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Autochthonous or Allocthonous Inception of the Macquarie Arc along Eastern Gondwana? Evidence from Zircon U/Pb and Hf Isotope Data

Zhang, Q., Buckman, S.*, Nutman, A.P.

University of Wollongong, NSW 2522, Australia. Corresponding author: solomon@uow.edu.au

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The Ordovician Macquarie Arc within the Lachlan Orogen of Eastern Australia displays all the geological characteristics of an intra-oceanic island arc. Many studies have focused on the evolution of the arc due to its metallogenic importance in hosting numerous porphyry Cu/Au deposits. However, no consensus has been established regarding its tectonic evolution and emplacement. Some models [1, 2] concentrate on the widespread distribution of Gondwana-derived mega-fans, but that does not explain the lack of intermingling between arc and Gondwana-derived sediments. Alternatively, the current "consensus" model centres on continuous, west dipping subduction associated with a retreating accretionary orogeny [3, 4], with the Macquarie arc representing an autochthonous marginal back arc to island arc system. The third more recent model [5] involves the development of an allocthonous, exotic island arc within the Panthalassa Ocean via east dipping subduction before being obducted and accreted onto the passive margin of eastern Gondwana followed by subduction flip and continental arc volcanism. A key question, to validate or refute any model, is to ask when, where and why did the Macquarie Arc initiate? Our study is using zircon U-Pb dating and Hf data to constrain better the early evolution of the Macquarie Arc.

Most researchers divide the evolution of the Macquarie Arc into four magmatic phases that span the whole Ordovician and extend into the early Silurian. From zircon geochronology, Glen et al. [6] showed that the Macquarie Arc developed with little or no Gondwana influence since Phase 2. Phase 1 volcaniclastic rocks show Gondwana inheritance (445-3400 Ma) but their depositional ages and geological relationships with other units assigned to the Macquarie Arc are unclear. We aim to constrain better the age and provenance of Phase 1 and Phase 2 units. We have established the age of Weemalla Formation and host of the Cadia Cu-Au porphyry (444 Ma) to be 454 Ma and therefore Phase 3. The Triangle Formation sits structurally above the Adaminaby Group and is thought to represent Phase 1 sedimentation in the Macquarie Arc but our zircon data reveal a youngest population of 456-460 Ma, which corresponds to Phase 2, and strong Gondwana inheritance between 1000-3500 Ma. Supposed Phase 1 units continue to give spurious ages. Perkins et al. [7] obtained a zircon age of 438.5 Ma (Phase 4) from Nelungaloo volcanics which is the only age dated by ion microprobe. Crawford et al. [8] obtained some true Phase 1 ages of 480 Ma from Nelungaloo andesite and basalt by Sm-Nd with positive initial εNd of +7.33 to 7.48. Glen et al. [8] obtained a very unusual youngest age population of 402-455 Ma from Yarrimbah Formation by U/Pb dating suggesting a maximum depositional age of Devonian. Therefore, we postulate that "Phase 1" may actually represent the last stage (Phase 4) of Macquarie Arc evolution when sediment from both the arc and Gondwana were mixing in the trench that lay between the two disparate tectonic entities before final collision in the earliest Silurian resulting in the Benambran Orogeny. Testing this hypothesis will require detailed sandstone and zircon provenance studies of Phase 1 and Phase 2 units and will result in more accurate tectonostratigraphy that will lead to a better understanding of the inception and accretion of the Macquarie Arc.

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