On GPR signal polarity: a comparison between theoretical findings and real case-studies

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Signal polarity is an attribute that can be used as additional key element to reduce ambiguities and pitfalls in the data interpretation step.

A theoretical analysis of the reflection and transmission phenomena for parallel and perpendicular polarization of the electric field was carried out highlighting that polarity changes (180-degree phase shifts) are caused only by reflection phenomena in specific conditions.

Numerical modelling, through the Finite Difference Time Domain (FDTD) method, helped visualize the theoretical findings and was employed to reproduce the GPR response in two simple contexts (high permittivity layer embedded in a lower permittivity material and vice versa). The findings showed the expected theoretical polarity of multiple reflections providing a tool to effectively recognise them along with travel time information and reflection shapes.

The FDTD technique was also used to analyse the polarity response of regular geometrical shaped air-filled cavities (circle, square and arched roof square), in lossless and lossy conditions. The output was then compared with real radargrams concluding that A-scan assessment should be considered when pronounced scattering and attenuation phenomena are experienced (although polarity analysis may not be possible in very complex environments) and that the shape of the target may affect the resulting signal polarity due to interference with other wave fields.

Polarity analysis should be carried out by comparing the direct wavelet with the signal pattern of interest to assess if a phase shift occurred: attention should be paid to the GPR system used as not all the GPR antennas record the direct wavelet.