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Of slabs, sutures and ophiolites: Reinterpreting the Mesozoic geodynamics of the Balkan peninsula supported by numerical modelling

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For decades, the Mesozoic geodynamics of the Balkan sector of the Alpine–Himalayan orogenic belt has been interpreted through contrasting geological and geodynamic models. Key debates have focused on the number of oceanic domains, the mode and timing of their closure, the mechanisms responsible for the emplacement of the Vardar Zone ophiolites, and the very existence of the enigmatic Sava-Vardar Zone (SVZ). In this contribution, we provide a synthesis of our recently published results together with ongoing numerical modelling efforts aimed at resolving the full complexity of Mesozoic Balkan geodynamics. To this end, we have used both 2D and 3D numerical geodynamic modelling based on the I2VIS and I3VIS codes, utilizing conservative finite-differences and marker-in-cell approach for solving the continuity, momentum and temperature equations.

While earlier models frequently invoked multiple oceanic basins, more recent studies have largely converged on a more parsimonious single-ocean scenario. Nevertheless, a major question persisted: how could compositionally and structurally distinct yet contemporaneous ophiolite belts have formed within a single Tethyan ocean? Our numerical models address this issue by demonstrating that a single NE-dipping subduction system can account for these contrasts, consistent with geological evidence indicating similar obduction ages on both the Europe- and Adria-derived continental units. In our models, this configuration leads to complete consumption of the ocean by the end of the Jurassic.

These results, however, stand in contrast to the widely held interpretation that a separate oceanic domain persisted into the Cretaceous – the so-called Cretaceous Sava Ocean. This idea came to prominence with the discovery of Upper Cretaceous basalts in the SVZ, initially interpreted as parts of ophiolite sequences. Subsequent work has shown this interpretation to be erroneous, leaving the subduction-like geochemical affinity of the Upper Cretaceous Apuseni–Banat–Timok–Srednogorie (ABTS) magmatic and metallogenic belt as the primary remaining argument. Our modelling demonstrates that the complex dynamics of an already-subducted Jurassic slab can generate this post-obduction magmatism, removing the need to invoke an active Cretaceous subduction zone. The model shows that in a post-obduction stage, a hydrated subducted slab undergoes detachment, rebound and subsequent partial melting,

allowing for delayed subduction-like magmatism to occur after ocean closure.
The final unresolved issue concerns the origin of the Upper Cretaceous magmatism within the SVZ. We propose that these occurrences reflect localized reactivation of the suture in response to strike-slip motion between the European and Adriatic plates, producing zones of transtensional opening along the former plate boundary. New 3D numerical models support this interpretation, demonstrating that transtension can indeed reactivate a suture and generate mantle-derived magmatism within associated pull-apart basins.