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Basin evolution and stratigraphic correlation of sedimentary-exhalative Zn–Pb deposits of the Early Cambrian Zarigan–Chahmir Basin, Central Iran

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ABSTRACT

The Zarigan–Chahmir basin is placed in the southern part of a crustal domain known as the Central Iranian microcontinent, at the northwestern margin of Gondwana. This basin hosts abundant mineral deposits, particularly of the iron oxide–apatite (IOA), Fe–Mn exhalative, and Zn–Pb sedimentary-exhalative (SEDEX) types. The evolution of this basin is governed by the Proto-Tethys oceanic crust subduction beneath the Central Iranian microcontinent and by the resulting continental arc and back-arc. This evolution followed two major stages of rifting: (I) Stage I or syn-rift phase, related to intra-basin extension, is indicated by coarse-grained detrital sedimentary rocks and bimodal volcanism (basis of the Early Cambrian Volcano-Sedimentary Sequence; ECVSS), which filled half-graben systems. During this stage, tuff-hosted stratiform, exhalative Fe–Mn deposits along with Kiruna-type IOA deposits formed. The former deposits (e.g., Narigan) are related to early submarine rhyolithic volcanism of the rift-phase sequence, whereas the latter (e.g., Esfordi, Choghart, Chadormalu, Chahgaz) are connected to hydrothermal activity directly linked to the arc calk-alkaline magmatism. (II) Stage II or sag-phase involved the deposition of calcareous shales, siltstones and carbonates (upper part of the ECVSS). Sedimentation during this phase was controlled by basin subsidence and by the reactivation of the half-graben faults. SEDEX deposits are hosted within a carbonaceous, black siltstone unit of the sag-phase sequence, which was deposited during a period of rapid basin subsidence and under anoxic conditions. The location of synsedimentary faults and the prevalence of poorly-oxygenated bottom water conditions were key factors controlling SEDEX mineralization processes in the basin. A high geothermal gradient caused by maximum syn-rift magmatism and sub-crustal lithospheric thinning, affecting primarily the center, western and northwestern basin, may have driven a basin-scale hydrothermal fluid circulation. This finding explains the occurrence of larger, well correlable SEDEX deposits in the northwestern and central parts of the Zarigan–Chahmir basin.

1. Introduction

The central lithotectonic domain of the Posht-e-Badam Block, within the Central Iranian microcontinent, contains the oldest (Late Neoproterozoic) basement of Iran. The Zarigan–Chahmir basin is located in the southern section of this lithotectonic domain (Fig. 1a) and hosts abundant mineral deposits, particularly those of the iron oxide–apatite (IOA), Fe–Mn exhalative, and Zn–Pb sedimentary-exhalative (SEDEX) types, being one of the main metallogenic provinces in Iran. The economically most important SEDEX Zn–Pb deposits of this basin include Koushk, Chahmir and Zarigan (Rajabi et al., 2012a).

The Zarigan–Chahmir basin — also known as the Bafq mining district — and its ore deposits have been the subject of many geological studies (Daliran, 2002; Daliran et al., 2009, 2010; Förster and Jafarzadeh, 1994; Nadimi, 2007; Rajabi, 2008, 2012; Rajabi et al., 2012a, submitted for publication; Ramezani and Tucker, 2003; Stosch et al., 2011; Yaghubpur and Mehrabi, 1997). However, there are still many unanswered questions regarding the Zn–Pb, Fe–Mn and IOA metallogenesis at the regional scale, including their stratigraphic and tectonic links.

In comparison with other ore deposit types in Iran, SEDEX Zn–Pb deposits and their tectonic setting are not fully elucidated and remain

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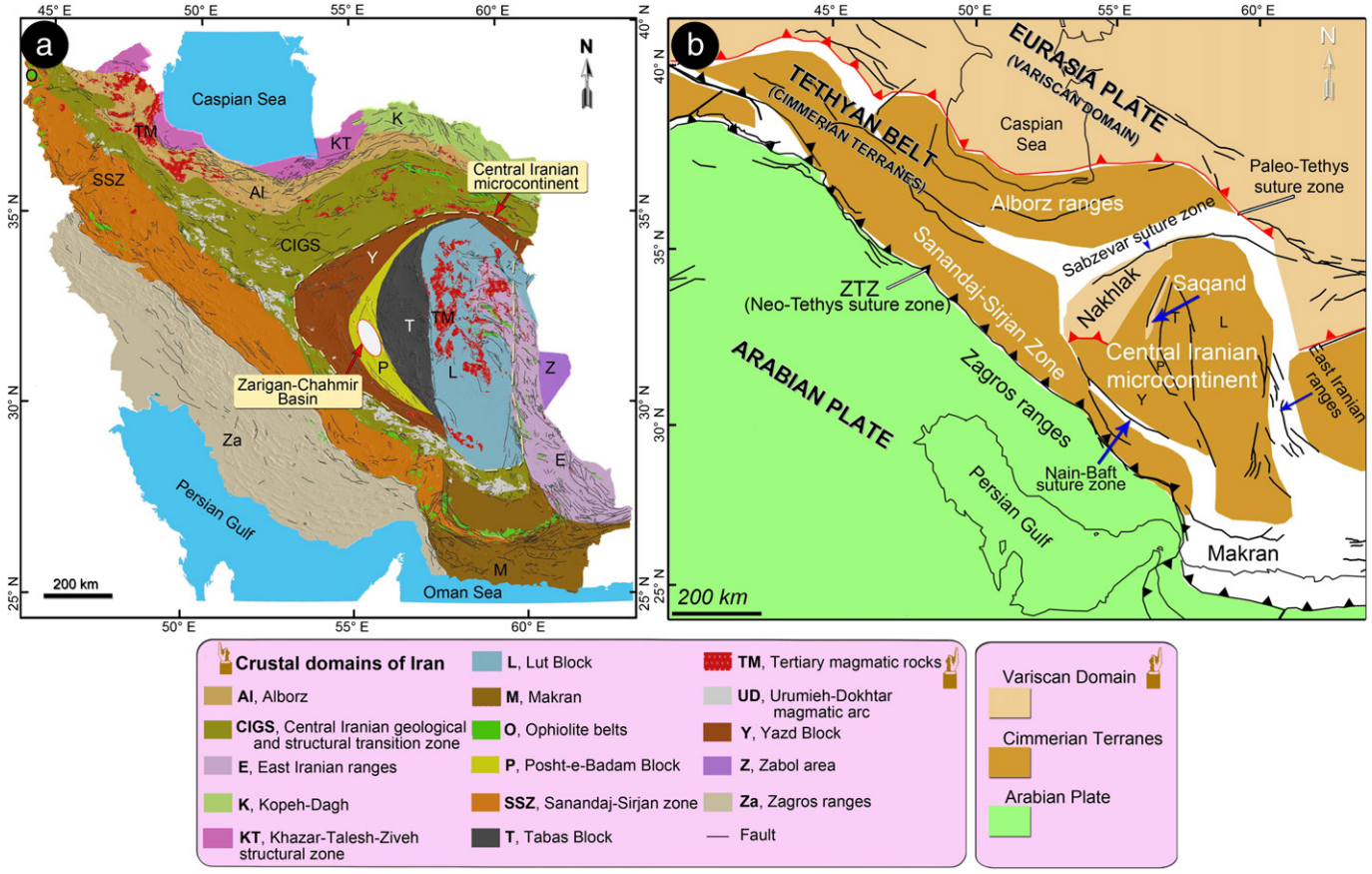

Fig. 1. (a) Simplified structural map of Iran (Aghanabati, 1998) and location of the Zarigan–Chahmir basin in the Posht-e-Badam Block. (b) Eastern part of the Terranes map of the western Tethysides (Rajabi et al., 2012b; modified after Stampfli, 2009; according to Bagheri and Stampfli, 2008). Note the location of the Iran Plate (Iranian Cimmerian terranes) between the Variscan domain in the north and the Arabian Plate in the southwest. ZTZ: Zagros Thrust Zone.

subject to considerable debate. Although detailed, mine-scale geological studies have provided key information to establish deposit-scale models for SEDEX Zn–Pb mineralizing processes; no previous study has focused on explaining why these deposits occur in a particular setting and stratigraphic position.

The aim of this paper is to provide an integrated metallogenic model, at the regional scale, for the SEDEX Zn–Pb mineralizations in the Central Iranian microcontinent, based on an accurate revision of recent geological data and on a tectono-sedimentary interpretation of the host sequence (the Early Cambrian Volcano-Sedimentary Sequence; ECVSS) and of the host basin. In addition, the geological factors controlling the SEDEX Zn–Pb metallogenesis and key questions explaining when, where and why these mineralizations formed are proposed and discussed in this study.

2. Regional geological setting

The crustal domain referred to as the Central Iranian microcontinent is a composite of three major structural zones, from E to W (Alavi, 1991): the Lut, Tabas, and Yazd blocks (Fig. 1a and b). The boundaries are defined by regional-scale faults (Fig. 1). In addition, there is the Posht-e-Badam Block (Alavi, 1991), a fault-bound, variably deformed and metamorphosed complex of supracrustal rocks that separates the Tabas and Yazd blocks (Fig. 1). Alternatively, Ramezani and Tucker (2003) defined the Kashmar–Kerman structural zone between the Yazd and Tabas blocks, coinciding with the eastern portion of the Posht-e-Badam Block of Alavi (1991) but with slightly different boundaries: the Kuhbanan–Kalmard Fault to the E and the Posht-e-Badam Fault to the W (Fig. 2).

The Posht-e-Badam Block is located within an area defined between three major fault systems (Alavi, 1991): the Chapedony, Kalmard and Kuhbanan faults (Fig. 2). A Precambrian crystalline basement and Early Cambrian to Tertiary sedimentary cover are exposed in the block (Förster and Jafarzadeh, 1994). The Precambrian basement consists of medium- to high-grade metamorphic rocks, Late Neoproterozoic in age, grouped in the Boneh-Shurow and Posht-e-Badam complexes (Figs. 3 and 4, Ramezani and Tucker, 2003; Verdel et al., 2007). The bulk of the Posht-e-Badam complex consists of a variable association of greenstones, schists, meta-greywackes, marbles, gneisses, amphibolites, pyroxenites, serpentinites, meta-basalts and conglomerates (Haghipour and Pelissier, 1977). This complex is exposed west of the Posht-e-Badam Fault (Fig. 3) and is severely disrupted by Triassic granitic plutons (Ramezani and Tucker, 2003). The Boneh-Shurow complex, which is the most widely exposed metamorphic unit, crops out east of the Posht-e-Badam Fault (Figs. 3 and 4, Haghipour and Pelissier, 1977). This complex is approximately 2000 m thick and exhibits a variety of metamorphic rocks, including quartz–feldspathic gneisses, green mica–schists and amphibolites (Aghanabati, 2008). Zircon U/Pb dating of this complex indicates an age of 602–617 Ma (Ramezani and Tucker, 2003).

The Boneh-Shurow complex is covered by a 2000-m-thick sequence of greywackes, quartzites and quartzitic schists, marbles, amphibolites, gneiss, slaty-shales, basaltic lavas, sandstones and arkosic arenites, argillites, tuffaceous rocks and limestones belonging to the Tashk Formation, of Late Neoproterozoic to Early Cambrian age (Ramezani and Tucker, 2003) that partly metamorphosed to the greenschist facies.

During the Early Cambrian, granitic plutons intruded the Precambrian sequence of the Tashk Formation, and felsic to intermediate volcanic and volcano-sedimentary rocks of the ECVSS were deposited. The