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An overview of the Greenland cross-shelf glaciations

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Nowadays, the Greenland Ice Sheet (GIS) is the largest glacial area in the Northern Hemisphere, covering most of the onshore Greenland. Offshore evidences show that a glaciated hinterland and tidewater glaciers in Greenland go back to Eocene and Miocene. However, the Greenland margins reveal marked differences in the history of the cross-shelf glaciations. Despite the lack of an accurate age model in several sectors of the Greenland margins, seismic reflection profiles together with the few existing boreholes and wells reveal differences in the modes and timing of cross-shelf glaciation. In the Northeast Greenland margin the first cross-shelf glaciation is estimated to occur during middle Miocene, followed by a late Miocene northward advance across the Central-East Greenland margin. In contrast, the first evidences of cross-shelf glaciation along the West Greenland margin are estimated from early Pliocene in the southern part and late Pliocene in the central to northern area.

The Arctic Ocean and the Nordic seas constitute the origin of one of the most widespread water masses in the planet, the North Atlantic Deep Water (NADW), which is formed in the high latitudes of the northern hemisphere and flows southward as part of the Meridional Overturning Circulation (MOC) arriving the surroundings of Antarctica. The formation of the Fram and Denmark straits to the east, and the Davis Strait to the west of Greenland caused major changes in the North Atlantic circulation linked to the MOC and thus influencing the GIS evolution. Within the present oceanographic pattern the East Greenland margin is cooled by cold arctic surface waters in contrast to the West Greenland margin which is warmed by heat derived from the North Atlantic.

A key pointer of the offshore GIS evolution is the presence of shelf troughs that mostly terminate at trough-mouth fans over the continental slope. Over thirty cross-shelf troughs have been documented in previous publications across the Greenland margins. Periods of glacial advance over the shelf, and carving of cross-shelf troughs, have been related to ice volume increase that may have been partly driven by long-term tectonic uplift. However, another factor influencing the mass balance of the GIS is the fluctuation of oceanographic currents around Greenland. The flow of water masses over the shelf and slope generally develops contourite drifts and other current related features. Several contourite drifts have been found along the Greenlandic margins, particularly along the southern part and in eastern Baffin Bay. Thus, besides tectonic, atmospheric and climatic events, differences in the evolution of the GIS are influence by variations in the oceanographic pattern around its margins. Here we present a review of the known major events in the evolution and variations of the cross-shelf GIS and the main controlling factors.