

Re-Os Systematics of the Proterozoic Velkerri and Wollgorang Black Shales, McArthur Basin, Northern Australia

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Black shales of the unmetamorphosed Wollgorang (Tawallah Group) and Velkerri (Roper Group) Formations have been the focus of recent geochemical studies regarding the nature and extent of Proterozoic deep ocean anoxia. The Velkerri Formation also contains three mature (oil-producing) organic-rich shales (TOC > 5%) that represent the source of prokaryotic cyanobacterial-rich and eukaryotic-poor biomarkers, bitumens and fluid inclusion – hosted oils in the stratigraphically underlying Bessie Creek Sandstone and ca. 1280 Ma dolerite sills. However, the age of the Velkerri Formation remains poorly constrained, with current estimates of ~ 1430 Ma based on a U-Pb SHRIMP zircon age of 1492 ± 4 Ma (from tuff in the Mainoru Formation over 700 m stratigraphically beneath the Velkerri Formation) and an Rb-Sr illite age of 1429 ± 31 Ma (from the stratigraphically overlying McMinn Formation). Here, we present two new Model 1 Re-Os dates of 1361 ± 21 Ma (2σ ; $n=14$; MSWD = 1.3) and 1417 ± 29 Ma (2σ ; $n=12$; MSWD = 1.3) that directly constrain the depositional age of the uppermost and lowermost (containing live oil) organic-rich intervals of the Velkerri Formation, respectively, in drillhole Urapunga 4 (136.9-137.9 m and 325.5-326.7 m). The new Re-Os ages are consistent with the ca. 1492 Ma U-Pb age from the Mainoru Formation, suggesting the Re-Os systematics of the Velkerri shales were not disturbed by hydrocarbon maturation and migration over > 1 Ga.

We have also examined the Re-Os systematics of the ~ 20 m black shale unit in the lower Wollgorang Formation - its age is well-constrained by two U-Pb SHRIMP zircon dates of 1729 ± 4 Ma and 1730 ± 3 Ma from tuff beds within the middle part of the black shale in drillhole Mt. Young 2. However, Re-Os isotope data from a ~ 3 m black shale interval (74-77 m) several meters stratigraphically beneath the dated tuff beds in the same drillhole show complex Re-Os systematics and do not yield a Re-Os isochron age. The degree of deviation from a ~ 1740 Ma isochron increases adjacent to small carbonate-rich veinlets, suggesting that post-depositional mobilization of Re and Os from the Wollgorang shales occurred as a result of hydrothermal fluid migration. This fluid flow may be associated with formation of the ca. 1640 Ma McArthur River Pb-Zn-Ag deposit, consistent with an overprinted paleomagnetic pole in the Wollgorang Formation also associated with formation of this deposit.