X-ray microtomography reveals secrets about the Late Devonian vertebrates of Siberia

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It was 375 million years ago, it was the Late Devonian, it was the 'Age of Fishes'. The living world was still mostly aquatic, but the first forests were being established, terrestrial arthropods began diversifying, and our ancestors, the lobe-finned fishes, were starting to evolve limbs and to drag themselves out of the water. The tetrapods were born, giving rise to all modern land vertebrates.

There were three continents. Gondwana was the largest, and comprised the present-day South America, Africa, Arabia, India, Australia, and Antarctica. Euramerica (the name gives it away) consisted of modern Europe and North America. And to the north lay a smaller, poorly known continent: Siberia.

It is perhaps not surprising that we know so little about Siberia, which has over time become this huge and yet remote region of the Russian Federation. But a few years ago, Per Ahlberg from Uppsala University, together with some Russian colleagues, collected some promising vertebrate fossils from a village called Ivanovka, on the Uryup River in the Kuznetsk Basin region of Siberia. They immediately recognized the value of the material: not only could it give a new picture of the Late Devonian fauna of the continent, it could also provide a better understanding of the transition between aquatic fishes and terrestrial vertebrates.

There was a catch, however. The fossils were numerous, but they formed a 'bone bed', that is, a mess of disarticulated bones, jumbled and packed together. The animals living in the ancient lake had suffered a mass-death event, and then their bones had been disturbed before being buried. This bone bed could hardly be prepared with traditional tools, because isolating one bone would most likely damage the others around it. Fortunately, a solution presented itself—x-ray synchrotron microtomography.

'Tomography' means imaging the internal structure of an object by scanning it (with x-rays, for instance) rather than destroying it. A medical scanner does exactly that. At the European Synchrotron Radiation Facility, in France, the most interesting fossil blocks underwent the more sophisticated technique called 'microtomography'—tomography with resolution up to the level of micrometers, allowing the imaging of precise details. With the resulting 3D images, we could extract the bone structures from the rock through computer modelling, allowing us at last to study the vertebrate fauna of Ivanovka.

What came from it? The most interesting specimens belong to a lobe-finned fish called *Megistolepis*, a transitional form between fishes and tetrapods. This is important, because even though *Megistolepis* has been known since 1955, very little material of it has ever been found and described (not to mention that when it was, it was published in Russian). The Ivanovka material thus contributes greatly to the knowledge of this species. Furthermore, we found several bones belonging to lungfish—fish that breathe air, are close relatives to tetrapods, and still exist today. Sadly, no decidedly tetrapod material was discovered, despite high initial hopes. But only a few blocks were scanned, after all, and it is still possible that some tetrapod remains are waiting for researchers, hidden within the 375 million years old claystone of Siberia.

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