Metallogenic Epochs & Provinces

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Controls of Mineralization

- The localization of economic minerals is controlled by following factors:
    - Structure
    - Stratigraphy
    - Physical and Chemical properties of Host Rocks
    - Relation between Host rock & Associated Rocks
    - Metallogenic Epocs & Provinces
    - Mineral Paragenesis & Zonation
- Scale: Regional or Detailed

- Paragenesis is the association of minerals in rocks and rock suites considered in relation to their origin

- Paragenesis is commonly used informally to mean paragenetic sequence, the sequential order of mineral deposition in an ore deposit.

Metallogenic Epocs & Provinces

- A metallogenic province is a notable concentration of deposits of a certain metal or metals within a large region or belt with one of its dimensions reaching as much as 1000 km or more.
- Note that not all deposits in a province formed at the same time!

- A metallogenic epoch is a period of time during which a significant concentration of deposits of one metal formed in one or more provinces.

Metallogenic Provinces in relation to Plate Tectonic Setting

Interior Basins

1- Placer Gold deposits (e.g. Witwatersand)
2- Unconformity type U deposits (e.g. Athabasca sands).
3- Evaporites (e.g. Zechstein)
4- MVT Pb-Zn deposits in platform carbonates (if in epicontinental basins)
5- Oil and Gas (e.g. Algeria).

Metallogenic Epochs and Provinces

- It has been recognized since a long time that there have been certain periods of time in the geological past during which the deposition of a metal or group of metals was most pronounced; and also that specific regions of the world possess a notable concentration of deposits of one or more metals.

- Mineral deposits are not distributed uniformly through the Earth's crust.

- Specific classes of deposit tend to be concentrated in particular areas or regions called Metallogenic provinces.

- These groupings of deposits occur because deposit-forming processes, such as the emplacement of magma bodies and the formation of sedimentary basins, are themselves controlled by larger processes that shape the face of the Earth.

- The shape and location of such features as continents and oceans, volcanoes, sedimentary basins, and mountain ranges are controlled, either directly or indirectly, through the process of plate tectonics.

Metallogenic Epochs and Provinces

- For example, the distribution of hydrothermal mineral deposits, which form as a result of volcanism, is controlled by plate tectonics because most of the Earth's volcanism occurs along plate margins.

- In addition, porphyry copper deposits are formed as a result of volcanism along a subduction zone (*i.e.*, the zone where one plate descends beneath another); this gives rise to metallogenic provinces parallel to subduction plate edges.

- Evidence indicates that plate tectonics has operated for at least two billion years, so that the locations and features of most metallogenic provinces formed over this period can be explained, at least in part, by this geologic process.

- Factors controlling the distribution of deposits formed more than two billion years ago are still a matter for research, but they too may have been linked to plate tectonics.

Metallogenic Epochs and Provinces

- Metallogenic epochs are units of geologic time during which conditions were particularly favourable for the formation of specific classes of mineral deposit.

- One conspicuous example of a metallogenic epoch is the previously mentioned 700-million-year period, from 2.5 to 1.8 billion years ago, when all of the great Lake Superior-type BIFs were formed.

- Because the iron in these deposits was deposited from seawater (an impossibility today, since the atmosphere is too oxidizing to allow seawater to transport iron), it is probable that a specific composition of the atmosphere and ocean peculiar to that period defined the BIF metallogenic epoch.

- Another great deposit-forming period occurred between about 2.8 and 2.65 billion years ago, when a large number of volcanogenic massive sulfide deposits formed; the probable cause of this metallogenic epoch was a period of extremely active submarine volcanism.

Metallogenic Provinces

Hot spots, rifts and failed rifts (aulacogens)

1- Sn deposits associated with A-type granites
2- PGM and Chromite associated with huge mafic intrusions (e.g. Bushveld)?
3- Carbonatites
4- Fe-Ti oxide deposits associated with anorthosite massifs.
5- Kimberlites?
6- Cu in Red bed type deposits
7- Evaporites
8- Oil & gas (e.g. North Sea).
9- MVT Pb-Zn-fluorite-barite deposits.
10- Native Cu in the Keweenawan basalts.
11- Cu – Fe – Ni deposits (e.g. Duluth and Noril'sk).

Mid-Ocean Ridge settings

1- Cyprus type VMS
2- Alpine type chromite deposits
3- Some evaporites (Red Sea type setting)?
4- Pb – Zn deposits associated with brine pools (Red Sea again!)

Metallogenic Provinces

Passive Continental Margins

1- MVT Pb – Zn deposits
2- Stratiform sandstone hosted Pb-Zn deposits.
3- Sedimentary Mn deposits
4- Banded Fe formations.
5- Beach placer deposits
6- Oil & Gas (provided other conditions attain).

Island Arcs (including back arc basins)

1- VMS deposits (Kuroko type).
2- Porphyry Cu and porphyry Mo deposits
3- Skarn deposits (magnetite).

Volcanic Arcs:

1- Porphyry Cu and porphyry Mo deposits
2- Skarn deposits (magnetite).
3- Base metal lode deposits (Cu – Pb – Zn) and some epithermal deposits (e.g. Ag and Au).
4- Sn deposits related to S-type granites.

Metallogenic Provinces

Collisional belts:

1- Sn & W deposits related to S-type granites.
2- Porphyry Cu and porphyry Mo deposit related to I-type granites
3- Placer deposits

Strike-slip settings:

1- Kaolinite deposits
2- Coal
3- Hypothermal Au deposits
4- Placer deposits
5- Oil & Gas
6- Mississippi Valley type Pb-Zn deposits

Metallogenic Epocs

Archean:

1- Chromite
2- PGM
3- Cu- Fe – Ni
4- Au
5- Some VMS

Proterozoic:

1- Placer Au & U deposits
2- PGM
3- Chromite
4- BIF
5- Fe – Ti oxides with anorthosite massifs.
6- Diamonds in kimberlites?
7- Sediment hosted Cu

Phanerozoic:

1- Phosphorites: Proterozoic – Cambrian boundary
2- Podiform (Alpine type) chromite
3- Coal: Carboniferous
4- PCD's (Mesozoic)
5- Residual (Cretaceous – Recent).

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Chief Metallogenic Epochs & Province in India

There are three epochs in India, they are:
1. Precambrian
2. Late Palaeozoic
3. Late Mesozoic to Early Tertiary

The important Metallogenic provinces in India are:
1. Gold province of Karnataka-Andhra Pradesh-Tamil Nadu (Hutti-Kolar-Anantpur-Gadag-Wynad Gold Province)
2. Copper province of Singhbhum
3. Copper province of Khetri-Pur-Banera
4. Lead Zinc province of Hesatu-Belbathan
5. Iron Ore province of Singhbhum-Keonjhar-Sundergarh-Mayurbhanj
6. Iron Ore province of Durg-Bastar-Chanda-Ratnagiri
7. Iron ore province of Karnataka-Goa
8. Manganese province of Balaghat-Bhandara-Nagpur