PLATE TECTONICS AND THE OCCURRENCE OF ORES

> At its heart, mining is defined by economics, just like any other business. An orebody is nothing more than a mineralized mass that can be mined at a profit. This means that the quantity of ore shrinks and grows in response to market forces. If there is no market, there are no ore bodies.
>
> —Richard E. Gertsch.[1]

Iron, aluminum, copper, and zinc, in that order, are volumetrically the most used metals.[2]

k37 Metallogenic epochs < anorogenic, orogenic, sedimentary >

> The combination of the supercontinent cycle and decreasing heat flow, reflected in the evolution of the lithosphere and tectonic style, gives economic geologists a remarkable framework for understanding the timing and distribution of many of the mineral deposits we have come to rely on.
>
> —Robert Kerrich, 1992.[3]

Geology has a bottom line, and that is kept in the black by discovery and assay of Earth materials. Cyclicity in the circumstances of various types of ore deposition would be a boon if found. Orogenic and mobile belts are where many important ores have been formed and cyclicities have been described by the great synthesizers of geology: Cuvier, de Beaumont, Suess, Umbgrove, Dana, Chamberlin, Kober, and Stille. However, whatever clear regularity was seen by these imaginative fixist (syn. *stabilist*)[4] pattern seekers[5] can only have been for the lack of information. Yet the parameters and constraints that make reasonable the principle of uniformitarianism do elevate from the idle, a contemplation of the motion of continents and the occurrence of ores.

We need to be mindful of the observed size, shape, and thickness of plates, and rates of seafloor spreading and model these (back in time) for the cooling Earth (no blueschists before the Neoproterozoic).[6]

In 1933, Waldemar Lindgren defined a metallogenic epoch as a time interval that was favorable for the deposition of particularly useful substances. Both metallogenic epoch and metalliferous province (space distribution of a mineralization, *see* Topic *k38*) are useful designations.

The time-space distribution of ores has been very episodic (***Figure k37.1***). And the often prospector's claim that the lead, or show , "will continue at depth," plays into quips as Mark Twain's that "a mine is a hole in the ground owed by a liar." [7]

For sedimentary ores, the oxidation state of the environment will have affected dissolution and precipitation. The free oxygen content of the atmosphere that increased to present levels in the early Paleozoic neatly accounts for the dearth of ironformation and unconformity-hosted uranium since the Proterozoic when, also from the fossil evidence of life's evolution, change to an aerobic, from an anaerobic, world took place.

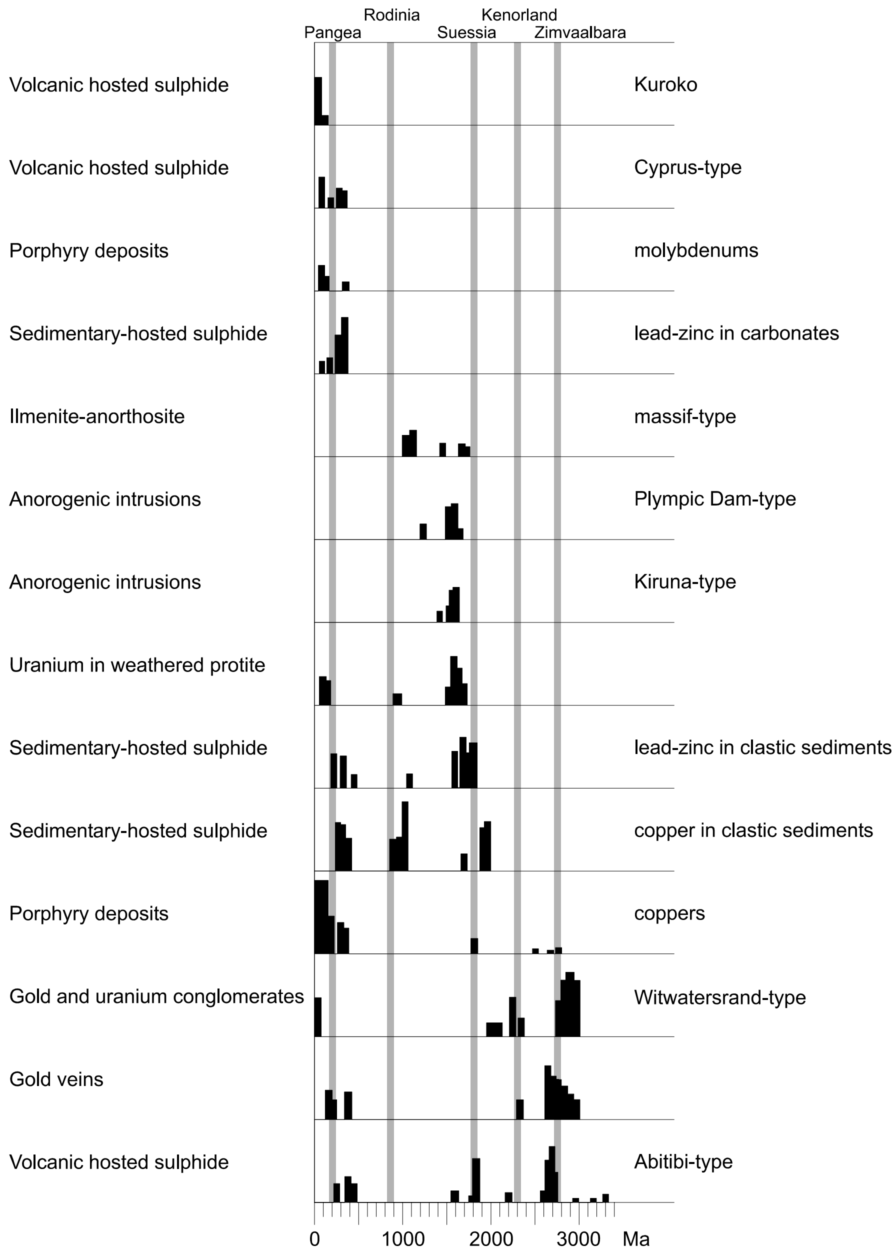
Volcanic-hosted Cu, Pb, Zn deposits of the Kuroko and Cyprus types forming today in shallow marine environments of the island arc depositional complex, are rarely preserved, whereas the Abitibi type deepwater deposits have been.[8]

The scarcity of porphyry Cu and epithermal Au ores before 200 Ma is explained by their low preservation potential (at high elevation) in rapidly eroded magmatic arcs and collisional mountain belts. M. E. Barley and D. I. Groves generalize that initial elevation makes what were peripheral Cordilleran type mountain belts better prospects than internal Himalayan type mountain belts.[9]

Mesothermal gold-silver vein deposits, of all ages have been emplaced by large fluid volumes mobilized through regional faults. Active island arc occurrences and Californian Mother Lode deposits indicate that these, even back to the Late Archean, are at their most abundant at oblique convergent (transpressional) plate margins.

Secular decrease in mantle temperature, by cooling and lessening radioactivity, could account for Kambalda-type komatiite (***Footnote k37.1***) associated nickel deposits being all older than 2000 My. ❏

Figure k37.1 [10]
The timing of specific classes of metal deposits
(black bars indicate found world abundances)



Footnote k37.1

Basalts erupt from magma chambers in which crystal settling can produce residual magmas with the composition of peridotite (>18 % MgO), which later can be found as dikes, sills, and flows of igneous rock called *picrite* that typically, as one described by Andrew C. Kerr from Curaçao, contains subhedral to rounded olivine phenocrysts. With a similar composition, a *komatiite* by contrast is defined by Nick T. Arndt and Euan G. Nisbet in 1982 as possessing "a well-developed spinifex texture" which, Arndt in 1994 continues, is "characterized by large, skeletal, platy, bladed or acicular grains of olivine or pyroxene" implying rapid cooling.[11] Komatiites, which originate as high temperature (~1,700 ºC)[12] mantle melts (not residual magmas), are ultramafic volcanic rocks most of which were erupted in the Archean Era (more than 2.5 Ga, *see* Chapter *L*). Those erupted at later times (for example, the Cretaceous komatiites of Gorgona Island) are rare and these, A. H. Wilson, S. B. Shirey and R. W. Carlson find, "tend to have lower MgO content than their Archaean equivalents. Komatiites [they generalize] are also characterized by their low incompatible-element content, which is most consistent with their generation by high degrees of partial (30-50 percent) melting."[13]