Lithos 261 (2016) 340–355

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Geochronology, fluid inclusions and isotopic characteristics of the Chaganbulagen Pb–Zn–Ag deposit, Inner Mongolia, China

Tiegang Li [a,b], Guang Wu [b,*], Jun Liu [b], Guorui Wang [b], Yanqing Hu [c], Yunfu Zhang [c], Dafeng Luo [c], Zhihao Mao [a], Bei Xu [d]

[a] School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, PR China
[b] Key Laboratory of Metallogeny and Mineral Assessment, Ministry of Land and Resources, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, PR China
[c] Yunnan Chihong Resources Exploration and Development Limited Liability Company, Qujing 6550000, PR China
[d] Key Laboratory of Orogen and Crust Evolution, Ministry of Education, Peking University, Beijing 100871, PR China

ARTICLE INFO

Article history:
Received 17 July 2015
Accepted 28 April 2016
Available online 6 May 2016

Keywords:
Sericite $^{40}Ar-^{39}Ar$ age
Zircon U–Pb age
Fluid inclusion
H–O–S–Pb isotopes
Chaganbulagen Pb-Zn-Ag deposit
Inner Mongolia

ABSTRACT

The large Chaganbulagen Pb–Zn–Ag deposit is located in the Derbugan metallogenic belt of the northern Great Xing'an Range. The vein-style orebodies of the deposit occur in the NWW-trending fault zones. The ore-forming process at the deposit can be divided into three stages: an early quartz–pyrite–arsenopyrite–pyrrhotite–sphalerite–galena–chalcopyrite stage, a middle quartz–carbonate–pyrite–sphalerite–galena–silver-bearing minerals stage, and a late quartz–carbonate–pyrite stage. The sericite sample yielded a $^{40}Ar-^{39}Ar$ plateau age of 138 ± 1 Ma and an isochron age of 137 ± 3 Ma, and the zircon LA-ICP-MS U–Pb age of monzogranite porphyry was 143 ± 2 Ma, indicating that the ages of mineralization and monzogranite porphyry in the Chaganbulagen deposit should be the Early Cretaceous, and that the mineralization should be slightly later than the intrusion of monzogranite porphyry. There are only liquid inclusions in quartz veins of the Chaganbulagen deposit. Homogenization temperatures, densities, and salinities of the fluid inclusions from the early stage are 261–340 °C, 0.65–0.81 g/cm^3, and 0.7–6.3 wt.% NaCl eqv., respectively. Fluid inclusions of the middle stage have homogenization temperatures, densities, and salinities of 209–265 °C, 0.75–0.86 g/cm^3, and 0.5–5.7 wt.% NaCl eqv., respectively. For fluid inclusions of the late stage, their homogenization temperatures, densities, and salinities are 173–219 °C, 0.85–0.91 g/cm^3, and 0.4–2.7 wt.% NaCl eqv., respectively. The ore-forming fluids of the deposit are generally characterized by moderate temperature and low salinity and density, and belong to an H_2O–NaCl ± CO_2 ± CH_4 system. The $\delta^{18}O_{water}$ values calculated for ore-bearing quartz vary from −17.9‰ to −10.8‰, and the $\delta D_{V\text{-}SMOW}$ values from bulk extraction of fluid inclusion waters vary from −166‰ to −127‰, suggesting that the ore-forming fluids consist dominantly of meteoric water. The $\delta^{34}S_{V\text{-}CDT}$ values range from 1.4‰ to 4.1‰. The $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$ values of the ore minerals are in the ranges of 18.302–19.037, 15.473–15.593, and 38.110–38.945, respectively. The data for the S and Pb isotopic systems indicate that the ore-forming metals and sulfur came from Mesozoic magma. The Chaganbulagen deposit is a low-sulfidation epithermal Pb–Zn–Ag deposit, and the temperature decrease is the dominant mechanism for the deposition of ore-forming materials.

1. Introduction

The Manzhouli area, located in the northeastern part of Inner Mongolia, bordering Mongolia to the west and Russia to the north (Fig. 1a), is one of the most important Pb–Zn–Ag–Cu–Mo metallogenic regions in China. To date, a great number of economically important porphyry Cu–Mo deposits (e.g., Wunugetushan and Badaguan), medium–low temperature hydrothermal vein-type Pb–Zn–Ag deposits (e.g., Jiawula and Chaganbulagen), and low-sulfidation epithermal Ag deposits (e.g., Erentaolegai) have been discovered (Liu et al., 2014; Wu et al., 2010). The Chaganbulagen and Jiawula deposits are only 5 km apart and are connected by the NWW-trending Jiawula–Chaganbulagen (Jia–Cha for short) fault, with the former developed in the southeast segment and the later in the northwest segment of the Jia–Cha fault. In addition, a few Cu–Zn–Sn skarns (e.g., Longling) and numerous high-sulfidation epithermal Cu–Au mineral occurrences (e.g., Bayanhaolei and Daba) have also been discovered in this area (Fig. 1b).

Previous studies in this area have mainly described geological characteristics of typical deposits (Qi et al., 2005; Zeng, 2010), host rock features and mineral paragenesis (Chen et al., 2008; Qin et al., 1999; Sheng and Fu, 1999), genetic classification (Nie et al., 2011; Yang et al., 2009), and fluid inclusions properties (Shuang, 2012; Wu et al., 2007, 2010; Zhai et al., 2010). But reliable ore-forming ages for the Chaganbulagen

* Corresponding author.
E-mail address: wuguang65@163.com (G. Wu).

http://dx.doi.org/10.1016/j.lithos.2016.04.029
0024-4937/

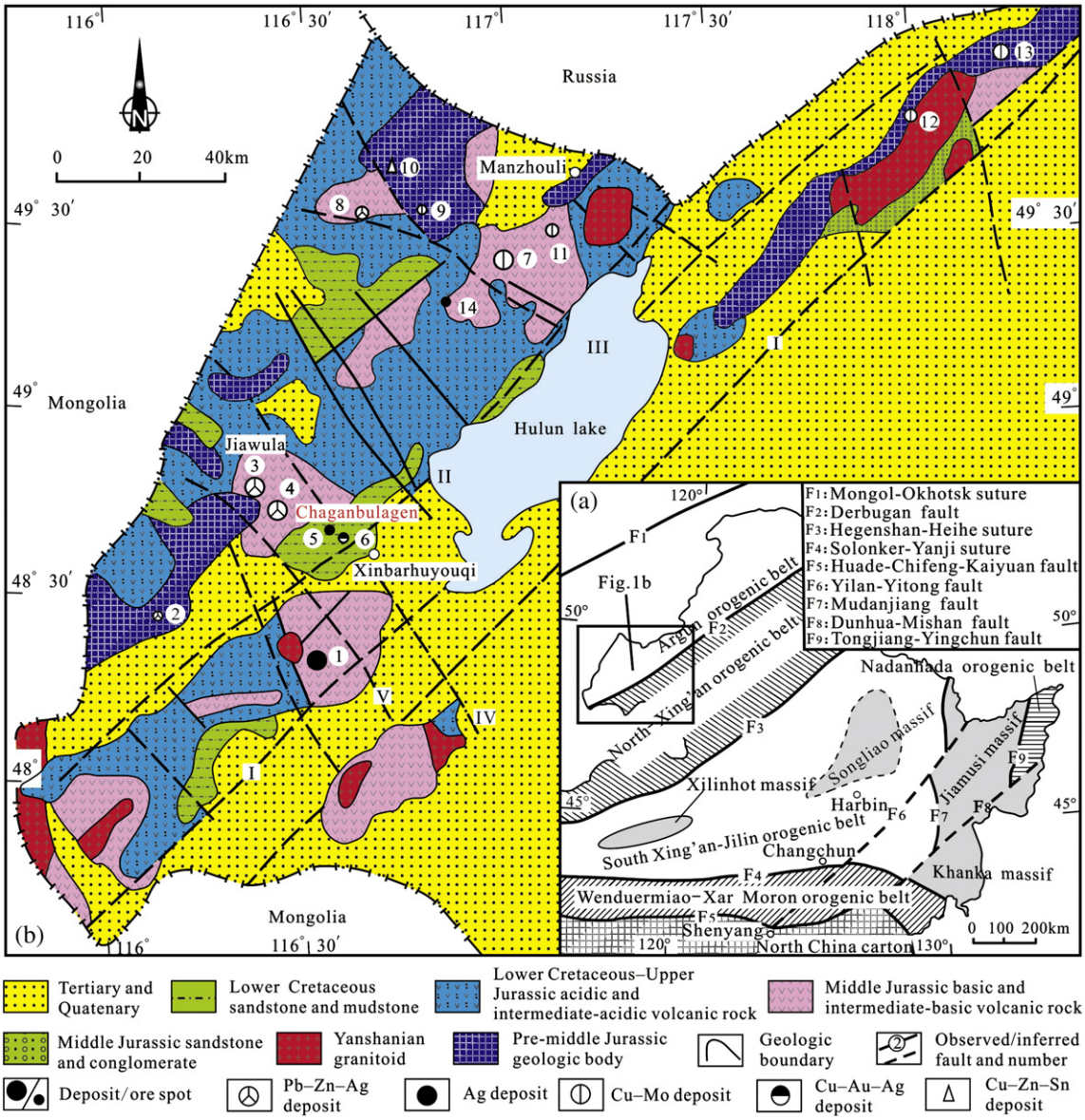

Fig. 1. Regional geological map of the Manzhouli area, Inner Mongolia, showing (a) geotectonic units and (b) locations of major deposits/occurrences (modified from Ge et al., 2007; Wu et al., 2010; Zhao and Zhang, 1997). 1, Erentaolegai low-sulfidation epithermal Ag deposit; 2, Wuqigenwula vein-type Pb–Zn–Ag occurrence; 3, Jiawula vein-type Pb–Zn–Ag deposit; 4, Chaganbulagen vein-type Pb–Zn–Ag deposit; 5, Erdengwula low-sulfidation epithermal Ag occurrence; 6, Bayanhaolei high-sulfidation epithermal Cu–Au occurrence; 7, Wunugetushan porphyry Cu–Mo deposit; 8, Halasheng vein-type Pb–Zn deposit; 9, Changling porphyry Cu–Mo occurrence; 10, Longling skarn Cu–Zn–Sn occurrence; 11, Toudaojing porphyry Cu–Mo deposit; 12, Babayi porphyry Cu–Mo deposit; 13, Badaguan porphyry Cu–Mo deposit; and 14, Daba high-sulfidation epithermal Cu–Au occurrence; I, Derbugan fault; II, Argunhe–Hulun fault; III, Hanigou fault; IV, Muhar fault; and V, Jiawula–Chaganbulagen fault.

Pb–Zn–Ag deposit have not been reported. Furthermore, sources for the ore-forming fluids and genetic classification of the Chaganbualgen Pb–Zn–Ag deposit are also controversial. Zhao and Zhang (1997) and Sheng and Fu (1999) reported a K–Ar age of 133–110 Ma and a single grain zircon U–Pb age of 139.2 Ma, respectively, for monzogranite porphyry that is spatially related to the Chaganbualgen deposit. However, these ages have a wide range and cannot directly represent the age of mineralization. As for sources of the ore-forming fluids, Pan et al. (1990) pointed out that the ore-forming fluids were mainly from the magmatic water, but Xie and Liu (2001) considered that they were mainly from the meteoric water. The Pb–Zn–Ag deposits in the Manzhouli area have mainly been classified as one of the two genetic types of deposits: medium–low temperature hydrothermal vein-type deposits (Wu et al., 2010; Zhao and Zhang, 1997) or low-sulfidation epithermal deposits (Li et al., 2015; Xie and Liu, 2001; Zhao and Wu, 2002). In this paper, we present new sericite $^{40}Ar - {}^{39}Ar$ age, zircon LA-ICP-MS (laser ablation multi-collector inductively coupled plasma mass spectrometry) U–Pb age, analyses of fluid inclusions, and H–O–S–Pb isotopes. The purpose of this study is to classify the deposit type, determine the mineralization age, reveal the characteristics of the ore-forming fluids and their evolution, and discuss the sources of ore-forming fluids and metals of the Chaganbulagen deposit.

2. Regional geology

The Manzhouli region is located in the southeastern margin of the Argun orogenic belt, also referred to as the Argun massif, which belongs to the eastern segment of the Sayan–Central Mongolia–Argun orogenic belt. The NE-trending Argun orogenic belt is one of the key tectonic units in northeastern China and is bounded by the Mesozoic Mongolia–Okhotsk suture to the northwest and the Derbugan fault to the southeast (Fig. 1a). This orogenic belt experienced a complicated