Shear wave sounding in archaeological prospecting

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Onshore seismic sounding has been applied in archaeological prospecting mainly for solving geo-archaeological questions such as the exploration of silted ancient harbor basins and waterways. For this sort of "wetland targets" the application of S-waves turned out to be advantageous because their propagation velocity is nearly independent of water saturation. Therefore, S-wave sounding is much more sensitive to lithological change in wetland soils than P-wave sounding and electric resistivity tomography, which might otherwise be considered as alternative tools for prospecting targets. Target depths are typically some meters to a few tens of meters. The standard tools of archaeological prospecting, magnetic gradiometry and ground penetrating radar (GPR), are not applicable for these targets because of lack of depth resolution or penetration, respectively. For the same reasons S-wave reflection imaging has proved to be a most promising approach for investigating the internal monumental grave mounds, so-called tumuli, which can reach several 10 m height.

But even for very near-surface targets at depths of only a few meters S-wave sounding may become attractive in the future in cases where electromagnetic absorption or lack of magnetization contrast cause GPR and magnetics to fail. This is because recent advances in full-waveform inversion (FWI) enable imaging near-surface structure at 10 cm scales thus showing structural resolution not much different from GPR. Still S-wave sounding and FWI are far from being a routine method in archaeological prospecting because of the comparatively large efforts in fieldwork and numerical computation required. But they open the possibility to access mechanical soil parameters in previously not possible resolution, which is attractive also for engineering purposes, especially for assessing ground stability and near-surface fracturing.

We demonstrate the potential of S-wave sounding in archaeological prospecting by showing examples from Central Europe and the western Mediterranean. In this we put a focus on the exploration of ancient harbors and waterways, tumuli and some suspect possibly archaeological structure, which produced seismograms that are not interpretable in a classical sense but could be deciphered by FWI.