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Characteristics of Ore-Forming Fluids of Gold Deposits in Daqingshan District, Inner Mongolia, China

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Abstract: Located in the mid-west of Inner Mongolia, Daqingshan district has many gold deposits occurring along a east-west striking ductile shear zone within a greenstone belt, which is mainly composed of the Archean Wulashan group. The hydrothermal mineralization can be divided into four stages: (1) pyrite-quartz, (2) quartz-pyrite, (3) polymetallic sulfides and (4) carbonates-quartz. The major metallic minerals in the ore of gold-bearing veins are native gold, electrum, pyrite, chalcopyrite and galena, but the gangue minerals are mainly quartz, secondarily sericite, ankerite and calcite. Principal alteration patterns in the gold deposits are sericitization, silicification, pyritization, carbonatization and chloritization. An investigation on fluid inclusions shows that the ore-forming fluids were low in salinities and high in CO_2 content. Measured δD of fluid inclusions in quartz from the ore veins ranges from −65‰ to −104 ‰, but $\delta^{18}O_{quartz}$ from 10.0‰ to 12.8‰. These data show that the water in hydrothermal fluid precipitating the ore bodies could have been mainly magmatic water and metamorphic water, but local meteoric water might take part in the late mineralization. $\delta^{13}C$ from fluid inclusions in the ore varys from −3.3‰ to −6.2 ‰, indicating that carbon was derived from magmatic or anatectic source. $\delta^{34}S$ from sulfide samples in gold deposits ranges from −4.1‰ to +4.0 ‰, which are identical with that from Shi, *et al.*. It is concluded that the gold deposits in Daqingshan district are similar to those in Xiaoqinling area, in aspects of geological characteristics, mineral association and stable isotope composition.

Key words: fluid inclusions; isotope composition; gold deposit; Daqingshan area

0 Introduction

Since 1980s many gold deposits have been found in Wulashan-Daqingshan area, Inner Mongolia, China [1], shown in **figure 1**. The types of gold deposits can be divided into three: (1) quartz-vein-altered rock type related to ductile shear zones, such as Houshihua, Liang-qian, No.12, No.15 and Songshubei; (2) altered-quartz vein type within fractured quartz diorites, such as Donghuofang and Dongqianwantu; and (3) veinlet-disseminated type in carbonate formation of proterozoic represented by Motianling gold deposit. The former two types of gold deposits are greenstone type. There are different understandings about their genesis. This

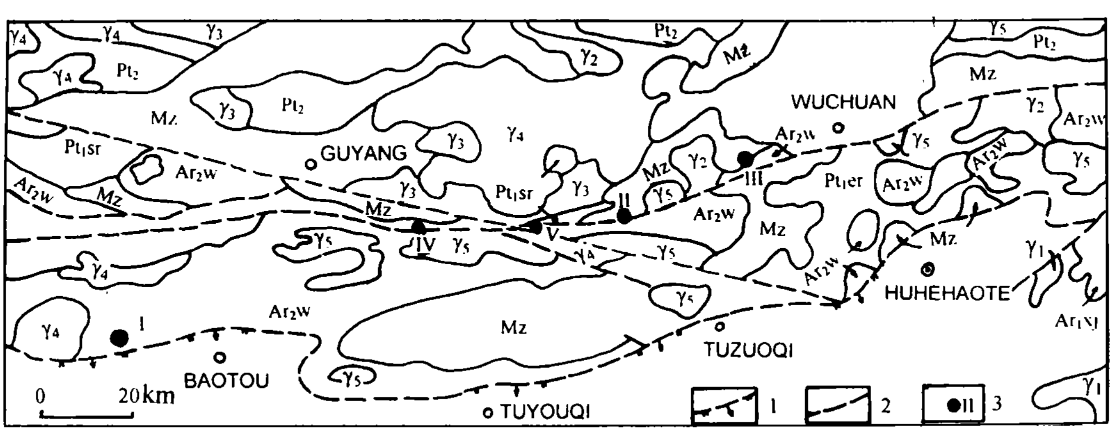

Figure 1 Regional geologic map of Daqingshan area (After Chen, *et al.*, [2])

Mz — Mesozoic; Pt_2 — Mid Proterozoic; Pt_1er — Low Proterozoic Erdaowa group/mid Proterozoic undivided; Pt_1sr — Low Proterozoic Seertengshan group; Ar_2w — Upper Archean Wulashan group; Ar_1xj — Archean Xiajining group; γ_1–γ_5 — Granite; 1 — Faults, 2 — Inferred faults, 3 — Gold deposits; I — Hadamenggou, II — Houshihua, III-Donghuofang, IV — Liangqian, V — No.12 and No.15.

study is focused on them by fluid inclusions and stable isotope composition.

1 Geological setting

1.1 Ductile shear zone type

This type of gold deposits is represented by Houshihua deposit, where stratum in the mining area is Wulashan group that is mainly composed of plagioclase gneiss, chlorite schist and hornblende schist. Yanshanian granite is distributed to the north of the mining area. There are three larger ore-controlling faults, striking SWW-NEE, and within the regional ductile shear zone — Guyang-Wuchuan hillback fault. More than 20 gold bearing veins are found in Houshihua deposit. Ore bodies strike along a east-west shear zone, dipping NNW in the shallow parts. Wallrocks are mainly chlorite schist, hornblende schist and plagioclase gneiss. Pyritization and carbonatization are developed near veins. The age of the altered sericite is (80 ± 5.6) Ma [1], indicating that the ore deposits were formed at Yanshanian period.

Liangqian gold deposit also occurs in Wulashan group composed of 10 gold-bearing veins, which strike east to west, dipping NE or NNE. To the southwest of Houshihua gold deposit is Renzihao, and to the northwest is Songshubei.

1.2 Altered fracture zone type

This type of gold deposits includes Donghuofang and Dongqianwantu. Donghuofang deposit occurs in high metamorphic greenstone terrain north to Guyang-Wuchuan fault. Stratum in the mine area is Wulashan group. Caledonian quartz-diorite was especially related with gold mineralization, which is host rock of the ore bodies. The most important ore-controlling fault is a east-west fault,extending 3 800 m,cutting quartz-diorite and Wulashan group.The fault dips SWW with angles between 70°–75°, in which the 1.1 km ore body occurs. Dongqianwantu gold deposit, located to the North of Donghuofang gold deposit, occurs in altered fracture zones with Hercynian quartz-diorite.

2 Mineralization and Alteration

2.1 Ore assemblage

For gold deposits in ductile shear zones, main metallic mineral is pyrite, with small amount of chalcopyrite, galena, sphalerite, pyrrhotite, molybdenite and magnetite. In addition, non-metallic minerals are dominated by quartz, calcite, sericite, microcline, ankerite and chlorite.Mineralization of the deposits can be divided into four stages:

(I) Pyrite-quartz stage, forming white quartz veins, with disseminated pyrite. Molybdenite was occasionally found in this stage.

(II) Quartz-pyrite stage. Pyrite veinlets and quartz occur along the side fissure of white quartz vein.

(III) Polymetallic sulfides stage. Mineral assemblage is composed of galena,chalcopyrite and sphalerite.

(IV) Carbonates stage. Ankerite and calcite filled fissures of quartz.

Gold is rich in stage II, and occurs as native gold, shown in **table 1**. Pyrite, pyrrhotite and chalcopyrite contain certain gold element, shown in **table 2**.

For gold deposits in altered fracture zones, mineral assemblage also composed of quartz and pyrite, with amounts of chalcopyrite, galena, sphalerite and pyrrhotite. Gold mostly occurs as native gold in fissures of pyrite and quartz. Mineralization stages are divided into three: (I) quartz-pyrite, (II) polymetallic sulfides and (III) carbonates. The former two are main gold-forming stages.

2.2 Wallrock alteration

Wallrock alteration types of gold deposits in ductile shear zones are mainly chloritization, sericitization, pyritization and carbonatization. Trace elements vary in alteration zones from veins to wallrock (see **table 3**).

Table 1 EMPA analysis of gold in gold deposits of Daqingshan, Inner Mongolia, China (mass fraction) %

Sample	Deposit	Au	Ag	S	Fe	Co	Ni	Cu	Zn	Te	Total	Mineral
N065(1)	No.12 mine	89.12	9.08	0.13	0.00	0.00	0.18	0.15	0.40	0.21	100.01	Au
N065(2)	No.12 mine	85.89	11.65	0.00	0.69	0.00	0.00	0.00	0.38	0.34	100.01	Au
N211(1)	Donghuofang gold deposit	98.79	0.00	0.00	0.96	0.00	0.08	0.18	0.02	—	100.02	Au
N211(2)	Donghuofang gold deposit	99.30	0.06	0.00	0.19	0.24	0.80	0.00	0.17	—	100.04	Au
N238(1)	Houshihua gold deposit	92.85	6.03	0.00	0.20	0.00	0.32	0.20	0.41	—	100.01	Au
N2389(2)	Houshihua gold deposit	92.02	6.99	0.00	0.57	0.00	0.00	0.21	0.22	—	100.01	Au
d76-1*	Donghuofang gold deposit	96.71	0.11	—	0.02	0.01	0.38	0.21	—	—	—	Au
d76-2*	Donghuofang gold deposit	67.81	29.30	—	0.06	0.10	—	—	—	—	—	El.

Note: * — According to Geology and Mineral Resource Beraeu, Inner Mongolia, China [2]; Au—Native gold, El.—Electrum.

Table 2 EMPA analysis of sulfides in gold deposits of Daqingshan, Inner Mongolia (mass fraction) %

Sample	Occurrence	S	Fe	Co	Ni	Cu	Zn	As	Sb	Se	Te	Au	Ag	Ti	Cr	Total	Mineral
N075	No.12,Ank	53.40	46.37	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.23	0.00	0.20	0.06	0.10	100.83	Py
N093	DQ,AR	52.60	44.45	0.00	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.05	0.00	99.95	Py
N065(1)	No.12,AuQ	52.59	45.95	0.00	0.18	0.00	0.00	0.10	0.16	0.03	0.15	0.35	0.20	0.09	0.09	99.89	Py
N065(2)	No.12,AuQ	53.51	46.15	0.00	0.07	0.20	0.17	0.17	0.00	0.00	0.00	0.07	0.00	0.01	0.04	100.28	Py
N056	No.15,AR	52.91	46.76	0.11	0.03	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.23	0.00	0.00	100.13	Py
N100	DQ,AR	39.22	58.15	0.16	0.78	0.17	0.00	0.01	0.08	0.00	0.39	0.16	0.08	0.08	0.00	99.24	Po
N074	No.12,CV	36.45	31.00	0.00	0.46	30.87	0.00	0.60	0.05	0.26	0.07	0.16	0.08	0.00	0.00	100.00	Cp
N084	DQ,MH	34.84	30.68	0.00	0.00	32.41	0.06	0.60	0.00	0.27	0.00	0.25	0.09	0.83	0.00	100.02	Cp
N093	DQ,AR	34.69	30.77	0.00	0.52	33.78	0.00	0.51	0.14	0.36	0.00	0.04	0.00	0.00	0.03	100.83	Cp
N100(1)	Di,DQ	34.16	30.23	0.15	0.00	33.51	0.00	0.51	0.37	0.36	0.13	0.45	0.18	0.00	0.00	100.05	Cp
N100(2)	Di,DQ	34.65	30.0	0.13	0.17	32.90	0.00	0.64	0.57	0.21	0.44	0.00	0.06	0.05	0.20	100.02	Cp

Note: DQ—Dongqianwantu gold deposit; No.12—No.12 gold deposit; No.15—No.15 gold deposit; AR—Altered rocks; AuQ—gold-bearing quartz vein; Ank—Ankerite vein; CV—carbonate vein; MH—Magnetite hornblede schist; Di—Diorite; Py—pyrite; Po—pyrrhotite; Cp—chalcopyrite.

Table 3 Wallrock alteration and variation of trace elements of gold deposits in ductile shear zones of Daqingshan area

Profile	Rock	$w_{Au}/10^{-9}$	$w/10^{-6}$						w_{Au}/w_{Ag}	w_{Cu}/w_{Pb}
			Ag	Cu	Pb	Zn	Mo	W		
Liangqian II ore body	Marble (hanging wall)	4.50	0.05	6.8	5.0	16.9	0.20	2.5	0.09	1.36
	Serpertinized Marble (hanging wall)	18.00	0.18	7.1	13.5	10.2	0.36	2.3	0.10	0.53
	Silicification Marble (hanging wall)	7.50	0.05	6.6	5.1	15.1	0.43	2.6	0.15	1.29
	Chloritization mylonite (foot wall)	200.00	0.16	39.7	26.9	21.0	1.23	6.4	1.25	1.48
	Altered migmatite (foot wall)	48.0	0.06	56.3	17.2	15.4	1.66	2.5	0.80	3.27
Changsheng	Weak altered migmatite	20.0	0.07	18.8	5.0	16.4	1.31	2.2	0.29	3.76
	Potassium altered rock	25.0	0.13	38.4	17.4	10.8	0.76	2.6	0.19	2.21
	Potassium altered rock	26.0	0.05	26.9	8.7	15.8	0.84	3.6	0.52	3.09
	Altered chlorite schist	48.0	0.05	8.5	5.3	10.3	3.52	3.1	0.96	1.60
	Altered mylonite	67.0	0.28	17.2	8.6	24.1	2.07	13.3	0.24	2.00
	Altered mylonite	85.0	0.45	13.7	21.1	20.9	2.11	9.8	0.19	0.65

Au and Ag contents increase with increasing of the alteration, especially in altered mylonite, which reflects ore-controlling of mylonite in gold mineralization. Pyritization, silicification, sericitization and K-feldspar alteration are also main types in gold deposits of altered fracture zones.

3 Physic-chemical Conditions of Ore-forming Fluids

3.1 General characteristics of fluid inclusions

A study of fluid inclusions has been made for Liangqian, No.12, No.15 and Dongqianwantu gold deposits. Large amounts of gas-liquid fluid inclusions were found in the quartz. All of them are very small and most of them are smaller than 2 μm in diameter. Microfractures in quartz suggest that the quartz has been damaged by the later structure and they made it difficult to measure homogeneous temperature. Eight samples selected were measured with decapitation method. The decapitation temperature (t_d) of gold-bearing quartz ranged from 325 to 400℃. For inclusions in the barren quartz from gneiss, t_d = 406℃; but for those from plagio-amphibolite and quartzite, t_d = 313 and 110℃ respectively.

According to Shi, *et al.*[1], the homogenization temperature (t_h) of quartz in pyrite-potassium feldspar-quartz stage, ranges from 358 to 440℃; and in polymetallic sulfide stage, from 150 to 390℃. t_h of main ore forming stage of Houshihua gold deposit is 350–400 ℃ in stage I and 250–350℃ in stage II.

Ore-forming temperatures of both the types of gold deposits are similar. The ore-forming pressure of Houshihua gold deposit is 130–180 MPa, similar to that of Wenyu-Dongchuang, Yangzhaiyu in Xiaoqinling (80–225 MPa), and concentrated in 132–190 MPa. The ore-forming pressure of Donghuofang is 78–105MPa, similar to that of Linglong, Jiaojia in Jiaodong peninsula (22–86, 80 MPa), and Hadamengou gold deposit in Wulashan area west to Daqingshan district.This difference indicated different tectonic settings of ore forming. The gold deposits occur along hillback fault and mylonite, similar to those of Wenyu and Dongchuang, thus are formed under higher pressures. On the other hand, main tectonic-rock of Donghuofang is cataclasite but not mylonite, similar to that Jiaojia gold deposit, thus is formed in lower pressure.

3.2 Composition of fluid inclusions

The results of composition analysis of fluid inclusions are listed in **table 4**.

(1) w_{CO_2} (w refers mass fraction) of fluid inclusions in Au-quartz veins generally ranges from 11.30×10^{-6}–25.70×10^{-6}, with w_{CO_2}/w_{H_2O} ranging from 0.023 to 0.045. The reduction index of gas composition $[(w_{CO}+w_{H_2}+w_{CH_4})/w_{CO_2}]$ is also a little higher, being from 0.78 to 0.97. w_{CO_2} of fluid inclusions in poor gold quartz or milky quartz are low (only $3.84\times10^{-6}-10.79\times10^{-6}$), and the reduction index is higher (1.77–2.44). C_2H_6 has been found in some gold-bearing quartz.Fluid inclusions of quartz vein that were found in gneiss and plagio-amphibolite have similar w_{CO_2} and w_{CO_2}/w_{H_2O} to those in ore-vein, but has lower w_{CH_4}/w_{CO_2} and reduction index.Quartz veins in the metaquartz-sandstone have of the highest w_{CO_2}/w_{H_2O} value, the lowest w_{CH_4}/w_{CO_2}, and the lowest reduction index. There are different value ranges in gold-bearing, poor-gold, and metamorphic rock (**figure 2**). Chen, *et al.* [2] proved that w_{CO_2}/w_{H_2O} is 0.015~0.146 in vein No.13 of Wu-lashan gold deposit, 0.02~0.06 in Donghuofang gold deposit, 0.01~0.10 in Houshihua gold deposit, which are similar to the results in this paper. It is indicated that there is no sharp difference between the two type gold deposits in the district.

In Daqingshan district, gold deposits have poorer CO_2, lower w_{CO_2}/w_{H_2O} than those in Xiaoqinling and Jiaodong Peninsula [5]. Perhaps, that there is no large gold deposit in Daqiinshan district may be related to the lower w_{CO_2} in fluids, which was beneficial to ore-forming.

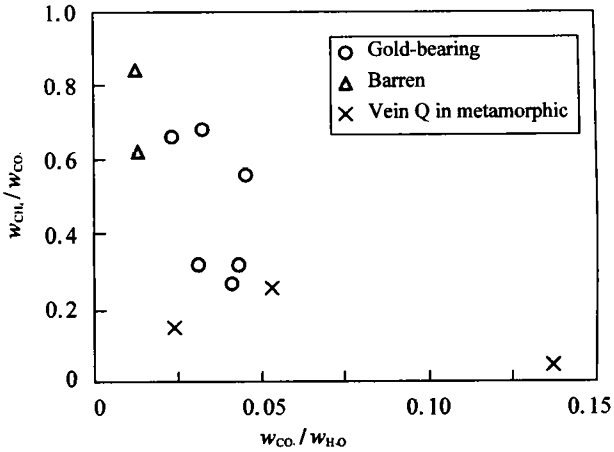

Figure 2 $w_{CO_2}/w_{H_2O}-w_{CH_4}/w_{CO_2}$ **coordinate diagram of fluid inclusions.**

(2) w_{K^+},w_{Na^+},$w_{Ca^{2+}}$ of liquid composition in gold-bearing quartz change slightly in various samples, but w_{K^+}/w_{Na^+} is a little difference among the various ore deposits. $w_{K^+}/w_{Na^+}>1$ in Liangqian, and <1 in Changsheng and Dongqianwantu. $w_{Cl^-}>w_{SO_4^{2-}}>w_{F^-}$ and $w_{F^-}/w_{Cl^-}<0.16$. Salinities calculated from ion composition in the fluid inclusions are lower. The salinities of gold-bearing vein quartz are from 0.68% to 4.83% in mass fraction, generally from 3.21 to 4.21, similar to those of Xiaoqinling and other greenstone-type gold deposits.According to Chen, *et al.*[2], w_K/w_{Na} of fluid inclusion in molybdenite-quartz stage is 0.26–3.10 (averages 0.90), and 0.32–3.10 (averages 1.41) in polymetallic-sulfide stage. However, in Donghuofang the value is low, that is, 0.07–1.00 (averages 0.34). These results are also similar to gold deposits in Xiaoqinling and Jiaodong

Table 4 Ion composition of fluid inclusions in quartz of gold deposits from Daqingshan area

Sample	t_d/℃	Ion composition / $g\cdot l^{-1}$								Salinity / %	w_K/w_{Na}	w_F/w_{Cl}
		F^-	Cl^-	NO^{3-}	SO_4^{2-}	K^+	Na^+	Ca^{2+}	Mg^{2+}			
N012	351	1.95	15.02	0.00	7.22	4.49	4.10	5.85	2.14	3.21	1.10	0.130
N019	406	1.63	11.98	0.00	4.36	3.27	4.90	2.99	0.00	4.25	0.67	0.140
N021	349	7.75	36.98	0.00	7.40	4.23	3.17	2.82	0.00	4.21	1.33	0.210
N035	344	2.84	18.10	0.00	4.14	3.10	5.43	6.98	0.00	3.69	0.57	0.160
N036	373	1.63	17.09	0.00	5.49	2.24	4.88	6.10	0.00	3.41	0.46	0.099
N041	373	0.77	8.76	0.00	6.70	4.89	5.92	5.92	0.00	3.42	0.83	0.088
N057	400	3.38	11.45	0.00	19.26	3.12	4.16	3.90	0.00	4.83	0.75	0.310
N089	325	1.24	12.62	0.00	3.31	3.10	5.38	4.76	0.00	4.38	0.58	0.099
N092	184,313	1.37	22.52	0.00	5.77	5.22	8.51	6.04	0.00	5.78	0.61	0.061
N105	110	0.28	14.49	0.00	2.90	4.28	6.07	15.59	0.00	3.31	0.71	0.022
N112	342	0.26	3.45	0.00	2.68	1.02	1.41	2.55	0.00	0.68	0.72	0.077

Peninsula.

4 Geochemistry of Stable Isotope

4.1 H, O, C isotope composition

Table 5 indicates that $\delta^{18}O_{smow}$ varys from 10‰~12.8‰, which is identical with other gold deposits of this area. $\delta^{18}O_{smow}$ is 11.36‰-12.89‰ in vein quartz of Wulashan gold deposit, 12.5‰-12.9‰ in Donghuofang, and 12.5‰-13.2‰ in Houshihua. In table 5, $\delta^{18}O_{smow}$ to $\delta^{18}O_{H_2O}$ with Craton formula can be turned

$\delta^{18}O_{H_2O}=\delta^{18}O_{quartz}-3.38\times10^{-6}T^{-2}+3.4$.

Most points projected in $\delta^{18}O_{H_2O}-\delta D_{H_2O}$ coordinate diagram (**figure 3**) is under normal magmatic water region, but there is an oxygen-shift towards rainwater. Hence, it is illustrated that ore-forming fluid was related with magmatic activity and locally influenced by meteoric water. δD ranges from -64‰ to -104‰, mostly in -74‰ to -97‰, which is in accordance with latitude effect and indicates the influence of meteoric water [5,6].

$\delta^{13}C$ of fluid inclusions in quartz ranges from -3.3‰ to -6.2‰, closing to that of carbonate rock and of diamond in kimberlite ((-5±2)‰). $\delta^{13}C$ of carbonate mineral from Hadamengou gold deposit also ranges from -4.0‰ to -5.1‰. This shows a mantle source, and $\delta^{13}C$ of gold deposit is regionally identical. As motioned above, H, O, C isotope composition of Daqingshan area is similar to that of Xiaoqinling greenstone type gold deposits.

4.2 Sulfur isotope composition

Sulfur isotope composition for Daqingshan district is listed in **table 6**. Except one high value (+15.1‰), all the other values of $\delta^{34}S$ range round 0, from -4.1‰ to +4.0‰. Pyrite of main ore-forming stage from Houshihua (including Songshubei and No.12 mine) has negative $\delta^{34}S$ values, from -4.1‰ to -0.5‰, near the one by Shi, *et al.*[1] (-2.6‰ to -6.2‰). $\delta^{34}S$ of pyrite of later stage (No.12 mine) is +4.0‰. The one of sulfides from Donghuofang gold deposit is positive, from +2.6‰ to +3.9‰. The $\delta^{34}S$ of pyrite is larger than that of chalcopyrite (except galena), so isotope exchange between pyrite and chalcopyrite had reached balance. The fact that $\delta^{34}S$ round 0 indicates that the ore sulfur would come from mantle or lower crust. From Hadamengou gold deposit to east, $\delta^{34}S$ changes in turn from -7‰--14‰ (Hadamengou), -0.5‰--6.2‰ (Houshihua, No.15), to +0.02‰-+6.1‰ (Donghuofang). That represented the same genesis type of gold deposits in this district. Greenstone-type gold deposits, including Xiaoqinling and Jiaodong Peninsula, also have regularity change [5].

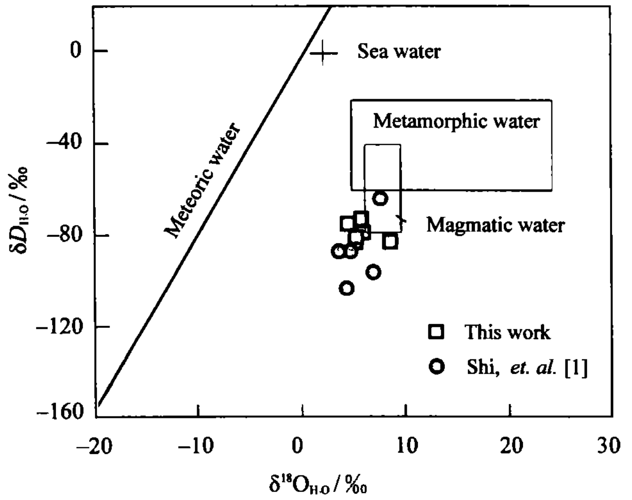

Figure 3 $\delta D_{H_2O}-\delta^{18}O_{H_2O}$ **coordinate diagram of ore-forming fluids from gold deposits in Daqingshan area.**

5 Genesis of Ore Deposit

Both types of gold deposits in the area are closely related with Archean greenstone belt, and Wulashan gro-

Table 5 $\delta D, \delta^{18}O$ **characteristics of vein quartz in gold deposits from Daqingshan area**

Sample	Characteristics	t_d/℃	$\delta^{18}O_{smow}$/‰	δD/‰	$\delta^{18}O_{H_2O}$/‰	Source
N012	gray quartz,Liangqian	351	11.2	-74	5.9	A
N021	Liangqian, Vein III	349	11.4	-80	6.1	A
N036	gold-bearing quartz	373	10.0	-84	5.3	A
N057	No.15, early quartz	400	12.8	-84	8.7	A
N089	Dongqianwantu, gold-bearing vein	325	11.5	-82	5.4	A
N112	Kuisu, bare gold vein	342	10.1	-76	4.6	A
dzh1	Donghuofang, gold-bearing vein	12.5	—	-104	4.43	B
dzh2	same as above	12.9	—	-88	4.84	B
H89189	Houshihua, gold-bearing vein	13.2	—	-65	7.79	B
H89377	same as above	13.0	—	-97	7.05	B
H89141	same as above	12.5	—	-88	3.69	B

Note: A expresses this work, and B expresses Inner Mongolia Geology Research Team, China [2]

Table 6 Sulfur isotope composition of main gold deposits in Daqingshan area

Sample	Occurrence	Mineral	$\delta^{34}S_{CDT}$ / ‰	Source
N060	No.15 mine, Py-Q vein	Py	−0.5	A
N065	No.12 mine Py-Q vein in mylonite	Py	+15.1	A
N074	No.12 mine, Py-Ca vein	Py_{II}	+0.4	A
N075	No.12 mine, Py-Q vein	Py	−2.2	A
N079	No.12 mine Py-Q vein	Py	−1.0	A
N238	Houshihua, Py in gray Q-vein	Py_I	−3.3	A
N257	Renzihao, Py-Q vein	Py_I	−2.7	A
N271	Songshubei, disseminated Py-Q vein	Py_I	−3.9	A
N272	Songshubei, gray Q vein	Py_I	−3.3	A
N273	Songshubei, Py in altered rock	Py_I	−4.1	A
N228(1)	Donghuofang, Py-Cp vein	Py_I	+3.3	A
N228(2)	Donghuofang, Py-Cp vein	Cp	+2.6	A
N224	Donghuofang, massive Cp	Cp	+2.9	A
N227	Donghuofang, polymetallic sulfide vein	Gn	+3.7	A
—	Donghuofang sulfide (8 samples)	—	0.02 − 6.1	B
—	Houshihua, Py (3 samples)	—	−2.6 − −6.2	B

Note: A expresses this work (Analysed by Institute of Mineral Resources, Beijing), and B expresses Shi, *et al.*[1]. Py — Pyrite, Cp — Chalcopyrite, Gn — Galena, Q — Quartz, Ca — Calcite.

up is important source strata. The gold mineralization varies with lithology of greenstone. Generally, in intermediate-basic plagio-amphibolite, amphibole-plagiogneiss and chlorite schist, gold mineralization occurs well than that in intermediate-acid gneiss and migmatite. Scale and gold grade of Houshihua, No.12, No.15 mines appear more advantages than those of Liangqian and Donghuofang gold deposits. Distribution of the mines is normally controlled by regional faults. Most of known gold deposits in this region occur along Guyang-Wuchuan hillback fault and their branch faults. The faults developed from ancient ductile zone, through ductile-brittle shear deformation and later stage's brittle deformation. Tectonic rocks (including phyllite, mylonite, tectonic-schist, cataclastic rock) occurring in shear zone were stacked by strong hydrothermal alteration will be prophecy advantageous for ore prospecting. For example, Renzihao, Houshihua, Songshubei are all controlled in chlorite-sericite phyllonite, sericite-quartz-phyllonite zone by hillback fault. There is no obvious difference of gold deposits between shear zone type and altered fracture zone type in fluid inclusions and isotope composition. They had similar ore-forming process and ore source.

Both types of gold deposits in this district are characterized by low salinities, rich CO_2, but lower w_{CO}/w_{HO} than that of Xiaoqinling. They had similar ore-forming temperatures and pressures to those of Xiaoqinling mountains and other typical mesothermal gold deposits [7−9]. Hydrogen, Oxygen, and Carbon isotope compositions are also similar to those of greenstone type gold deposits in other region. Hydrothermal fluids were active companying with regional magmatic intrusion, and were influenced by mixing of meteoric water. Ore sulfur came from mantle and lower crust, ore-forming elements originated from greenstone strata. Donghuofang gold deposit is spatially acompanied with volcanic breccia, but its mineral association, ore-forming fluid and stable isotope composition differ from typical volcano hydrothermal ore deposits, and are similar with No.12, No.15, Houshihua gold deposits.

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