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Infusing rock physics into seismic inversion

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Mick Jagger, philosopher and singer of The Rolling Stones back in 1969, sang rather pessimistically “You can’t always get what you want.” These words should ring true to all geoscientists: What we really want are measures of rock properties (such as facies/rock types, porosity, saturation, etc.), but what we typically measure in the field are quantities like resistivity, density, seismic wiggles, etc., —signals that are “somehow” related (to a smaller or larger degree) to these desired rock properties.

Obtaining profiles of rock properties from measured well logs is called petrophysical evaluation. Geologists, when they want to obtain estimates of overpressures, talk about prediction. Geophysicists, trying to obtain 3D images of rock properties from processed 3D seismic data, have a perhaps better, more formal name for this process: inversion.

Seismic inversion is a difficult endeavor, for the simple reason that the earth filters out a lot of the useful signal as it travels from a source through the subsurface to the receivers. What we are left with is a band-limited signal with restricted information content. This can be readily seen when we compare a seismic trace against a corresponding impedance profile: The latter typically becomes larger as we go deeper (compaction hardens the earth), whereas the former keeps wiggling around zero. What a mismatch!

Even though the new broadband seismic acquisition technique increases the seismic information content (good!), the signal is still band-limited, and keeps wiggling around zero. Thus, the mismatch with the hardening impedance profile is still there.

In that same song, Jagger also sings of a more optimistic moment: “If you try sometimes, you might find … you get what you need!” — a sentiment I wholeheartedly agree with! Seismic inversion may be difficult, and the information content of the seismic signal may be limited, but there are ever more sophisticated ways to perform seismic inversion, and that is what this lecture is all about.

The trick really is that somehow we need to add information to the seismic inversion process that is not in the seismic itself. For instance, low-frequency information (as the seismic is band-limited), or high-frequency information (for the same reason). Much of this lecture is about adding this extra information, because there are many ways to do this, though not all equally successful. We shall focus specifically on using rock-physics models to better derive the extra information, because these are nothing other than relationships between what we get and what we want!

Just to put the reader’s mind (and ears) at ease: I shall *not* be singing during the lecture.

Biography

Michael Kemper is a geoscientist/petroleum engineer with 28 years experience in geophysics, petrophysics, and reservoir engineering. He spent the first 13 years with Shell International in The Hague, Nigeria, and London, during which time he made a number of contributions to the interface between petrophysics and geophysics.

In May 1999, Kemper became team leader of petrophysics/petroacoustics at Ikoda Ltd., working on a wide variety of projects. It is during this time that RokDoc, now one of Ikon Science's main products, was started. As one of the cofounders of Ikon Science, Kemper now serves as director of research and innovation. In this role, he is responsible for the development of new, innovative, and impactful algorithms and workflows in the area of rock physics, seismic inversion, and numerical earth modeling in the Ikon Science software portfolio.