Geophysics Bright Spots

Coordinated by Christine Krohn

This Bright Spots column spotlights four papers from the January-February 2018 issue of Geophysics. As usual, these articles were nominated by the Geophysics editors as worthy of a greater audience than their assigned specialty area within the journal. We hope the summaries below will motivate you to peruse these and other outstanding papers in Geophysics. I echo Ken Mahrer from past columns: "As always, Geophysics is worth your effort."

Geophysics to the bone. Can ground-penetrating radar be used to detect prehistoric animal remains? In "Bone permittivity and its effect on using ground-penetrating radar," Schneider et al. show that locating bone deposits as part of archaeological investigations may be possible, depending on the encasing material. The authors measured dielectric properties of samples of ancient mammoth bone and modern bison, cow, deer, and elk bones and found significant differences between different animals (Figure 1). They utilized common dielectric-mixing models for determining the dielectric values of dry animal bone and determined that sample porosity, bulk density, water saturation, and volumetric water content do not explain the observed differences.

RTM imaging with stabilized amplitude Q-compensation. Compensation for attenuation losses, which should include both amplitude and phase effects, during imaging can suffer from numerical instability because of the boost high-frequency noise. In "Adaptive stabilization for Q-compensated reverse time migration," Wang et al. use k-space Green's function to explain the instabilities and to derive a stabilization operator. Compared to the standard low-pass-filtering approach, the method exhibits improved amplitude and phase behavior. Wang et al. further demonstrate superior performance and enhanced resolution for noisy data.

Joint inversion of gravity and traveltime data. Zheglova et al. use joint inversion of gravity and seismic traveltime data to determine the boundaries between subsurface regions with distinct known properties. In their paper, "Multiple level-set joint inversion of traveltime and gravity data with application to ore delineation: A synthetic study," they describe a multiple level-set method that considers up to four regions, each with constant or slowly varying properties. Given the challenge of small target size and the specific physical property contrasts involved in mineral exploration, they show that the traveltime and gravity data complement each other. The joint inversion is especially helpful for slow targets and limited data as shown in Figure 2 for a slow sulfide body in a dike.

Joint petrophysics-seismic inversion with uncertainties. Fjeldstad and Grana in "Joint probabilistic petrophysics-seismic inversion based on Gaussian mixture and Markov chain prior models" propose a probabilistic method for the simultaneous prediction of continuous reservoir properties, such as petrophysical and elastic attributes, and discrete properties, such as lithology/fluid class, from the measured geophysical data. The authors developed a Bayesian inversion method that combines rock physics and seismic inversion with Gaussian mixture and Markov models. The method has the advantage that it accounts for the uncertainty associated with each step of the modeling workflow. A case history (Figure 3) is presented using partial stacked seismic and well-log data from a field in the Norwegian Sea. The results are consistent with well logs. TLE

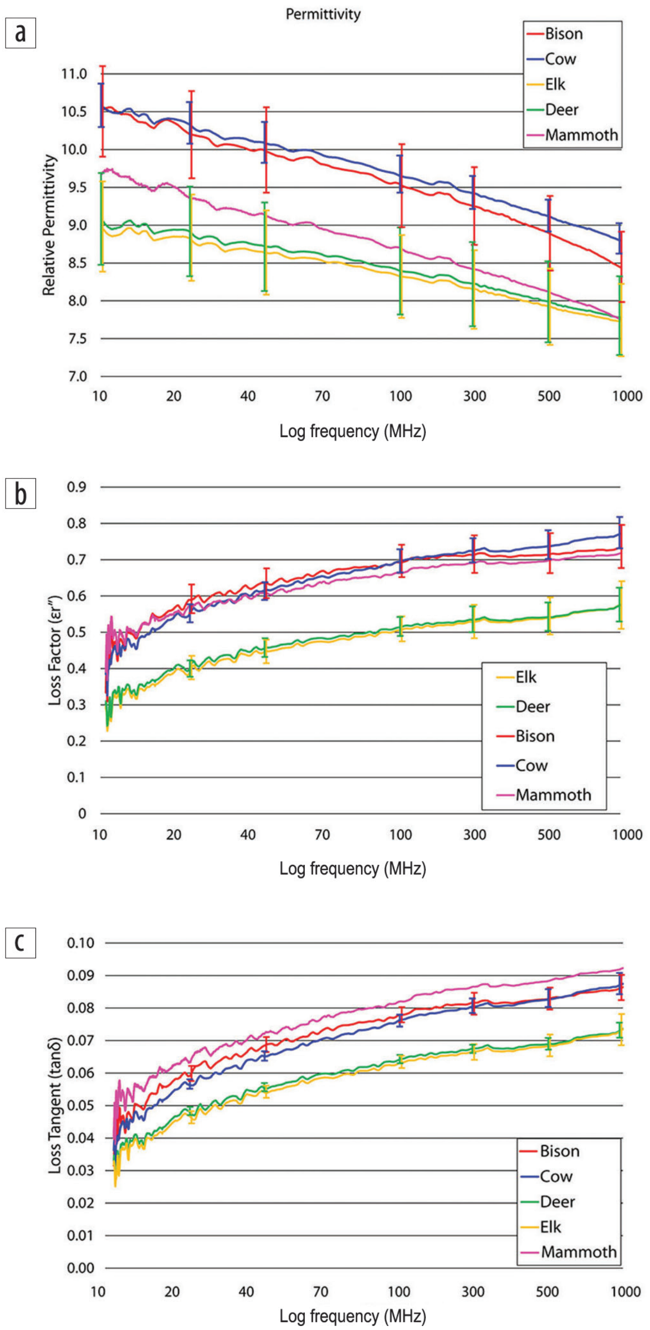

Figure 1. (Figure 2 from Schneider et al.). (a) Relative permittivity, (b) loss factor, and (c) loss tangent for frequencies of 10 MHz to 1 GHz for bones from different species. For modern bones, two distinct groupings are seen: deer-elk and cow-bison. The behavior of the ancient mammoth sample falls within the overall range of relative permittivity values but is closer to the deer and elk values than to those for cow and bison.

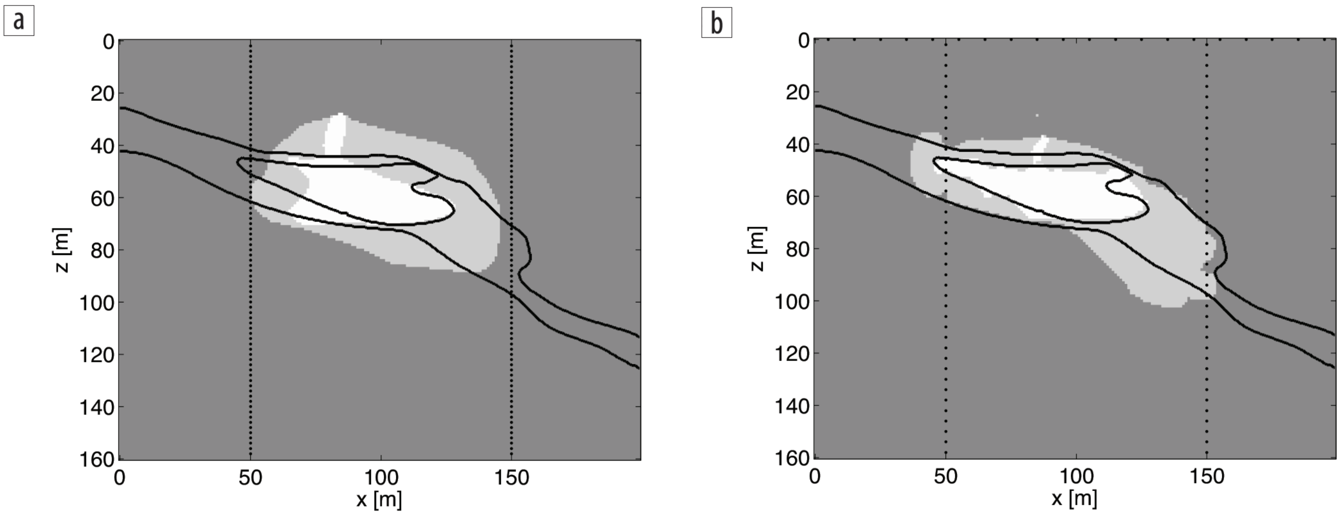

Figure 2. (Figure 9a, 9b from Zheglova et al.). Recovery of a slow dense sulfide body in a dike: (a) traveltime inversion and (b) joint inversion. The true model is plotted as black lines.

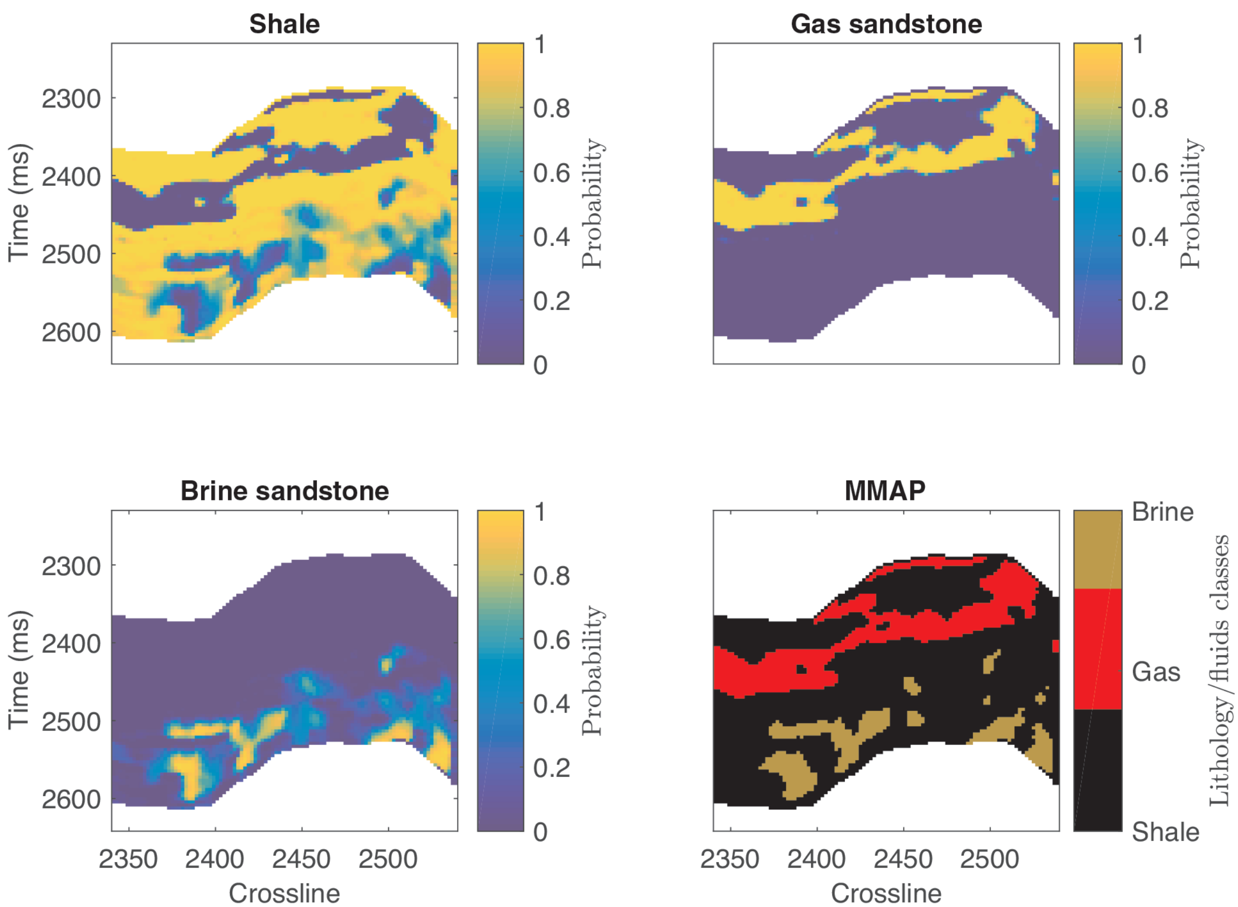

Figure 3. (Figure 10 from Fjeldstad and Grana). The figure shows predicted probabilities for the various lithology/fluid classes and the most probable lithology/fluid classes for the cross section. Other figures in the paper show results for continuous reservoir properties such as, porosity, water saturation, clay content, and for P-wave impedance, and V_P/V_S ratio.