



Integrated stratigraphy of the Agrio Formation (Neuquén Basin, Argentina): towards an intercalibration with the Mediterranean basins during Valanginian-Hauterivian times

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The Valanginian and Hauterivian stages (Early Cretaceous) represent an 11-myr interval. They were periods of transition between the relatively cold Late Jurassic to the greenhouse world which continued in the rest of the Cretaceous, and the world seemed to have distinct climate zones, reflected in distinct Boreal, Tethyan and Austral marine faunas. It was also a time of great paleogeographic reorganizations related to the opening of the Atlantic Ocean which notably affected the paleoceanographic patterns, producing numerous environmental changes. In that sense a positive shift in $\delta^{13}\text{C}$ in the early–late Valanginian transition (known as the ‘Weissert Event’), and deposits of black shales in the Mediterranean nearly at the end of the Hauterivian (the ‘Faraoni Event’) have been recognized. However, due to the fact that the durations of the Valanginian and the Hauterivian stages are presently under much debate, the numerical ages of these two events are poorly constrained. This fact has also hindered its globalism and the possible factors that caused their deposition. To tackle these and other Valanginian and Hauterivian topics we are studying the Agrio Formation of west-central Argentina. The Neuquén Basin is a retro-arc basin developed in a normal subduction segment at the foothills of the Andes. Laterally continuous outcrops and an abundant fossil record, combined with tuffaceous layers interbedded in thick, expanded sedimentary successions make the basin an excellent site for stratigraphical, paleontological, and radio-isotopic studies. The infill of the basin during the late early Valanginian to the earliest Barremian is represented by the Agrio Formation. We have studied this unit for more than 20 years with bed-by-bed collection of fossils and more recently we have started sampling the tuff layers. There are three high precision CA-ID TIMS U-Pb radio-isotopic ages; the three horizons are well constrained biostratigraphically by ammonites and calcareous nannofossils which correlate with the ‘standard’ sequence of the Tethyan Realm. The oldest one is 130.39 ± 0.16 Ma (early Hauterivian), the second is 129.09 ± 0.16 Ma (base of late Hauterivian) and the third one is 127.42 ± 0.15 Ma (late Hauterivian). Now, we have selected a stratigraphic section at the locality El Portón where this formation is composed of marl-limestone alternations, likely forced by orbital cycles and have performed magnetic susceptibility measurements having the first orbital time scale of the Agrio Formation. We are also improving our chemostratigraphical data. Thus, we have achieved a robust combination of cyclostratigraphy, biostratigraphy and high-precision radio-isotopic ages for the Agrio Formation. This new data have been used to correlate the results obtained in the Neuquén Basin with those of classic sections of the Tethys, including the candidates for the base of the Hauterivian (La Charce, France) and the base of the Barremian (Río Argos, Spain). Therefore, the new geological time scale for the Valanginian–Hauterivian stages proposed in the Mediterranean region integrating astrochronological, biostratigraphic and radiochronological data differs with the current official geological time scale which still maintains poorly constraint absolute ages for the Valanginian-Hauterivian interval.