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Physics and Simulation of Waves for Exploration and Environmental Geosciences

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Use of wave modeling and inversion for the interpretation of the characteristics of rocks and geologic formations requires the understanding of the relationship between the seismic attributes and the rock properties. In particular, in the exploration of oil and gas reservoirs, it is important to predict the porosity, the presence of fluids (type and saturation), the preferential directions of fluid flow (anisotropy), the presence of abnormal pore pressures (overpressure), etc. These microstructural properties and the in-situ rock conditions can be obtained, in principle, from the seismic attributes, using realistic constitutive equations.

This lecture briefly outlines the physics and simulation of wave propagation in anisotropic, anelastic, and porous media, including the analogy between acoustic waves (in the general sense) and electromagnetic waves. Most of the numerical techniques have been recently developed; for instance, the solution of the poro-viscoelastic wave equation for reservoir seismics, and the domain-decomposition methods for wave propagation at the ocean bottom.

The applications include evaluation of methane hydrate content, upscaling techniques, detection of overpressure, propagation in permafrost, exploration of the Earth's deep crust, time-lapse seismics for monitoring of CO₂ sequestration, borehole stability, the mesoscopic loss mechanism in rocks, geo-radar applications, and low-frequency electromagnetic prospecting in the Earth. The emphasis is on geophysical applications for seismic exploration, but researchers in the fields of earthquake seismology, rock physics, and material science — including many branches of acoustics of fluids and solids (acoustics of materials, nondestructive testing, etc.) — may also find the presentation useful.

Biography

José M. Carcione was born in Buenos Aires, Argentina in 1953. He received the degree Licenciado in Ciencias Físicas from Buenos Aires University in 1978, the degree Dottore in Física from Milan University in 1984, and the Ph.D in geophysics from Tel-Aviv University in 1987. From 1978 to 1980 he worked at the Comisión Nacional de Energía Atómica at Buenos Aires. From 1981 to 1987 he was employed as a research geophysicist at Yacimientos Petrolíferos Fiscales, the national oil company of Argentina. Presently, he is a senior geophysicist at the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), formerly Osservatorio Geofisico Sperimentale in Trieste. He was awarded the Alexander von Humboldt scholarship for a postdoc at Hamburg University, where he stayed from 1987 to 1989. In 2007, he received the Anstey award at the EAGE in London. José Carcione has published more than 160 journal articles on acoustic and electromagnetic numerical modeling, with applications to oil exploration and environmental geophysics. He is the author of the book *Wave fields in Real Media – Theory and numerical simulation of wave propagation in anisotropic, anelastic, porous and electromagnetic media* (Pergamon Press, 2001; Elsevier Science, 2007) and co-author of *Arqueo-geofísica: Una metodología interdisciplinaria para explorar el pasado* (Fundación de Historia Natural, 2006). He has been an editor of GEOPHYSICS since 1999.