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First discovery of Antarctic amber

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Here, we report the first discovery of Antarctic fossil resin (commonly referred to as amber) within a ~5 cm-thick lignite layer, which constitutes the top part of a ~3 m-long palynomorph-rich and root-bearing carbonaceous mudstone of mid-Cretaceous age (Klages *et al.* 2020). The sedimentary sequence (Fig. 1) was recovered by the MARUM-MeBo70 seafloor drill rig at Site PS104_20 (73.57° S, 107.09° W; 946 m water depth) from the mid-shelf section of Pine Island trough in the Amundsen Sea Embayment, West Antarctica, during RV *Polarstern* Expedition PS104 in early 2017 (Gohl 2017; Fig. 1a). So far, amber deposits have been described from every continent except Antarctica (Langenheim 2003, Quinney *et al*. 2015; Fig. 1a).

Resin is a direct plant product defined as a lipid-soluble mixture of volatile and non-volatile compounds usually exuded within a plant or at its surface (Langenheim 2003), predominantly by gymnosperms. Some plant resins are able to fossilize under certain conditions and get preserved in the geological record as amber. Until now, the southernmost amber finds are of mid-Cretaceous age and have been discovered in the Otway basin in southern Australia (Otway amber; Quinney *et al.* 2015) and as part of the Tupuangi Formation on the Chatham Islands, New Zealand (Tupuangi amber; Mays *et al.* 2017), respectively (Fig. 1a). The palynomorphs preserved in the carbonaceous mudstone containing the amber-bearing lignite indicate a mid-Cretaceous (~92–83 Ma) swampy temperate rainforest environment near the South Pole that was dominated by conifers (Klages *et al.* 2020). Such environmental conditions are ideally suited for the preservation and fossilization of wood and its associated plant resins because these require the presence of trees producing resin with a chemical composition suitable for fossilization as well as burial conditions devoid of oxygen (Langenheim 2003).

After air-drying, the lignite fragments from the carbonaceous mudstone's top (Fig. 1b) were crushed into ~1 mm fragments (Fig. 1c) and subsequently investigated by incident light and fluorescence microscopy. These investigations revealed the presence of lignite-typical amber varieties, 0.5–1.0 mm in size, translucent with yellow to orange colouration and typical conchoidal fractures (Fig. 1d–g). The numerous amber pieces from Site 20 disclose intense yellow to brownish fluorescence emissions with or without internal structure depending on the host plant. They further show signs of pathological resin flow (Fig. 1e–g) induced by traumatic resinosis, a process that mobilizes resin to seal bark injuries typically resulting from parasites or forest fires (e.g. Langenheim 2003, Brown *et al.* 2012). This creates a chemical and physical barrier against post-injury insect attacks and pathogen infections (e.g. Franceschi *et al.* 2005). Evidence for wildfires in late Cretaceous forests has been frequently reported from elsewhere but, so far, only rarely from polar biomes (Brown *et al.* 2012, Mays *et al.* 2017). The environment reconstructed for West Antarctica (Klages *et al.* 2020) explains the good preservation of the discovered amber with only rare peripheral signs of corrosion (i.e. high water levels quickly covered the resin and protected it from atmospheric agents such as ultraviolet radiation and oxidation; Langenheim 2003). The newly discovered Antarctic amber further reveals potential tree bark remains preserved as micro-inclusions (Fig. 1e), hence indicating subaerial resin exudation on the plant's surface. The amber and its high amber-standard quality (i.e. solid, clear and translucent particles) indicate shallow burial, as amber would dissipate under increasing thermal stress with burial depth. Based on its locality, we refer to this first Antarctic amber find as 'Pine Island amber'.

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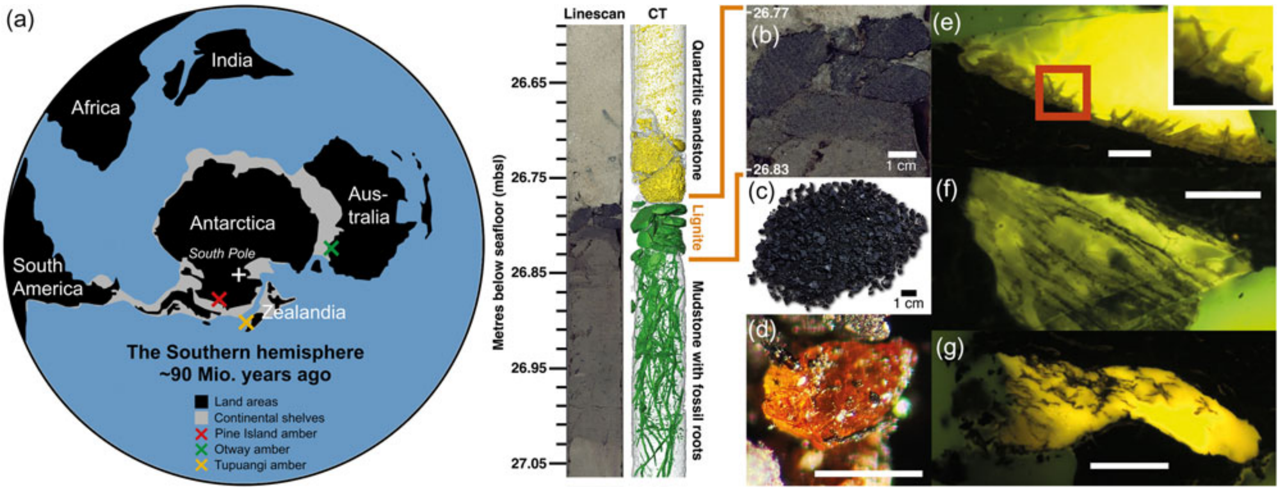

Figure. 1. a. Southern Hemisphere continental configuration ~90 million years ago, including sites of southernmost amber finds: the 'Otway amber' (green cross; Quinney *et al.* 2015), the Tupuangi amber (yellow cross; Mays *et al.* 2017) and the 'Pine Island Amber' described in this study (red cross; it remains largely unclear which parts of the indicated continents were submerged or exposed land). **b.** Lignite layer on top of carbonaceous mudstone at MeBo drill site PS104_20 (depth range below seafloor indicated); see Klages *et al.* (2020) for further stratigraphic context. **c.** Crushed, air-dried lignite fragments. **d.** Photograph of sand-sized amber (V. Schumacher, Alfred Wegener Institute). **e.** Photomicrograph of an amber piece with micro-inclusions (probably tree bark remains) at the transition from lignite to amber (see inset). **f. & g.** Photomicrographs of amber pieces with indications of pathological resin flow. Scale bars in **d.–g.** are 50 μm. CT = computed tomography scan.

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Author contributions

JPK and HG led the study and together with US, JM, C-DH, SMB and TB conceived the idea for the study and wrote the manuscript. HG, US and GN performed the microscopic work.

Competing interests

The authors declare none.

References

Brown, S.A.E., Scott, A.C., Glasspool, I.J. & Collinson, M.E. 2012. Cretaceous wildfires and their impact on the Earth System. *Cretaceous Research*, **36**, 162–190.

Franceschi, V.R., Krokene, P., Christiansen, E. & Krekling, T. 2005. Anatomical and chemical defenses of conifer bark against bark beetles and other pests. *New Phytologist*, **167**, 353–376.

Gohl, K. 2017. The Expedition PS104 of the Research Vessel *POLARSTERN* to the Amundsen Sea in 2017. *Berichte zur Polar- und Meeresforschung = Reports on Polar and Marine Research*, **712**, 10.2312/BzPM_0712_2017.

Klages, J.P., Salzmann, U., Bickert, T., Hillenbrand, C.-D., Gohl, K., Kuhn, G., *et al.* 2020. Temperate rainforests near the South Pole during peak Cretaceous warmth. *Nature*, **580**, 81–86.

Langenheim, J.H. 2003. *Plant resins: chemistry, evolution, ecology, and ethnobotany.* Cambridge: Timber Press, 586 pp.

Mays, C., Cantrill, D.J., & Bevitt, J.J. 2017. Polar wildfires and conifer serotiny during the Cretaceous global hothouse. *Geology*, **45**, 1119–1122.

Quinney, A., Mays, C., Stilwell, J.D., Zelenitsky, D.K., & Therrien, F. 2015. The range of bioinclusions and pseudoinclusions preserved in a new Turonian (~90 Ma) amber occurrence from southern Australia. *PLoS ONE*, **10**, 10.1371/journal.pone.0121307.

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