1 Regional Geological Setting

The Tongling region is situated in the Yangtze craton in central eastern China. During the Yanshanian period (Jurassic/Cretaceous), this region became active, in an event that has long been interpreted as an intraplate deformational stage with abundant magmatism (Chang et al., 1991). Deposits so far discovered in the Tongling district are usually grouped into several ore fields, which characterized by skarn-type mineralization, whereas porphyry-type Cu deposits are generally minor and occur in the deeper parts of a few skarn deposits.

Shujiadian Cu-Au deposit is the first large-scale porphyry deposit found in Tongling region, which could be divided into three types: Cu-Au bearing pyroxene diorite, diorite and diorite porphyrite ores, all locate in the Hinge zone of the Shujiadian brachyanticline (Lai et al., 2012). The strata are composed of Silurian formation, ore-bodies mainly distributed in the diorite and pyroxene diorite rock mass near the contact zone with sandstone and shale.

2 Ages of Diagenesis and Mineralization

The age of medium-acid intrusive rocks mainly range from 135 to 145, and may relate to their lithology. The zircon extracted from ore-bearing pyroxene diorite consisted of coarse, clear, subhedral to euhedral, partly broken grains. CL imaging showed that most grains had relatively big oscillatory zones. U-Pb analyses of 17 spots yield a range of Th/U ratios change slightly from 1.07 to 2.26, similar to the typical magmatic age. The apparent ages ranged from 137±3Ma to 144±3Ma, with an average of 140.5±1.4Ma (MSWD = 0.57), represent the diagenetic age of pyroxene diorite.

This age is a little older but similar than the Ar-Ar age of 138.2±4.6Ma (Wu et al., 1996) and U-Pb age of 139.2±2.1Ma (Wang et al., 2011), and similar to the age of pyroxene diorite elsewhere in Tongling. This result shows that the age of pyroxene diorite is about 140Ma, younger than the age of granite diorite (Xie et al., 2012).

The result of mineralization age shows that copper mineralization occurred at 140.6±2.0Ma (Wang et al., 2012), similar to its diagenesis age. As an important ore type, the zircon U-Pb age of Cu-Au bearing pyroxene diorite is similar to the metallogenic age of other deposit in Tongling, and that zircon CL imaging showed no obviously hydrothermal activity in the orebody, indicating mineralization was consistent with diagenesis.

3 Geochemistry and Petrogenesis

The Shujiadian pyroxene diorite rocks show small compositional variations, with SiO$_2$ contents ranging from 50.0 to 53.5 wt.%. The total alkali contents of (Na$_2$O+K$_2$O) vary from 5.89 to 7.57 wt.%, showing characteristics of the alkaline series. Fe$_2$O$_3$ and MgO contents decrease as SiO$_2$ increase, indicating fractional crystallization of Fe-Mg rich mineral such pyroxene and amphibole.

The ore bearing pyroxene diorite rocks have 172~249 ppm of total REE, with an average of 220ppm, and display coherent REE patterns characterized by relative enrichments of LREE and nearly flat HREE (La/Yb)$_N$ =14.4~23.7; with weak negative Eu anomalies (average Eu*/Eu=0.84). On a primitive mantle normalized trace element plot, Shujiadian pyroxene diorites show coherent patterns, with pronounced negative HFSE anomalies, such as Zr, Nb, Hf, and a positive LILE anomalies, such as Ba, Sr, Th, Pb, which is different from magmatic rocks formed in a continental intraplate setting.

The ages of medium-acid intrusive rocks has
long been debated, as well as their mineralization possibilities. Since the SiO$_2$ contents are relative low, even similar to the basic rock, the genesis of pyroxene diorite may the key to understand the mineralization background in Tongling region. The geochemical features of pyroxene diorite are different from magmatic rocks formed in a continental intraplate setting, but similar to those formed related to subduction zone. And the features of high Ba and Sr contents and low Rb content of the Shujiadian pyroxene diorite are similar to the the syntectic granite series, geochemical features show that rock samples belong to island-arc origin according to discriminating diagrams, these petro-geochemical features indicate that pyroxene diorite formed in the continental marginal magmatic arc which is closely related to the subduction of the Pacific Plate. The pyroxene dioritic magma may derive from lithospheric mantle and transformed by subducted oceanic slab, as well as crustal contaminations.

### 4 Formation of Adakitic Rocks and the Cu-Au Mineralization

High Sr content is the characteristic of adakite, average Sr content in pyroxene diorite is 1160ppm, as well as their high Al$_2$O$_3$ content, low Y content and adakite is widely distributed in the Tongling region, formation of pyroxene diorite in Shujiadian may relate to subduction.

Adakite melts and supercritical fluids derived from partial melting of oceanic crust have high oxygen fugacity due to they are rich in Fe$_2$O$_3$, makes it possible to carry tons of mineralization materials. Ba is the most active incompatible element in fluids released from subduction, and Th element usually enrich in melt formed by subduction. Melt and fluid both play an important role in the formation of pyroxene diorite rocks in Shujiadian in Nb/Y-Ba diagram, and the fluid involve in mineralization is close related to subduction fluids in Sr/Nd-Th/Yb diagram.

The source of ore-forming elements in the Tongling region should be hydrothermal fluids and/or melt derived from dehydration of the subducting oceanic crust. These magma would lose Cu-Au when they evolved (crustal contamination or fractional crystallization), then it need extra role to make Cu-Au enrich again, that is why skarn ore is the most important deposit in Tongling region. Compared to other magmatic rocks in Tongling, pyroxene diorite in Shujiadian is relatively low in SiO$_2$, their Cu-Au loss were less, that is why they can form porphyry type deposit. These maybe the evidence of subduction, while, they were not direct derived from partial melting of oceanic crust (Ling et al., 2009), but from mantle wedge partial melting caused by subduction.

### 5 Conclusion

1) Both diagenetic and metallogenic ages in Shujiadian are c.a. 140Ma, similar to mass magmatic activation in the Tongling ore-cluster filed.

2) Pyroxene diorite in Shujiadian formed in the continental marginal magmatic arc which is closely related to the subduction of the paleo-Pacific Plate. The magma of pyroxene dioritic intrusion was possibly due to ascend and emplacement of magma derived from partial melting of mantle wedge which was metasomatized by melt and/or fluid caused by subduction.

3) The ore-forming elements were provided by hydrothermal fluids and/or melt derived from dehydration of the subducting oceanic slab, the mantle source magma might have been transformed with crustal contaminations.

### Acknowledgements

This study was supported by the Natural Science Foundation of China (Grant Nos. 41173057 and 41090372) and Scientific Research Foundation of East China Institute of Technology (DHBK2013209).

### References


