



## **Multi-proxy provenance analysis of the hydrocarbon-bearing upper Roper Group, Beetaloo Sub-basin, Northern Territory, Australia**

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The subsurface Beetaloo Sub-basin of the McArthur Basin, Northern Territory, Australia, comprises a succession of shallow-water, dominantly marine, clastic sedimentary rocks that form the main depocentre of the Mesoproterozoic Roper Group; the volumetrically largest part of the 1000 km-scale outcropping Wilton package. Shale formations in the Roper Group form the world's oldest potential unconventional gas play and is of considerable economic interest for unconventional petroleum.

LA-ICP-MS detrital zircon U–Pb age data presented in this research illustrate that the Roper Group extends to younger ages than previously identification. The newly-recognised sandstone-rich basin, recently named Balmain Group, unconformably overlying the upper Roper Group, was deposited after  $959 \pm 18$  Ma. Whereas the minimum depositional age of upper Roper Group was re-constrained by new TIMS baddeleyite U–Pb age ( $1312.9 \pm 0.7$  Ma) obtained from the dolerite intrusion (Derim Derim Dolerite).

Coupled detrital zircon U–Pb age and Hf isotope data suggest the upper Roper Group was mainly sourced from the south (Arunta Region) and southeast (Mount Isa Province), and significant temporal variation existed within the upper Roper Group. The first provenance changing event happened at ca. 1400 Ma due to rifting between Laurentia and the Northern Australian Craton. The second event is interpreted to have been caused by the exhumation of the southern and southeastern margins of the North Australia Craton during the amalgamation of NAC&SAC and WAC, resulting in uplifting of the Arunta Region. The Neoproterozoic Balmain Group mainly sourced from the Musgrave Province in the far south. This provenance shift happened after the amalgamation of the Australian part of the supercontinent Rodinia, which lead to the late Mesoproterozoic to Tonian exhumation of the Musgrave Province.

Whole-rock geochemistry data reveal that most of the Neoproterozoic Balmain Group was deposited in a suboxic environment, whereas the Kyalla Formation (top formation of the Roper Group) deposited in an anoxic environment with TOC (total organic carbon) enrichment at the top of this formation. Whole-rock Sm–Nd isotope data suggest that this TOC enriched section had sourced from a relatively juvenile provenance. Juvenile rocks (e.g. basalt) usually contain higher P contents which is the limit nutrient for bacteria photosynthesis. So the weathering of this type of rock would deliver significant nutrients to the basin, therefore, resulting a high primary productivity, as recorded by the higher TOC concentration in the top of Kyalla Formation. We suggest that this juvenile influx may be related to the Derim Derim mafic event. The mafic intrusion intruded the Roper Group at about 1313 Ma, and the related mafic volcanic rocks sourced the basin at the same time.