

Deducing temporal information from mafic volcanic rocks in the context of an offshore hydrocarbon system

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Fine-grained mafic volcanic rocks are notoriously difficult to date. In this work, we apply a U–Pb and (U–Th)/He double-dating approach to zircon and apatite grains extracted from basaltic lithologies in the Roebuck Basin, North West Shelf, Australia. While Triassic sedimentary successions that host hydrocarbons are relatively well understood from a sedimentological perspective, little is known about the underlying volcanic sequences, although they could play a crucial role in the thermal evolution of the basin. Zircon and apatite U–Pb geochronology and (U–Th)/He thermochronology was conducted on seven drill core samples from three wells that all reached their maximum depth beneath the Triassic section. Petrographic observations, Archean apatite U–Pb age components, and one 3052 ± 33 Ma zircon U–Pb age reveal that samples from the Poissonnier-1 well belong to (meta)volcanic units from the offshore extension of the Pilbara Craton. Apatite from the Bedout-1 well yields a well-defined Permian U–Pb age (274 ± 17 Ma), confirming the relative age and stratigraphic position of the extensive Bedout Volcanics as basin fills. Volcanic rocks from the Apus-1 well are correlatable to Bedout-1 on seismic images and hence expected to also be Permian in age. Apatite U–Pb results from Apus-1 yield a less well-defined linear regression intercept age of 526 ± 36 Ma, hinting at inherited apatite components, possibly derived as multi-cycle detritus from underlying Permian sedimentary successions. The (U–Th)/He analyses on the same grains complemented with thermal history modelling provide constraints on the low-temperature thermal history of the rocks and point to a very recent thermal pulse with heating to the apatite He partial retention zone (40–90 °C) during the Quaternary. This temperature increase is implied from all cores and represents a possible link to dynamic topography effects in the area with a potential heat source to the northeast, which could indicate the investigated rocks thermally shielded the hydrocarbon system. Overall, this work illustrates how useful geochronological and thermochronological information can be deduced from mafic volcanic rocks and placed in a geological context.