Migration, Tomography and Datuming by Seismic Interferometry

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SUMMARY

Inteferometric seismic data can be defined as the correlation between two selected events, event $P_g^A = e^{i\omega(\tau^{unint.}+\tau_g^{interest})}$ at trace g and event $P_{g'}^B = e^{i\omega(\tau^{unint.}+\tau_{g'}^{interest})}$ at trace g'. The A and B events are similar in the sense that a portion of their raypaths coincide through uninteresting parts of the media (such as overburden or the crust), so that the correlated data $\phi(g,g',s) = P_g^A \; P_{g'}^{B*}$ $= e^{i\omega(\tau_g^{interest}-\tau_{g'}^{interest})}$ removes the uninteresting kinematic effects (i.e., eliminates $\tau^{unint.}$) as well as source+receiver statics. Applying interferometric imaging formulas to crosscorrelation data allows one to, e.g., automatically migrate multiples in seismic data, redatum sources and receivers below uninteresting parts of the medium (such as the crust or overburden) without needing to know the associated velocity model, migrate converted reflection and transmission waves, and detect the location of hidden sources. Synthetic and field data sets are used to demonstrate the effectiveness of interferometrically converting VSP, CDP or HSP (horizontal seismic profile) data to effective single well imaging data where both sources and receivers are at depth; no velocity model is needed. This could be important for VSP experiments along the San Andreas fault. Other uses of interferometry include imaging the reflectivity structure of the crust by ghost reflections (preliminary results for Utah earthquake data are presented), velocity analysis by interferometric traveltime tomography and generalization of the receiver-function imaging method. Examples of migrating, datuming and tomographically inverting seismic data are presented and clearly illustrate the higher resolving power of seismic interferometry compared to standard seismic imaging.