

Spatial Distribution Patterns in Lead Isotopes from the Lachlan and Delamerian Orogens: Implications for Tectonics, Metallogenesis, and Mineral Exploration in Southeast Australia

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Compilation of new and existing data can be used to show systematic variations in initial ore-related Pb isotope ratios and derived parameters for the Lachlan and Delamerian orogens of southeast Australia. In addition to mapping tectonic boundaries and providing genetic context to mineralizing processes, these variations map mineralized provinces at the orogenic scale and can provide vectors to ore at the district scale.

In New South Wales and Victoria, mapping using a parameter termed the “Lachlan Lead Index” (LLI), which measures relative mixing between crustal- and mantle-derived Pb using the curves of Carr et al. clearly demarcates the boundary between the Eastern and Central Lachlan provinces, and seems to identify boundaries between zones within the Western Lachlan Province of Victoria. The LLI also maps the extent of the isotopically juvenile Macquarie arc in New South Wales. However, rocks in the Rockley-Gulgong belt, initially mapped as part of the Macquarie arc, have a more evolved isotopic character, suggesting that these rocks are not part of the Macquarie arc. This interpretation supports recent mapping that casts doubt on the attribution of this belt to the Macquarie arc. The LLI has also identified small exposures of Ordovician volcanic rocks, well removed from the main Macquarie arc, as possible correlates to this arc, with potential to host porphyry and epithermal deposits.

Metallogenically, porphyry Cu-Au deposits in the Macquarie arc are characterized by juvenile Pb. In contrast, Sn and Mo deposits in the Central Lachlan Province (i.e., the Wagga tin belt) are characterized by highly evolved Pb even though these deposits formed over 30 m.y. Moreover, the Pb isotope data suggest that the original interpretation that copper deposits in the Girilambone district are volcanic-associated massive sulfide deposits was correct and that these deposits formed in a back arc to the Macquarie arc at ~480 Ma.

In the Mount Read Volcanics of western Tasmania, all deposits appear to cluster along the same growth curve. However, when divided according to age (i.e., Cambrian ~500 Ma, versus Devonian ~360 Ma), spatial patterns are visible in $^{206}\text{Pb}/^{204}\text{Pb}$ data. For Cambrian deposits, $^{206}\text{Pb}/^{204}\text{Pb}$ decreases overall to the southeast, although low values are also present in the far south (i.e., Elliott Bay) and northeast. The most highly mineralized central part of the belt seems to be broadly associated with the zone of highest $^{206}\text{Pb}/^{204}\text{Pb}$.

Variations in $^{206}\text{Pb}/^{204}\text{Pb}$ for Devonian deposits broadly mimic the patterns seen for the Cambrian deposits. More importantly, a district-scale pattern in $^{206}\text{Pb}/^{204}\text{Pb}$ is present in the Zeehan district. Isotopically, the Sn-dominated core of the Zeehan district (e.g., Queen Hill and Severn deposits) is characterized by high $^{206}\text{Pb}/^{204}\text{Pb}$, which decreases outward into the Zn-Pb-Ag-dominated peripheries. Lead isotope distribution patterns can potentially be used as an ore vector in this and other intrusion-centered mineral systems.