# Nature, timing and implication of green-clay authigenesis in the Drake Passage: An indicator of paleoenvironmental conditions before the onset of full-scale Antarctic glaciation

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## INTRODUCTION

The environmental changes leading up to the first continent-wide glaciation of Antarctica during the Eocene-Oligocene Transition (EOT) are still not fully understood. Declining atmospheric $CO_2$ concentrations and associated feedbacks have been invoked as underlying mechanisms, but the role of the coeval opening/deepening of Southern Ocean gateways (Drake Passage and Tasman Gateway), and subsequent changes in paleoceanography remain poorly understood. Evidence suggests both a temperate late Eocene and cooling before the EOT, both broadly coetaneous with a wide, supra-regional diagenetic event that resulted in green-clay (glaucony) formation in the marine realm around Antarctica (Houben et al., 2019; López-Quirós et al., 2019).

Glaucony formation and evolution are driven by the activity of bacteria thriving in the organic-rich environment, a bio-geochemical system now considered to play a key role in the control of global ocean chemistry. Investigation of the reaction mechanisms throughout the formation of glaucony provides reliable information about (i) macro-scale environmental conditions, such as ocean transgression-regression cycles and ocean circulation changes, and (ii) the micro-scale sedimentary environment, such us sediment permeability, ion mobility and organic matter content – all of which are registered in the fabric and crystal-chemical characteristics of glaucony (e.g., López-Quirós et al., 2019; 2020; 2023). In addition, K-Ar dating of glaucony has provided 40% of the absolute-age dates for the geological timescale of the past 250 Ma. Glaucony is thus an important tool to date depositional ages of sediments and to reconstruct paleoenvironmental conditions. In spite of all, the nature, depositional setting, paleoenvironmental implications and chronology of the late Eocene glaucony reported in diverse shallow-marine settings in the Southern Ocean are loosely constrained (López-Quirós et al., 2019).

In this contribution we describe, for the first time in the Drake Passage, a coetaneous late Eocene glauconitization event, utilizing textural, mineralogical and geochemical analyses. Based on this multi-proxy approach, we evaluate the paleogeographic implications and temporal variations of glaucony-bearing sediments deposited in the Drake Passage before major ice sheet advance during the EOT (Fig. 1).

## MATERIALS AND METHODS

This contribution focuses on sediments containing high amounts of late Eocene glaucony grains recovered from DSDP 511 (eastern Falkland Plateau), ODP 696 (northern Weddell Sea) and Section-M4 (Submeseta Formation, Seymour Island) (Fig. 1). Glaucony grains were studied first under binocular microscope for morphological characterization. In addition, the micro-textures of the glaucony grains were examined under scanning- and transmission-electron microscope (SEM and TEM). The mineralogical composition was determined by X-ray powder diffraction (XRD) from glaucony grain concentrates and oriented aggregates (<2 µm fraction). Quantitative elemental analyses of the main glaucony-forming elements were obtained by electron probe microanalysis (EPMA).

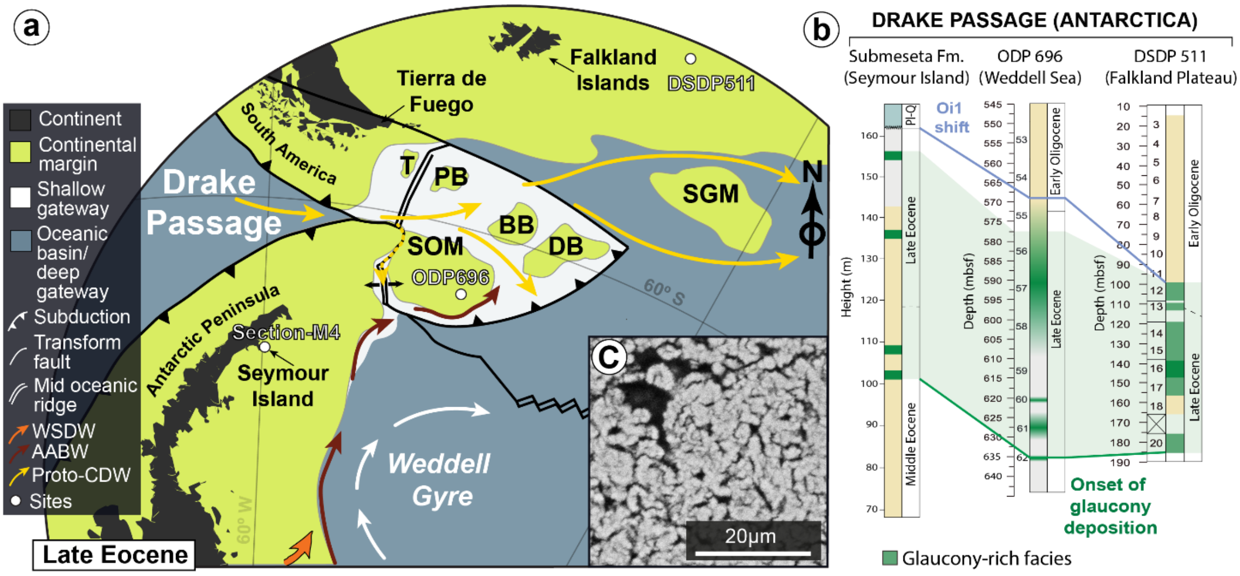


*Fig 1. a) Paleolocation of recorded late Eocene glaucony-bearing sections (DSDP 511, ODP 696, and Section-M4) around the Drake Passage (Modified after López-Quirós et al. 2021). b) Simplified lithologic logs and correlation between glaucony-bearing sedimentary sections (after Houben et al., 2019). c) SEM photomicrograph (BSE) showing the spotty flaky texture in section of evolved glaucony (glaucony grain from Section-M4, Seymour Island).*

## RESULTS AND CONCLUSIONS

Green-clay authigenesis at the late Eocene DSDP 511, ODP 696 and Section-M4 (Seymour Island) occurred mainly by the replacement of faecal pellets. The $K_2O$-rich (>6.5 wt%), flaky/rosette-shaped clay nanostructures (Fig. 1c), and complex pellet shapes reflect an evolved (mature) stage and a long term (>100 ka) authigenic process. The mineralogy, chemistry, morphology, and textural properties demonstrate that glaucony grains have formed *in situ* (autochthonous) and consist mainly of smectite-poor interstratified ~10Å glauconite-smectite. Syn-sedimentary conditions that prevailed during late Eocene controlled the glaucony composition, as slightly reducing conditions cause Fe-enrichment whereas oxidizing conditions favour Fe-depletion. Glauconitization in the Drake Passage developed thus under sub-oxic, partially reducing conditions at the sediment-water interface. These environmental conditions were triggered in an open shelf environment, at >50 m water depth, where low sedimentation rates and recurrent winnowing action of bottom currents led to stratigraphic condensation. In this sense, results from this work provide important new insights into changing paleoceanographic conditions during a late Eocene supra-regional transgressional event, about 1 Ma before the EOT. We conclude that glauconitization was associated to continuous rising sea levels related to plate reorganization and deepening of the continental blocks as the Drake Passage opened, pre-dating the onset of full-scale Cenozoic Antarctic glaciation.

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