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Research description

The authors have pioneered, and led the development of rock physics to link observable seismic characteristics of rocks to reservoir properties (porosity, lithology, texture, permeability) and conditions (saturation and pressure). In addition to the scientific value of the models developed by the authors, the practical applications in oil industry workflows are unlimited. The focus of the authors' research has been on integrating fundamental physics, mechanics, statistics, and wave propagation for applications in reservoir characterization and monitoring. This group has demonstrated a unique and extraordinary ability for developing, understanding, and combining theories from diverse fields to arrive at elegant scientific and practical solutions to complex problems in hydrocarbon exploration.

Rock physics links seismic data to reservoir modeling: it establishes transforms between elastic properties obtained from seismic data and rock properties to be used in reservoir modeling. Rock physics can be used for seismic interpretation, reservoir property estimation, pore pressure studies, feasibility analysis, time lapse seismic inversion and seismic history matching. In addition to traditional rock physics workflows, over the past five years the authors have introduced models for anisotropic rock properties as well as for unconventional reservoirs. Newly developed rock physics equations and models quantify the seismic response of heavy-oil reservoirs. The unique body of science thus created by the authors has revolutionized quantitative reservoir characterization and seismic time-lapse monitoring.

The theoretical rock physics models introduced by this group are now an industry standard widely used in interpreting seismic measurements for rock properties and conditions, including fluid, pressure, and porosity mapping as well as anisotropy and fracture characterization. The authors have been at the forefront of introducing and developing cutting-edge new disciplines and methods such as statistical rock physics, rock physics diagnostics and computational rock physics. Over the last five years these new disciplines have begun to gain worldwide acceptance by academia and industry.

The authors pioneered modern Monte Carlo methods in rock physics, inventing the relatively new field of statistical rock physics. This has critical practical applications for assessing uncertainties in any quantitative reservoir interpretation based on rock physics models. The authors developed several methodologies to quantitatively use statistical rock physics models in inversion and reservoir characterization workflows, thus not only improving the reservoir

description, but also quantifying the associated risk and uncertainty. Recent inventions by the authors include Bayesian inversion methods and stochastic optimization approaches where the authors combine rock physics models and geostatistical methods to quantitatively interpret seismic data in terms of lithologies and pore fluids. Advancing along another forefront, the authors pioneered the emerging field of computational rock physics: a domain where the authors creatively combined high resolution pore-scale imaging and innovative computation to derive computationally-based rock physics transforms for use in reservoir characterization.

Not only have they invented new methodologies, they have also been outstanding educators and communicators, sharing and transferring their knowledge through innumerable international industry courses, and producing students many of whom are now academic and industry leaders. Articles by the authors in peer-reviewed journals total several hundreds. Together, the authors have written three books (*Seismic Reflections of Rock Properties*, 1st edition, *The Rock Physics Handbook*, 2nd edition, and *Quantitative Seismic Interpretation*, 1st edition) which are on the desktops of industry experts and students alike. Their widely-recognized books have become influential in shaping rock physics and its practical use by the industry and academia worldwide.