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Ore genesis and fluid evolution of the Kaladawan South Zn–Pb–Cu ore field, eastern Altyn Mountains (NW China): Evidence from fluid inclusions, H–O isotopes and geochronology

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ABSTRACT

The newly-discovered Kaladawan South Zn–Pb–Cu orefield in eastern Altyn Mountains is composed of five Zn–Pb(–Cu) deposits, with the largest one containing 414.4 thousand tonnes (kt) Zn, 265.2 kt Pb and 149.2 kt Cu. Stratiform/lenticular orebodies are hosted by the Ordovician volcanic–sedimentary sequences subjected to greenschist-facies metamorphism. Two major ore-forming stages with significant cross-cutting relationship are identified at Kaladawan South: Stage (I) of the earlier massive, banded, disseminated barite-rich sulfide ores, and Stage (II) of the later polymetallic sulfide–quartz veins with economically less importance. Fluid inclusions (FIs) locked in quartz of Stage I massive sulfide ores are homogenized completely at 226–354 °C with calculated seawater-like salinities of 2.7–4.2 wt% NaCl equiv. These characteristics of ore-forming fluids coupled with ore textures of typical VMS deposits, are interpreted to be originated from the modified seawater by sea-floor volcanic-hydrothermal activities. In compared, the Stage II FIs yielded lower homogenization temperatures ranging 251 °C–357 °C with higher salinities of 0.8–14.4 wt% NaCl equiv. Laser Raman analyses identified large amounts of CO_2 ± (CH_4–N_2) in the hydrothermal fluids of Stage II. The $\delta^{18}O_{H2O}$ values (0.5–5.7‰) and δD_{H2O} values of (−68.1‰ to −32.3‰) of Stage II quartz are plotted in the range of metamorphic fluids in the D–O isotopic diagram, which indicating that the CO_2-rich and mesothermal fluids are metamorphic-derived. The phlogopite paragenetic in the Stage II polymetallic vein yielded a $^{40}Ar/^{39}Ar$ plateau age of 435.4 ± 3.9 Ma, similar to the age of the metamorphic muscovite (451.0 ± 4.1 Ma) from the ore-hosting schist. Based on the ore deposit geology, mineral assemblages and fluid geochemistry, the Kaladawan South Zn–Pb–Cu mineralization is attributed to be an Ordovician VMS-type deposit overprinted by the Silurian metamorphic fluids.

1. Introduction

Volcanogenic massive sulfide (VMS) deposits provide large amounts of Zn, Pb and Cu reserves, and are widely distributed in ancient orogenic belts or modern seafloor (Franklin et al., 2005, 1981; Hannington et al., 2005; Huston et al., 2010). Investigations on the modern seafloor black smokers have contributed immensely to our understanding about the hydrothermal fluids, tectonic framework and metallogeny for VMS mineral systems (Francheteau et al., 1979; Hannington et al., 2005; Hekinian et al., 1980; Iizasa, 1999; Pat Shanks III and Thurston, 2012; Spiess et al., 1980). The vast majority of VMS deposits and their volcanic host rocks preserved in orogenic belt have undergone complicated metamorphic and tectonic modifications (Mosier et al., 2009). These post-mineralization modifications can generate physical and chemical changes of the pre-existing VMS ores (Gilligan and Marshall, 1987; Marshall et al., 2000; Marshall and Gilligan, 1993, 1987). During the processes, the ores have commonly upgraded enhancing the economic values.

The newly-discovered Kaladawan South Zn–Pb–Cu ore field, located in the eastern part of the Altyn Mountains, contains the Kaladaban, Kaladawan West, Genxinggou and Cuiling Zn–Pb(–Cu) deposits, as well as a number of Zn–Pb(–Cu) prospects. The Kaladaban Zn–Pb–Cu deposit (41.4 kt Zn, 26.5 kt Pb, 14.9 kt Cu) is the largest in the ore field. Previous studies on the Kaladawan South Zn–Pb–Cu mineralization focused mainly on the geochemistry of the host rocks and the S–Pb isotopes of the ores (Chen et al., 2017; Cui, 2010; Liu et al., 2012). Different genetic models have been proposed for these Kaladawan South deposits, including syngenetic exhalative–sedimentary (Chen et al., 2017), magmatic hydrothermal (Zhang et al., 2015) and epigenetic hydrothermal origin (Liu et al., 2012), and the source of the ore-

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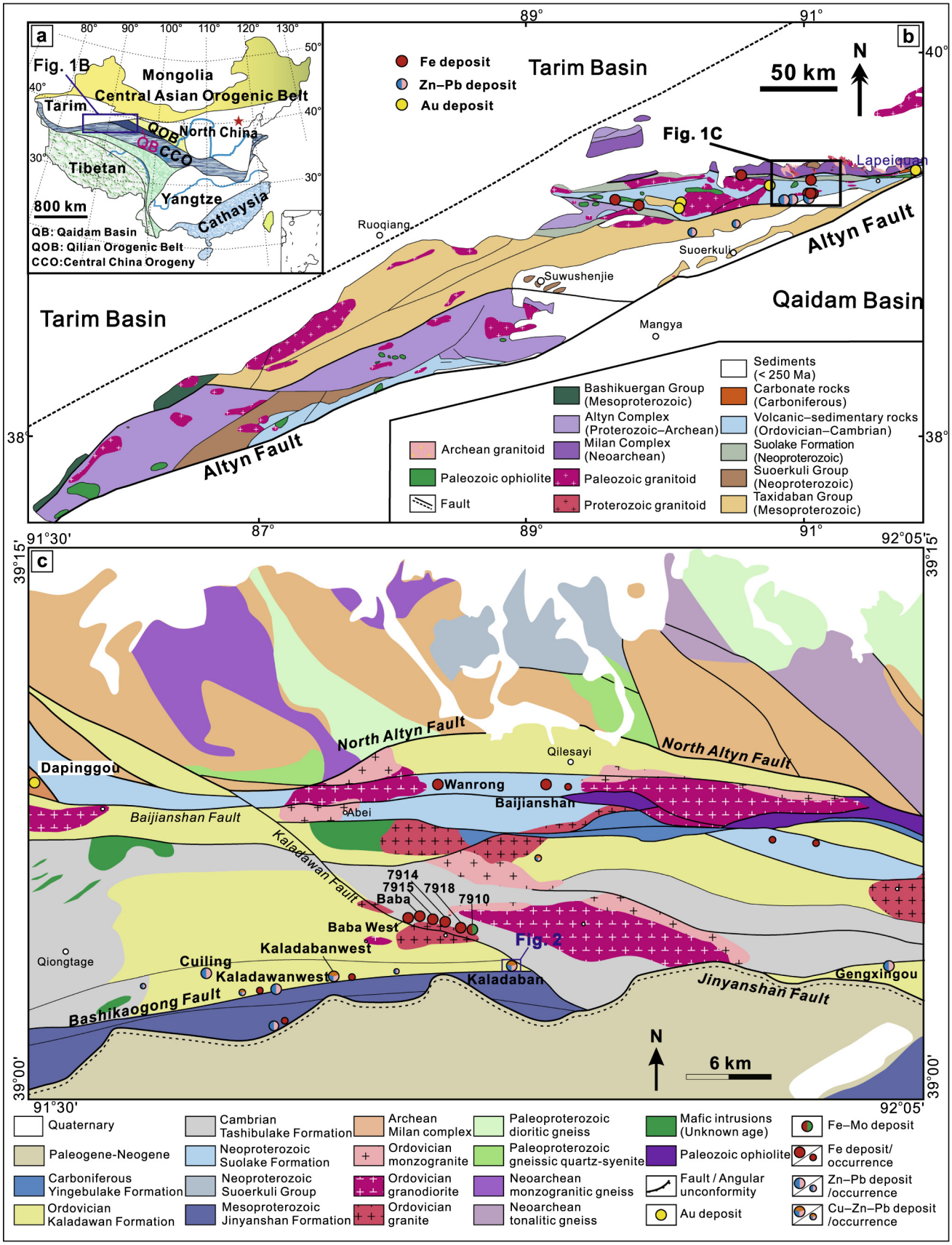

Fig. 1. (a) Tectonic framework of China, showing the location of the Altyn Mountains (modified after Li et al. (2012)). (b) Geologic map of the Altyn Mountains and the location of Kaladawan district. (c) Geologic map of the Kaladawan district, showing the location of the Kaladawan South Zn–Pb–Cu orefield (modified after Wang et al. (2017)).