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Accessing to magma flow direction in dykes from vesicle shapes and orientations

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Magmatic mesoscope features like deformed vesicles or amygdules are usually interpreted as flow-related textures on coherent extrusive or shallow intrusive volcanic rocks. Deformed vesicles (or amygdules) with ellipsoidal shape may form planar or linear alignments and their imbricated fabrics have been successfully used as a field criterion to determine magma flow direction on lavas and dykes.

Recent analysis of the shapes and orientations of vesicles on shallow basaltic dykes from the Mafra Radial Dyke Swarm (MRDS) was carried out to determine the magma flow direction.

The MRDS is assigned to the Late Cretaceous alkaline cycle of the western Iberia continental margin associated with the opening of the North Atlantic. The studied dykes, narrow and trending WNW-ESE, show oriented elongated vesicles usually filled with secondary minerals (amygdules) which enhances their field recognition.

Photo-mosaics were made for the well exposed vesicle sections on different dyke locations, on the dyke margins or on its interior, measuring the major and minor ellipses axes or 3D when possible.
The vesicles show generally a highly elongated oblate ellipsoid shape with axial ratios up to 30:5:1 and major axes length up to ∼10,6cm.
The major and minor axes of the vesicles usually lay on a sub-horizontal or gently dipping plane (XZ plane) where as the XY plane is usually vertical, parallel or imbricated with respect to dyke margins. The imbrication angles present values between 15º and 35º (locally may vary up to 55º) becoming sub-parallel to the dyke trend, i.e., to the flow plane. This imbricated pattern indicates a direction of flow from E to W, for all dykes. The attitude of x-axis from 3D vesicle dykes (vesicle lineation) shows values between (24, N115) and (27, N117), with an average attitude of 26º dipping towards ESE.

This study shows that the vesicle fabrics present on these dykes are related to a low angle magma flow, with an upward flow direction towards WNW, which may reflect a main lateral propagation of the dykes over the vertical component.
The results are also consistent with the AMS study results for magma flow determination performed on these dykes.