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A review of the Cu–Ni sulphide deposits in the Chinese Tianshan and Altay orogens (Xinjiang Autonomous Region, NW China): Principal characteristics and ore-forming processes

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Abstract

Several Cu–Ni sulphide deposits and occurrences have recently been discovered along parallel deep faults in the Chinese Tianshan and Altay orogenic belts, Xinjiang Province, NW China. The Kalatongke and several other Cu–Ni mineralized intrusions are located along the Irtysh fault, which separates the Altay orogenic belt from the Junggar basin. The Huangshan, Huangshandong, Xiangshan, Tudun, Erhongwa, Tula'ergen, and Hongling deposits occur along the Kanggurtag suture, which separates the Jueluotage orogenic belt from the Turpan-Hami (Tuha) basin. The Baishiquan, Tianyu, and Tianxiang deposits are located along the Arqikekuduke fault, which separates the Jueluotage orogenic belt from the Central Tianshan Precambrian terrane. The Poyi, Poshi, and Luodong deposits are located along the Baidiwa fault, which separates the Central Tianshan Precambrian terrane from the Beishan Paleozoic rift. Re–Os dating of Cu–Ni sulphide ores reveals that these Cu–Ni ore belts formed in a narrow age range of 298–282 Ma. This age range is about the same as those of associated intrusions and dykes dated by the SHRIMP zircon U–Pb method. Tectonic and geochronological constraints suggest that the amalgamation of continental blocks mainly occurred during the Late Carboniferous in the Central Asian orogenic belt. Large-scale hydrothermal and magmatic metallogenesis in the region occurred during post-collisional stages of Latest Carboniferous to Early Permian age. The Cu–Ni sulphide deposits are part of this metallogenic event.

The Cu–Ni orthomagmatic sulphide deposits in northern Xinjiang are represented by: (1) net-textured type deposits by segregation of a Cu–Ni metal sulphide melt and (2) magma conduit type. Some mafic–ultramafic suites exhibit lithological zoning caused by strong differentiation. Stratiform orebodies are hosted by ultramafic rocks at the base of the magma chamber. Good examples are the Kalatongke, Huangshandong, and Poshi deposits. Others, such as the Xiangshan, Baishiquan, Tianyu, and Tula'ergen deposits, are hosted by magma conduits, consisting of peridotite, troctolite, and pyroxenite. These ultramafic rocks either occur within faults or are surrounded by gabbroic and dioritic intrusions. These two types of orthomagmatic Cu–Ni sulphide deposits are also distributed along the same ore belts. For instance, the differentiated sill-related Huangshandong deposit co-exists with the magma conduit type Tula'ergen deposit in the Jueluotage orogenic belt.

Orthomagmatic Cu–Ni sulphide deposits in northern Xinjiang formed during post-collisional extension and are possibly related to a Late Carboniferous–Early Permian mantle plume event. The mafic–ultramafic suites and associated Cu–Ni deposits are commonly accompanied by dyke swarms and are characterized by elongated outcrops occurring along parallel E–W-trending regional faults. These mafic–ultramafic suites and accompanying dyke swarms are generally fractionated, implying that they were feeders of presently eroded flood basalts.

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1. Introduction

In the 1970s, Cu–Ni sulphide deposits (Kalatongke, Huangshan, Huangshandong, Xiangshan, Tudun, and Hulu) were discovered in the southeastern Altay Mountains and in the East Tianshan, Xinjiang, China. In recent years, exploration successes for magmatic Cu–Ni sulphide deposits include the discoveries of Baishiquan, Tianyu, and Tianxiang on the northern margin of the Central Tianshan, south of the Huangshan–Jing'erquan ore belt, and the Poshi, Poyi, and Luodong occurrences in the Pobei area, in the Paleozoic Beishan rift south of the Central Tianshan. More recently, the Tula'ergen Cu–Ni deposit was found at the eastern end of the Huangshan–Jing'erquan ore belt and the Hongling deposit was identified at the western end of this ore belt. Re–Os dating of sulphide ores and SHRIMP zircon U–Pb dating of related mineralized mafic intrusions indicate that these Cu–Ni sulphide deposits formed at 298–270 Ma (Li et al., 1998; Mao et al., 2002; Han et al., 2004; Zhou et al., 2004; Wu et al., 2005; Zhang et al., 2005) during post-collisional extensional tectonism.

In the past 20 years, many researchers have discussed the basic features of the Kalatongke, Baishiquan, Huangshan, and Huanshandong deposits (Wang et al., 1991; Pan and Wang, 1992; Yan et al., 2003). Wang et al. (1992), Li (1996), and Wang et al. (2000) summarized the metallogenic characteristics of local districts in northern Xinjiang. Ni (1992), Gao (1992), Bai (2000), Shen (2003), Zhang et al. (2003), Zhou et al. (2004), and Chai et al. (2006) discussed the mineralization associated with these mafic–ultramafic rocks. Based on previous research, combined with the new advances in current mineral exploration and prospecting, in this paper we summarize the main characteristics of these deposits, examine ore-forming processes, and attempt to understand the relationship of these deposits and host mafic–ultramafic rocks with the geodynamic evolution of the region and explore their possible link with mantle plume activity.

2. Geological setting

In NW China (Xinjiang Province), the Altay Mountains, the lower mountains and hills of the East Junggar, Junggar basin, and the East Tianshan ranges, in northeastern Xinjiang Uygur Autonomous Region, are on the southern margin of the Altaid or Central Asia Orogenic Belt (Sengör et al., 1993; Jahn, 2004; Li et al., 2006b; Windley et al., 2007). The main tectonic features of NW China consist of Late Paleozoic NW- and nearly E–W-trending orogenic belts with inliers of pre-Sinian blocks (Li et al., 2003b). These orogenic belts were originally separated by a Paleo-Asian Ocean, developed during the Paleozoic. From north to south, the principal tectonic units of Xinjiang are the Altay orogen, eastern Junggar orogen, Junggar block, Bogda Shan orogen, Tuha basin, East Tianshan (or Jueluotage), and Beishan orogens (Li et al., 2006b).

The tectonic evolution in the region was divided into the pre-Sinian, Sinian-Carboniferous, Permian to Cenozoic stages. The pre-Sinian stage includes an Archean–Paleoproterozoic basement and the Mesoproterozoic to early Neoproterozoic successions of the Tarim craton, as well as microcontinental fragments within the Tianshan and other areas which correspond to the stages of assembly of the supercontinents Columbia and Rodinia (Li et al., 2006). In the Middle Neoproterozoic, concomitantly with the breakup of the supercontinent Rodinia, a Paleozoic ocean formed in Central Asia. The Altay and Tian Shan orogens, the Tarim craton and the microcontinental fragments that are included in these orogenic belts were separate terranes within this paleo-ocean. The Sinian–Cambrian stage was a period of seafloor spreading, but from the Ordovician onward, the paleo-ocean began closing and in the Late Carboniferous the terranes became amalgamated to form the continental crust of present day Central Asia.

A stage of extensional tectonics began in the Permian and continued through the Triassic to the Neogene. The Permian was a stage of post-collision crustal evolution in the region characterized by mantle-derived magmatism. From the Late Triassic to Jurassic, the crustal evolution of the region was mainly dominated by the closing of the Paleo-Pacific Ocean (an ocean that was the precursor of the Mongolia-Ochotsk orogenic belt) and Paleo-Tethys Ocean (an ocean that was the precursor of the Kunlun Mountains). The Cretaceous to Neogene was a period of relative quiet and stability in the geological history of the region. From the Pleistocene on, as a result of the India–Eurasia collision, reactivation and on-going uplift of the orogenic belts took place, forming the present basin-range framework.

3. Cu–Ni sulphide deposits

Northern Xinjiang is one of the regions in the world where Cu–Ni sulphide deposits are particularly numerous. Up to now, 19 Cu–Ni sulphide deposits and occurrences including Huangshan, Huangshandong, Xiangshan, Huangshannan, Tudun, Erhongwa, Kalatongke, Xingdi, and Qingbulake deposits were discovered in the 1970s and 1980s, with the Hongling, Baishiquan, Tianyu, Tianxiang, Tula'ergen, Poshi, Poyi, and Luodong deposits discovered in the past few years. The distribution of these deposits and occurrences are shown in Fig. 1 and their main characteristics are given in Table 1. Due to the preli-