#### Summary

##### Permanent electromagnetic monitoring of $CO_2$ sequestration in deep reservoirs

Most schemes currently proposed for carbon sequestration rely on storing $CO_2$ in a supercritical state in deep saline reservoirs where buoyancy forces drive the injected $CO_2$ upward in the aquifer until a seal is reached. The permanence of this type of sequestration depends entirely on the long-term geological integrity of the seal. In this SBIR project, we propose the development of an integrated electromagnetic (EM) acquisition, processing and imaging system for the permanent monitoring, verification, and accounting of $CO_2$ in deep saline aquifers. The system will be capable of producing time-lapsed 3D resistivity images of the $CO_2$ container and its geological integrity.

Electric (E) field have superior sensitivity to variations in formation resistivity compared to magnetic fields. However, this has historically meant using galvanic electrodes which rely on electrochemical coupling. It is unfeasible to permanently deploy these electrodes. We will apply a new type of electric (E) field sensor developed by GMI which employs chemically inert electrodes that capacitively couple to the E-field. This coupling is a purely electromagnetic phenomenon, which, to first order, has no temperature, ionic concentration or corrosion effects. These factors are critical for year-round deployment and should result in an operational lifetime of many years, even when exposed to extreme environmental conditions. In addition, the E-field sensor employs ultra-high impedance feedback techniques to provide unprecedented gain and phase accuracy under varying ground moisture conditions.

To monitor, verify, and account for $CO_2$, the EM data will be processed to produce 3D resistivity images. However, the resistivity characteristics of different $CO_2$ states are poorly understood. This is largely because there has been an absence of an adequate rock physics model which can describe different states of $CO_2$, and which can be used as a constraint on the 3D inversion of the measured EM data. For in-situ rock property and fluid content determination using EM, we will develop our 3D imaging based on rigorous 3D modeling and inversion of the EM responses with the generalized effective medium theory of induced polarization (GEMTIP), which directly relates the observed electric fields to rock and fluid properties such as fraction volume, grain size, grain shape, porosity, fluid saturation, conductivity and polarizability.

Phase I will provide the first accurate projection of the feasibility and cost of deploying a practical EM-based measurement system for monitoring $CO_2$ in deep saline aquifers. These results will enable us to define a proof-of-concept scaled-down measurement system for quantifying $CO_2$ saturation, or an equivalent physical variable, at a test site in Phase II. Commercial applications for the technology exist in the oil industry, resource exploration and geophysics.