An 80 million year redox history from Panthalassa: Japanese deep-sea records

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The accreted terranes of Japan provide the best evidence of abyssal conditions from the long-subducted Panthalassa ocean. The interval from the Permian to the Jurassic coincides with the zenith of this 'super-ocean' when red, radiolarian cherts were the dominant depositional style. These record persistently well-oxygenated depositional conditions, but they were punctuated by oxygen-poor phases, notably during end-Permian and Early Jurassic extinction crises when organic-rich shales are encountered. Framboid size assay of these anoxic events shows that Panthalassa only became truly euxinic at the initiation of these black shale events whilst bottom water anoxia/dysoxia was prevalent during most of their depositional history. In detail, the link between euxinia and organic enrichment is not clear cut. Euxinic conditions are recorded within siliceous facies immediately below black shales that record dysoxic conditions Two other extinctions, within the Middle Permian and at the end of the Triassic, are not associated with a decline in seafloor oxygenation although radiolarian productivity shows does decrease at these times.

A purported 'superanoxic event' – 20 million years of anoxic oceanic conditions stretching from the Middle Permian to the Middle Triassic – is not clearly manifest, especially in the Late Permian when normally oxygenated conditions were developed. The Early Triassic was an interval of generally lower seafloor oxygenation with notable peaks of anoxia at the Permian/Triassic boundary and in the later part of the early Triassic (Spathian Stage). The redox history of Panthalassa is more complex than previously recognised with relatively brief periods of anoxia punctuating a generally well-oxygenated ocean.

Retrograde history of eastern Dabieshan revealed by $^{40}Ar/^{39}Ar$ laser incremental heating, ablation and stepwise crushing

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Laser stepheating can be used to obtain cooling histories from single grains and small separates of minerals. Spot ablation can be used to resolve age information for small amounts of sample when high spatial resolution is required. Stepwise crushing of minerals may reveal the age of saline (K-bearing) fluids hosted in fluid inclusions. Here we apply this integrated approach to examples from Dabieshan, China.

The Zhujiachong eclogite, located in the southeast of Dabieshan, is now recornized as part of the ultra-high pressure (UHP) domain [1]. New $^{40}Ar/^{39}Ar$ apparent ages indicate that UHP phengite may have formed as early as ca 265 Ma whereas ages associated with amphibolite facies retrogression range from 242 Ma to 217 Ma, and late veining in the greenschist facies caused the formation of coarse paragonite with ages in the range 217 Ma - 200 Ma, with the latter age also found for fluid inclusions in late actinolite by stepwise crushing.

The stepwise crushing technique is a powerful approach that complements the spot ablation and incremental heating techniques as it allows the separation of argon originating from different reservoirs not easily accessible by ablation or incremental heating: an excess ^{40}Ar component is released during the early stages of crushing, and a distinct more radiogenic component in the later stages of crushing. Once the fluid hosted argon component is depleted after continued crushing, the remaining powder can be analyzed by stepwise heating which will liberate an argon component that is hosted in the solid phase. In the case of eastern Dabieshan, late quartz veins cross cutting the metamorphic fabric in various locations yielded ages of ca 200 Ma and 100 Ma, which is consistent with slow cooling of the crust following the Triassic events.

[1] Li *et al.* (2004) *Contrib. Mineral. Petrol.* **148**, 443-470.