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Editorial
Seismic Imaging

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As organized and intelligible displays of data, seismic images constitute invaluable tools for gaining and conveying information on structural and material properties of the Earth. The present special issue on "*Seismic imaging*" aims to explore basic and/or applied aspects of seismic data that are relevant to meet today's challenges in subsurface imaging. It comprises 13 articles, covering a wide variety of state-of-the-art topics on seismology and seismics, on both theoretical, and practical issues.

H. Kern examines, in the form of a review, the interdependence of elastic wave propagation and physical and lithological parameters. For that aim, compressional (Vp), shear wave velocities (Vs) and velocity anisotropy of crustal rocks measured at conditions of greater depth are used to evaluate how elastic properties of rock materials are controlled by lithology at in situ pressures and temperatures. Laboratory seismic measurements and theoretical calculations are used to interpret a shallow seismic reflection line and a deep-crust refraction profile.

P. Singh and T. Davis investigate the detection of Morrow sandstones in connection to the exploration of new oil fields and the characterization of existing ones. Such sandstones are often very thin and laterally discontinuous. Full waveform modeling is performed to understand the Morrow sandstone signatures on compressional wave (P-wave), converted-wave (PS-wave), and pure shear wave (S-wave) gathers. Modeling tied with the field data demonstrates that S-waves are more robust than P-waves in detecting the Morrow sandstone reservoirs.

By means of a detailed study of P-wave arrival times of a significant number of local earthquakes, H. Li et al. obtain three-dimensional, high-resolution, P-wave velocity models under the Zipingpu reservoir in Longmenshan fault. The 3D velocity images at shallow depth show that the low-velocity regions have strong correlation with the surface trace of the reservoir. From the study, the infiltration depths directly from the Zipingpu reservoir, and also downwards along the Beichuan-Yingxiu, are quantitatively estimated.

In a review article, M. Kanao et al. analyze broadband seismic deployments carried out in the Lützow-Holm Bay region, East Antarctica. Recorded teleseismic and local events enable imaging the structure and dynamics of the crust and mantle of the terrain. By combining the active and passive source studies of the mantle structure, an evolution model for constructing the present mantle structure in the region is proposed.

X. Yu et al. present a new tomographic method that uses P arrival times to determine 3D crustal velocity structures, as well as hypocenter parameters of seismic events under the Beijing-Tianjin-Tangshan region. In the North China Basin, the depression and uplift areas are imaged as slow and fast velocities, respectively. A broad low-velocity anomaly exists in Tangshan and surrounding area from 20 km down to 30 km depth. The results suggest that the top boundary of low-velocity anomalies is at about 25.4 km depth. The event relocations inverted from double-difference tomography are clustered tightly along the Tangshan-Dacheng Fault and form three clusters on the vertical slice. The maximum focal depth after relocation is about 25 km in the Tangshan area.

Nowack assesses the potential of dynamically focused Gaussian beams for seismic imaging. Focused Gaussian beams away from the source and receiver plane allow the narrowest and planar portions of the beams to occur at the depth of a specific target structure. To provide additional control of the imaging process, dynamic focusing is investigated where all subsurface points are specified to have the same planar beam fronts. The approach is tested with a simple model of 5-point scatterers which are then imaged with the data, and then to the imaging of a single dynamically focused beam for one shot gather computed from the Sigsbee2A model.

W. Burnett and S. Fomel extend time-domain velocity continuation to the zero-offset 3D azimuthally anisotropic case. Velocity continuation describes how a seismic image changes given a change in migration velocity. This description turns out to be of a wave propagation process, in which images change along a velocity axis. In the anisotropic case, the velocity model is multiparameter, so that anisotropic image propagation is multidimensional. A three-parameter slowness model is considered which is related to azimuthal variations in velocity, as well as their principal directions. This information is useful for fracture and reservoir characterization from seismic data. Synthetic diffraction imaging examples are provided to illustrate the concept and potential applications of azimuthal velocity continuation and to analyze the impulse response of the 3D velocity continuation operator.

J. van der Neut et al. employ controlled-source seismic interferometry to redatum sources to downhole receiver locations without requiring a velocity model. Interferometry is generally based on a source integral over cross-correlation pairs of full, perturbed (time-gated), or decomposed wavefields. An overview is provided on the effects of ghosts, multiples, and spatial blurring that can occur for different types of interferometry. It is shown that replacing crosscorrelation by multidimensional deconvolution (MDD) can deghost, demultiple, and deblur retrieved data, but it leaves particular multiples in place. To remove all overburden-related effects, MDD of decomposed fields should be applied.

T. van Leeuwen et al. explore the use of stochastic optimization methods for seismic waveform inversion. The concept of stochasticity is introduced in waveform inversion problem in a rigorous way via a technique called randomized trace estimation. Theoretical results are reviewed that underlie the use of stochastic methods for waveform inversion. By means of illustrative numerical examples, it is found that it is possible to reproduce results that are qualitatively similar to the solution of the full problem with modest batch sizes. This may lead to an order of magnitude speedup for waveform inversion in practice.

T. Alkahlifah and P. Sava consider transversely isotropic (TI) models in which the tilt is constrained to be normal to the dip. Such consideration allows for simplifications in the imaging and velocity model building efforts as compared to a general transversely isotropic TI (TTI) model. Although this model cannot be represented physically in all situations, it handles arbitrary reflector orientations under the assumption of symmetry axis normal to the dip. Utilizing the reflection features of such a model, efficient downward continuation algorithms, as compared to the general TTI ones, can be constructed. These features enable a process in which one can extract velocity information by including tools that expose inaccuracies in the velocity model in the downward continuation process. The model is tested on synthetic data corresponding to a general TTI medium showing good results.

E. G. Asgedom et al. develop a higher-resolution method for the estimation of the three travel-time parameters that are used in the 2D zero-offset, Common-Reflection-Surface stack method. The underlying principle in this method is to replace the coherency measure performed using semblance with that of MUSIC (multiple signal classification) pseudospectrum that utilizes the eigenstructure of the data covariance matrix. The performance of the two parameter estimation techniques (i.e., semblance and MUSIC) is investigated using both synthetic seismic diffraction and reflection data corrupted with white Gaussian noise, as well as a multioffset ground penetrating radar (GPR) field data set. The estimated parameters employing MUSIC were shown to be superior of those from semblance.

Three-dimensional wave-equation migration techniques are still quite expensive because of the huge matrices that need to be inverted. J. C. Costa et al. compare the performance of splitting techniques for stable 3D Fourier finite-difference (FFD) migration techniques in terms of image quality and computational cost. The FFD methods are complex Padé FFD and FFD plus interpolation, and the compared splitting techniques are two- and four-way splitting. From numerical examples in homogeneous and inhomogeneous media, we conclude that, though theoretically less accurate, alternate four-way splitting yields results of comparable quality as full four-way splitting at the cost of two-way splitting.

Linearized multiparameter inversion is a model-driven variant of amplitude-versus-offset analysis, which seeks to separately account for the influences of several model parameters on the seismic response. R. Nammour and W. W. Symes suggest an approach based on the mathematical nature of the normal operator of linearized inversion, which is a scaling operator in phase space, and on a very old idea from linear algebra, namely, Cramer's rule for computing the inverse of a matrix. The approximate solution of the linearized multiparameter problem so produced involves no ray theory computations. It may be sufficiently accurate for some purposes; for others, it can serve as a preconditioner to enhance the convergence of standard iterative methods.

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