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Skolkovo Institute of Science and Technology

Energy Colloquium

Pitfalls and Challenges of Seismic Imaging

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ABSTRACT:

While depth migration and the so-called "full-waveform inversion" play an increasing role in seismic exploration, none of them can be considered as an ultimate tool to infer the interior structure of the earth. Each of these methods has its own limitations and pitfalls. The lecture has a conceptual character and is therefore not structured in sections dealing with theory and numerical examples; rather, the examples will continuously support the argument. In the first part of my lecture, I will formulate a number of fundamental questions which should be addressed to make the field of geophysical inverse problems a mature science rather than a set of recipes. The ill-posedness of seismic inverse problems is fundamental and does not depend on a particular type of algorithm or on the approach underlying the algorithms. I will introduce and discuss a way to look at model-independent seismic imaging using the quantum mechanics concept. Can Feynman's path-integral idea be used for seismic imaging? In analogy to the path-integral method, we can construct the seismic image by summation over the contributions of elementary signals propagated along a representative sample of possible paths between the source and receiver points. The quantum imaging converges to a standard imaging procedure only in trivial situations of a deterministic and known velocity model. Small-scale structural details and heterogeneities of the subsurface such as faults, karsts, and fractures are of crucial importance for exploration, production, and development of unconventional oil and gas reservoirs. Small-scale elements of the subsurface are capable of generating strong scattered/diffracted waves, which are recognized as main information-carrying signals. I will present several ways to separate the total wave field into two components: specular reflections and diffraction. Images of the separated diffractive component of the total wave field are able to emphasize small but important geologic objects that often are invisible after conventional seismic processing.

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