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Pennsylvanian emergence of anabranching fluvial deposits: the parallel rise of arborescent vegetation and fixed-channel floodplains

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Recent research into Palaeozoic fluvial deposits has shed new light on the ways in which ancient river systems were physically transformed by the expansion of embryophytes from the Cambrian through to Devonian. Extensive literature reviews and field studies show that the greening of the continents progressively increased retention of mud in terrestrial environments, stabilised floodplains (e.g., by roots), and promoted single-channel (meandering) fluvial deposits, which are prominent from the Siluro-Devonian onwards. By the end of the Devonian, a broad spectrum of vegetation-dependent fluvial styles had developed, which persist to the present day. However, in the course of original fieldwork and a comprehensive literature review of 144 Cambrian-Devonian fluvial successions, it was observed that no strata had been interpreted as anabranching river deposits.

Anabranching (anastomosing) rivers are low-energy fluvial systems consisting of multiple channels separated by stable islands, which evolve over time through avulsion. Such river systems host a variety of terrestrial sub-environments and habitats that have been relatively common during the Mesozoic and Cenozoic and into the present day. Anabranching requires bank stability, usually provided by vegetation or cohesive floodplain muds, both of which were prominent in the fluvial realm by the Siluro-Devonian. However, based on a literature review of 188 Carboniferous successions, facies interpreted as anabranching river deposits do not appear until the Pennsylvanian (Bashkirian).

Original field data from Carboniferous fluvial strata in Atlantic Canada and the SW USA support the assertion that a distinct suite of fluvial facies and sandbody geometries, still apparent in recent anabranching fluvial deposits, makes its first appearance at about this time. The channel deposits are narrow (width:thickness typically <15) with steep margins and aggradational fills, with little evidence for lateral accretion, and encased in floodplain muds with palaeosols. Although it is rarely possible to demonstrate that the parent channels formed 3D networks, it is probable that some suites were anabranching. Although a few small, narrow channel bodies are known from Devonian and Mississippian formations, this “fixed-channel” style is conspicuously absent from older fluvial formations but is widespread from the Pennsylvanian onwards.

It is argued that the seemingly delayed appearance of this fluvial style in part reflects the infrequency of repeated short-term triggers for avulsion prior to a threshold-crossing increase in arborescent floodplain vegetation. The increase in arborescent vegetation through the Carboniferous would have resulted in an increase in the size, abundance and distribution of large woody debris in fluvial channels. Such debris would have provided, for the first time, one of the most common triggers for river avulsion: as demonstrated by the fact that large log-jam deposits also first appear in the rock record during the Bashkirian.

The first appearance of the fixed-channel style and, probably, of anabranching systems, during the Pennsylvanian thus marks one of the final major developments in the vegetation-dependent biogeomorphology of fluvial systems. The persistence of such features to the present day re-iterates that the greening of the continents was arguably the most significant event to have influenced the Phanerozoic evolution of terrestrial landscapes and habitats.