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Pore Structure, Porosity and Permeability of Continental Carbonates: A Case Study of Pleistocene Travertine (Southern Tuscany, Italy)

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Travertines are continental carbonates precipitated from hot water (>20°C) issuing from hydrothermal vents. They display a large variety of growth fabrics and associated pore structures. This variety reflects their origin (by interplay of biotic and abiotic processes) and subsequent diagenesis. Samples from a Pleistocene–Holocene travertine bodies located in southern Tuscany (central Italy) were examined for reservoir properties. Seventy horizontally and vertically drilled plugs were measured for porosity and permeability. The results were integrated with petrographic observations and the pore structure of ten samples was quantified using microCT scanning. Morphometric parameters were calculated on 3D based surface-rendered volume models and on 2D binarized cross-section images. Eight fabric categories were identified: shrub, crystalline crust, stromatolitic, raft, wavy sheet, coated grains, bubble and reeds. Porosity types include: depositional porosity as inter-dendritic form, bubble, inter-stromatolitic laminae, shelter, and intraskeletal; and, secondary porosity as biomoldic, vuggy meteoric dissolution, and fracture. The measurements show that travertines display a wide range in porosity, from 1 to 29%, and permeability, from 0.006 to 50000mD. This wide range is a direct function of: 1) primary fabric orientation; 2) amount of cementation; 3) travertine fabric. Horizontally drilled plugs have consistently higher permeability values than the vertically drilled plugs. This reflects the intricate horizontal organization of porous and tight layers at the mm- to cm-scale. In horizontal direction the pore network is well connected. The lowest porosity and permeability values are associated with well-cemented deposits. Blocky calcite cementation partially or completely occludes the primary porosity and retards the permeability. Pore structure have a strong control on permeability: simple pore structures with large pores (from 3 to 20 mm long and from 3 to 8 high) such as those of raft and reed fabric show high permeability values. Coated bubble facies display high porosity and large pores but have low permeability as the pores are not connected. This study provides the first comprehensive evaluation of the reservoir properties of hot-spring carbonates.