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3D Geological Modeling Using Generative AI

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Objectives/Scope: This study aims to show the feasibility of a novel artificial intelligence (AI) agent to create precise, compliant, and constrained 3D geological models. The objective is to demonstrate that an agent tasked with interpreting textual descriptions and imagery, and producing structured Extensible Markup Language (XML) outputs that adhere to specific geological modeling Document Type Definitions (DTDs) can effectively generate 3D subsurface models featuring intricate geological formations such as salt domes, mineral deposits, or sedimentary basins.

Methods, Procedures, Process: The AI agent leverages the latest most capable Large Language Models (LLMs) instructed with geological modeling protocols and XML schema definitions. The model processes textual descriptions and reference images, methodically converting these inputs into organized, validated XML files that delineate specific 3D geological formations derived from vertical cross sections. Key procedures include strict adherence to the specified DTD, rigorous internal validation to avoid XML structural errors, and iterative refinement based on the cross-sectional data that covers the modeled domain. The accuracy and efficiency of the agent are tested through real-life case studies of geological scenarios involving complex salt dome structures and sedimentary basins. These findings are then compared to established geological models developed using vertical cross sections.

Results, Observations, Conclusions: Preliminary results demonstrate that the AI agent can effectively represent various geological features, such as sedimentary folding or irregular-shaped salt diapirs. A comparative analysis with conventional manual geological modeling reveals notable decreases in the time required for modeling. The modular XML structure intrinsically allows the AI agent to flexibly update and modify the entire model or adjust individual cross sections or specific geological features independently. Observations indicate that the AI agent reliably approximates geological body geometry, dimensions, and spatial placement according to provided descriptions, as long as it uses a suitable LLM that can accurately follow the instructions and is suitable for consistent generation of compliant XML documents. Conclusions highlight that such an AI agent can significantly streamline geological modeling processes, ensuring consistency, compliance, and efficiency, thereby offering substantial operational benefits and improved decision-making capabilities in exploration and drilling activities.

Novel/Additive Information: This study showcases significant progress in the use of generative AI for geological modeling, highlighting remarkable abilities for the complete automation of digital geological 3D model creation. This innovation directly addresses existing gaps in accuracy and efficiency, offering significant practical benefits for petroleum exploration and reservoir characterization.