

Technology Trends Impacting Geoscience Interpretation

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For geoscientists, the three most significant technologies impacting seismic/well data quality and interpretation processes are elastic full-waveform inversion (eFWI), AI/ML, and increasing computer power. The output from eFWI processing is producing dramatic improvements in our seismic imaging and the overwhelming application of AI/ML methods is changing the geoscientists' workflows. The evolution of AI/ML and eFWI is directly impacted by increased computer power.

In November 2022, ChatGPT (Large Language Model – LLM) was introduced and produced unprecedented proficiency in understanding and generating human language. Based on Transformer Architecture, it incorporates self-supervised learning (self-attention), where a model learns from unlabeled data, creating its own labels based on the data's internal structure. Will LLMs like ChatGPT be the future of interacting with our geological and geophysical data? The hottest trend in AI/ML today is Agentic AI. This approach represents autonomous, goal-oriented systems capable of independent decision-making, learning, and interaction within complex environments, rather than responding to individual prompts. It consists of AI agents, entities designed to perceive their environment through sensors, process information, and act on it, all while striving to achieve specific goals (Nash, 2025). Can Agentic AI automate our interpretation workflows?

There have been dramatic results in seismic processing over the last few years where Full Waveform Inversion (FWI) iteratively updates an estimated subsurface model and produces corresponding synthetic data to reduce the difference (the data misfit) between the synthetic and recorded data. Initially, acoustic FWI (aFWI) was developed to produce high-resolution velocities, but only using P-wave data. The ultimate objective of FWI is to match the synthetic and recorded data in a comprehensive way, such that all information in the waveforms (e.g., travel times, amplitudes, converted waves, multiples, etc.) is accounted for in the data misfit. Elastic FWI (eFWI) has accomplished this and has produced such impressive results that its requirements have influenced the marine seismic acquisition industry to dominantly employ Ocean Bottom Node (OBN) systems.

Today, the necessary computer power and associated architecture for advanced technologies like AI/ML and FWI are centered around CPU/GPU configurations, High-Performance Computing (HPC), and the Cloud. However, most experts indicate that within a decade, quantum computers will be operational, and estimates of increases over today's computational speed range from millions to exponentially faster. What geoscience challenges could be resolved in a world with fully operational quantum computers?