Mapping Geochronological Data of Rock Formations Across the Southeast U.S.

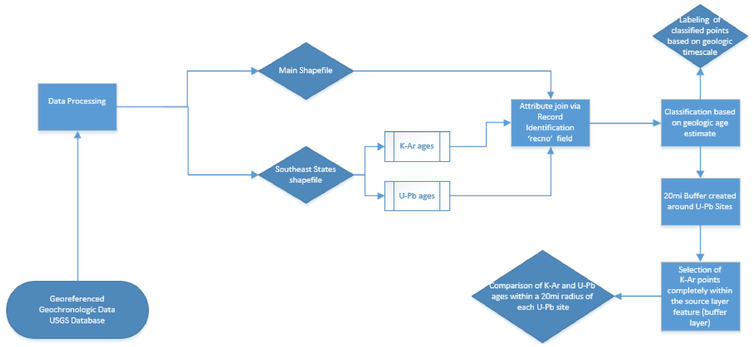
Jade-Ashley Carberry

Earth and Environmental Science Department Furman University, Greenville, SC 29613

Abstract

The primary objective of this project is to map the geochronological data of various rocks across the south east based on location, age, geochemistry and type of geochronological analysis used (various radiometric isotope systems). Through this visualization, an understanding of the tectonic history of various rocks in this area can be obtained and through this, a determination of the distribution of Precambrian rocks across this area can be obtained. Secondly, the work of such an analysis will also allow for the discovery of various patterns amongst the rocks in this area, for example patterns which may exist in the rock types as well as in the progression in age of these rocks. This research also seeks to uncover the relationships which may exist between the Precambrian rocks of this area and the younger rocks which they are surrounded by, in order to determine if the geology and tectonic history of this area is more significantly grounded/based on geochemistry versus structural processes. Using GIS as a tool for analysis of geochronological data from the national USGS database effectively creates the advantage of examining tectonic events through the lens of time, thereby allowing for observation of the patterns which may exist between the rock types of various ages.

Methods

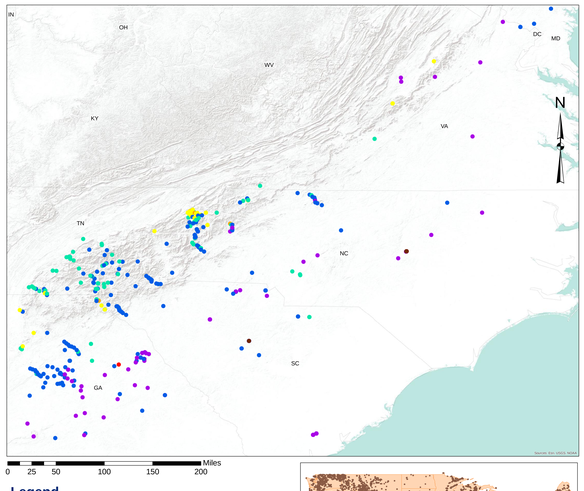


In order to initiate this research project, georeferenced geochronological data was first obtained through the USGS Geochronologic Database. This data included shapefiles of all the sites where radiometric dating was carried out across the United States. An attribute join was then performed between this main shapefile and database files (also obtained from USGS) that contained the radiometric ages determined by each dating mechanism. After the points of interest and their corresponding ages were isolated for each dating mechanism, a manual classification of these points was completed in order to label each point based on an age consistent with the geologic timescale. A buffer with a 20 mile span was then created around each U-Pb dating site, in order for effective comparison of the relative ages obtained from each mechanism within a specific area.

Results

Maps showing the calculated age estimate (in millions of years) of various rock formations in the Southeastern United States, based upon both K-Ar as well as U-Pb dating.

Geochronology of the Southeastern US
Potassium- Argon Radiometric Dating

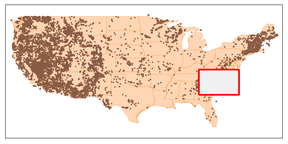


Legend

K-Ar dating sites

geologic age & period

- 0-65 Cenozoic period
- 65-260 Mezosoic period
- 259-374 Paleozoic Era- Acadian
- 375-540 Paleozoic Era-Taconic
- 541-999 Neoproterozoic period
- 1000-1599 Mesoproterozoic period
- 1600-2000 Palaeoproterozoic period



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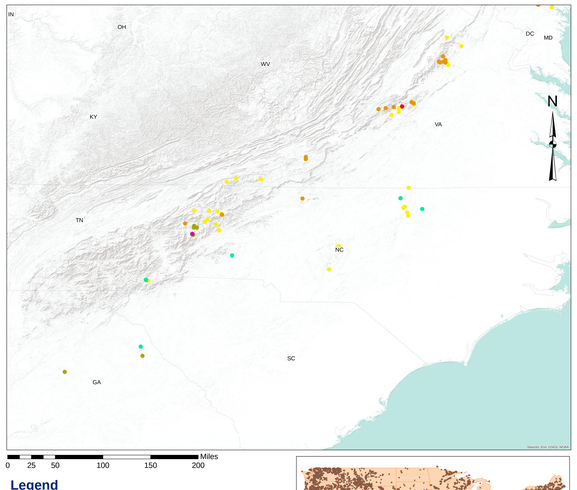
Map 1- showing the calculated age estimate (in millions of years) of various rock formations in the Southeastern United States, based upon Potassium-Argon radiometric dating analysis.

Geochronology of the Southeastern U.S.
Uranium-Lead Radiometric Dating



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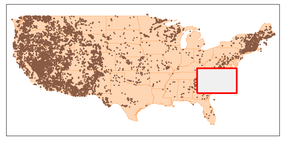
U-Pb dating sites

geologic age & period

- 248-260 Permian Period
- 261-325 Paleozoic Era (Alleghanian)
- 326-425 Paleozoic Era (Acadian)
- 426-541 Paleozoic Era (Taconic)
- 542-999 Neoproterozoic period
- 1000-1599 Mesoproterozoic period
- 1600-2000 Palaeoproterozoic period



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Map 2- showing the calculated age estimate (in millions of years) of various rock formations in the Southeastern United States, based upon Uranium-Lead radiometric dating analysis.

Discussion

The continent of North America was formed over billions of years, and various geologic processes still continue to shape it today. All of the mountain ranges across the globe were built millions of years ago during events called orogenies, which operated in repeated 'bursts' of activity through time. The Grenville orogeny was a long-lived Mesoproterozoic mountain-building event that is associated with the assembly of the supercontinent Rodinia via the collision of 3 or 4 existing continents. It is this orogenic event (1090-980 Ma) that marks the beginning of the formation of the Appalachian Mountains we see today. Since the Grenville orogeny, the Appalachians have been shaped by many other periods/ episodes of mountain building.

In each of these various mountain building events that led to the formation of the Appalachians, beginning with the Grenville orogeny through to the Alleghanian orogeny, material has been recycled from the previous orogenic episode and used within the subsequent tectonic event. As such, it is expected that the rocks which exist in the Appalachians today contain Grenville-age material and younger. However, the premise of this research lies in the mystery which has arisen as a result of the presence of a set of rocks that are trapped within the Appalachians that pre-date the Grenville orogeny (fig 2).

An advancement in modern technology in recent years has allowed for the formation of a rapidly expanding geochronological database, which has thus led to significant advances in understanding the geochronology and tectonic evolution of various regions and the similarities and differences which may exist between them. These rocks of interest in this research (represented as the black areas on the map in figure 2) are essentially "too old", as their age suggests that they belong to the Precambrian, Mesoproterozoic era (~1,600-1,000 Ma) and thus could not have been incorporated in the Grenville orogeny. The results from this research indicate the presence of rocks of this era which is in general consistent with the locations of these Mesoproterozoic inliers proposed by Karlstrom et al (figure 2). The results also confirm the presence of a small amount of rocks which exceed 1600 Ma. Results from the comparison between these two dating techniques indicate that the Ur-Pb radiometric ages are generally older than the surrounding K-Ar ages, within a 20 mile radius.

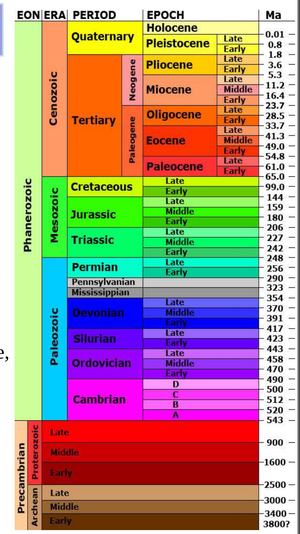


Figure 1 (above) The geological time scale as a system of chronological dating. Showing the various eras mentioned in the text alongside the corresponding time period in millions of years from present.

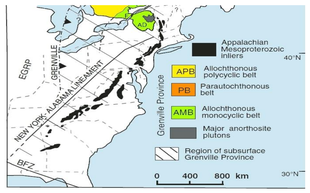
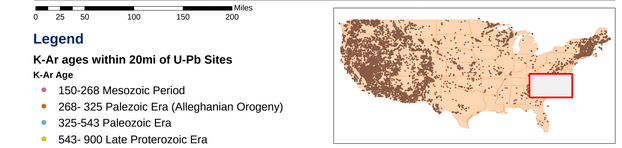


Figure 2 (left) showing The extent of the Grenville Orogeny in eastern North America and the Mesoproterozoic inliers of the Appalachians which are designated in black.

Geochronology of the Southeastern U.S.
Uranium-Lead Radiometric Dating



Legend

K-Ar ages within 20mi of U-Pb Sites

K-Ar Age

- 150-268 Mesozoic Period
- 268- 325 Palezoic Era (Alleghanian Orogeny)
- 325-543 Paleozoic Era
- 543- 900 Late Proterozoic Era
- 900- 1270 Middle Proterozoic Era

buffer - 20 mile radius

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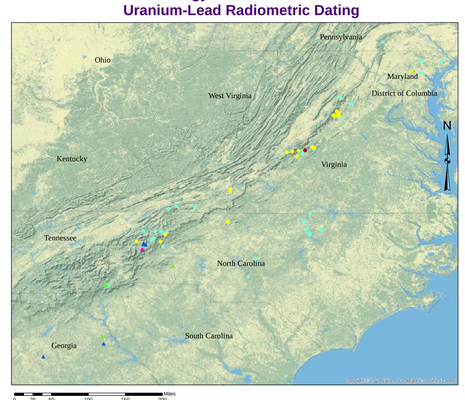
Map 3- showing the calculated age estimates (in millions of years) of various rock formations in the Southeastern United States, through a comparison of Uranium-Lead radiometric ages (indicated by triangles on the map), and Potassium-Argon radiometric ages within a 20 mile radius of each Uranium-Lead site.

Geochronology of the Southeastern U.S.
Uranium-Lead Radiometric Dating



Legend

U-Pb dating sites

geologic age & period

- 248- 260 Permian Period
- 261-325 Paleozoic Era (Alleghanian)
- 325-425 Paleozoic Era (Acadian)
- 425-480 Paleozoic Era
- 480- 979 Post Grenville
- 980-1299 Grenville
- 1300-1499 Picuris
- 1500-2000 Yavapi Mazatzal

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Map 4- showing the calculated age estimate (in millions of years) of various rock formations in the Southeastern United States, based upon Uranium-Lead radiometric dating analysis, specifically distinguishing between the rocks older than 480 Ma.

Conclusion

Through the analysis of this data, I was able to look at tectonic events through the lens of time and observed the patterns which may exist between the rock types of various ages. Various geoprocessing tools such as the buffer tool were used to create a buffers around the area in the southeast with the highest concentration of Proterozoic inliers. Although the value of these geoprocessing has proven to be undisputed, further investigation of this geochronologic data, in combination with sampling and observations in the field, will allow for the generation of a more comprehensive answer to the question of how or why these older rocks are present in this matrix of younger rocks in the Appalachians. This will in turn help to gain an understanding of the geologic history of the region, in an effort to answer the larger question of how and when different parts of North America formed.

References & Data Sources

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