MGT

Mineralogical and geochemical type

Analysis of the mineralogical and geochemical type of hydrothermal gold deposit

Dr. Mansour Ziaii
Mziaii@shahroodut.ac.ir
Department of Mining Engineering
Shahrood University of technology

Post Code: 84156-83111
Office: 0098 - (0)273 - 3335509
Mob: 0098 - (0)9151164886

1.Hydrothermal Gold Deposits: Introduction

Gold deposits compose the most representative group among hydrothermal deposits. The theory of hydrothermal ore formation was largely formulated in the past few decades by study of the composition and physicochemical property of ore-bearing solutions, source of ore components and ore-forming fluids, and conditions and mechanisms of ore deposition.

The origin of hydrothermal solutions that take part in the formation of most commercial base metal deposits is one of the most important and complicated problems of the theory of ore formation (Betekhtin,1955). This is the first phrase of the well-known work by A.G. Betekhtin Hydrothermal solutions, their Nature, and Ore-forming Processes. More than 40 years have passed since the first issue of this book. This statement, however, is still true. A.G. Betekhtin, like most other investigators in the middle of the century held to the idea of a magmatic origin of hydrothermal solutions.

By the end of the century, the suggestion about the polygenetic nature of ore-forming solutions related to the forming of most nonferrous and noble metal deposits predominates, recent studies are focused on evaluating the proportions of juvenile or meteoric waters, primary magmatic (mantle or crust-derived) and secondary sources of ore components. Detailed studies of sulfur, oxygen, and carbon isotopes as indicators of the origin of ore and gangue minerals from ore bodies and wall rocks, as well as comprehensive geological, mineralogical, and geochemical investigations suggest vadose-hydrothermal, exhalative-sedimentary, hydrothermal-sedimentary, sedimentary-hydrothermal, infiltrational, and other mechanisms of ore formation. The idea that magmas are the main source of ore components and solutions was significantly revised to the extent of the full negation of any relation of ore deposits to magmatism. However, as new data are accumulated, it is becoming obvious that origin of ore deposits is a very complicated process and depends on various factors.

Magmatic processes (crustal, crustal-mantle, or mantle) are almost always involved in the formation of hydrothermal gold deposits. Their contributions to the initiation and evolution of ore-forming system are unequal in different geological settings and are still not clear in many cases. Likewise, the role of non magmatic hydrothermal processes has not yet been fully evaluated.

The study of deposits of gold having low clarke and low solubility in fluids and magmas is particularly difficult. Gold deposits have received more attention in the last 40 years. Many interesting gold deposits were discovered in this period (Carlin-type deposits in the United States, Hemlo in Canada, Sukhoi Log and Olympiada in Russia, Muruntau in Uzbekistan, Ladolam and Pangune in Papua New Guinea, Olympic Dam in Australia, and Pueblo Viejo in the Dominican Republic). These discoveries have substantially enhanced our knowledge of diversity of gold deposits and the types of ore-forming systems. This research considers the hydrothermal gold deposits of the world using a universal approach, namely, analysis of the geological-historical position of the largest deposits, their systematic in mineralogical and geochemical types (MGT), and approximate evaluation of the productivity of ore-forming systems.

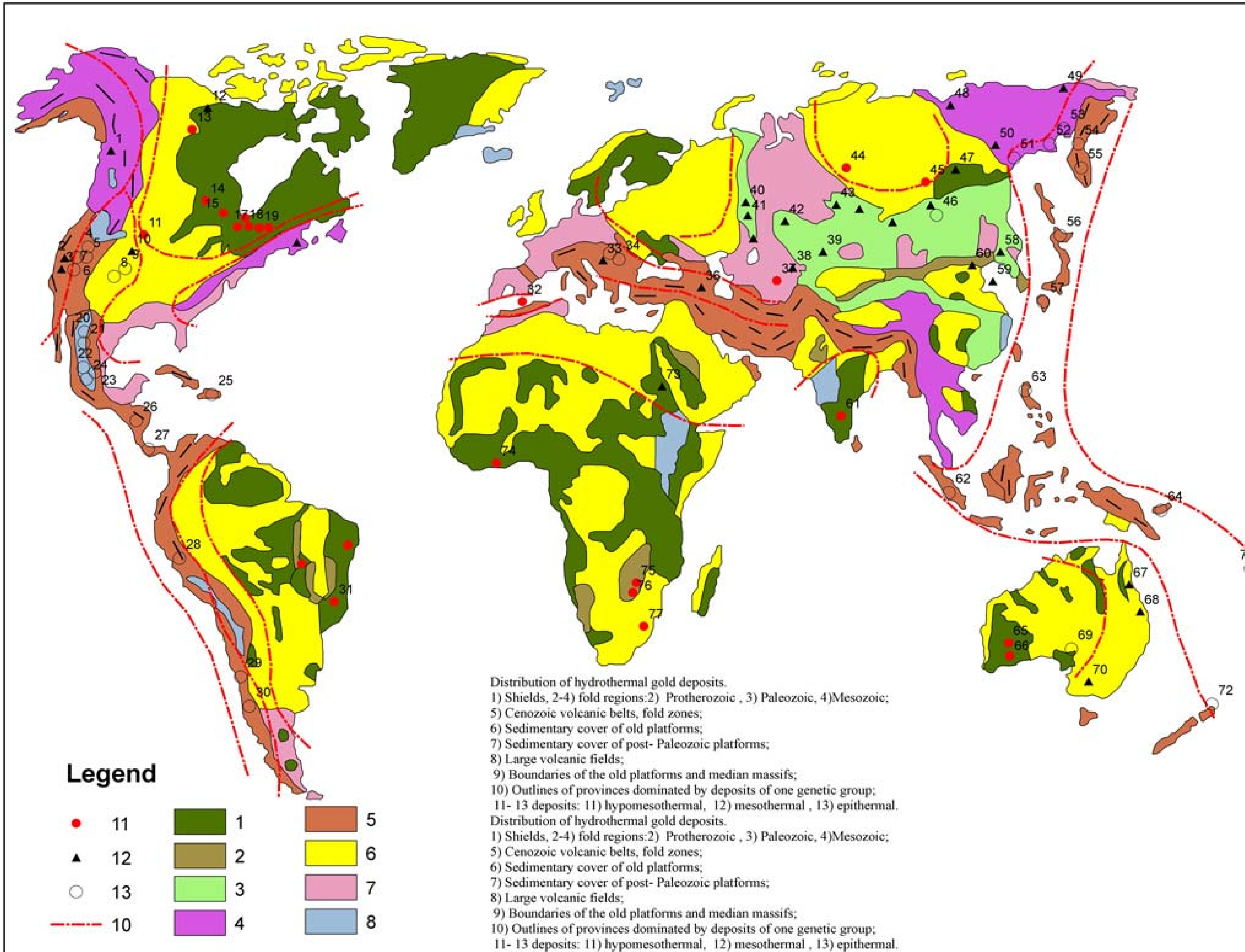
These problems have also been treated by some investigators (Hutchinson, 1987; Hodgson et al, 1993; Phillips, 1993; Safonov, 1997 and et al). However, their analysis was incomplete, because they had no possibility to include data on gold deposits in the former USSR.

This research is based on data obtained during study of gold deposits in the former USSR, India (Kolar, Chigargunta, Ramagiri, etc.), and Iran (Kharvana, Gandy, Motah).We also used vast published information. Each year there is new information on mineral properties and their MGT conditions. In some cases, this information allows one to determine relations between characteristics of minerals and their MGT, which reveals typomorphic indications of minerals and mineral associations. Depending on the relationship between genetic and typomorphic properties of a single mineral or complex, decoding processes of formation of the minerals includes allowing possible evaluation of their geochemical anomaly and estimation of the potential reserves.

2. Classification of Gold Deposits

The classification is conditional, because the total ore amount depends on the cut-off grades (0.5, 1, 2, 3 or 5 g/t) used for outlining ore bodies. Safonov uses the following classification of gold deposits in the earth's crust: 1st order (> 1000 ton), 2nd order (> 100), 3rd order (> 10 ton), and 4th order (> 1 ton).

Many geologists in the CIS are presently using the classification of gold deposits proposed by Petrovskaya (1973). Petrovskaya's classification is also applied thanks to the simplicity of its structure. Safonov (1997) proposed a classification of gold deposits which determined the associated mineral types with their distribution, geological-genetic types, and productivity of ore-forming systems which represent the probable sources of ore-forming solution. Hydrothermal gold deposits were related to ore-forming systems of 16 MGT types. Based on the classifications of Petrovskaya et al. (1976), Konstantinov (1991), Safonov (1997) hydrothermal gold deposits were related to ore-forming systems of different kinds and classified MGT. This model is based on data obtained during a study of gold deposit (Ziaii, 1999) in the former USSR where 12,000 monomineralic pyrite, galena, arsenopyrite, and sphalerite samples from 100 hydrothermal gold deposits were studied (Fig 2). Analysis of the spatial and temporal distribution of hydrothermal gold deposits shows a complicated pattern of allocation and evolution of ore-forming systems and helps us to outline a general rule for the cluster-like distribution of large gold accumulations within global tectonic provinces (Safonov 1997).



Distribution of hydrothermal gold deposits.
1) Shields, 2-4) fold regions:2) Protherozoic , 3) Paleozoic, 4)Mesozoic;
5) Cenozoic volcanic belts, fold zones;
6) Sedimentary cover of old platforms;
7) Sedimentary cover of post- Paleozoic platforms;
8) Large volcanic fields;
9) Boundaries of the old platforms and median massifs;
10) Outlines of provinces dominated by deposits of one genetic group;
11- 13 deposits: 11) hypomesothermal, 12) mesothermal , 13) epithermal.

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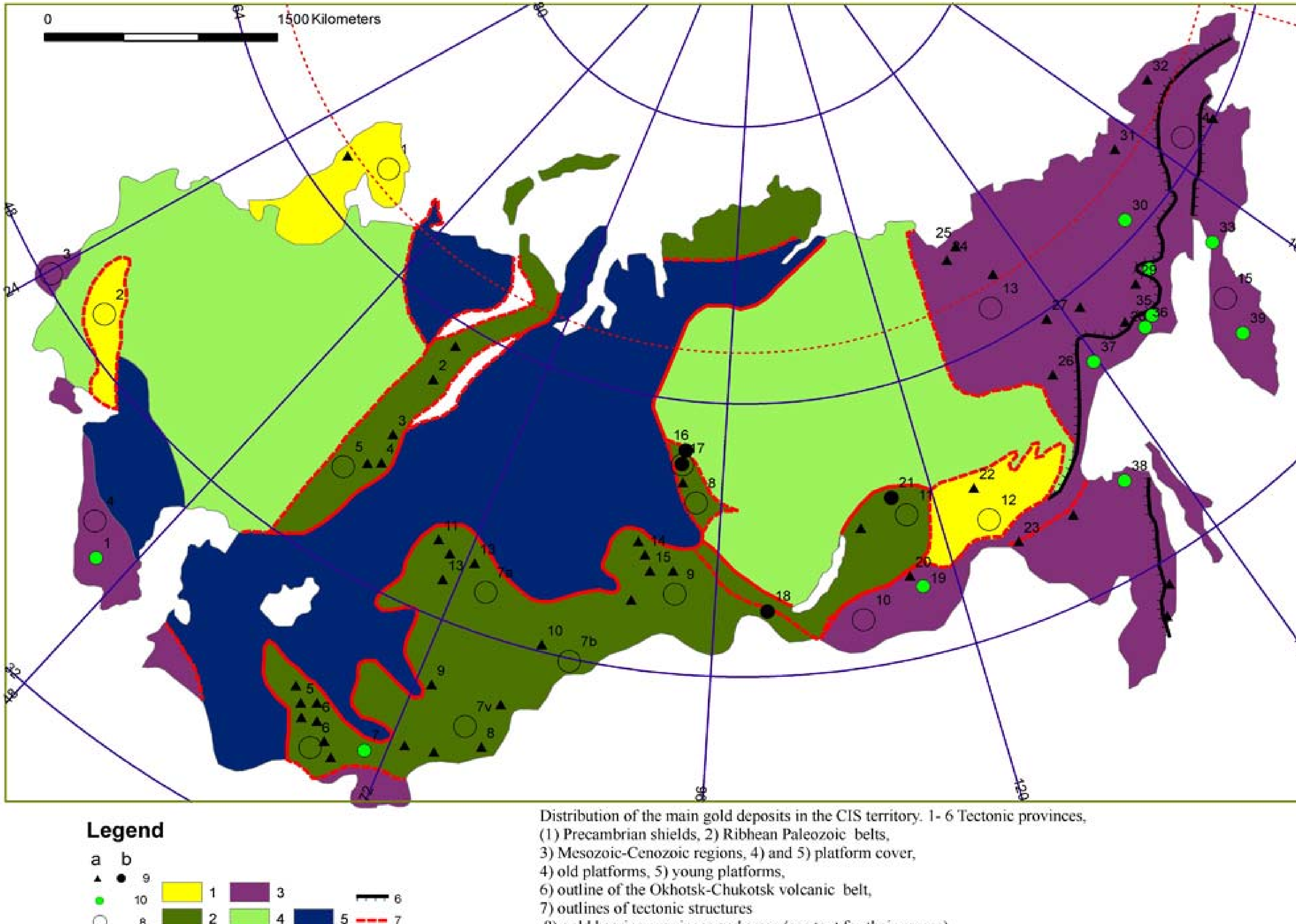
3. Distribution of hydrothermal gold deposits:

The total number of hydrothermal gold deposits is estimated at 3000 (with reserves > 1 ton of Au) (Safonov, 1997). Considering the uncertainties in the separation of individual ore deposits and fields, the number of primary hydrothermal deposits with reserves > 1 ton of Au is about 1500.

The distribution of the 1st (> 1000 ton) and 2nd (> 100 ton), order hydrothermal deposits is shown in Fig. 1. The main tectonic structure are also outlined as related to the geological and historical distribution of gold deposits. Russian geologists usually correlate metallogenic epochs with epochs of global tectogenesis.



Distribution of the main gold deposits in the CIS territory. 1- 6 Tectonic provinces,
(1) Precambrian shields, 2) Ribhean Paleozoic belts,
3) Mesozoic-Cenozoic regions, 4) and 5) platform cover,
4) old platforms, 5) young platforms,
6) outline of the Okhotsk-Chukotsk volcanic belt,
7) outlines of tectonic structures
8) gold bearing provinces and areas (see text for their names),
9) hydrothermal gold deposits (a) mesothermal, (b) hypomesothermal ,10) epithermal deposits.

The most informative trace elements analysed in monomineralic samples of ore minerals

Pyrite	Galen	Sphalerite	Arsenopyrite
As	Sb	Cu	Pb
Pb	Mn	Pb	Zn
Co	Zn	Cd	Cu
Cu	As	Sb	Sb
Zn	Au	Mn	Co
Ni		Co	Ni
Au		Sn	Au
		Ga	Ag
		Ag	
		Au	

Result of MGT based of trace element in pyrite

- **1- Gold-Sulfide**
- **2- Quartz +Gold**
- **3- Gold with Sb**
- **4- Gold+ Quartz**
- **5- Gold-sulfide-base metal**
- **6- Gold-massive sulfide**
- **7- Gold-Silver**
- **8- Gold-Skarn-sulfide**
- **9- Gold-base metal**
- **10- Quartz-sulfide**
- **11-Gold-hematite**
- **12- Gold-carbonate-sulfide**
- **13- Gold-sulfide-quartz**
- **14- Gold-listvinate**
- **15- Gold-barite-base metal**
- **16- Gold with Mo**
- **17- Gold-quartz-base metal**