SMALL-SCALE HETEROGENEITY ANALYSIS OF CLASTIC SEDIMENTS BY USING X-RAY COMPUTER TOMOGRAPHS

Theses of PhD dissertation

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Department of Geology and Paleontology, University of Szeged is the home of basic research of clastic sedimentary rocks. The task of this research is the numeric processing and defining the structural characteristics of clastic sediments and sedimentary structures; and to provide database for the numeric control of one- and two-phase flow simulations. The tool for this is the connection between the structural and textural characteristics of sedimentary rocks, and the CT generated image/data.

The aim of this paper was to give answer to the following questions: (1) Weather the sedimentary structures can be identified on the images obtained from the density based CT measurements? How can the basic clastic rock types are recognized on the bases of Hounsfield Units (HU) by using statistical methods (hypothesis tests, distribution fitting, and confidence intervals). (2) Weather the alterations of measured data mirror the textural characteristics of clastic sediments. (3) Whether the numerical pattern of HU obtained from small scale analyzing of some particular sedimentary structures coincide to the textural expectations of those sedimentary structures. (4) How does this recognition depend on depositional history of samples tested? (5) Is it possible to reveal zones of weakness, flow surfaces and paths based on data obtained from CT measurements, only? (6) Are the HU values provided by the CT measurements capable of evincing micro-cycles belonging to a particular depositional history?

CT measures have done on a Siemens Somatom Plus 40 instrument provided by the Department of Diagnostic Imaging and Oncoradiology, University of Kaposvar.

In general, attenuation of incoming X-ray radiation depends on the bulk density, atomic number, porosity, water content, and chemical composition of clastic sedimentary rocks.

I selected core samples from the collection of Department of Geology and Paleontology, University of Szeged and from the storehouse of Hungarian Oil and Gas Company (MOL Group).

To avoid data-loss, one should use “Nearest neighbor” method to calculate grid contours, and define grid spacing as one in both X and Y direction. Thus, you can visualize the real measuring data, and the image obtained has a better efficiency.

In case of thicker samples, some “errors” might occur due to reflection and extinction, which makes the interpretation difficult. A database handler system joins up the individual sections, so images generated from them can be interpreted more easily, and due to correct data, results are accurate.

The principal of data analysis is to display all statistical data in distinctive graphs. Statistical quantities are data-functions that define set of data numerically (mean, median, modus, expected value, and variance), and they are suitable to visualize the aspects of data and populations data are coming from. Graphically displayed data are useful to reveal the interconnection and correlation of data sets. Besides, the interpreter could accept or reject a hypothesis throwing a glance at them.

The principals of my research are the following:

1. HU data and the displayed images obtained from CT measurements are capable clearly identifying different sedimentary structures and macroscopic textural variability. All the displayed images are identical to the core samples or the photographs of them.
2. HU values can interpret macroscopic textural variability and small-scale heterogeneity of homogeneous units fairly well. Due to high resolution, you can easily identify the position of laminae in sand ripples or dunes, and inner heterogeneity of an individual lamina.
3. Different types of sediments and sedimentary rocks are numerically identifiable and clearly distinguishable from each other. However, confidence intervals and distribution-types of HU values belonging to basic rock types are significantly different, supposing similar depositional environment and degree of diagenesis, some overlapping might occur. It is essential to be significant difference between expected values of HU in order to numerical distinguish basic rock types from each other. One should keep in mind that changes in the conditions of environment could influence diagenetic processes, physical and chemical properties, and the HU values, consequently. Thus, quantitative comparisons can involve samples from similar depositional environments with slight differences in the degree of diagenesis.
4. Distinctiveness considerably depends on the geologic history of the environment and the sample. Older sediments are at higher degree of diagenesis than the younger ones, therefore their attenuation coefficients are higher, as well.
5. Attenuation of X-ray depends on grain size. The bigger is the grain size of sediment or rock, the smaller is the attenuation coefficient, taking age and geological history into consideration.
6. Grid files generated with the Laplacian operator coincide with the structural characteristics and inner heterogeneity of sedimentary rocks. Potential flow surfaces and paths represent the zones of weakness of sedimentary rocks within the range of resolution of medical CT. Consequently, we cannot reject the

assumption that these flow surfaces and paths linked with zones of weakness and its three-dimension system outside of this range. I can draw a conclusion concerning to indicating the potential flow surfaces relying on the displayed grid contours based on the calculations with the Laplacian operator, although fulfilling experiments is the task of the future.

7. HU data provided by CT measurements of macro-scale homogeneous sediments are capable for evincing depositional micro-cycles. Profile of a sequence represents the geologic time. Plotting HU data on an equidistant scale, we get a time-sequence. Then time-sequence analysis can reveal the cycling character of the deposition.

Results published and presented in the following journals and conferences:

1. Hunyadfalvi Z. (2002): Üledékes ciklusok kimutatása laza üledékből röntgen computer tomográf alkalmazásával. *Előadóülés, magyarhoni Földtani Társulat, Geomatematikai Szakosztály,* 2002, február 5. MÁFI, Budapest
2. Hunyadfalvi Z. (2002): Üledékes ciklusok kimutatása laza üledékből. Hidrológiai Közlöny, 2002. 82. évf. 5. sz. p.279-282
3. Hunyadfalvi Z. (2003): Üledékföldtani heterogenitás vizsgálatok CT felvételek alapján. *PhD Konferencia,* 2003. április 24. Szeged, SZAB Székház
4. Hunyadfalvi Z. (2003): Üledékföldtani heterogenitás vizsgálatok CT felvételek alapján. *VIII. Geomatematikai Ankét, Térinformatika és Távérzékelés Alkalmazásai a Környezetvédelemben és Földtudományokban SZEGED 2003,* 2003. május 5-6. Szeged SZAB Székház
5. Hunyadfalvi Z. (2003): Üledékföldtani heterogenitás vizsgálatok CT alkalmazásával. *Nemzetközi geofizikai – földtani – fluidumbányászati – környezetvédelmi vándorgyűlés/ konferencia és kiállítás.* Szolnok, 2003. szeptember 19-20.
6. Hunyadfalvi Z. (2004): Üledékes kőzetek kisléptékű heterogenitás vizsgálata CT alkalmazásával. *XXXV. Ifjú Szakemberek Ankétja.* Sárospatak, 2004. március 19-20.
7. Hunyadfalvi, Z. (2004): Heterogeneity analysis of clastic sediments by computerized X-ray tomographs. *Acta Geologica Hungarica, Vol. 47/1, pp.53-62*

8. Geiger, J., **Hunyadfalvi, Z.**, Bogner, P. (2006): Analysis of small-scale heterogeneity in clastic rocks by using computerized X-ray tomography (CT). *Journal of Engineering Geology*. In print.