Streaking Across the Gabbro: The Wichita Mountains' Quanah Granite Dikes Exposed

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GSA Section Meeting in San Antonio, Texas, USA-March 2016, Paper No. 8-4, Session #8-Booth #26

Introduction

The predominantly igneous Wichita Mountains expose the products of the Eocambrian Southern Oklahoma Aulacogen (SOA), a rift formed during dismemberment of Rodinia. The Quanah Granite is one of roughly a dozen alkali-feldspar granite plutons that intruded the upper crust of the SOA (Figure 1). It cuts into the Glen Mountains Layered Complex (GMLC), a series of older SOA gabbroic rocks. Dozens of dikes north of the Quanah Granite margin also intrude the GMLC (Gilbert, 2014). The majority of these are likely sourced by the Quanah Granite pluton.

The dikes are exposed over a few square kilometers in the Central Lowlands of the Wichita Mountains Wildlife Refuge. The dikes range in width from a few centimeters to almost two meters, and the longest is continuously exposed for a third of a kilometer.

The dikes are a potentially useful piece to the puzzle that is the Southern Oklahoma Aulacogen. Documenting the orientation of the dikes constrains stresses present during dike emplacement.

Methodology

We started this project with scant information on the dikes; we knew of general locations and the potential magmatic source. We used Google Earth to locate large surface expressions. We began fieldwork by looking for outcrops and walking the dikes.

The rocks of the Central Lowlands are highly weathered but the granite is less weathered than the surrounding GMLC gabbro. The dikes are preserved as a few in-place outcrops (Figure 2A), but their dominant expression is trends of large float in gabbro-derived soil (Figure 2B). Fortunately, the area is modestly vegetated. The dikes are also partially obscured by younger sediments, including expanses of the Permian Post Oak Formation on the higher elevations north of West Cache Creek (the Fish Lakes).

We traversed exposures and plotted waypoints every few decimeters using a handheld GPS-WAAS (Figure 2C).

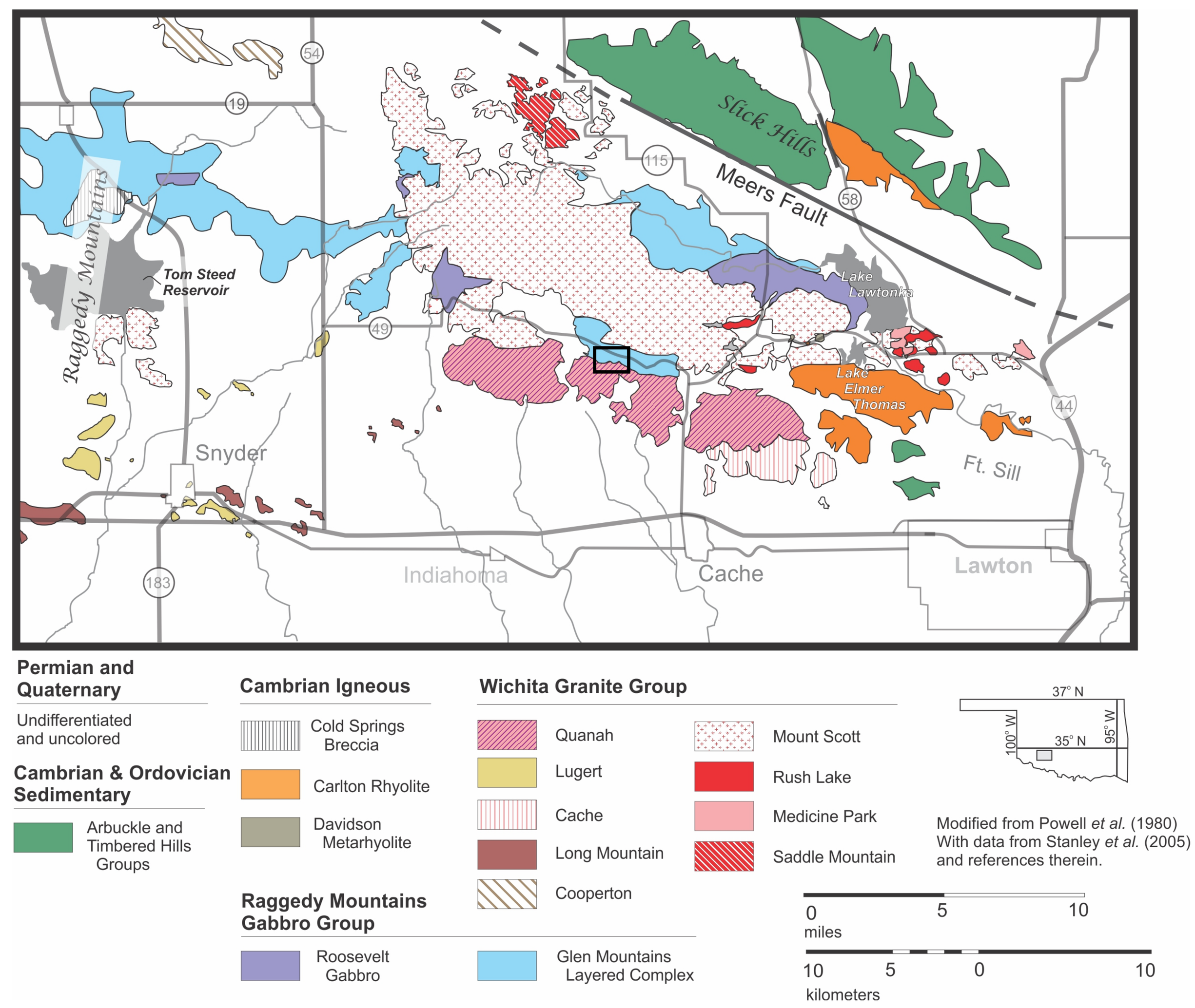


Figure 1: A geologic map of the Eastern Wichita Mountains. The Central Lowlands study area is outlined. The Quanah Granite occupies a large portion of the southern part of this region. This pluton is one of the two relatively coarse-grained granites in the Wichitas. The coarse facies of the Quanah Granite contains distinctive sodic amphiboles, and is cut by quartz veins and large vugs. These features are present in many of the adjacent dikes as well.

Figure 2: Fieldwork on the resistant dikes in the weathered GMLC. Dikes are pink to orange pink. Each is dominated by feldspar and quartz. Some contain sodic amphiboles, and many have quartz veins and vugs. A.) Six of the dikes are demonstrably in place; their attitudes were measured using a Brunton pocket transit. B). The majority of the dikes are weathered boulders and cobbles that retain directional trends. This dike can be seen on Google Earth images. C.) Dike trends were outlined using a handheld GPS.

We measured orientations on well-exposed outcrops using a handheld Brunton pocket transit. After walking the entirety of the study area and acquiring nearly 300 annotated GPS waypoints, we imported our points into DeLorme Topo North America 10.0 mapping software. The points were projected on DeLorme digital elevation maps and the U.S.G.S. digital orthoimage quarter quadrangles (DOQQ) for our area (Figure 3). In addition to the waypoints, the GPS recorded tracks for each field excursion. We then traced dike surface trends. These data were verified with subsequent fieldwork.

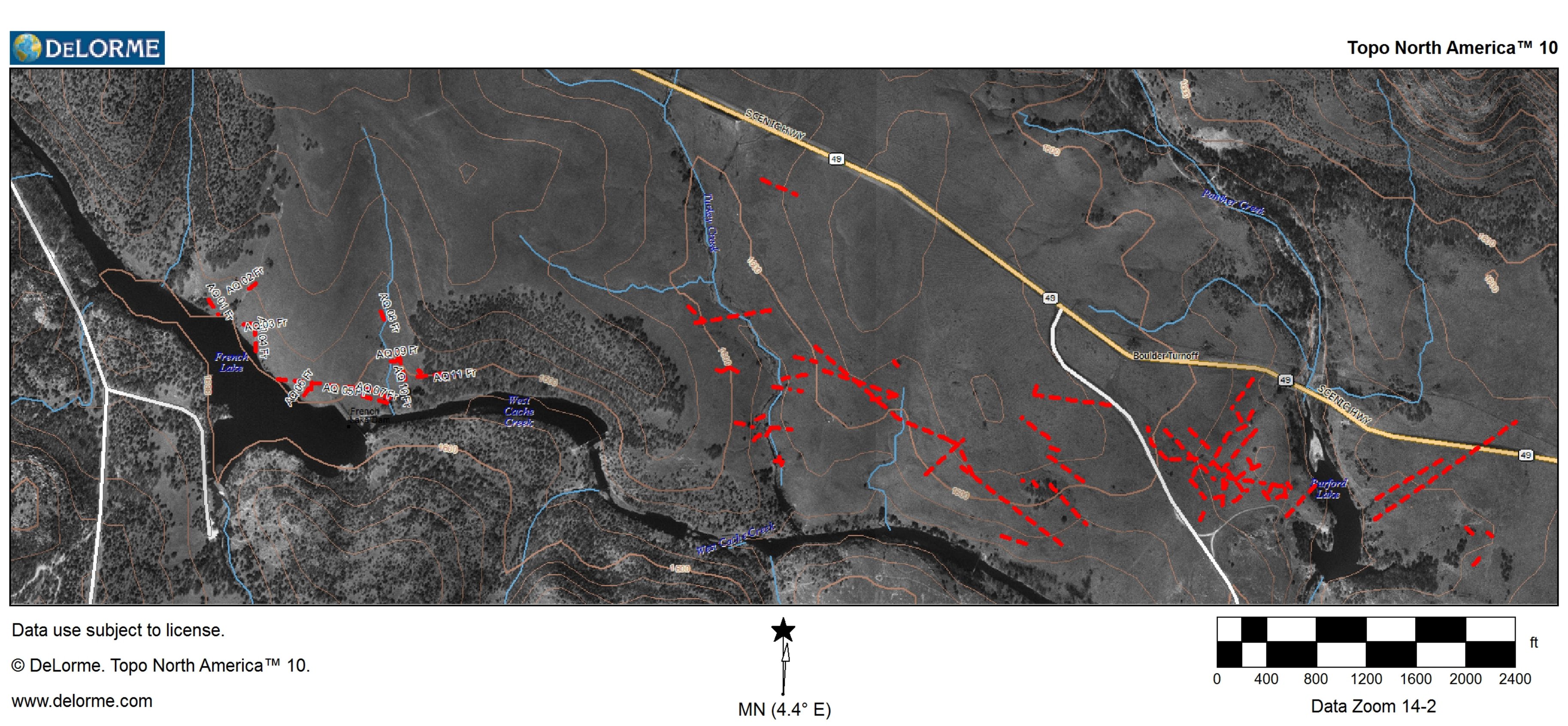


Figure 3: Initial map in DeLorme Topo showing dike surface expressions on DOQQ imagery. The aerial view aided dike placement by providing vegetation and landscape features not on the topographic map. This map and image could also be compared to Google Earth images.

This version of the map shows the western dikes labeled and named as an example. In total, we determined and named 76 individual lines based on our waypoints.

The surface trends were then mapped and given unique identifiers. The name of each dike includes three pieces of information: 1. the first author's initials, 2. the number of the dike in that area (west to east), and 3. the location of the dikes.

The region is broken into three zones defined by the nearby lakes to the south: "Bu" for Burford Lake, "Fi" for Fish Lakes, and "Fr" for French Lake. Dikes are numbered in each zone from west to east. For example, the westernmost dike north of Burford Lake is labeled "AQ 01 Bu."

These dikes were then projected onto the U.S.G.S. Quanah Mountain 7.5' quadrangle topographic sheet (Figure 4). Orientations of dikes that cross cut three or more topo lines were resolved using 3-point analysis. For dikes that did not cross sufficient contours, we used the measured strike from the map and an assumed dip of 90°.

We then ranked our data using 4 grades:

A. Brunton measured dikes
B. Orientations resolved through 3-point analysis on the U.S.G.S. topographic map
C. Map-delineated strike and assumed dip (90°) for dikes that failed to cross three contours
D. Map-derived strike and assumed dip for dikes (90°) that did not inflect with topography or those that crossed less than two topographic lines.

We then uploaded the dike orientations into Stereonet (Almendinger et al., 2013), where we graphically evaluated trends (Figures 5 and 6). We produced plots based on two sets: set 1 used A- and B-grade data and set 2 used A-, B-, and C-grade data.

Findings

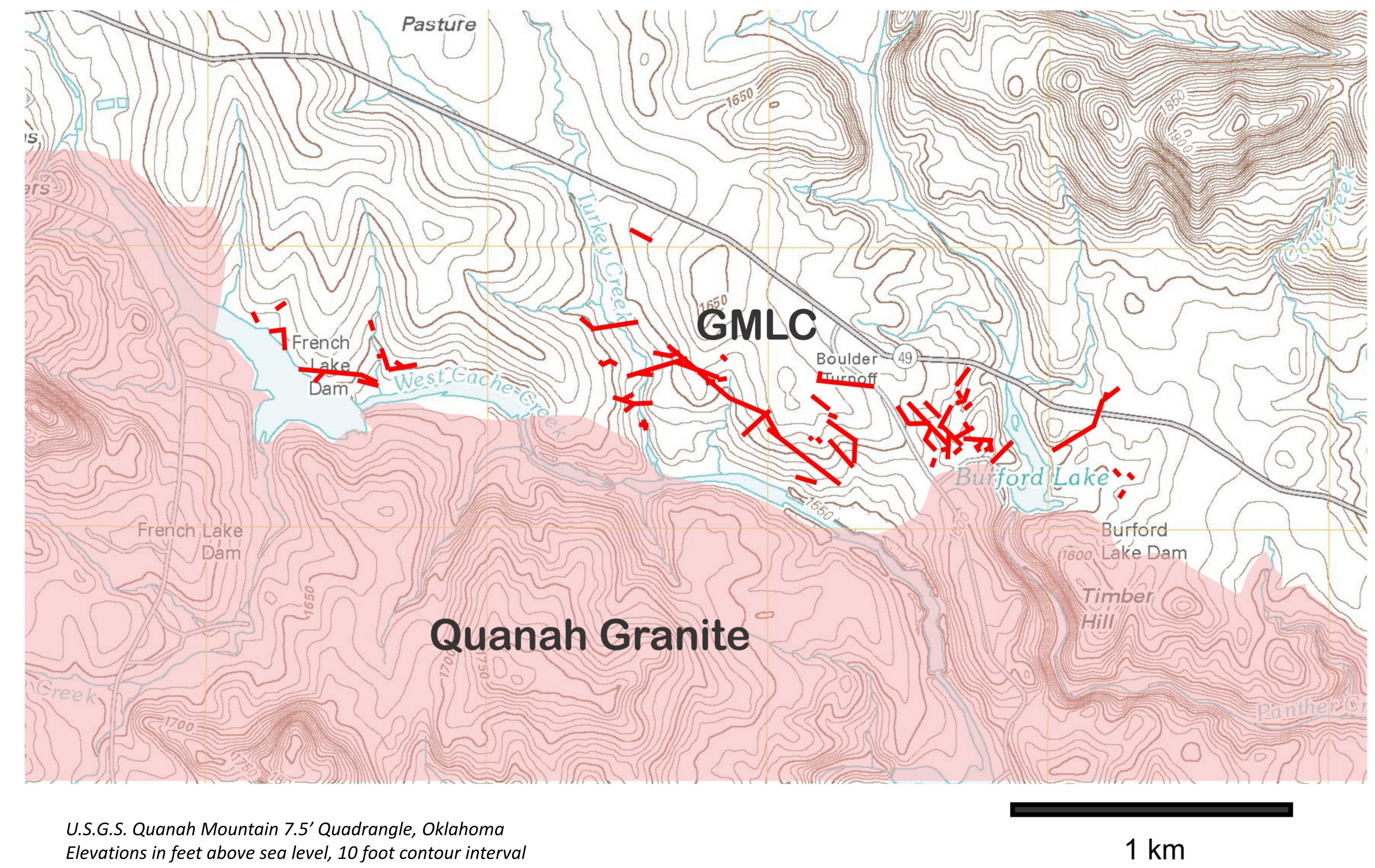


Figure 4 is the finalized map of the dikes. We identified 76 individual dikes on the basis of their exposure and trends.

All of these dikes are exposed in the GMLC, the gabbroic rock found largely north of the Fish Lakes (West Cache Creek). The Quanah Granite is exposed south of the Fish Lakes.

At this point, the data suggest that the bulk of the dikes are derived from the Quanah Granite pluton, injected fractures immediately north of the main intrusion. Like the Quanah Granite, many of the dikes have quartz veins and vugs, and a few contain sodic amphiboles.

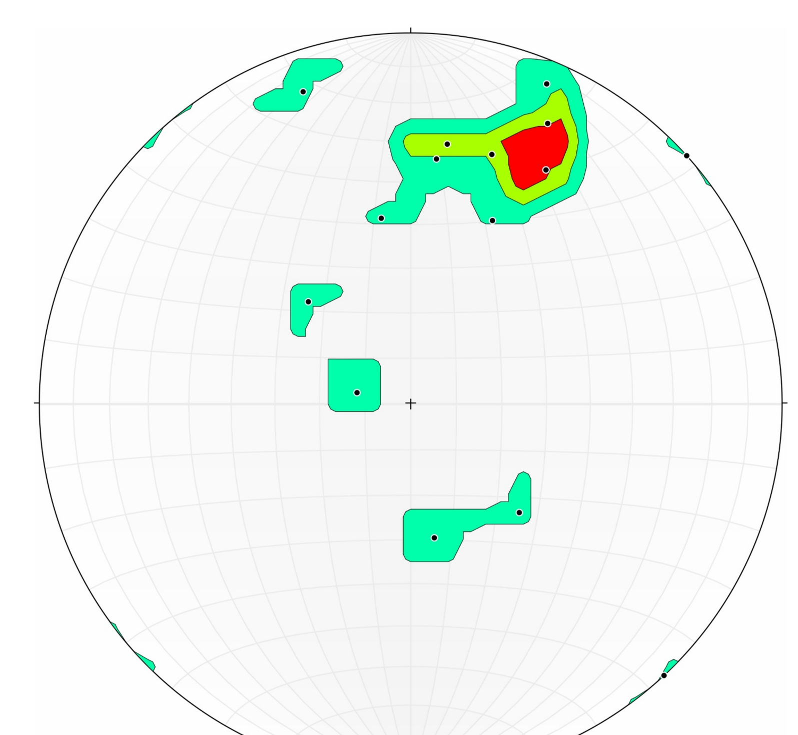
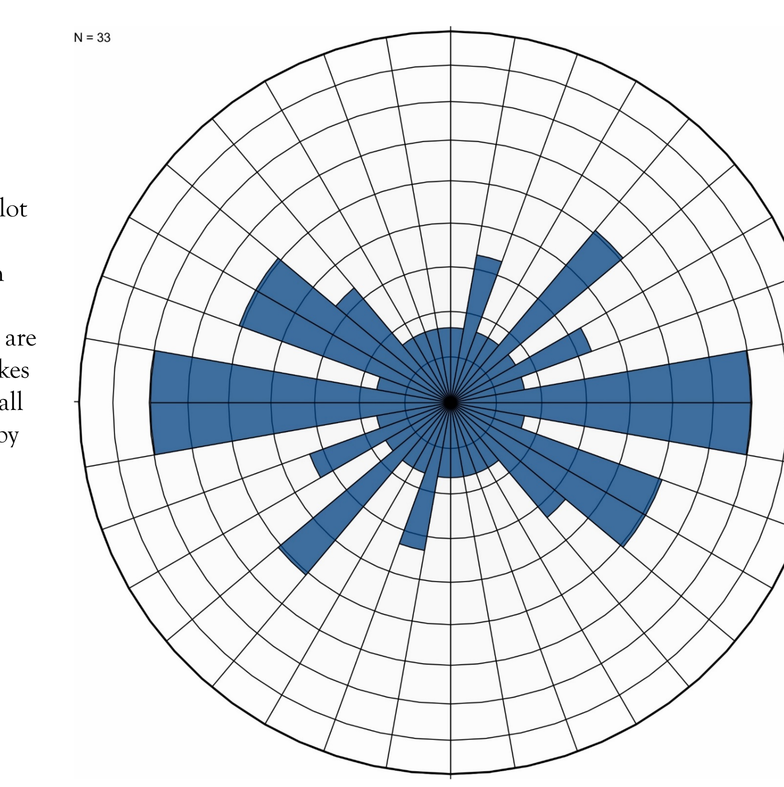


Figure 5: A stereographic plot of poles for the A- and B-grade data (17 points). Contours indicate 118°, 65° S as the prominent trend. This corresponds to the 120° seen in the larger data set and consistent with the general trend of the Southern Oklahoma Aulacogen.

Figure 6: A 10° rose plot of the A-, B-, and C-grade dike orientation data (33 points). The dominant dike trends are 90°, 120° and 45°. Dikes also exhibit trends in all directions as defined by the 10° bins.



Stereonets (Figure 5) indicate that the trend of our most robust data (A- and B-grades) is scattered, but contours show a dominant 118° strike and 65° dip. Rose plots (Figure 6) of the greater data set (A-, B-, C-grades) reveal three predominant strike directions: 45°, 90°, 120°. The 118° from the stereonet and the 120° from the rose plot are roughly parallel to the general trend of boundary faults and magmatic trend in the Southern Oklahoma Aulacogen. These results indicate that rift-induced stresses influenced emplacement of the dikes. The rose plot also reveals that the dike trends are scattered, with examples in every 10° bin. This may reflect local stress fields present during diking, perhaps influenced by the intrusion or cooling of the Quanah Granite.

Conclusions

The Quanah Granite pluton produced dozens of dikes into the Glen Mountains Layered Complex on its north margin, now exposed as in-place outcrops and weathered rubble in the Central Lowlands adjacent to West Cache Creek. We produced a novel, detailed map of these features. Once mapped, we used Brunton measurements and 3-point analysis to accurately ascertain orientations for 17 dikes. We used these data along with general trends from another 16 dip-unconstrained dikes to evaluate significant attributes of diking geometry. Stereographic and rose diagrams revealed a portion of the dikes are a response to the extensional stress present during the formation of the Southern Oklahoma Aulacogen.

Acknowledgements

The authors wish to thank Brandy Moody and Alex Weiskircher for extensive assistance with fieldwork. We thank the Wichita Mountains Wildlife Refuge for sampling and work permits. We also thank the MSU EURECA undergraduate research program and the Perkins-Prothro Foundation for funding this study.

References

Allmendinger, R. W., Cardozo, N. C., & Fisher, D. (2013). *Structural Geology Algorithms: Vectors and Tensors*. Cambridge: Cambridge University Press.

Gilbert, M. C. (2014) The Wichita Mountains in Oklahoma: Their Story Through Time, Oklahoma Geological Survey, Guidebook 39 p.