Comparative Analysis on genesis of mineral deposit between Scandium anatase deposit in Qinglong Shazi and Laterite Gold Deposit in Western Guizhou

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Abstract. This paper makes a comparative analysis on genesis of mineral deposit between Scandium anatase and laterite gold deposit in Western Guizhou, the study shows that: 1) High-gold source rock of laterite gold ore in western Guizhou is formed at the initial period of strong eruption of basalt in Mount Emei at the top of Maokou limestone; 2) The high-gold source rock is remaining in micro depressions at the erosion surface of paleokarst and is exposed or near to the superficial zone through later tectonic change. 3) Scandium anatase deposit of Qinglong Shazi is formed through basaltic volcanic breccia, volcaniclastic rock and tuff dropping into the water of paleokarst micro depression. Basaltic matters immerse and disintegrate titanium in rock which forms to anatase in low temperature and pressure and alkalescence water. 4) Through quaternary long-time evolution, surrounding rock changes into red clay and anatase is stored steadily in normal temperature and pressure. 5) With differences in micro-phase paleogeographic environment, eruption of basalt in Mount Emei and falling of pyroclasts in different environments lead to the differences of mineral element combination and formation of ore deposits of different mine types.

Introduction

Mantle plume active region in Emei is the important concentration zone of super- large and large ore deposit [1-4]. Taking basalt region in the west of Guizhou as an example, mineral products like gold, antimony, copper, arsenic, mercury, thallium, rare earth have produced here [5-7]. In recent years, large-scale scandium anatase deposit has been founded in the Qinglong Shazi in Guiyang [8]. The genetic type of large-scale scandium anatase deposit in the Qinglong Shazi belongs to the thermal water deposit- slope deposit related with basalt eruption of Emei. The orebody occurred on the plane of unconformity of Permian Maokouan limestone karst and in red clay of the Karst negative terrain on the bottom of Emeishan basalt, of which the occurrence space is the same with red-clay gold mineral in the west of Guizhou province. However, the scandium anatase ore can't be found in red-clay gold deposit and vice versa. Therefore, this paper aims at make a comparative analysis of the scandium anatase deposit of Qinglong Shazi and three typical laterite gold deposit of Laowanchang, Baozidong and Shaguochang in west of Guizhou, so as to discuss the differences the minerogenetic conditions between scandium anatase deposit of Qinglong Shazi and three typical laterite gold deposit of Laowanchang, Baozidong and Shaguochang in western Guizhou.

Geological setting

Both scandium anatase deposit of Qinglong Shazi and laterite gold deposit in west of Guizhou are located in gold-concentrated area in the southwest of Guizhou province which is in the intersection portion of the southwestern margin of the Yangzi landmass and the west section of the south China fold system from the perspective of geotectonic location. It is the gore which is under the control of regional deep fracture and the main distribution in the region is the Permian Emeishan basalt (Fig. 1).

This area, living through one period of uplift and denudation after reef deposits of flats and limestone in the late middle Permian of Maokou formation, sink into the coastal zone[9]. Due to the volcanic eruption at the end of middle Permian and early of late permian epoch, on the plane of unconformity of Permian Maokouan limestone karst deposited the Emeishan basalt's first section of the clay basaltic volcanic breccia, then pyroclastic rock and tuff, which became the basalts exposed in this area in the southwest of Guizhou Province. It locates in the southeast edge of the basalt distribution range in the west of Guizhou with the thickness more than 200 meters below the earth[10]. and the eruption at the end of middle Permian and early of late permian epoch. Conditions in the early eruption period are the littoral tidal flat[10]. Except for the general properties of the common continental tholeiite, the basalt in the region holds properties like slightly alkaline, high grade ferrotitanium, low-magnesium, SiO2 saturation, generally containing quartz and few olivines. The degree of alkaline is the highest in the basalt distribution area in the western Guizhou province and also the volatile component is higher than that of the other regions [11]. The mine-source stratum in initial stage of the lateritic gold deposit also serves as the ore bodies and country rocks of scandium anatase deposit of Qinglong Shazi.

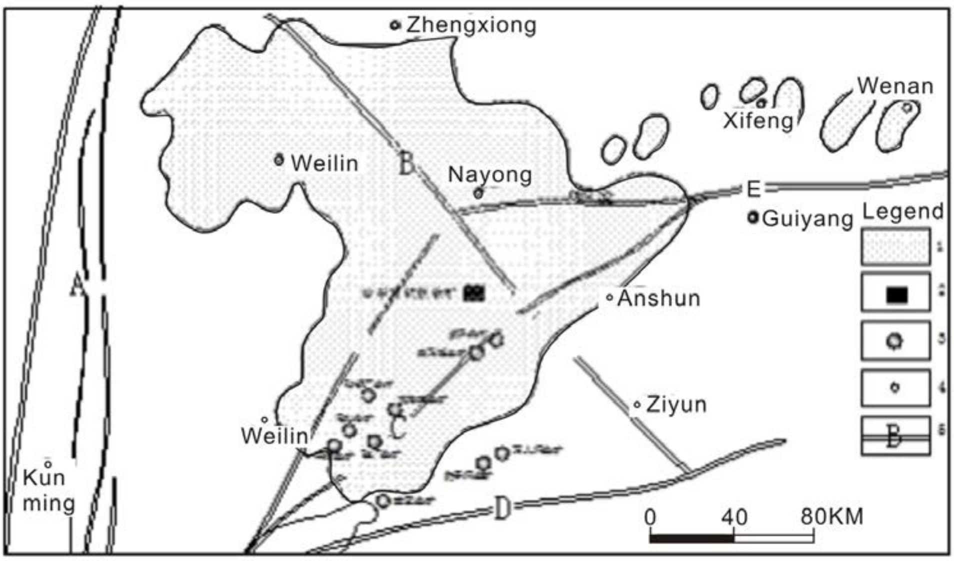

Fig.1 Geology map of the study area (based on, [1-2],[5-6],[10] revision);1 Large distribution of Emeishan basalt in Guizhou province; 2 scandium anatase ore; 3 laterite gold deposit (point); 4 Geographical names of the cities and counties; 5.Deep fracture zone and fracture zone A Xiaojiang fault B Shuicheng-Ziyun fault C Mile-Shizong fault D Nanpan River fault E Nayong-Anshun fault (based on Luo Yaonan, 1985, Gao zhenmin, Li Hongyang, 2002, Regional geology of Guizhou province 1987, Wang Yangeng, Chen lvan, 2000 revision)

Forming conditions of laterite gold deposits in western Guizhou

There are mainly three forming conditions of laterite gold deposits in west of Guizhou which are as follows specifically: (1) Gold-rich source rock: Due to the volcanic eruption at the end of middle Permian and early of late permian epoch, on the plane of unconformity of Permian Maokouan limestone karst deposited the Emeishan basalt's first section of the clay basaltic volcanic breccia, then pyroclastic rock and tuff, which became the basalts exposed in this area in the southwest of Guizhou Province. In the end, this became the gold-rich source rock with the combination of Au-Ag-As-Sb-Hg-Tl. (2) Special ancient karst: cultivated with the middle Permian Maokouan limestone karst erosion surface with the mini-type depression on the Karst is full of complexity and the depth is about 100 meters. There is some gold-rich source rock left on the surface. (3) Water-rock interaction under the normal temperatures and pressures in the epigenetic zone: the atmospheric precipitation, surface water and the groundwater etc. shall have water-rock interaction such as oxidation, hydrolysis, leaching etc. with the gold-rich source rock in the mini-type depression on the ancient Karst erosion surface. It would form the lateritic soil after the Quaternary evolution, and thus the Au would be free from the source rock and then be absorbed and accumulated by the lateritic soil which form the lateritic deposit in the end [12].

Forming condition for scandium anatase deposit of Qinglong Shazi

Forming conditions of anatase mineral： Anatase mineral is formed in weak alkaline medium with conditions of low temperature and low pressure [13]. In nature, the formation of anatase ore deposit needs the following three conditions: 1) the material source of forming titanium ore; 2) low temperature and low pressure and weak alkaline medium to form anatase; 3) environment of high temperature and high pressure making it transform into rutile.

Mineral-formation geologic conditions analysis of anatase ore deposit in western Guizhou： Material source of forming anatase ore in this area: chemical component of basalt in Qinglong Shazi area contains high titanium and low magnesium which belongs to tholeiite with high titanium. Mine basalt contains 3.64％ of TiO2. Accessory minerals of titanic magnetite and ilmenite are rarely seen in basalt of this area. Titanium in basalt enters into the silica tetrahedron of augite with heterovalent isomorphism of Ti4+ +Al3+=Mg2++Si4+. Qinglong area is in late Early Permian of Maokou formation. With strong eruption of basalt in Mount Emei, the basaltic eruptive material will fall down into the water and be immersed and disintegrated [14]. Dark-colored mineral augite disintegrate and all the heterovalent isomorphism Ti4+ in augite almost precipitine and enter into the water to provide rich titanium source for formation of anatase ore in this area. With the same area of mineralization background to the laterite gold ore in western Guizhou, main oxide of SiO_2, Al_2O_3 and Fe_2O_3 in ore are closely to the main features of red clay in laterite gold ore in western Guizhou; micro elements Au-Ag-AS-Sb-Hg-Tl combination in ore is same to the micro elements combination of three laterite gold ores in western Guizhou. At the initial eruption period of basalt in Mount Emei, the argillite formed at the top of Maokou limestone is the surrounding rock of laterite gold ore and also the main surrounding rock to form anatase ore. Micro elements Sc-TiO_2-Cu-Fe-Mn combination in ore reflects the same combination to micro elements of the original basalt.

Special geochemical barriers of karst depression with weak alkaline water in this area: paleokarst highland and karst depression are formed at the top of Maokou limestone in Permian System at the area of Qinglong, Guizhou. Close to rivers and lakes, hydrops exist in some karst depressions [15]. According to research, high-Na and low-K is in Qinglong Shazi with 5.33% of Na2O and 0.17% of K_2O. High-Na feldspar immerses and disintegrates in water of karst depression with K+ entering into the clay mineral and Na^+ dissolved in water which makes the special geochemical barriers of karst depression with weak alkaline water exist in this area. In addition, enough O_2 at ground oxidation zone of karst depression with weak alkaline water provide the formation of TiO_2 with sufficient conditions. This karst depression water is separated by karst highland to each isolated weak alkaline waters. This special geochemical barrier provides necessary environment for formation of anatase ore in this area.

Low temperature and low pressure for formation of anatase ore in metallogenic epoch in this area: remote sensing data of ETMLandsat-7 is employed to select waveband of 7, 4, and 1 and combine them into remote sensing image to construct and explain. Annular and linear construction in this area expands along the north and east direction and overlaps obviously in space with explored No. 1, 2 and 3 ore body. Based on the regional data analysis, the ore is situated at the Shizong-Mile fault belt. It is predicted that eruption period of basalt might be regional heat source. In addition, high-temperature volcanic materials erupted by basalt fall down into the karst depression water and hydrolyzed into surface hot water. We predict on the basis of thickness of tephra sediments in karst depression that the water body at that moment was up to tens of meters with certain static pressure. It is environment of low temperature and low pressure and meets conditions of forming anatase ore in conditions of low temperature and low pressure.

Formation mechanism of anatase deposit of Qinglong Shazi: Basalt of Mount Emei in western Guizhou enters into the silica tetrahedron of augite with heterovalent isomorphism of $Ti^{4+}+Al^{3+}=Mg^{2+}+Si^{4+}$. With strong eruption of basalt in Mount Emei, the basaltic eruptive material will fall down into the water and be immersed and disintegrated. Ti^{4+} in augite is released in silica tetrahedron and enters into water. TiO_2 is generated through its combination with oxide in water. There are several paleokarst highland and karst depression at the top of Maokou limestone in Permian System. Eruptive matters of basalt of Mount Emei fall into water with Na^+ dissolved in water which leaves weak alkaline water in karst depression. In superficial oxidizing environment and the limited water body of low temperature and low pressure, the relatively pure TiO_2 is generated (anatase deposit). Water limitations in single karst depression makes small differences of the water temperature, pressure and PH value; small concentration difference of Ti^{4+} and O_2 leads to uniform mineralization in a single karst depression with grade variation coefficient of TiO_2 ore smaller than 20%. Short late depositional break of Maokou results into little undulation of karst depression at the top of Maokou limestone and relatively stable thickness change of ore bed with their thickness change coefficient smaller than 50%. Remote sensing data of ETMLandsat-7 is employed to select waveband of 7, 4, and 1 and combine them into remote sensing image to construct and explain. Annular and linear construction in this area expands along the north and east direction and overlaps obviously in space with explored No. 1, 2 and 3 ore body. The ore is situated at the Shizong-Mile fault belt. It is predicted that eruption period of basalt might be regional heat source. In addition, high-temperature volcanic materials erupted by basalt fall down into the karst depression water and hydrolyzed into surface hot water. We predict on the basis of thickness of tephra sediments in karst depression that the water body at that moment was up to tens of meters with certain static pressure and condition of low temperature and low pressure. The anatase deposit is formed. After anatase ore body is formed, this area experienced late Permian and later sediment and tectonic change in Yanshan Period. For failure in reaching regional metamorphosis and environment of high temperature and high pressure for anatase deposit having a phase transition into rutile, anatase deposit formed is stored stably. The himalayan period and new tectonic movement make anatase ore body exposed to the surface and suffer from the weathering. The surrounding rock is further dripped wet and disintegrated—laterization. Anatase deposit id further enriched in residual red soil.

There exists obvious concentration of the element Scandium (Sc) in anatase ore in Qinglong Shazi. The Scandium (Sc) atom has an outer electron structure of $3d^1 4s^2$ and exists stably in nature. Sc^{+3} in this area is not equivalently replaced with Fe^{2+} and Mg^{2+}. It exists in augite of basalt, amphibole and olivine. When basalt and eruptive materials fall into the water, Sc^{+3} is released in the rock with immersion and disintegration of minerals like augite. PH value has a vital influence on behavior of Sc^{+3}. In acid solution, Sc^{+3} is in dissolved state and will run off with water; in neutral—alkaline solution, $Sc(OH)_3$ or Sc_2O_3 colloform is formed or complex ion is absorbed by iron oxide, ouatite and clay mineral to make the anatase ore high-Sc in this area. With ferritin, manganese, titanium and scandium derived from the same basalt, scandium has high relevance with titanium, ferritin and manganese: the correlation coefficient of scandium with ferritin is +0.9155; the correlation coefficient of scandium with manganese is +0.7268; the correlation coefficient of scandium with titanium is +0.6568.

High-scandium anatase ore deposit of Qinglong Shazi is volcanic-clastic sedimentary deposit at top of Maokou limestone and in conditions of low temperature and low pressure and weak alkaline water of karst depression at the initial period of strong eruption of basalt in Mount Emei and experienced through Quaternary weathering, leaching and decomposition. Then titanium and anatase ore are enriched to form the ore deposit.

Comparison of laterite gold deposit forming conditions in western Guizhou and scandium anatase deposit forming condition of Qinglong Shazi

(1) The formation of laterite gold ore in western Guizhou and scandium anatase deposit of Qinglong Shazi is related to eruption of basalt of Mount Emei.

(2) Laterite gold ore in western Guizhou forms high-gold source rock at the initial period of strong eruption of basalt in Mount Emei at the top of Maokou limestone; the high-gold source rock is remaining in micro depressions at the erosion surface of paleokarst and is exposed or near to the superficial zone through later tectonic change. Through water-rock reaction in normal temperature and pressure in supergene zone with quaternary long-time evolution, the red clay is formed. The gold is dissociated from source rock and adsorbed by red clay to form ore deposit [5-6].

(3)Scandium anatase deposit of Qinglong Shazi is formed through basaltic volcanic breccia, volcaniclastic rock and tuff dropping into the water of paleokarst micro depression. Basaltic matters immerse and disintegrate titanium in rock which forms to anatase in low temperature and pressure and alkalescence water. Through quaternary long-time evolution, surrounding rock changes into red clay and anatase is stored steadily in normal temperature and pressure. Partial Impurities of surrounding rock is leached and scandium anatase is further enriched.

Ore Prospecting Implications

Basalt in Mount Emei is the largest volcanic eruption recorded in the earth. Basalt of Mount Emei in western Guizhou has a wide distribution with the Zhijin-Anshun-Xingren line as the eastern edge of basalt of Mount Emei. Basalt in this field is slightly alkaline, high-titanium and high-ferritin, low-magnesium and saturate in SiO_2 with containing quartz, gold, stibium, arsenic, mercury and thallium and highest alkalinity in distribution area of basalt in western Guizhou. Meanwhile, the volatile component in this area is higher than in other areas which will bring more ore-forming elements [16]. The eruption era is from the end of middle Permian to the early late Permian. The environment at the earlier stage of eruption is the coastal tidal flat. This region experienced uplift and denudation for some period after the sediment of reef flat limestone in late Maokou of middle Permian and then sank into the coastal field. This depositional break made karst appear at the top of Maokou limestone in middle Permian and further left the ground undulating. Due to the differences in micro-phase paleogeographic environment and chemical and physical differences in micro-phase environments, eruption of basalt in Mount Emei and falling of pyroclasts in different environments lead to the differences of mineral element combination and formation of ore deposits of different mine types. Different degrees of abundance in containing mineral elements in different environments will lead to deposit grades. This differentiation not only forms the laterite gold ore and Carlin-type gold deposit but also the scandium anatase deposit. The above research will provide some implications for exploring new deposits in basalt distribution in western Guizhou.

Conclusions

Through the comprehensive comparison between scandium anatase deposit of Qinglong Shazi and laterite gold deposit in western Guizhou, we make the following conclusions: 1) High-gold source rock of laterite gold ore in western Guizhou is formed at the initial period of strong eruption of basalt in Mount Emei at the top of Maokou limestone; 2) The high-gold source rock is remaining in micro depressions at the erosion surface of paleokarst and is exposed or near to the superficial zone through later tectonic change. Through water-rock reaction in normal temperature and pressure in supergene zone with quaternary long-time evolution, the red clay is formed. The gold is dissociated from source rock and adsorbed by red clay to form ore deposit; 3) Scandium anatase deposit of Qinglong Shazi is formed through basaltic volcanic breccia, volcaniclastic rock and tuff dropping into the water of paleokarst micro depression. Basaltic matters immerse and disintegrate titanium in rock which forms to anatase in low temperature and pressure and alkalescence water. 4) Through quaternary long-time evolution, surrounding rock changes into red clay and anatase is stored steadily in normal temperature and pressure. Partial Impurities of surrounding rock is leached and scandium anatase is further enriched. 5) With differences in micro-phase paleogeographic environment, eruption of basalt in Mount Emei and falling of pyroclasts in different environments lead to the differences of mineral element combination and formation of ore deposits of different mine types.

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