Multiscale Analysis of Well Logs

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The trend towards more cost-efficient hydrocarbons exploration, field development, and production requires a detailed and accurate understanding of the subsurface geology. Over geological times, strata are laid down at various scales reflecting changes in the environment at the time they were deposited. Based on well logs investigation, a number of geophysical rock properties have proved to exhibit a non-stationary multiscale behavior. Moreover, because of the complex chain of processes by which the climatic changes and plate tectonics are transformed and encoded in the strata, typical geological characteristics are unlikely to exhibit simple sinusoidal cyclicities. Conventional spectral analysis may not then be appropriate to identify and evaluate characteristics of well logs, such as superimposed cyclicities, scale-invariance and abrupt changes in the geological trends. In this paper, a multiscale analysis is proposed to disentangle both local and global subdivisions of such complex phenomena and to provide the necessary tools for the characterization of the subsurface complexity. It will be shown that the continuous wavelet transform (CWT) possesses the required power and flexibility to extract various multi-scaling patterns from well logs. The wavelet transform will be first introduced and the guidelines for the selection of a suitable wavelet kernel will be outlined. The mechanisms of the CWT will be then demonstrated through synthesized computer simulations. Finally, the performance of the proposed wavelet transform in detecting cyclicities, zonations, and other abrupt changes in sedimentary successions will be demonstrated using real well logs.