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Imaging deep structures by advanced techniques

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In this study, we demonstrate that the applications of the wave equation datuming (WED) on two dataset acquired in Sicily and Tuscany is essential to improve signal/noise ratio extracting information previously hidden by approximate static corrections and near surface noise. Therefore, this algorithm allows obtaining a good imaging of the geological features. Kirchhoff integral solution to scalar wave equation (using both nearfield and far-field terms) can provide a basis computation to deal in the datuming with irregular surfaces and variable velocities. In the pre-stack domain, WED is applied in two steps: (i) common-source and (ii) common-receiver domains. Operating on a common-source gather, it has the effect of extrapolating receivers from one datum to another, and, because of reciprocity, operating on a common-receiver gather, it changes the datum of the source. Basically, WED is a process of upward or downward continuation of the wave-field between two arbitrarily shaped surfaces. Recalling main principles of the theory, we should consider the importance of distinguishing between migration and WED. WED produces an unmigrated time section at a specified datum plane; migration involves computing the wave-field at all depths from the wave-field at the surface. In addition to downward continuation, migration requires imaging principle. In this respect, WED is an ingredient of migration, when we apply migration as a downward continuation process. The WED was applied to move shots and receivers to a given datum plane, removing time shifts related to topography and to near-surface velocity variations. The datuming procedure largely contributed to attenuate ground roll, enhance higher frequencies, increase resolution and improve the signal/noise ratio.
The first transect allowed exploring structures of Central Sicily, showing blocks fragmentation with dramatic crustal thinning and allochthonous terrains accumulation within the Caltanissetta trough, the huge anticline and stack of units after the collision the Tyrrhenian crust. The Tuscany dataset highlights the reflectivity of the deep crustal structures and the extension of the major reflector H and K characterizing the Geothermal Province.
Since WED application requires a reliable velocity field, in both cases we first proceeded to pick all first arrival times in the field records in order to perform a tomographic inversion of first breaks. This step allowed us to build a velocity model for near-surface sequences, where significant complexities are present, like highly variable lithology and rough topography. After the WED application, the data was processed in order to obtain a stacked section. A post-stack migration was applied.
In both cases, the WED application let us differentiate seismic facies, offering a direct image of ongoing tectonic setting and of variable lithology and petrophysical properties.