The Relationship of Faults and Springs in the Ramuschaka Watershed in Zurite, Peru

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Abstract

The town of Zurite in Andenes, Peru is an agricultural community that acquires a vast majority of its water for farming from the local Ramuschaka watershed. Understanding how water moves in and out of this watershed is key to developing a water budget (how much water can actually be used) and implementing constrictive water use practices and storage methods. Faults can affect the water flow through watersheds by creating conduits to bring water to the surface and create springs or take water away (Rowland et al., 2008, Aghai and Ghoreishi, 2008). We analyzed the relationships between faults and springs in the Ramuschaka watershed. Unfortunately, our results are inconclusive as data is too inconsistent to make inferences from. Further data collection and re-analysis will be needed before any definitive conclusions can be drawn.

Introduction

The town of Zurite in Andenes, Peru is an agricultural community that relies on the local watersheds of the area as their main source of water for farming and a partial source for drinking water; the largest watershed in the surrounding area is the Ramuschaka watershed. Understanding how water moves in and out of the Ramuschaka system is essential to narrowing down the water budget (how much water can actually be used) of Zurite and implementing sound water use practices in wet and dry seasons and storage methods within the community of Zurite. The goal of this project is to use the skills learned thus far through this semester to help assess whether mapped spring locations within the Ramuschaka are consistent with the inferred geologic faults mapped within the watershed. Geologic faulting can be beneficial to groundwater occurrence, however, the presence of faulting can just as likely cause a negative impact on groundwater storage as the new space can provide a conduit for water to emerge or provide a new space for water to descend (Rowland et al., 2008, Aghai and Ghoreishi, 2008). Springs can crop up when "fractures consisting of joints, bedding planes, columnar joints, openings due to cleavage, fissility, schistosity, cross-bedding planes, and faults in impervious sedimentary, igneous, and metamorphic rocks" create openings and weak points that water can travel through - these types of springs are called fracture springs (Bryan, 2018).

Figure 1. – Locator map of Zurite, Andenes, Peru with the Ramuschaka watershed outlined in red.

Methods

In-Field:

The data utilized in this project was collected in July of 2018 in Zurite, Peru by a team of geology students and geology graduate students lead by Professor Jasper Oshun of the Humboldt State University Geology Department and Professor Margaret Lang of the Humboldt State University Engineering Department. Using a georeferenced topographic base map of the watershed individual geologic maps were interpreted in the field by Professor Jasper Oshun, Jared Walbert, and Olivia Helprin. Within these maps 6 different geologic units were interpreted and mapped based on changes in the geology, strike and dips of bedding were taken, fault and depositional contacts were inferred, and anticlines and synclines were mapped. Spring locations were mapped by Jared Walbert, Olivia Helprin, Wyeth Wunderlich, and Emily Santos using a handheld Garmin GPS (global positioning system) and an RTK (real-time kinematic) GPS.

In-Lab:

The geologic maps were converted in ArcMap from PDF format to tiff format for use within ArcMap. The georeferenced topographic base map that the geologic maps were developed on in-field was used to georeference the created geologic maps by Oshun, Walbert, and Helprin. Once properly georeferenced the geologic maps were then digitized. To begin, the geologic units: P-mu (red), P-mu (green), Kis-ma, Qal, Qcl, and PN-cot/gd, were digitized as polygons and re-colored to match the original mapping. The strikes and dips were then digitized as polylines, once these polylines were all created, we added a new field, “Dip”, to the attribute table associated with the strike and dip features. This field was then filled in with the in-field recorded dip measurements for each feature and was used to label the features on the digitized map. Then the precise locations of the contacts were digitized as a black polyline and the inferred/approximated locations of the contacts were digitized as a dashed black polyline feature. Following this the fault contact locations were digitized as a red polyline feature and the inferred/approximate locations were digitized as a dashed polyline feature. Then the axial trace of the anticlines and synclines were digitized as a purple line with arrows out (anticline) or in (syncline). Each of these steps were repeated for the individual geologic maps. For the maps created by Oshun and Walbert a normal fault was digitized as a red polyline feature expressed by a line with circles on it. On the digitized Oshun map a thrust fault was digitized as a red polyline feature expressed by a line with perpendicular lines pointing in the direction of the faults dip direction and igneous dykes were digitized as orange polylines with shorter perpendicular crossing lines. Then the springs were placed into the map via a CSV file of the latitude (Y) and longitude (X) locations of each spring by placing the file into ArcMap and displaying the XY data. Finally, we used the buffer tool to analyze how many springs fall within a 50 meter radius of any type of fault or inferred/approximate location of any type of fault on each geologic map. We then used the selection tool to select any of the springs partially or fully within the fault buffer zone to count how many springs fell within the fault buffer zone of each geologic map.

Results

The outcome of our individual analyses of the spring locations within each geologic map was Jasper Oshun’s map having one spring within the 50 meter fault buffer boundary (fig. 2). Olivia Helprin’s map contained four springs within the 50 meter fault buffer boundary (fig. 3). Jared Walbert’s map contained no springs within the 50 meter fault buffer boundary (fig. 4).

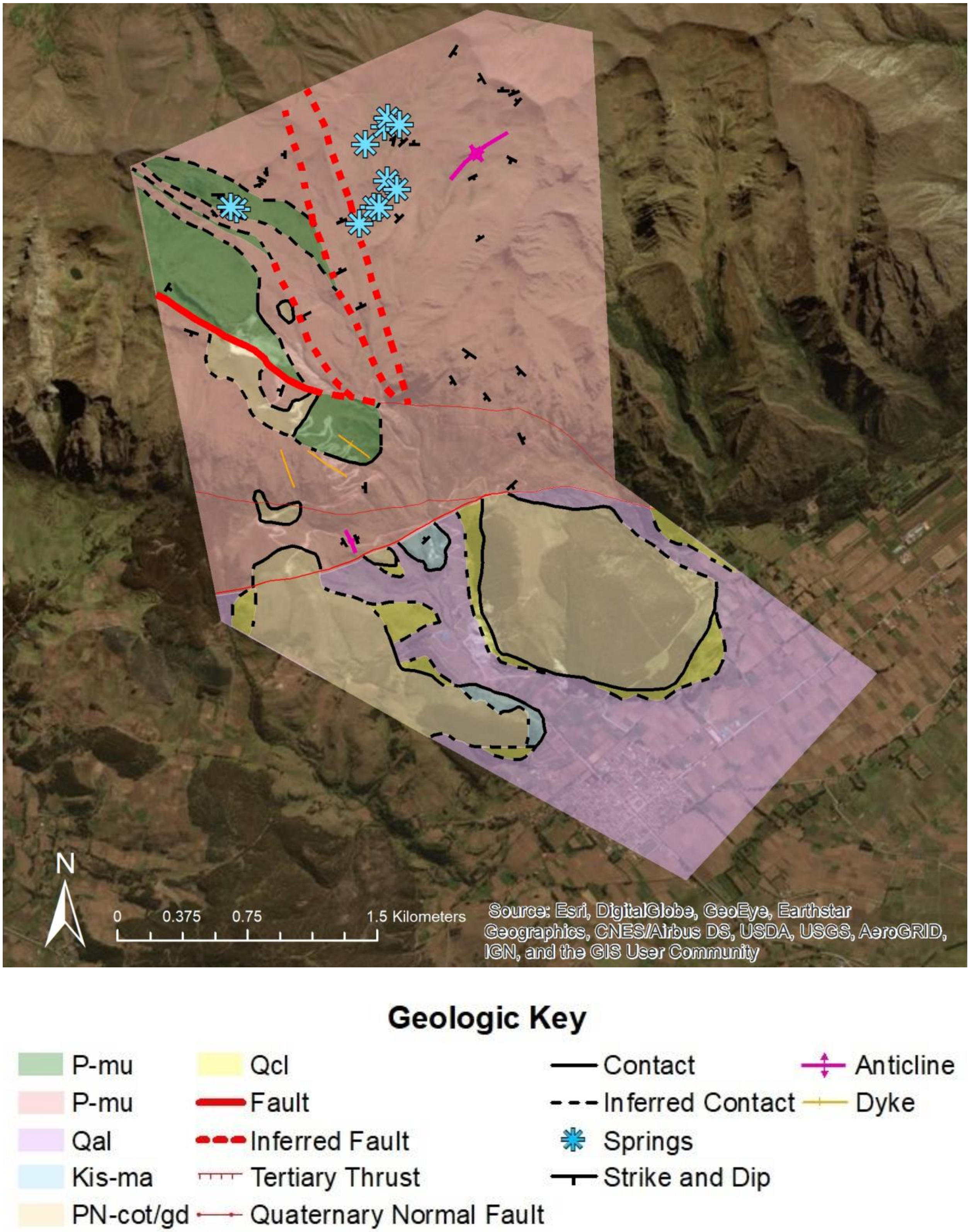

Figure 2. – Top: Digitized geologic map of Jasper Oshun's field map. Bottom: Geologic key of the different geologic units, faults, contacts, springs, strike and dips, anticlines, and dykes. 1

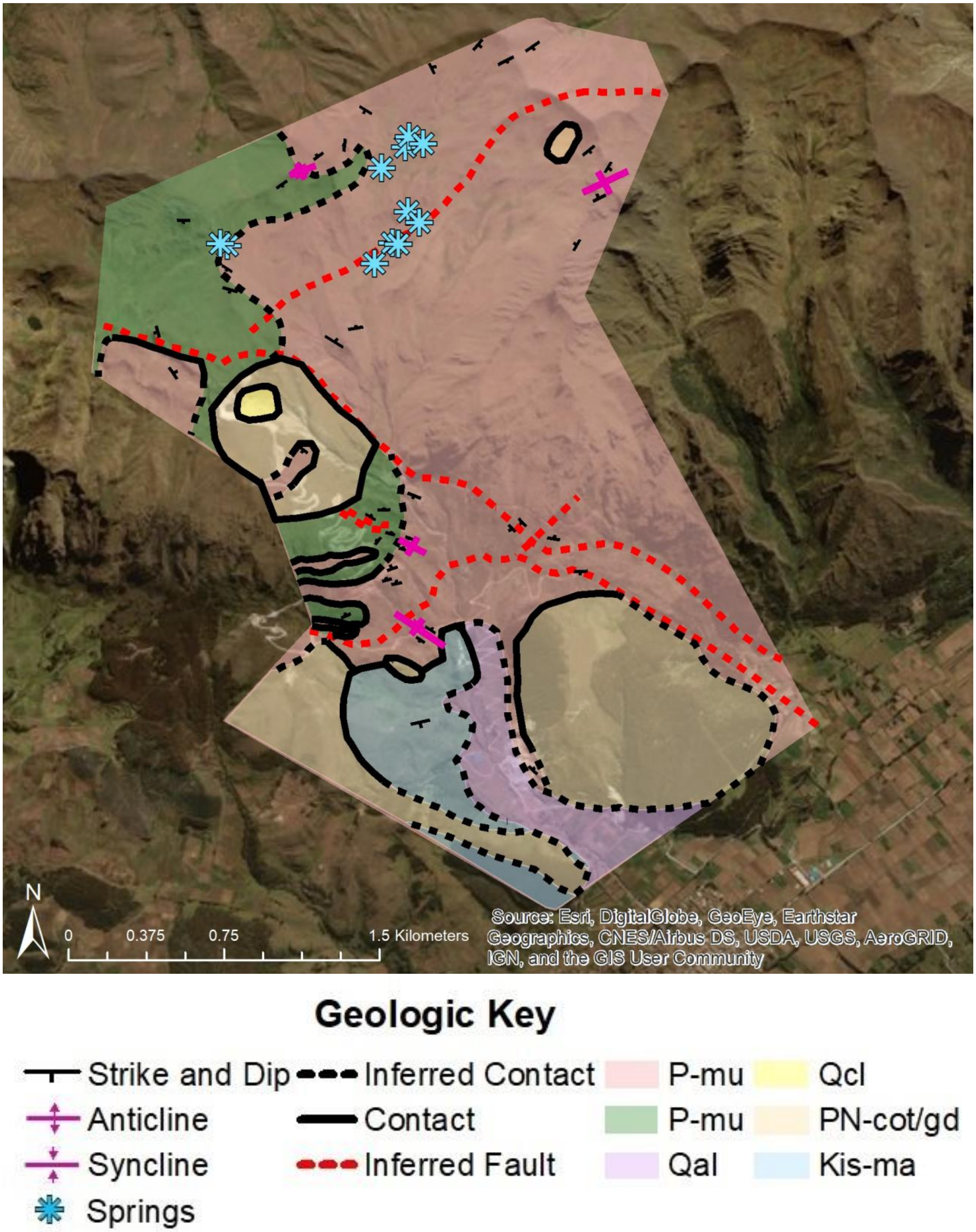

Figure 3. – Top: Digitized geologic map of Olivia Helprin's field map. Bottom: Geologic key of the different geologic units, faults, contacts, springs, strike and dips, anticlines, synclines, and dykes. 4

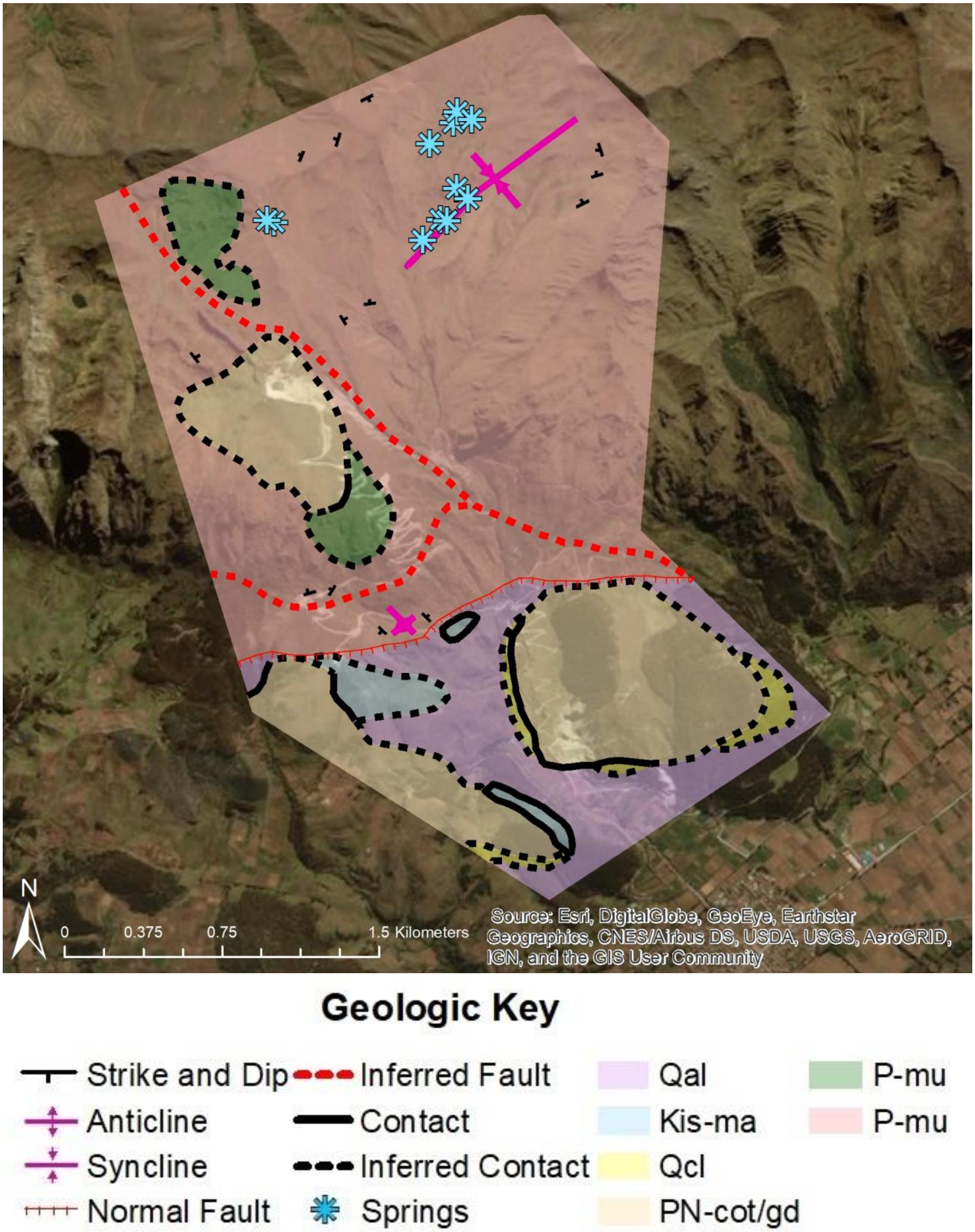

Figure 4. – Top: Digitized geologic map of Jared Walbert's field map. Bottom: Geologic key of the different geologic units, faults, contacts, springs, strike and dips, anticlines, synclines, and dykes. 0

Conclusion

Understanding the factors that provide an influx of water as well as the factors that remove water from the system is key to helping define the water budget of Zurite. Using the geospatial analysis skills acquired over the past semester we analyzed the relationship of the faults and springs within the Ramuschaka watershed. Unfortunately, the data is too inconsistent to draw any sort of strong overall conclusion on the Ramuschaka watershed and the relationships between the faults and springs within the region. The first issue is that all three digitized maps are significantly different from one another. Second, the spring locations were partially taken with a Garmin handheld GPS which can have accuracy an error of up to 10 m. Lastly, the results of the analyses from each map are inconsistent. The digitized maps produced by Jasper Oshun and Jared Walbert both indicate that there is not a strong relationship between faults and the production of springs. Olivia Helprin's map is the only map that provides any sort of correlation between the fault locations and spring production, however, this correlation is still weak as it only connects with four out of the eleven mapped springs.

A continuation of data collection and recollection of previous data with consistent methods, re-mapping the geology, and a re-analysis of this new data would provide a stronger conclusion regarding whether the faults in the Ramuschaka watershed do or do not have a relationship with the springs in the region.

Acknowledgements

We would like to thank Professor Jasper Oshun and Professor Margaret Lang of Humboldt State University for spearheading this project. In addition, we would like to thank Olivia Helprin, Jared Walbert, Emily Santos, and Wyeth Wunderlich for their data contributions to this project.

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