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Changing the Game with Geological Modeling: Then and Now

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From the early days of bedrock mapping, geoscientists have sought to capture and communicate geological features as models (2D and 3D). This modeling process involves gathering observations, applying assumptions, and generating interpretation realisations. However, as geological knowledge increases and computation power grows, new opportunities for data-focussed modeling and interrogation are revolutionizing how geological features are captured and communicated. The progression from hand-drawn interpretations such as cross-section and block models to fully computed 3D implicit model ensembles has facilitated a shift to more quantitative and repeatable modes of inquiry. With 3D modeling, it is now possible to pose complex questions related to geochemical or ore distributions, crustal-scale hypothesis testing, and uncertainty analysis. The process of 3D modeling also forces internal consistency checks between interpreted map features from all datasets, which is an informative process rarely achieved through 2D modeling alone. Looking forward, advancements in 3D modeling should integrate geological knowledge and principles with modern data analytics to produce interrogatable and geologically reasonable realizations. Cutting edge 3D modeling includes capturing increasingly complex geological feature geometries, respecting convoluted geological histories, and enhancing resource estimation.

Figure 1: Progression of modeling innovations from ancient Egypt quarry records in 1160 BC, 2D geological mapping by William Smith (1815), conceptual 3D block modling by Andreson (1884), and 3D graphical framwork modeling by Stirewalt and Henderson (1995). Novel and comprehesive implimentartions for the last decade include 3D prospectivity modeling by Payne et al. (2015) and uncertainy esitmation from Pirot and Lindsay (2021).