Metallogenic mineralization vs the granite series in the Mesozoic-Cenozoic Circum-Pacific plutonic belts

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Major metallic mineralizations occur in the form of sulfides, such as molybdenite, chalcopyrite, bornite, sphalerite, galena, argentite, etc. These S-combined metals are brought by oxidized, magnetite-series granitoids, because of predominance of oxidized species sulfur, which takes out metals from the host granitic magmas the vapor phase, then to the granite cusps and the surrounding wall rocks. Gold can be transported and concentrated as bisulfide or chloride complex. The bisulfide Au is concentrated around the oxidized pluton, but the chloride Au may occur with plutons with variety of oxidation status. Identification of oxidized type of granitoids is most fundamental in mineral exploration of important metals in granitic terranes.

The oxidized type of granitoids are most dominant in the East Pacific rim, while the reduced type prevails in the West Pacific rim (Ishihara, 1977). These two types are most easily determined by measurement of magnetic susceptibility. In the largest batholith of the Coast Plutonic complex in Canada, the measurement of L. Carmel on the Jim Roddick collection indicates an average of 14.5 ±11.7 x 10^{-3} SI (n=937) on granitoids of the main Coast Belt and 16.9 ±16.0 x 10^{-3} SI (n=56) on those of the Vancouver Island. Both the values are higher than 3.0 x 10^{-3} SI; thus belonging to the magnetite series. The granitoids are reduced in the katazonal granitoids associated with high-grade gneisses. Calc-alkaline porphyry-type Mo-Cu and alkaline porphyry-type Au-Cu deposits occur mostly related to epizonal oxidized plutons of the Intermontane Belt (Fig. 1).

The Sierra Nevada batholith is also composed of largely oxidized type. Three E-W transects study of magnetic susceptibility passing through north of Bishop by Bateman et al. (1991) indicates that the oxidized type possesses 90 %, 66 %, 55% on the northernmost A-A', central B-B', and southernmost C-C' transects, respectively (Fig. 2). As a whole (n=382), the oxidized type is 68 %. Along each transect, the magnetic susceptibility decreases westward, although the batholith becomes generally mafic toward west, suggesting the western foothill granitoids are reduced to ilmenite-series (below NNO buffer) or intermediate series. The Mother Load Au veins and dissemination, and many of small Au veins occur in the western foothill area. Skarn, vein and porphyry types scheelite and copper deposits tend to occur in the eastern part related to the oxidized-type granitoids.

In the Peninsular Range batholith, variation of the magnetic susceptibility is geographically reversed, i.e., it increases to the west, where the plutonic rocks are associated with coeval volcanic rocks (Fig. 3). The western magnetite-series belt corresponds to low δ^{18}O (less than +8 ‰) region, and the eastern ilmenite-series belt is seen in the high δ^{18}O (more than +8 ‰) region (Gastil, 1991). The magnetite/ilmenite-series boundary is very close to the alignment of La Posta-type zoned plutons. A little mineralization has been known in and around the Peninsular Ranges Batholith.

Along he Peruvian Coast, similar I-type granitoids occur in narrow belt (Cobbing et al., 1981). They were divided into several segments from north to south. Transect study across the central Lima Segment indicates that their magnetic susceptibility is generally higher than 3.0 x 10^{-3} SI (Ishihara et al., 2000), being oxidized type except for local granitic phase (Fig. 4). Large porphyry copper deposits occur in the southeastern, Toquepala Segment, but most other deposits are associated with oxidized smaller intrusions located toward the east of the Coastal Plutonic Complex, e. g., Cordillera Blanca batholith (Fig. 4). The related mineralizations are late Cretaceous Cu veins, Cu-Mo-W skarns, Au-(Cu) veins and Porphyry Cu, and Paleogene Cu-Pb-Zn skarns and porphyry Cu-Mo deposits.

The situation is similar in the north-central Chile. Here, I-type magnetite-series plutonism initiated in Jurassic time onward (Ishihara et al., 1984). In addition to similar styles of the mineralization to Peru, manto-type Cu and magnetite deposits and huge size of the porphyry copper deposits are distinct in the Chilean side.

In porphyry copper deposits, S can easily exceed 10 times of Cu content; thus the ore deposits can be huge sulfur deposits. Sulfur could be carried by mafic magmas because solubility of sulfur correlates with that of iron. There are two possibilities proposed: (1) basaltic magmas but mingled with felsic magma, and (2) andesitic magmas. Ultimate source of sulfur could be juvenile upper mantle or recycled sea-water sulfate. If given magmas are barren in copper, huge pyrite deposits may only be formed. Thus we need magmas initially high in copper to form chalcopyrite deposits. Copper sulfide can occur in magmatic temperature as *iss*, so that copper content of unaltered granitoids can be useful for mineral exploration.

References

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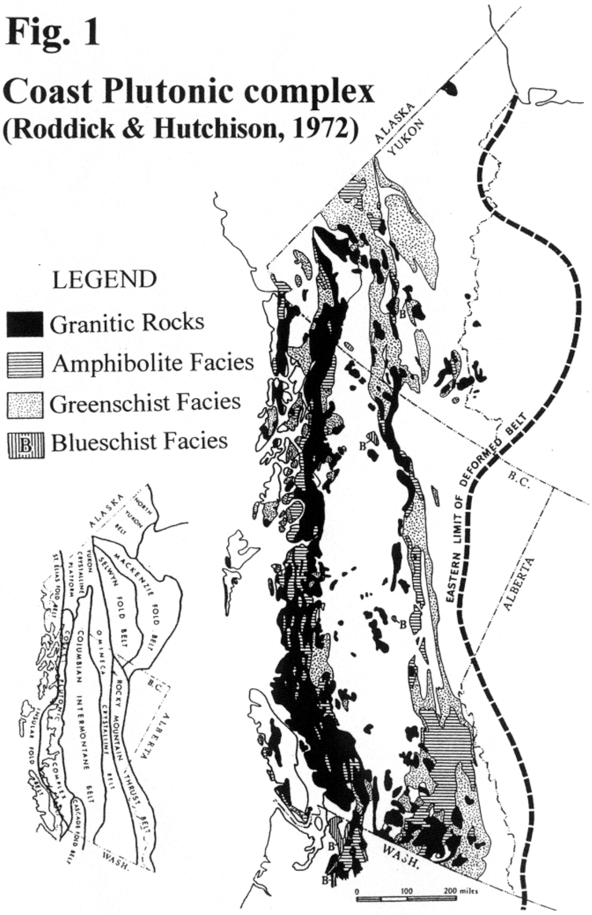
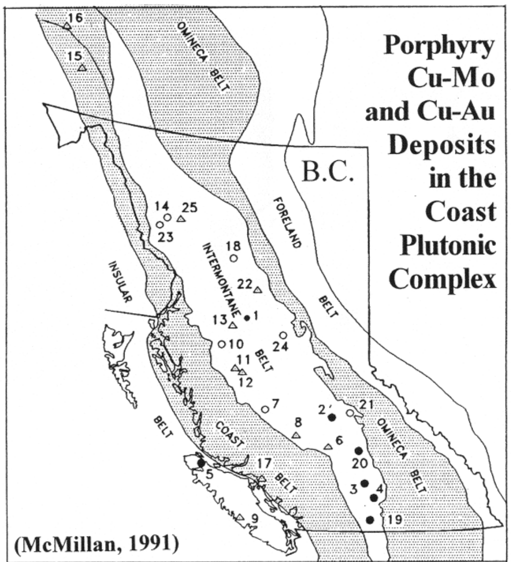
Fig. 1

Coast Plutonic complex
(Roddick & Hutchison, 1972)





Calcalkaline Class
1 Bell, Granisle, Morrison
2 Gibraltar
3 Highland Valley Deposits–Lornex, Bethlehem, Highmont, Valley Copper, JA
4 Brenda
5 Island Copper
6 Maggie
7 Fish Lake
8 Poison Mountain
9 Catface
10 Berg
11 Huckleberry
12 Ox Lake
13 Glacier Gulch
14 Schaft Creek
15 Mount Nansen
16 Casino
17 OK
18 Kemess

Alkaline Class
19 Copper Mountain–Similkameen
20 Afton
21 Mt. Polley (Cariboo Bell)
22 Lorraine
23 Stikine (Galore Creek)
24 Mt. Milligan
25 Red Chris

Symbols
● Producing mine or district with producing mines
○ Major prospect
△ Prospect

Fig. 2 Magnetic susceptibility across the Sierra Navada Batholith (Bateman et al., 1991)

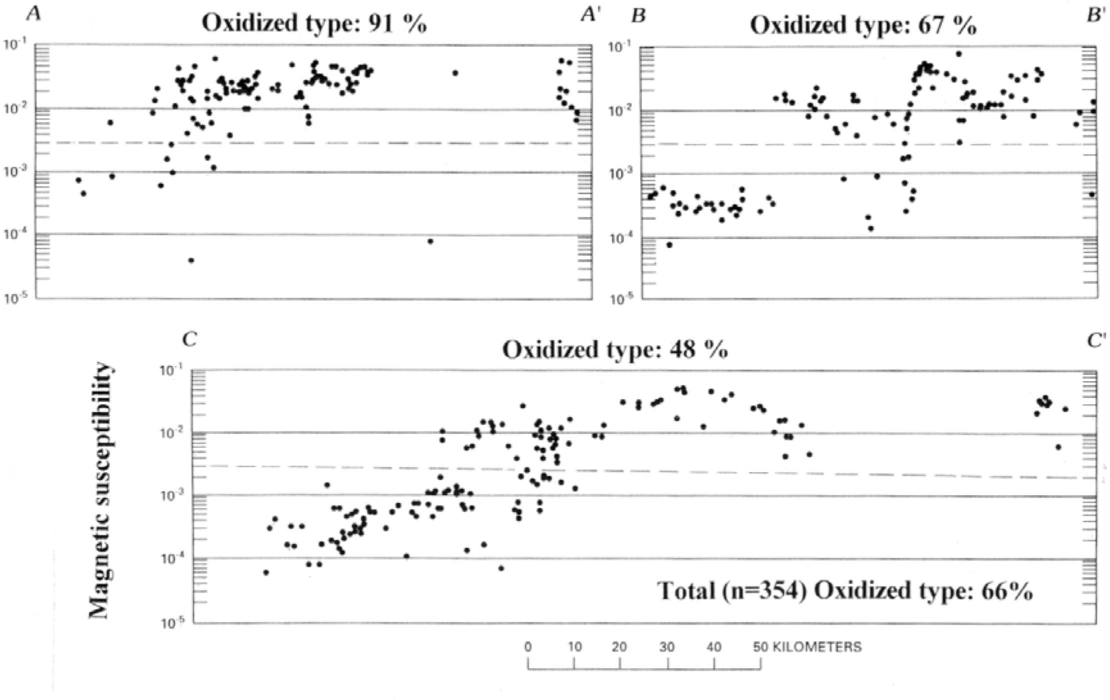


Fig. 3 Magnetic susceptibility and whole rock $\delta^{18}O$ ratio,
Peninsular Range Batholith (Gastil, 1990)

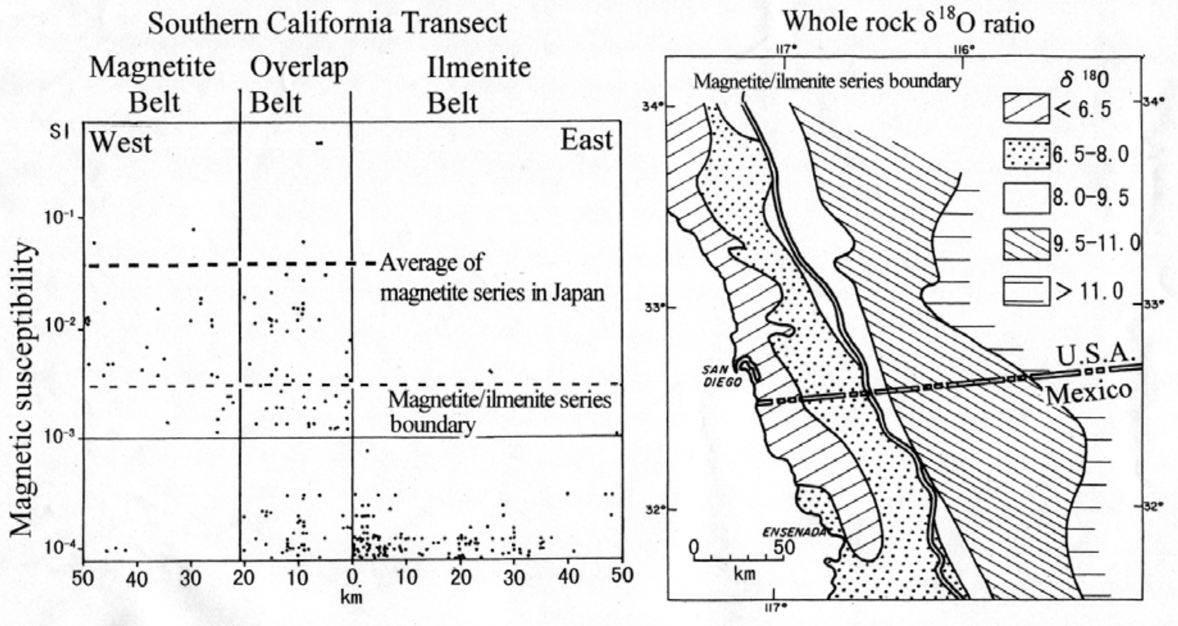
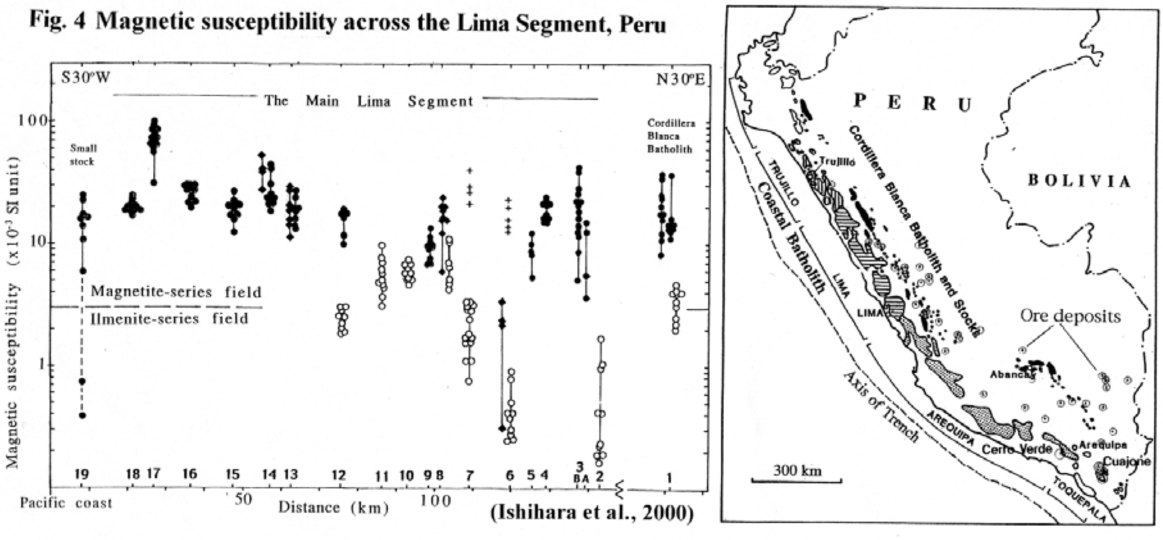


Fig. 4 Magnetic susceptibility across the Lima Segment, Peru



(Ishihara et al., 2000)