A brief analysis on contribution of Emeishan basalt to the formation of deposits in Guizhou

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Abstract. All Based on previous data and field research, we consider that Emeishan basalt is important for genesis of numerous mineral resources in the southwest and northwest of Guizhou Province, and distribution of different types of mineral resources may be used as reference for geological surveys. With the advancement of technologies, aluminium and rare earth elements will have great potential for development.

1. Introduction
At present, Emeishan basalt is the only one that is recognized by the international academic circle as large igneous province in China (Courtillot et al., 1999). It has been studied by Mei Houjun and Huang Kainian et al since the 1980s (Huang, 1988; Nie, 2014), investigated by many scholars from the perspective of its distribution features, formation time, petrology, geochemistry and isotopes in their studies, where numerous outcomes have been gained (Zhang et al., 2003; Song et al., 2005; Xu et al., 2002; Hu et al., 2005; Ni, 2007, 2014; Qian et al., 2007; Zhu et al., 2011; Meng et al., 2015; Li, 2014). The content of many elements in Emeishan basalt is above the background value of the crust. Emeishan basalt has gone through multistage denudation during its eruption and genesis. Owing to its relatively high content of elements, weathering, denudation and enrichment, the formation of multiple minerals has become possible. In spite of numerous previous research outcomes, there has been very little research about metallogenic regularity of Emeishan basalt across the Southwest China. According to previous research outcomes, multiple mineral resources of Emeishan basalt are statistically analyzed in a comprehensive manner, and their contributions are discussed to analyze causes of metallogenic differences in Emeishan basalt among different areas.

2. Distribution of Emeishan Basalt
Emeishan basalt originally meant the basalt on the Maokou Formation in mountainous areas of Emeishan in southwestern Sichuan Province, whereas it was generally known as trap extensively distributed in three provinces of southwestern China, especially represented by late Permian basalt (Fig 1), and widely utilized by a formal lithostratigraphic unit of the Upper Permian (Bureau of Geology and Mineral Resources of Sichuan Province, 1991). With a volume that appropriately equaled to 0.3x10⁶KM³, Emeishan basalt is differs in thickness in different areas, distributed along hundreds and even fifty thousand meters (Xu et al, 2001; Ali et al, 2005). In Southwestern China, Emeishan basalt is irregularly distributed approximately from the northwest to the east. There is
Longmenshan fault zone in northwestern China, Honghe fault zone in southwestern China and large fault zones in central China (Fig 1, Fig.2, a). Limestone of the Maokou Formation underlies under Emei basal t, which is covered by late Permian strata and tends to be increasingly thinner from the west to the east (He et al., 2003).

![Fig.1 Distribution of Emeishan Basalt [Modified from xu (2008)]](image)

3. Deposits Related to Emeishan Basalt

Emeishan basalt has created conditions for the formation of many mineral resources, and deposits related to Emeishan basalt mainly include: 1) Cu-Ni-PGE deposits with direct connections with mantle plume activities of Emeishan (Nie, 2007; Tang, 2013); 2) V-Ti-Mt deposits associated with magmatic differentiation of basic-ultrabasic rocks (Li et al., 2002; Zhang et al., 2004); 3) Cu deposits connected with hydrothermal action (Li et al., 2005; Zhang et al., 2008), Cu-Fe deposits formed for weathering/deposition (Wang et al., 2006; Wang et al., 2011; Li, 2014), anatase associated with weathering/deposition (Nie, 2014); 4) mesothermal and epithermal hydrothermal gold/antimony deposits (Jiang et al., 2009; Nie et al., 2009; Liao et al., 2010); 5) Ore deposits of northwestern Guizhou Province include bauxitic strata, where there is a high content of REE (Fig 2, b). In some areas, both aluminum and REE are likely to be enriched and form ores. 6) Basalt is widely used in engineering construction of railways and roads as stone materials (Fig 2, a).

Since surveying of mineral resources is so complex and uncertain that mineral resources related to basalt of Emeishan basalt would not just include the metal minerals mentioned above. With the advancement of surveying technologies and progress of surveying, new mineral resources related to the basalt will be inevitably discovered. In addition, industrial grades of some minerals or elements will decline with the advancement of extraction technologies. These resources will also become integral parts of mineral resources of Emeishan basalt.
4. Contribution of Emeishan Basalt to Metallogenesis and Metallogenic Differences
The genesis of numerous minerals is related to Emeishan basalt, which provides provenance for plenty of mineral resources. This is just the tremendous contribution of Emeishan basalt to the Metallogenesis in three provinces of southwestern China. It is generally uncontroversial that Emeishan basalt offers provenance to multiple types of deposits, whereas the roles of the basalt in lead-zinc ores are highly controversial. Some scholars consider that Emeishan basalt provides provenance for lead-zinc ores (Han et al., 2001; Huang et al., 2001) and some others think both of them just have overlaid spatial relationships (Zhou, 2002). In addition, some other scholars believe that Emeishan basalt provides thermodynamically activated and extracted materials during metallogenesis of lead-zinc ores, acting as “shielding strata” and “protective strata” (Zhang et al., 2003; Li et al., 2012). The author reports that even if Emeishan basalt is not the provenance of lead-zinc ores, it has created certain conditions for the genesis of these ores, because such large-scale spatial overlay would be not accidental, they are critical for metallogenesis even if they are just employed for “blocking” or “protection”.

Metallogenic zonation is detected in areas where Emeishan basalt is distributed, typically including “northwestern copper-lead-zinc and southwestern Au-As-Hg-Sb” in western Guizhou Province (Nie, 2014), and there is abundant iron resource in northwestern Guizhou. Except for lead and zinc, multiple types of mineral resources such as copper, iron and antimony need to be migrated for metallogenesis. The mineral resources with weak migration capabilities deposit easily, while those with strong migration capabilities may move for a relatively long distance until they deposit in appropriate paleogeographic environment. The differences in sea-land layouts contribute to two different kinds of metallogenic environment, so the author considers that paleogeography is an important factor for zoning of mineral resources. From the distribution of mineral resources on different belts, it may be discovered that future surveying work can be carried out according to metallogenic distribution laws: copper, lead and zinc are approximately negatively correlated to gold, arsenic, antimony and mercury. Gold, arsenic and antimony would be contained in copper, lead and zinc-free areas, while copper, lead and zinc would exist in gold, arsenic and antimony-free areas. The rare earth elements were possibly negatively correlated to gold.

5. Conclusion
After a comprehensive analysis, following conclusions are reached: 1) The research of numerous experts and scholars has suggested that Emeishan basalt is important for genesis of many metallic mineral resources, it does not only provide metallogenic materials for several categories of metallic minerals, but also possibly creates certain conditions for lead-zinc ores. 2) With the advancement of surveying technologies and intensification of geological work, aluminum and rare earth elements will have potential value for development and utilization.
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