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Walsh列率域中多维分形模型与GIS环境下地球物理信号处理

李庆谋[1],成秋明[1,2],刘少华[3]

1 Dept. of Earth & Atmospheric Sciences, York Univ., Toronto, ON, M3J 1P3, Canada;2 地质过程与矿产资源国家重点实验室， 中国地质大学(武汉) 430074;3 中国科学院地质与地球物理研究所，北京 100029

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摘要 地球物理信号通常在多个尺度段表现尺度不变性，这些不变性起因于不同的地质、地球物理或成矿过程的自相似性. 利用这种在多个尺度段的尺度不变性可以设计多维分形滤波器，滤波所得信号表征了具尺度不变性的地质地球物理或成矿过程，可以用于成矿预测或环境评价. 本文研究了Walsh变换列率空间地球物理信号的列率功率谱密度与列率之间的分形与多维分形关系, 试验证实了大洋钻探、石油以及煤系地层地球物理测井资料在Walsh域的多维分形性质，提出了用于分解地球物理场,提取有用信号并用于矿产资源勘探或环境评价的多维分形W-A模型. 利用波列率域中的多维分形关系构造了W A图解(W-A Plot). 借助W-A图解可以确定最小平方误差（LS）意义下Walsh功率谱变化的不同自相似性的频率分界点,从而用于设计W-A分形滤波器. 这种滤波器可将地球物理场分解成具有不同自相似性的局部场,并且保留原场的各向异性结构. 与通常使用的基于Fourier变换的滤波技术相比,W-A模型具有许多优点：W-A适用于检测地球物理信号中的突变、线性、环状、局部与纹理结构等弱信号. 同时，由于Walsh变换中只有简单的变号(加法与减法)，其计算速度远快于建立在复数乘法之上的Fourier变换，所以W-A计算速度远快于Fourier域的滤波方法，可以用于地球物理信号的现场实时处理. 用加拿大Nova-cotia省西南地区的布格重力异常进行了W-A方法的试算，处理结果反映了地质、矿产分布规律，能够很好地进行矿产预测.

关键词 W-A模型,多维分形,特征提取,Walsh变换,纹理分析,成矿预测

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Scale invariant property in Walsh frequency domain and a multifractal model for geophysical data processing in GIS environment

LI Qing-Mou[1], CHENG Qiu-Ming[1,2], LIU Shao-Hua[3]

1 Dept. of Earth & Atmospheric Sciences, York Univ., Toronto, ON, M3J 1P3, Canada;2 Sate Key lab of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China;3 Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029,China

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Abstract Geophysical fields present scale invariant property in multiple scale ranges. This is originated from the self-similarity or self-affine attributes of geological, geophysical, geochemical, and mineralization processes. To separate geophysical signals of these types into mono-scale invariant patterns reflecting simple geological, geophysical, geochemical or mineralization processes is useful for mineral exploration and environment assessment. The fractal and multifractal attributes between power spectrum and frequency of geophysical data in Walsh domain are investigated. A wide variety of geophysical well loggi ng data from Ocean Drilling Program (ODP), oil bearing, and coal bed section is tested and approved of multifractal property in Walsh domain. Multifractal alsh Spectrum Area (W-A) accumulation model is proposed and implemented for extracting geophysical anomalies for mineral exploration in GIS environment. Using the W-A method, Walsh power spectrum density “thresholds" or “breaks" could be defined by means of Least Square (LS) and these breaks can be further used in filter design. W-A filter can be used to decompose geophysical data into signals with distinct local self-similarity with the anisotropy attributes of the original geophysical data retained. W-A has some advantages over the S-A a filtering technique in the Fourier Domain, such as suitable for detecting local features of sharp edges, linear or curvilinear, and weak signals. Further more, W-A is much faster than Fourier based method because Fast Walsh Transformation (FWT) and Inverse Fast Walsh Transformation (IFWT) require only addition and subtraction operation whereas Fourier based methods need complex multiplying in Fast Fourier Transformation (FFT) and Inverse Fast Fourier Transformation (IFFT). Therefore, W-A is suitable for real time geophysical processing or in situ fast data processing. The Bouguer anomaly of southeast Nova Scotia, Canada is processed using W-A method and the results showing good agreement with the known spatial distribution of lithology units, and mineral deposits and

occurrences.

Key words W-A model Multifractal filter Scale invariant property Texture analysis Mineral potential mapping

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通讯作者:

作者个人主页: 李庆谋[1];成秋明[1;2];刘少华[3]