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Geology and sulfur isotope geochemistry of Dafulou tin-polymetallic deposit in Dachang orefield, Guangxi, China

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Abstract: No. 22 ore of Dafulou deposit was systematically analyzed for sulfur isotopes. The results show that the δ^{34}S values of sulfide minerals, ranging from −0.154 to +0.218% and with an average value of +0.114 1%, are mostly positive and characterized by rich sulfur (S) content. This suggests that the sulfur of the Dafulou ore deposit is derived from magma and relates to the Longxianggai concealed granite, which points to the important role of magma during mineralization and implyies the product of the active continental margin. By comparison between the Dafulou and the Kengma tin deposit, significant differences exist in the sulfur isotope composition. In the Kengma deposit, the sulfur isotope composition is characterized by the high negative value, which is different from the Dafulou tin-polymetallic deposit. The difference of the enrichment and fractionation of the sulfur isotope is the synthesized result of the metallogenic conditions. It also has the difference in the metallogenic environment and metallogenic characteristics of the deposit in the same ore belt.

Key words: tin-polymetallic deposit; sulfur isotope; ore-forming material sources; Dafulou deposit

1 Introduction

The Danchi ore belt, situated in the Nandan County of the Guangxi Zhuang Autonomous Region in Southern China, hosts a number of world-famous, super-large-scale tin-polymetallic deposits, as shown in Fig. 1. The Dachang ore field holds one of the richest and largest tin (Sn) ore deposits in the world, producing zinc (Zn), lead (Pb), copper (Cu), silver (Ag), antimony (Sb), mercury (In) and cadmium (Cd), among others [1−2].

According to the tectonic characteristics and relations [3−4], the Dachang ore field consists of three main metallogenic belts (see Fig. 1): the west ore belt (Changpo−Tongkeng Sn-Pb-Zn ore deposit), the central ore belt (Lamo Zn-Cu ore deposit and Chashan W-Sb-Pb ore deposit), and the east ore belt (Dafulou Sn ore deposit and Kengma Sn-Zn ore deposit). In general, the different ore belts are of different mineralization types and characteristics.

The Dachang ore field has long been regarded as the best laboratory for the study of tin-polymetallic deposits. Much geological research, such as metallogenic prognostication, deposit mechanism, metallogenic age, and ore-forming materials sources, among others, has been conducted since its discovery [5−9]. However, considerable debate still exists regarding the genesis of the deposits [10−14]. Undeniably, the central issues of the dispute are focused on the metallogenic age and ore-forming material sources [15−17].

Early research on the Dachang tin-polymetallic ore deposit suggests that the vein-type ore body is related to magmatism in Late Yanshan. However, debates continue regarding the genesis of the bedded ore body. More recent studies have focused on the mineralization age, the ore fluid and the ore source among others. These studies indicate that the Dachang deposit is characterized by multiple geneses, ore sources and mineralization stages. However, despite the progress achieved in the last few years, the genesis of the Dachang ore deposit remains not yet fully understood, and the fundamental questions of fluid origin, evolution and mineralization age with associated mineral deposits remain unanswered. The mineralization age, the sources of fluid and the

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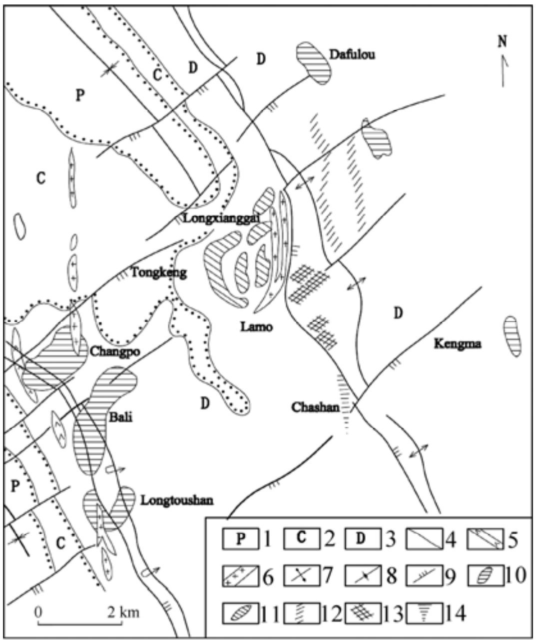

Fig. 1 Mineralization zoning of Dachang ore field (compiled from China Nonferrous Metals Industry Corporation, 1987): 1- Permian limestone and siliceous; 2- Carboniferous limestone; 3- Devonian limestone, shale and siliceous; 4- Parallel unconformity stratigraphic contact; 5- Diorite porphyrite; 6- Granite and granite porphyry; 7- Anticline axis; 8- Syncline axis; 9- Faults; 10- Tin orebody; 11- Zn−Cu orebody; 12- Scheelite veins; 13- Wolframite veins; 14- Antimony veins

mechanisms of ore deposit have been the subject of several studies and different interpretations.

The Dafulou deposit, located in the Dachang ore field, is a large-scale tin-polymetallic ore deposit. The No. 22 tin-polymetallic ore body of the Dafulou ore district, including geological logging, geological sketch, and sampling (minerals and rocks), among others, were systematically studied. Based on the above study, the current study conducts a field investigation and identification of thin and polished sections of ore body samples in order to determine the features of petrology and mineralogy. Although the No. 22 ore body, the dominant part of the Dafulou ore district, has been mined for many years and is currently the main body for mining, data regarding the Dafulou ore deposit have been deficient.

Sulfur isotope compositions of the sulfide minerals are useful indicators for determining the origin of ore fluid components [18] and have been widely used to interpret the fluid evolution of ore deposit in order to determine mineralization age and ore source. The sulfur isotope analyses have been carried out in Dachang ore field [19−22]; however, no consensus on these issues has been reached.

To deepen the knowledge on the genesis of the Dafulou ore deposit, the current study presents the results of sulfur isotopes on sulfide analyses from samples collected in the recent mining tunnel of Dafulou ore deposit, as well as findings from the field investigation of No. 22 ore. The ore environment and genesis of the Dafulou ore deposit have not been discussed systematically in previous studies. The purpose of the current work is to evaluate the ore source and the tectonic setting, thereby providing new data for promoting the research of the Dafulou ore deposit and the Dachang ore field.

2 Regional geological setting

The Dachang ore field is located at the junction of the Guangxi platform and the Jiangnan uplift in Northwest Guangxi. A partially restricted sea basin formed in this area during late Paleozoic as a result of depression along the NW-striking basement fault, with the fast-depressing sector developing in the Middle–Late Devonian Nandan-type basin in Guangxi [4]. The major stratum, with a total thickness of over 1 700 m, consists of C- and S-rich black shale and argillaceous or silty sediment. The Longxianggai anticline and fault are the major structural systems in this area, together with a series of parallel small folds. Moreover, the main fold is asymmetrical, with a tight NW limb influenced by the NE-trending Longxianggai fault.

Most of deposits are hosted in a Devonian stratum in the Dachang ore field (Fig. 2). For example, the Dafulou, Huile and Kengma deposits are from the Lower Devonian, whereas the Lamo and Chashan deposits are from the Upper Devonian. The giant economic deposits of Longtoushan and Tongkeng- Changpo occurred in the Middle–Upper Devonian. Ore bodies are of three major types: 1) stratabound, bedded, and massive type, 2) vein type, and 3) stockwork type. The host rocks of the deposit are Devonian carbonates, siliceous rocks and shale (Fig. 3).

Overall, the host rocks of the Dachang deposit are typically banded, consisting mainly of siliceous rock and limestone, with less but significant amounts of alternating thin beds of sulfides and K-feldspar-rich rocks.

The Dafulou deposit, which belongs to the eastern ore belt of the Dachang tin ore field and has been mined before the foundation of the People’s Republic of China, is located in the eastern flank of the NNW–SSE-trending Danchi anticlinorium. Aside from the Dafulou ore deposit in the eastern mineralization belt, several small-scale Sn ore deposits are also present, such as Huile, Tongkan, Huanglaqiao and Maopingchong. According to spatial relation, the ore deposits are approximately

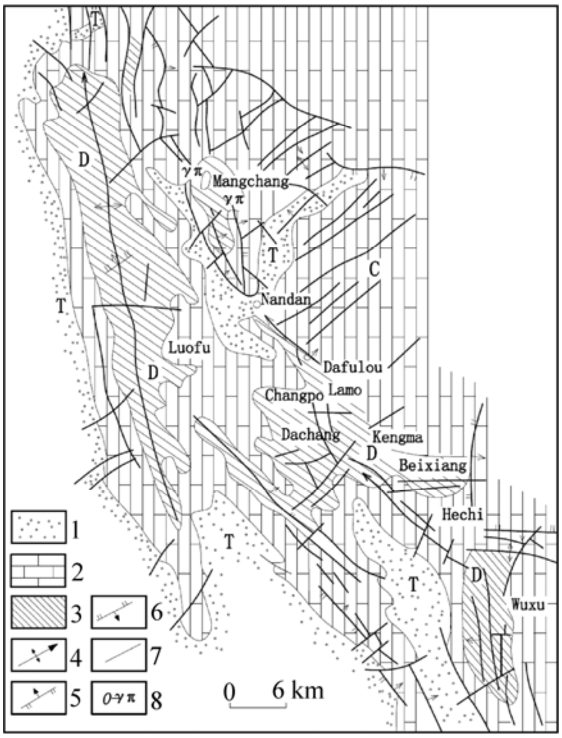

Fig. 2 Simplified geological map of Dachang Sn-polymetallic ore deposit, Guangxi Province, China: 1- Triassic; 2- Carboniferous–Permian; 3- Devonian; 4- Anticline axis; 5- Normal fault; 6- Thrust fault; 7- Faults; 8- Granite porphyry

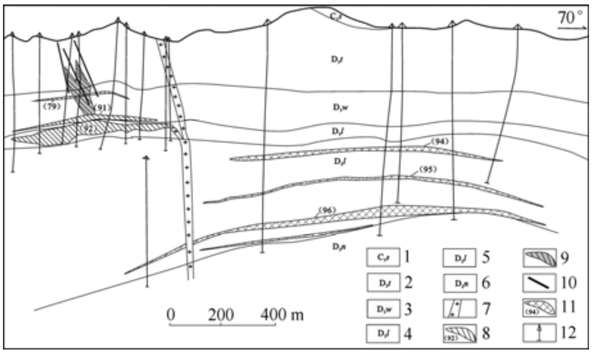

Fig. 3 Geologic cross-section of Changpo deposit (compiled from Geology Team of Guangxi No. 215, 2007): 1- Lower carboniferous Simen group; 2- Upperd Devonian Tongchejiang group; 3- Upperd Devonian Wuzhishan group; 4- Upperd Devonian Liujiang group; 5- Middle Devonian Luofu group; 6- Middle DevonianNabiao group; 7- Granite porphyry vein; 8- Tin-polymetallic orebody; 9- Small vein tin-polymetallic orebody; 10- Large vein tin-polymetallic orebody; 11- Zn-Cu orebody; 12- Drilling

equidistant (i.e., Dafulou, Huile, and Kengma deposits) because of the superposition of the NW- and NE-trending structures that control the No. 0, 21 and 22 ore bodies in the Dafulou ore district. In the Dafulou ore district, the main ore body consists mainly of vein and bedded ore characterized by stable occurrence and super-large scale.

3 Ore geology

3.1 Stratigraphy

In the Dafulou ore district, the Devonian stratum has plenty of outcrops, including the Upper Devonian (Liujiang Formation), Middle Devonian (Luofu Formation and Nabiao Formation), Lower Devonian (Tangding Formation), among which the lower Devonian Tangding formation is the main host rock of the bedded ore (No. 21 and 22) (as listed in Table 1).

1) Upper-Devonian Liujiang Formation (D_3^1, 60−80 m thick) is composed mainly of gray–black, thick-layered siliceous limestone, with intercalated carbonaceous limestone, limestone, and argillaceous limestone, among which the limestone is a dense, hard, and thick layer with a gray–dark quartz vein. A large deposit of breccias is cemented by limestone of various shapes (i.e., elongated, spindle, and pea). The breccias, with medium psephicity and approximately parallel arrangement, are less than 20 cm long and 8 cm wide.

2) Middle-Devonian Luofu Formation (D_2^2, 424−654 m thick) is composed mainly of charcoal-grey–black calcareous argillaceous rock, shale, charcoal-grey argillaceous limestone, weathered yellow shale, and argillaceous rock. The fresh rock is composed of gray-black shale, carbonaceous shale, and charcoal-grey–gray-black limestone. The Luofu Formation conforms to the lower stratum.

3) Middle-Devonian Nabiao Formation (D_2^1, 305–852 m thick) is composed mainly of gray−black carbonaceous limestone and pure limestone with intercalated calcium nodule, argillaceous limestone, and fine sandstone. The outcrop was weathered strongly to brownish-yellow, and is soft and fragile because of the higher content of argillaceous than the lower stratum.

4) Lower-Devonian Tangding Formation (D_1^3, 225−328 m thick) is composed mainly of gray−black calcareous argillaceous (shale), with intercalated thin-layer argillaceous limestone. This formation is highly carbonaceous, which leads to fragile and special mechanical properties to some degree. In the Dafulou ore district, the No. 21 and 22 ore bodies are hosted in the Tangding Formation (Fig. 4).

3.2 Igneous rocks

In the Danchi ore belt, the main magmatism occurred in the Middle–Late Yanshan period, belonging to shallow super-magmatic rocks, which were distributed in the area of Longxianggai, Dachang, and Mangchang in the way of dikes, rock strain, and rock bed [23]. The rock types consist of biotite granite, granite porphyry, quartz porphyry, fraidronite, and diorite porphyry, among others [24]. The granite belongs to alkali-calcium

Table 1 Regional stratum in Dachang orefield

System	Series	Group	Code	Thickness/m	Lithology
Carboniferous	Upper	Maping	C_3m		
	Middle	Huanglong	C_2h	1 391	Limestone, dolomitic limestone
		Dapu	C_2d		
	Lower	Bading	C_1bd		Clastic rock
Devonian	Upper	Tongchejiang	D_3t	340−370	Neritic facies terrigenous clastic rock
		Wuzhishan	D_3w	66−127	Bean limestone, banded limestone
		Liujiang	D_3l	5−174	Gray black siliceous
	Middle	Luofu	D_2l	206−519	Black mudstone, argillaceous limestone, siltstone
		Nabiao	D_2n	563−>1 791	Black mudstone, argillaceous limestone, siltstone
	Lower	Tangding	D_1t	240−＞894	Mudstone, argillaceous limestone
		Yilan	D_1y	20−35	Argillaceous limestone, mudstone, silty mudstone
		Nagaoling	D_1n	412	Quartz sandstone, argillaceous siltstone
		Lianhuashan	D_1l	＞287	Quartz sandstone, greywacke and conglomerate

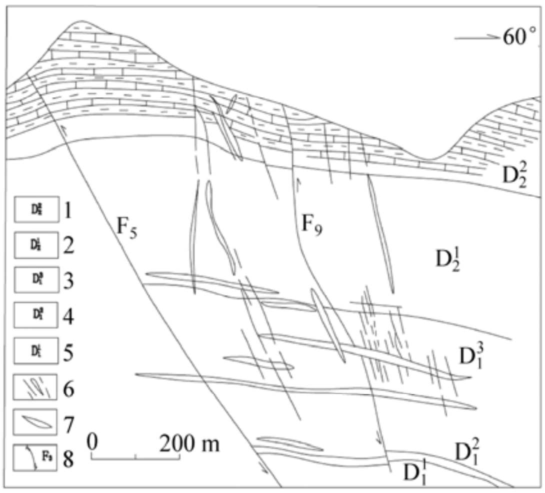

Fig. 4 Geological section of exploration line No. 5 at Dafulou ore deposit (modified from China Nonferrous Metals Industry Corporation, 1987): 1- Mudstone and limestone; 2- Black shale; 3- Mudstone with siltstone layer; 4- Siltstone; 5- Sandstone; 6- Vein-type orebody; 7- Stratiform orebody; 8- Faults

rock series or close to the alkali rock series, which is rich in silicon and aluminum, and poor in magnesium, iron, and calcium. The porphyritic biotite granite is characterized by high alkali and rich potassium, iron, calcium and magnesium, and poor silicon. The grains of porphyritic biotite granite are rich in silicon, potassium, ferrous, calcium, and magnesium. These characteristics suggest that the formation environment of granite belongs to molten magma type, which also implies that the grains are the result of magma activity in different phases and stages. In the Danchi ore belt, the rock is characterized by its small size and extreme depth; the wall rock alteration occurs in large scope and hosts several kinds of endogenic metal deposits. Moreover, a close relationship is evident between the intrusive rock and regional structure, and many types of rock protrude from both sides of the Danchi fault.

3.3 Ore bodies

The ore bodies of the Dafulou deposit can be classified into two major types based on their occurrence and shape: vein and bedded ores (Fig. 4). Their metal minerals are mainly composed of cassiterite, pyrrhotite, iron sphalerite, pyrite, arsenopyrite, and jamesonite, in which tin is the important economic mineral in this ore district, even in the Dachang ore field [25]. The nonmetallic minerals consist of quartz, calcite, tourmaline, feldspar, muscovite, chlorite, fluorite, tremolite, and barite.

1) Vein-type ore body. This is very common in the Dafulou ore district. The No. 0 ore body, is the largest and located at an elevation of approximately 560–60 m. The controlled length and depth are approximately 1 250 and 500 m, respectively, with an average thickness of 2.07 m. The vein ores usually contain 0.35%−2.20% Sn, with the maximum and average values of 10.48% and 0.90%, respectively. They also contain 0.02%−0.06% Zn with a maximum value of 0.23%.

2) Bedded ore body. The bedded tin-polymetallic mineralization formed concordantly in the Tangding Formation of the Lower Devonian shale. The bedded ore consists mainly of the No. 21 and 22 ore bodies that are roughly parallel to each other. The No. 21 ore body, situated 60−80 m above the No. 22 ore body, is approximately 450 m long and 2.5 m thick, with an average content of 1.14% Sn. Both ore bodies consist of several kinds of industrial minerals, such as cassiterite,

pyrrhotite, pyrite, arsenopyrite and marmatite.

3.4 Wall-rock alteration

Several kinds of wall-rock alterations are found in the Danchi ore belt, corresponding to different mineralization types. The hydrothermal alteration of cassiterite-sulfide ore body is rather extensive, which is relevant to high- and medium-temperature hydrothermal alteration, and shows a special close relation to K-feldspar and tourmalinization. Moreover, it is characterized by weak hydrothermal alteration for bedded ore body. Ore deposits are characterized by significant mineralization zoning around the Longxianggai concealed biotite granite [26].

The main types of the wall-rock alteration in the Dafulou ore district consist of silicification, carbonatation, sericitization, pyritization and pyrrhotization. Twenty-one polished and thin sections of representative ore samples were investigated using a polarizing microscope. The all-rock alteration in the Dafulou deposit is simple. The most important and common alteration is pyrrhotization, occurring in both footwall and hanging-wall rocks, but occurring more extensively in the hanging wall. Another main type of wall-rock alteration is silicification, which occurs in both wall rocks. Silicification results in dense hard rock, such as silicified limestone and silicified marble. Carbonatation is mainly characterized by marbleization, such as marbleized bioclastic limestone. Although host rock carbonatation is evident in the Dafulou deposit, it is not widespread and is restricted only to some places. Pyrrhotization is always accompanied by pyrrhotization, thereby altering the ore-hosting rock.

4 Sulfur isotope studies

4.1 Sampling and analysis

Sulfur is an important element in most ore deposits. Through analysis of sulfur isotope geochemistry, some problems can be studied, such as ore source, deposit model, and mineralization age, among others. If mineral assemblages are simple, the value of δ^{34}S could represent the total sulfur value, which is usually expressed as $\delta^{34}S_{CDT}$ [18].

Eight sulfur isotope samples (consisting of one galena, two pyrite, and five pyrrhotite samples) were collected from the latest tunnel. These samples were cleaned using distilled water, and then crushed to 60−80 mesh. Specific minerals were then singled out (purity above 98%).

The sulfur isotope analyse were performed at the Isotope Geology Laboratory of Wuhan Institute of Geology and Minerals Resources, Chinese Ministry of Land Resources. Sulfur in the sulfide was oxidized directly into SO_2, and the values of δ^{34}S were measured by the isotope mass spectrometer MAT-251, which was made by the Finnigan Company. Results were expressed using the International Standard CDT. The analysis precision was ±0.02% under 20 °C and 30% humidity (see Table 2).

4.2 Results and discussion

The sulfur isotope geochemistry research of sulfide minerals in the Dachang ore district has been previously reported [20, 22]. FU et al [20] measured the δ^{34}S values of Longxianggai biotite granite ranging from −0.13% to −0.01%. Overall, the δ^{34}S values in the Dafulou ore deposit show certain similarities with the Longxianggai biotite granite, and a systematic change from rock to ore body is evident, even at a distance from the rock. In the Dachang ore district, the δ^{34}S values of rock and cassiterite-sulfide deposit range from 0% to +0.4% and −1.083% to +1.18%, respectively [11].

According to this study, the δ^{34}S values of sulfide minerals in the Dafulou ore deposit range from −0.154% to +0.218%, with an average value of +0.114 1% (Fig. 5). The δ^{34}S value of galena is +0.216%. The δ^{34}S values of pyrrhotite vary from −0.154% to +0.208%, with an average value of +0.099 6%. However, the δ^{34}S values of two pyrite samples are −0.019% and +0.218%, with an average value of + 0.099 5% (Table 2).

The maximum δ^{34}S value of galena is 0.216%. The average δ^{34}S values of pyrite and pyrrhotite are approximately the same. The δ^{34}S values of pyrrhotite are mostly positive. Two pyrite samples consist of one positive and one negative δ^{34}S value. In the Dachang ore district, the δ^{34}S values change greatly, consisting of higher positive and lower negative values [27]. Overall, in this area, the δ^{34}S values are mostly positive, implying high sulfur content.

The isotope composition of sulfide precipitating from the mineralizing solution is unlike the original sulfide isotope composition. This composition depends not only on the original isotope composition, but also on physical and chemical conditions.

In China, the sulfide source of tin deposit consists of the magma and the mixed (the magma and stratum) sources. The sulfur isotope values of magma source deposit usually vary from −0.2% to +0.6%, with a higher $\delta^{34}S_{\Sigma S}$ value (>+0.6%), higher positive value, and larger range of $\delta^{34}S_i$ for the mixed-sulfide source deposit.

Thus, the sulfur of the Dafulou ore deposit is possibly derived from magma. The sulfur isotope value of Longxianggai biotite granite ranges from −0.13% to −0.01% [20]. The δ^{34}S value of Longxianggai biotite granite is −0.1% [26], which is roughly consistent with the results of this study (−0.154% to +0.218%). These results suggest that the sulfur of the Dafulou ore deposit

Table 2 Sulfur isotope compositions of Dafulou and Kengma ore deposits in east ore belt

No.	Sampling location	Sample	Mineral	$\delta^{34}S$/%	Mean value/%	Data source
1	Dafulou	Y03-1	Pyrrhotite	0.208	+0.114 1	This study
2	Dafulou	Y03-2	Pyrite	−0.019		
3	Dafulou	Y05-3	Pyrrhotite	0.180		
4	Dafulou	Y05-3	Pyrrhotite	0.173		
5	Dafulou	Y16-4	Pyrrhotite	−0.154		
6	Dafulou	Y28-7	Galena	0.216		
7	Dafulou	Y29-4	Pyrrhotite	0.091		
8	Dafulou	Y29-6	Pyrite	0.218		
9	Kengma	390-2	Sphalerite	−1.001	−0.867 1	Ye et al [29]
10	Kengma	390-2	Arsenopyrite	−1.037		
11	Kengma	493-1	Marmatite	−1.082		
12	Kengma	493-2	Pyrite	−0.851		
13	Kengma	456-1	Marmatite	−0.891		
14	Kengma	456-2	Pyrite	−0.709		
15	Kengma	565-1	Pyrite	−0.552		
16	Kengma	565-2	Pyrrhotite	−0.945		
17	Kengma	6806-1	Pyrite	+0.089		
18	Kengma	6806-2	Pyrrhotite	−0.855		
19	Kengma	1597-1	Marmatite	−0.968		
20	Kengma	1597-2	Pyrite	−0.754		
21	Kengma	1735-1	Pyrite	−0.868		
22	Kengma	1735-2	Marmatite	−1.025		
23	Kengma	531	Pyrite	−0.879		
24	Kengma	552	Pyrite	−0.091		
25	Kengma	551	Pyrite	−0.897		
26	Kengma	390-2-1	Marmatite	−0.534		
27	Kengma	390-2-2	Pyrrhotite	−0.987		
28	Kengma	390-3-1	Pyrrhotite	−0.966		
29	Kengma	390-3-2	Marmatite	−0.980		
30	Kengma	390-10-1	Pyrrhotite	−0.966		
31	Kengma	390-10-2	Marmatite	−0.875		
32	Kengma	406-2-1	Pyrrhotite	−0.999		
33	Kengma	406-2-2	Marmatite	−1.032		
34	Kengma	406-1-1	Pyrrhotite	−1.039		
35	Kengma	406-1-2	Marmatite	−1.017		
36	Kengma	561-1	Pyrrhotite	−0.912		
37	Kengma	561-2	Marmatite	−0.921		
38	Kengma	477-1	Marmatite	−1.018		
39	Kengma	477-2	Pyrrhotite	−0.959		
40	Kengma	443-1	Marmatite	−1.083		
41	Kengma	443-2	Pyrrhotite	−1.012		

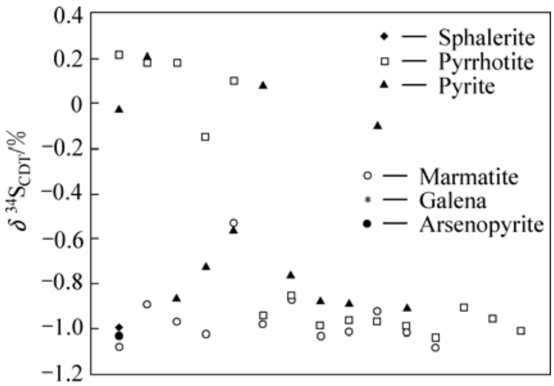

Fig. 5 Sulfide δ^{34}S scatter diagram from Dafulou deposit

could be from the Longxianggai concealed granite, and point to the significance of magma in the period of mineralization. The δ^{34}S value of I-type granite ranges from −0.5% to +0.5% [28]. The Dafulou tin deposit is closely related to I-type granite, which also suggests that it is the product of the active continental margin.

Sulfur is rather common in every kind of meteorite, with the highest content found in the iron meteorite (>10%), and with lower content in chondrite (>1%) and in nonchondrite (<1%). In a meteorite, sulfur isotope composition is mostly consistent, without any relation to the sulfur content.

In the iron meteorite, the δ^{34}S value of the troilite is rather stable, ranging from −0.04% to +0.08% (average −0.03% to +0.05%). In all kinds of meteorites, the δ^{34}S values vary from −0.2% to +0.3%; however, ^{32}S is rich in the sulfate and ^{34}S is rich in the troilite. The sulfur isotope composition is roughly the same between the ultramafic rocks and mafic rocks. The δ^{34}S value of the ultramafic rocks ranges from −0.13% to +0.55% (average 0.12%); however, the δ^{34}S value of the mafic rocks ranges from −0.57% to +0.76% (average 0.20%) [28]. The δ^{34}S values of the Dafulou ore deposit deviate from the δ^{34}S value range of the mafic rocks [27]; however, they coincide with the meteorite sulfur value, characterized by the mantle source.

The Kengma tin-polymetallic ore deposit is also located in the east ore belt of the Dachang orefield (as shown in Fig. 1). The metallogenic conditions and deposit characteristics are resemblance to the Dafulou ore. The sulfur isotope geochemistry of the Kengma tin-polymetallic ore had been studied in 1980s [29]. According to Table 2, the δ^{34}S values of sulfide minerals in the Kengma ore deposit range from −1.083% to +0.089%, with an average value of −0.8671%. Among the 32 sulfur isotope values, only one result is low positive value. And most of the results are high negative values (Fig. 5), ranging from −1.083% to −0.091%. About 88% values are lower than −0.7%. It shows significant differences from the Dafulou ore deposit in the sulfur isotope geochemistry. This also suggests the different sulfur enrichment and sulfur fractionation characteristics between them. Even under the similar geology condition and dynamic background, in the period of the mineralization, the influence of tectonic position, physical and chemical conditions, sedimentary environment cause the discrepancy in the sulfur isotope geochemistry characteristics.

5 Conclusions

1) The main stratum involves the upper Devonian (Liujiang formation), middle Devonian (Luofu formation and Nabiao formation) and lower Devonian (Tangding formation). Yet, the lower Devonian Tangding formation is the main host rock for the Dafulou ore deposit. The major orebody type consists of vein and bedded ores. The main metallic minerals are composed of cassiterite, pyrrhotite, iron sphalerite, pyrite, arsenopyrite and jamesonite, etc. The nonmetallic minerals consist of quartz, calcite, tourmaline, feldspar, muscovite, chlorite, fluorite, tremolite and barite, etc. The wall-rock alteration involves the silicification, carbonatation, sericitization, pyritization, and pyrrhotization, etc.

2) The δ^{34}S values range from −0.154% to +0.218%, with an average value of +0.114 1%, and being mostly positive in the Dafulou ore deposit. This implies the high sulfur content. The sulfur could have been derived from the magma, and a very close relation exists between the Dafulou tin deposit and I-type granite. The ore deposit is possibly the result of the active continental margin.

3) The δ^{34}S values of sulfide minerals from Kengma ore deposit range from −1.083% to +0.089%, with an average value of −0.8671%, being high negative values mostly. There exist significance differences in the sulfur isotope composition between the Dafulou and Kengma ore deposits. It shows the different sulfur enrichment and sulfur fractionation to different ore deposits. Even under the similar geology characteristic and tectonic condition, the result of the mineralization is characterized by a large difference, which may be caused by the different tectonic position, physical and chemical condition, sedimentary environment, etc.

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