Reologické chování modelových suspenzí

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Spatial Distribution of Particles and Cavities in Sedimentary Deposits

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Abstract:

The observation is focused on liquid suspensions, an area of multiphase systems. In the process of sedimentation, the particles are set in motion. The basic features of the hydrodynamic motion result in a particular structure of the deposit, growing beneath the settling layer. Our goal is in analysing the deposit structure, using visualisation of particles and cavities. Experiments are done in water with a limestone powder. Commercial program MATLAB is used to graphic analysis. All our partial results gathered in this study contribute to comprehension of hydrodynamic behaviour of collective particle sedimentation and can explain questions of creating cavities in sedimentary geology.

1. Aims:

Generally, our goals were divided into two distributions and one comparison. The first distribution manifests an end of particles sedimentation and we can describe it with the question: „Where will fall a how big particle? “. Second one is concerned cavities in a sedimentary deposit and we can ask similarly as in a previous case: „Where are cavities after sedimentation in a deposit? “. The comparison of both of particles and cavities distributions leads directly to the main question. Which particle is responsible for creating cavities?

2. Motivations:

We have two approaches on the contribution about the sedimentary process. It has little known about collective particle sedimentation, especially about real shaped particles (see fig. 1). What is happening during a particles settling? Do hydrodynamic instabilities have an influence on a finish state of sedimentation or do not? There is too many mechanical interactions affected whole process and of course other parameters. We have chosen few of them, probably most important for creating cavities in a deposit, size of the particles fraction and ratio of the fractions. All these mentioned facts belong into chemical engineering approach and they are the subject of this study.

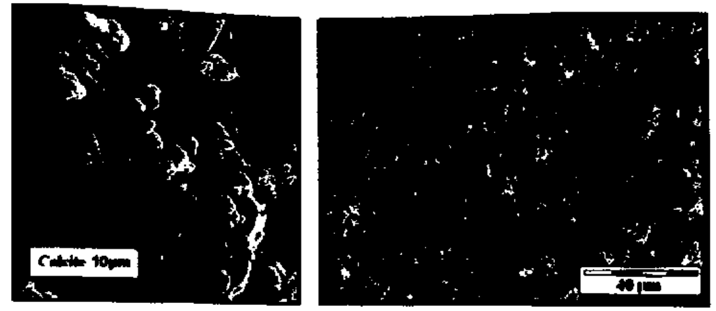


Fig. 1: Representative sample of crushed limestone as a real material. On the left side is trigonal µm large particle of limestone (calcite). Limestone silt (4-63 µm) is at the right.

The cavities in deposit interest a group of geological society. Sedimentary deposit turns to the stone after long time. We were able to imitate some of the cavities structures in laboratory conditions in a previous work (fig. 2). Shapes and volume of cavities, structure of sample patterns help to geologists to recognise origin of cavities and storyline going along origin of sedimentary rocks. So it can be an important guide to find the effects, which are participating in the creation of petrified deposit and time before it.

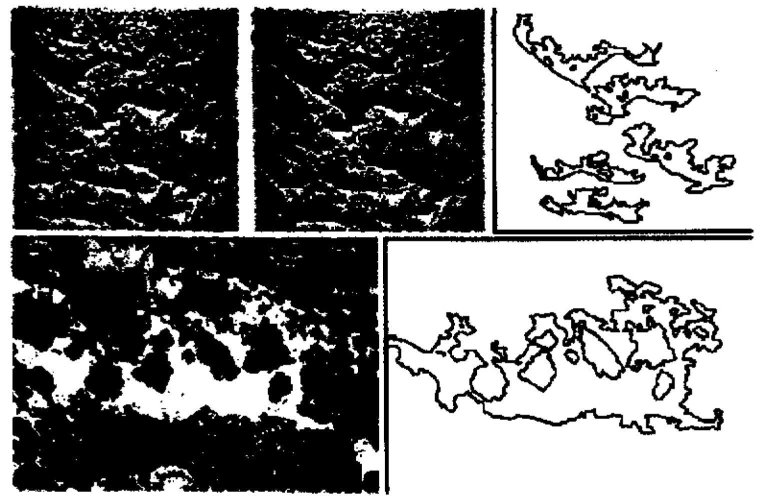


Fig. 2: Similarity of the cavity shapes between a laboratory deposit (particles of limestone) and petrified geological deposit (sedimentary whinstone).

3. Preparation of experiment:

The liquid suspension is composed of water and differently large particles. Limestone rock is crushed and sieved in five fractions by size. The particles are divided either differently by size coloured limestone or only white multi-sizing limestone (see fig. 3). For measuring of particles distribution are using coloured particles and colourless water. White limestone particles and blue water are used for measuring of cavities. We get "how deep is particle falling in the vessel" from the first measurement, particle size and density is playing main rule here. Of course we cannot measure holes like by clear limestone particles, because of stained surface. Therefore we have prepared the same uncoloured mixture. Then for better visualization of cavities blue water was used. Each particles fraction in a mixture is in volume ratio 1:1.

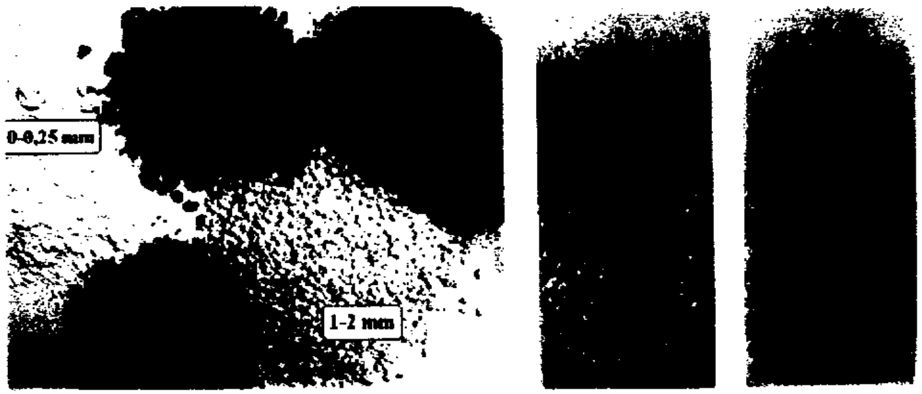


Fig. 3: Five limestone fractions by size, vessel with coloured particles and water, vessel with white particles with blue water.

4. Device and experimental procedure:

Very simply device was used for the experiment (see fig.4). Two-plug glass vessel with a suspension can turn upside down around a holder. Vessel was filled with prepared mixture and completed with water to the punch mark. The air at the top of a vessel serves for agitating a mixture. Completely homogenizing mixture in water is an initial state. Initial state must fulfil the conditions of repeatable (error max. 5% after 5 s) curves of sedimentary rates (see fig. 5). Then let the sample settle in a vertically direction after an initial state.

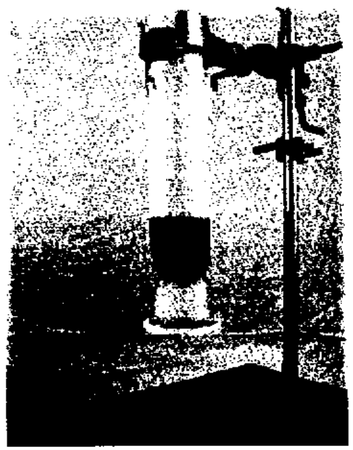


Fig. 4: The rotatable device.

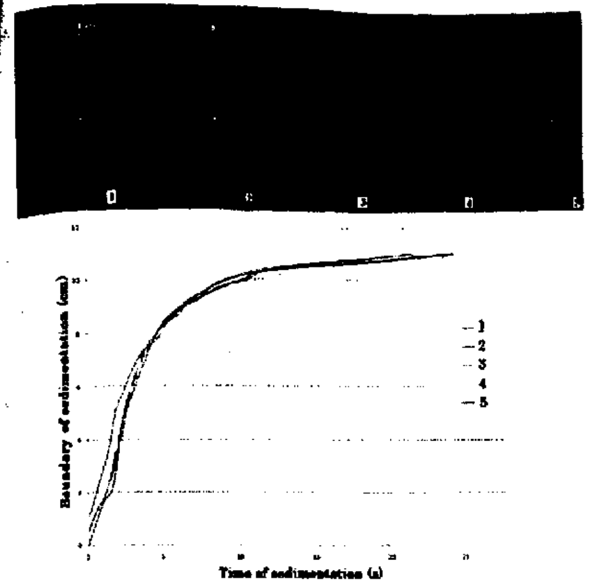


Fig. 5: Five boundary states sedimentary rates for determin of initial state conditions.

For visualisation deposit on the bottom are stabilized conditions like brightness and con For stable brightness was used light-diffusion tent lighting by three lamps (3 x 1 kW). For s contrast was used reflex camera with macro objective.

5. Principle of image analysis:

Image analysis is the principle of data evaluation created in the software MATLAB. The output of each experiment is just a one photography, which can be decomposed into pixels. The each pixel is assigned by a characteristic colour. For better identification of colours they must belong into the "edges" of a RGB spectrum cube (000-black, 100-red, 010-green, 001-blue, 101 violet, 110-yellow, 011-cyan and 111-white). We used just 6 of 8 colours, other 2 unused colou falls simply to the black box. It is created then new 8-numeric matrix, where pixels are counted line (horizontal axis). The sum of each characteristic pixel is a function of the vessel height (ve axis). Such function is called as the distribution of particles here. Distribution of cavities is crea similarly like distribution of particles. We are working with grey scale image. It is sufficient to grey scale image in BW (Black and White) spectrum. BW is standard operation of software MATLAB-graphic toolbox. It can be set up only threshold of gray spectrum here (see fig. 6 and 7).

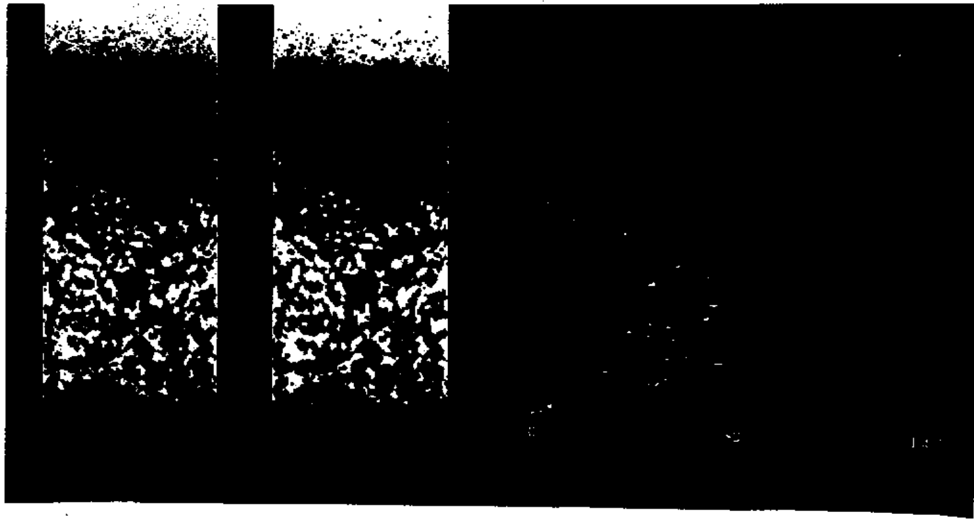


Fig. 6: Photography, image and distribution of particles.

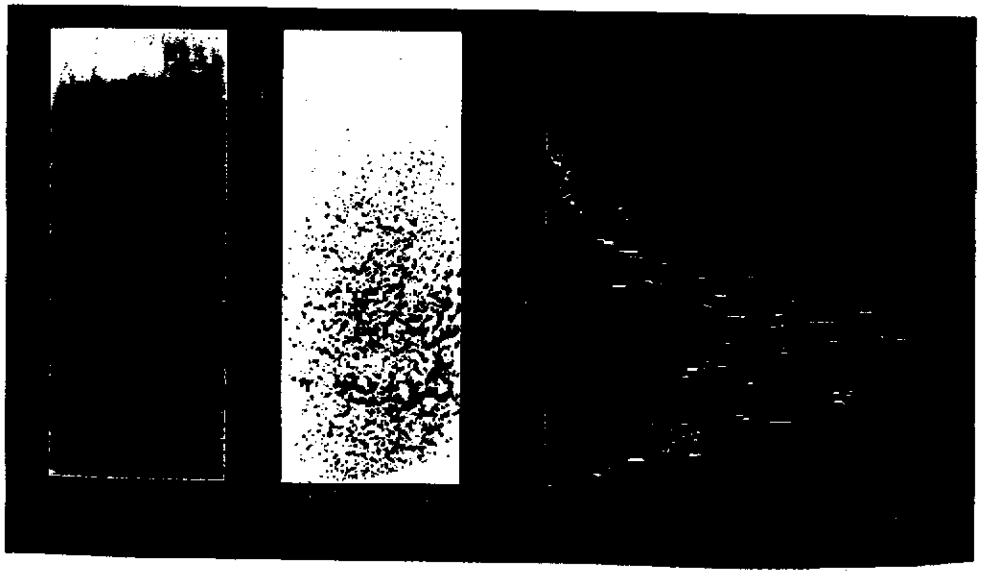
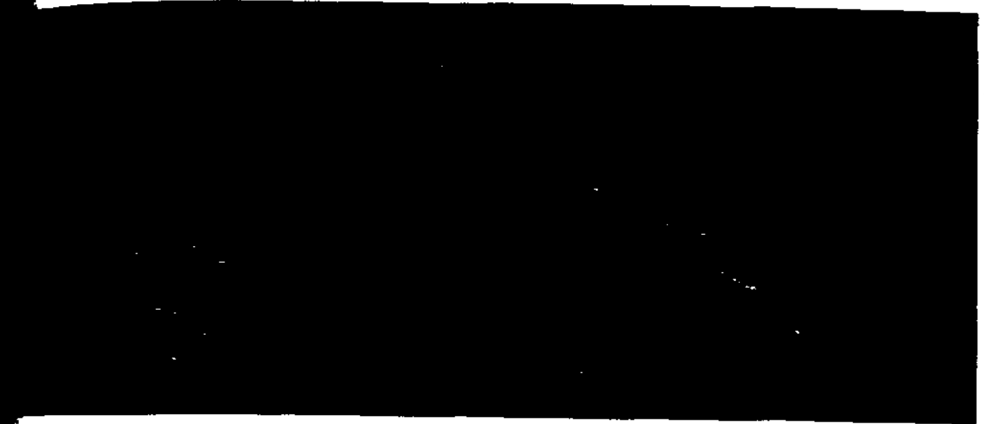


Fig. 7: Photography, image and distribution of cavities.

First results come from measurement of missing fraction. Every fraction is in bulk volum 1:1. Initial state is 5-fractional sample continuous in the size 0 – 4 mm (see the left side o). Such sample of coloured or white particles follow 30 logic combinations of less than the 5 tional example, where one fraction (resp. two, three and four fractions) is missing. So it i ted non-continuous fractions, where are size gaps. One of such example is pictured in fig. 9 re can we observe the double time larger cavities than in the 5-fractional initial state.



ig. 8: Five continuous fractions are statistically processed (8 particles and 8 cavities distributions).

ig. 9: Four continuous fractions are statistically processed (8 particles and 8 cavities distributions). he second biggest fraction (yellow colour) is taken away.

Each result sample is an average of 8 distributions. The average will be statistically oothed in respect of great numbers of pixels. Then it will check appropriateness of each image. ther results and complete analysis is still waiting for our following investigation.

7. Conclusions:

This particular study opens new possibilities, how to study granular material. Softw[...] developed in ICPF is able to process coloured pictures. It is working with RGB spectrum of colou[...] and it can:

- identify sample in a vessel,
- choose volume of pixels,
- statistically processing of more samples together.

It promises next analysing after identification of a sample. For example, how much sedimentary materials are hided inside of a vessel?

From the first several pictures we have been able to predict, than the biggest particles are responsible for the large of cavities. Generally it can be said: "What the bigger particle than the larger cavity." Second one new piece of knowledge is about missing fraction. If one fraction is taking out of a mixture and the mixture is non-continuous (it has fraction gap or gaps), than bigger cavities emerge in a sample (sedimentary deposit).

8. Acknowledgements

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Vybrané elementární děje v pivní pěně

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1 Úvod

Jedním z hlavních znaků charakterizujících pivo patří hustá a dlouhotrvající pěna. Spotřebitel hodnotí kvalitu pivní pěny z různých hledisek, jako například stabilita pěny, barva pěny, její chuť, přilnavost na skle (tzv. kroužkování pěny), struktura atd. Nejdůležitějším kritériem, jednak pro spotřebitele, ale také pro pivovary, je stabilita pivní pěny. Pěna je dynamický systém, procesy tvorby a rozpadu probíhá současně, což komplikuje studium dílčích dějů. Mezi základní typy dějů ovlivňující pivní pěnu patří tvorba bublin a jejich následný vzestup k hladině tvořice tak na ní vrstvu pěny, praskání kapalného filmu, odvodňování pěny (drainage) a vzájemné rozpouštění bublin (disproporcionace).[1] Tyto děje probíhají do značné míry současně a navzájem se ovlivňují. Pro stabilitu pěny je rozhodující, které procesy v daný okamžik převládají.

1.1 Tvorba bublin

Pěna je tvořena z bublin (disperze plynu v kapalině), proto jejich vznik zásadně ovlivňuje stabilitu pěny. V pivu vznikají nejčastěji bubliny po nalití do sklenice heterogenní nukleací z přesyceného piva. Zárodkem pro vznik nové bubliny může být koloidní částice, nečistota, povrchová nerovnost na sklenici (rýha, prasklina atd.).[1,2] Vznik bublin v pivu homogenní nukleací se nepředpokládá z důvodu nízkého tlaku plynu v pivu. Minimální přetlak potřebný pro vznik bublin homogenní nuklací je asi 100 MPa.[1] Rychlost a množství vytvořených bublin závisí na velikosti průtoku kapaliny („rychlost nalévání piva") a chemickém složení plynu v pivu rozpuštěném.[3] Bublina na nukleačním centrum zvětšuje svůj objem do doby, než vztlaková síla působící na bublinu ($F_{VZ}=\Delta\rho g V$) překoná sílu adhezní ($Fa=\sigma O$), kde $\Delta\rho$ je rozdíl hustot mezi kapalinou a plynem v ní rozpuštěném, g je gravitační konstanta, V je objem bubliny, O je obvod nukleačního místa a σ je povrchové napětí piva. Poté se bublina odtrhne a stoupá vzhůru k hladině. Velikost odtržené bubliny závisí na poloměru nuklaečního místa a povrchovém napětí piva.(Rov. 1)[4]

$$Rb= (3Rm\sigma/2\Delta\rho g)^{1/3} \quad \text{(Rov. 1)}$$

kde Rb je poloměr bubliny, Rm je poloměr nukleačního místa.

Rychlost stoupání bubliny k hladině významně ovlivňuje koncentrace surfaktantů v roztoku. V čisté vodě a v koncentrovaných roztocích surfaktantů bublina po odtržení z nukleačního místa akceleruje (působení vztlakové síly) a brzy dosáhne rovnováhy sil na ni působící. Díky tomu dojde k rychlému ustálení vzestupné rychlosti. V roztocích surfaktantů o nízké koncentraci s[...] v důsledku některých jevů jako je Marangoniho efekt apod. ustálí rovnováha sil působící n[...] bublinu mnohem později. Povrchově aktivních látky také ovlivňují vzájemnou koalescenc[...]