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The Earth Model: Using Geologic Data and Global Processes to Enable Predictive Exploration

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Exploration success is related to our ability to accurately predict the nature of the subsurface. In hydrocarbon exploration, it is necessary to determine if effective reservoirs, seals, and source rocks are present and if the timing of hydrocarbon expulsion happened after trap formation. To assist in this task, we have developed a data constrained scalable 4D model of the Earth that integrates an understanding of different geologic processes to allow informed prediction. Although tailored to the hydrocarbon industry, this model has many applications for mineral exploration.

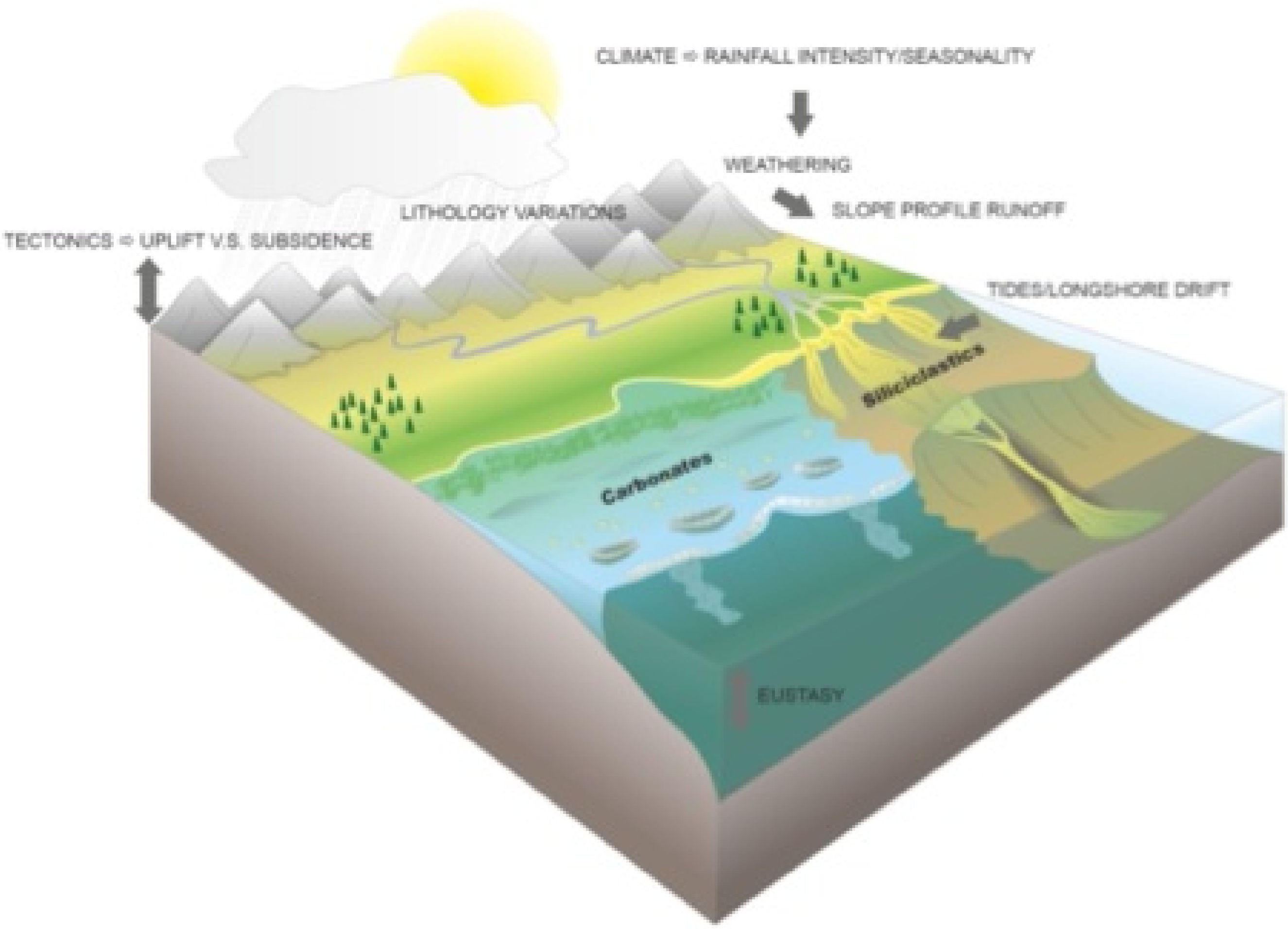
The first process to integrate is an understanding of global plate tectonics. For this, we use a geodynamic model that provides insights into the evolution of tectonic settings and features, such as collision or subduction zones, that may control depositional processes and petroleum systems or influence the timing of trap formation. The geodynamic model also allows data to be reconstructed into its true paleogeographic position, providing greater insights than is possible from only a modern worldview. As many mineral deposits are intrinsically linked to geodynamic processes, this tool can also be used to high-grade areas to explore for new mineral provinces and deposits under cover.

Before disparate geologic data can be reconstructed, they must first be integrated into a common chronostratigraphic framework. For this, we use a global sequence stratigraphic model covering the past 800 m.y., generated through the interpretation of many thousands of stratigraphic sections from across the globe. Sequence stratigraphy provides insights into the processes controlling sedimentary geometries, architecture, facies, and lithologies, allowing these factors to be predicted away from data. Stratigraphic data interpreted using this framework yields hundreds of thousands of data points on sedimentary systems through time.

From temporally attributed and paleogeographically restored data, it becomes possible to create global gross depositional environment maps for key stratigraphic time intervals. These in turn can be used to construct global paleodigital elevation models (PDEMs) that are bolstered using statistical information on modern landscapes and their relationship to plate tectonic settings. PDEMs can be used as inputs for paleoclimate models, the outputs of which provide additional insights into the factors controlling sediment supply and enabling the likely distribution of key petroleum system elements (e.g., source rocks, reservoirs) to be understood and even predicted away from data control.

These combined insights allow predictive global maps of sedimentary facies and their composition, including potential reservoir quality and source rock effectiveness to be created. Using a set of plate-scale structure-contour maps derived from the integrated subsurface data allows the effects of burial on petroleum system elements effectiveness to be assessed, facilitating basin screening and play risking. This same framework can also be used to identify sediment-hosted mineral deposits.

By combining time-attributed data and knowledge of different geologic processes, the 4D model of the Earth provides insights from reservoir to global scale, allowing informed decision-making. Emerging digital solutions promise the ability to significantly increase the accuracy of such models and the efficiency with which they are built.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