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GPR application to the study of tufa constructions: a tool for hydrocarbon exploration

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High porosity carbonate rocks are excellent hydrocarbon reservoirs and aquifers explored and exploited wide world. They accumulate in a wide variety of depositional settings but those related with carbonate marine platforms are the best studied. Among continental settings, fluvial carbonates could be important reservoirs. The primary porosity of fluvial tufas could give one of the required characteristics to act as hydrocarbon traps. A considerable effort is needed in order to understand the complexity of these systems. Not only the sedimentary facies and the subsurface permeability distribution (intimately linked to the sediment texture), but also the geometry and spatial distribution of sedimentary strata, are important in such knowledge. Accurate understanding of the internal architecture is especially important when incorporating geological heterogeneity into models simulating reservoir behaviours. Although tufas are very erodible systems that defy accurate reconstructions, there exist some areas where they have been preserved. This is the case of the Holocene Añavieja-Dévanos system (Iberian Range, NE Spain) where cascades, perched tufas and fluvial barriers are commonly recognised. Among all of them, barriers and small pools between, are the best preserved. More than 20 m-thick series has been preserved in this area. Tufa barriers are dominated by highly porous facies (mainly phytoherms and phytoclasts although stromatolites are also frequent) whereas the laterally related pools were dominated either by marls including oncolites and tufa debris. Organic matter is common in such a context not only in the pools but also in adjacent peatland zones.
In order to determine the geophysical characteristics of these deposits and to test the potential Ground Penetrating Radar (GPR) applicability in their sedimentological characterization, a geophysical survey using GPR has been carried out. The study has been centered in the expected lateral prolongation of an outcropping carbonate barrier. Different central frequency devices ranging from 50 to 500 MHz have been used. Two different subsoil behaviors (in the sense of radarfacies) have been detected. Radarfacies A (RA) is characterized by high scattering reflectivity and hyperbolic anomalies clusters with low to middle electromagnetic wave propagation velocity, and low attenuation rates. Radarfacies B (RB) presents a higher attenuation factor, middle to high propagation wave velocities and a general homogeneous behavior. These radarfacies show complex relations between them more easily recognized in low frequency profiles. Correlation with close boreholes permits to propose a correspondence between RA and tufa barriers (highly heterogeneous), as well as between RB and filling of pools (with low structural complexity). This allows to identify lateral facies changes between barrier and pool facies in the subsoil. Moreover high-resolution devices show interestratified RA within RB, or local RA development within RB suggesting a complex evolution for the system. Geometries point out a subvertical development of RA that aggrades downstream, with RB appearing displaced by the former. On the contrary, upstream of RA or tufa barrier location, RB progress over RA and partially covers it. In general, profiles show that RB onlap RA. These data permit to establish a general situation of progradation and aggradation of both radarfacies in the direction of the river curse. Our survey also demonstrates the existence of not outcropping carbonate deposits, interpretable as fluvial barriers, that also prograde following the expected current direction. Normal profiles to the current river direction evidence that carbonate deposits developed over an irregular substratum.
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