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Mono-spectral (greyscale) imaging for Nanoscale physical character analysis of Silica from lake deposition: An experimental study

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ABSTRACT

Digital microphotography and image analysis is considered as an important tool in sedimentology and mineralogy for the assessment of physical characteristics at micro and nano level. The authors attempted to analyse the physical characteristic like surface condition of a silica grain of a lake deposition layer from mono-spectral imaging at nanometre scale. For that purpose a silica grain was picked up from microphotography of a thin section of sediment layer and 1μm X 1μm base image in greyscale was prepared for operation with sophisticated software. Reflectance capacity of the particle has been considered to measure the topographic condition. Contour plot from the base image was prepared along with a topographic image prepared on the basis of blackbody law. A complete topography map of silica grain was prepared on the basis of two previous plots. A 3D image and four profiles were also consulted for understanding the geometry of the surface of silica. Roughness analysis was also done from the mono-spectral image.

INTRODUCTION

Microscopy is considered as one of scientifically fascinating subjects of profound importance in geophysical researchers especially for analysing physical and chemical properties of rocks and sediment depositions. Inventions of sophisticated scientific tools in the 70s, 80s and 90s played an important role behind many experimental works in microscopic sedimentology. Uses of SEM and optical microscopy, molecular adsorption, SAXS and SANS resulted massive development in petrographic image analysis (PIA) which was reflected by some remarkable works of Bale & Schmidt (1984), Katz & Thompson (1985), Wong, Howard & Lin(1986), Jacquin & Adler (1987) and Hansen & Skjeltrop (1988). Apart from those, some contemporary works by van der Meer (1987, 1993 and 1996), van der Meer & Laban (1990), Menzies & Maltman (1992) discussed the evidences of genesis and deformation. Over the last 20-25 years, especially from the middle of 90s, the method of digital microscopy has become very popular in sedimentological as well as mineralogical studies. Bryant and Davidson (1996) attempted a micromorphological study by image analysis on old cultivated soils. Later Cooper (1998) also observed the usefulness of digital image analysis in sediment studies. In a recently published book Vernon (2004) presented a general outline on practical approach to igneous, sedimentary and metamorphic rock microstructure analysis. Meanwhile some experiments on lake sediment thin section making by Cocquyt & Israe (2004) and Rohrig & Schar (2006) resulted remarkable advancement in sediment microstructure research especially in Limnology because their work concentrated on lake sediments. Recent development of nano-science opens a new dimension in sedimentology and mineralogy (Frazer et al., 2004). It has created more wide opportunity for geoscientists to go ahead for through the path of indepth study which is directed from microstructure to nanostructure and breaking the barrier of geosciences and physical science. Some very recent works by Udubasa et al., (2007) and Jiang et al., (2008) reflects the recent multi disciplinary trends of experiments with technical advancement in nanoacale imaging and analysis. Considering the recent trends the present authors have performed a study on physical characteristics of silica from the deposited sediments in Rudrasagar lake of Tripura, North-east India.

METHODOLOGY

In Sedimentology or Minarology multy-spectral images (RGB combination) are very common use for assessing the physical features at micro or nano levels. Under some specific conditions, researchers of earth sciences and physical sciences also use mono-spectral images for physical analysis. The present research has been concentrated on the study of physical characteristics especially the surface geometry of some specific mineral of the selected sediment layer of Rudrasagar lake in mono-spectral or single band grey scale digital image. Thin section was prepared from the sediment sample collected during field from the bottom of the lake. Optical microscope and digital camera was used for microphotography. The image was zoomed upto pixel level for identifying individual minerals and their area of coverage. From the microphotograph a 1μm X 1μm area of a silica grain was taken for processing final data set. Visibility of the selected part of the image was tested by LSM Image Browser software and necessary editing was done. Physical features at nanometre scale were analysed by WSxM4.0 software. Smooth filter was used on raw data for image processing before various operations (Fig.1).

RESULTS AND DISCUSSION

Surface condition analysis of the selected sample:

For understanding the surface condition the present authors have verified a contour plot prepared from the base image (Fig.2A). From this plot maximum value of contour was found 232.6311 nm and minimum contour value was recorded -294.1859 nm (intermediate contour 10). Since reflectance capacity of the sample under was considered as the parameter of topographical measurement, an attempt of surface condition analysis has been done on the basis of Blackbody law (Fig.2B). Here reflectance increases from black to white colour which represents increase of elevation at nanoscale within 1μm. Besides that a comparative landscape mapping (Fig.2C) has been done on the basis of contour plot and the blackbody image.

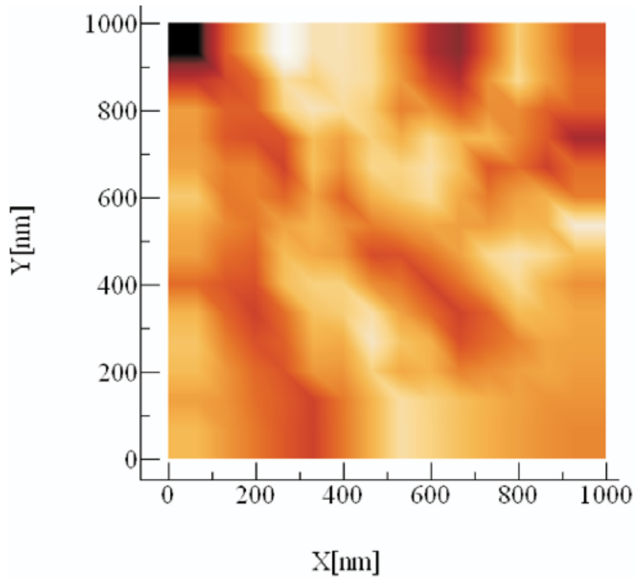

Figure 1. Digital data set of processed image (smooth filtered) of a silica grain.

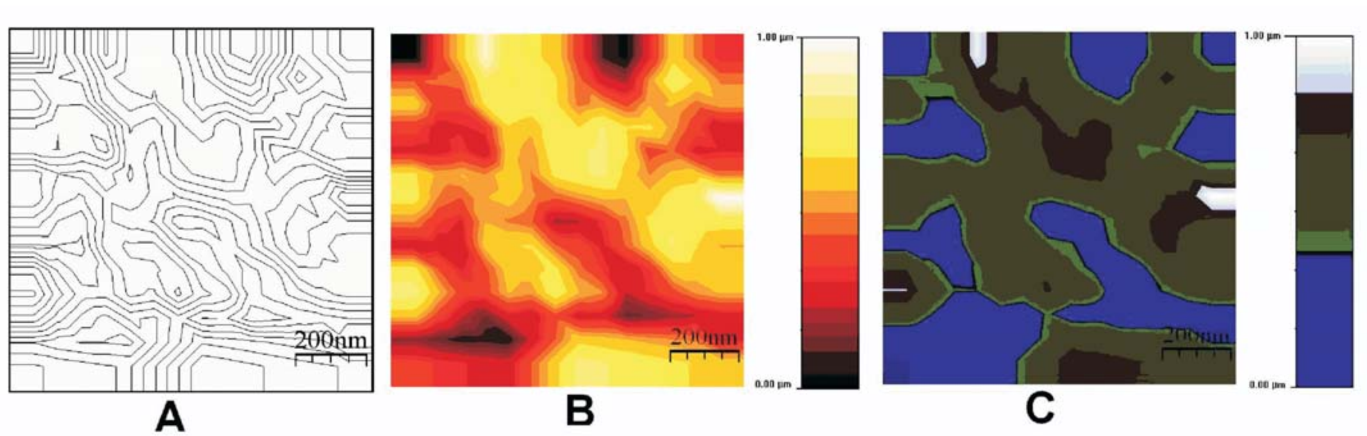

Figure 2. Surface analysis by (A) contour plot, (B) image based on blackbody law and (b) landscape mapping

A 3D image was prepared for assessing the real world surface condition of the selected silica grain sample (Fig.3). This Image shows that through at micro level silica grain looks very smooth but actually it has a very undulating surface if it is measured in nanometre scale. In this image the highest part is indicated by white colour due to its high reflectance of light and grey to dark grey colours are corresponding the lower parts. Narrow and elongated valley type low portions are observed in grey coloured which results the variation of nano-relief.

Variation of relief:

To understand the relief variation four cross sections namely AB, CD, EF and GH has been drawn by the authors (Fig.4). The first profile AB shows a typical high rise of elevation with very steep slope. The

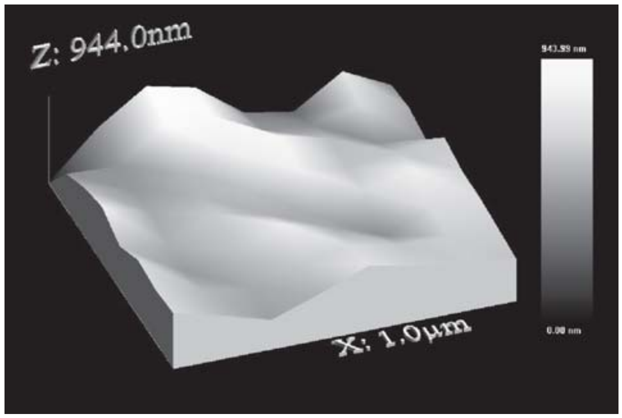

Figure 3. Topography of silica grain from 3D view

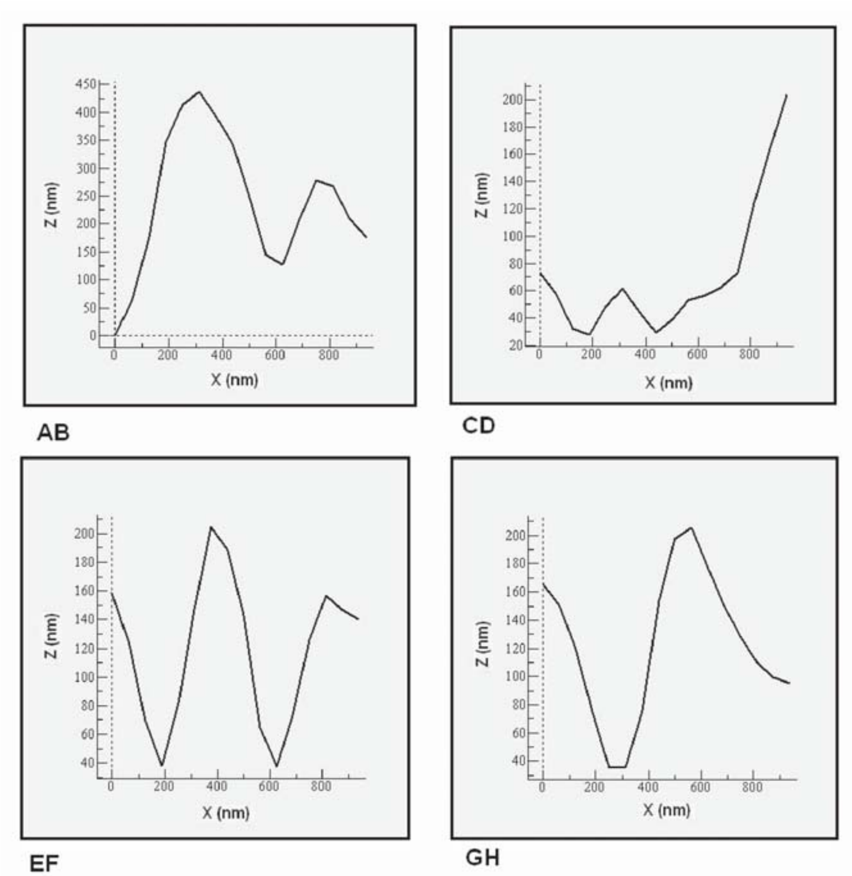

Figure 4. Profiles on silica grain

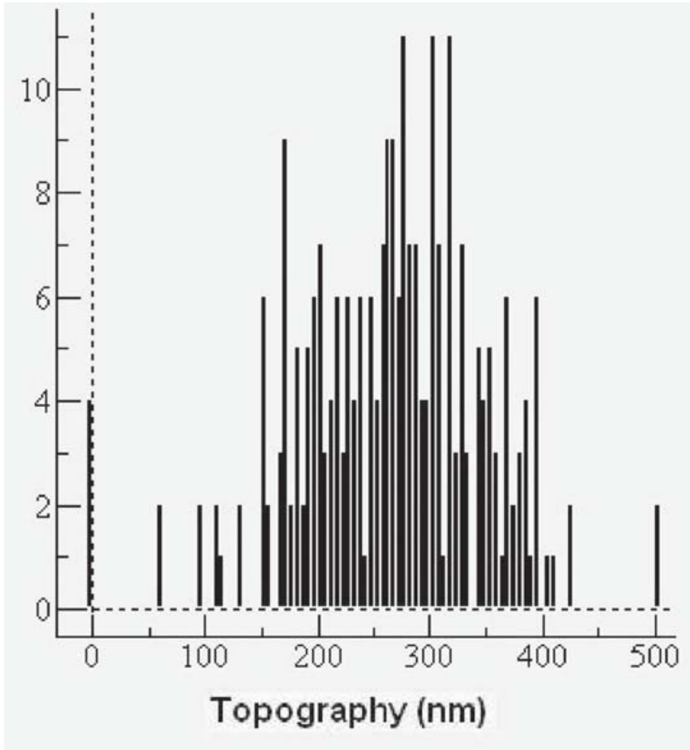

Figure 5. Roughness analysis.

second profile CD shows little different type slope topographic condition. In this profile little change of elevation (35 nm to 65 nm) within very small distance is observed along with a steep slope with high elevation change (nearly 300 nm). The angles of slopes are also very variable in this profile. Profiles EF and GH have similar type of characters. In both those profiles low and narrow valley with very high rise and steep slopes are observed. All the profiles show that the selected silica grain has very irregular surface which results a wide scale of variation of reflectance.

Roughness analysis:

For better understanding the surface condition the present authors have also done roughness analysis (Figure-5). Maximum variation of topography recorded within 150 nm to 400nm which is remarkably very wide range for a glossy mineral which shows very high level reflectance due to its smooth topography condition. Highest topographic variation is found 500nm. This also strongly supports the undulating condition of silica at nanometre scale.

CONCLUSIONS:

The physical base of mono-spectral imaging is standing on reflectivity capacity of any object which is represented within black (low) to white (high) shades in greyscale. Through the present study it has been observed that mono-spectral imaging is very suitable to assess the topography even at nanometre scale. Rise and fall of heights at nanometre are visible by the changing of shades in greyscale. In this experiment nanomorphology is analysed by 3D and some profile drawing which are actually depend on the greyscale values. A logical roughness analysis has also been done from mono-spectral image which shows the efficiency of perfect computation within greyscale parameters for understanding the physical characters of any objects.

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