Using the Extrusive Volcanic Features of Mt. Marsabit, Kenya to Identify Regional Tectonic Stress

Cora Van Hazinga* (Salem State University), James Muirhead (Syracuse University), Sara Mana* (Salem State University) *coravh@gmail.com, *smana@salemstate.edu

INTRODUCTION
Extrusive volcanic features like vents, craters, and cones can provide alignments and other linear structures that indicate the orientations of subsurface feeder dikes and regional tectonic stresses. These dikes form parallel to the maximum compressional stress ($\sigma_3$) and perpendicular to minimum compressional stress ($\sigma_1$), and/or exploit pre-existing planes of weakness. Volcanic constructs led by these magmatic intrusions are therefore indicators of tectonic stress directions and subsurface structural fabrics, which can be deduced through detailed mapping and assessment of the spacing, shapes, and linear arrays of these features.

Mt. Marsabit (2.32°N, 37.97°E) is a massive 6,300 km² domal stratovolcano located in northern Kenya on the eastern shoulder of the Kenya Rift, 170 km east from the center of the East African Rift. The features of Mt. Marsabit have been long observed to trend in a NE-SW direction, oblique to the general N-S trends observed in nearby sectors of the East African Rift (Figure 1). Data from features on Mt. Marsabit have never been analyzed with newly available geographic information systems. Mapping these features can help us identify the nature of regional tectonic stress in this active volcano.

CONFLICT LEVELS

CONFIDENCE LEVELS

● High confidence maar crater
● Low confidence maar crater

SPATIAL ANALYSIS

Figure 3. (A) A maar crater that meets spatial analysis criteria. Rims are well defined, the crater is located within 500 meters of other features, and the long axis/short axis ratio is greater than 3:1.
(B) A maar crater that does not meet spatial analysis criteria. It is badly eroded with unclear boundaries. The lowest feature is 9 km away.

METHODS

- The northern slope of Mt. Marsabit was divided into three sections to aid in mapping and to prevent missing features.
- Features were mapped using Google Earth Pro satellite imagery (Version 7.32). Oblique view, map view, and elevation profiles were utilized.
- Each feature was assessed for reliability and assigned a confidence score ranging from 1 (high confidence) to 3 (low confidence). Confidence rating were decided by several factors such as proximity to other features, erosion levels, and completeness of crater rims (Figure 3).
- Features with a confidence score greater than 2 and a long axis/short axis ratio of 1.2 or greater were considered likely to mark a subsurface feeder dike, and therefore candidates for analysis.
- The orientation of the elongation of feature ellipses and the orientation of linear arrays were calculated using ArcMap (Version 10.7.1) (Figure 4). The orientations of feature ellipses were interpreted as an indicator of the regional tectonic stress. A better understanding of the forces operating in this area can help us understand the roots of this regional change.

REFERENCES

Rose diagrams were created using Excel (version 3.4.0). The orientation of the elongation of feature ellipses and the orientation of linear arrays were calculated using ArcMap (Version 10.7.1) (Figure 4).

SPATIAL ANALYSIS

Figure 4. (A) Cones forming a linear array. (B) A cone within the linear array that meets spatial analysis criteria. It is interpreted independently. The Minimum Bounding Geometry tool in ArcMap creates an enclosing rectangle around the polygon and calculates the orientation of the long axis of the featured ellipse.

CONCLUSIONS

- Of the 275 mapped features, 97 met analyses criteria.
- The orientations of ellipses strongly indicate NE-SW trending subsurface feeder dikes.
- Linear arrays are also oriented NE-SW although this trend is less pronounced.
- The NE-SW orientation of volcanic features suggest either of the following:
  - a local NW-SE extension direction
  - a NE-SW oriented crustal fabric controls the geometry of the underlying plumbing system.
- The stress field observed at Mt. Marsabit is oblique when compared to other features in the eastern branch of the East African Rift.
- Mapping and analysis of other volcanics in the East African Rift is needed for a complete picture of regional tectonic stress in this dynamic area.