Chapter 6

Conceptualization of the Dike Distribution Analysis Aiming at Identification of Eruptive Centers

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ABSTRACT

Formation of dikes is typical for most of the volcanic centers. Different types of eruptive centers tend to create different patterns of dike distribution by strike. Looking at this distribution, one may suggest, by purely geometrical reasons, where the vent should be (if buried) or should have been (if removed by denudation or new eruptions). However, wide application of this technique raises the issue of interpretation of the results in the context of the geological history of a particular volcano. Impartial and universal interpretation may be possible in a framework of knowledge of eruptive center evolution that can be built by means of the event bush method. Such a framework, however, may have wide application in volcanology extending far from the initial task it has been developed for.

INTRODUCTION

Volcanic eruptions are accompanied by intrusion of dikes that often indicate the location of past eruptive centers. This has led Carniel et al. (2017) to develop an algorithm aiming to identify the location of buried or denudated eruptive centers based on the documented dikes where their density allows to do so. The algorithm was implemented as an R opensource script entitled FIERCE (FInding volcanic ERuptive CEnters) and tried at a number of volcanoes and volcanic areas, both modern and ancient, with encouraging results. Position of the vents computed by this algorithm coincided with the observed (for modern centers) and was in concordance with the distribution of volcanic products and other evidence of

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their location. Naturally, in every case the reliability of the computed position of eruptive center should be supported by the interpretation of volcanological and geological history of the volcano.

Every time this interpretation was made ad hoc, based on the geological data available, and it seems to be a good luck that so far we have been finding a self-consistent and palpable explanation for the results of computation. Still, this good luck is more or less explained by that (i) we have addressed a very small number of volcanoes and that (ii) almost all of these volcanoes have had a long record of geologic research. Query, what happens if we interpret dozens or hundreds of datasets? Wouldn’t there be some typical interpretations? Wouldn’t different scenarios of geological evolution be potentially responsible for the same dike pattern? Is the diversity of these patterns infinite or it can be somehow constrained?

To answer these questions, one should systematize the existing interpretations and put them in a coherent framework of volcano-tectonic knowledge. To build such framework is the purpose of this work.

Below in this chapter we will briefly overview the FIERCE methodology and the results achieved, suggest a knowledge framework to host these results and discuss its use in volcanology.

**PREVIOUS WORK**

**FIERCE Methodology**

Dikes in volcanic areas usually have radial, tangential (circumferential), or regional patterns (e.g., Chadwick & Howard, 1991; Takada, 1997; Acocella & Neri, 2009). The radial patterns suggest control by a local stress field caused by the load of the edifice, an effect that increases with edifice height, while tangential dikes are often related to caldera collapses (McGuire & Pullen, 1989; Corbi et al., 2015). Distinguishing with certainty between radial and tangential dikes is generally possible only if the vent position is known. Conversely, when denuded volcanoes preserve dike segments, their orientations may prove highly useful for identifying the position of its central or peripheral vents. Once we identify the vent’s location, we can then determine which dikes are radial or tangential and hence understand the morphological and structural evolution of a volcanic edifice, i.e., what caused its shape (Fiske & Jackson 1972). We can also identify evidence for features like sector collapses, because the orientation of the dikes may be controlled by the collapse scarps (e.g., McGuire & Pullen1989; Acocella et al. 2006a, 2013; Neri et al. 2008; Battaglia et al. 2011).

By Carniel et al. (2017), one should first consider a very simple case and assume that all dikes are radial with respect to their unknown eruptive center. In such an ideal case, the directions of all the dikes should intersect exactly in the sought eruptive center. To find such an intersection, one needs to mathematically define the direction to which each of the dike segments belongs.

In reality, some dikes may belong to the classes of tangential and regional stress dikes. If they are erroneously assumed as radial with respect to the eruptive center, they will actually do no harm in the computation, as their directions basically become random, i.e., will not lead to a wrong solution. However, tangential dikes also preserve useful information that is: if a dike is tangential, any section of it observed in the field can be approximated by the line joining its ends. This line must be tangential to an imaginary circle surrounding the eruptive center. Then a perpendicular line that passes through the midpoint of this line would act in the same way as a radial direction.