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# Insect biostratigraphy of the Pennsylvanian Souss basin, Morocco: implications for late Carboniferous non-marine – marine correlation

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## Abstract

Situated in the South-western branch of the late Palaeozoic Euramerican orogenic belt of the Hercynides, the Late Pennsylvanian Souss Basin was considered to have been an evolutionary hotspot for diverse biota which appear later in the Euramerican province from Europe to North America (Hmich et al., 2003, 2005, 2006; Lagnaoui et al., 2018; Belahmira et al., 2019; Werneburg et al., 2019). The continental Pennsylvanian deposits of the Souss Basin in the western High Atlas Mountains occur as tectonically bounded remnants of a once much larger intramontaneous basin. The recent Souss Basin consists of the two tectonically separated sub-basins of Ida Ou Zal and Ida Ou Ziki. The Carboniferous sedimentary succession of the Souss Basin includes: basal conglomerates of the Ikhourba in the Ida Ou Zal, and the Tajgaline formations in the Ida Ou Ziki subbasin, which are overlain by more than 1200 m thick gray braidplain sediments of the El Menizla and the Oued Issene formations respectively (Saber et al., 2001, 2007). All processes of the geotectonic and sedimentary evolution along with relevant biotic events are preserved in the sedimentary fill of the basin. In order to elucidate the mainly climatically driven evolution of the Late Pennsylvanian Souss biota as well as the reconstruction of their biogeography, a geochronological frame is absolutely crucial. In addition, an implementing of an accurate geological time of the fossil host strata will lead to a well-established biostratigraphic framework for the Late Pennsylvanian (Stephanian) locally, correlating a part of the deposits of the Souss Basin with the West-European Regional Scale (WERS), the North American Stages (NARS), and globally with the Standard Global Chronostratigraphic Scale (SGCS).

Moreover, the biostratigraphic schemes of the late Palaeozoic-early Mesozoic Moroccan basins, including the Souss Basin, have become in the last decades a focus of the Nonmarine-Marine Correlation Working Group of the Subcommissions on Carboniferous Stratigraphy, Permian Stratigraphy, and Triassic Stratigraphy (Schneider et al., 2020). State-of-the-art of steady increase in sampling and cm-scale resolution lithostratigraphic logging techniques were used to establish a high-resolution biostratigraphic framework from key outcrops in

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several Moroccan basins.

Despite the lack of a high-resolution radioisotopic ages, as well as marine intercalations with index fossils such as conodonts from the late Pennsylvanian Souss Basin, other alternative methods have been used, e.g. the macro-plant biostratigraphy (e.g Broutin et al., 1989), the insect biostratigraphy based on morphophylogenetic spilloblattinid lineages (Hmich et al., 2005; Belahmira et al., 2014). Additionally, further fauna-based proxies might be successfully integrated into biostratigraphic dating for the Late Pennsylvanian of the Stephanian (Kasimovian) in the Souss Basin, such as branchiosaur-like temnospondyls (Discosauriscids) of the *Branchierpeton* lineage (Werneburg et al., 2019) and clam shrimps (conchostracans) (Scholze et al., 2015; Schneider et al., 2018; Schneider et al., 2022) which occur associated with fossil insects and plants.

Nevertheless, new improved entomological data from the Late Pennsylvanian to early Permian continental and mixed marine continental sections, which are widespread in the paleotropical belt, especially in North America, have contributed to a high temporal resolution biostratigraphy for the non-marine Early Pennsylvanian (middle Bashkirian) up into the early Permian (early Asselian) subdivisions of the European, North American, and North African basins, as well as to non-marine-marine cross correlations Schneider et al. (2022).

In summary, the age of the fossiliferous strata from Souss is older than what was previously assumed (Hmich et al., 2005; Belahmira et al., 2014). Accordingly, the inferred age of the Late Pennsylvanian Souss stratigraphic units is constrained to the early to latest Stephanian A of the WERS, middle to the latest Missourian of the NARS, which are tied to the Late Pennsylvanian middle to late Kasimovian stage of the marine SGCS.

Ongoing research in the Moroccan late Carboniferous to Triassic basins is focused on the improvement of global correlations for the understanding of global processes (e.g. Zouheir et al., 2022).

**Keywords:** Biostratigraphy, insects, Carboniferous, Souss Basin, Morocco