



# Glacial dropstones in the western Tethys during the late Aptian–early Albian cold snap: Palaeoclimate and palaeogeographic implications for the mid-Cretaceous



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## ABSTRACT

The late Jurassic–early Cretaceous is commonly considered the only cold climatic interval in Earth history without any direct evidence of polar ice. A newly discovered dropstone-bearing interval from the subtropical Iberian Basin (western Tethys) is described and provides evidence of contemporaneous polar glaciation. This interval is correlated laterally for 4.8 km and contains a boulder and two cobble-sized quartzite dropstones that are encased in mid-Cretaceous fissile black shales and fine-grained sandstones. Based on previously published dimensions of similar large clasts, only glacial dropstones and impact ejecta blocks reach the dimensions of the boulder-sized dropstone reported from Iberia. The dropstones show morphological features compatible with glacial transport and abrasion in a subglacial setting which closely resembles the features observed in recent glacial boulders exposed near the snouts of glaciers in Iceland. These Late Aptian dropstones from Spain correlate with many other similar erratics in the northern and southern palaeohemispheres, and suggest that ice sheets formed around the palaeo-North Pole during certain periods of the early Cretaceous. Our results and associated evidence such as the occurrence of glendonites, tillites, moderate- to high-amplitude sea-level oscillations worldwide, minimum pCO<sub>2</sub> concentrations, variation in calcareous nannofossil assemblages from low and high latitudes and isotopic excursions suggest that during the mid-Cretaceous there were periods of ice growth and decay that influenced the palaeotemperature, palaeoecology and sedimentology of the marine realm. The new data from Iberia are supported by recent results from Arctic Canada that indicate cool shelves and a mid-Cretaceous cold snap that developed for ~6 Myr between 118 and 112 Ma. The late Aptian dropstones reported in eastern Iberia were likely transported from high northern latitudes towards subtropical ones in the western Tethys by an extreme iceberg drift similar to those occurring at the present day in the Atlantic Ocean. Icebergs released from a northern fringing ice sheet may have travelled southwards through the Greenland–Norwegian Seaway.

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## 1. Introduction

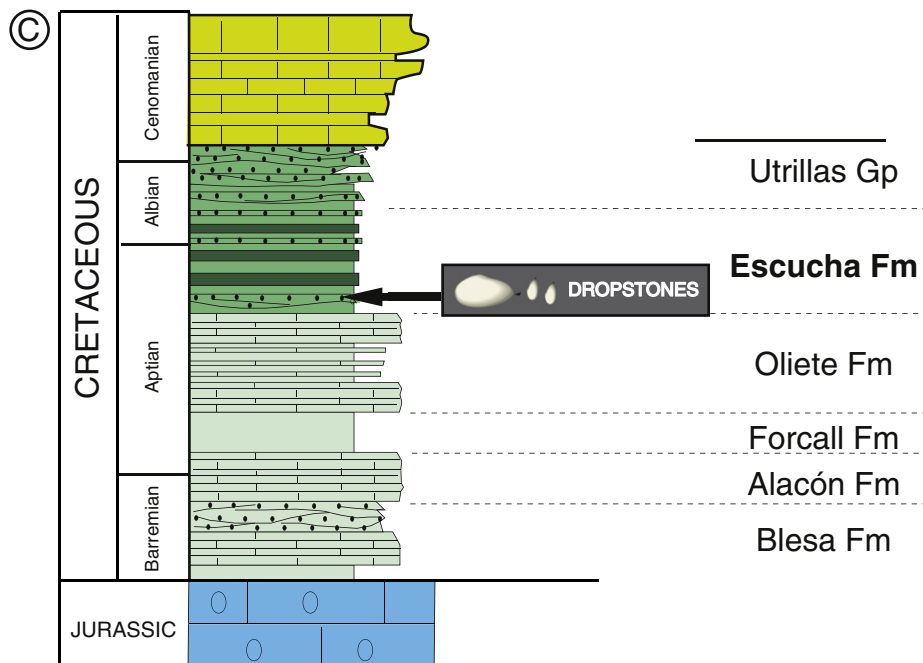
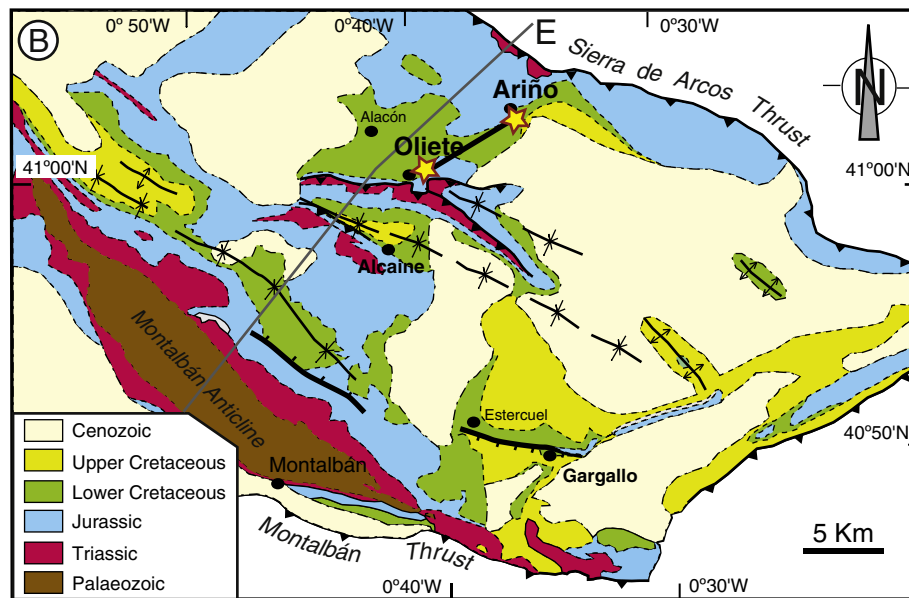
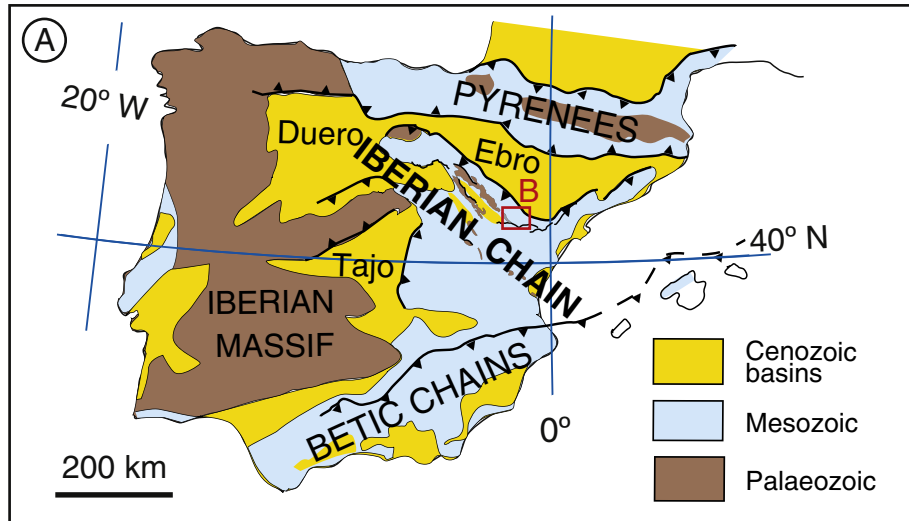
For many years the Cretaceous has been considered a greenhouse period of about 79 Myr duration with no ice present at the poles. After Frakes (1979); Frakes and Francis (1988) and Frakes et al. (1995) reported a 3-m-diam. dropstone from Australia, the possibility of polar ice came under scientific discussion and remains a controversial topic (Koch and Brenner, 2008). The interpretation of Cretaceous large clasts

as dropstones has been problematic due to the occurrence of these deposits in the standard model of an ice-free Cretaceous world (Frakes and Francis, 1988). Hence, most of these Cretaceous erratics, particularly those reported from tropical and subtropical latitudes, have been interpreted as deposited from driftwood (wood-rafting) in both lacustrine (e.g., Doublet and Garcia, 2004) and marine settings (e.g., Noe-Nygaard, 1975).

The present manuscript presents the occurrence of an isolated quartzite dropstone boulder (74 × 50 × 40 cm) in the late Aptian–early Albian Escucha Formation in an outcrop near Oliete (central-eastern Iberia), and two cobble-sized dropstones from the same stratigraphic interval in the Ariño sector (Fig. 1A–D). These clasts represent the southernmost Cretaceous dropstones reported from

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