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# Trace and Minor Elements in Smithsonite from Huoshaoyun Nonsulfide Zinc Deposits in Southwest China: A LA–ICP–MS Study

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**Abstract:** Epigenetic carbonate-hosted Zn–Pb deposits are estimated to contain ~16% of known Zn and Pb resources worldwide (Leach et al., 2005). During them, more than 70% resources of zinc and lead are developed in the Himalayan–Zagros orogenic system. The system generated by the collisions of India–Eurasia and Arabia–Eurasia (Fig. 1), is a classic example of a young and active continent–continent collisional orogenic system (Hou et al., 2011). The carbonate-hosted Pb–Zn deposits in the Sanjiang-Teyhys Belt (Fig. 1b), including from southeast to northwest, the Jinding deposits (22 million ton , with grade of 6.1% Zn and 1.3% Pb) in Lanping basin (Xue et al., 2015), the Dongmozhazhua and Mohailaheng deposits (>100 million ton Pb + Zn, with grade of 2.18% to 4.23%) in Yushu−Nangqian basin (Liu et al., 2015), the Duocaima deposit (Pb+Zn 6.4 million ton) and Chaqupacha deposit (1.9 million ton , with grade of 2.2 wt% Pb and 0.3 wt% Zn) in Tuotuohe basin (Jia et al., 2018). The Huoshaoyun was newly discovered giant Zn-Pb deposit, the reserve of Zn+Pb is more than 19.6 million ton (grade of 23.6% Zn and 5.6% Pb) (unpublished data), which located in the west Sanjiang-Tethys belt. Different from other carbonate-hosted sulfide deposits in China, Huoshaoyun deposit is mainly composed of smithsonite and cerucite instead of sulfide ores. Indeed, a large number of oxides discovered in the mining area, only a small amount of sulfide was exposed and the composition ratio of Zn and Pb is 4:1. The smithsonite is the most important ore mineral, which mainly developed after the oxidation of sphalerite. Geochemical study of smithsonite was managed using electron probe microanalysis (EPMA) and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to track the distributions trace elements, discuss smithsonite genesis, and try to revealing the nonsulfide ore-forming processes. New data indicated that the deposition of smithsonite is experienced oxidation and inherited the geochemistry features of sphalerite, except the rare earth elements. High concentrations of Mn, Pb and Fe, which indicated these elements entered the lattice via isomorphous replacement of Zn from the early to late stage during crystallization (Table 1). According to the Zn/Cd ratios, we speculate the temperature of ore-forming fluid in Huoshaoyun is no more than 200 ℃, probably even lower. Combining with the geological features and low-temperature setting, Huoshaoyun shares the generality of Mississippi Valley Type (MVT) deposit, which probably affected by the involvement of regional basin fluid.

**Key words:** EPMA, LA–ICP–MS, nonsulfide deposit, smithsonite, trace elements

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**Table 1 Summary of EPMA and LA-ICP-MS element data for smithsonite from Huoshaoyun deposit**

| No. | FeO | ZnO | PbO | Na | Mg | Al | Si | K | Ca | Mn | Ge | Tl | Sr | Cd | In |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | wt% | | | ppm | | | | | | | | | | | |
| 1 | 8.44 | 87.39 | 0.39 | 299 | 940 | 226 | 888 | 25.7 | 11774 | 6389 | 7.77 | 11.60 | 49.3 | 812 | 1.25 |
| 2 | 9.15 | 85.07 | 1.51 | 507 | 931 | 258 | 1063 | 149.5 | 12335 | 7060 | 8.81 | 12.64 | 51.4 | 1136 | 0.95 |
| 3 | 9.28 | 85.59 | 0.43 | 342 | 1243 | 170 | 941 | 45.0 | 15578 | 7163 | 8.86 | 9.13 | 76.0 | 995 | 2.16 |
| 4 | 10.34 | 83.07 | 2.28 | 383 | 1316 | 151 | 837 | 56.7 | 12108 | 7730 | 10.82 | 11.38 | 48.6 | 843 | 1.85 |
| 5 | 13.03 | 81.75 | 0.98 | 338 | 1646 | 254 | 963 | 45.3 | 10485 | 9408 | 9.53 | 10.24 | 46.4 | 643 | 0.94 |
| 6 | 10.47 | 84.45 | 1.13 | 389 | 1263 | 285 | 837 | 24.0 | 11163 | 7679 | 8.70 | 15.98 | 42.8 | 1024 | 1.13 |
| 7 | 10.42 | 84.12 | 0.94 | 407 | 1411 | 173 | 1028 | 68.3 | 13133 | 7734 | 8.39 | 12.18 | 58.0 | 964 | 0.91 |
| 8 | 9.96 | 84.90 | 0.64 | 332 | 1245 | 152 | 938 | 21.9 | 14397 | 7531 | 10.61 | 8.54 | 65.7 | 866 | 2.01 |
| 9 | 15.86 | 79.25 | 0.86 | 308 | 1697 | 295 | 868 | 21.3 | 9705 | 9077 | 9.82 | 11.63 | 41.7 | 973 | 1.43 |
| 10 | 8.71 | 86.77 | 0.48 | 377 | 973 | 232 | 973 | 103.6 | 12148 | 6934 | 7.49 | 10.75 | 54.4 | 1002 | 1.11 |
| 11 | 8.44 | 72.43 | 15.92 | 266 | 983 | 192 | 966 | 62.1 | 8877 | 5629 | 8.52 | 10.82 | 60.1 | 840 | 1.64 |

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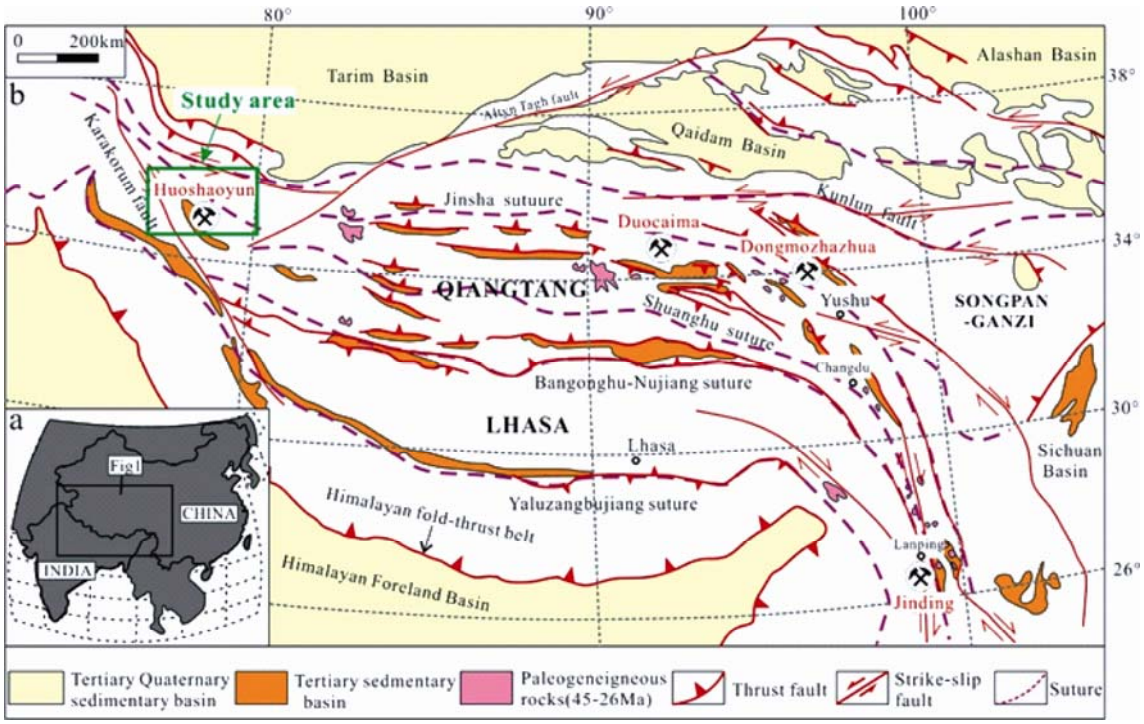


Fig. 1.Tectonic map of Southwest China.
(a) Sketch map of India- Ouya Block; (b) sketch tectonic map of the Tibetan collision belt and locations of the study zones (modified after Jia et al. (2018)).

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