2018 25th International Lightning Detection Conference &
7th International Lightning Meteorology Conference
March 12 - 15 | Ft. Lauderdale, Florida, USA

Lightning data analysis provides geologic insights at South Carolina EPA Superfund Site

Kathleen S. Haggar[1], Dr. D. James Siebert[1], L.J. Berent[1], and H. Roice Nelson, Jr.[1]
1. Dynamic Measurement LLC, 211 Barker Rd. #382, Baker, TX 77413
http://www.dynamicmeasurement.com kathy@dynamicmeasurement.com

ABSTRACT

Lightning strikes occur over most of our planet. They are the most powerful natural electrical energy source on Earth. This case history introduces fast, economical, and safe game-changing lightning data-based technologies. Vast areas can be analyzed without permitting, public notice, landowner rights of entry, or boots on the ground – no one is steering the lightning. Vaisala's lightning-strike databases plus Dynamic Measurement's patented and field-proven methodologies improve geologic and geophysical analysis across a variety of industries at a fraction of the cost of traditional geophysical methods (Nelson, 2016). This paper describes the electromagnetic subsurface characterization methods for enhanced remediation at the former Barite Hill Gold Mine, McCormick County, South Carolina – and EPA Superfund Site.

Barite Hill is a metavolcanics-rock-hosted, stratiform gold-silver deposit. Mesozoic rifting created high-angle faulting and thrusting, which offset orebodies (Clark, et al, 1999). This former gold mine was placed on the National Priority List in 2009 as a result of elevated heavy metal concentrations and elevated pH in the adjacent streams and in the groundwater (Chapman, et al, 2015). Observations obtained exclusively from drilled wells, borehole geology, hydraulic heads, and local hydraulic conductivity, yielded a sparse data set for accurately modeling groundwater conditions and the horizontal and vertical positions of preferential flow paths and patterns. Insufficient data, and the sensitivity of the parameters, often cause groundwater models to be non-unique. Drilling wells to define contaminant transport modeling is an imperfect technique (Andros, et al, 2017). Our lightning analysis supplemented Willowstick's fluid modeling studies done in 2016.

Lighting currents interact with and are a primary source of induced telluric currents, all the way to the Mohorovičić discontinuity (Cagniard, 1953). Maps and volumes generated for this project show patterns related to shallow and deep geological structural patterns. For this 1.99 square mile study area, there were 1017 lightning strikes over 18.9 years. After data cleaning, the number of strokes dropped to 629. Cross-Plots of various lightning attributes were calculated to insure data consistency.

An interesting anomaly occurred on many of the lightning derived rock property and lightning attribute maps. This anomaly ties preferred groundwater flow maps generated by Willowstick (Andros, et al, 2017). The anomaly was first outlined on the Energy lightning attribute, and then was overlaid on Peak Current

(Absolute, Negative, and Positive), Apparent Permittivity, Apparent Resistivity, and several other attribute maps. Willowstick did a comparison of GEOMOD fluid flow models generated without and with the results of their flow path detection methodology. Adding lightning-detected flow paths to those models better constrained the flow path. It appears Dynamic's lightning attribute maps would also enhance the modeled preference flow paths, resulting in better constrained GEOMOD fluid flow models and provide considerable assistance with designing and optimizing Willowstick flow path detection surveys.

Lightning attribute volumes were also generated for comparison with the USGS conventional conductivity profiles generated at several sites near the Main Pit Lake and across a clay capped waste rock site. Creating lightning derived apparent resistivity cross-sections at the same three locations as USGS conductivity surveys shows a remarkable correlation with the USGS electrical conductivity cross-sections (Chapman, et al, 2015).

We conclude investigation of the near subsurface for geohazards can be conducted remotely with Dynamic Measurement's Natural Sourced Electromagnetic data (NSEM). This study demonstrates the utility of robust integrated EM technology applications for projects focused on hydrology and geohazards for dams, levees, and structures, in addition to commercial mineral and hydrocarbon exploration projects.

REFERENCES

Andros, C., V. Kofoed, and M. Jessop (2017), The Potential of Uniting Groundwater Flow Path Detection Technology with Groundwater Modeling Techniques, Pre-Print,Department of Geosciences, Brigham Young University, Provo, UT, Willowwtick Technologies, LLC, 132 East 13065 South Suite 100, Draper, UT 84020.

Cagniard, L. (1953), Basic Theory of the Magneto-Telluric Method of Geophysical Prospecting. Geophysics, 18(3), 605-635. https://doi.org/10.1190/1.1437915.

Chapman, M. J., B. A. Huffman, and K.B. McSwain (2015), Delineation of Areas Having Elevated Electrical Conductivity, Orientation and Characterization of Bedrock Fractures, and Occurrence of Groundwater Discharge to Surface Water at the U.S. Environmental Protection Agency Barite Hill/Nevada Goldfields Superfund Site Near McCormick, South Carolina, U.S. Geological Survey Scientific Investigations Report 2015-5084.

Clark, S. H. B. (1999), Geologic Maps and Block Diagrams of the Barite Hill Gold-Silver Deposit and Vacinity, South Carolina and Georgia, U.S. Geological Survey Open-File Report 99-148A.

Nelson, H. R., Jr., Lightning Analysis for Mapping Faults and Identifying Exploration Sweetspots, Search and Discovery Article #41987 (2017) adapted from oral presentation given at 2016 AAPG Pacific Section and Rocky Mountain Section Joint Meeting, Las Vegas, NV, Octoer 2-5, 2016, http://www.searchanddiscovery.com/pdfz/documents/2017/41987nelson/ndx_nelson.pdf.html.