Palaeozoic carbonates from the subsurface Barents Sea Part II: Paleokarst distribution and heterogeneity from 3D seismic data

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Paleokarst networks are complex, multi-scale, heterogeneous features that are commonly modified by gravitational, structural and diagenetic processes during burial. In subsurface carbonate reservoirs, paleokarst systems can be a source of significant heterogeneity and complexity. While 3D seismic data commonly can reveal exquisite details of paleokarst systems at the level of the 'top reservoir', the beauty and use of such images is normally superficial. This is because horizon-based interpretations reveal little of the three-dimensional paleokarst network *within* the reservoir. In order to extract a more complete 3D representation of paleokarst systems, we have focused on the utilisation of volume-based methods of seismic data analysis. Specifically, a concerted effort to develop reliable methods and workflows for paleokarst detection has been made through the analysis and comparison of 6 different carbonate 3D seismic datasets. The results of this research are presented here using a spectacular subsurface case study.

The workflow is illustrated using an example of extensively karst-modified Upper Palaeozoic (Moscovian-Asselian age) carbonates preserved on the eastern flank of the Loppa High, Norwegian Barents Sea. Here it is estimated that some 300-500 m of uplift, erosion and karstification of a mixed carbonate-evaporite succession occurred during c. 20 million years of subaerial exposure (i.e. Roadian-Induan times). Major drainage systems can be traced across basement rocks and into and through the karstified carbonate succession. The carbonates are cut by steep km-scale canyons and penetrative sinkholes. The dataset shows a range of contrasting paleokarst features, so that some of the key seismic attributes and spectral decomposition methods used to delimit contrasting genetic elements of paleokarst systems can be illustrated. Results from the seismic data analysis have been quality-controlled against well data and horizon-based interpretations. The study reveals; 1) how horizon-based interpretations can potentially be misleading, 2) that different seismic properties/attributes are required to recognise and extract paleokarst features formed by different processes, 3) the important controls of bed rock geology and faulting/fracturing on paleokarst development, 4) new insights as to heterogeneity within paleokarst networks.