Using publicly available national geoscience and geochemical geographic data sets to predict the probable presence of the rare blue tourmaline Paraiba in the United States

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Introduction

Tourmalines are boron aluminosilicates that occur in crystalline igneous rocks, particularly pegmatites. Paraiba is a species of tourmaline, also known as elbaite tourmalines, that get their vivid blue color from traces of copper. Paraiba tourmalines are uncommon because the "crystal zones where they form are distinguished by not only high copper content, but also higher values of lithium and fluorine, iron values near zero, and lower concentrations of manganese" (Beurlen and others, 2011)

Geographic data will be used to generate maps utilizing ArcGIS Pro to predict the presence of this rare gem in the United States. First, maps of concentrations of boron, copper, lithium, fluorine, iron, and manganese across the United States will be produced. From there, focusing on one region or state that possesses qualities that could sustain the existence of this precious stone will create a more focused investigation and the ability to find finer data supporting igneous activity. Research will also be conducted on the active tourmaline mines in this chosen region and predictions will be made on where to explore next.

Background

Paraiba tourmaline is a rare gemstone originally found in Paraiba Brazil in 1989. The very specific factors that host the environments that can create and preserve this mineral are limited making it one of the most valuable forms of tourmaline, considered rarer than a diamond costing upwards of $20,000 per carat. A lot of extensive research has been conducted surrounding this topic including Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and Electron Microprobe Analysis (EMPA) to determine chemical composition of different tourmalines as well as examining the different environmental factors that provide a suitable condition to produce and maintain this precious mineral.

The environmental factors that host Paraiba tourmaline are quite specific and rare, making it a semiprecious gemstone. Intensity of color and uncommon host environments are the main reason this type of tourmaline is so expensive and exclusive. Many scientists that have studied this gem agree that the vibrant blue coloration is due to copper content in the mineral. Many scientists examining this topic agree that pegmatites are crucial in the creation and conservation of tourmalines as well as other gemstones.

Prior Results

Beurlen et. al. (2011) state that "Paraiba tourmaline crystal-zones are distinguished not only by high Cu contents, but also by higher values of Li and F (mostly fluor-elbaite), Fe concentrations near zero, and lower concentrations of Mn than the contiguous zones with other colors" (Beurlen and others, 2011). Beurlen et. al.'s (2011) study implies that "Paraiba tourmaline-bearing pegmatites are rich in spodumene [or lepidolite] and are emplaced in iron-poor quartzites or meta conglomerates" (Beurlen and others, 2011), while also arguing that the rarity of this gemstone could be due to spodumene or lepidolite replacing the tourmalines in late-stage mineral conversion. Katsurada et. al (2019) infer that Paraiba-type tourmalines were "formed by direct crystallization from a hydrous melt, rich in boron and lithium with an unusual concentration of copper prior to the appearance of secondary lepidolite and other late hydrothermal minerals" (Katsurada and others, 2019). Beurlen et. al. (2011) observed that "all Paraiba tourmaline-hosting pegmatites have maximal thicknesses less than 20 meters" (Beurlen and others, 2011) and Katsurada et. al. (2019) agree that "most of Brazil's Paraiba tourmaline mining sites are primary deposits in pegmatites that intruded quartzites or meta conglomerates between 530 and 480 million years ago" (Katsurada and others, 2019).

The LA-ICP-MS and EMPA results from the Brazilian samples in Katsurada's (2019) study include an average copper content of 11,400 ppm with a range of 119 ppm to 38,800 ppm. Ertl's (2012) table 1 shows that the studies on the Brazilian samples display a range of 2,063 ppm to 14,180 ppm copper. They also state that "Cu-bearing tourmalines from Brazil exhibit relatively low Pb contents (up to about 95 ppm) and sometimes significant amounts of Mg (up to about 1200 ppm)" (Ertl and others, 2012). Okrusch (2016) study shows that the blue tourmaline samples from Brazil contain a value of 93,100 ppm to 108,000 ppm boron-oxide, 23,000 ppm to 29,000 ppm manganese-oxide, about 321,000 ppm iron-oxide, 11,700 ppm to 18,700 ppm lithium-oxide, 19,700 ppm to 20,900 ppm fluorine concentration, and 3,200 ppm to 20,000 ppm copper content.

Work Plan

Data from the USGS Mineral Database will be used to create maps of the United States that could potentially host the rare environment for Paraiba tourmaline to form. The USSOILS dataset was downloaded and specific attributes, or elements in ppm, were separated from the original data and made into their own layer. Finding information on pegmatite data and hydrothermal activity and adding it to the USSOILS data will also occur. The pegmatite data will be specified to be 20 meters or less and of the age between 530 and 480 million years old. Projecting all the layers to Lambert Conformal Conic will take place while also quality checking the data and making sure all the values are in appropriate format. After that, each vector layer will be transitioned into a Raster Layer using the Kriging method. Once that is complete, the specific ppm values from the researchers in past results will be considered as well as the pegmatite and hydrothermal data. By using a raster calculator to combine all the layers and their specific values, a new raster will be created showing the areas where this specific environment may occur. Finally, one of those areas will be chosen to concentrate on and the process will begin again. This procedure will occur until a map of high detail and quality is constructed and ready for the final draft of the poster project.

Timeline

January 17 to January 29 was dedicated to choosing the research topic as well as finding data on the USGS Mineral Database of elemental concentrations in soils in the United States. Meetings with Dr. Parr and Dr. K also occurred to further the understanding of the project and data found. January 29 to February 7 was used to create a research question and complete the research contract establishing what the research was going to concentrate on as well as the format that would be used to present it. February 7 to February 26 was devoted to researching past studies on this topic and producing a literature review, giving further background, and understanding to this subject. February 26 to March 3 is dedicated to writing a research prospectus, giving a more detailed timeline and work plan for the project. March 5 to April 9 will be more focused on using ArcGIS Pro and the data retrieved from the USGS Mineral Database to create the maps needed for this project. The goal is to complete the Kriging method on the data currently collected and utilize a raster calculator to determine a more specific area of the US to focus on. Once that portion is completed, the data will be concentrated in that area that was chosen and additional maps will be created. April 9 to April 27 will be centered on constructing the first draft of the poster for this research project and the complete maps from ArcGIS Pro. April 27 to May 9 will be dedicated to receiving feedback from peers and editing the first draft of the research project to complete the final draft of the poster.

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