Facies Architecture of Subaqueous Felsic Lava Dome - Building of Training Image for Multi-point Geostatistical Reservoir Modeling

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Subaqueous felsic volcanic rock reservoirs deeper than 4000m produce a large amount of hydrocarbon, mainly natural gas (TCF class), in the northeastern Japan. The reservoir evaluation of such volcanic rock reservoirs on the basis of layer-style geological units often came with difficulty due to their three-dimensional heterogeneity attributed to the morphology of stacked lava domes and cryptodomes. The multi-point geostatistical reservoir modeling is presumed to be the most suitable for such three-dimensionally heterogeneous reservoirs. However, building of a training image in the three-dimensional context is not well-established so far. We studied the facies architecture of subaqueous felsic volcanic rocks based on field surveys and obtained the statistical data of the lava dome distribution (the distance between domes and the size of domes) from GIS-based geological maps in order to use them as input data in building a training image. The subsurface distribution of volcanic rock lithofacies were determined as hard data in multi-point geostatistical approach mainly based on borehole images and artificial neural network analysis of logging data.

These felsic volcanic rocks erupted under seawater along with rifting of Japan Sea, a backarc basin, during Miocene age. Felsic volcanic rocks are subject to extensive fragmentation due to quenching by water and subsequent perlitization (accompanied with the formation of perlitic cracks) by hydration. Such fragmentation and perlitic cracks grant good reservoir quality to them. The facies architecture of lava domes and cryptodomes are, therefore, crucial for the reservoir evaluation of subaqueous volcanic rock reservoirs. A subaqueous felsic lava dome was classified into 5 volcanic facies from the center of a dome to the margin by the field surveys. Field surveys also revealed that the development of brecciated facies depends on the shape of domes, especially their aspect ratios (the ratio of the thickness to the bottom diameter): smaller lava domes with a low aspect ratio develop a higher proportion of brecciated facies. These kind of field-based data together with the distribution and size statistical data of lava domes were successfully used to build a proper training image by a simple object-based method. Delineation of three-dimensionally heterogeneous volcanic rock reservoirs is enabled in the multi-point geostatistical modeling based on the training image built in this study.