PETROPHYSICAL CHARACTERISTICS OF IMPAKTITES S.1 Mayr[1] and Yu. Popov[2], [1]Department Section Geophysics, Freie Universität Berlin, Germany (Malteserstrasse 74-100, 12249 Berlin, Germany; sibylle.mayr@alumni.tu-berlin.de), [2]Skolkovo Institute of Science and Technology, Moscow, Russia (Odintsovskiy district, Skolkovo village, Novaya St, 100, 143 025 Moscow region, Russian Federation; y.popov@skoltech.ru).

Introduction: Geophysical prospecting plays an important role in the discovery and the exploration of impact structures, e.g. [1,2]. It is reasonable, as an impact dramatically influences the petrographic rock properties and by this the petrophysical properties of rocks.

By geophysical methods the structure of impact craters can be resolved clearly, whereas the delineation of boundaries between different impactites can be performed only with uncertainties e.g. [3]. Moreover the impact induced changes occure in various scales. Heterogeneities on borehole scale are leading to diffuse seismic reflectors, e.g. [1,3].

A proposed IUGS nomenclature of impactites by petrographic methods is available [4,5], whereas a classification is terms of petrophysical properties is much less far developed, and only rather general observations are reported, e.g. [1,2,3,4,6].

Interdisciplinary laboratory investigations on densely sampled rock samples taken from boreholes into impact structures can serve as a bridge between different scales and methods.

We here briefly review the works of our groups [7,8,9,10,11]. We then give examples for petrophysical characteristics of different types of Impactites.

Review of method and main results: Data, which were obtained within scientific drilling projects on different impact structures, were compared [11]: the Puchezh–Katunki impact structure (Vorotilovo borehole, Russia, [7]), the Ries impact structure (Noerdlingen-73 borehole, Germany, [8]), the Chicxulub impact structure (ICDP Yaxcopoil-1 borehole, Mexico, [9]), and the Chesapeake impact structure (ICDP-USGS-Eyreville borehole, USA, [10]). The unique datasets obtained on densely sampled half cores of the boreholes were used for a joined interpretation [11]. The following petrophysical properties were considered: thermal properties (measured using the optical scanning technique) as well as the porosity and density (determined using the Archimedes method). For the two ICDP boreholes also P-wave velocities determined in ultrasonic frequency range on a subset of samples were used. The interpretation was carried out in combination with geological, chemical, and optical analysis. In a first step allochthonous impactites: lithic impact breccia & suevites (including impact melt rocks) and parautochthonous & autochthonous impactites: shocked (& displaced) target rocks were distinguished. For the first group we use in the following the proposed IUGS nomenclature: impact breccia and impact melt rocks.

Physical properties of the *impact breccia and impact melt rocks* are influenced mainly by their impact-related porosity. Moreover, physical properties of lithic impact breccias and suevites with porosities of less than 15 % are additionally influenced by their chemical composition [11].

For *shocked target rocks* of the Puchezh–Katunki and the Ries impact structures the porosity and thermal conductivity reflect shock metamorphism [7,8,11]. For the shocked target rocks from Chicxulub and Chesapeake impact structure the absence of shock metamorphism is confirmed [9,10,11].

Example #1 porosity: The most important physical property which reflects the characteristics of impactites is the porosity. This is due to the fact that the porosity defines the fraction between solid material and pore space, see also example #2.

Impact breccia and impact melt rocks. Various groups of impact breccia and impact melt rocks taken from the above mentioned four impact structures have significant different mean porosity values (Figure 1).

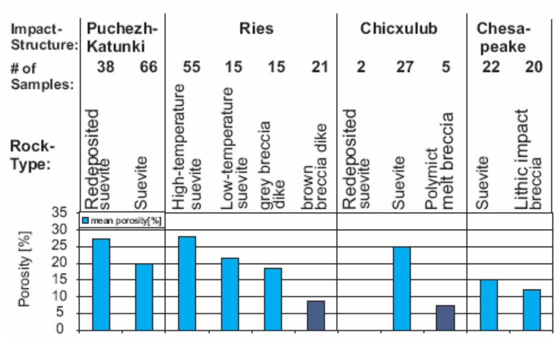

Figure 1: Mean values of porosity for the investigated suevites and lithic breccias, after: [11]. Note the low mean porosity values for rocks taken from the brown breccia dike (Ries) and the polymict melt breccia (Chicxulub).

We want to point out that a) samples take from the the brown breccia dike (Ries) have significant lower mean porosity as the other impact breccia. b) the porosity allows to distinct between the suevites (Chicxulub, impactites units 1-5) and the polymict melt breccia (Chicxulub, impactites unit 6) [see 9,11 for further discussion]. This comparison illustrates, that the porosity reflects differences in the texture of these suevites i.e. amounts of pores, rock clasts, fine grained matrix, or melt as well as indirectly their distribution.

Shocked target rocks. For Puchezh - Katunki the porosity and by this the thermal conductivity can be correlated to the grade of shock metamorphism in shocked target rocks [7,11]. In the Exmore sediment clast breccia and megablock section (borehole Eyreville, Chesapeake) a general increase of porosity with depth (besides some scattering) is observed [10]. This can be attributed to an increasing compaction of this section after the impact.

Porosity and elastic wave velocity. Moreover, a distinction has to be made between the pores with an aspect ration (ratio of height to length of the pore) of nearly 1 and pores with higher aspect ratio. The first ones contribute most to the measurable porosity, the latter ones represent fractures and influence most the velocities. The latter one can be determined via saturation dependent velocity measurements, but they also control the stress dependency of a rock, e.g. [12].

In the borehole Yaxcopoil-1 (Chicxulub) an abnormal porosity depth dependency is observed between 1300 m and 1400 m. Together with the interpretation of velocity measurements this abnormal dependency confirms the existents of rotated and fractured megablocks [11]. Stress and saturation dependent measurements of velocity allows for a subdivision of the granitic megablock (borehole Eyreville) in terms of micro fractures [10]. At the same time no significant shock metamorphism is reported.

Example #2 mineralogical composition: Pores and the various minerals building up a rocks have significant different petrophysical properties, therefore it is obvious that petrophysical properties of the rock depends on both, the porosity and the petrophysical properties of the single constituents i.e. minerals, e.g. [12]. An illustrative example of this is the *density vs. porosity* plot of Cretaceous calcarenites and dolomites taken from megablocks drilled by the Yaxcopoil-1 borehole (Chicxulub), see Figure 2. Lower density values for porosity less than 0.1 can have possible reasons: a) changes in the chemical composition and b) the existents of the closed porosity, which is not accessible by water saturation. For a further interpretation thin sections and chemical composition of each single sample would be necessary.

Influence of target properties: Impact breccia and impact melt rocks consist of clasts originated from the target, and have a certain mineralogy. Petrophysical properties of diverse minerals differ, e.g. [11,12]. By these differences the petrophysical properties of the impact breccia and impact melt rocks are influenced by the target properties.

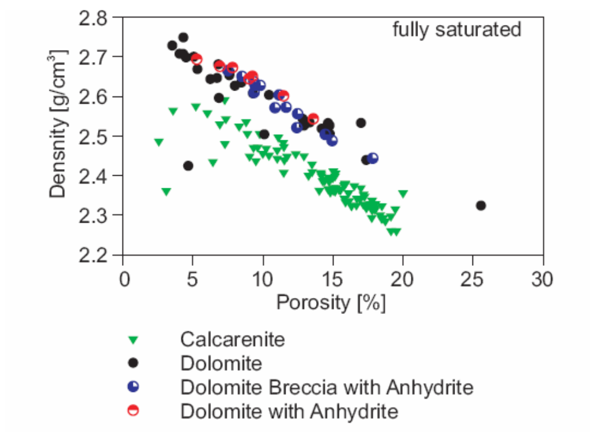

Figure 2: (a) Density ρ_{sat} versus porosity Φ. The different correlation of density with porosity shows influence of different mineralogical composition of shocked target rocks, data: [9].

Conclusions: The quantifiable property porosity is the most important influencing property. Next to the amount of pore space, petrophysical properties reflect the shape of the pores as well as the mineralogical composition. Petrophysical properties can serve as indicator and delineator, e.g. between impact breccia and impact melt rocks. Furthermore they help in the interpretation of the properties of the shocked target rocks with respect to e.g. shock metamorphism as well as the orientation and origin of megablocks. Interdisciplinary research is necessary for further and detailed interpretation.

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