



3D seismic evidence of buried iceberg ploughmarks from the mid-Norwegian continental margin: a Quaternary record of North Atlantic Current variability

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An extensive 3D seismic dataset covering $\sim 40,000$ km² of the mid-Norwegian continental margin reveals over 7500 buried linear and curvilinear depressions interpreted as iceberg ploughmarks. These features are up to 28 km long, 700 m wide and are incised up to 31 m deep. On average, ploughmarks are incised 5 m deep, with median width of 185 m and median lengths ranging from 1.2 to 2.7 km for individual palaeo-surfaces. Width to depth ratio is on average 36:1. The presence of ploughmarks buried deeply within some palaeo-slope surfaces implies the occasional presence of large 'megabergs' since the middle Quaternary, suggesting that thick ice-sheet margins with fast-flowing ice streams were present in order to calve icebergs of such dimensions into the Norwegian Sea. The wide geographical distribution of ploughmarks suggests unrestricted iceberg drift and an open Norwegian Sea during the periods of iceberg calving since the early Quaternary. Ploughmark trajectory analysis demonstrates that the ocean current circulation, now dominated by the northeasterly flowing Norwegian Atlantic Current (NwAC), has largely persisted throughout the Quaternary. However, some palaeo-surfaces contain a considerable fraction (i.e. >10%) of ploughmarks that show dramatic, more than 90° westward deviations from the general orientation trend. This observation provides possible evidence for relatively short-lived reductions of the NwAC, perhaps related to major pulses of iceberg discharge from the FIS during the middle and late Quaternary.