First structural approach to the SE Sardinia mafic dyke swarm

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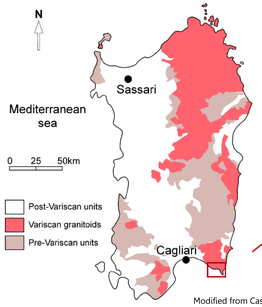
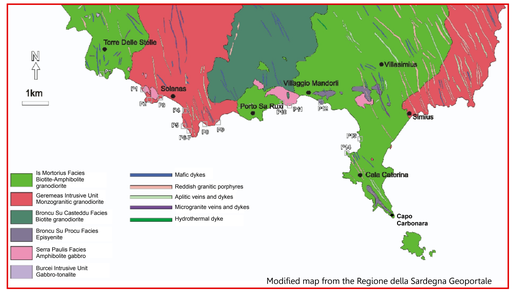
Geological context



Modified from Casini et al (2012)



Modified map from the Regione della Sardegna Geoportale

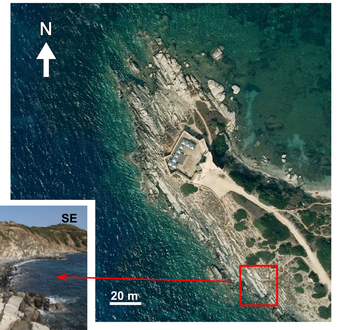
The mafic dyke swarm of interest is located in SE Sardinia (Italy), west of Villasimius and Capo Carbonara.

It has a predominant NNW-SSE trend, as seen in aerial photographs.

Dykes are emplaced into the late Variscan Sàrrabus pluton, which is composed of several intrusions of monzogranites and granodiorites with minor gabbroic and tonalitic rocks.

Different typologies of dykes are present in the swarm, from porphyritic to lamprophyric dykes, with a predominant calc-alkaline affinity.

They were emplaced during the Lower Permian at about 290-270 Ma (Vaccaro et al., 1991).

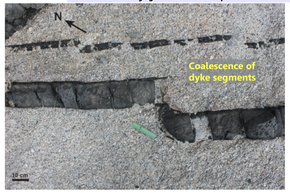


Aerial and outcrop images of the dyke swarm at Fortezza Vecchia area (locality P14 in the geological map)

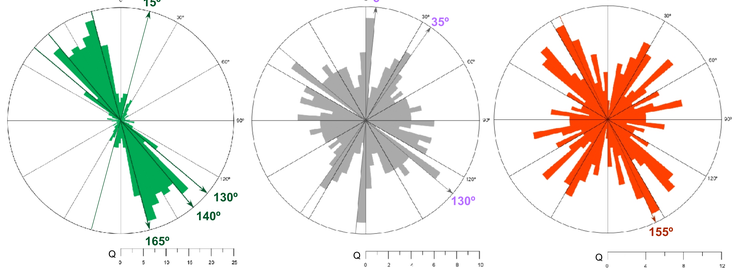
Swarm pattern

Directional data was obtained from applaying the circular scanlines method (Mauldon et al. 2001) to linear traces of dykes and joints on aerial photographs (©Google maps) and "in situ" field measurements. These allowed us to determine the dyke pattern and the joint network present in the granitoid rocks and in the dykes:

***Subvertical dykes** have a **~N140º ~N165º** mean trend, with secondary sets at **~N130º** and **~N15º**, the last one mainly corresponding to a previous intrusive pulse.
***Joint** network in the **host rock**, preferent sets at **~N05º**, **~N35º** and **~N130º**
***Joint** network **inside the dykes** has a wider range of orientations, with multiple sets.
*The ~N130-165º trend of dykes matches the orientation of secondary joint sets present in the host granitoids.



Typologies of segmentation structures found in the mafic dykes



Dyke trends | **Joint trends in the granitoid host rock** | **Joint trends inside the dyke**

Different joint sets inside a dyke

Location P5 in the geological map

3D Stress Analysis

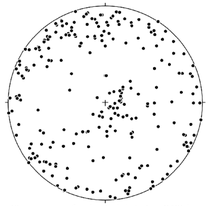
We performed a paleostress analysis (Jolly and Sanderson, 1997) to determine the **principal stress axes** compatible with the emplacement of the swarm:

σ_1: 135/77 σ_2: 335/13 σ_3: 244/05

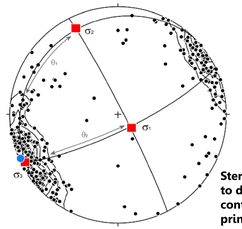
σ_1 is sub-vertical, implying an extensional tectonic regime in the area during dyke intrusion.

σ_3 is sub-parallel to the obtained sub-horizontal mean dyke opening direction, both being normal to the mean trend of the dyke swarm. The stress ratio (Φ=0.33) corresponds to a close to prolate stress ellipsoid with $\sigma_1 > > > \sigma_2 > \sigma_3$

During the dyke intrusion, the magmatic pressure (P_m) was lower than σ_2, as indicated by the driving pressure ratio (R'= 0.13). This implies emplacement due to tectonic stresses and along pre-existing fractures.



Stereogram of poles to joints (n= 249) in the granitoid host rocks



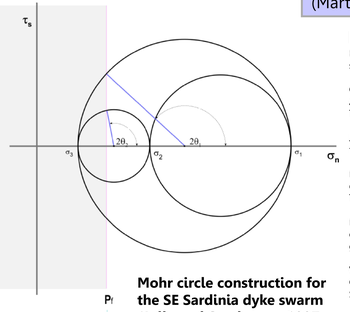
Stress axes:
σ1 244/05
σ2 335/13
σ3 135/77
θ1: 50.6º
θ2: 68.7º
Dilation axis 246/02

Stereogram of poles to dykes (n=314) and contours and principal stress axes

In this case, $P_f < \sigma_2$, so we use the following equations to calculate the **driving pressure ratio** (**R'**) and the **stress ratio** (Φ):

$$R' = \frac{P_f - \sigma_3}{\sigma_1 - \sigma_3} = \frac{\alpha}{2\tau_{max\,2}} = \frac{(1 + cos2\theta_2)}{2} \qquad R' = 0.132$$

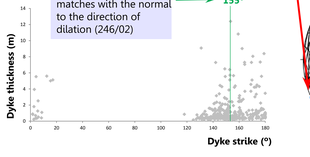
$$\Phi = \frac{\sigma_2 - \sigma_3}{\sigma_1 - \sigma_3} = \frac{\tau_{max\,1}}{\tau_{max\,2}} = \frac{1 + cos2\theta_2}{1 + cos2\theta_1} \qquad \Phi = 0.327$$

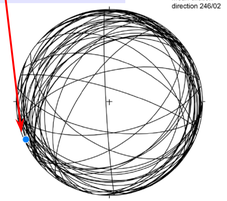


Mohr circle construction for the SE Sardinia dyke swarm (Jolly and Sanderson, 1997 method)

Dilation analysis

Using dyke orientations from field data, we applied the Bussell (1989) method to deduce the **mean dilation direction** of the dykes (**246/02**)





Notice the presence of a sub-horizontal joint set apart from the multiple sub-vertical sets.

Conclusions

·Dykes intruded into extensional fractures and exploiting some joint sets of a previous fracture network at relatively low fluid pressure conditions in comparison with the relatively higher regional differential stresses.

·Dyke emplacement was likely taking place under an ENE–WSW extensional regime (without considering the effect of post-intrusion crustal block rotations).

·Further work is needed in order to fully understand the emplacement of the SE Sardinia dyke swarm and to correlate it with other neighboring dyke provinces of the European Variscides in Permian times, such as the Aiguablava lamprophyre dyke swarm (NE Spain) (Martinez-Poza et al. 2014).

References:

Bussell, M.A., 1989. A simple method for the determination of the dilation direction of intrusive sheets. Journal of Structural Geology. 11, 679–687.

Casini, L., Cuccuru, S., Maino, M., Oggiano, G. and Tiepolo, M. 2012. Emplacement of the Arzachena pluton (Corsica-Sardinia Batholith) and the geodynamics of incoming Pangaea. Tectonophysics 544-545, 31-39.

Jolly, R.J.H., Sanderson, D.J., 1997. A Mohr circle construction for the opening of a pre-existing fracture. Journal of Structural Geology 19, 887-892.

Martinez-Poza, A.I., Druguet, E., Castaño, L.M. and Carreras, J. 2014. Dyke intrusion into a pre-existing joint network: The Aiguablava lamprophyre dyke swarm (Catalan Coastal Ranges). Tectonophysics 630, 75-90.

Mauldon, M., Dunneb, W.M. and Rohrbaugh Jr., M.B., 2001. Circular scanlines and circular windows: new tools for characterizing the geometry of fracture traces. Journal of Structural Geology 23, 247-258.

Vaccaro, C., Atzori, P., Del Moro, A., Oddone, M., Traversa, G. and Villa, I.M., 1991. Geochronology and Sr isotope geochemistry of late-Hercynian dykes from Sardinia. Schweizerische Mineralogische und Petrographische Mitteilungen, 71, 221-230.

Villasimius page geological map (DEM 5m). Geografia della Sardegna. Sardegna Geoportale (http://www.sardegnageoportale.it/). Region della Sardegna.