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289 Million year old terrestrial vertebrate community revealed

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The Dolese Brothers Limestone Quarry, near Richards Spur, Oklahoma, USA, preserves an Early Permian (298 million years old) infill in a series of Ordovician limestone and dolostone karst fissures. Speleothems intimately associated with the site indicate that Richards Spur is a cave system, suggesting a unique preservational environment for vertebrates, one that is distinct from those of more typical Early Permian lowland deltaic/fluvial localities. The locality is unique in the preservation of exclusively terrestrial vertebrates, with the vast majority of fossil material found at this site during the last 8 decades of excavations being completely disarticulated. However, recent collecting activities have yielded articulated material, indicating that many of these recently discovered animals were likely washed in before being disarticulated or probably fell into the caves during monsoonal rains. The fossil materials are also unique preservationally because they have been impregnated with hydrocarbons derived from the underlying Woodford oils of Oklahoma. Fossilization has resulted in dark colored skeletal elements preserved in gray clays and limestones, making them easily recognizable, but the process likely occurred under conditions that facilitated the formation of abundant pyrite around and inside the bones. This unique combination makes the fossils from this vast cave system difficult to image using x-ray, but ideally suited for imaging using the quasi-parallel collimated bean of neutrons, as provided by the OPAL reactor at ANSTO. The superior image quality provided by this method has provided unprecedented access to the detailed anatomy and structure of both unprepared fossil materials, and to the internal anatomy of numerous new or little-known taxa from this locality, the richest and taxonomically most diverse assemblage of terrestrial vertebrates for the Paleozoic Era. The fossil materials examined using the DINGO facility include several small and medium sized amphibians, a stem amniote, several eureptiles and parareptiles, and a synapsid. The anatomical details of the skulls of these terrestrial vertebrates provided by neutron computed tomography have opened up new avenues for the study of the conquest of land by amniotes, the distant ancestors of living reptiles, birds and mammals, and by the amphibians that also were apparently able to compete with them for a relatively short time, 300-270 million years ago, during the Early Permian. Most significantly, the internal braincase anatomy revealed by this method is allowing us to examine in detail the evolutionary changes in the brain and some of the sense organs housed in the cranium across major transitions, from amphibians to amniotes, and through the dichotomy of amniotes into the reptilian and mammalian neural and sensory systems.

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