Construction of a Digital Geologic Map and Interpretation of the Tectonic and Geomorphic History of Upstate South Carolina

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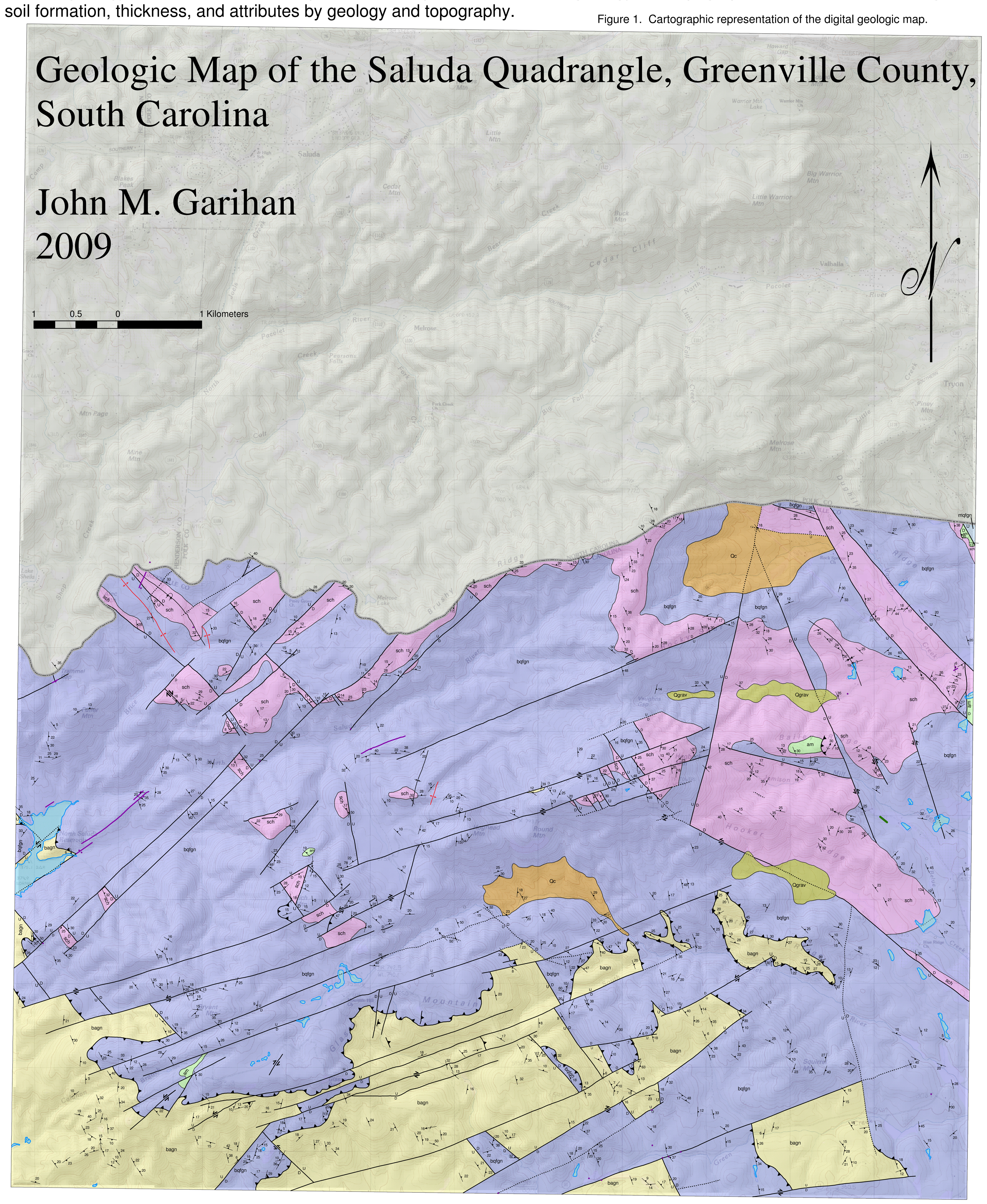
I. Abstract

Recent advances in GIS technology have improved analytical capabilities and access to data for both mappers and map users (Soller 2000). Recognizing the advantages of digital geologic map data, the South Carolina Geological Survey (SCGS) has initiated a program of digital geologic mapping, which has to-date produced digital geologic maps of many quadrangles in the southeastern and south-central regions of South Carolina. In the northwestern corner of the state, some 15 quadrangles have been mapped at 1:24,000 scale along the state line, due to the efforts of field geologists and undergraduate students from Furman University (Garihan 2008) and the SCGS. Recent Mapping (2007-2009) by John M. Garihan has completed about 95% of the Saluda Quadrangle in north-central South Carolina, east of Landrum, SC. This geologic data was compiled into digital form for the SCGS. This is an important step in publishing the map for general distribution. A USGS topographic map of the Saluda Quadrangle containing geologic data collected in the field was scanned and digitized to GIS format using on-screen digitization method. Points with strike-dip measurements were plotted in the data set. A topology was created for the resulting vector data set and the attributes of specific features were stored in a geodatabase. Cartographic representation of the data was done in ArcGIS. Quantitative analysis of the brittle fault, fold, and seneca thrust orientations in the Saluda Quadrangle, and spatial analysis of SSURGO soil data, a USGS DEM, and the geology data illustrates the complex relationship between bedrock geology and topographic relief, and the resulting control of soil formation, thickness, and attributes by geology and topography.

Figure 1. Cartographic representation of the digital geologic map.



Legend

microbreccia float	silicified quartz-feldspar microbreccia in isolated locality
small spring or seep	
minor antiform	*arrow points along hinge, plunge is given*
minor s-fold	*arrow points along hinge, plunge is given*
minor synform	*arrow points along hinge, plunge is given*
minor z-fold	*arrow points along hinge, plunge is given*
strike/dip	*strike and dip of metamorphic or tectonic foliation in layered rock*
Quadrangle Boundary	
State Boundary	
antiform	
synform	
overturned synform	
oblique slip fault	*upthrown and downthrown blocks identified where known or inferred*
concealed oblique slip fault	*upthrown and downthrown blocks identified where known or inferred*
strike slip fault	*sense of motion given where known or inferred*
contact	
concealed contact	
thrust fault	
concealed thrust fault	
overturned thrust fault	
microbreccia	Brittle fault rocks - silicified quartz feldspar microbreccia and cataclasite
ultramafic body	
water shoreline	

Rock Units

Qc	quaternary colluvium
Qgrav	quaternary gravel
	Rocks of the Six Mile Thrust Sheet listed in order of metamorphic sequence
am	amphibolite
sch	schist, paragneiss, and amphibolite
mqfsgn	muscovite-quartzo-feldspathic gneiss, a metamorphosed felsic instrusive sill
bqfgn	biotite-quartzo-feldspathic gneiss
	Seneca Thrust
bagn	biotite-augen gneiss
Bodies of Water (2006)	Boundaries of water bodies are delineated from 2006 digital ortho-quarter quadrangle photos (DOQQs)

II. Methods

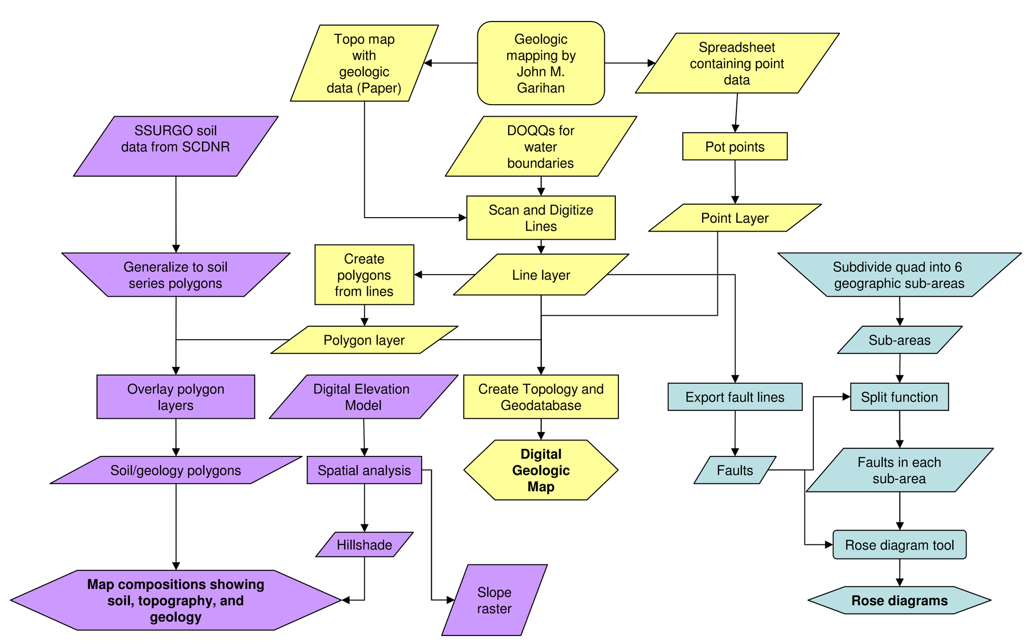


Figure 2. Flow chart explaining methodology. The project can be subdivided into three components. First, a geologic map was digitized (yellow elements). The geologic data was used to examine the orientations of faults (blue elements), and the relationship between geology and soils (purple elements). All digitization, analysis, and cartography was done in ArcGIS 9.3. The geologic map was digitized according to the methods of the South Carolina Geologic Survey.

III. Results of Analysis

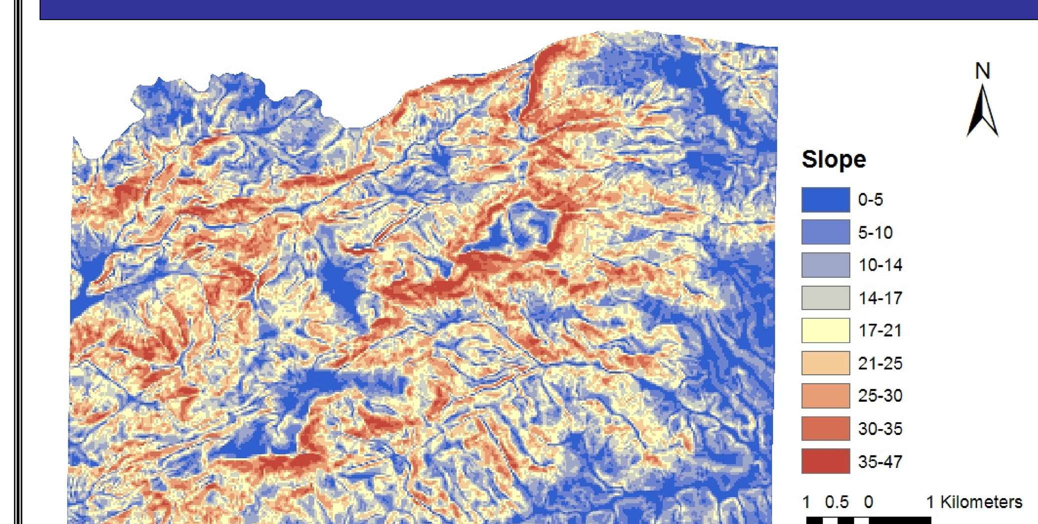
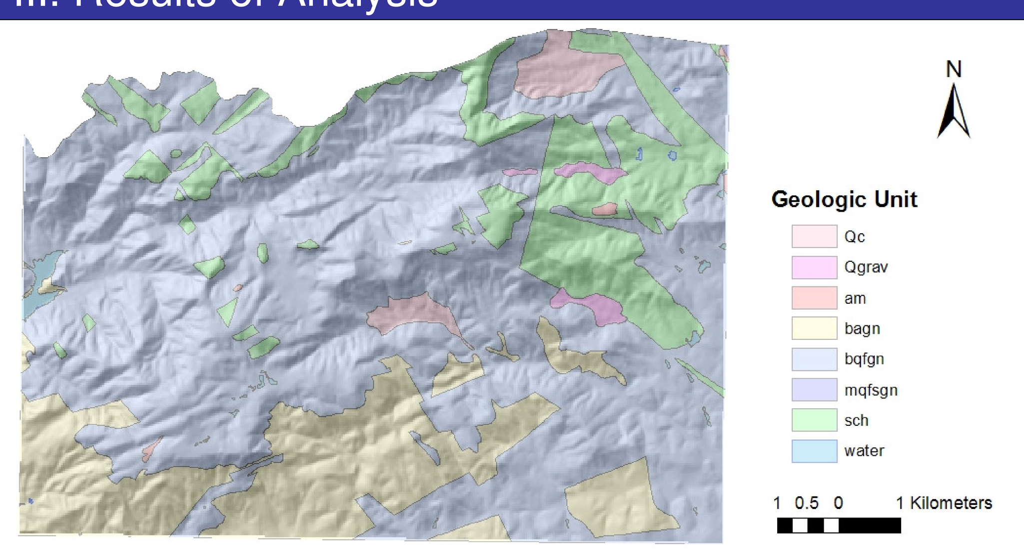


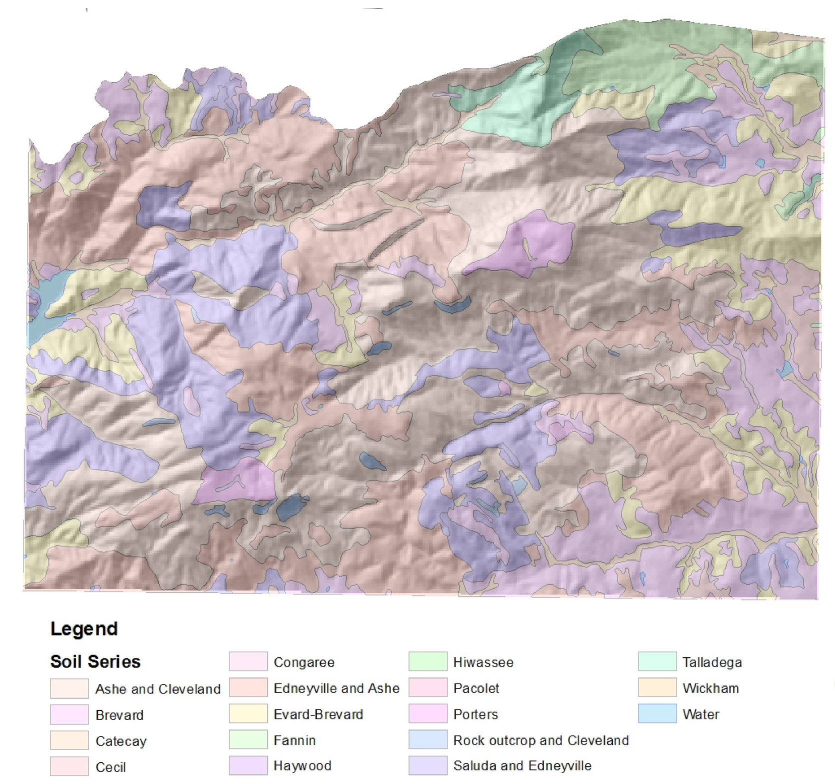
Figure 3 (left). Slope data for the Saluda Quadrangle produced from spatial analysis of a Digital Elevation Model in ArcGIS.

Figure 4 (right). Polygon layer showing geologic map units in the Saluda Quadrangle underlain by a hillshade map produced from the Digital Elevation Model.



Geology controls topography in a complex fashion. Often ridges and valleys follow geologic contacts (Figure 3), but faulting also produces surface relief (Figure 7, Garhian and Ranson 1989). The combination of differential erosion across geologic contacts and rate of uplift/subsidence on faults controls the topography of a region. The degree of topographic variation impacts the rate of erosion and sedimentation. To better locate areas of high slope, see the map of topographic slope in the Saluda Quadrangle (Figure 2).

Generalized Soil Map of the Saluda Quadrangle



Relationships between Geology, Soils, and Topography

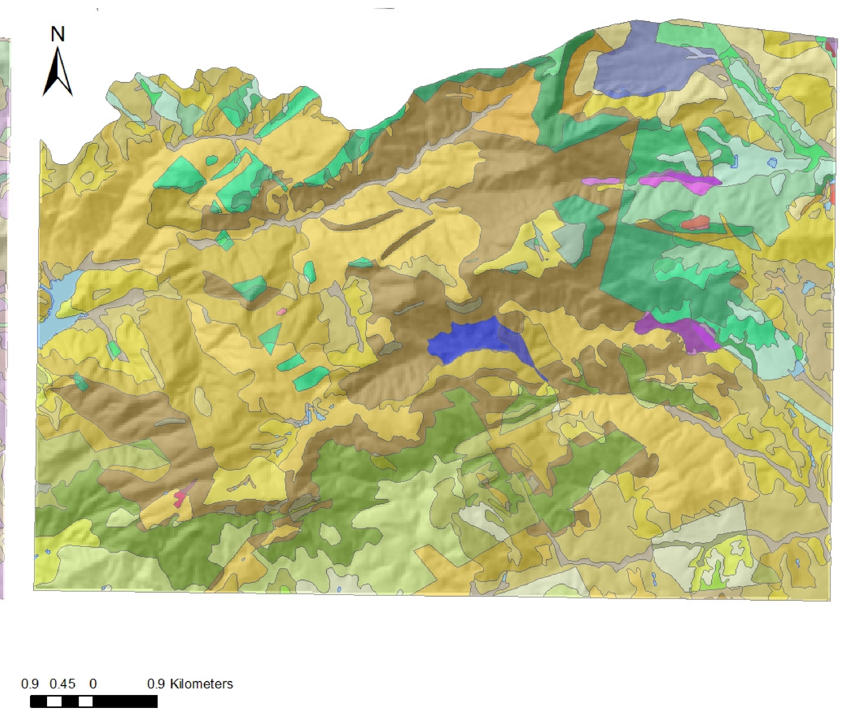
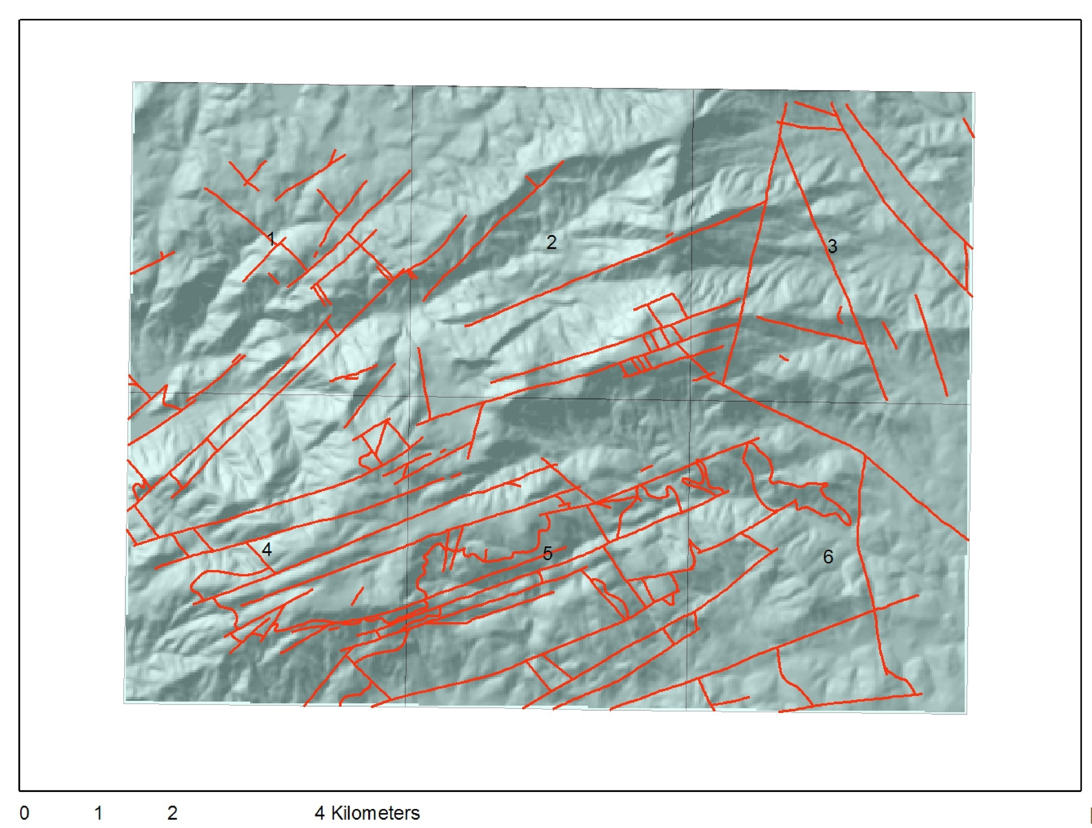


Figure 5. Map of the Saluda Quadrangle showing colored polygons representing each soil series defined by the Greenville County Soil Survey (Natural Resources Conservation Service, 1972).

Figure 6. Overlay of the soil series polygons and the geology polygons. Geologic units are shown as unique colors, different soil series are shown as varying shades (lighter or darker)

Each soil series in the map above has a generally uniform thickness and characteristic profile (Figure 5). The topography plays a role in the development of soils; there are characteristic units for ridgetops, valleys, and steep slopes. For example, the Ashe and Cleveland series is found on steep slopes throughout the map. The Saluda and Edneyville series is found in the southeast of the quadrangle, in lower areas of relatively little slope. The geologic units were combined with the soil series polygons in a vector overlay, and the resulting map is also shown superimposed on the hillshade layer (Figure 4). In most cases, the soil type appears more strongly associated with topographic slope, rather than the bedrock geologic unit. In places, some association is possible, for example the Fannin series may be derived from gneisses and quaternary gravels in the northeast of the quadrangle. A high degree of topographic variability in this region and comparatively little geochemical variability in the composition of the rocks explain account for the topographic, as opposed to geologic, control of soil formation. The formation of the soil is due mostly to the topographic position of the locality and the degree of chemical weathering. Although the geochemistry is relatively homogenous, geology still exerts an profound influence on soil formation due to the geologic controls of faults and contacts on the surface relief and topographic slope.

Fault Orientations in the Saluda Quadrangle



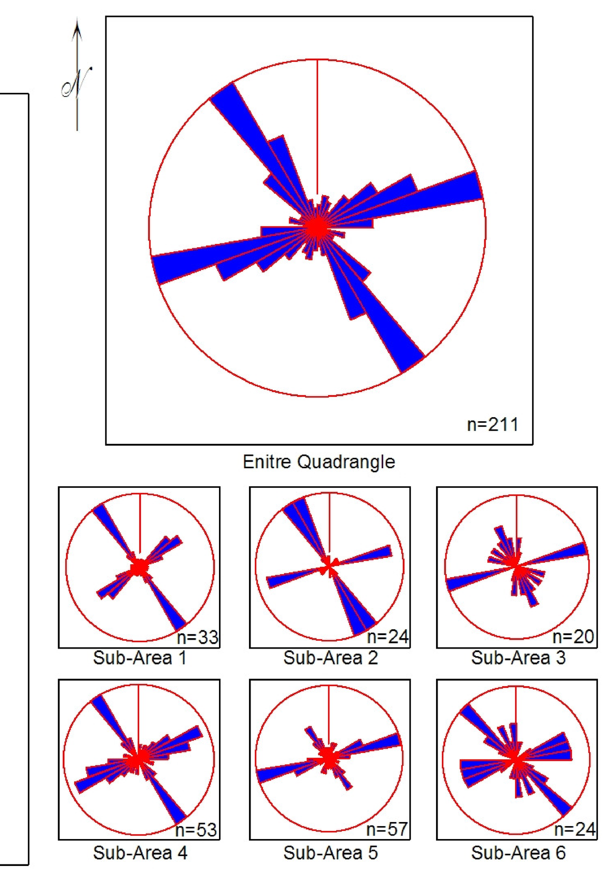


Figure 7. Rose diagrams showing the dominant orientation of faults for 6 geograhpic sub-areas in the South Carolina portion of the Saluda Quadrangle

Rose diagrams were constructed with a VisualBasic programmed tool for ArcGIS by Shan Chen (Chen 2005). Based on their orientations in the Saluda Quadrangle, brittle faults appear to belong to four main sets and one minor set. Two sets (a northeast set and an east-northeast set) lie between N50°-80°E. Two sets (a north-northwest set and a northwest set) lie between N20°-50°W. Poorly represented in this compilation is a N20°E fault orientation' set. The NW-trending faults are consistently truncated or offset by the NE-trending faults. More northerly faults in turn truncate the northeasterly sets. The influence of faulting on the topography is evident in east-northeast trending ridges, especially in the central and southwestern portions of the quadrangle. The NW trending faults are not commonly associated with ridges.

IV. Conclusions

- ArcGIS was used in this study to seamlessly digitize, represent, and analyze geologic data.
- Spatial Analysis of the geology and soils in the Saluda Quadrangle, SC, does not indicate a strong relationship between geologic unit and soil series at a fine scale. Soil formation is more strongly linked to topographic factors. Topography is controlled by the geologic contacts and faults.
- Two primary sets of brittle faults in the Saluda Quadrangle are oriented N50°-80°E and two other primary sets are oriented N20°-50°W. The control of faulting over topography can be seen in many large east-northeast trending ridges associated with these faults.

V. References

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VI. Acknowledgements

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