Geological Setting

The lead-zinc deposits in the northern margin of the Sichuan basin are classified into Mississippi Valley-type (MVT), their major ore minerals mainly consist of galena and sphalerite while the major gangue minerals are barite, fluorite, dolomite, calcite and bitumen (Wang et al., 2011). Fluorite and barite can occur as a separate orebody respectively, such as the barite deposit at Yanjinghe and the fluorite deposit at Xinli. All these nonmetallic deposits are closely associated with the lead-zinc deposits with regard to spatial distribution in this area.

A paleo-oil (gas) reservoir in Dengying Formation at Nanjiang-Mayuan was recognized (Dai et al., 2009). Both the MVT lead-zinc deposits and paleo-oil (gas) reservoir were confined to the Upper Sinian Dengying Formation, and they coexisted with each other in spatial distribution in this area. The source rock of the paleo-oil (gas) reservoir was the Cambrian Guojiaba Formation (Niutitang Formation) (Dai et al., 2009). The research indicated that Niutitang Formation was not only the source rock of the paleo-oil (gas) reservoir, but also the one of the polymetallic deposits.

Analysis on the Source Rocks of the MVT Pb-Zn Deposits in Nanjiang, Sichuan

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2 Analysis on the source rocks

We collected 11 dark mudstone samples with rich organic matters in the study area, and the contents of the organic matters and the metallogenic elements were analyzed to determine the source of ore-forming matters of the Pb-Zn deposits, fluorite deposits and barite deposits. The results show that the contents of Pb, Zn and Ba of the mudstone samples are 9.6×10^-6 - 25.2×10^-6, 11×10^-6 - 127×10^-6 and 300×10^-6-1210×10^-6, averaging 20.1×10^-6, 60.5×10^-6, 981×10^-6 accordingly. Except two of the mudstone samples have a low background values of Pb that are less than crustal clarke value (12.6×10^-6), it is generally 1.1 to 2 times as high as the crustal clarke value.

For most mudstone samples, their Zn contents are lower than crustal clarke value (73×10^-6), however, it can be 1.7 times as high as crustal clarke value. As for Ba, it is 2 to 4 times the content of crustal clarke value (390×10^-6). Meanwhile 2 bitumens were collected, and the contents of the Ba in bitumen are 326×10^-6 and 366×10^-6, their averaging content (346×10^-6) is very close to crustal clarke value.

The organic fluids may play an important role during the formation of the lead-zinc deposits. Most of the mudstone samples from the Guojiaba Formation have a higher value of Pb and Ba than crustal clarke values, furthermore, the MVT lead-zinc deposits are rich in bitumen, suggesting that the mudstones of Guojiaba Formation may provide the Pb and Ba source for the lead-zinc deposits and barite deposits. All these ore-forming elements might migrate out from the mudstones during the generation of the hydrocarbon and entered into the oil reservoir and oilfield brines. Once the environment changed, they would precipitate and infill the fissures and pores of the dolomite, thus forming the Pb-Zn deposits and the barite deposits under favorable conditions.

The ore-forming materials Pb and Zn can also come from basement Huodiya Group and Chengjing Period granites. Previous data (Hou et al., 2007 ) demonstrates that the contents of Pb and Zn of the two possible source rocks in this area are 35×10^-6-50×10^-6 and 300×10^-6-325×10^-6 respectively, it is 2.8-3.9 times and 4.1-4.5 times as high as crustal clarke value accordingly. However, dolomite of Dengying Formation has a low value of Pb (12×10^-6), Zn(71×10^-6) and Ba(163×10^-6), all of them are too low to supply metallogenic matter.

Considering that the mudstone of the Cambrian Guojiaba Formation is low in Zn, the Zn of the MVT deposits may mainly come from the basement Huodiya Group and the alkaline granite of Chengjing Period. As for
Pb, its sources are multiple, besides the Cambrian Guojiaba Formation, the basement and the Chengjing Period granites both have a potential to provide Pb and Zn for the MVT Pb-Zn deposits.

The $^{87}\text{Sr}/^{86}\text{Sr}$ of fluorite from fluorite deposits are $0.709813\pm0.000012$ and $0.709787\pm0.000009$, which is close to $0.7095-0.7099$ of dolomite infilled the pores in Dengying Formation, indicating that they are from the same fluid. Abundant CH$_4$ inclusions were detected by Raman spectroscopy, suggesting that ore-forming materials may come from oilfield brines. The calcite (Ca) may be from the host rocks, dissolved in oilfield brines, thus forming the fluids rich in calcium and organic. The fluoride (F) may come from deep hydrothermal solution.

3 Conclusions

The ore-forming materials of the MVT Pb-Zn deposits in Nanjiang have a variety of sources: ①the Cambrian Guojiaba Formation can furnish the deposits with Pb and Ba; ②the basement Huodiya Group can supply Pb and Zn; ③the alkaline granite of Chengjing Period have a potential to provide Pb and Zn for the deposits; ④the host rock, the dolomite of Dengying Formation, may be the main contributor for Ca that is necessary for the fluorite deposit; ⑤the deep hydrothermal solution may participate in the metallogenetic process by supplying F.

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