Research Progress in Metallogenic Rules of Pb-Zn Ores in Western Guizhou, China

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Abstract. Current situation of research on metallogenic rules of Pb-Zn ores in western Guizhou Province is summarized in combination with previous research materials. The results suggest that many scholars have explored metallogenic rules of Pb-Zn ores and achieved abundant outcomes, generally concluding that Pb-Zn deposits of Western Guizhou Province are similar to MVT and ore-forming material sources are diverse, details about metallogenic epoch, material sources and metallogenic mechanisms of Pb-Zn ores are still quite controversial and remain to be confirmed with new methods or materials through further research.

1. Introduction
Western Guizhou Province is rich in Pb-Zn ores, which have been investigated by many experts and scholars (Jin, 2006; Nie et al., 2007,2014; Zhang, 2005; Li et al.,2012), who have gained abundant outcomes in their research. Although plenty of experts and scholars have explored Pb-Zn ores of northwestern Guizhou Province, so far categories of Pb-Zn deposits are still rather controversial. In this paper, the author summarizes previous research materials to know about research progress in metallogenic rules of Pb-Zn ores in western Guizhou Province and discuss metallogenic rules of these ores in that area.

2. Geological Background of Metallogenesis
Sichuan, Yunnan and Guizhou provinces are the most potential areas of super large Pb-Zn ores and gold deposits in China (Tu et al., 2000). Located in the southwestern margin of Yangtze Para platform and in the east of the Xikang Yunnan axis, western Guizhou Pb-Zn ores are upper Yangtze metallogenic sub provinces of the met allogenic provinces on Yangtze paraplatform as integral parts of areas with polymetallic ores in Sichuang, Yunnan and Guizhou provinces (Jin, 2006). Arranged in order from the old to the new, exposed strata include Simian Dengying Formation, cambrian, silurian, devonian, carbonic, Permian, Triassic, Jurassic, tertiary and quaternary, among which Permian Emeishan Basalt is distributed most widely within the province.
3. Features of Ores in Pb-Zn Ores
In these ores, ores are mostly massive, vein-shaped and impregnated mainly with idiomorphic-hypidiomorphic textures, allotriomorphic granular textures, metasomatic intersertal textures, pressure textures and frambooidal textures (Jin et al., 2006; Zhang, 2016). Sphalerite, galenite and pyrite are major minerals, followed by chalcopyrite, limonite, hydrozincite and malachite and so on, while the gangue minerals mainly include dolomite, calcite, barite, quartz and fluoride and so on (Zhang, 2005).

4. Metallogenic Epoch
Mineragenetic epoch of Pb-Zn ores is still controversy, concerning which there are mainly several views as follows: 1) Period of hercynian orogeny - Yanshan orogeny (Liu, 1995); 2) late permian period (Huang et al, 2001); 3) period of Yanshan orogeny (Ou, 1996; Qin, 2016; Zhang, 2016); 4) period of Himalayan oroge (Zhou, 1998); there is a lack of effective symbols for dating Pb-Zn ores, so related problems still remain to be solved although metallogenic epoch of Pb-Zn ores of northwestern Guizhou Province have been explored by numerous experts and scholars. In the future, more efforts can be made to perform related research and look for suitable authigenic minerals for dating Pb-Zn ores, or else it is impossible to identify metallogenic epoch of these ores.

5. Geochemical Characteristics
Being Mn, In, Sn and Cd deficient, trace elements are rich in Ce, Ga (content changes within a narrow scope), Pb, Ag and as (content changes within a wide range), which indicates that deposits are metallogenic at low temperature (Li et al., 2016). Pb, Zn and Ag have significant positive correlations to As, Sb and Cd in ores of all deposits, where the content of rare earth elements is much lower than ore-bearing wall rocks, which indicates that source beds are not major sources of ore-forming materials (Jin, 2006). The geochemical characteristics of Pb-Zn ores suggest that apart from lead and zinc, no other elements are found to be apparently rich in these ores. For instance, the trace elements haven’t been discovered in relatively common strata rich in rare earth elements in bauxites of WZD area- Zunyi of northern Guizhou Province (Fig 2, a), areas like Kaili - Huangping in middle Guizhou Province and iron ores in northwestern Guizhou Province (Fig 2, b), which suggests that neither rare earth elements nor other elements have heavily precipitated and enriched during metallogenesis of Pb-Zn ores.
6. Types and Metallogenic Causes of Deposits

Pb-Zn deposits are mainly divided into 3 categories, including volcanogenic massive sulfide (VMS) deposits, MVT Pb-Zn deposits and SEDEX (sedimentary exhalative deposits) Pb-Zn deposits. Except three main types, there are some transitional types. Zhang (2005) considers that Pb-Zn ores of Western Guizhou Province are MVT deposits, while these ores are thought to be similar to MVT deposits by Jin (2006) who deems that they differ from each other to certain extent. Qin et al. (2016) thinks that all above three types of deposits are seen in adjacent areas of Sichuan, Yunnan and Guizhou provinces, but they are mostly MVT deposits in western Guizhou.

The metallogenic mechanism of Pb-Zn ores in this area has been studied by lots of experts and scholars, among whom Liu (1995) regards that the ores are epigenetic after sedimentation and regeneration. In other words, they are sedimentary deposits, but regenerated in the later stage; Chen (1986) deems that the deposits have formed after sedimentation and in-situ regeneration, while Zhang (2016) and Peng et al. (2016) thinks that the metallogenesis of the deposits shall be attributable to hydrothermal regeneration and superimposition during diagenesis. Zhao (1995) and Chen (2012) have reported that Pb-Zn ores form through sedimentation and regeneration. Scholars such as Zhang (2005), Qin et al. (2016) and Li (2016) consider that like MVT Pb-Zn ores, these ores also belong to MVT Pb-Zn deposits. Liu (2016) deems that the Pb-Zn deposits are volcanic hotwater sedimentary deposits. Although theory of mantle plume has aroused great concern and led to intensive research on mantle plume, many scholars think that the genesis of Pb-Zn ores in northwestern Guizhou Province is related to Emei mantle plume activity (Huang, 2001; Han, 2001; Nie 2014). Based on existing research, it may be discovered that there are multiple views about metallogenic causes of deposits of Pb-Zn ores in northwestern Guizhou Province. Although their ore body features and metallogenic rules suggest that the Pb-Zn ores in western Guizhou are similar to MVT Pb-Zn deposits, the final conclusions can’t be reached until intensive research, on the grounds that deposits with similar ore body features and metallogenic rules would also appear among different categories of deposits. The author considers that the metallogenesis of Pb-Zn ores in western Guizhou is attributed to multiple factors, repeated metallogenesis or alternation. The geochemical characteristics of Pb-Zn ores suggest that sedimentation and regeneration are possibly not the major metallogenic causes of these ores.

7. Conclusions

After a comprehensive summary and analysis of previous research materials, following conclusions are reached: 1) Ore features, ore body characteristics and distribution laws of Pb-Zn ores have been explored relatively clearly. 2) Metallogenic epoch and deposit type of Pb-Zn ores are still quite controversial that they remain to be investigated more deeply. 3) The metallogenesis of Pb-Zn ores is attributable to superimposed metallogenesis, whereas sedimentation wouldn’t be the major metallogenetic cause of Pb-Zn ores. 4) The enrichment of associated elements like rare earth elements
is not evident in Pb-Zn ores, so there is no great potential for comprehensive or independent development of these ores in view of existing research.

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