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Multi-proxy paleoenvironmental analysis of the Miocene, long-lived, hard-water Lake Sinj (Dinaride Lake System, SE Croatia)

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Lake Sinj formed in a 342 km^2 large, rhomboidal, NW-SE elongated pull-apart basin. The basin was initiated in the Early Miocene, following the traspressional wrenching of the External Dinarides due to northward oblique-slip motions of the under-thrusting Adriatic block. Its sedimentary infill comprises exclusively lacustrine deposits and attains an average thickness of about 370 m. The basin formed in a karst environment. Whereas the pre-Neogene basement is dominated by Mesozoic platform carbonates along the basin margins, extensive Permian evaporite deposits with a direct sedimentary contact with the basal lake sediments occur beneath the basin. Doming of those evaporites decreased subsidence rates within the basin. The presence of steep hinterland topography is pinpointed by massive breccia intercalations into marginal lake deposits. The lake sedimentation is dominated by authigenic carbonates; the siliciclastic input is minor to absent. The basal and the uppermost beds include coal seam intercalations, whereas the middle part of the infill shows exclusively carbonate rocks intercalated occasionally by volcanic ash layers. The section investigated in detail is

about 140 m thick and provides insight into the upper coal bearing part of the infill and its transition into the central part.

The paleoenvironmental analysis combining sedimentology, microfacies analysis, coal petrology and paleoecology of molluscs and plant remains, inferred a variety of environments including (1) littoral below the fair weather wave base, (2) littoral above the fair weather wave base, (3) infralittoral with vegetated areas dominated by aquatic, perennial plants, (4) low supralittoral to upper infralittoral with starfruit meadows, (5) areas covered by cyanobacterial mats, (6) carbonate marshes, (7) peripheral swamps, (8) stream catchments areas and low-lying mires, which were (9) more or (10) less frequently flooded. The latter environment was inhabited by large land mammals related to elephants and rhinoceroses.

Two depositional systems with several cyclic changes were traced, both of them related to a shallow water marginal environment. The first one resulted from deposition within rather stable littoral conditions. It was characterized by relatively uniform sedimentation of bedded limestones. That depositional phase was accompanied by conspicuous accumulations of starfruits (*Damasonium*), but otherwise a remarkable low biotic diversity. The fossil-poor intervals were interpreted as phases of repetitive lake acidification due to periodical flooding of marginally established starfruit meadows during the lake high stands. That induced the input of H^+ ions from aerated limy mud into the water column of the lake. The catastrophic influence of repetitive chemical disturbance hindered the evolutionary progress of the ecosystem. The second depositional system type differs from the previous one by a slight decrease in lake level. Consequently, the shallower environment was more prone to lake level fluctuations. The changing conditions resulted in alternating limestones and coal seams. That alternation was triggered by a short-term, orbitally forced cyclic fluctuation of humid and dry periods. That phase, characterized by stable hard-water lake conditions, witnessed a spectacular diversification of the ecosystem followed by a significant morphospace increase in melanopsid and hydrobiid snails.

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