USING MAGNETICS TO APPROXIMATE THE RELATIVE AGE OF MAFIC SILLS WITHIN DAGGER MOUNTAIN IN BIG BEND NATIONAL PARK, TX

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Abstract

- The main goal of this project was to obtain additional magnetic surveys of mafic sills located at Dagger Mountain in Big Bend National Park, TX in order to better determine the shape of the sills in relation to the surrounding bedrock. By understanding the shape of the sills, we will be able to interpret the relative age of the intrusions. According to Cullen et al, (2013), it was believed that the intrusions were tertiary aged and had been folded with the Cretaceous aged sedimentary layers during the Laramide Orogeny (~70-50 MA) since the orientations of the sills appeared to resembled the orientation of bedrock at map scale. However, a study conducted by Mata and Lehto (2014) used magnetic surveys of one sill in Dagger Mountain to conclude that the mafic stills were in fact not folded with the surrounding bedrock and instead appeared to be flat lying and intruded through the folded bedrock. Since the sills did not appear to have been folded with the Cretaceous age sedimentary bedrock, Mata and Lehto (2014) concluded that the sills were emplace post Laramide (~50-70 MA). Our study aimed to collected additional magnetic data over other sills in the Dagger Mountain area to compare to the previously collected data. In addition, there were several lines of magnetic data collected for the previous study that had not been modeled and as such we have included that data in our study.
- We collected data in the Fall of 2016 with the assistance of the geophysics course at Angelo State University. The new data and data from the previous study will be modeled and we expect to find similar results to the Mata and Lehto (2014) study; namely that the sills are flat-lying and intrude through the folded sedimentary rocks at the site and are thus post-Laramide.

Background

- Our research is located at Dagger Mountain, within the sierra del Carmen Mountain Range in Big Bend National Park. Our research area went through significant geologic changes throughout its history. The study area is underlain by Boquillas limestone of Cretaceous age (145.5-65.5 million years), intruded by mafic sills (magma that has risen from depth and been laid down laterally between layers of rock). The mafic sills are believed to be from the Trans-Pecos volcanic field, which was active between 50-17 million years ago (Moustafa 1988). The mafic sills that are the focus of this study are mapped as the same age as mafic sills found in Dagger Flats nearby, which have been dated to ~32 million years (Morgan and Shanks, 2008). However, the sills in our study area have not been dated and thus cannot be confirmed to be the same age as those in Dagger Flats (Cullen et al., 2013).
- Mapping conducted by students and faculty at ASU (Cullen et al., 2013) shows the Dagger Mountain intrusions are folded with the Boquillas limestone, which was deformed during the Laramide orogeny (~70-50 million years ago in BBNP). However, if the Dagger Mountain sills are indeed folded with the Boquillas limestone then they must be as least 70-50 million years old (intruded before the Laramide Orogeny) and thus are not the same age as the Dagger Flats intrusions (~32 million years).
- Mata and Lehto (2014) modeled a single profile for the same area and found that the intrusion is most likely flat, and not folded as is suggested by outcrop observations.

Objectives

- Construct a 3D model of the magnetic data collected by Mata and Lehto (2014) using IGMAS+ software.
- Interpret the 3D model in order to determine the geometry of the mafic sills at Dagger Mountain.
  - The model shows the sills parallel to, and folded along with the local bedrock.
- Determine the relative age of the sills, based upon the geometry.

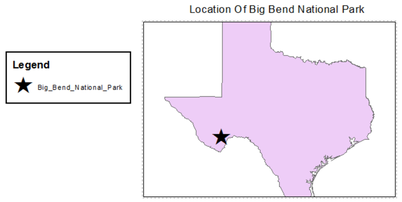


Figure 1. Map of the study area, Big Bend National Park.

Methods

- Data was collected using a GB89 Magnetometer & GPS in December of 2014 by Mata and Lehto (2014). The survey was over the mafic sills at Dagger Mountain in Big Bend National Park, Texas.
- IGMAS+ software was utilized to create a 3D block model of the map area using map data collected by Cullen et al. (2013).
  - The block model shows the mafic sills as parallel to and folded along with the Boquillas limestone.

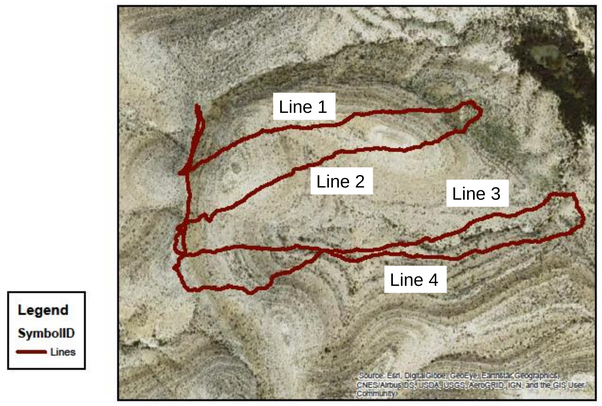


Figure 2. Map of magnetic survey lines collected by Mata & Lehto (2014) and used in this study.

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter
Units: Meter

Results

- The 3-D magnetic data collected by Mata & Lehto (2014) is shown on the figure 5. As expected, the magnetic data show a significant increase where the sills outcrop at the surface.
- Figure 3 shows the magnetic anomaly data collected during the magnetic survey in 2014 in map view.
- While figure 4 shows the calculated magnetic model based on the geology of the project area as mapped by Cullen et al. (2013).
- The modeled magnetic anomaly (figure 4) for the sill geometry as a syncline folded along with the Boquillas limestone clearly does not match the magnetic data collected in 2014.

Acknowledgments

We would like to thank the undergraduate student research program for funding our research. The geophysics course of 2016 was also important in helping us to collect data in the field. We would also like to thank Big Bend National Park in allowing us to conduct research in the area. We would also like to thank Dr. Lehto for her invaluable insight and assistance. Many thanks goes out to all the help and support we have received from the above mentioned.

References available upon request.

Results

- This is a map view of the magnetic anomalies for both the collected and modeled data for the mafic sills at Dagger Mountain.

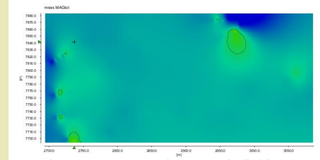


Figure 3. Measured, magnetic field anomaly map

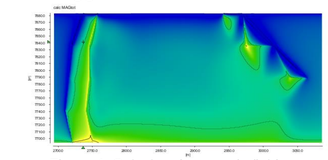
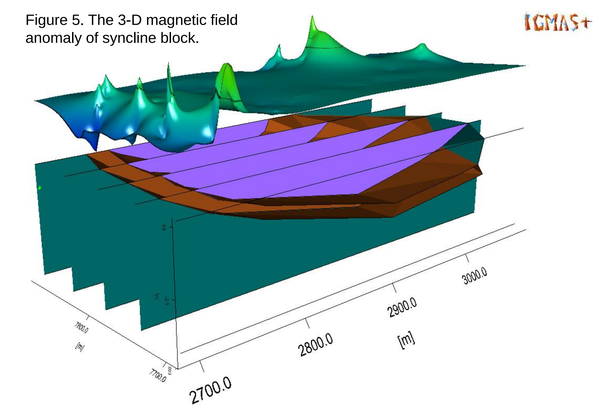


Figure 4. Calculated magnetic field anomaly map

Figure 5. The 3-D magnetic field anomaly of syncline block.



Conclusions

- When comparing the measurements that Mata & Lehto(2014) gathered in the field (figure 3) to the synclinal model (figure 4), we can say that the mafic sills are not parallel to the bedding of the Boquillas Limestone.
- By coming to this conclusion we can show that the mafic sills must be younger than ~50 million years. They have to be part of a different event that post dates the Laramide Orogeny.

Future Development

- For further research, an alternative 3D model can be created that accurately fits the magnetic data gathered from the field. This will provide a definite interpretation of the structural shape of the mafic sill.
- An additional magnetic survey was collected by Mata & Lehto in 2014 at another sill in the Dagger Mountain area and should be modeled in a similar way as is presented here.
- In addition to the magnetic surveys that were conducted, resistivity surveys may also be useful in aiding the interpretation of the geometry of the Dagger Mountain sills as it can provide an alternate perspective on the given area.
- It would also be very helpful to radiometrically age date the Dagger Mountain sills to obtain a much more accurate, numerical date.