Characteristics of fluid inclusions from two types of gold deposits in central part of Yi-Shu fault belt and their geological significance

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Abstract

In order to understand the ore-forming temperature and source materials, this paper studied fluid inclusions well developed within calcite and quartz from both alteration type and quartz vein type gold deposits in the central part of the Yi-Shu fault belt. Three types of fluid inclusions were recognized, namely, single liquid inclusion, gas-liquid inclusion, and gas inclusion. The freezing temperature of the inclusions is about −2 ~ −8.6 °C, and the salinity w(NaCl eq) is 3.39 % ~ 12.39 %. The homogeneous temperatures of the inclusions vary in a wide range of 107 ~ 550 °C, and can be divided into three temperature concentrated areas, i.e., 125 ~ 160 °C, 177 ~ 230 °C and 260 ~ 330 °C. These concentrated temperature areas suggest three ore-forming stages, i.e., the early stage represented by the formation of moderate-temperature quartz at 260 ~ 330 °C, the second stage by low to moderate temperature minerals of quartz and calcite at 177 ~ 260 °C, and the late stage by low-tempe-
natural calcite at $125 - 160 \, ^\circ C$. The Yi-Shu fault belt is a transform fault between eastern Shandong and western Shandong, and the characteristics of fluid inclusions and mineralization conditions in this area are similar to characteristics of western Shandong, especially to characteristics of the Pingyi gold deposit, but not similar to characteristics of gold deposits in Jiaodong area.

**Key words:** geochemistry, Yi-Shu fault belt, gold deposit, fluid inclusions, source material, ore-forming temperature

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**Figure 1** Geological sketch map of studied area


Y-1—Tangwu-Gexou fault Y-2—Yishui-Tangtou fault Y-3—Anju-Juxian fault Y-4—Changyi-Dadian fault

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**Figure 2** Distribution map of fluid inclusions and temperature determinations


Y-1—Tangwu-Gexou fault Y-2—Yishui-Tangtou fault Y-3—Anju-Juxian fault Y-4—Changyi-Dadian fault

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**Figure 3** Distribution map of fluid inclusions and temperature determinations


Y-1—Tangwu-Gexou fault Y-2—Yishui-Tangtou fault Y-3—Anju-Juxian fault Y-4—Changyi-Dadian fault
图1 沂沭断裂带两种类型金矿分布图

1—地表岩石
2—第四系
3—白垩纪大盛群马郎沟组
4—元古代辉长岩
5—元古代二长花岗岩
6—断裂构造
7—硅化破碎带
8—糜棱岩带
9—蚀变岩型金矿体
10—石英脉型金矿体

Fig. 2 Distribution of two types of gold deposits in central part of Yi-Shu fault belt
1—Quaternary
2—Maolan Formation of Cretaceous Daxing Group
3—Proterozoic gneiss
4—Proterozoic monzogranite
5—Faulted structure
6—Silicified shear zone
7—Mylonite zone
8—Shatter zone
9—Altered-rock type gold deposit
10—Quartz vein type gold deposit

表1 沂沭断裂带中段两种类型金矿流体包裹体特征及其地质意义

<table>
<thead>
<tr>
<th>样品号</th>
<th>矿物名称</th>
<th>测试点数</th>
<th>包裹体类型</th>
<th>包裹体形态</th>
<th>大小/μm</th>
<th>气相百分数/%</th>
<th>t℃</th>
<th>t℃</th>
<th>NaCl质量分数/%</th>
<th>计算密度/g cm⁻³</th>
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<td>规则</td>
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<td>159</td>
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</table>
图10 沂沭断裂带中段金矿床均一温度及冰点直方图

图11 方解石均一温度直方图；方解石冰点直方图；石英均一温度直方图；石英冰点直方图

石中流体包裹体的均一温度为108～300 °C，峰值主要为125～160 °C和205～260 °C，数据点主要集中在270～300 °C之间，该区间内又出现了双峰，分别在2.0～6.4 °C和-2～-5 °C之间，NaClaq 3.39 %～9.73 %。

数据点主要集中在270～300 °C之间，该区间内又出现了双峰，分别在2.0～6.4 °C和-2～-5 °C之间，NaClaq 3.39 %～9.73 %。

石英中流体包裹体的温度峰值集中于177～230 °C和260～330 °C，数据点主要集中在440～550 °C之间，NaClaq 4.49 %～12.39 %，0.708～0.981 g/cm³。

石英和方解石中流体包裹体显微测温结果表明：测温数据在空间上有从深部向地表逐渐降低的趋势。另外，从石英中获得一些177～550 °C的测温数据，这些流体包裹体多数为富气相，气相百分数从5.0 %～90 %均有，在均一过程中液相均一到气相中。由于沂沭断裂地区中生代岩浆活动强烈，因此，这种流体的出现与其有关。
方解石中流体包裹体的温度峰值主要为125～160°C和210～260°C。这可能暗示出成矿流体的三期运移，对应的温度区间从高到低依次为125～160°C、175～260°C和260～330°C，分别反映了以中温石英为代表的早期成矿阶段，以中低温石英和方解石为代表的中期成矿阶段，以及以低温方解石为代表的晚期成矿阶段。

石英和方解石中流体包裹体的冰点温度为25°C，对应的盐度为1%-2%。石英中流体的盐度稍高，变化范围较宽，可分为1%-3%和3%-8%两个盐度段，可能代表了两种流体端员组分，即中等盐度的岩浆流体（或深源流体）和低盐度的深循环大气水流。方解石中流体的盐度相对较低，推测为岩浆流体与大气水混合的结果。

成矿意义
流体包裹体的盐度均一温度图解被广泛应用于成矿作用的研究（张德全，2007）。沂沭断裂带中段地区流体包裹体的盐度均一温度图解（图4）具有以下特点：成矿流体的温度变化较大，但盐度波动范围较窄；石英内包裹体中流体的盐度可分为中等盐度和低盐度组，且以中等盐度的流体为主，随着温度的降低，流体的盐度基本保持不变；方解石中的流体均为低盐度流体，大体上可分为两个温度段，集中在125～160°C和175～260°C，对应着方解石中包裹体均一温度的两个峰值。流体包裹体中盐度分群可能暗示，成矿过程中有多种温度相近而盐度不同的流体发生了混合作用。本区流体盐度的分群，说明成矿过程中可能存在温度和盐度不同的端员组分的混合。结合氢氧同位素测试结果（李洪奎等，2005），可推断成矿过程中至少存在有岩浆流体（或深部流体）和深循环的古大气水两个端员组分。因此，本区金矿床的形成与断裂切割造成流体的减压沸腾以及深源成矿流体与大气水的混合有关。

毛景文等（2004）研究指出，在地幔熔融和交代过程中可以形成富金和CO₂的流体，这些流体在岩浆去气过程中上升到地壳，参与成矿作用。同位素研究则进一步表明，胶东地区金矿床的成矿流体来源于地幔，并与壳源流体发生了不同程度的混合。胡华斌等（2003）对鲁西平邑地区金矿床内石英、方解石和萤石中的流体包裹体进行了详细研究，其结果为：包裹体大小变化较大，为200-400μm，个别达500μm，但以300μm为主；从成分看，仅发现盐水溶液包裹体，在铜石岩体中有少量CO₂型包裹体；从相态看，有单一液相包裹体、气液两相包裹体和富气相包裹体。

Fig. 4 Diagram showing homogeneous temperature and salinity of gold deposits in central part of Yi-Shu fault belt
则状为主，个体相对较小，多数为液相包裹体、气液两相包裹体和富气相包裹体等。英中流体包裹体的研究资料表明：包裹体均较发温度为103～500℃。液相包裹体的均一温度集中于280～370℃，190～270℃，100～180℃。气相百分数的变化较大，从5%～10%。

产于脆韧性构造带中的蚀变岩型金矿，二是受脆性断裂主断裂面下盘的糜棱岩化碎裂岩和花岗质碎裂岩。南侧断裂带的金矿与鲁西归来庄金矿和磨坊沟金矿的包裹体特征有集中于65～70℃的较为常见。

English abstract.


附中文参考文献


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