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Geological Controls and Metallogenesis of the Giant Muruntau Gold Deposit, Uzbekistan : An Overview

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The Muruntau gold deposit in Kyzylkum desert of western Uzbekistan is one of the largest orogenic gold deposits in the world, with total gold resources more than 5100 metric tons (Morelli et al., 2007).

1 Regional Geologic Setting

The Muruntau gold deposit is hosted by the Ordovician-Silurian Besopan Suite, which is a 5000-m-thick sequence that composed of metamorphic siltstone, sandstone and lutite. Most previous studies have divided the Besopan Suite into four units including, from bottom to top, the Bs 1, Bs 2, Bs 3 and Bs 4 members (Drew et al., 1996; Wall et al., 2004). The gold mineralization of Muruntau is predominantly hosted in the Late Ordovician to Early Silurian Variegated Besopan of the Bs 3 member.

In the vicinity of Muruntau, there are two regional shear zones including the northwest-striking Sangruntau-Tamdytau and the northeast-striking Muruntau-Daugyzau which were considered to have formed due to the collision of Karakum craton and the central Kazakhstan-North Tien Shan continent (Drew et al., 1996). The continental collision resulted in the development of nappes onto the Karakum craton in the Late Carboniferous, and the Hercynian compression led the nappes to north-dipping; the northwest-striking, left-lateral Sangruntau-Tamdytau shear zone and the southwest-striking, left-lateral Muruntau-Daugyztau shear zone were formed subsequently (Drew et al., 1996). The movement of the shear zones changed the nappes and resulted in a Z-like-shaped fold, in which the Muruntau open pit is being developed.

The Hercynian granitoid intrusions were emplaced into the vicinity of the deposit. The sardarin pluton, exposed 7 km southeast of the Muruntau area, yielded an Rb-Sr isochrone age of 286.2 ± 1.8 Ma (Kostitsyn, 1996). The

diorite dikes in the Muruntau mining district yielded 286 Ma by the Rb-Sr isochron method (Kostitsyn, 1996). Granitoid from 4005 m deep of the hole SG10 drilling hole has a Rb-Sr isochrone age of 287.1 ± 4.6 Ma (Kostitsyn, 1996).

2 Geology of the Muruntau Gold Deposit

Gold mineralization at Muruntau is located within the Bs 3("Variegated Besopan"), comprising of green-schist-facies metamorphosed siltstone and sandstone. The orebodies are controlled by ductile/brittle shear zones (Wilde et al., 2001). According to the geometry of the vein shapes and relationships, three major groups have been subdivided, including flat veins, stockwork-type veins, and steeply dipping central veins (Graupner et al., 2001). The gold content is highly enriched in stockwork-type veins and steeply dipping central veins.

The ore minerals are major consisting of pyrite, arsenopyrite, native gold and scheelite with pyrrhotite, chalcopyrite, galena, sphalerite and molybdenite. The gangue minerals are mainly quartz, feldspar and biotite, with minor tourmaline and muscovite (Mao et al., 2001). Wall-rock alterations in the Muruntau deposit include silicification, carbonatization, tourmalinization, chloritization, biotitization and feldspathization.

The Muruntau gold deposit underwent a protracted deformation history and a complex tectonism, which can be subdivided into four major episodes (D1-D4) (Wall et al., 2004). The D1 stage deformation exhibited major regional NNE-SSW shortening, and is defined by lower greenschist facies assemblages. The D2 stage deformation was the product of roughly N-S shortening and overprinted the D1 stage deformation. The D3 stage deformation occurred as NE folds and small displacement faults and was accompanied by Muruntau-Daugyzau shear zone development. The interaction of the D2 and D3

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stages deformation played a major role in the development of Z-shaped fold. The D4 stage deformation represents weak E-W shortening.

3 Metallogenesis of the Muruntau Deposit

The reliable age of gold mineralization is important for explanation of metallogenesis at Muruntau. Gold mineralization was determined to be 245 and 220 Ma by $^{40}\text{Ar}/^{39}\text{Ar}$ dating of hydrothermal sericite selvages (Wilde et al., 2001), which is consistent with the Rb-Sr dates on auriferous quartz veins (Kostitsyn, 1993) and is 30 m.y. later than subjacent intrusions as defined by Rb-Sr method (Kostitsyn, 1996). Thus, it seems that the intrusion can hardly have genetic association with gold mineralization. The Bs 3 bearing gold (483×10^{-9}) which is more than 10 times higher than the adjacent stratum ($11.2 \times 10^{-9} \sim 25.8 \times 10^{-9}$) can be the metal source and the basal Devonian sedimentary rocks were probably the large reservoir of the ore-forming fluids and reduced sulfur which could be released by the deformations like D2 (Wilde et al., 2001). The Helium in the ore-forming fluid (95%) also support a crustal sources (Graupner et al., 2006). Morelli et al. (2007) utilized Re-Os arsenopyrite geochronology to determine the absolute age of gold mineralization at 287.5 ± 1.7 Ma which is in excellent agreement with Sm-Nd dates of scheelite (Kempe et al., 2001). The age overlaps the emplacement of the granitoid intrusions, and the initial Os (0.37 ± 0.27) and $^3\text{He}/^4\text{He}$ ($0.23 \sim 0.33\text{Ra}$) suggest that the presence of mantle-derived component in the ore systems, which may have originated from the granitoid magmas.

The Muruntau gold deposit was formed within the brittle/ductile transition zone during the later stages of processes related to the collision of two tectonic plates (Drew et al., 1996). Multiple slip events of the faults and efficient flash vaporization may be one of the depositional mechanism (Weatherley et al., 2013). The different gold-stage quartz veins and complex deformation history may

suggest a protracted or multistage hydrothermal event for formation of the giant deposit. Two stages of mineralization (Permian and Triassic) may all exist in Muruntau with different sources of metal and ore fluid. The exact age of structural deformation could give more information for ore forming processes.

Above all, the “ancient crust + tectonic deformation + magmatic hydrotherm” could be the key factors of the giant Muruntau gold deposit.

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