Chalk porosity and sonic velocity versus burial depth: Influence of fluid pressure, hydrocarbons, and mineralogy

Seventy chalk samples from four formations in the overpressured Danish central North Sea have been analyzed to investigate how correlations of porosity and sonic velocity with burial depth are affected by varying mineralogy, fluid pressure, and early introduction of petroleum. The results show that porosity and sonic velocity follow the most consistent depth trends when fluid pressure and pore-volume compressibility are considered. Quartz content up to 10% has no marked effect, but more than 5% clay causes lower porosity and velocity. The mineralogical effect differs between P-wave and shear velocity so that smectite-bearing chalk has a high Poisson's ratio in the water-saturated case, but a low value in the dry case. Oil-bearing chalk has up to 25 units higher porosity than water-saturated chalk at similar depth but similar velocity, probably because hydrocarbons prevent pore-filling cementation but not pore-structure stiffening cementation in this presumably water-wet chalk. These results should improve the modeling of chalk background velocity for seismic inversion analysis. When describing the porosity-reducing process, pore-volume compressibility should probably be disregarded when correcting for fluid pressure because the cementing ions originate from stylolites, which are mechanically similar to fractures. We find that cementation occurs over a relatively short depth interval.

General information
Publication status: Published
Organisations: Department of Environmental Engineering, Section for Geotechnics and Geology, Department of Civil Engineering, Geological Survey of Denmark and Greenland
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Pages: 201-223
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: AAPG Bulletin
Volume: 92
Issue number: 2
ISSN (Print): 0149-1423
Ratings:
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.594 SNIP 1.737
Web of Science (2008): Indexed yes
Original language: English
DOIs:
10.1306/10170707077
Source: orbit
Source ID: 210815
Research output: Contribution to journal › Journal article – Annual report year: 2008 › Research › peer-review