

## ABNORMALLY THICK EGGSHELLS OF *MEGALOOOLITHUS SIRUGUEI*: PARATAXONOMIC AND PALAEOLOGICAL IMPLICATIONS

Miguel Moreno-Azanza<sup>1</sup>, José Ignacio Canudo<sup>1</sup>, Rute Coimbra<sup>2</sup>, Carmen Núñez-Lahuerta<sup>3,1</sup>,  
Manuel Pérez-Pueyo<sup>1,4</sup>, Eduardo Puértolas-Pascual<sup>1,5</sup>, Cristina Sequero<sup>6</sup> & Lope Ezquerro<sup>6</sup>

<sup>1</sup>Aragosaurus-IUCA, Recursos geológicos y Paleoambientes, Departamento de Ciencias de la Tierra, Universidad de Zaragoza, Zaragoza, Spain.

<sup>2</sup>GeoBioTec, Department of Geosciences, University of Aveiro, Portugal.

<sup>3</sup>Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain.

<sup>4</sup>Departamento de Geología/Geología Salla, Facultad de Ciencia y Tecnología/Zientzia eta Teknologia Fakultatea, Universidad del País Vasco/Euskal Herriko Unibertsitatea, Leioa, Euskadi, Spain.

<sup>5</sup>Museo Geominero, Instituto Geológico y Minero de España (IGME-CSIC), Madrid, Spain.

<sup>6</sup>Dpto. Geodinámica, Estratigrafía y Paleontología, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Madrid, Spain.

E-mail: mmazanza@unizar.es

**Keywords:** Megaloolithidae, dinosaur eggs, Late Cretaceous, Campanian, Maastrichtian.

*Megaloolithus siruguei* is a south European endemic oospecies, probably laid by titanosaurian sauropods. Clutches, eggs and eggshells of this oospecies have been reported from France, Romania and Spain, dating late Campanian to early Maastrichtian. It is characterized by a compactituberculated ornamentation, tubospherulithic morphotype, a somewhat branching, profuse pore system, and a thick eggshell, ranging between 1.75 and 3 mm. Nevertheless, several localities in the Iberian Peninsula, in the provinces of Barcelona, Burgos, Huesca, Lleida, and Valencia have produced abnormally thick *Megaloolithus* eggshells, up to 5 mm in thickness, sharing ornamentation, eggshell morphotype and pore system with *M. siruguei*. They have been referred using open nomenclature, either as *Megaloolithus* cf. *siruguei* or *Megaloolithus* aff. *siruguei*. These eggshells have been regarded in previous studies as either taphonomically altered or pathological eggshells, caused by ecological stress of the egg layers caused by faunal replacements. Importantly, these extremely thick eggshells have not been reported neither from France nor Romania. Here we report abnormally thick eggshells from Santa Marina 1 locality, in the Garumnian facies of Loarre (Huesca), reaching over 1 cm in thickness. A combination of SEM imaging, EBSD mapping, isotopic analysis, and microprobe geochemistry allowed us to disregard taphonomic alteration of the eggshell, pointing towards a pathological origin of the eggshell thickening. Interestingly, these eggs and eggshells appear in the same egg laying horizons as regular thickness *Megaloolithus siruguei* eggs. Importantly, normal *Megaloolithus siruguei* eggs exist in layers over the levels with coexisting abnormal and normal eggs. The coexistence of normal and abnormally thick *Megaloolithus siruguei* eggs in the same stratigraphic horizons support its pathological condition. The restriction of pathological eggshells to the lower latitudes and its intermittence on the record suggests they may be related to stress caused by climate factors and not ecological competition, such as hydric restrictions or temperature variations.

**Acknowledgements:** PID2024-158833OB-I00 by MICIU/AEI/ 10.13039/501100011033/FEDER, UE); PR17/24-31911, by Comunidad de Madrid-UCM, by E18\_23R Aragosaurus: Recursos Geológicos y Paleoambientales founded by Gobierno de Aragón. MMA by RYC2021-034473-I, MCIN/AEI/10.13039/501100011033, and EU (NextGenerationEU).