Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

3D Gravity and Magnetic Vector Inversion Modelling at Buffalo Valley, Nevada, USA

Jeffrey B. Witter[1]*, William D. Schermerhorn[2,3], Jonathan Glen[2], and Tait Earney[2]
Innovate Geothermal Ltd[1]*, U.S. Geological Survey[2], Zanskar Geothermal & Minerals[3]
jeff@innovategeothermal.com

INTRODUCTION

Geothermally-favourable structural settings have been recognized in Buffalo Valley, Nevada, USA (Burgess & Faulds, 2024; Figure 1) and it is one of the detailed study sites of the INGENIOUS project, a U.S. Department of Energy-funded research program aimed to accelerate discoveries of hidden geothermal systems in the Great Basin (Faulds & Richards, 2023). This poster presents results of 2D & 3D potential field inversion modelling performed in Buffalo Valley to aid construction and refinement of a 3D geologic model which forms the basis of a 3D geothermal conceptual model used to identify exploratory drilling targets. The aim is to improve the conceptual models by building 3D geologic models that are quantitatively consistent with gravity and magnetic survey data.

The potential field data used in this study includes: new gravity data collected by USGS, aeromagnetic data from the GeoDAWN survey (Glen & Earney, 2024), and rock property data collected by USGS. Geologic and structural data are from Burgess (2024).

METHODS

The workflow pursued in this study involved construction of an initial 3D geologic model, 2D potential field profile modelling, and multiple rounds of 3D gravity and magnetic vector inversion (MVI) modelling (performed separately).

Software: Rhino3D software (3D geology)
Geosoft Oasis-Montaj GM-SYS (2D joint grav/mag profile modelling)
SimPEG (3D gravity and MVI modelling; Cockett et al., 2015)

Data: 180 gravity data points
Magnetic data from gridded TMI data (100m cell size)

Constraints: 3D geologic model & rock property data

Model Mesh: 40 m cells (gravity) & 80 m cells (MVI)

Assumptions: 2.67 g/cm^3 background density & magnetic field parameters of decl. = 12.64°, incl. = 64.65°, and total field = 50,341.5 nT

Target Obs vs. Calc misfit for inversion: 0.1 mGal (gravity) and 5 nT (MVI)

The output rock density and magnetic models (i.e. susceptibility, inclination, and declination) were investigated to find areas of mismatch between the rock property inversion models and the rock property reference values in the constraining geologic model. For the areas of mismatch, the geometry of the 3D geologic model requires adjustment (e.g. the geologic horizons and/or fault contacts were moved) to improve the match between the reference 3D geologic models and the 3D potential field inversion models.

RESULTS

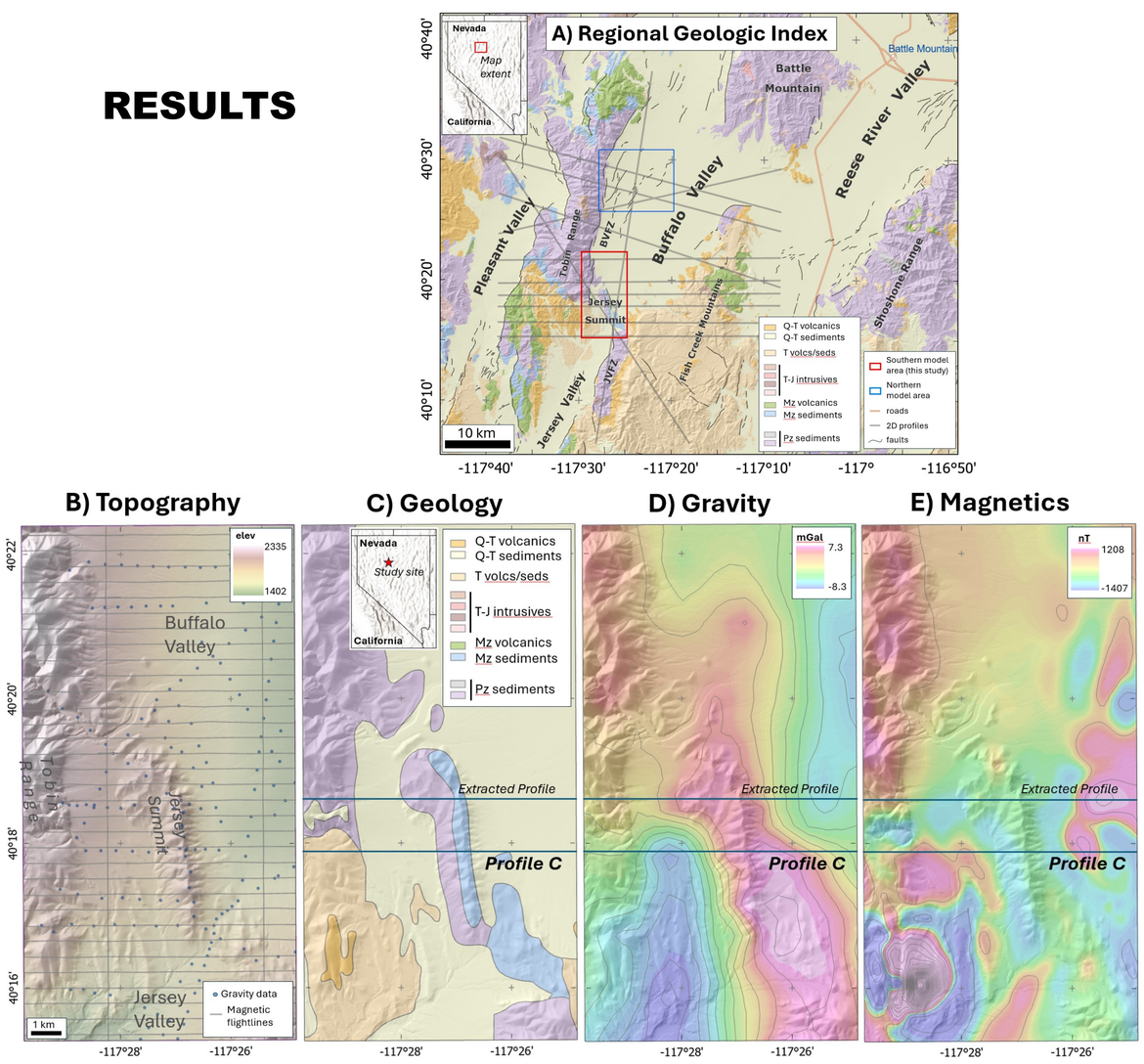


Figure 1. A) Index map of the study area showing regional geology, and the locations of 3D geophysical focus areas (red and blue rectangles), and 2D geologic profiles (thick grey lines). The red polygon spans a 13.2 km (N-S) x 7 km (E-W) area constituting the southern Buffalo Valley project area depicted in figures 1B-E. B) topography with the locations of gravity stations (blue dots) and GeoDAWN aeromagnetic survey lines (grey lines), C) Generalized geologic map after Stewart & Carlson (1976) , D) Residual Isostatic Gravity Anomaly map, E) Residual RTP magnetic survey map. Cross-sections along Profile C are shown in Figs. 2 & 3. Cross-sections along the "Extracted Profile" are shown in Fig. 4.

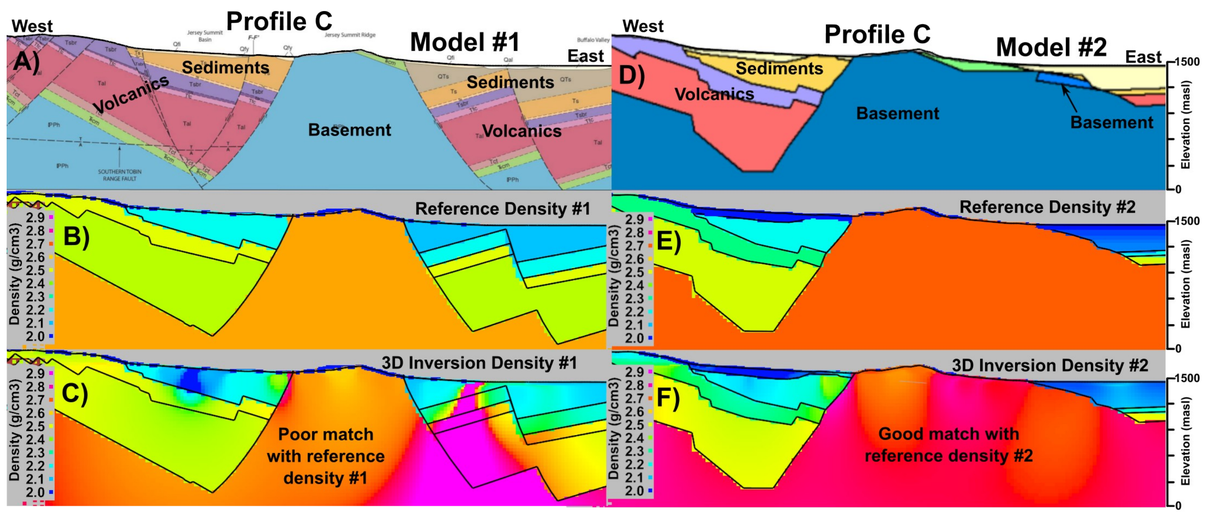


Figure 2. Results of 3D gravity inversion modelling shown along Profile C using two different geologic models as constraints. A) Geology model #1 (Burgess, 2024), B) Model #1 populated with reference density values, C) 3D gravity inversion model output showing the density distribution that agrees with the gravity survey data and uses geologic model #1 as constraints, D) Geology model #2 based on Burgess (2024) and 2D potential field profile modelling, E) Geology model #2 populated with reference density values, F) 3D gravity inversion model output showing the density distribution that agrees with the gravity survey data and uses geologic model #2 as constraints.

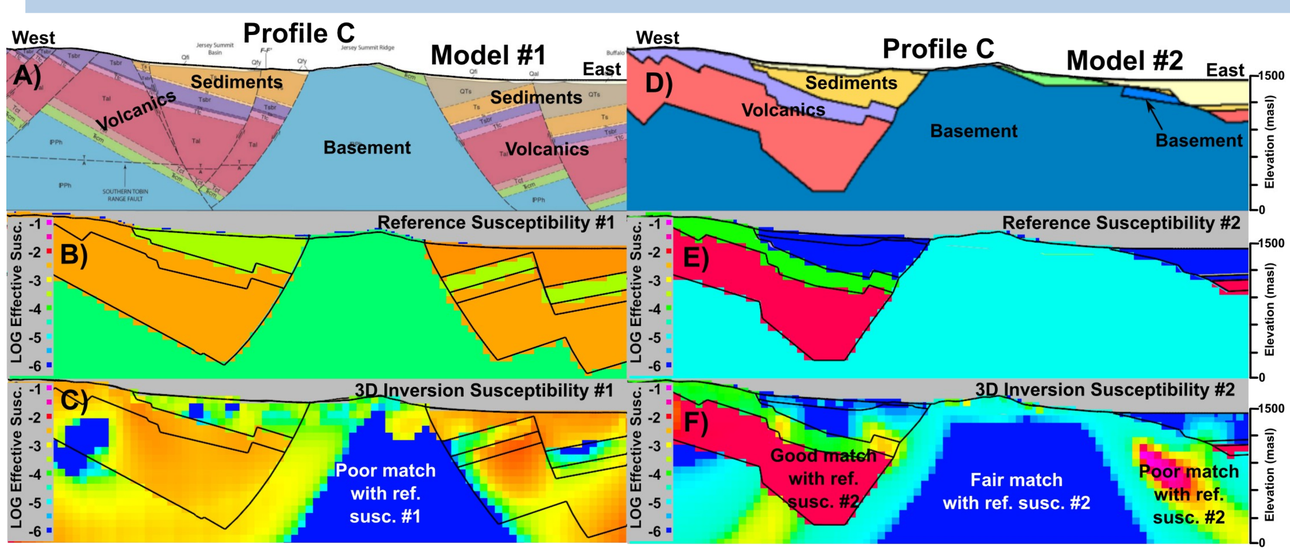


Figure 2. Results of 3D MVI modelling shown along Profile C using two different geologic models as constraints. A) Geology model #1 (Burgess, 2024), B) 3D MVI model #1 populated with reference susceptibility values, C) 3D MVI model output showing the susceptibility distribution that agrees with the magnetic survey data and uses geologic model #1 as constraints, D) Geology model #2 based on Burgess (2024) and 2D potential field profile modelling, E) Model #2 populated with reference susceptibility values, F) 3D MVI model showing the susceptibility distribution that agrees with the magnetic survey data and uses geologic model #2 as constraints.

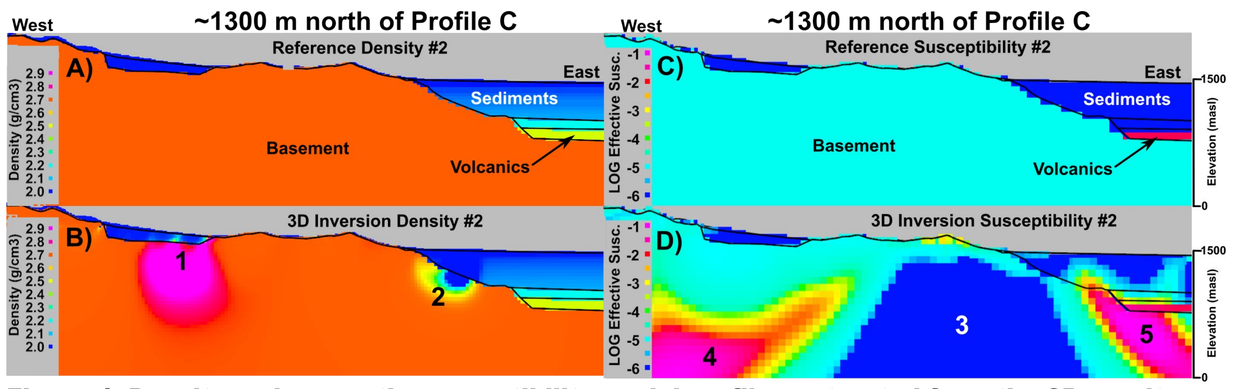


Figure 4. Density and magnetic susceptibility model profiles extracted from the 3D gravity and MVI models along an E-W line located ~1300 m north of Profile C. At this location an independently generated geologic cross-section or 2D potential field profile model is not available. A) Geologic model #2 populated with reference density values, B) 3D gravity inversion output showing the density distribution that agrees with the gravity survey data and uses geologic model #2 as constraints, C) Geologic model #2 populated with reference susceptibility values, F) 3D MVI model output showing the susceptibility distribution that agrees with the magnetic survey data and uses geologic model #2 as constraints. Locations marked "1" and "2" need adjustments to the geometry of the geologic model. Locations marked "3", "4", and "5" need additional investigation. The location of this profile is shown in Fig. 1 as "Extracted Profile".

DISCUSSION & CONCLUSIONS

3D gravity and magnetic vector inversion (MVI) modelling can be useful to:

- Help make the 3D geologic model quantitatively consistent with gravity and magnetic survey data
- Test for 3D effects along a 2D potential field profile model
- Refine the 3D geologic model between existing geologic cross-sections and 2D potential field profile models
- Test for regions of magnetic remanence (e.g. reversely magnetized rock bodies)

Acknowledgements: We thank Grant Rea-Downing for a constructive review of this poster. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. This work was funded by U.S. Department of Energy (DE-EE0009254, INnovative Geothermal Exploration through Novel Investigations Of Undiscovered Systems (INGENIOUS) awarded to the Nevada Bureau of Mines and Geology at the University of Nevada, Reno, and with support from the U.S. Geological Survey Energy Program. Special thanks to the INGENIOUS research team for all of their excellent work and support.

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