AIRBORNE ELECTROMAGNETIC SURVEYS FOR 3D GEOLOGICAL FRAMEWORKS: STANDARDS, CALIBRATION, FORWARD MODELING, INVERSION, AND PITFALLS.

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Airborne Electromagnetic (AEM) surveys have found use in the development of many geological frameworks. AEM is a geophysical tool capable of rapid acquisition over large areas. Consequently, the method has been increasingly applied to regional-scale hydrogeologic studies of groundwater aquifers and 3D geological frameworks such as Fitterman and Deszcz-Pan (1998); Auken et al. (2009a); Abraham et al. (2012), and Jørgensen et al. (2012). These and many more successful projects have been accomplished using AEM. While there are many published works on the successes, what about the failures? Physics does not fail, so what are the potential problems with AEM? Do the systems not work all the time? No, they do work within the bounds they were designed to operate. Factors influencing a successful AEM 3D mapping project come down to several key points in the use of the AEM technique: 1) Electrical conductivity of the geological materials; 2) The electrical conductivity contrasts between the geological materials that we want to map; 3) The depth of the materials; 4) The thickness and extent of the materials; and 5) the inherent limitations of the AEM systems that we use. These can all be summed up as physical properties and AEM system design.

The Danish have made the best effort at putting together standards for calibration, acquisition, processing, and inversion of AEM data (Aarhus Geophysics, 2010). Through mapping the 3D geology of Denmark, they have produced many papers on the use of AEM techniques (Christiansen, and Christensen, 2003; Auken et al., 2008; Auken et al., 2009b). Can these techniques be applied in North America and throughout the rest of the world? Perhaps they should be. Is this a feasible approach? Processing of the data can be a technical challenge for the inexperienced, leading to many consequences that can adversely impact data quality and the resulting product (Viezzoli et al., 2013).

One important concept that is typically missed in planning AEM surveys is the development of simple forward models of the electrical properties of the targets of interest and the AEM system that is proposed to map the area. These forward models, when an appropriate level of system noise is added, can be priceless in determining the usefulness of AEM and a specific AEM system as it relates to mapping the target of interest. There are several free or relatively inexpensive electromagnetic modeling programs that can provide informative forward models to the potential user. However, these forward models only provide information as good as the input. So what is good information? Basically, it is a good understanding of the electrical properties of the materials of interest. Those can be obtained through geophysical well logs or ground geophysical surveys. Coupling this information with a good description of the AEM system is critical. Note that not all AEM vendors want to provide this information.

In the end, as with everything else in life, there is no simple answer that does not include doing careful homework and gathering as much information as possible about the area of interest. The lessons learned are that if a shortcut is taken at any step in the process, the end product usually suffers. Remember that the success of an AEM 3D mapping project is dramatically impacted by everything from careful calibration and acquisition to the color scale in final reports.

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