Mesozoic Au-Ag-Pb-Mo mineralization in the Xiong'ershan area, western Henan Province, China

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Abstract. The Xiong'ershan district is located on the southern margin of the North China Craton and is the second largest Au area in Henan Province, China. It contains Mesozoic hydrothermal Au and Ag, Pb and Mo deposits. The deposits can be classified into different types: cryptoexplosive breccia type Au deposits, structural alteration type Au, Ag and Pb deposits, and porphyry type Mo deposits. The porphyry type Mo deposit formed earlier than other types of deposits. Various deposits formed in an extensional environment that resulted from rapid lithospheric thinning in eastern China during 140-120 Ma, and the combination of a tectono-thermal event and deep deep-seated magmagtic ore fluids and meteoric water that resulted in the formation of large-scale hydrothermal mineralization.

Keywords. Deposit type, mineralization characteristics, metallogeny, mineralization model, Xiong'ershan

1 Introduction

The Xiong'ershan area islocated on the southern margin of the North China craton and is the second largest Au area in Henan Province, China (subsequent to the Xiaoqinling Au area). It extends 80 km from east to west and is 15 to 40 km wide, covering an area of ca.2000 km^2. It is bounded on the north by the Luoning fault and on the south by the Machaoying fault (Fig. 1). A wealth of published data about this gold-polymetallic area is available (Chen and Fu 1992; Chu et al. 1992; Ren et al. 1996; Wang et al.1996; Zhang et al. 1996, 2001; Guo et al. 1997; Luo et al. 2000; Zhang et al. 2002; Mao et al. 2002a, b, 2003, 2005; Li et al. 2004a, b, 2005). Since the 1980s, many Au deposits and Ag- Pb-Mo deposits have been found and several state-owned gold mines developed. To date geological parties, state-owned gold mining enterprises, private companies and joint ventures have been successfully conducting exploration for Au, Ag, Mo and Pb resources in the area. Among the deposits, the Qiyugou cryptoexplosive breccia type gold deposit has attracted a good deal of attention of geologists for its specific geological characteristics.

2 Regional geological setting

The North China and Yangtze blocks collided in the Tertiary, forming a unifying continent (Ames L et al. 1993; Zhang GW et al. 1996, 2001). Later, the Xiong'ershan area became an important component part of the Qinling orogen. The strata in the area are divided into three tectonic units: medium- and high-grade metamorphic basement rocks of the Neoarchean Taihua Group (green formation); low-grade metavolcanic rocks of the Mesoproterozoic cover Xiong'er Group, and littoral-neritic sedimentary rocks of the Guandaokou Group; and Meso-Cenozoic red clastic sedimentary rocks in the extensional downfaulted basins, including sandy conglomerate with mudstone of Late Cretaceous Qiuba Formation, lacustrine- dilluvial-shallow lake-swampy clastic deposits of Paleogene Gaoyugou, Dazhang and Tantou Formations from bottom upwards in the most developed Tantou basin (Chu et al. 1992). Of these the Taihua Group metamorphic rocks form the basement of the craton, overlain by the widespread Xiong'er Group volcanic rocks in west Henan and Guandaokou Group littoral-neritic sedimentary rocks. Both the Taihua and Xiong'er Groups are main host rocks for Au-Ag-Pb-Mo deposits in the area (Wang et al. 1996; Ren et al. 1996; Luo et al. 2000; Mao et al. 2002a).

The metamorphic complex and detachment faults developed in the area are a record of Meso-Cenozoic extensional tectonic movement (Wang et al. 1996; Wang et al. 2002; Mao et al. 2005). The detachment fault extend along the unconformity between the metamorphic basement of the Neoarchean Taihua Group and the overlying Mesoproterozoic Xiong'er Group, and the north detachment fault is easier recognizable (Guo et al. 1997). The other important regional faults include the Luoning fault in the north and Machaoying faults in the south.

There are four sets of ore-controlling faults in the area: NE-ENE, NNE, NNW and nearly E-W, which form the structural framework of the area. Among them, the NE-ENE trending faults are best developed, widespread and closely related to the common gold-silver-lead type-the structural alteration type deposits.

Three periods of magmatism occur in the region: (1) Neoarchean magmatism appeared as intermediate -basic volcanic rocks of the Taihua Group, which were metamorphosed into various of gneiss in the late stage; (2) Mesoproterozoic magmatism mainly gave rise to rift-type intermediate-basic-acid volcanic rocks; and (3) Mesozoic magmatism which extensively and intensely occurred in Jurassic -Cretaceous age, forming abundant of granitoids. The Huashan granitic batholith is a representative com-

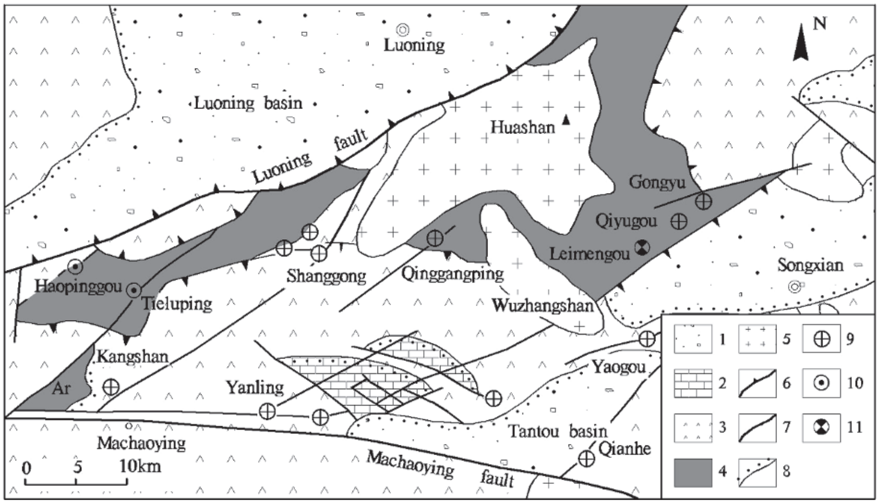

Figure 1: Distribution of Mesozoic hydrothermal deposits in the Xiong'ershan area (modified from Wang et al. 1996) 1- Red clastic sedimentary rocks and sediments of Meso-Cenozoic; 2-Quartz sandstone and dolomitite of Mesoproterozoic Guandaokou Group; 3-Volcanic rocks of Mesoproterozoic Xiong'er Group; 4- Metamorphic rocks of Neoarchean Taihua Group; 5-Mesozoic granitoids; 6-Detachment fault; 7-Fault; 8-Unconformity; 9-Au deposit; 10-Ag-Pb deposit; 11-Mo deposit.

Table 1: Main types and characteristics of hydrothermal deposits in Xiong'ershan area

Type	Deposit	Host rock	Ore-controlling structure	Ore mineral assemblages	Wall-rock alteration	Mineralization ages
cypto-explosive breccia type	Qiyugou gold deposit	Taihua Group metamorphic rocks	Explosive breccia pipe related to Mesozoic magmatism	Au-poly-metallic sulfides	Silicification,potassic alteration,sericitization,pyritization and epidotization	125.11±1.59 Ma (Ar-Ar method, Wang YT et al. 2001)
porphyritic Mo type	Leimengou Mo deposit	Mesozoic Porphyry and Taihu Group metamorphic rocks	Endo- and exo-contact of granitoids and surrounding rocks	Molybdenite-pyrite	Silicification,potassic alteration,sericitization and pyritization	133.1-133.6 Ma (Li YF et al. 2004a)
structural alteration type Au-Ag-Pb	Shanggong Au deposit, Gongyu Au deposit ,Tieluping Ag-Pb deposit	Taihua Group metamorphic rocks and Xiong'er Group volcanic rocks	Steeply-dipping altered fracture zone	Au-poly-metallic sulfides	Silicification,potassic alteration,sericitization and pyritization	122 Ma (Gongyu Au deposit, Ar-Ar method, Li and Qi, 2002
	Qingangping Au deposit	Taihua Group metamorphic rocks and Xiong'er Group volcanic rocks	Detachment fault and gently-dippint fracture zone	Au-pyrite-quartz	Silicification and pyritization	

posite in the area. In addition, intermediate -acid stocks and mafic dykes are also exposed. Spatially, mineralization in the area exhibits a close relation to Mesozoic granitoids, and most deposits occur around or within them (Wang et al. 1996; Mao et al. 2003).

3 Types of Au-Ag-Pb-Mo deposits

The main hydrothermal mineralization includes structural alteration type, (which contains steeply dipping-subtype, e.g. the Shanggong Au, Gongyu Au, Kangshan Au, Tieluping Ag-Pb and Shagou Ag-Pb deposits, and gently dipping-subtype deposits, e.g. Qingangping Au and Luyuangou Au deposits), cryptoexplosive breccia type (Qiyugou Au deposit) and porphyry–type deposit (Leimengou Mo deposit). The location of various main deposits is shown in Figure 1 and their characteristics are given in Table 1.

4 Metallogeny of Mesozoic Au-Ag-Pb-Mo hydrothermal ore deposits

In the Mesozoic eastern China underwent an event of prominent lithospheric thinning (Deng et al. 1996) and tectonic regime transition, thus resulting in strong magmatism and extensive mineralization (Mao et al. 2003, 2005). Magmatism and mineralization in this area mainly occurred at 140-120 Ma. The reliable ages obtained in recent years are as fellows:

The Huashan granite batholith has a SHRIMP zircon U-Pb age of 132.0 ± 1.6 Ma, the Leimengou granite- porphyry has a SHRIMP zircon U-Pb age of 136.2 ± 1.5 Ma (Li 2005), the Mo deposit has a Re-Os model age of 132.4 ± 2.0 Ma (Li et al. 2004a), the Qiyugou Au deposit has a mineralization age of 125 Ma (Wang et al. 2001) and the Gongyu Au deposit has a mineralization age of 122 Ma (Li and Qi 2002). The ages show that: firstly, the granite-porphyry formed earlier than the Huashan granite batholith and secondly, the Leimengou porphyry Mo deposit formed earlier than structural alteration type deposits and crypoexplosive breccia type Au deposit.

Spatially, various types of deposits occur in the same tectonic unit, reflecting that they are possibly correlated.

The structural alteration type (including steeply dipping and gently dipping subtype) is directly controlled by faults and detachments, and the cryptoexplosive breccia type and porphyry type are mainly controlled by the intersection site of faults. Porphyry deposits generally occur in the granite porphyry stocks, while cryptoexplosive breccia type deposits mainly occur in the overlying country rocks of them.

The porphyries related to the Mo deposit are mainly derived from the upper mantle and low crust represented by the metamorphic rocks of Neoarchean Taihua Group (Wang et al. 1986; Zhang et al. 2002; Li 2005), and the $\delta^{34}S$ values for sulphide minerals from the main mineralization of Mo and Au deposits exhibit a narrow range of closing to naught, implying a deep origin of the ore substance which possibly derived from the Taihua Group green formation and upper mantle (Mao et al. 2002b; Li et al. 2004a).

The Hydrogen-Oxygen, Helium-Argon and Nitrogen isotopes show the close relationship of the ore-forming fluids with the magmatic fluids, and in some deposits (e.g.Qiyugou and Gouyu gold deposits) the meteoric water participated in the hydrothermal mineralization system in late stage (Mao JW et al. 2002b; Li et al. 2004b).

5 Hydrothermal mineralization model

The North China Block and Yangtze Block collided in the Triassic, resulting in extensive N-S compression and crustal shortening in the Qinling region (Zhang et al. 1996; Ren et al. 1998; Mao et al. 2003, 2005) including the Xiong'ershan area. High pressures and temperatures lead to partial remelting of the lower crust. Approximately in the Late Jurassic to Early Cretaceous (140-120 Ma), rapid lithospheric thinning in eastern China resulted in regional extension, upwelling of the asthenosphere and emplacement or eruption of voluminous magmas (ca.130 Ma). Under the combined controls of the tectono-thermal event and deep-seated magmatic ore fluids and late meteoric shallow fluids, large-scale mineralization occurred (Mao et al. 2003, 2005).

Porphyry type Mo mineralization occurred earlier, and then cryptoexplosive breccia type Au mineralization and structural alteration type Au- polymetallic mineralization occurred. For the structural alteration type, the ore-controlling faults has the features of multi-stage activities: in the early stage they usually exhibited a thrust and mylonization; and during the mineralization stage, the principal stress was oriented in a NE-SW direction (Wang et al. 1996; Wan TF et al. 2002) and the faults of the similar direction exhibited relatively extensional features, which lead to ascent and filling of ore fluids along them and formation of steeply dipping NE- and NNE-trending ore veins, which occur nearly parallelly in swarms and zones.

There are also gently-dipping structural alteration gold deposits occurring within detachment faults (e.g. the Qingganping gold deposit). The early-formed ductile shear zones were superimposed by brittle faults and filling of hydrothermal ore fluids during the mineralization stage (Guo et al. 1997).

In the Late Cretaceous some small extensional basins began to form in the surrounding area of the mining area. Piedmont and fluiviolacustrine sandy conglomerate with mudstone of the Late Cretaceous Qiuba formation are developed on the south slope of Xiong'ershan (Chu et al. 1992). The coarse sands and poorly-sorted gravels, are mainly derived form volcanic rocks of the Xiong'er Group rather than metamorphic rocks of the Neoarchean Taihua Group or Mesozoic Huashan granite, indicating that the Taihua Group and Huashan granite had not been exposed on the surface despite significant uplift at that time. Later, the deposits of the Paleogene Dazhang and Tantou Formations contain the gravels derived from the Neoarchean Taihua Group, suggesting that the Taihua Group was exposed on the surface at that time.

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