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Stratigraphy and paleoenvironment of the Danish Eocene Azolla event

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Spores (massulae and megaspores) of the freshwater fern Azolla are recorded in several Danish Eocene outcrops and boreholes. The Azolla-bearing interval is 0.5 - ca. 3 m thick and occurs within the L2 Bed, a unit in the lower part of the hemipelagic, bathyal Lillebælt Clay Formation deposited in the central and eastern parts of the North Sea Basin.

Intervals of organic-rich clay, usually including two distinctive, black sapropels, are present in the lower part of Bed L2, indicating a generally reduced oxygen content in the bottom waters during this time, with at least two episodes of severe, basinwide stagnation. The oxygen-deficit points to reduced circulation and/or enhanced marine productivity in the North Sea Basin. Azolla occurs in the upper part of this mainly organic-rich interval. The frequency of Azolla spores relative to marine dinoflagellate cysts fluctuates within the interval. The Azolla interval has previously been correlated to levels near the Ypresian/Lutetian transition in Belgium, based on dinoflagellate stratigraphy.

Calibration of a new magnetostratigraphic study of the lower Lillebælt Clay with the dinoflagellate biostratigraphy suggests that Bed L2 spans the upper part of Chron 22r, C22n and lower part of C21r. The Azolla pulse spans the upper part of C22n and lowermost part of C21r.

The combined bio-magnetostratigraphy from Denmark allows a detailed comparison with published data from the northern part of the Norwegian-Greenland Sea (ODP Hole 913B). The correlation confirms earlier assumptions, which were based on biostratigraphy alone, that the marine Azolla pulse in the two areas, and therefore probably over the whole Norwegian-Greenland Sea – North Sea region, is of the same age.

An ongoing palynological study of the L2 Bed has so far revealed no indication for freshwater episodes or brackish waters in the basin during the Azolla pulse, except perhaps for Azolla itself. It is, therefore, suggested that the Azolla spores were transported to the sea by rivers from swamps and lakes in coastal areas of surrounding landmasses. Azolla habitats may have existed in Fennosarmatia 200-400 km away. It is noteworthy that the Azolla pulse coincided with a major, apparently eustatic, sea-level fall or the slow subsequent transgression, during which widespread swamps may have formed in the coastal areas. The combination of a low sea-level and a warm, humid climate may have led to increased productivity, both in Azolla-swamps and in the adjacent marine waters. This may explain the presence of organic-rich marine clays with Azolla spores.