

**What controls the taphonomy of exceptionally preserved taxa—Environment or biology? A case study using frogs from the Miocene Libros Konservat-Lagerstätte (Teruel, Spain)**

Maria E. Mcnamara,<sup>1,2\*</sup> Patrick J. Orr,<sup>2</sup> Luis Alcalá,<sup>3</sup> Pere Anadón,<sup>4</sup> And Enrique Peñalver<sup>5</sup>

<sup>1</sup>Department of Geology & Geophysics, Yale University, New Haven, Connecticut 06520-8109, USA, [maria.mcnamara@yale.edu](mailto:maria.mcnamara@yale.edu); <sup>2</sup>UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4, Ireland, [patrick.orr@ucd.ie](mailto:patrick.orr@ucd.ie); <sup>3</sup>Fundación Conjunto Paleontológico de Teruel-Dinópolis, Avenida Sagunto s/n, 44002 Teruel, Aragón, Spain, [alcala@dinopolis.com](mailto:alcala@dinopolis.com); <sup>4</sup>Consejo Superior de Investigaciones Científicas, Institut de Ciències de la Terra “Jaume Almera,” Lluís Solé i Sabarís s/n 08028, Barcelona, Spain, [panadon@ija.csic.es](mailto:panadon@ija.csic.es); <sup>5</sup>Museo Geominero, Instituto Geológico y Minero de España, Calle Ríos Rosas, 23, E-28003, Madrid, Spain, [epenalver@uv.es](mailto:epenalver@uv.es)  
\*Corresponding author.

Keywords: skeletal taphonomy, exceptional fauna, soft tissue preservation, lakes, Cenozoic

**ABSTRACT**

The exceptional preservation of organisms is potentially influenced by various factors that reflect either the environmental context or aspects of the organisms' biology. There has been no systematic investigation of the relative impact of such factors upon the fidelity of preservation of an exceptionally preserved taxon. In this study, we present an integrated approach to taphonomic analysis of exceptionally preserved taxa using primarily quantitative data to analyze the taphonomy of exceptionally preserved frogs (*Rana (Pelophylax) pueyoi*) from the lacustrine-hosted, upper Miocene, Libros Konservat-Lagerstätte (Teruel, northeastern Spain). The frogs occur within several different laminated mudstone facies and vary in their size, degree of completeness, degree of articulation, limb positions, and the extent, type, and fidelity of preserved soft tissues. For each specimen, we coded its physical and soft-tissue taphonomy using twelve indices, and identified its lithological context. Systematic statistical analysis reveals no correlation between specimen size, any taphonomic index, and lithological context: variations in the taphonomy of the frogs are independent of centimeter-scale variations in lithology and, by inference, short-term fluctuations in environmental conditions. The consistently high fidelity of skeletal preservation and the preservation of soft tissues, therefore, ultimately reflect the general nature of the sedimentary environment, i.e., burial within laminated organic-rich muds below anoxic, monimolimnetic waters of a deep, stratified meromictic lake. The statistical analysis did, however, identify significant correlations between various taphonomic indices. These indicate that the observed variation in the fidelity of frog preservation can be attributed, in large part, to a suite of

factors related to the biology of the frogs; the most important of these is the original biochemistry of specific tissues, especially the skin, and the postmortem fate of the skin.