Accepted Manuscript

Heterogeneity analysis of geophysical well-log data using Hilbert-Huang transform

Gaurav S. Gairola, E. Chandrasekhar

PII: S0378-4371(17)30191-7
DOI: http://dx.doi.org/10.1016/j.physa.2017.02.029
Reference: PHYSA 18009

To appear in: *Physica A*

Received date : 30 May 2016
Revised date : 5 January 2017

Please cite this article as: G.S. Gairola, E. Chandrasekhar, Heterogeneity analysis of geophysical well-log data using Hilbert-Huang transform, *Physica A* (2017), http://dx.doi.org/10.1016/j.physa.2017.02.029

Heterogeneity Analysis of Geophysical Well-log data Using Hilbert-Huang Transform

Gaurav S. Gairola and E. Chandrasekhar*

Department of Earth Sciences, Indian Institute of Technology Bombay, Powai, Mumbai – 400076, India.

*Corresponding Author: esekhar@iitb.ac.in

Abstract

Geophysical well-log data manifest nonlinear behaviour of their respective physical properties of the subsurface layers as a function of depth. Therefore, nonlinear data analysis techniques must be used, to understand and characterize the nature of the subsurface lithologies, vis-à-vis their degree of heterogeneity. One such nonlinear technique is the fully data adaptive Hilbert Huang Transform (HHT), which constitutes two independent techniques, namely, the empirical mode decomposition technique (EMDT) and the Hilbert spectral analysis (HSA). While EMDT facilitates to decompose the well-log data into oscillatory signals of different wavelengths called intrinsic mode functions (IMFs), which represent different frequency characteristics of the signal and which in turn helps to calculate the degree of heterogeneity in the subsurface, the HSA facilitates to determine the instantaneous amplitudes and frequencies of the IMFs, which can be used to characterize the heterogeneity in the signals. In this study, HHT has been applied to gamma-ray log of the thickest limestone reservoir zones of two different wells: Well B and Well C, located in the western offshore basin of India to determine the respective IMFs. The estimated instantaneous amplitudes and frequencies of the derived IMFs by HSA qualitatively suggested well C to be more heterogeneous than well B. By establishing a relationship between the IMF number (m) and its mean wavelength (I_m), a heterogeneity index (ρ) associated with subsurface layers was determined using $I_m = k\rho^m$, where 'k' is a constant. ρ bears an inverse relation with the heterogeneity of the subsurface. The estimated ρ values confirm our observations from HSA. We attribute the higher degree of heterogeneity in Well C to high average shale volume in the limestone reservoir zone in Well C than in Well B. Interpretation of the results together with those of the heterogeneity analysis of the gas zone in limestone reservoir of Well C is made by comparing with the results of multifractal analysis of the same data carried out earlier.