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3D-printed models: new tools for teaching 3D visualization of subsurface geology

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Summary

Much of basic structural geology involves projecting data from maps of the Earth's largely two-dimensional (2D) surface into the opaque, three-dimensional (3D) subsurface, where structural relationships are typically invisible, or are sampled in very limited form by boreholes or geophysical data. Understanding 3D relationships in this opaque volume involves major challenges for the student. An important part of Earth science education provides students with the skills needed to visualize these relationships. Typically, this involves introducing students to the tools that are used by professionals: structure contours, stereographic projections, and computer simulations. All these techniques present students with challenges of scale, dimensionality, and abstraction. Challenges of scale involve the representation of macroscopic structures on printed pages at reduced scale. Challenges of dimensionality involve mentally or mathematically projecting the real, but invisible 3D subsurface world into 2D representations such as cross-sections and stereographic projections. Challenges of abstraction involve representing physical features, such as rock formations or dipping surfaces, with idealized representations such as a map patterns or sets of structure contours. 3D-printed models offer the potential to ease some of these challenges. Models are designed to exactly match the scale and color of 2D maps introduced in lab exercises. Students will be able to directly observe otherwise hidden subsurface structural relationships by manually separating geologic domains. Write-on wipe-off surfaces will allow students to draw structure contours directly on geologic structures. The impact of 3D-printed models on the students' ability to visualize subsurface geology will be assessed using established survey instruments that test 3D visualization skills, and with metacognitive evaluations that assess students' perceptions of what they have learned. Digital files for the 3D-printed models and associated geologic maps will be made publicly available such that any instructor will be able to print copies to incorporate in their teaching.