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Forensic zirconology on Mesoproterozoic sediments sheds light on the subduction-collision history at the eastern active continental margin of the Archaean Kalahari-Grunehogna Craton

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The Grunehogna Craton (GC, East Antarctica) was a part of the Archean Kalahari Craton of southern Africa prior to Gondwana breakup. Granite from the basement of the GC has been dated by U-Pb zircon dating to 3,067 Ma with inherited grains showing ages of up to 3,433 Ma [1].

At the eastern margin of the craton, the Ahlmannryggen nunataks comprise an ∼2000 m thick pile of clastic and volcanic sediments of the Ritscherflya Supergroup. These were sourced from eroding an active volcanic arc. The relatively immature nature of many members of the sediment sequence (greywackes, conglomerates) point to a proximal source of that arc, and the intercalation of the clastic sediments with volcaniclastic materials and andesitic lava flows strongly support this interpretation. No agreement, however, exists on the polarity of subduction, nor on the nature and location of the arc. Contrasting models suggest inboard subduction with an active continental margin [e.g., 2], or outboard subduction and accretion of Mesoproterozoic island arcs to the craton by post-subduction collision [e.g., 3].

In this study, we investigated internal zonation, U-Pb ages and Hf isotopes of detrital zircon grains from all units in the Ritscherflya Supergroup to characterise the crustal sources from which these sediments were derived. Our results show an age distribution with a dominant age peak at 1,110 to 1,170 Ma, i.e. close to the sedimentation age. Older age peaks in the Ritscherflya sediment zircons include those at 1350 Ma, 1750 Ma, 1880 Ma, 2040 Ma, 2700 Ma and 2800 Ma. Palaeo- and Mesoarchaean zircon grains (2800–3500 Ma) were also discovered, corresponding to the age of the Kalahari-Grunehogna Craton basement, but these comprise less than 2 % of the dateable detrital population. Most significantly we found a number of inherited Archaean cores in ∼1130 Ma zircons.

The age spectrum of the zircons bears strong evidence for (i) derivation of the entire Ritscherflya sediment sequence from an active volcanic zone, as the highly dominant age peak in the population histogram coincides with the deposition age of the sediments; (ii) a cratonic provenance of part of the sediments from population peaks coinciding with major tectono-thermal events in the Kalahari Craton; (iii) at least some of the active volcanism being located on cratonic basement rather than a juvenile island arc, as clearly demonstrated by Paleoproterozoic and Archean cores in ∼1130 Ma zircons.

Detrital zircons in the dominant age group at ∼1130 Ma show several contrasting populations in their Hf isotopic compositions. The clearly dominant group shows negative εHf values of -11.5 corresponding to a model age (TDM) of ∼2700 Ma (average crustal 176Lu/177Hf = 0.015). A smaller group shows εHf values of approximately +2.5, corresponding to model ages of ∼1750 Ma. The lowest εHf group with approximately -21 corresponds to Mesoarchaean model ages.

Hence, the Ritscherflya sediments were not sourced from a homogeneous volcanic centre. Instead, contemporaneous volcanic activity hosted by several continental blocks with contrasting crustal ages delivered material into the sediment basin. We conclude that the proposed active margin hosted volcanism on old cratonic sections (inboard subduction), but also on ∼1750 Ma crust. The latter unit may be the accreted Proterozoic island arcs of [3].

References

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