The tectonogeochemical dynamic system in Dexing porphyry copper deposit, Southeast of China

G. Heming

Institute of Geochemistry Chinese Academy of Sciences, Guiyang 550002, China

Introduction

With plentiful and clear geological phenomena, porphyry copper deposits type have been taken as examples in the study of rock-forming and ore-forming theories and many important achievements have been obtained[1-3]. Geologists have, on one hand, put forward some geological-geochemical zoning patterns in light of zonal characteristics of alteration and mineralization, and, on the other hand, discovered a lot of fractures and veinlets (called fracture-vein system later) in the deposits, which were formed mainly by the emplacement and evolution of porphyritic magma. However, there are few researches done on the relationship between evolution of stresses, formation of fracture-vein systems, movement and distribution of matter, alteration and mineralization. The relationship mentioned above comprises a typical problem in tectonogeochemistry and a new scientific subject. The present author made a systematic study in this field selecting the famous Dexing porphyry copper deposits in China as an example.

The general characteristics in the deposit

The fracture-vein system in Dexing porphyry copper deposit, which has clear symmetric planar zoning of alteration and mineralization along the contact between porphyry body and its wall-rock[4], was well developed and was orientated and distributed in a regular pattern[5]. The strikes of the fracture-vein system are distributed around the porphyry concentrically and radially. It is found that the top of the porphyry body is the favourable position for the development of fractures and veinlets and then the contact zone between the porphyry body and wall rocks, few fractures and veins are found far away from the contact zone. The fracture-vein system, the planar alteration zones and the ore body have evident spatial relationships: the fracture-vein system was well developed in a strong planar alteration zone, it was, however, poorly developed in a weak planar alteration zone. Ore bodies distributed mainly in a strong planar alteration zone where the fracture-vein system was developed well. All the above features and other results reveal that a genetic relationship existed between alteration zone, ore body and fracture-vein system, and, consequently, genetic relationship also existed between evolutions of stresses and matter in the deposits.

Evolution of stresses and the formation of fracture-vein system

The study of stresses produced by emplacement and the second boiling of porphyritic magma and the thermal stress show that there were high compressive stress in the vicinity of the contact zone, but low compressive stress, even tensile stress far away from the contact zone. The stresses and hydraulic fracturing processes controlled by the stresses formed most of the fractures and veins in the deposits[6]. The analysis of the hydraulic fracturing dynamics reveals that the fluid-driven cracks propagated easily once they occurred and the process was controlled mainly by hydrothermal fluid dynamics. This may be the primary cause for the formation of abundant veins and disseminated ore in the porphyry copper deposits. The formation of veins were accompanied by quick migration of hydrothermal fluid and changes of the physicochemical conditions which were very important to the extensive alteration and mineralization as well as the deposition of large amount of ore minerals in veins.

The theoretical studies show that the fracture-vein system be formed first on top of the porphyry, then at the contact between porphyry body and its wall-rocks and spread out from both side the contact latter on. This was important to the zoning of alteration and mineralization in the deposit.

The geochemical dynamics of rock-forming and ore-forming process

The evolution of temperature field in the deposit continued for more then ten thousand years which reflected prolonged rock-forming and ore-forming processes . The temperature, being high in the vicinity of porphyry body and low far away from the porphyry body, were very important to the zoning of alteration and mineralization. The coupling relationship between transport of mass and reactions were primary cause for alteration and mineralization. If initial porosity of rocks, mole density of matter in reactions and concentration of reactants in coming fluid were specialized, the expanding velocity of reactive front was controlled by the flux of hydrothermal fluid. The stresses in the deposits controlled the flux of fluid, and therefore the geochemical dynamics of alteration and mineralization. In the system of interact between transport of matter and reactions in stress field, high temperature and great compressive stresses were helpful for metamorphic differentiation. In other words, stresses had a strong effect on zoning of alteration and mineralization.

The tectonogeochemical dynamic system for the deposit

In the rock-forming and ore-forming processes of the deposits, a mutual coupling existed in the evolution of stresses and transportation of matter. The coupling effects were substituted by the coupling actions between evolution of stresses and formation of fracture-vein system, movement and distribution of matter, alteration and mineralization. The evolution of stresses and formation of fracture-vein system, on one hand, controlled the transport and distribution of matter,on the other hand,effected alteration and mineralization by changing the physicochemical conditions; the movement and distribution of matter decided the scale and intensity of alteration and mineralization, at the same time, effected the evolution of stresses and made fracture-vein system form easier; alteration and mineralization changed properties of rocks effecting transportation and distribution of matter, evolution of stresses and formation of the fracture-vein system. In the early stage of the rock-forming and ore-forming process, the coupling actions worked strong on the top of porphyry body and produced the K-alteration zone and veins containing K-minerals by the high temperature, rich in potassium, but poor in ore-forming matter. In the middle stage, the coupling effects moved to the contact between porphyry and its wall-rock and the moderately-high temperature, complex composition and rich in ore-forming matter hydrothermal fluid formed the strong (moderate) zone and main ore body along the contact. During the latter stage, the coupling actions spread away from both sides of the contact and let the (moderate) weak alteration zone be formed by the low temperature, complex composition, lot of ore-forming matter.

It was the spatio-temporal evolution of the coupling actions that caused the formation of the fracture-vein system, the zoning of alteration and mineralization, and produced the special rock-forming and ore-forming processes as well as spatio-temporal structure in Dexing deposits.

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