Compaction and rock properties development of Mesozoic and Cenozoic mudstones in the Hammerfest Basin, Norwegian Barents Sea.

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This study focuses on compaction and rock properties development of Mesozoic and Cenozoic mudstones in the Hammerfest Basin, Norwegian Barents Sea (Fig. 1). The area is highly faulted due to tectonics resulted several stages of uplift and erosion. An integrated approach, using a suite of well log data from 6 exploration wells and published mudstone compaction curves (Mondol *et al*., 2007, Mondol, 2009), has been utilized to understand the shale rock properties as a function of burial depth under the effect of both mechanical and chemical compaction. For shale volume calculation, a cutoff of Vsh≥0.75 has been applied for shale data points in the gamma ray log of all the studied wells. Bottom hole temperature has been used to infer the transition zone temperature.

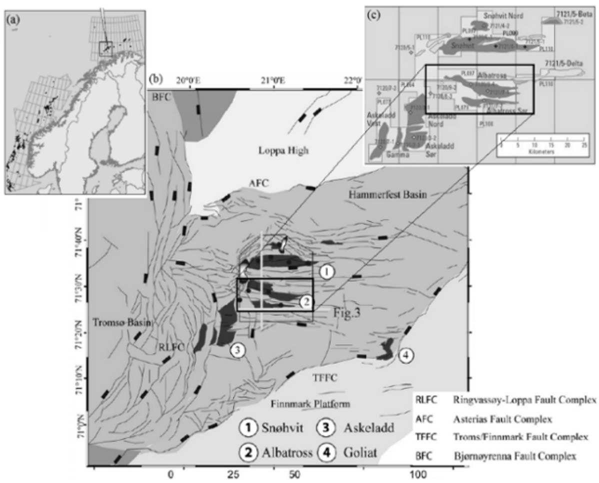

Fig. 1: (a) Location of the study area, highlighted with black rectangle (Modified from Wennberg *et al.*, 2008) (b) structural elements of the Hammerfest Basin (Modified from Ostanin *et al.*, 2012), (c) location of the wells used (Modified from World oil).

Vp-depth and density-depth crossplots of Mesozoic and Cenozoic mudstones of six studied wells show that the present day transition zone depth from mechanical to chemical compaction occur in the Knurr Formation of the study area which is obviously marked on the basis of sharp increase in the velocity versus depth trends (Fig. 2). All the formations younger than the Knurr Formation are dominated by mudstones. Due to the combine effect of mechanical and chemical compaction, the rock properties such as velocity, density and porosity alter continuously with increasing burial depth (Mondol *et al.*, 2007). Gamma ray log does not show much variation within Knurr Formation in the study area. This indicates a uniform lithology distribution throughout study area. Thus, onset of quart cementation as a function of temperature is accountable for the increase in velocity. The present day complex structural configuration of the Hammerfest basin described the variation in the transition zone depth from well to well. Moreover, temperature plays a vital role in changing the compaction processes from mechanical to chemical compaction. Lower velocities in the overpressured rocks have been related to the reduction in the effective vertical stress that results in less mechanical compaction and preservation of the primary porosity. Present day temperature of the transition zone in the Snøhvit development is not sufficient to start a transition from mechanical to chemical compaction. It is lower than the standard temperature (70-80^{0}C), giving indication of exhumation (Fig. 3).

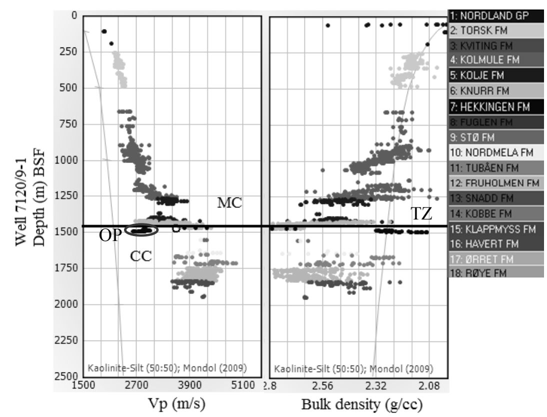

Fig. 2: The velocity, density versus depth cross-plot showing the demarcation of transition zone from mechanical (MC)to chemical compaction (CC). Red circle is showing over-pressured zone.

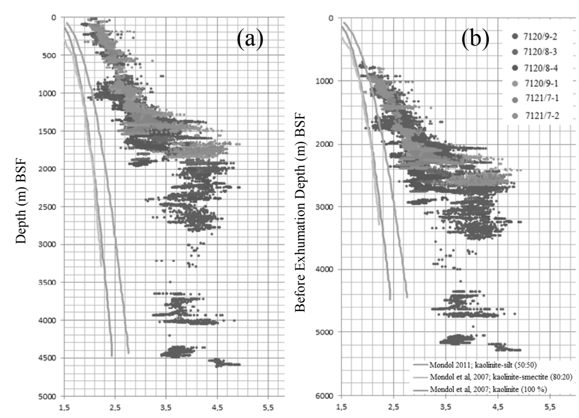

Fig 3: Velocity-depth crossplot of shale data points in all the studied wells (a) before and (b) after exhumation correction.

It can be stated from our study that the rate of sedimentation, mineralogical, textural and temperature variations with depth and time, overpressure, exhumation and types of pore fluid in the sediments are the factors should be taken into account while investigating compaction and evolution of rock properties.

Mondol, N. H., Bjørlykke, K., Jahren, J., Hoeg K. (2007): Marine Petrol Geol, 24: 289-311.
Mondol, N. H. (2009): Porosity and permeability development in mechanically compacted siltkaolinite mixtures. SEG Houston International Exposition and Annual Meeting.
Ostanin, I., Anka, Z., di Primio, R., Bernal, A. (2012): Marine Geol, 332: 109-125.
Wennberg, O. P. (2008): Petrol Geosci, 14/2: 139.