DIGITAL MAPPING TECHNIQUES 2025

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2D to 3D Cross Section Translation Workflow:
A New Technique for 3D Data Transformation of Subsurface Geologic Cross Section Data

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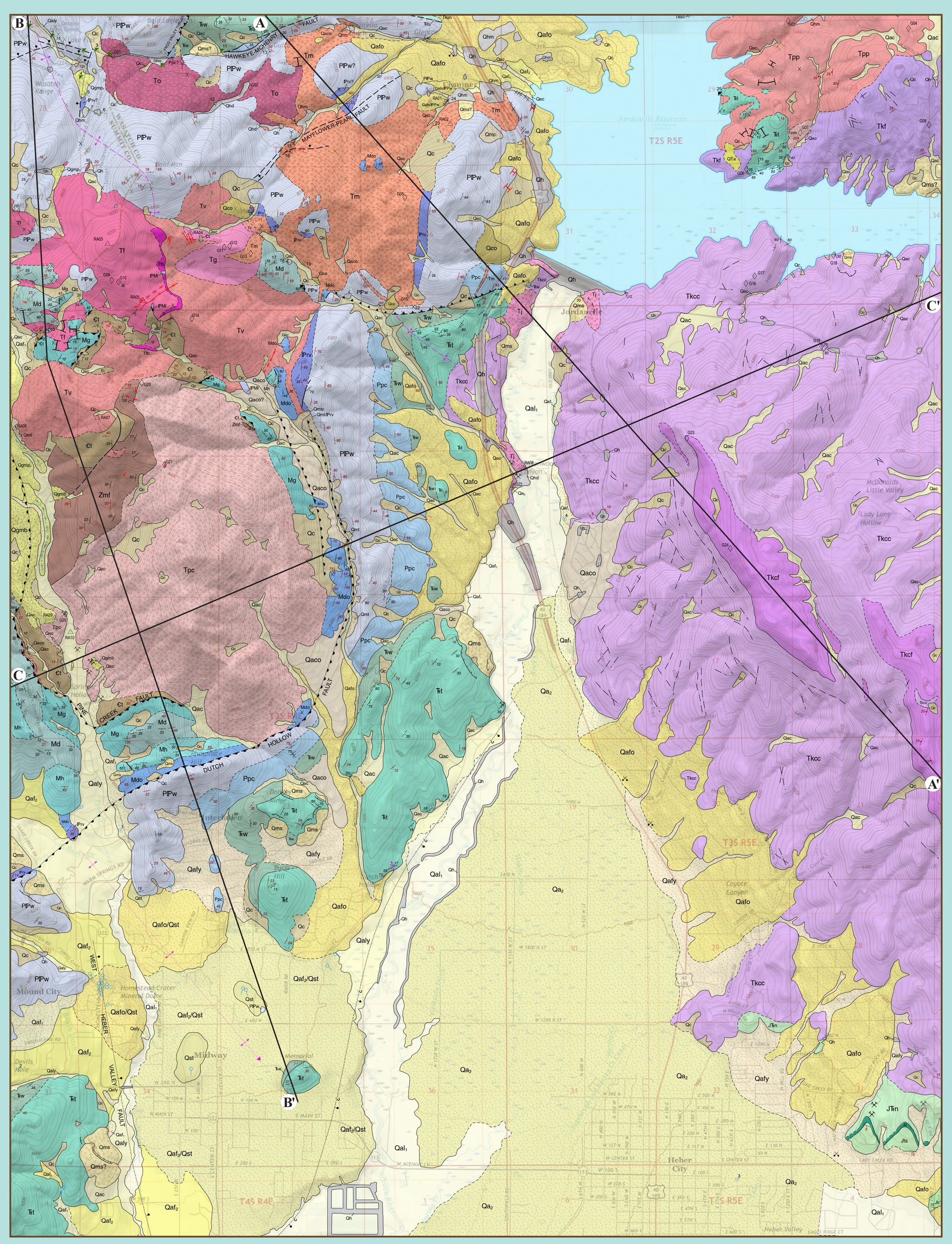
Introduction

In partnership with the U.S. Geological Survey (USGS), the Utah Geological Survey (UGS) was tasked with developing a process to create georeferenced 3D subsurface geologic cross sections. Previously available only as static, 2D "plan view" PDF figures, these cross sections required digitization in ArcGIS Pro and transformation into accurate 3D models using a custom Python tool. While traditional 2D cross sections are essential for visualizing subsurface geology, their complete spatial context can only be fully appreciated through 3D representation. This workflow outlines a draft method for converting 2D cross sections into georeferenced 3D fence diagrams within ArcGIS Pro's Scene environment.

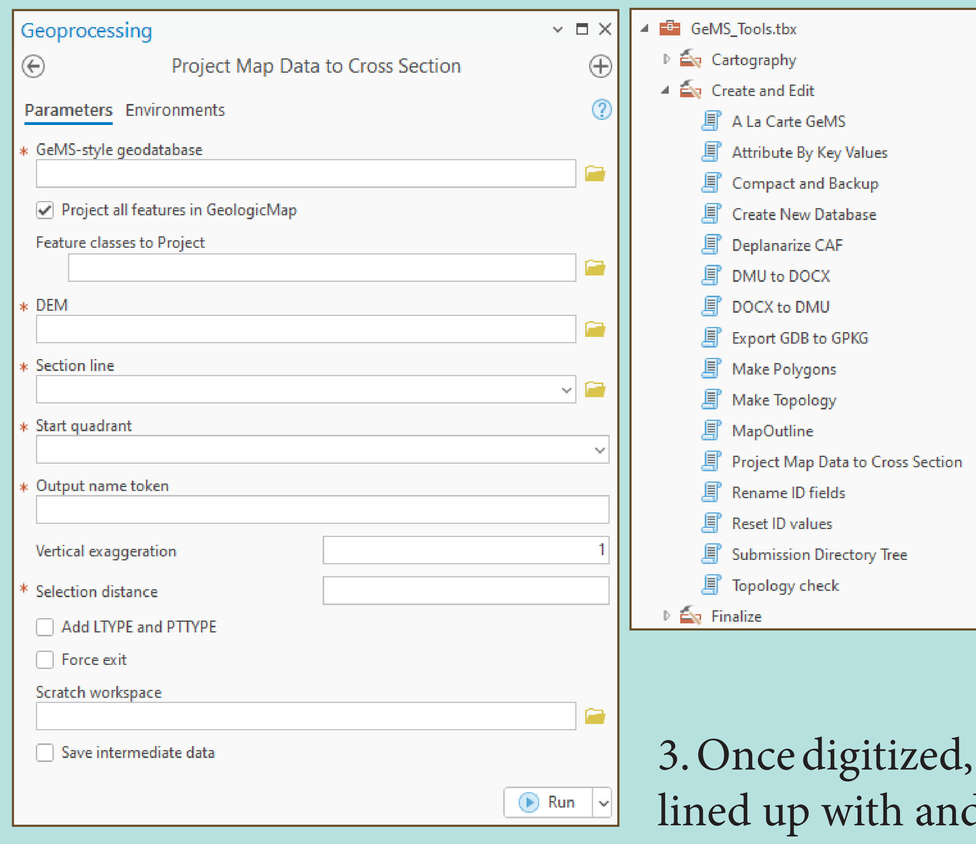
What Is a Geologic Cross Section?

A geologic cross section is a two-dimensional diagram that represents a vertical slice through the Earth's subsurface. It shows the arrangement, thickness, and relationships of rock layers (stratigraphy) and geologic structures such as faults, folds, and intrusions. The cross section helps geologists interpret subsurface conditions, reconstruct geologic history, and support resource exploration, engineering, and environmental studies.



Surficial geologic map of the Heber City quadrangle[1] showing lines of cross section (A, B, and C).

Methods



GeMS toolbox and ***Project Map Data to Cross Section*** *tool.*

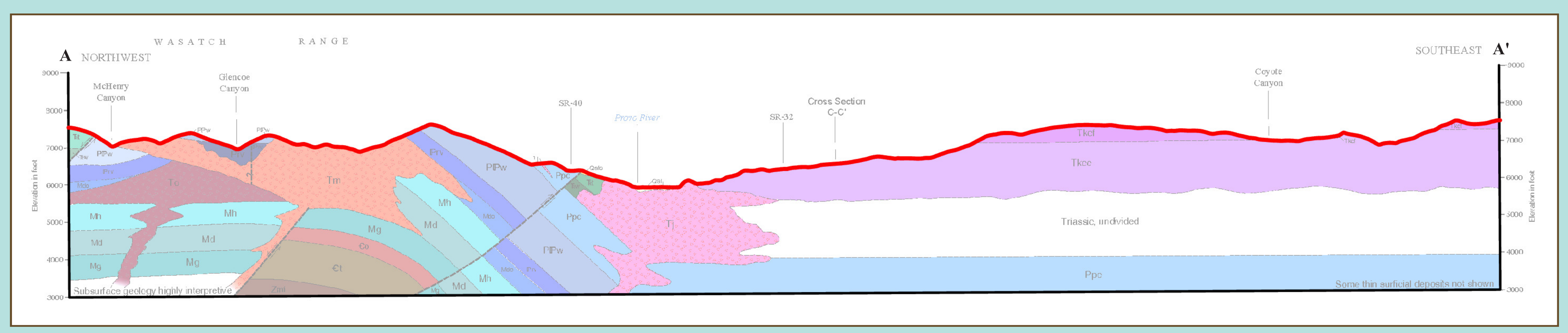
1. Using the Geologic Map Schema (GeMS) Project Map Data to Cross Section[2] tool, we created the surface topographic profile along the selected cross section line.

2. With the profile and cross section boundary created, we georeferenced the original cross section PDF and used it as the source to digitize a new, updated version of the cross section in ArcGIS Pro. Using ArcGIS Pro, the digitization process converted the original 2D cross section, often in PDF format, into vector data stored in a GeMS geodatabase. As we digitized, we added details to each feature such as geological unit names, fault types, top of unit, base of unit, and other key attributes.

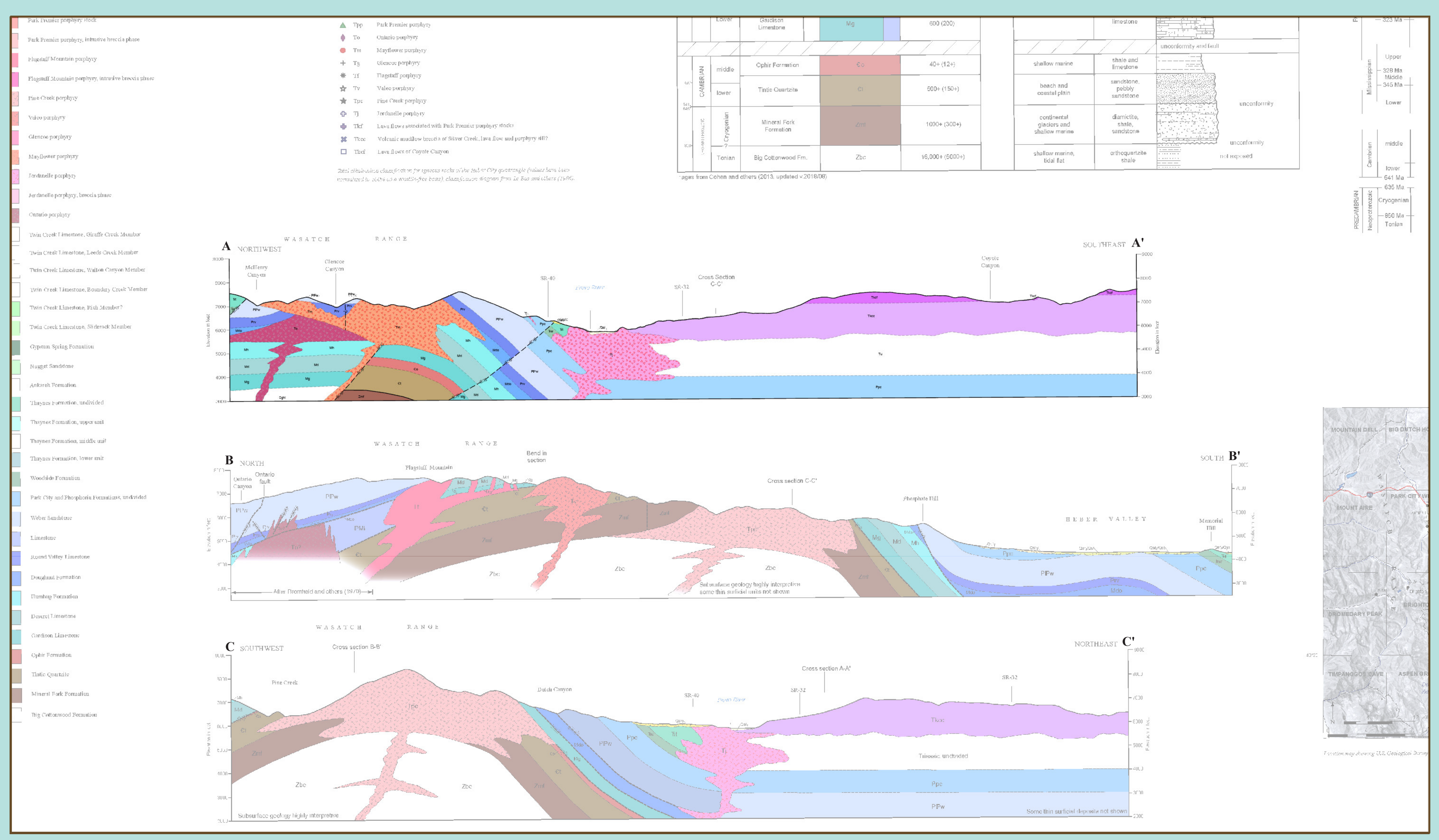
3. Once digitized, we reviewed all features for accuracy, ensuring that all features lined up with and attributes matched the existing geologic context.

4. After reviewing the cross section features for accuracy, we used a custom Python script to transform the vector data into spatially accurate 3D features. The script accurately mapped all 2D geological features, such as fault lines, contacts, and stratigraphic layers, into their correct 3D spatial positions (X, Y, Z), considering topography and geological context. The transformed data was then visualized as fence diagrams within ArcGIS Pro's 3D Scene, allowing for an immersive and accurate representation of the subsurface geology, which could be further analyzed and interpreted.

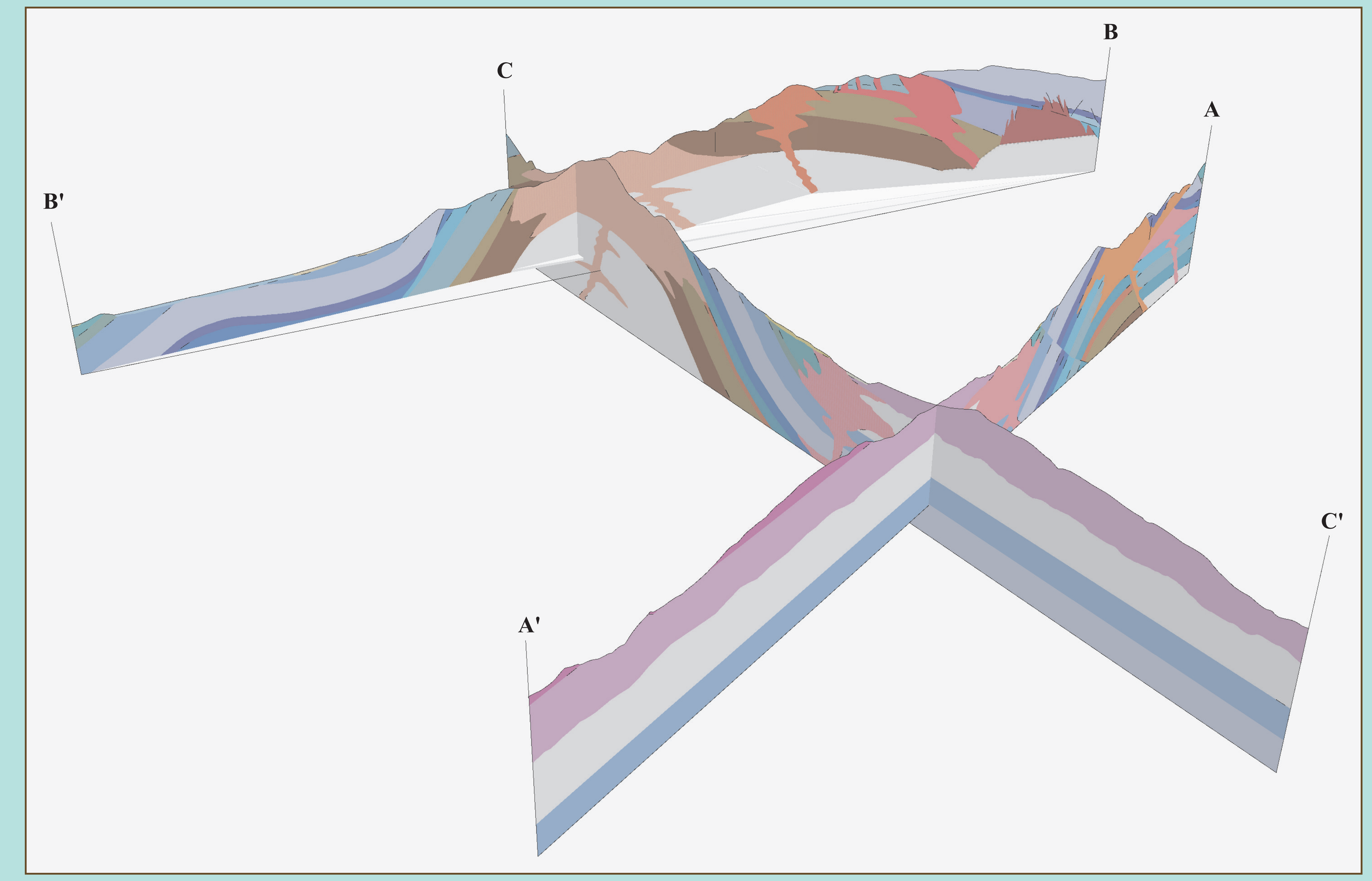
5. All Feature Datasets were combined into one geodatabase and reviewed for GeMS compliance.



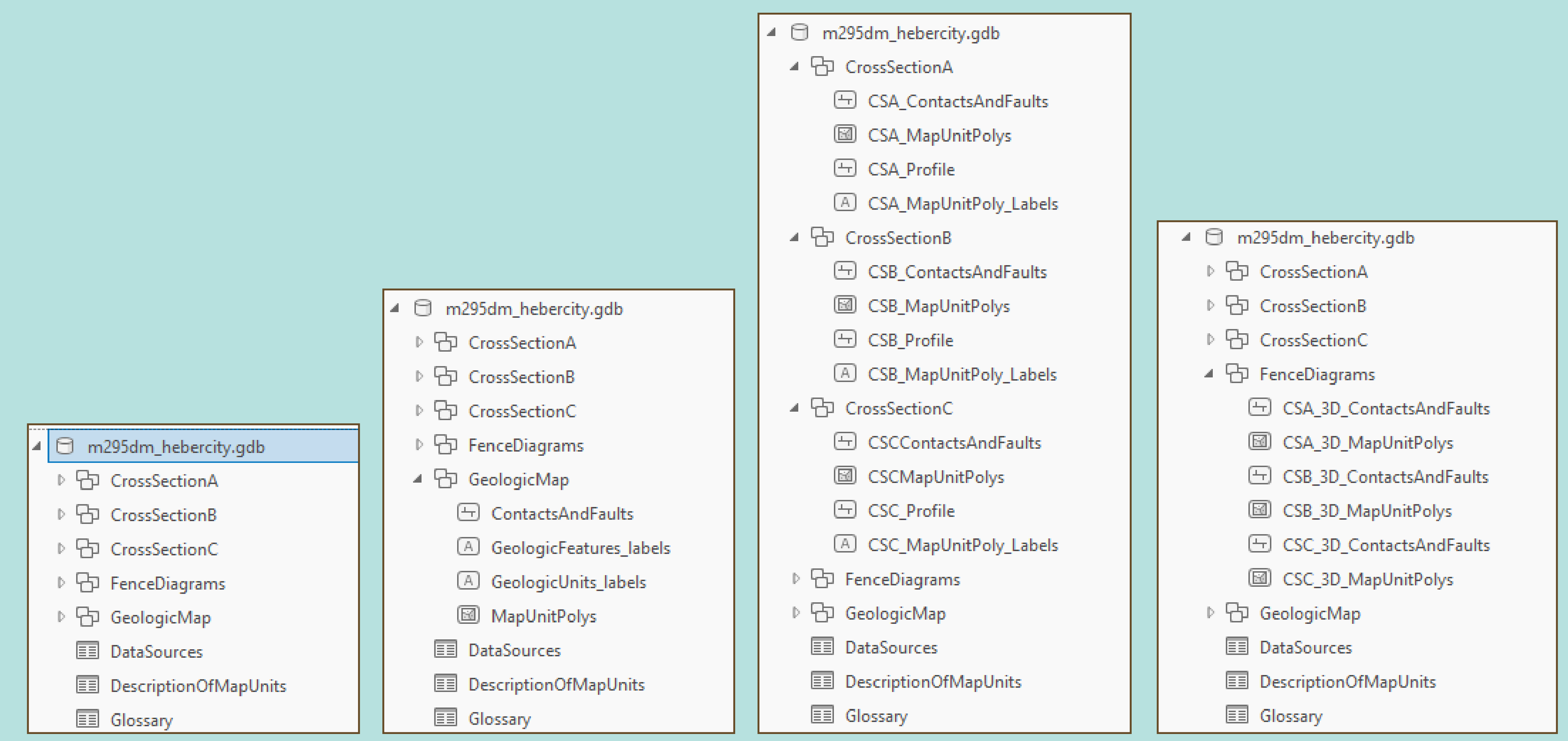
Georeferenced PDF cross section with profile (red line) and boundary (black lines).



Georeferenced cross section A–A' PDF (from UGS publication M-295DM) with digitized 2D plan view overlain.



3D subsurface "fence diagrams" of Heber City quadrangle cross sections A, B, and C in ArcGIS Pro Scene View. Cross sections are in correct and accurate X, Y, and Z (subsurface) locations.



Example of final GeMS geodatabase with feature datasets for geologic map data, each cross section (plan view), and all fence diagrams.

Conclusions/Results

This workflow not only improves subsurface visualization but also provides a vital foundation for geologists, particularly those with limited 3D experience, to start developing and managing 3D geologic data. By creating a standardized (GeMS), georeferenced database of key features, especially cross section lines, this method enables a wide range of practical applications including, but not limited to resource exploration, geotechnical assessments, environmental modeling, and the integration of geologic data into broader subsurface models for infrastructure planning and hazard assessment.

This workflow both enhances the accuracy of geological interpretation and streamlines the integration of 3D data across various geoscience fields.

References

[1] Biek, R.F., 2022, Geologic map of the Heber City quadrangle, Wasatch and Summit Counties, Utah: Utah Geological Survey Map 295DM, 24 p., 2 plates, scale 1:24,000, https://doi.org/10.34191/M-295DM

[2] https://ngmdb.usgs.gov/Info/standards/GeMS/