**Tuffs and Volcaniclastics: A Potentially Underexplored and Underdeveloped Reservoir Type**

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Tuffaceous reservoirs are known to contain hydrocarbons which can sometimes be of significant volumes, examples being in the San Joaquim Basin in Northern California (USA), Songliao Basin (China), Austral-Neuquén basins (South America), various basins in Japan (Funakawa, Nishikurosawa, Nanatani formations) and the North West Java Basin (Indonesia)

However, such reservoirs are relatively underexplored and underproduced, fundamentally because they are challenging to understand. Typically, if tuff facies are encountered in conventional reservoirs, they are ignored. Yet, a proper understanding of how such reservoirs behave may prove appealing to explorers looking for the next big “whale” in exploration, particularly in Asia with aging conventional brown field production.

The flow mechanism in such reservoirs is governed by numerous variables; the very nature of the tuffaceous facies means that pore structure, pore type/ size, mineralogy, and rock-fluid interactions impact reserves estimation, recovery factor and sweep efficiency at the reservoir scale. Pore scale distribution of fluids within the rock will, in turn, determine petrophysical and geophysical response of the reservoir rock. Conventional logging methods may not necessarily work well in tuffs as they contain trace amounts of radioactive minerals, and grains sometimes contain surface roughness at the nanoscopic scale that impacts how fluids are distributed.

The main challenge with the interpretation of tuff facies is the lack of a universally accepted interpretation methodology, because of variability in the logs and fields. In this paper, we will discuss how we conducted an analysis of a tuffaceous reservoir located onshore Cuba, South America, which has been in production for over 30 years. Through an integrated approach based on first principles that considers aspects of the geology, geophysics, petrophysical and reservoir engineering, and by combining deterministic, statistical, and probabilistic methods, we will prove that one can sufficiently de-risk properties, which would allow methods defined by the SPE Petroleum Resource Management System (SPE PRMS) to evaluate resource size and remaining reserves potential.

Our method is based on first principles because we consider the reservoir holistically, across scales that span nine orders of magnitude. We started our analysis by firstly looking at thin sections and cores to cement our understanding of the facies, particularly the pore morphology (nm scale), before moving on to the macro properties, such as porosity-permeability and trapped residual saturation (mm to cm scale). As logging tools are not designed to measure tuff properties accurately, we next applied a statistical approach and calibrated our log measurements to core on a field-wide basis (cm to m scale). We combined our calibrated properties with the structure and stratigraphy at the geological scale (m to km). To close the loop, we tied our results to the production profile and estimated recovery factor, which was cross-checked against reservoir engineering principles. Through this integrated approach of understanding the field at multiple scales, we could deterministically define the boundary for static properties, statistical results from the DCA and finally probabilistic volumes via a Monte Carlo simulation. Next, we used our understanding to de-risk prospects and leads in the adjacent blocks or in deeper reservoir targets.

Our integrated approach has demonstrated that conventional thinking can be applied to challenging reservoirs, albeit with caveats that boundaries between scales must be respected and addressed. The application of this approach to other underexplored volcanic plays in Asia and Australasia may mean potentially unlocking vast new accumulations of oil and gas and new sources of revenue for operators.