira rift is the slowest rift on Earth. Some authors suggest it is the slowest but other not. The Terceira rift is connected to the convergent boundaries between African plate and Eurasian plate between Africa and Europe so there should be a cross over somewhere in the east of the Azores. The plate movement relative to a stable African plate is shown on Figure 4.

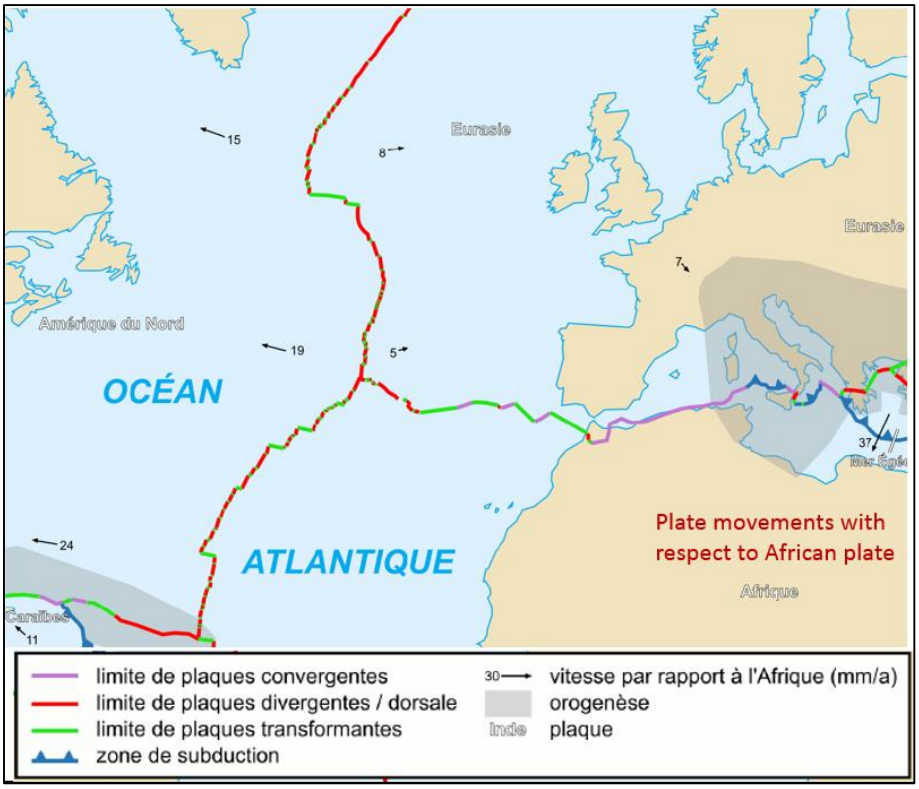

Figure 4: Plate movements around the triple junction at Azores with respect to the African plate (Einarsson, P., 2012)

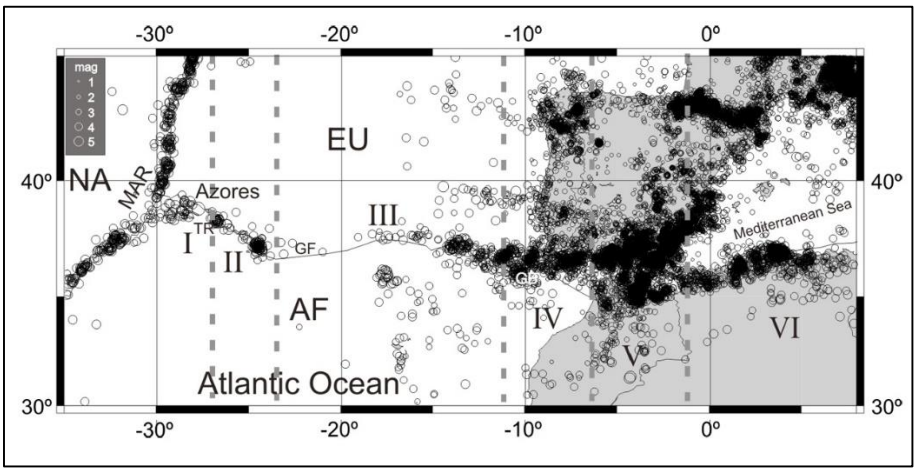

Figure 5: Seismicity in area of the Azores and boundaries between the African and the Eurasian late. Earthquakes of magnitude > 1 in the period 1973 - 2008 (Bezzeghoud et al, 1998)

Earthquakes are on all plate boundaries, see Figure 5. Based on a figure from Quarto (2007) there are both strike slip earthquakes as well as normal faulting earthquakes on the Terceira Rift. On the active transform zones of the Mid Atlantic Ridge the earthquakes are from strike slip faulting but the main pattern in earthquakes on the ridge are normal faulting earthquakes in the divergent stress environment. There is no or very little activity on the East Azores Fracture Zone (EAFS) see Figure 1.

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