

**BOOK OF TUTORIALS AND ABSTRACTS**

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**PETROLOGY - MICROBEAM ANALYSIS OF CORE SAMPLES FROM  
EXPLORATION WELLS AND OUTCROPS**

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Johannes M. Rykkje received a B.Sc. in Chemical Engineering in 1972. He started his professional career as a chemical engineer for the Institute of Atomic Energy (IFA). Subsequently, he moved to Norzink Odda, where he was involved in production control of zink metal and alloys and in environmental analysis of sea water. From 1982 to 2008 he worked for StatoilHydro on different petrography projects. During this time he also received an M.Sc. in Biology-Marine Science from the University of Oslo in 1985. In 2008 he moved to IRIS - International research institute Stavanger, where he is involved in petrography projects, among which are the study of fluid inclusions, reservoir characterisation, and carbonates.

## 1. ABSTRACT

For many years, optical microscope petrography studies on thin sections have been the most common technique for characterisation of minerals and morphology in sandstone and carbonate reservoirs. The additional use of electron microscope analysis increases our knowledge of mineral structure and composition. An electron microscope integrated with a modern X-ray micro analysis system makes the analyses less dependent on “hands on” operation. Recently, also the  $\mu$ -CT scanning techniques make 3D porosity visualisation and quantification possible.

In petrography, often relative variations in mineral compositions or morphology are more important than accurate quantitative measurements. The reason for focusing on relative variation is that inhomogeneous rock samples are much more common than homogeneous ones, particularly in carbonates. One accurate quantitative measurement on a specific part on the sample will not necessarily represent the mineral composition of the entire sample. In addition, further upscaling from core plugs to a sediment reservoir will give an even poorer description. Frequent sampling and analysis over the cored interval are of crucial importance for a representative petrographic description. Reservoir quality is mainly dependent on the permeability. The microscopic framework of the rock may explain the variation in permeability and electronic log responses commonly observed. Typical factors of importance are clay morphology, clay coatings, cementation caused by diagenetic processes, preservation of primary porosity and the distribution of closed and connected porosity. These properties can be studied using microbeam analysis techniques. The methodologies are very similar for both siliclastic and carbonate rocks.

SEM analysis comprising 2D quantification of porosity and mineral distribution using EDS X-ray element mapping followed by multivariate mineral classification are presented (Fig. 1). For further method details, see Flesche *et al.* [1], Larsen *et al.* [2], and Nielsen *et al.* [3].

3D visualisation of porosity and fluid distribution in pores are demonstrated using the  $\mu$ -CT scanning technique (Fig. 2). Quantitative measurements are performed applying a voxel growing algorithm on the segmented pore volumes. Closed and connected porosity and fluid phase distribution are visualised and quantified. These parameters are crucial in the prediction of permeability properties of siliclastic and carbonate reservoir rocks.

## 2. ACKNOWLEDGEMENTS

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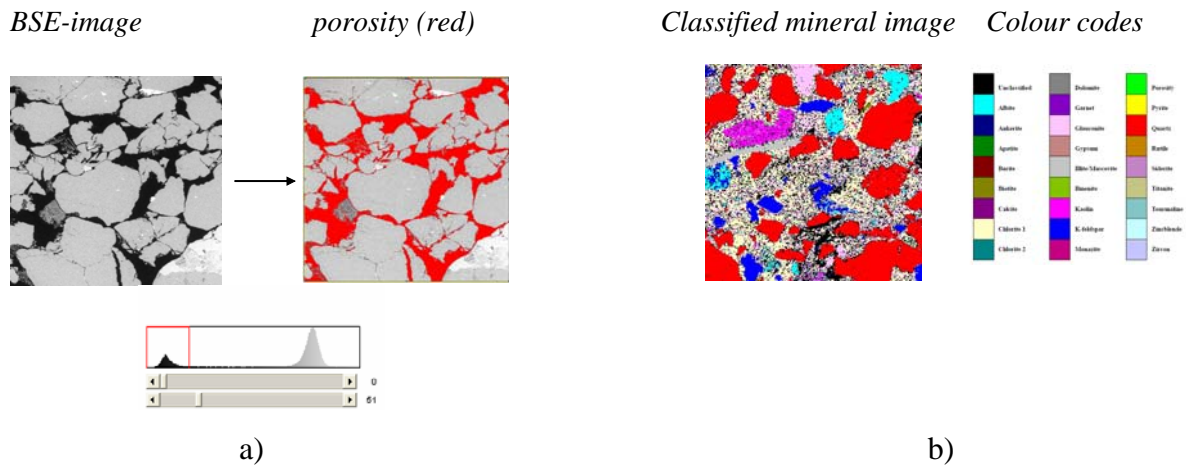


Figure 1. a) Area porosity determined by BSE image grey level histogram segmentation. Porosity fraction coloured in red.  
 b) Mineral area quantification by X-ray element mapping and multivariate classification methodology.

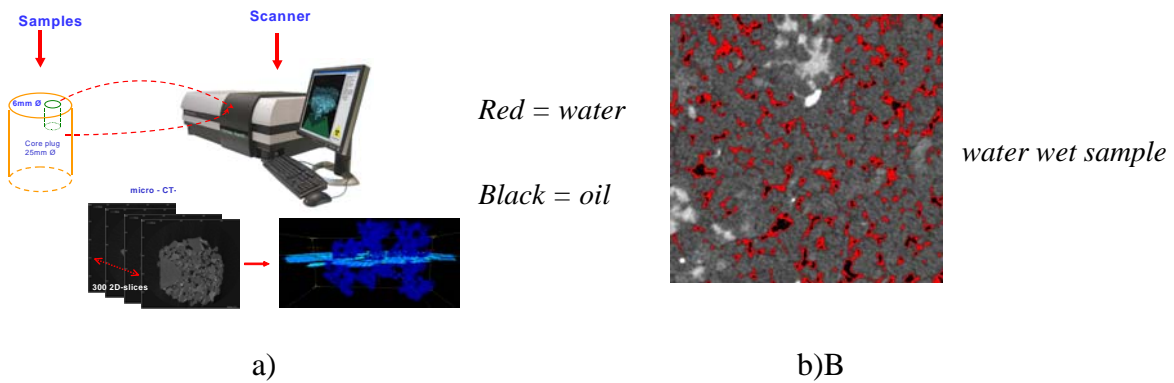


Figure 2. a)  $\mu$ -CT scanning instrument for analysis of porosity (dark blue) in porous reservoir rocks.  
 b) 2D slice from  $\mu$ -CT scanned fluid saturated core plug showing oil and water distribution.

### 3. REFERENCES

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