Introduction

LVPM can model the effects of vuggy porosity on neutron and density logs – i.e. finite pore size effects. In the example shown here, bed thickness is not used – the focus is on pore size variations at a fixed porosity.

The formation was a 20% porosity oil dolomite with a matrix density of 2.87 g/cc and a matrix absorption cross section of 10.0 CU; the LVPM default oil was used: $C_{12}H_{26}$ with a density of 1.05 g/cc. The pore size was varied from 0.0001 to 1.0 cm.

Heterogeneous Mode Results

When LVPM is run in Heterogeneous Mode, there results OUTPUTS for an infinite medium with finite pore sizes. Each of the five figures below details some aspect of density-neutron logging measurements, including the impact of pore size on bulk density, density porosity, neutron porosity, capture cross section, thermal neutron diffusion length, thermal neutron diffusion coefficient, and neutron slowing down length.

In Figure 1, LVPM heterogeneous bulk density decreases linearly from 2.510 g/cc to 2.471 g/cc as pore size varies from 0.0001 cm to 1.0 cm. The slope is –0.0386 g/cc per cm. From Figure 2, note that the corresponding heterogeneous density porosity increases from 0.117 pu to 0.140 pu at a rate of 0.0229 pu per cm over the same pore size interval.

In Figure 3 the heterogeneous neutron slowing down length increases from 9.954 cm to 11.464 cm as the pore size varies from 0.0001 cm to 1.0 cm. This leads to the dramatic decrease in heterogeneous neutron porosity from 0.364 pu to 0.177 pu shown in Figure 2, as the LVPM proxy model uses this slowing down length to compute neutron porosity.

Figure 4 shows that the heterogeneous neutron capture cross section (Σ) decreases linearly as the pore size increases; the slope is –0.0329 cu/cm. Recall that Σ is interrelated with the thermal neutron diffusion length (L) and the thermal neutron diffusion coefficient (D) by the expression:

$$D = L^2 * \Sigma$$

Figure 5 reveals the variation in heterogeneous thermal neutron diffusion length and thermal neutron diffusion coefficient as the pore size varies. Although the change in capture cross section with pore size is not large in this example, these variations of L and D with pore size are an important aspect of the *correction* of Σ for thermal neutron diffusion.

These variations with pore size also have important implications for *porosity logging based on the thermal neutron diffusion coefficient* [see U. S. Patent 3,818,225 and also the excellent review article “Nuclear Geophysics in Prospecting, Exploration and Development of Oil and Gas Fields” by E. V. Karus and Yu. S. Shimelevich, in All-

Union Research Institute of Geophysics, 8 Warshavskoye Shosse, M-105, Moscow, USSR; also published in 1983: International Journal of Applied Radiation and Isotopes, v. 34, no. 1, p. 95-117, by Elsevier Science Ltd.]