

Estimating and Modeling of Spatial Variability of Volumetric Attributes of a Nigerian Heavy Oil and Bitumen Deposit

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Abstract

Deposits of heavy oil and natural bitumen have been long-discovered in the Dahomey basin south-western Nigeria. However, inconsistency in estimates of volumes of hydrocarbon contained in these deposits has inhibited commercial interest in the deposits. The inconsistency is attributable to the little or no consideration for spatial variability in those studies. This work is therefore motivated by the need for spatially-coherent geomodels leading to reliable volumetric estimates. An existing database of porosity, depth-to-top and thickness attributes of a section of the deposits located at Agbabu is the subject of this work.

This work conducted exploratory spatial data analysis (ESDA) as well as empirical variogram estimation, interpretation and modeling of the attributes. Here, the estimation and interpretation of empirical variogram faced a number of challenges with potentials to render the estimates uninterpretable, unstable and inconsistent with geologic information. These include presence of spatial outlier data, clusteredness of variogram clouds, data paucity, and irregular distribution of point-pairs on variogram clouds. Spatial outliers were either removed or correlated with existing geologic information. The clusteredness issues were resolved using a machine-learning – aided variogram estimation technique recently proposed. Variogram cloud binning approach was deployed to handle irregular distribution of point-pairs. In attempting to deploy an automatic fitting algorithm, cases of insufficient empirical points leading to lack of convergence were encountered. Such cases were resolved by adopting a combination of manual and automatic fitting approaches.

Ultimately, this work presents a three-dimensional anisotropic (zonal) porosity variogram model and two-dimensional anisotropic (geometric) models for the depth-to-top and thickness variograms. These models are suitable inputs to spatial interpolation algorithms in generating maps of these volumetric attributes.

Keywords:

Reservoir Characterization, variogram estimate, machine learning, Upstream Oil & Gas, agbabu field porosity data, variogram cloud plot, porosity data, estimation, variogram model, variogram