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Magmatic Cu–Ni sulfide mineralization of the Huangshannan mafic–untramafic intrusion, Eastern Tianshan, China

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A B S T R A C T

The Huangshannan Ni–Cu (–PGE) sulfide deposit, a new discovery from geological prospecting in Eastern Tianshan, is in a belt of magmatic Ni–Cu (–PGE) sulfide deposits along the southern margin of the Central Asian Orogenic Belt. The host intrusion of the Huangshannan deposit is composed of a layered ultramafic sequence and a massive gabbro–diorite unit. The major sulfide orebodies occur mainly within websterite and lherzolite in the layered ultramafic sequence. In-situ zircon U–Pb dating analyses yielded a crystallization age of 282.5 ± 1.4 Ma, similar to the ages of the Permian Tarim mantle plume. Samples from the Huangshannan intrusion are characterized by nearly flat rare earth elements patterns, negative Zr, Ti and Nb anomalies, arc-like Th/Yb and Nb/Yb ratios, and significantly lower rare earth element and immobile trace element contents than the Tarim basalts. These characteristics suggest that the Huangshannan intrusion was not generated from the Tarim mantle plume. The primary magma for the Huangshannan intrusion and its associated sulfide mineralization were formed from different pulses of picritic magma with different degrees of crustal contamination. The first pulse underwent an initial removal of 0.016% sulfide in the deep magma chamber. The evolved magma reached sulfide saturation again in the shallow magma chamber and formed sulfide ores in lherzolite. The second pulse of magma reached a level of 0.022% sulfide segregation at staging chamber before ascending up to the shallow magma chamber. In the shallow conduit system, this sulfide-unsaturated magma mixed with the first pulse of magma and with contamination from the country rocks, leading to the formation of sulfide ores in websterite. The third magma pulse from the deep chamber formed the unmineralized massive gabbro–diorite unit of the Huangshannan intrusion.

1. Introduction

Most world-class magmatic sulfide deposits are formed within cratons or on their margins in association with intra-plate magmatism (Barnes and Lightfoot, 2005; Begg et al., 2010). Such examples include Jinchuan on the western margin of the North China Craton (Fig. 1a; Tang and Li, 1995; Tang et al., 2002; Lehmann et al., 2007), the Bushveld igneous complex in the Kaapvaal Craton (Clarke et al., 2009), and Noril'sk in the Siberian Craton (Naldrett et al., 1992; Maier et al., 2000). Thus the magmatic evolution and mineralization processes forming magmatic Cu–Ni deposits within cratons have been well documented (Barnes and Lightfoot, 2005; Naldrett, 2009; Begg et al., 2010). Conversely, the relatively small magmatic sulfide deposits formed in orogenic belts that have undergone complex evolution histories have not been well studied, resulting in a debatable understanding of their sulfide mineralization and magmatic conduit systems (Gao et al., 2012, 2013; Su et al., 2013).

Many important magmatic Ni–Cu (–PGE) sulfide deposits are distributed along the southern margin of the Central Asian Orogenic Belt (CAOB), including Kalatongke (Gao et al., 2012), Huangshandong (Sun et al., 2013), Erbutu (Peng et al., 2013), Heishan (Xie et al., 2013) and Hongqiling (Wei et al., 2013) (Fig. 1a). The Eastern Tianshan region is projected to become an important source of Ni and Cu metal in the CAOB, especially from those deposits along the Huangshan–Kangguer fault (Fig. 1b). Study of these Ni–Cu (–PGE) sulfide deposits provides us with the possibility to understand how their magmatic conduit systems evolved and to examine the relationship between their sulfide mineralization and the sequence of magmatic emplacement in the Eastern Tianshan region. In addition, most mafic–ultramafic intrusions in the Eastern Tianshan were intruded between 300 and 270 Ma, which is similar to the eruption age of the ~280 Ma alkaline basalts of Tarim plume in northwest China. Whether these mafic–ultramafic intrusions were related to the Tarim mantle

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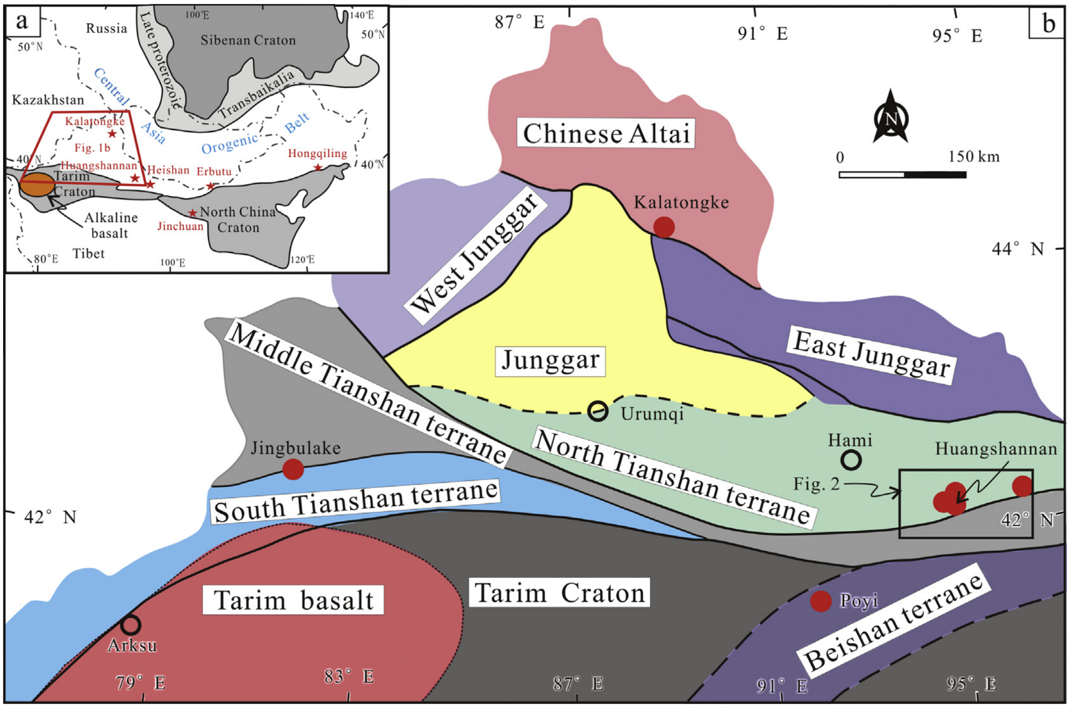

Fig. 1. (a) Simplified tectonic units of Asia (modified from Jahn, 2004). (b) The distribution of magmatic Cu–Ni sulfide deposits associated with mafic–ultramafic intrusions in northern Xinjiang (modified from Sun et al., 2013).

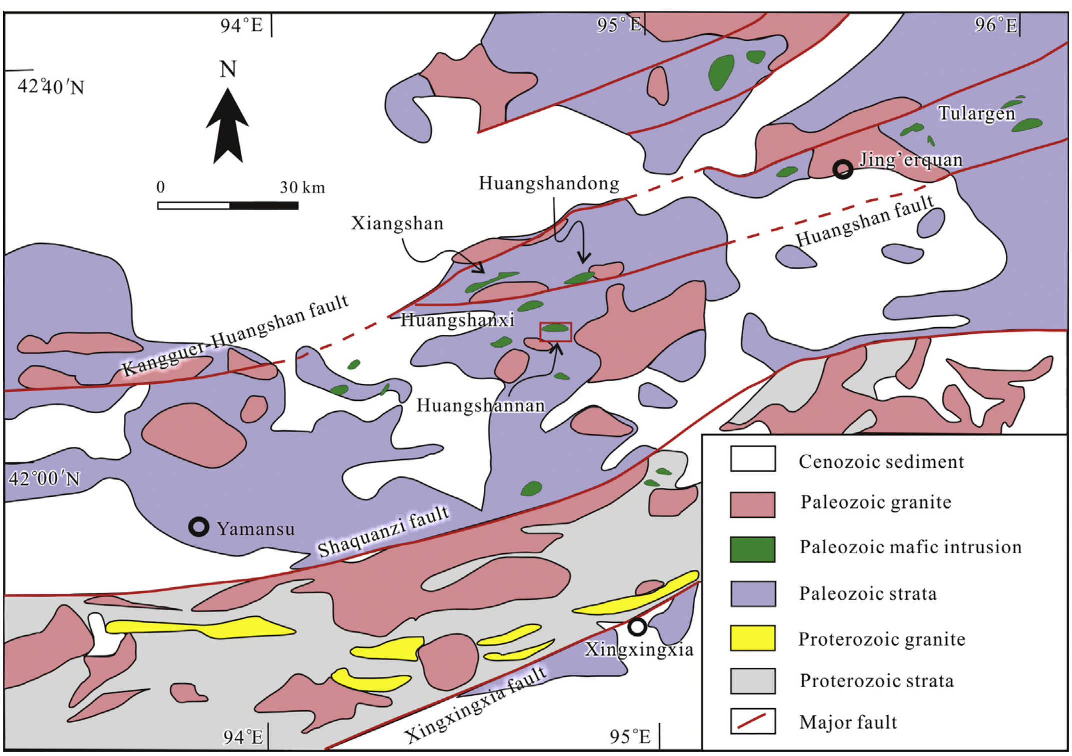

Fig. 2. Simplified geological map of the Huangshan area and the distribution of magmatic Ni–Cu (–PGE) deposits. (Modified from Wang et al., 2006; Gao et al., 2013).

plume (e.g., Pirajno et al., 2008; Qin et al., 2011; Tang et al., 2011; Mao et al., 2003) or to a post-collisional setting (e.g., Gao and Zhou, 2013; Gao et al., 2013; Sun et al., 2013) is still debatable.

The Huangshannan Ni–Cu (–PGE) sulfide deposit is a new discovery from geological prospecting in Eastern Tianshan in recent years and has attracted the interest of many Chinese geologists. The deposit contains about 30 million metric tons (Mt) of sulfide ore with an average grade of 0.4 wt% Ni and 0.12 wt% Cu. The size and grade of the Huangshannan deposit makes it a good choice for studying the evolution of a magmatic mineralization system in an orogenic belt, given that there has been almost no geological research to date on the topic.

In this paper, we describe the geology of the Huangshannan intrusion and the varieties of sulfide ores found within its different