NORTH CAROLINA GEOLOGICAL SURVEY
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Rare-Earth Elements Minerals Placer Deposition Modeling From Landsat 8 Multispectral Remote Imaging in a Section of North Carolina's Northern Coastal Plain

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Raleigh GIS Day 2019

Wednesday, 13 November 2019
9:00 am - 3:00 pm
RALEIGH UNION STATION
510 W Martin Street, Raleigh, North Carolina

NORTH CAROLINA DEPARTMENT OF ENVIRONMENTAL QUALITY
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Background

The advent of multispectral satellite imaging has enabled surficial geologic mapping to be performed remotely. Using light wavelength ranges in both the visible and non-visible spectra, these images can be utilized to interpret surface lithologies and placer deposits. Using ArcMap 10.6 raster processing tools, this study is using spectral band combinations and ratios from imagery captured by the Operational Land Imager (OLI) onboard the Landsat 8 satellite (an Earth observation collaboration between NASA and USGS) in order to locate surface deposits of iron oxide- and hydroxyl-rich materials. In humid environments lateritic deposits are frequently associated with phosphate minerals such as monazite - one of the most abundant phosphate minerals bonded with rare-earth elements (REE). By identifying areas rich in iron oxide- or hydroxyl-bearing minerals, then comparing these identified areas to other sources of lithologic data - including previously constructed geologic maps and drilling borehole records - this study anticipates aiding in locating areas of high potential for REE-bearing minerals recovery.

Geologic Setting

The Roanoke Rapids 1:100,000 map sheet (Weems and Lewis, 2007) straddles the Coastal Plain/Piedmont boundary in northernmost North Carolina (Fig. 1). The USGSrecovered one core and augered 97 research test holes for the area. Within the lithologic descriptions some formations were described as having "dark heavy minerals". The area of interest for this research is in the southwestern corner of the Roanoake Rapids 1:100,000 map area (specifically the Red Oak and Drake 1:24,000 quadrangles).

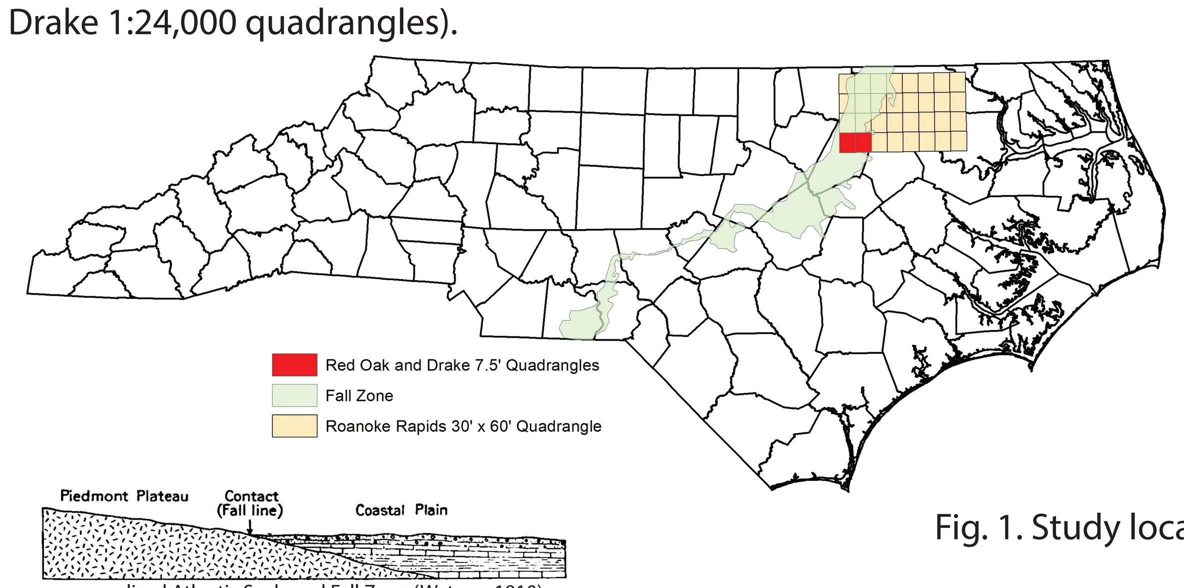

Fig. 1. Study location

Methods

The methodology presented here involves the use of compound band rations to identify areas where one or more specific spectral absorption features are present. Phosphate minerals -the REE-bearing monazite, in particular- are heavily associated with Fe-oxide deposits (Elliott et al., 2018). Fe-oxide placer deposits are identified from reprocessed satellite imagery. Procedural process:

- Download Landsat 8 imagery from USGS-EarthExplorer (path15, row35)
- Create band composite (bands 1-7, bands 9-11; band 8 is the panchromatic band)
- Ture color: red = band 4, green = band 3, blue = band 2
- Make 2-7 floating points
- Create composite images with the following RGB ratios: (B4/B2), (B6/B7), (B6/B5)
- Overlay composite image over georectified lithologic map

(see Landsat 8 Spectral Band Wavelengths table)

Results

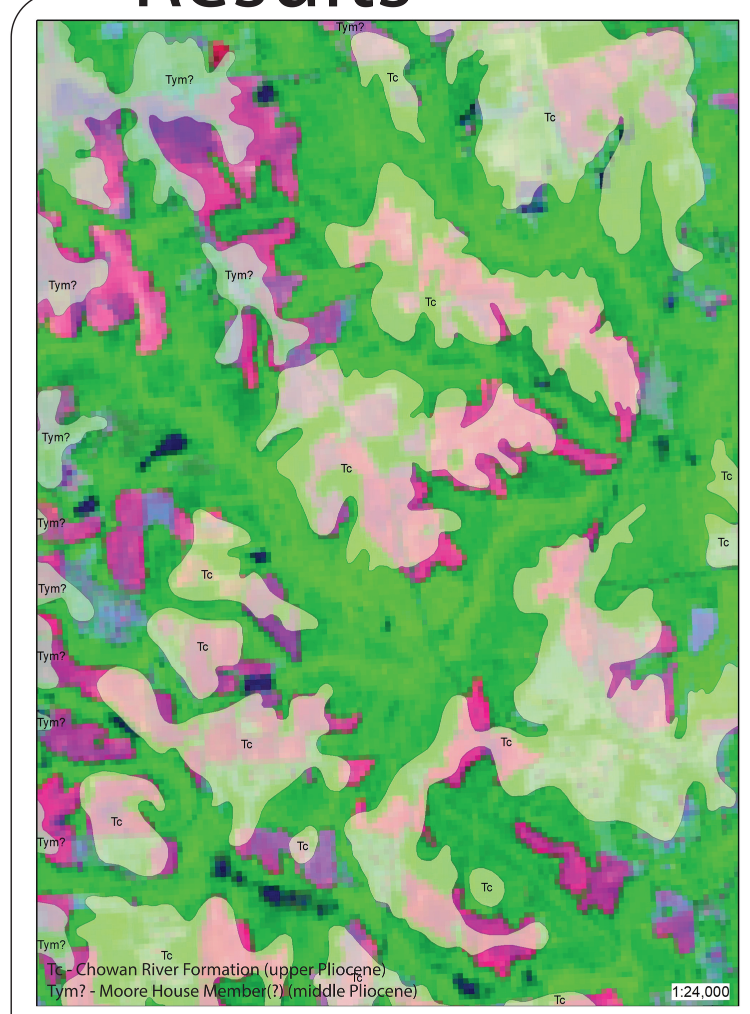

Fig. 2. Lithology overlaying image band false-coloring in a portion of the two-quadrangle study area

The 1:100,000 Roanoke Rapids mapping area, delineated by Weems and Lewis (2007), provides a convenient control base-layer for cursory first-order analysis of the image bands combining/ratioing method (Fig. 2).

Planned drilling operations in the study area, with detailed lithologic mapping (Farrell et al., 2012) will provide the detailed field analysis to provide a more detailed quality control estimation for this method in a humid and heavily vegetated research area.

In Fig. 2, the results of the image band ratioing can be seen. In the image yellow specifies the hydrothermally-altered areas; black identifies water, dark green specifies vegetation; and the clays-rich rock is represented by the light green. The blue highlights sands athe the red-pink-magenta areas indicates iron oxides minerals.

It is clear that there is significant matching overlay of the lithology layer and the potential iron oxides-rich placer soil underlain, especially at, and near, the outlines.

A more quantified analysis of the results will be provided by a supervised classification procedure from the following workflow:

(1) Create a subset of bands for the classification;

(2) Create training samples;

(3) Evaluate training samples;

(4) Manage training samples;

(5) Execute interactive supervised classification;

(6) Create signature file;

(7) Execute a maximum likelihood classification procedure

Landsat 8 Spectral Band Wavelengths

Spectral Bands	Wavelength (micrometers)	Resolution (meters)
B1 - Ultra Blue (aerosol)	0.43 - 0.45	30
B2 - Blue	0.45 - 0.51	30
B3 - Green	0.53 - 0.59	30
B4 - Red	0.64 - 0.67	30
B5 - Near Infrared (NIR)	0.85 - 0.88	30
B6 - Shortwave Infrared 1	1.57 - 1.65	30
B7 - Shortwave Infrared 2	2.11 - 2.29	30
B8 - Panchromatic	0.50 - 0.68	15
B9 - Cirrus	1.36 - 1.38	30
B10 - Thermal Infrared 1	10.60 - 11.19	100
B11 - Thermal Infrared 2	11.50 - 12.51	100

Summary

Question: Is it possible to use satellite remote sensing imagery to delineate heavy metal placer deposits in the humid, heavily-vegitated eastern United States?

Task: Use previous geologic mapping in a target area to provide a base for accuracy for light wavelength band false-coloring reimaging method.

Results: Preliminary analysis, before a detailed supervised classification and a detailed field lithologic mapping effort, appears promising - if potentially limited.

Discussion: Future detailed analysis, using different points of time from the same location, should provide a depositional rate for current processes which can help form paleo-models.

Discussion / Outlook

Traditionally, satellite remote sensing techniques have only had a high degree of success is arid, bare-earth (sparsely vegetated) target areas. This research has had promising preliminary results when considering the process as a tool for culling a larger field area to more potential sites for surface and near-surface heavy mineral rich placer deposition.

Rationing techniques and geologic image interpretation date back to the early days of air photo geology and the early Landsat multispectral scanner data sets. Landsat images have been used for many years by the geologic remote sensing community for mapping of lithology and delineation of lineaments specifically to map alteration mineralogy in arid, bare-earth areas. The potential for heavy mineral placer delineation, even in heavily vegetated areas, is an underlooked research investigation line.

If iron-oxide mineral deposits can be used to locate REE-bearing phosphate minerals (such as monazite), that tend to deposit together, then a deposition model for currently forming placers can be built from this technique.

References

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