SEG 2017 Conference

# The Vasilkovskoye intrusion-related gold deposit (Kazakhstan)

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The Vasilkovskoye deposit is located in northern Kazakhstan is hosted in the Kokshetau Massive, a large block of Precambrian metamorphic rocks, with anatexis and Paleozoic magmatism comprising gabbro and granodiorite series. The deposit is a typical example of a large intrusion-related gold system of the stockwork type. Faults and fracture zones of NW, NE, and latitudinal directions are identified as feeder structures. The Vasilkovskoye deposit is situated at the contact of gabbrodiorite and diorite with hornblende-biotite granodiorite and plagiogranite. The deposit is characterized by concentric metasomatic, mineralogical, and geochemical zoning. The mineralogical zoning is expressed by distinct paragenetic assemblages and characteristic minerals. Gold grade is irregular and varies from 1.5 to 3.6 g/t (cut-off 0.8 g/t). Native gold is fine-grained (up to 0.12 mm) and associated with pyrite-arsenopyrite-quartz and bismuthinite-pyrite-arsenopyrite-quartz assemblages. Results of our geological, geochemical, and mineralogical study allow us to reconstruct the intrusive sequence and to distinguish the sequence of the different intrusive phases and mineral associations within the Vasilkovskoye gold deposit.

Major and trace elements were analyzed for 27 least altered igneous rock samples. Based on geological observations, samples were grouped in seven distinct rock types, here listed in sequence of formation: gabbro, gabbrodiorite, diorite, quartz diorite, plagiogranite - that form a combined group (called collectively here “gabbro series”) and granodiorite, granite (called here “granodiorite series”). All sample series plot within the volcanic arc granite + syn-collision granite setting on the tectonic discrimination diagram. Overall, granodiorite and gabbro series show similar enrichment resp. depletion patterns. The chondrite normalized spider diagram of the Vasilkovskoye rock suite exhibits pronounced negative K, Nb, P and Ti anomalies, but lesser Sr anomaly. Negative Nb anomalies are also characteristic of the continental crust and may be an indicator of crustal involvement in magma processes. Notable is the significant enrichment in U, Ta, and La that is more profound in granodiorite series compared to gabbro series. There are also some notable differences between the two series. For example, granodiorite series are enriched in Rb, Th, Ce, and Zr, whereas gabbro series show depletion in these elements.

Granodiorite series with highest REE abundances show a distinct pattern with enrichment in light REE relative to heavy REE and strongest developed negative Eu anomaly compared to gabbro series that display much flatter REE patterns and a positive Eu anomaly. Positive Eu anomalies suggest plagioclase accumulation. REE pattern of one plagiogranite sample differs from other rock suites reflecting strong potassic alteration. Different patterns for behaviour of REEs with negative vs. positive Eu anomalies respectively, as well as contrasting behaviour of other elements as discussed above, indicates either derivation of the granodiorite and gabbro series from different sources or variable melting mechanisms.

New U-Pb (SHRIMP) zircon ages of ~465-466 Ma were obtained for 15 samples including gabbro, plagiogranite, and granodiorite from the Vasilkovskoye deposit. The crystallization of studied intrusives took place within a narrow time interval of just a few million years.