Electrical Resistivity Imaging of Mantled Karst in the Buffalo River Basin, Arkansas

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Electrical resistivity imaging (ERI) provides a good method to understand the distribution of fluids and rock properties in the subsurface environment especially in the presence of fractures or karst features (Bolyard, 2007, Smith et al., 2008, Gary et al., 2009, Halihan et al., 2009). The method allows an electrical image to be created with a resolution of half the distance between electrodes, which typically provides a meter-scale dataset that can be utilized to evaluate heterogeneity and fluid distribution. Improvements in sensitivity generated by the Halihan/Fenstemaker method (OSU, 2004) allow greater differentiation of these signatures (Miller et al, in press). In a field setting, this will result in a two-dimensional mapping of subsurface electrical properties for each dataset.

For these experiments, the electrical imaging will be conducted on a one time basis to evaluate rock properties, but can also be repeated on a pre- and post-infiltration basis to generate images of changes in the electrical properties (Albano et al., 2010, Halihan et al., 2011). These transient datasets will allow an understanding of changes in fluid electrical properties as the infiltrating fluid and associated reactions will be the only subsurface change. The datasets will be used to interpret groundwater movement in a complex mantled karst with applied agricultural waste.

As part of cooperative research, Oklahoma State University (OSU) will design and conduct ERI imaging experiments and integrate ERI data with well data and other site data to provide an understanding of the subsurface distribution of flowpaths at a background and waste application study sites. Dr. Todd Halihan and his graduate research assistant (OSU) will travel to the sites to assist in experimental setup of the imaging and collecting initial data. University of Arkansas (UA) will provide 2-3 field assistants to aid in collecting data and clearing brush as needed. Aestus, LLC will be utilized to provide 3-D visualization of the field data utilizing RockWorks™. Data analysis and reporting will be performed in conjunction with research team members at UA and Aestus, LLC. The work is anticipated to begin 1 October 2014 and conclude 30 September 2015.

Potential hurdles for the research are field logistics and constraints due to site access and stream access. For this site, data quality is anticipated to be high due to the geologic setting lacking metallic infrastructure. The resistivity structure of the site will be evaluated with OSU working with UA and Aestus to ensure proper integration of the ERI acquisition location and scale with the UA well and soil sampling protocols.

The results of the work will be reported to UA, and published in appropriate journal locations. The work is intended to be applied to understanding best management practices for conducting land application of agricultural waste in karstic settings.

1.0 Scope of Work

ERI data will be collected at two sites near Mount Judea, Arkansas (Figure 1). A total of 18 ERI lines are planned to be acquired and visualized in 3-D. Current planning involves acquiring data along 10 transect lines at the northern site (MJN; Site 1) (Figures 1 and 2), and 8 transect lines at the southern site (MJS; Site 2) (Figures 1 and 3). A dozen lines will be acquired at a ~1.5 meter resolution (3 meter electrode spacing), providing datasets that are ~165 meters long horizontally with a depth of imaging of approximately 33 meters. An additional six higher resolution transect lines are planned at a ~0.5 meter resolution (1 meter electrode spacing) to provide higher resolution imaging of pathways observed during the acquisition of the coarser data for each site. It is anticipated that two field acquisition efforts will be required to ensure proper data acquisition and integration. The locations of lines may need to be shifted as field conditions dictate, relative to land access or thick vegetation.

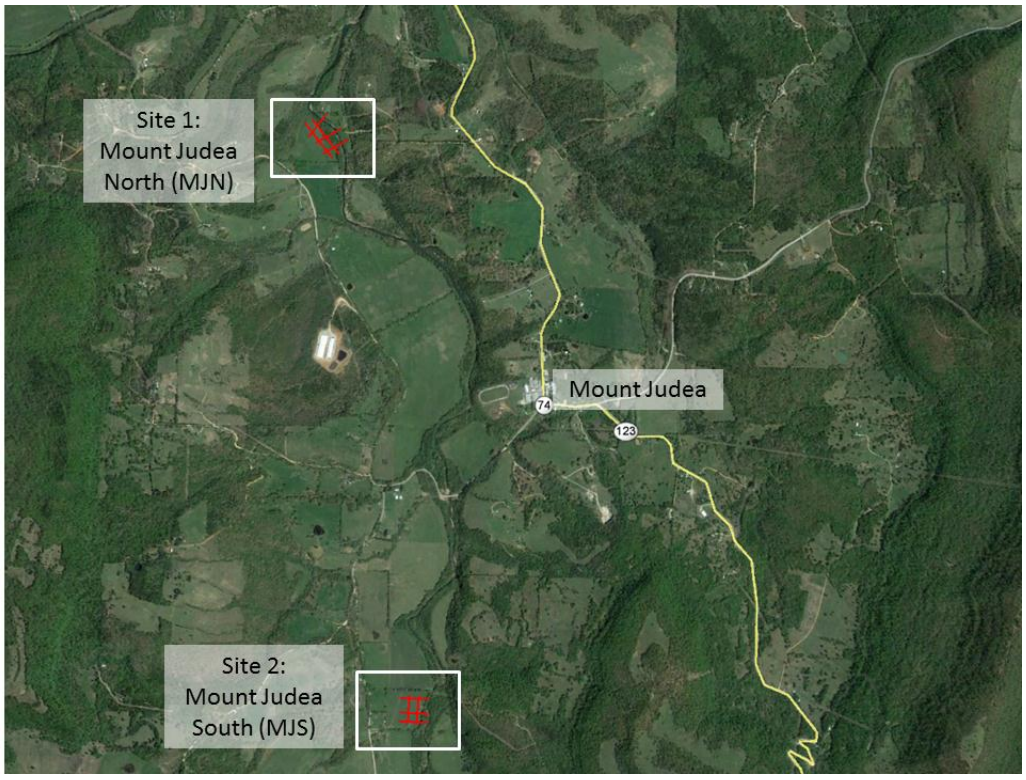

Figure 1. Location of sites for ERI imaging near Mount Judea, Arkansas.

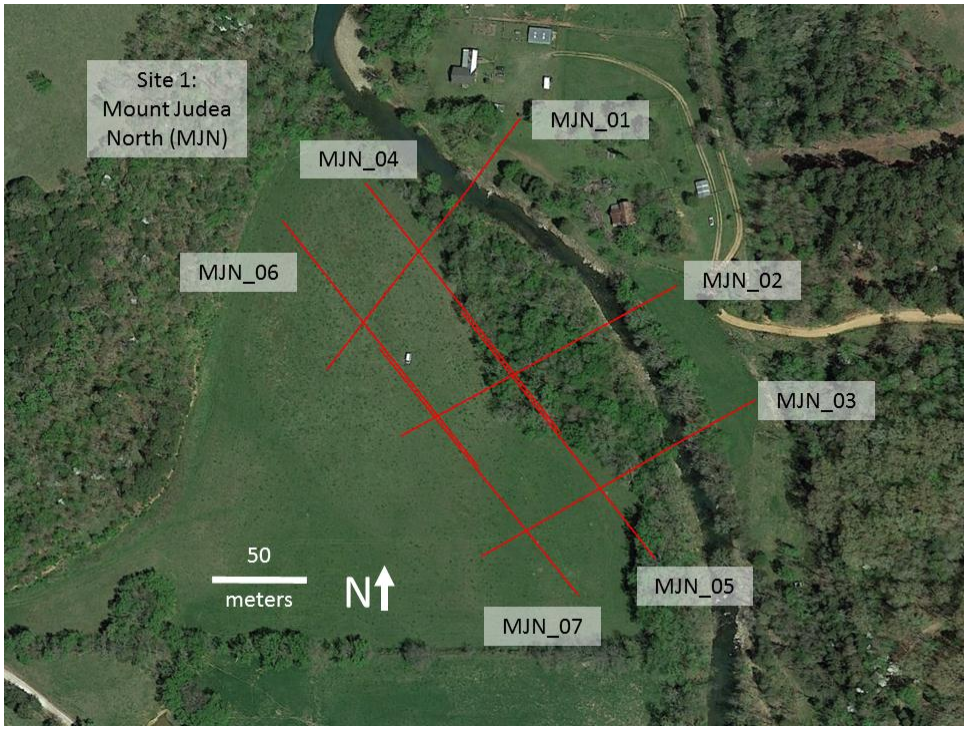

Figure 1. Location of ERI lines at northern (downgradient) site MJN. Seven 165 meter long lines illustrated. 3 additional high resolution lines (placement not shown) will be acquired after evaluating initial data.

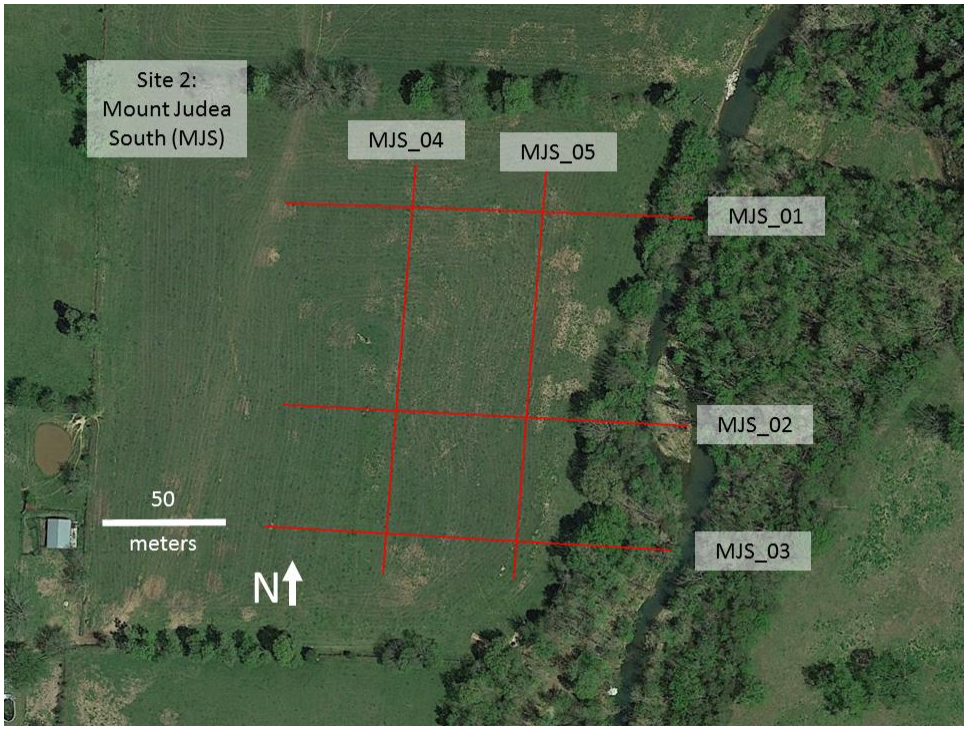

Figure 2. Location of ERI lines at southern (upgradient) site MJS. Five 165 meter long lines illustrated. 3 additional high resolution lines (placement not shown) will be acquired after evaluating initial data.

1.0.1 Assumptions for OSU

The work plan assumes the following for OSU:

1. OSU will utilize their own resistivity instrumentation for acquisition of ERI data.
2. OSU will utilize their own GPS instrumentation for acquisition of 3-D survey data.
3. ERI data can be obtained on the sites as they are largely natural settings.
4. GPS can be obtained on the sites as they are largely cleared fields.
5. OSU will work with Aestus, LLC to visualize the data. Note that Dr. Halihan has a managed conflict of interest between OSU and Aestus, LLC.

1.0.2 Assumptions for UA

The work plan assumes the following for UA:

1. UA will provide 2-3 field assistants on site to assist with acquiring ERI and survey data.
2. UA will work with land owners to obtain legal access for the OSU field team and answer questions regarding the field work.
3. UA will provide well data to OSU to include in the visualization model of the site data.

2.0 Budget

The total cost for the project is $27,550. This includes $1500 for supplies and equipment maintenance, $3405 for travel costs, and $22,645 in labor costs. Facilities and administrative costs of $11,487 have been waived for this project.

2.0.1 Budget Justification

The cost of supplies and maintenance applies to both electrical resistivity instrumentation and GPS instrumentation and associated field supplies. The travel costs include cost for travel to the field site for 8 days total on two trips and a trip for data integration to Fayetteville. Labor costs apply to a graduate research assistant and data visualization. Dr. Halihan will receive no salary for this project.

Facilities and administration costs have been waived for this project as the state of Arkansas funding for this project will not support F&A costs.

3.0 References

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