A newly discovered mid-Carboniferous – ?early Permian reef complex in the Wandel Sea Basin, eastern North Greenland

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Three types of carbonate build-ups occur in the mid-Carboniferous – ?early Permian (Moscovian–?Asselian) succession at Kap Jungersen, southern Amdrup Land, North Greenland: (1) *Palaeoaplysina*-dominated build-ups; (2) Algae-dominated build-ups; and (3) Bryozoan-dominated build-ups. The build-ups are less than 15 m thick and up to a few hundred metres wide. They often coalesce to form laterally widespread, build-up dominated units and are locally stacked to form up to 100 m thick build-up dominated sections along platform margins.

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The mid-Carboniferous to Early Permian Mallemuk Mountain Group in Amdrup Land and Holm Land, eastern North Greenland, is dominated by shallow water carbonates with minor evaporites and siliciclastics (Fig. 1; Håkansson *et al.*, 1981; Håkansson & Stemmerik, 1984; Stemmerik & Håkansson, 1989, 1991). During the 1993 field season, detailed facies studies of the lower part of the succession, including the Kap Jungersen, Foldedal and lower Kim Fjelde Formations (Fig. 2; cf. Stemmerik & Håkansson, 1989), revealed much new information on facies types and the sequence stratigraphy of these deposits. Carbonate build-ups were found to be much more common than previously thought, and several types of build-ups were found in addition to the bryozoan-dominated mounds described by Stemmerik (1989, 1993). Thus, the Kap Jungersen section is the first in the North Greenland – Barents Sea region to record more or less continuous development of carbonate build-ups from the Moscovian to the (?) Asselian succession (e.g. Steel & Worsley, 1984; Stemmerik & Worsley, 1989, in press). In contrast, carbonate build-ups are widespread in the time-equivalent deposits of the Sverdrup Basin in Arctic Canada (Beauchamp, 1993).

This paper briefly describes the different types of carbonate build-ups identified in the field. Descriptions are based on field observations; more detailed descriptions await microfacies analyses of the build-ups.

Geological setting and stratigraphy

The Upper Palaeozoic sediments in Holm Land and Amdrup Land post-date the Caledonian orogenesis (Håkansson *et al.*, 1981). They were deposited during the initial stages of rifting between Greenland and Norway, and the depositional basin forms part of an extensive mosaic of interconnected basins covering the Barents Sea region and the marginal parts of North Greenland during the Late Palaeozoic (Håkansson & Stemmerik, 1989; Stemmerik & Worsley, 1989, in press).

The main structural feature in Holm Land and Amdrup Land is the north–south trending East Greenland Fault Zone (Fig. 1), and Late Palaeozoic sedimentation was probably restricted to the subsiding areas east of this fault zone. A series of NW–SE trending faults divided the subsiding platform into a number of subbasins with different depositional histories.

The Kap Jungersen section is located on the south Amdrup Land block (Stemmerik & Håkansson, 1989). This block was transgressed during the earliest Moscovian or possibly earlier, and during the late Carboniferous and early Permian more than 1200 m of shallow marine sediments were deposited (Fig. 1). The basement for the sediments is not exposed in southern Amdrup Land. In northern Amdrup Land and 10–15 km to the south in northern Holm Land, the mid-Carboniferous sediments directly overlie Caledonian deformed Precambrian basement (Håkansson *et al.*, 1981). Based on fusilinid datings of Dunbar *et al.* (1962), Stemmerik & Håkansson (1989)

divided the succession at Kap Jungersen into the early Moscovian Kap Jungersen Formation, the late Moscovian – early Gzhelian Foldedal Formation and the late Carboniferous – (?)Kungurian Kim Fjelde Formation (Fig. 1). Additional fusulinid datings from the lower part of the Kim Fjelde Formation indicate that this formation ranges down into the late Moscovian at Kap Jungersen (Nilsson *et al.*, 1991).

Detailed sampling of fusulinids was carried out during the 1993 field work with the aim of providing a better biostratigraphic zonation of the sediments. Based on field observations in the Holm Land – Amdrup Land area, it is evident that a major hiatus is present within the Kim Fjelde Formation (Fig. 1). This hiatus probably spans much of the latest Early Permian; the lithostratigraphic scheme of Stemmerik & Håkansson (1989) is clearly in need of revision.

Carbonate build-ups

At Kap Jungersen, carbonate build-ups were found to be common in the upper part of the Kap Jungersen Formation, the upper part of the Foldedal Formation and the lower part of the Kim Fjelde Formation, below the unconformity (Fig. 1). Build-ups also appear to be abundant in northern Amdrup Land (cf. Stemmerik, 1993) whereas in Holm Land, build-ups appear to be restricted to the lower part of the Kim Fjelde Formation.

Most build-ups are less than 15 m thick and up to a few hundred metres wide (Fig. 2). However, they often coalesce to form laterally widespread, build-up dominated horizons. Occasionally the build-ups are stacked to form up to 100 m thick build-up dominated units. These units formed along the margins of the platforms and delineated the boundary between the carbonate dominated platforms

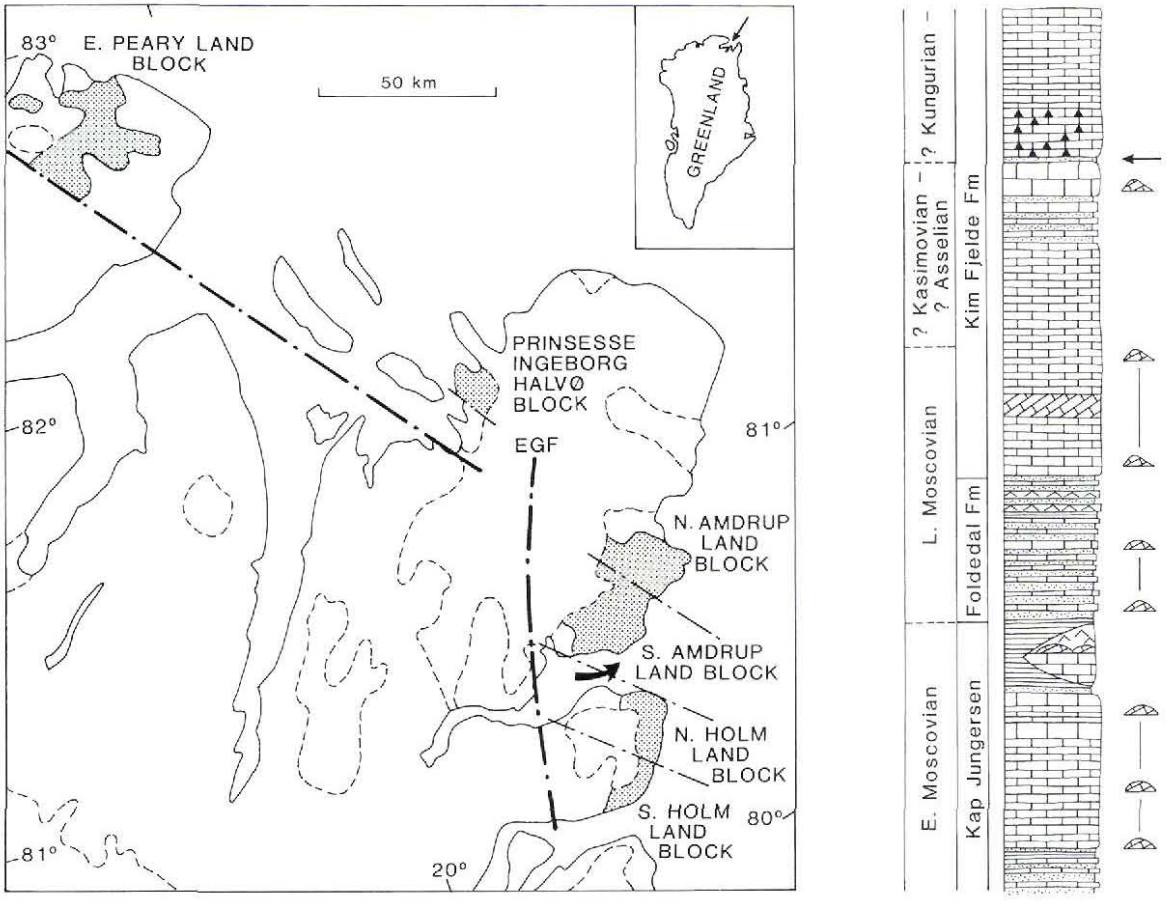

Fig. 1. Map of eastern North Greenland showing distribution of the Upper Palaeozoic deposits and location of Kap Jungersen (arrow). EGF: East Greenland Fault Zone. The stratigraphic log shows the gross lithology, the position of the newly discovered build-ups and the intra – Kim Fjelde Formation unconformity (arrow). Based on Stemmerik & Håkansson (1989) and Nilsson *et al.* (1991).

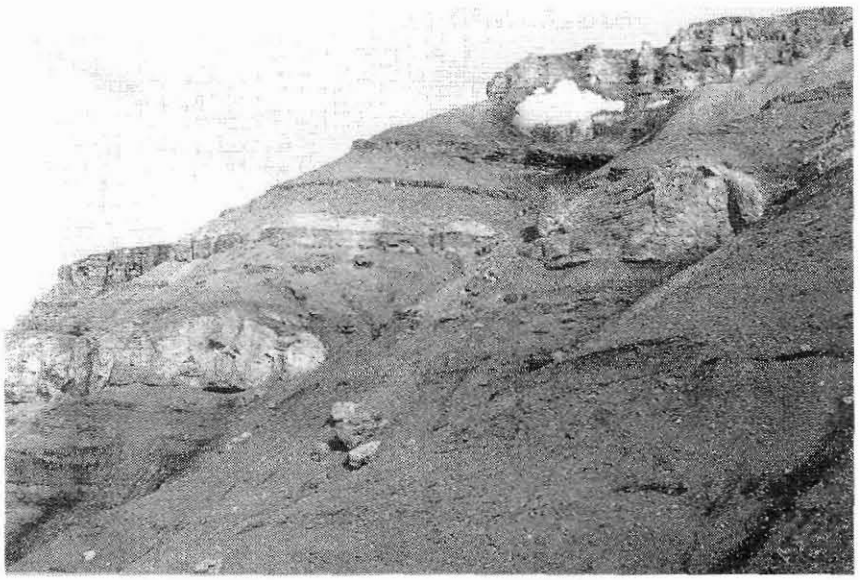

Fig. 2. Bryozoan-dominated build-ups overlying a siliciclastic-dominated unit in the lower Foldedal Formation. Note individual build-ups are lenticular, approximately 15 m high and 50–100 m wide. They form a laterally persistent horizon.

Fig. 3. *Palaeoaplysina*-dominated build-up with unbroken plates of *Palaeoaplysina* associated with tubular algae. Kap Jungersen Formation.

Fig. 4. Algal boundstone from the core of an algae-dominated build-up. Kap Jungersen Formation.

to the west and the basinal siliciclastics and evaporites to the east. Based on field observations, three different types of build-ups are represented.

Palaeoaplysina-*dominated build-ups.* Build-ups dominated by *Palaeoaplysina* are common in the upper parts of the Kap Jungersen and the Kim Fjelde Formations. These build-ups are usually less than 10 m thick and coalesce to form laterally widespread units. Build-up facies vary from boundstones of tightly packed *Palaeoaplysina* plates to packstone and wackestone with isolated, more than 1 m long plates of *Palaeoaplysina* associated with a rich fauna of brachiopods, algae, corals and crinoids (Fig. 3). These build-ups show marked lateral facies variations within their cores. The flank deposits are dominated by fine-grained packstones and wackestones.

The build-ups are usually dolomitised and display considerable macroporosity.

Algae-dominated build-ups. Build-ups dominated by algae were found to be common throughout the succession. The build-ups in the lower part appear to be dominated by tubular algae. They vary from boundstones composed entirely of tubular algae to wackestones and packstones where tubular algae occur associated with a diverse fauna of brachiopods, bryozoans, corals and crinoids (Fig. 4). These build-ups also contain *Palaeoaplysina*, and there is a transition between the algae-dominated build-ups and the *Palaeoaplysina*-dominated build-ups described above.

The build-ups in the upper part of the succession are dominated by phylloid algae. They are often associated with bryozoans and the dominant microfacies appears to be cementstones.

The build-ups in the lower part of the succession are dolomitised and contain considerable macroporosity. The cement dominated build-ups are mainly composed of calcite and show no or very little visible porosity.

Bryozoan-dominated build-ups. Build-ups dominated by bryozoans and marine cement are common in the Foldedal and Kim Fjelde Formations. The build-ups are up to 15 m thick, often lenticular with steeply dipping flank deposits. Individual build-ups have a lateral extent of less

than 200 m and either occur isolated or coalesce to form laterally persistent horizons of reef-dominated facies (Fig. 4). In the upper part of the succession, these build-ups contain abundant phylloid algae and there is a transition towards the algae-dominated build-ups.

Most build-ups are preserved as calcite and have little visible porosity. However, in the lower part of the Foldedal Formation, build-ups are dolomitised and contain visible macroporosity.

In addition to these three types of build-ups, small patch reefs composed mainly of corals are widespread in the succession. They often form the basal part of thicker units of biogenic packstone and may be dominated by chaetetids or *Syringopora*-like corals.

Comparison with adjacent areas

The majority of carbonate build-ups in the Upper Palaeozoic Wandel Sea Basin occur in the Kap Jungersen section. Elsewhere in the basin, carbonate build-ups are rare. Isolated *Palaeoaplysina* build-ups of proposed Gzhelian age occur in eastern Peary Land, and a few phylloid algae mounds of Gzhelian age have also been recorded there (Stemmerik *et al.*, in press). In northern Amdrup Land, Moscovian bryozoan build-ups are common (Stemmerik, 1993). In Svalbard and Bjørnøya, the stratigraphic distribution of carbonate build-ups and their faunal variability are limited compared to the Kap Jungersen reef complex. Most build-ups are of Gzhelian–Asselian age and dominated by *Palaeoaplysina* (e.g. Skaug *et al.*, 1982; Lønøy, 1988). However, in the offshore areas seismically defined build-ups are more widespread and they have been recorded in the ?Moscovian to Artinskian part of the succession (Gerard & Buhrig, 1990). They include isolated bryozoan-dominated build-ups of Moscovian age in the western Barents Sea, more widespread mixed phylloid algae and *Palaeoaplysina* build-ups of Gzhelian–Asselian age and bryozoan-*Tubiphytes* build-ups of Sakmarian–Artinskian age along the margins of the Nordkapp Basin (e.g. Stemmerik *et al.*, in press).

The three build-up types found in the Kap Jungersen section compare well to the build-ups known from time-equivalent deposits in the Sverdrup Basin of Arctic Canada (Beauchamp, 1993). However, the build-ups in North Greenland are thinner and in many cases more mud-dominated than the build-ups described from the Sverdrup Basin.

The occurrence of more widespread reef development in the Wandel Sea Basin thus confirms the close connection between Sverdrup Basin, Barents Sea and Wandel Sea Basin during the Late Palaeozoic (e.g. Stemmerik & Worsley, in press). However, widespread development of bryozoan-*Tubiphytes* build-ups as seen in the Sakmarian–Artinskian of Sverdrup Basin and the Barents Sea (Gerard & Buhrig, 1990; Beauchamp, 1993) has yet to be confirmed in North Greenland.

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