Paper 11: Distribution of Metals

"Major peaks in the abundance of metal deposits that formed, or were preserved in convergent-margin orogenic belts in the Late Archaean and metal deposits associated with either anorogenic magmatism or continental sedimentation in the Proterozoic are difficult to reconcile with the idea that Plate Tectonic processes have operated since the Late Archaean." Barley and Groves (1992).

The global distribution of a selection of metals outlined in this paper is based on the USGS Mineral Resource Data Set (MRDS) 2015 which lists the locations of metallic and non-metallic mineral resources throughout the world. Most commodities are listed as metal associations, e.g. gold-copper-silver-molybdenum, where, in this example, gold is the dominant commodity. It should be noted that, because the MRDS is a USGS data set, there is a strong bias in the presence and distribution of metals in the Americas as compared with data from the rest of the world.

The MRDS data represent locational data and are not age dated. In order to model this data over time on small Earth models, the data are modelled only for the present-day, Permian, and Cambrian models. This modelling reflects metal distributions and associations persisting at the end of the Precambrian—shown on the Cambrian model, just prior to the end-Permian supercontinental breakup—shown on the Permian model, and where these same metals are located today—shown on the Pliocene/present-day model. Because there is no age dating, the plotted data represent either where the particular metals were located on each of the small Earth models, or where they reside within the crust or mantle prior to formation and preservation as mineral deposits. This plotting then reflects where the particular metal originated from; that is, the location of its original mantle or crustal source. Deposits within continental Greenland and Antarctica beneath present-day ice-sheets are unknown and not shown.

A number of distinct metallogenic provinces are highlighted within the plotted data whereby provinces from adjoining continents or tectonic regimes coincide, extending across present-day geographical boundaries. Many of these provinces are now separated by sedimentary basins or large oceans during post-Permian continental breakup and dispersal.

Examples of metallogenic provinces on small Earth models include:

- The western North American Proterozoic gold (e.g. Homestake mine) and base metal (e.g. Sullivan mine) province located adjacent to the north Australian Proterozoic uranium-gold (e.g. Rum Jungle and Kakadu mines) and base metal (e.g. McArthur River and Mt Isa mines) provinces. Each of these metal deposits are sediment hosted and together form part of a distinct ancient sedimentary basin located between the South American Guyana Craton and Canadian Superior Provinces (Figures 1 and 2).

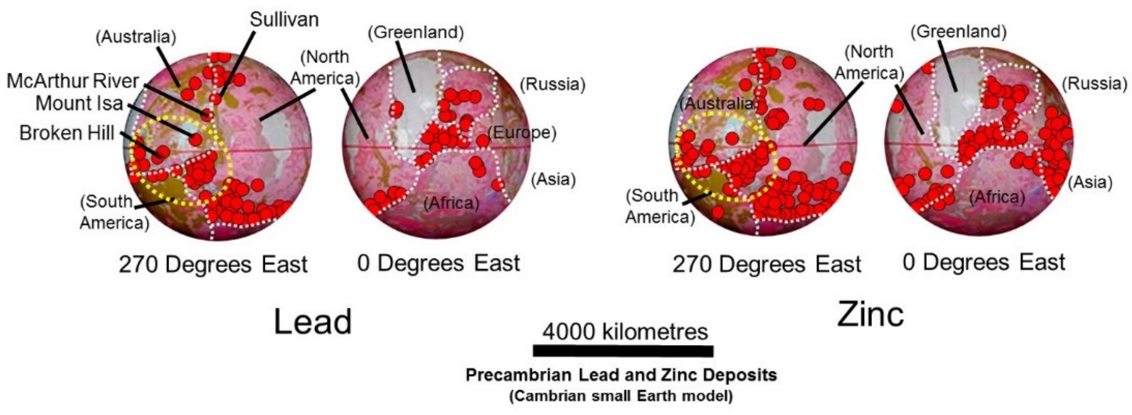

Figure 1 Distribution of lead and zinc plotted on the Cambrian small Earth model. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Lead and zinc metallogenic province is highlighted by dashed yellow shape.

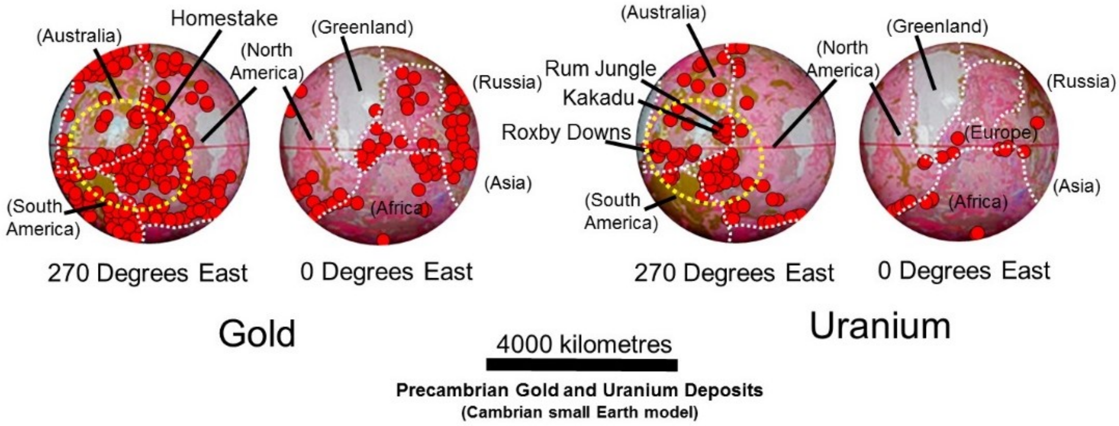

Figure 2 Distribution of gold and uranium plotted on the Cambrian small Earth model. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Gold and uranium metallogenic province is highlighted by dashed yellow shape.

- The Proterozoic sedimentary banded iron formations of the Hamersley Basin, Western Australia, are located adjacent to Archaean to Proterozoic high-grade metamorphic and sedimentary iron deposits in northern China and south-eastern Russia (Figure 3).

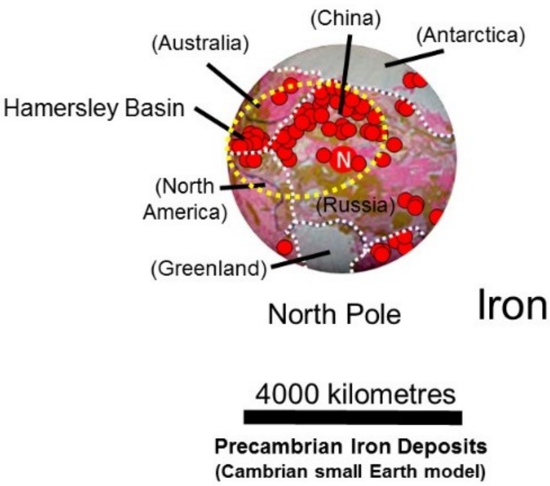

Figure 3 Distribution of iron plotted on the Cambrian small Earth model. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Iron metallogenic province is highlighted by dashed yellow shape.

- Palaeozoic granite-associated tin deposits in southern Asia and China coincide with the assembled continental margins of East Antarctica and Australia and are located adjacent to Archaean tin-tantalum-tungsten pegmatite deposits in southwest Australia (Greenbushes mine) and the Pilbara Craton (Figure 4).
- Palaeozoic tin deposits in Tasmania and Eastern Australia are located adjacent to the Palaeozoic Bolivian tin deposits in South America (Figure 4).

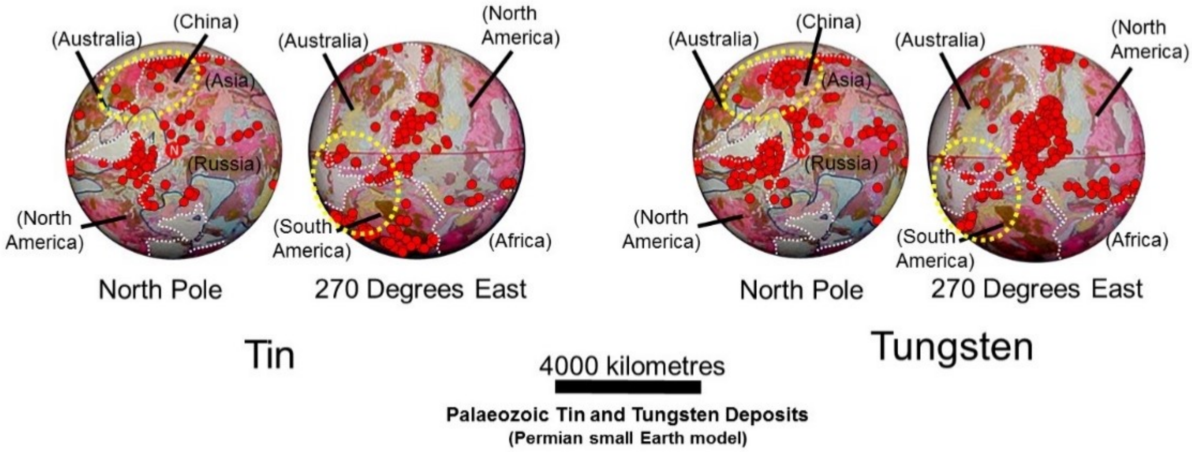

Figure 4 Distribution of tin and tungsten plotted on the Permian small Earth model. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Tin and tungsten metallogenic province is highlighted by dashed yellow shape.

- Host rocks to nickel-cobalt-base metals in Queensland (Greenvale mine) and Central America (Honduras, Salvador and Guatemala) coincide with ophiolite-hosted and lateritic deposits in Cuba and New Caledonia (Figure 5).

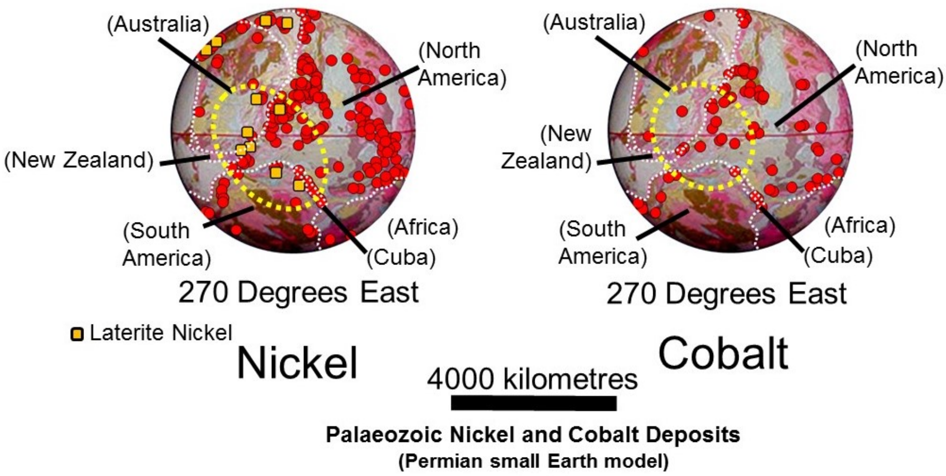

Figure 5 Distribution of nickel and cobalt plotted on the Cambrian small Earth model. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Lateritic nickel deposits are shown as yellow squares. Nickel and cobalt metallogenic province is highlighted by dashed yellow shape.

The Mesozoic and Cenozoic metallogenic distribution on small Earth models highlight the abundance of porphyry-associated metals concentrated within Phanerozoic orogenic belts, in particular the Cordilleran-Andean tectonic belt along the west coasts of the Americas, shaded yellow in Figure 6. The distribution of selected Mesozoic and Cenozoic orogenic-hosted metals is shown plotted on the Permian small Earth model (Figure 6). The Permian model highlights the distinct alignment of Mesozoic and Cenozoic orogenic metals with present plate boundaries prior to breakup of the continental crusts. The orogenic metal deposits shaded in yellow are shown to crosscut pre-existing Precambrian metallogenic provinces prior to complete separation during opening of the Pacific Ocean (Figure 7).

Metals include:

- Porphyry-associated copper, molybdenum, silver, gold. Additional metals include tungsten and tin mineralization shown plotted in Figure 4, which are abundant within Phanerozoic orogenic belts;

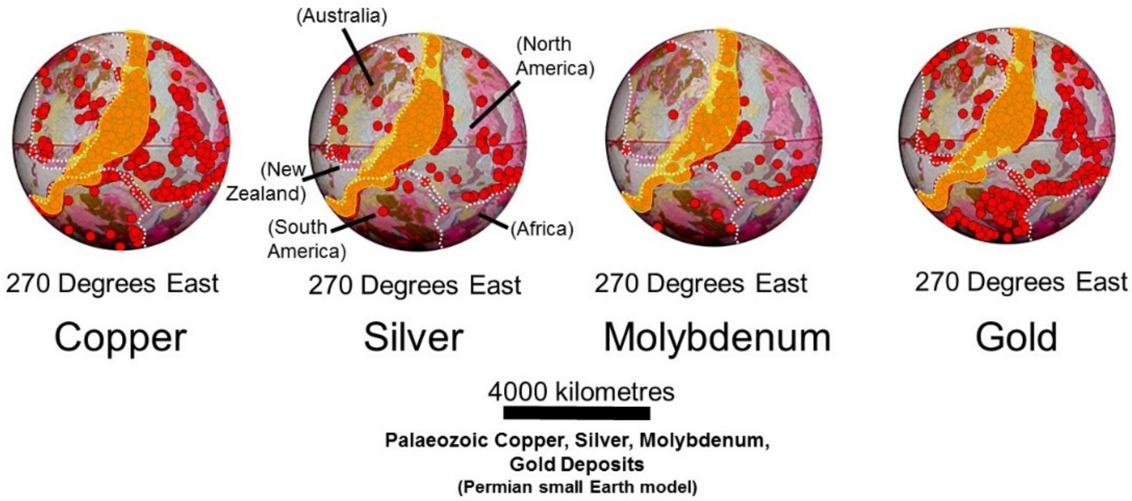

Figure 6 Distribution of orogenic copper, silver, molybdenum, and gold plotted on the Permian small Earth model. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Cross-cutting orogenic plate boundary metal deposits located along the west coasts of the Americas are shaded yellow.

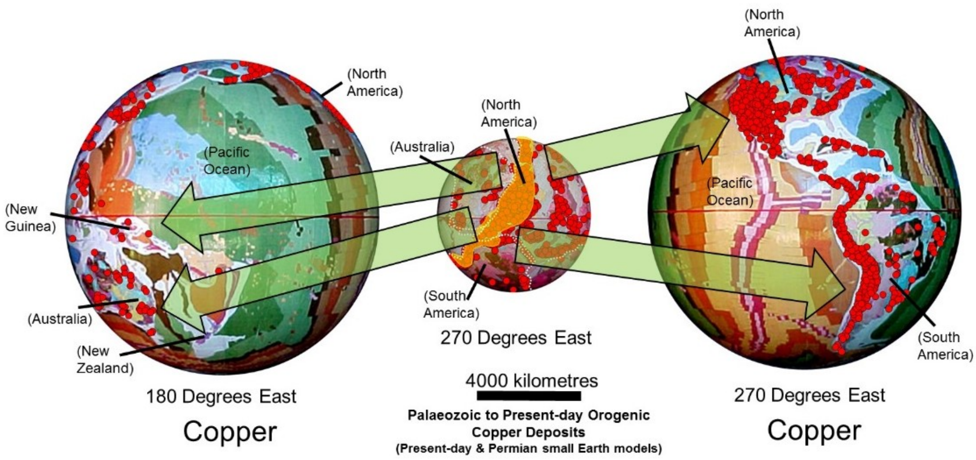

Figure 7 Distribution of orogenic copper in relation to opening of the Pacific Ocean plotted on the Permian and present-day small Earth models. Data are shown as red dots (after USGS Mineral Resource Data Set 2015) in relation to continental crustal assemblages highlighted as dashed white lines. Cross-cutting orogenic metal deposits located along the west coasts of the Americas and east coasts of Australia and New Guinea are shaded yellow prior to opening of the Pacific Ocean.

The plotting of the distribution of minerals and recognition of mineralisation settings on an increasing radius Earth provides a means to investigate the spatial and temporal distribution of metals across adjoining continents and crustal regimes. Recognition and understanding of past metal distributions on the present Earth then potentially enables mineral search and genetic relationships to be extended beyond their known present-day type localities.