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Mineralogy and Formation Conditions of Turquoise in Ali Abad Cu Porphyry Deposit

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Introduction

In porphyry copper deposits, turquoise is considered to be a supergene oxidation product (John et al., 2010; Chavez, 2000). Based on Rezaian et al., 2003; Zarasvandi et al., 2005 and Eslamizadeh, 2004, the Aliabad index is introduced as a porphyry copper system. The first published report on turquoise events around Ali-Abad was presented by Momenzadeh et al., 1988. This area is located 57 km southwest of Yazd. Alterations often include siricitization, advanced argillization. Kaolinization and silicification have occurred frequently in the arkose and microcan glomerate of the Sangestan formation. The aim of this research study is to try to reconstruct and investigate the formation and origin of turquoise by using the latest mineralogical and geochemical data. Field evidence shows occurrence of turquoise in the form of a veinlet and nodules, with blue-green and blue-white colors. Jarosite, alunite, quartz and iron oxides are found together with turquoise.

Materials and Methods

A geological map of the area with a scale of 1/15000 was prepared. 35 samples of intrusive bodies, sandstones and altered rocks were selected to produce thin and polished sections. XRD and the EDS analyses were carried out at the central laboratory of Isfahan University and the University of Oklahoma, USA, respectively in order to identify the chemical composition of phases.

Results

Based on the studies, several chain processes have been involved in the form of turquoise: the initiator of the reactions is the formation of an oxidant environment (gossan), in which metal sulfides (Cu, Fe) in the phyllic zone of porphyry copper deposit have played a fundamental role. Turquoise has two species in this area. One is in the form of direct deposition in the veinlets, away from the alteration of the host rock and the mineralization center, and the other one is in the form of substitution. It is undeniable that the host rock with Kaolinite-sericite alteration is required for substitution. The close association of alunite-turquoise may imply that turquoise is a product of the phosphatization process of alunite. The Alunite Supergene event in the alteration zone and its accompaniment with turquoise indicates the mineral complex of advanced argillic alteration. The mineral chemistry highlighted the high percentages of aluminum concentration which is a property of minerals in advanced argillic zone.

Discussion

The phyllic zone has the largest part of the region's alteration (Taghipour and Mackizadeh, 2011; Moore et al., 2011). An advanced argillic zone with the presence of alunite-jarosite with turquoise is scattered inside the phyllic zone. To confirm microscopic observations, XRD and EDS analyses were used. These analyses prove the presence of the turquoise phase.

In some analyses performed on the turquoise

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mineral phase, the presence of potassium and silicon probably indicates the transitional phase of conversion of sericite or alunite to turquoise. Pyrite in the oxidant condition has been disrupted by the effects of atmospheric water and created goethite and sulfuric acid. The produced ferric sulfate can induce dissolution of chalcopyrite. The occurrence of iron oxides and oxy-hydroxides will lead to the development of the gossan zone. Gossan's transformation, in addition to supplying copper, causes acidic fluids to continue the reaction. Under acidic conditions, the phosphate leaching from the arkose has been subjected to the following reaction:

$Ca_5\ (PO_4)_3OH + 5H_2SO_4 + 9/2O_2 \rightarrow 5CaSO_4\ 2H_2O + 3H_3PO_4$

In addition to phosphate and copper, aluminum is the most important element in the structure of turquoise. Under an acidic environment, arkose feldspars and hydrolysis reactions during alteration will be used for the formation of sericite, kaolinite and gypsite. With the presence of sulfate and potassium released from the alteration of feldspars, alunite and turquoise can be formed. The alunite-turquoise paragenesis confirms formation of turquoise by alunite (Espahbod, 1976). Turquoise will be formed by the reaction of potassium, copper sulfate and anion phosphate with alunite:

$8K^+ + CuSO_4 + 4H_2PO_4^- + 2KAl_3\ (SO_4)_2(OH)_6 \rightarrow CuAl_6\ (PO4)_4(OH)_8\ 4H_2O + 5K_2SO_4 + 4H^+$

The hydrogen ions released in this reaction will lower the pH of the environment and cause progression of hydrolysis reactions. Finally, jarosite will be formed by the interaction of K^+, sulfate and Fe^{3+}. Based on these reactions, an aluminum-rich phase is needed for stabilizing phosphate and soluble copper.

References

Chavez, W.X.Jr., 2000. Supergene oxidation of copper deposits: zoning and distribution of copper oxide minerals. Society of Economic Geologists, 2(41):10–21.

John, D.A., Ayuso, R.A., Barton, M.D., Blakely, R.J., Bodnar, R.J., Dilles, J.H., Gray, F., Graybeal, F.T., Mars, J.C., McPhee, D.K., Seal, R.R., Taylor, R.D. and Vikre, P.G., 2010. Porphyry copper deposit model. Chap. B of Mineral deposit models for resource assessment. U.S. Geological Survey Scientific Investigations, United State of America, Report 2010-5070, 169 pp.

Eslamizadeh, A., 2004. Petrology of Ali-Abad-Darreh Zereshk igneous rocks and related copper mineralization. Ph.D. Thesis, Islamic Azad University, Tehran, Iran, 231 pp. (in Persian with English abstract)

Espahbod, M.R., 1976. Le District minier de la mine de Turquoise de Kuh-e-madan (Neychabur, Iran): Mineralisations et caracteres geologiques, geochimiques et metallogeniques de I'uranium, du cuivre et du molylodene. Ph.D. Thesis, Univesite de Nancy, Nancy, France, 191 pp.

Momenzadeh, M., Farjad Bastani, M. and Rashid Nejad Omran, N., 1988. Primary study on Yazd Province Ore Deposirs. Proceedings of ore deposits and mining potential of Yazd Province, Yazd University, Yazd, Iran. (in Persian)

Moore, F., Deymar, S. and Taghipour, B., 2011. Genetic relation between skarn mineralization and petrogenesis of the Darreh Zerreshk granitoid intrusion, southwest of Yazd. Journal of Economic Geology, 3(2):97–110. (in Persian with English abstract)

Rezaian, K., Noghrehiyan, M., Mackizadeh, M.A. and Sherafat, Sh., 2003. Geology and genesis of Turquoise in the Ali-Abad index (Taft-Yazd). Research Journal of University of Isfahan "Science", 18(2): 138–145. (in Persian with English abstract)

Taghipour, B. and Mackizadeh, M.A., 2011. Petrogenesis of skarn related Cu-porphyry intrusion deposit, Ali-Abad- Darreh Zereshk, Yazd. Journal of Economic Geology, 3(1):79–92. (in Persian with English abstract)

Zarasvandi, A., Liaghat, S. and zentill, M., 2005. Geology of the Darreh-Zerreshk and Ali-Abad Porphyry Copper Deposits, Central Iran. International Geology Review, 47(6): 620–646.