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Acoustic properties of rocks compacted from powders.

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SUMMARY

During the drilling process core samples often are damaged and proper measurements on samples cannot be performed. The objective of this study is to investigate rock powders and evaluate how their seismic properties relate to the seismic properties of their corresponding rocks. Consolidated and poorly consolidated rocks and fine powders made of those rocks have been used in this study to assess such possibilities. A comparison between the seismic properties of dry powders to the properties of wet powders has been done. A correlation in mechanical properties (Young's modulus and Poisson's ratio) between compacted powder and samples from host rock has been found.

Key words: compaction**,** rock powders, ultrasonic velocities, sandstone

INTRODUCTION

Rock samples extracted from drill holes are used for calibration of log data as well as for petro-physical analysis. Often samples are not available for laboratory measurements after drilling, cutting and polishing due to sample damage introduced by internal stress. However, during the process of drilling significant amount of rock powders or sands are being created. It will be practical to use these powders or sands for estimation of mechanical properties of rocks crossed by the drill hole. Despite the significant importance of this problem only limited information is available in literature. In order to fill this gap we built up experimental apparatus and performed preliminary experiments on compaction of different materials, such as rocks and powders made of these rocks.

In this paper first results on correlation of mechanical properties such as seismic velocities and Poisson's ratio between compacted sands and powder and two sandstones and one hard rock are pressented. Difference in mechanical properties between samples compacted from dry and wet initial materials will be discussed as well.

EXPERIMANT SETUP AND METHOD

The experiment setup, as shown in Figure 1, consists of the sample, which is held by a Perspex compression chamber (internal diameter 40 mm, high 70 mm) and prevented from expanding radially. The adjustment plastics are holding the sample from the top and the bottom and adjusting between the diameter of the transducers and the diameter of the sample.
The two ultrasonic transducers (V103-RM, Panametrics, central frequency of these transducers is 1 MHz) are sending and receiving P-waves and S-waves through the sample and the received waves are recorded by the oscilloscope (TDS 3034C, Tektronix). The transducers are connected to a pulser/receiver (5077PR, Olympus) that produces a square wave to excite waves and records the signal, which is monitored by digital oscilloscope (TDS 3034C, Tektronix). Sample is compacted in axial direction by applying stress using the manual hydraulic pump.

We used three types of samples: 1) quartz-albite-muscovite schist (a metamorphosed sedimentary rock), 2) Fountainebleau sandstone and 3) poorly consolidated sandstone B. The measurements were performed for three different states of the sample: rock, dry powder and wet powder. After measurement of rock, dry powder was manually crushed using the mortar and pestel; wet powder was prepared by pouring water on the top of the dry powder and letting it permeate slowly to the bottom of the sample until it became fully saturated.

All the measurements were performed at room temperature. Axial stress from 2 to 50 MPa is applied to sample with increment of 4 MPa. During unloading of the sample same increment (4 MPa) is used.

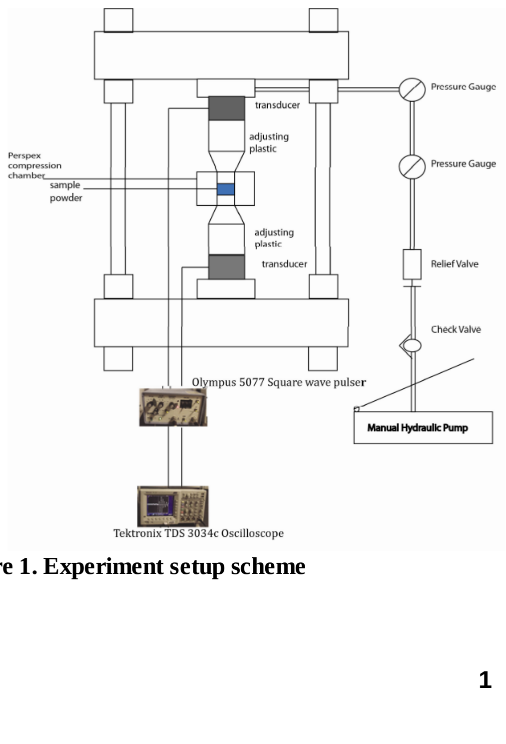

Figure 1. Experiment setup scheme

Velocities are estimating by taken the average between the compacted and the released sample length and dividing it by the waves arrival times.

RESULTS AND DISCUSSION

Powders are analysed using a scanning electron microscope (SEM), portable X-ray Fluorescence (pXRF) and X-ray diffraction (XRD) in order to study the mineral and chemical composition of the powders and document the particle size and shape distribution. This analysis shows the following:

- Fountainebleau and sandstone powders are almost pure quartz (SiO_2). This is the only mineral that can be identified in the XRD patterns.
- Chemical analysis confirmed that Fountainebleau powder consists mainly of pure quartz. However, the sandstone B powder contains very low levels of clay mineral. The amount of this mineral was too for being detected by XRD analysis, but its presence is obvious from the chemistry of the sample. Besides Si, the sandstone B contains Al and K at percent level as well as other trace elements.
- The XRD analysis of quartz-albite-muscovite schist powder shows that it consists of 26.1% quartz, 22.1% albite, 12.2% biotite and 39.7% muscovite.

SEM study showed that powders are homogeneous fine-grained media with an average particle size less than 100 µm (Figs. 2 and 3). Occasional larger particles are up to 500 µm (Fig. 3).

The P-wave and S-wave velocities' dependence on pressure is shown in the Figures 4-16. As it was expected the results show that both, P-wave and S-wave velocities in hard rocks are 2-3 times higher than the velocities in powders. Except for the P-wave velocities in sandstone B wet powder, which are only slightly different form the sandstones P-wave velocities. Furthermore, we can see that P-wave velocities of wet powders are higher than the velocities of dry powders, although the difference decreases with an increasing pressure. Nevertheless, the charts do not demonstrate unequivocal tendency in the S-wave velocities.

After exceeding compaction strain above 30 MPa all the three samples show similar Vp/Vs values, which are converging towards the value about 2 for most of the pressures, however, Fountainebleau powder and sandstone B powder show significantly higher Vp/Vs ratios at low pressures (up to 10 MPa).

DISCUSSION AND CONCLUSIONS

From the results above we can see that, to a certain extent, the behaviour of the rock powders and their measured velocities strongly resemble the stress sensitivity behaviour of the hard rocks that they were made of.

For the quartz-albite-muscovite schist sample we have the best agreement on the values of Vp/Vs (and/or Poisson's ration) between the rock sample and the wet powder.

For most of the samples there is a saturation pattern of the powders, both wet and dry, measured velocities at high pressures, meaning that the velocities are fairly different from the velocities of the rocks. However, for sandstone B the P-wave velocities of the wet powder are similar to P-wave velocities of the rock (Fig. 9). This might be due to the fact that sandstone B is poorly consolidated, Two of the other samples are hard rock and tight sandstone and there is no similarity between the stress sensitivities of velocities of the hard rock and the powders in these cases.

ACKNOWLEDGMENTS

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FIGURES AND TABLES

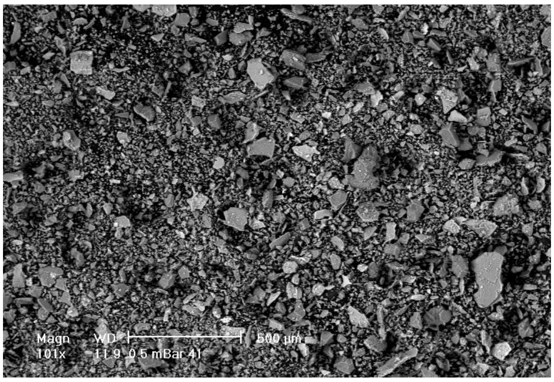

Figure 2. Scanning electron microscope (SEM) image of Quartz-albite-muscovite schist powder.

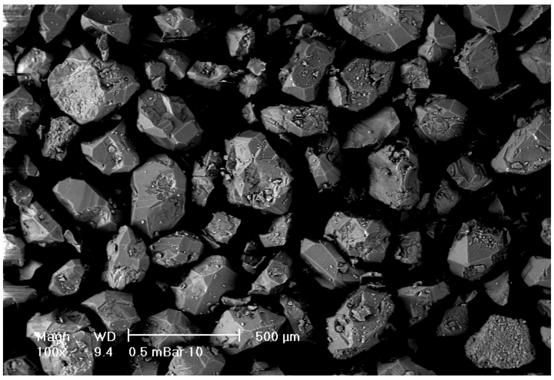

Figure 3. SEM image of crushed Fountainebleau powder.

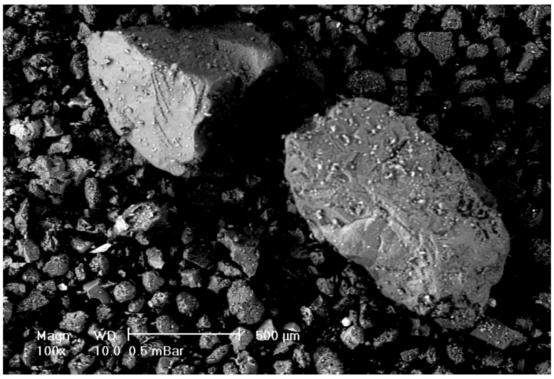

Figure 4. SEM image of crushed sandstone B powder.

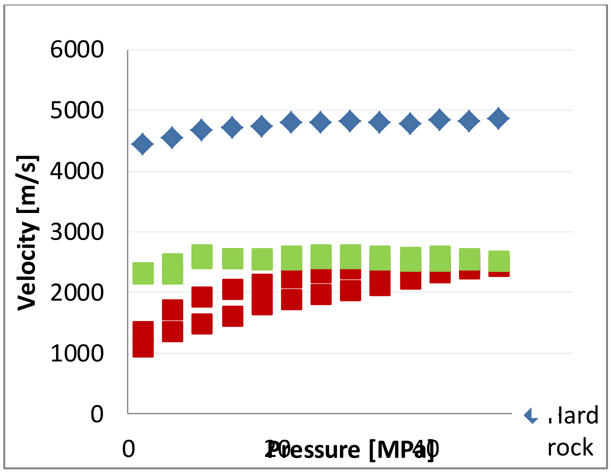

Figure 5. P-wave velocities of Fountainebleau powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

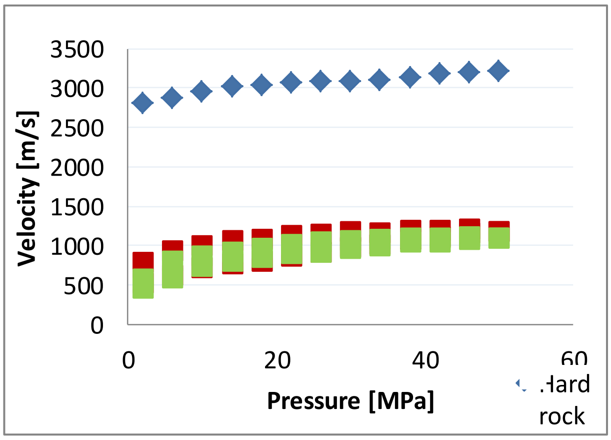

Figure 6. S-wave velocities of Fountainebleau powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

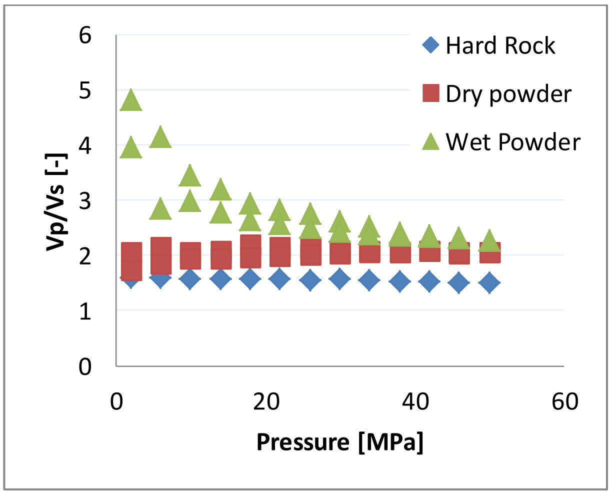

Figure 7. Vp/Vs of Fountainebleau powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

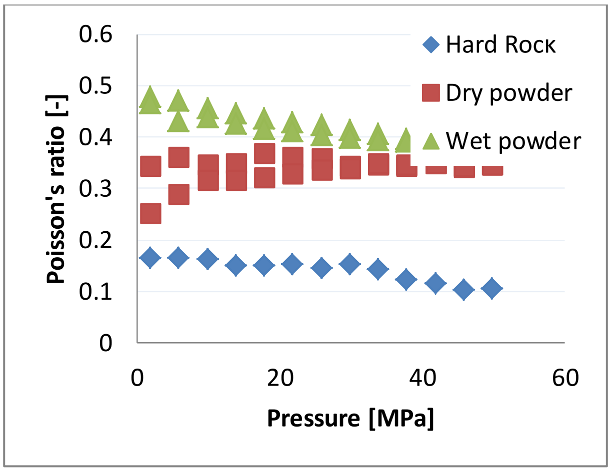

Figure 8. Poisson's ratio of Fountainebleau powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder

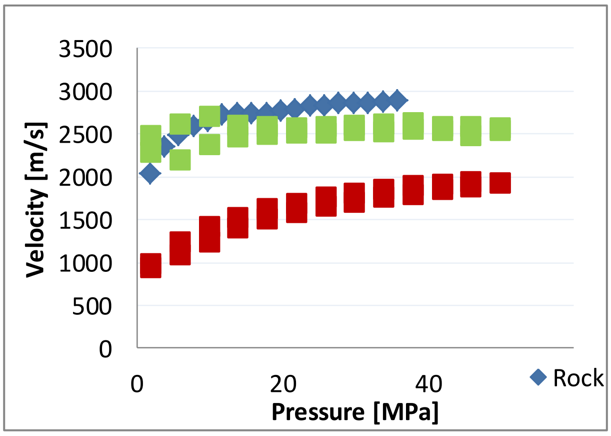

Figure 9. P-wave velocities of the sandstone B powder vs. pressure. Comparison between measurements in rock, dry powder and wet powder.

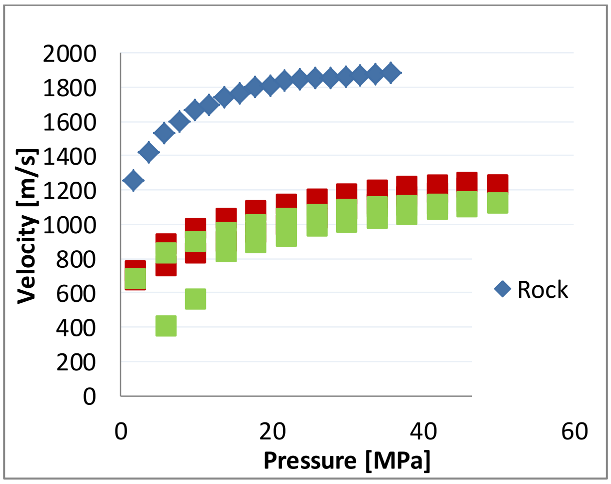

Figure 10. S-wave velocities of the sandstone B powder vs. pressure. Comparison between measurements in rock, dry powder and wet powder.

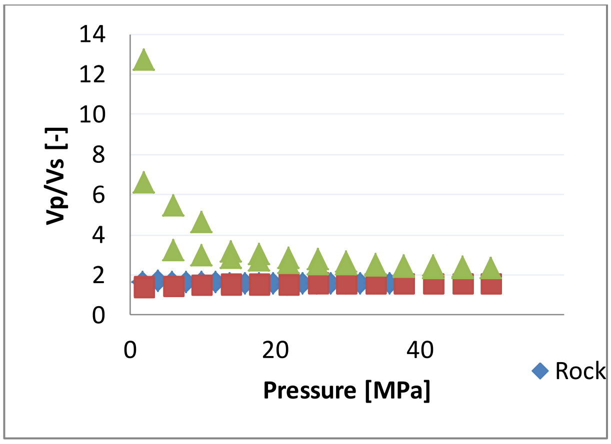

Figure 11. Vp/Vs of Sandstone B powder vs. pressure. Comparison between measurements in rock, dry powder and wet powder.

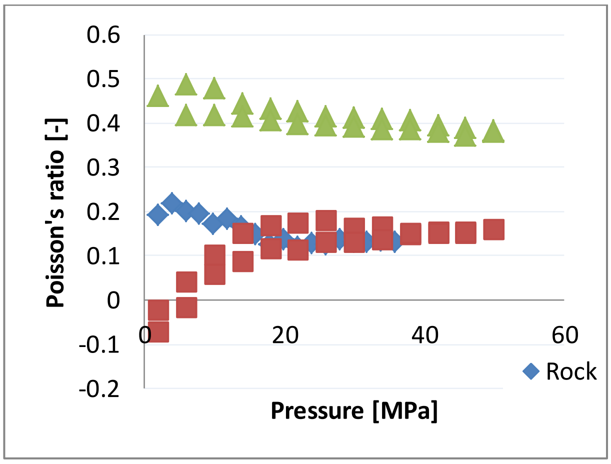

Figure 12. Poisson's ratio of Sandstone powder B vs. pressure. Comparison between measurements in rock, dry powder and wet powder

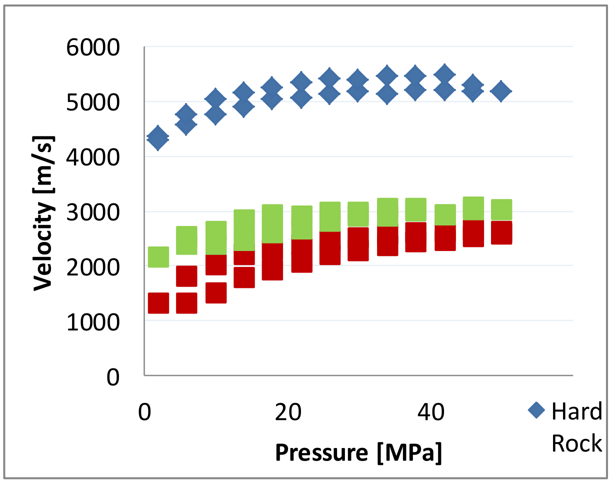

Figure 13. P-wave velocities of Quartz-albite-muscovite schist powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

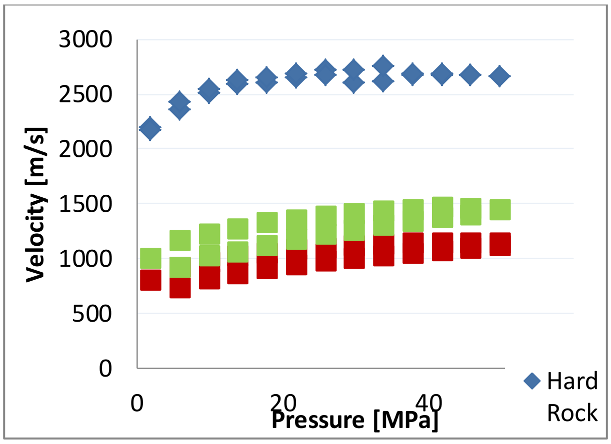

Figure 14. P-wave velocities of Quartz-albite-muscovite schist powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

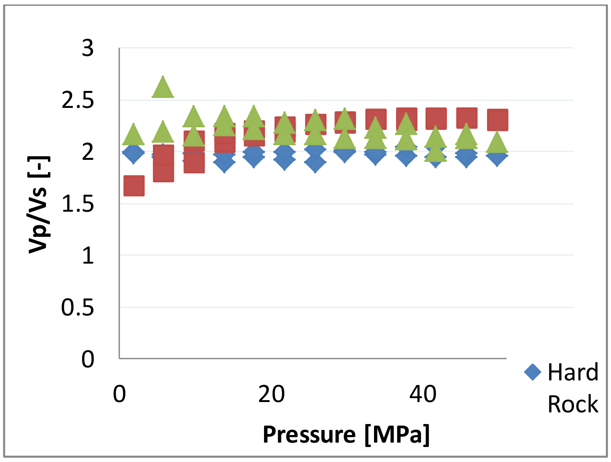

Figure 15. Vp/Vs of Quartz-albite-muscovite schist powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

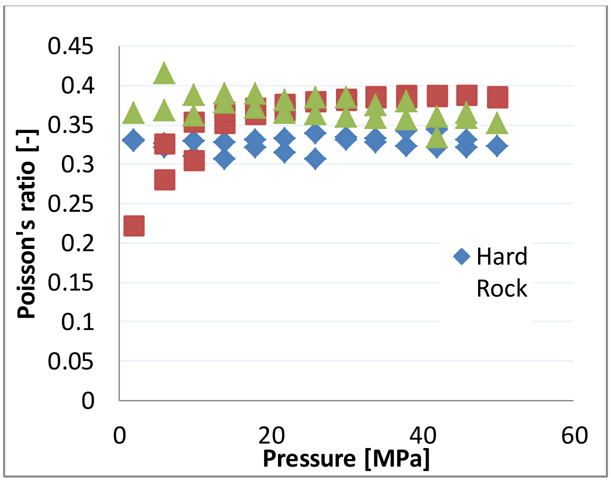

Figure 16. Poisson's ratio of Quartz-albite-muscovite schist powder vs. pressure. Comparison between measurements in hard rock, dry powder and wet powder.

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