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Introduction Part I

Traditionally, seismic exploration and solid Earth seismology have developed into two distinct branches of science. These diverging courses can be explained partly by the different scales of investigation and the different questions each of the two branches address. As a consequence, the way data are acquired and the way information is extracted from the data are quite different. Hence, there has been little previous exchange of practices.

The main goal in seismic exploration and production (E&P) is to obtain a map of the first few kilometres of the subsurface, with particular emphasis on locating and characterizing potential hydrocarbon bearing structures. Such a map is obtained by imaging and analysing seismic reflection information. For this reason, data are usually acquired on dense and regular grids of receivers with controlled sources. The acquisition geometries – relatively short offsets, high channel counts and subsurface redundancy – are designed in such a way that the data contain mainly reflection information with high signal-to-noise ratio. To even further increase the signal-to-noise ratio and to increase the resolution of the seismic images, multichannel processing is routinely applied to exploration data.

In seismology, on the other hand, the scales of investigation are much larger: for example the mantle or entire crust, with the aim to determine the Earth's structure and understand processes such as subduction. Also on account of the prohibitively expensive seismometers, data have traditionally been acquired by sparsely and irregularly positioned (multi-component) stations. In crustal seismology, one is used to working with long offset data, analysing mainly first arrival information to retrieve layer velocities. In solid Earth seismology, one relies on naturally occurring sources, the location of which is only approximately known, while the source time-series can be quite complicated. From earthquake responses, mainly transmission information (surface waves and P- and S-body waves) is exploited and the main processing consists in tomographic inversion of the interpreted arrival times of the different phases.

Several recent developments warrant a more intensive dialogue between the exploration and solid Earth seismology communities. With the advent of cheaper seismometers, earthquake and global offset data have become more densely sampled, allowing the application of E&P-style multichannel processing and imaging to global seismic data, providing relatively high-resolution images of the entire crust and mantle, even up to the core-mantle boundary. Both global and exploration seismologists look for more information in the seismic data and combine different types of data to better characterize physical properties and processes in the Earth. In exploration and production, some of this novel information comes from continuous recording of induced seismicity. Tomography and source-location and -inversion provide information on fractures and the stress state of the reservoir. New data inversion schemes require input data with different frequency and wavenumber content, for example obtained from global offset active experiments or tomography from local earthquake responses. The increased use of multicomponent receivers at the sea-bottom and on land make S-waves and P-S converted waves increasingly important sources of information in E&P. The relatively new field of seismic interferometry has sparked the interest of both exploration and global seismologists, who are now exploring the use of parts of the seismogram that were previously considered noise: coda, multiples and even ambient noise.

For the workshop 'What Can E&P Learn from Seismology and *Vice Versa*?' organized at the EAGE Conference in Vienna in 2006, researchers from both fields were invited and challenged to use their imagination to stimulate cross-fertilization between these fields. Because of the quality of the contributions and the original ideas presented in them, the decision was made to dedicate a special issue to the topic of the workshop. This turned out to be such a success, that the papers had to be split into two parts. Many of the contributions in the special issue on 'What Can E&P Learn from Seismology and *Vice Versa*?' were presented at the workshop of the same name.

During the preparation of the special issue, we have received great support from the EAGE office. In particular, Publications Coordinator Wendel van der Sluis kept us on track with the deadlines and regular updates. *Geophysical Prospecting* Editor-in-Chief Aldo Vesnaver has played an important stimulating and supporting role throughout the preparation of the issue. Last but not least, we thank all reviewers for their careful and constructive reviews.

In this first part of the special issue 'What Can E&P Learn from Seismology and *Vice Versa*?', we divided the papers into two sections in which the papers deal with generally the same topics. The first six papers address multicomponent data (including surface waves) and processing. The remaining four papers of part I deal with seismic interferometry.

MULTICOMPONENT SEISMOLOGY: S, P-S CONVERTED AND SURFACE WAVES

In E&P, S waves or P-S converted waves are not yet routinely interpreted. Nonetheless, important additional information on elastic properties of the medium (not provided by P-waves) can be obtained from S-waves. One such use is the study of shear-wave splitting related to anisotropy of reservoirs due to fractures. Bansal and Sen discuss the modelling of wave propagation in arbitrary anisotropic media. Using synthetic data, they investigate S-wave splitting in various scenarios, such as dipping, non-orthogonal and corrugated fractures. Van der Neut, Sen and Wapenaar discuss a model for P-P, P-S and S-S reflection coefficients of faults. For relatively low frequencies these coefficients are straightforwardly related to the parameters of the fault and the surrounding medium, which facilitates the determination of these parameters from seismic reflection data. Passive excitation by the ocean of low-frequency waves is emphasized by Crawford and Singh in order to reconstruct sediments structure using sensors deployed on the sea bottom. These low-frequency waves through the compliance function are related to surface waves, which might be used for retrieving shear information through dispersion curve inversion. However, the inversion of surface-wave dispersion curves is non-unique and depends strongly on the initial model. Socco and Boiero discuss a Monte Carlo approach to sampling the model space in dispersion curve inversion. Using the scaling properties of modal curves, the parameter space is sampled more efficiently. The results of the inversion are interpreted by subjecting them to a statistical test. Both methodologies are tested and validated with synthetic and field data. Edme and Singh adapt the traditional receiver function technique that uses P to S converted waves from teleseismic earthquakes to investigate near-receiver structure, to data from seismic reflection acquisition geometry. Their adapted method, based on the deconvolution of the vertical component seismogram from the horizontal component seismogram, results in a PS reflectivity trace, which may be used for amplitude *versus* slowness or offset analysis. Finally, Zahradnik *et al.* discuss an improvement in double couple determination by complementing the conventional momenttensor retrieval with a spatio-temporal grid search to improve source location and time. This algorithm allows them to determine subtle deviations from double-couple mechanisms in the estimation of earthquake source processes.

SEISMIC INTERFEROMETRY

An exciting development that has been evolving concurrently in both seismic exploration and seismology is seismic interferometry, that is, a method of retrieving additional information from seismic data by cross-correlating responses measured at different receivers. Exploration seismologists use this for extracting and/or improving reflection information (either from passive or active data) whereas seismologists have shown that they can reconstruct surface waves between stations by correlating ambient noise observations. Moreover, seismic interferometry shows great promise for retrieving more information from the seismic coda as well as for a wide range of other applications. Gouédard *et al.* analyse theoretically the process of extracting phase information from random noise. In their paper, they also describe successful applications of this technique across different scales, from the extraction of reflection data in laboratory measurements to the construction of surface waves on a regional scale. Ruigrok, Draganov and Wapenaar recognize the sparse distribution of earthquakes as a potential limiting factor in imaging the mantle and core. They derive elastodynamic representation theorems for the retrieval of Green's functions between receiver stations on a global scale. The application of these theorems allows them to extract from earthquake records a data set in which each receiver station also acts as a source, thereby increasing the source distribution. Numerical examples serve to illustrate the validity of their interferometric representations. Wapenaar, Slob and Snieder make a generalization to existing interferometric relations in that they allow dissipation in the medium. By replacing the cross-correlation used in most interferometry relations with a multidimensional deconvolution, they open up the way to apply interferometry to any controlled-source wave and diffusion field. A numerical example with controlled-source electromagnetic (CSEM) data is used to illustrate this. Yokoi and Margaryan explore theoretically and experimentally the similarities between the conventional spatial autocorrelation method and seismic interferometry, based on elastodynamic representation theorems. These investigations might open new strategies for weak time variations of the medium sampled by waves, either because of natural evolution or because of anthropogenic excitation.

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