Persian Turquoise of Neyshabour Mine, NE Iran: Implication for Mineral Chemical Variations and Genesis

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The world-class Neyshabur turquoise mine (Persian Turquoise) is known as a unique occurrence of gem-quality turquoise in the world. It is hosted by a Tertiary volcano-sedimentary sequence that belongs to the Binalud zone (Eastern Alborz), NE, Iran. The whole-rock analysis of the least-altered volcanic rocks show an alkaline affinity with a wide compositional range of basaltic trachyandesite, trachyandesite, and trachyte. In the upper portion of the sequence, highly fractionated trachytic rocks display high values of Nb, Hf, Zr, Th, and U. The highly brecciated and altered part of this unit is the main host of high quantity and quality veins, veinlets, and concretion of turquoise. The dominant alterations in association with turquoise mineralization are argillic and advance argillic alterations.

There are two main mineral assemblages in association with turquoise occurrence, including (1) alunite, pyrite, and hematite and (2) alunite, jarosite, limonite, hematite, and goethite. The color of turquoise changes between turquoise blue, pale blue to greenish blue, and green, which reflects slight changes in the composition. SEM-EDS analysis of different colors of turquoise displays a variation in copper and iron contents, by which higher Cu-bearing turquoise tends to show bluish color, whereas green turquoise sample are more enriched in Fe. Alunite-turquoise association is widespread in all of the mineralized samples. SEM-EDS results of alunite show K_2O = 11.23 wt %, Al_2O_3 = 35.11 wt % and very low P_2O_5 (0.86 wt %) and FeO (0.77 wt %). Associated turquoise minerals display Al_2O_3= 32-37 wt %, P_2O_5=33–34 wt %, and variation in the contents of Cu (up to 8.6 wt %) and Fe (up to 6.5 wt %).

Formation of alunite in the alteration zones is hydrothermally controlled. Because of the high-level formation of alunite in this area, subsequent weathering processes might be influential on their trace element contents. LA-ICP-MS of the alunite shows the incorporation of Cu (19 ppm on average), Zn (41 ppm on average), and minor values of Pb and Bi. Therefore, it is likely that the weathering and meteoric water circulation in the shallow part of this system caused the oxidation of coexisting sulfides (in particular, pyrite) and incorporation of trace elements in the alunite structure. Formation of turquoise occurs as the last mineralization stage in the supergene zones. Genesis of turquoise is likely related to a changing Al-bearing mineral such as alunite, accompanied by oxidation of sulfides, in particular, pyrite in the cap rock of the system. LA-ICP-MS of turquoise is consistent with predicted major value for P and Cu, as well as occurrence of trace abundances of Zn, Ti, and As (1470, 266, and 511 ppm on average, respectively).