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Geological Controls of Orogenic Gold Mineralization at Zarmitan, Uzbekistan Tianshan

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1 Introduction

The Zarmitan deposit is located in the central Kyzylkum-Nuratau gold metallogenic province of the South Tianshan Hercynian thrust-fold-belt, north Nuratau mountain of western Uzbekistan. The Zarmitan deposit represents one of the best explored examples of gold deposit hosed in narrow quartz veins in granites and meta-sedimentary rocks, and is estimated to contain as much as 314 t Au at an average grade of 9.8 g/t (Abzalov, 2007). Previous studies on the Zarmitan deposit emphasized on gold mineralization in host granitoids and other geological characteristics, and classified it as an intrusion-related gold system during the orogenesis of the South Tianshan (Abzalov, 2007; Graupner et al., 2010). However, significant gold enrichment is confined to hydrothermal altered fracture zone only. This paper reviews the regional geological setting of the Zarmitan deposit, with an emphasis on the geological controls of gold mineralization, especially the possible links between meta-sedimentary strata, magmatic intrusions, and structural activities, and their roles in the formation of the world-class Zarmitan deposit.

2 Regional Background

Tectonically, the Zarmitan deposit is localized in the north Nuratau mountain area, which represents a Paleozoic accretionary terrane overlain by Mesozoic-Cenozoic sediments. This area consists of Devonian-Carboniferous volcano-sedimentary and carbonates sequences and Ordovician-Silurian flysch sequences overlying greenschists and epidote-amphibolite facies metamorphic basements of Cambrian-Ordovician (Abzalov, 2007). The Late Carboniferous molasse unit unconformably overlain the Paleozoic volcano-sedimentary rocks in north Nuratau mountain region. The Paleozoic volcano-sedimentary sequences were intruded by voluminous of Hercynian granitoids. The Koshrabad intrusion, which hosts the Zarmitan and Guzhumsai gold deposits, is a W-E strike, wedge-like complex with an area of 196 km^2. The Koshrabad complex comprise mainly of quartz monzonite and granite batholith, and intruded by dikes and stocks of aplite, gabbro, gabbro-syenite, and quartz syenite. The quartz monzonite batholith yielded U-Pb zircon SHRIMP age of 286 ± 2 Ma (Seltmann et al., 2011), and referred to as a post-collisional A-type granite (Konopelko et al., 2011). The Nuratau area is characterized by two major tectonic structures, including the northern Nuratau suture fault striking north-east-north and the Karaulkhana-Zarmitan sinistral strike-slip high-angle fault.

3 Gold Mineralization at Zarmitan

The main strata exposed at Zarmitan are Ordovician to Lower Silurian sedimentary rocks of sandstone and siltstone interlayed with carbonates and tuffaceous sediments, and are intruded by the Koshrabad complex. The sedimentary sequences underwent intense contacting metamorphism due to the intrusion of the Koshrabad complex, and resulted to form a 50 to 200 m thick hornfels along the complex. The Karaulkhana-Zarmitan sinistral strike-slip high-angle shear zone occurs in the south of the hornfel zone and splits into a serises of faults and fractures near the intrusion zone between the Koshrabad complex and meta-sedimentary sequences. Gold mineralizations at Zarmitan occur as veins in the Koshrabad intrusion and meta-sedimentary rocks, forming a continuous mineralized zone ca. 7 km long and 300 to 1000 m wide. High-grade orebodies are controlled by the Karaulkhana-Zarmitan shear zone and associated shears, faults, fractures systems, preferentially at their intersections.

The gold mineralization at Zarmitan can be divided into

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four stages, each characterized by different mineral assemblages in the veins, including quartz–K-feldspar–scheelite veins, quartz–pyrite–arsenopyrite–gold veins, quartz–sphalerite–galena–pyrite–gold veins, and quartz–carbonate–fluorite–pyrite veins (Graupner et al., 2010). Major gold mineralizations were formed during the first three gold-bearing veins. The gold-bearing veins occurring within meta-sedimentary are discontinuous small veinlets and quartz stockworks, generally of 1 to 3 m thick, whereas those occurring in the Koshrabad intrusions are continuous and typically several hundred meters long. Quartz veins both in the intrusion and in the host meta-sedimentary rocks show narrow alteration halos of quartz, K-feldspar, carbonate and fluorite.

4 Discussion and Conclusion

The Zarmitan gold deposit is located at the western part of the Southern Tianshan thrust-fold-belt, which formed in response to the late Paleozoic collision between the Karakum-Tarim craton and the Kazakhstan-Yili plate. Gold mineralization occurs as narrow veins that are hosted in the Ordovician to the Lower Silurian meta-sedimentary rocks and in the Permain Koshrabad intrusion complex. The meta-sedimentary rocks at Zarmitan are generally greenschist facies and contain high gold contents. The sulfides within meta-sedimentary mineralized ores show similar He-Ar isotopic composition with those from Muruntau, Kumtor and Amantaitau (Graupner et al., 2010), suggesting that the meta-sedimentary strata are precondition in the formation of the Zarmitan gold deposit. The Permain Koshrabad complex intruded into the meta-sedimentary rocks and represents a multiple granitoid plutons with narrow isotopic ages of 280–295 Ma (Konopelko et al., 2011), which is similar to the mineralization age determined by gold-bearing pyrite Re-Os geochronology (286 Ma; Goldfarb et al., 2014), and also overlaps the age of Muruntau (287.5 ± 1.7 Ma; Morelli et al., 2007). Moreover, amphibole, biotite and ilmenite in the Koshrabad intrusions contain gold contents of 0.002 to 0.03 g/t, and aplitic dikes intruded into the Koshrabad quartz monzonite have gold contents of ca. 0.3 g/t (Konopelko et al., 2011). Thus, the intense magmatic intrusion also seems to play an important role during the formation of the Zarmitan gold system. Foremost, the ore-controlling Karaulkhana-Zarmitan high-angle shear zones and associated faults, fractures, especially their intersections, host the most high grade orebodies. Hence, the structural activities at Zarmitan are vital for high grade mineralization, which superimposed on the early gold mineralization event in Koshrabad intrusions and their hosting meta-sedimentary rocks.

In a conclusion, gold mineralizations at Zarmitan are controlled by three major factors, including greenschist facies meta-sedimentary, multiple gold-bearing magmatic intrusion, and intense structural activities. These geological controls may be significant for exploration of other similar orogenic gold systems in the Tianshan.

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