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## The Geochemistry Feature and Geological Significance of Ore-forming Granites in Caosiyao Molybdenum Deposit, Central Inner Mongolia, China

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### 1 Geological Setting

Located in Liangcheng uplift of Inner Mongolia massif (Axis) within the North China Craton, Caosiyao molybdenum is a newly discovered superlarge scale deposit, which lies in center geographic coordinate 113° 52' 37"E and 40°49' 30"N. dual structures of stratum were recognized in the region. (1) Archean Huangtuliang formation is the oldest units, which composes of the major part of crystalline basement. (2) the Cover is basically composed of the sedimentary rocks formed since Mesozoic. The regional magmatic activity is strong and complex by means of volcanic eruption and magmatic intrusion. The Precambrian rock is mainly medium ultrabasic plutonic metamorphic rock; the Mesozoic rock mostly contains acid intrusive (or extrusive rock), the main outcropped rock is medium-fine grained porphyritic granite in Late Jurassic and granite porphyry in Early Cretaceous. And again, In terms of structure features, the regional fault structure is well developed mainly along NE-striking, subordinately NW-striking and near SN-striking. It is needed to pointed out that Caosiyao deposit is located in the intersection between regional discordogenic fault and subordinate fault and attributed with extensional structure features (Nie Fengjun, 2012), the subsidiary fracture beam derived from the regional large faults is the main impounding structure.

### 2 Description of the Mo Deposits

So far, it is preliminarily determined that Caosiyao Mo deposit has 2.2 billion tons of ore, 176 million tons of explored metal tonnage, an average grade of 0.101%, and associated Au(Cu)-Pb-Zn and other metal elements as well. The deposit that the main orebodies are thick-bedded, saccate, veined and lenticular is characterized of

shallow bury, large scale and good continuity. Due to the surface oxidation, the top (or upper) of all major orebodies are composed of oxidized ore belts, the middle (or lower) consist of thick primary sulfide orebodies. Overall, the rock is wholly mineralized, the deposit stretches nearly 2 km from east to west with a north-south width of 0.7~1.4 km, and the controlled thickness of the orebody is 400~900 m, averaging 520m, the orebody occurs as doom and reverse clock in sectional view (Nie Fengjun, 2012). The primary ore minerals are mainly molybdenite, wolframite, magnetite, galena and sphalerite etc., the gangue minerals mainly include potassium, feldspar, quartz, plagioclase, sericite, biotite and calcite. The ore structure is mainly dense disseminated structure, sparse disseminated structure, vein and veinlet structure, brecciated structure and honeycomb structure, the ore mainly has subhedral granular texture, flake texture, cataclastic texture etc., in addition, some molybdenite can form scaly aggregate.

### 3 The Geochemical Characteristics of Ore-bearing Rock

#### 3.1 The major element

The ore-forming parent rock is granitic intrusives which mainly is composed of porphyaceous granite, granite and granite porphyry, quartz porphyry. According to the test data statistics about the main oxides of the metallogenic mother rock, the main geochemical characteristics are as follows: (1) the content of SiO<sub>2</sub> for granite porphyry ranges from 71.71% to 79.01%, averaging 75.03%, both higher than chinese granite. (2) alkalis (K<sub>2</sub>O+Na<sub>2</sub>O) content is relatively higher and the potash content is also so, the total alkali content (K<sub>2</sub>O+Na<sub>2</sub>O) ranges from 3.93% to 8.23%, averaging about 6.39%; the radio of K<sub>2</sub>O/Na<sub>2</sub>O has a wide range from 2.90 to 32.27, with an average of 16.08. Rittman index  $\sigma=0.46\sim2.54$ , the rock belongs to the transition series between high kalium calc alkalic series

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and shoshonite series. (3) Caosiyao granite porphyry with  $A/NK=1.39\sim 2.78$ ,  $FL=89.90\sim 98.60$ , experiences a high degree of differentiation. (4) Felsic index (FL) is higher and changes in the range from 89.90 to 98.60, with an average of 96.18. In conclusion, Caosiyao granite porphyry is characterized of high acidity, high poash, high fluorin and high aluminum and generally belongs to acid K-rich calc-alkaline series. Caosiyao granite porphyry with  $A/NK=1.39\sim 2.78$ ,  $FL=89.90\sim 98.60$ , mainly composed of porphyaceous granite, granite and granite porphyry, quartz porphyry and characteristic of high acidity, high potash and high alumium, experiences a high degree of differentiation and generally belongs to acidic K-rich calc-alkaline series.

### 3.2 The trace and rare element

The characteristics of trace element for Caosiyao granite are as follows: (1) The ratio of U/Th is 0.1~0.3, with the average content of 0.17, less than the earth crust average of 0.26; the ratio of Rb/Sr is greatly changeable from 1.04 to 12.35, 4.99 on average, far higher than the earth mantle average of 0.025 (Taylor and McLennan, 1985); the ratio of K/Rb greatly ranges from 57.22 to 212.69, averaging 141.31, this demonstrates that granite magma experiences the process of crystallization differentiation evolution. (2) The right-oblique serration is generally shown in the primitive mantle standardized trace element spider diagram. Note that there are the respective peak value of LIL elements (K, Rb), REE (Nd, La, Sm, Tb) and the negative anomaly of HFS elements (Ti, Zr, Nb, Ta, Y) and P, Sr, reflecting the features of the continental crust.

The  $\sum REE$  of Caosiyao granite porphyry greatly ranges from  $152.71\times 10^{-6}$  to  $345.10\times 10^{-6}$ , with an average of  $279.12\times 10^{-6}$ . The characteristics are as follows: firstly, REE standard element spider diagram is arranged in seagull type, in which the content of LREE is relatively higher, with an average of 260.18; HREE has a lower content averaging 18.99. secondly, LREE shows a much bigger slop of curve and an obvious fractionation, but the curve of HREE is opposite; the ratio of LREE/HREE ranges from 7.74 to 18.68, with an average of 13.92, the value of  $(La/Yb)_N$  is from 8.09 to 27.02; there is an obvious differentiation between LREE and HERR. what is more,  $\delta Eu$  changing in the range from 0.17 to 0.60, with an average of 0.33 and the samples showing negative Eu anomaly demonstrate the plagioclase belongs to the stable mineral facies in the process of magmatic condensation.

## 4 Discussion and Conclusion

(1) Caosiyao granite rock mass is characterized by high

acidity, high potash, high aluminum and generally represents acid metaluminous potash series. the aluminium-containing index ( $A/CNK$ ) is between 1.20 and 2.49, most samples is greater than 1.1, with the negative anomaly of Ti and Nb, suggesting the characteristics of aluminous A-type granite. In addition, the average of  $10000Ga/Al$  is 4.11, greater than 2.6; the content of Nb is from  $23.9\times 10^{-6}$  to  $43.2\times 10^{-6}$ , with an average of  $33.76\times 10^{-6}$ , and show negative Nb anomaly, probably indicating the crustal material is involved in the magmatic process. At the same time, both the rock is strongly depleted in Sr, Eu, P, Ti; and the chondrite-normalized patterns of REE are in seagull forms characterize the A-type granite. In addition, the high content of F averages 1.5%, present as fluorite, also showing the characteristic of A-type granite. This is also confirmed by the samples falling in the A-type granite area in Ce-SiO<sub>2</sub> and Ce-10000Ga/Al diagram.

(2) Judging by the petrochemistry, trace-rare element chemistry and comprehensive factors of granite porphyry, Caosiyao granite is the mixed-genetic granite with the main crustal material mixed with mantle material involved as its origin, the dating of Caosiyao granite porphyry by the high-precision microgranular zircon U-Pb dating method by Lixiangzi etc. has yielded a  $^{206}Pb/^{238}U$  weighted average age of 131-134 Ma when the magmatic activity stage of Middle Yanshanian happens in Early Cretaceous, suggesting that the diagenesis and mineralization of Caosiyao was formed in the post-orogenic intracontinental rift during the period of tectonic regime transformation in the northern margin of North China Craton.

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