# Potassic nature of Karaj Dam Sill and its association with Cu, Au, Mo mineralization of Senj deposit

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## Abstract
*In 57 km NW of Karaj city, Karaj Dam Sill, intruded to the pyroclastic rocks of Karaj formation and made contact metamorphism and hydrothermal alteration. The composition of the Sill changes from gabbro and monzogabbro to monzodiorite and in lower contact with country rocks, Cu, Au, Mo mineralization occurred. Based on geochemistry, rocks in different parts of the sill present high values of $K_2O$, $K_2O+Na_2O$ and high ratios of K/Na and Ce/Yb, which put the sill on high-K igneous rock series with shoshonitic nature .Enrichment on incompatible elements such as Ba, Rb, Th, K and presence of depleted HFSE(Ti, Zr, Nb) compare to LREE (La,Ce) is also geochemical characteristic of potassic rocks related base and precious metals in subduction zone. Based on geochemical diagrams for potassic rocks, igneous rocks in the area formed in continental arc tectonic setting. It seems that, mineralization of Cu, Au and Mo in Senj deposite has direct association with potassic igneous rocks. It could be suggested that the process which made enrichment of LILE and K where also responsible for enrichment of S, base metals, fluids and Cl*

**Key word:** *Karaj Dam sill, Potassic rocks, shoshonitic, Mo, Cu, Au mineralization*

## Introduction
Senj polymetal ore body (Cu, Mo, Au), is located in 57 km NW Karaj city. Rocks around ore body formed from pyroclastic rocks of Karaj formation that Karaj Dam intrusive body, intruded to motioned rocks. Intrusion intrusive body made contact metamorphism and hydrothermal alteration and in lower contact with country rocks, Cu, Au, Mo mineralization occurred

Pottassic igneous rocks have high ability for reconstruct old tectonic environment and determine origin of igneous rock. For this reason, petrologist pays especial attention on this group of rocks. Also recently many researchers work on relationship between potassic igneous rocks, like Shoshonite with base and precious metals.

Base on geochemistry evidence, Karaj Dam sill igneous rocks can place in high potassic igneous rocks series, also base on field observation and geochemistry evidence, exist direct relationship between potassic igneous rocks in study area with

Around the ore body. Mineralization

The aim of this paper is, geochemistry study on part of Karaj dam intrusive body that famous to Karaj Dam sill, on base of result of XRF analysis, demonstrate potassic nature of study area' s rocks and relationship them with mineralization around ore body and determine tectonic environment forming sill. Exist this relationship will be very important for exploration in other part of this intrusive body.

Also, the study area, located in corners of 4 geological map(Tehran, Karaj, Shakran, Marzanabad) with 1/100000 scale.(Fig,1)

## Methods

For study of sill geochemistry features, prepare thin section from rocks for different part of sill, after study thin section, 9 samples that be more fresh were chosen and analysis by XRF method. The result of analysis present in table1.

## Discussion

Below evidence to lead on potassic nature of region' s rocks:

1- $TiO_2$ Concentration in all samples is less than 1/3 weight percent

In all samples more than 5 weight percent) $Na_2O+K_2O$ (2- Ratio alkaline elements

3- $Al_2O_3$ Concentration is between 11/91-14/98

This features are similar to shoshonite series features that described by Morrison (1980), Joplin (1968), Muller et al(1992).

4- In $K_2O$-$SiO_2$ diagram (Peccerillo and Taylor. 1976), most samples located in shoshonite series and 2 samples in high –k- calcoalkaline series.(Fig2)

5-On base description by Muller and Groves (1997), if molecules ratio K/Na in samples are more than 1, can name rocks, high potassic. More samples in study area with minimum alteration have this ration.

6-All samples have high ratio Ce/Yb (between 14 to 29). (table1), that this ration is indicator for potassic rocks with shshonite nature (Pearce, 1982- Muller & Groves1982).

7- On chondrite-normalised 'spider grams' (Thompson 1982), (Fig. 3), all samples show patterns of enrichment and depletion typical of magmas from subduction-related tectonic settings (Wilson 1989; Foley and Wheller 1990). In particular, there are negative anomalies for Ti, Nb and Ta and strong enrichments in mantle incompatible elements such as Ba, Rb, Th and K.

## Relationship potassic igneous rocks with mineralization

A lot of reserves of Porphyry copper-gold, skarn copper-gold, sediment-hosted (Carlin-style) gold, breccia pipe, lowsulphidation epithermal gold, porphyry molybdenum-gold deposits plutonic-related (mesothermalor organic) gold vein and volcanogenic massive sulphide deposits are discovered that associated with High-k alkaline rocks (Sillitoe 2002). In study area on base of field observation and geochemistry, there is direct relationship between potassic igneous rock and mineralization around or body.

Reasons for the possible association may include enrichment of the igneous protoliths in metals, S, water and Cl by the same processes that cause K andLILE enrichments.

Blevin 2002).

With a view of geochemistry, region 's potassic rocks are similar to potassic igneous rocks hosted porphyry copper – gold in LFB in Australia (Blevin 2002، Holiday et al .2002), in Greece( Kroll et al.2002), in Chile(Muller& Groves 2000) and some porphyry copper(Mo, Au, Ag) mineralization in Iran (Atapur and Aftabi, 1380)

## Tectonic setting

On chondrite- normalized spider grams (Thomson, 1982), samples show patterns of enrichment and depletion typical of magmas from subduction- related tectonic setting (Wilson 1989, Foley & Wheller, 1990) and similar to potassic igneous rocks (Blevin, 2002. Muller & Groves, 2000). But Muller and Groves (2000), believe that spider diagrams can't useful for separation tectonic environment in potassic rocks, For examples, although related arc potassic igneous rocks having high value of K, Ba and negative anomalies for Ti, Nb and Ta (Foley&Wheller 1990) but Within- plate potassic rocks also show the same features (Bergman et al. 1988) and potassic igneous rocks in subdactin zone also have negative anomalies of Ti, Nb and Ta. (Rock, 1991).

Muller and Groves ( 2000), suggested 5 major tectonic environment for Potassic igneous rocks: 1- Continental arc potassic rocks (CAP), 2- Postcollisional arc potassic rocks(PAP), Initial oceanic arc potassic rocks (IOP), Late oceanic arc potassic rocks (LOP), Within plate potassic rocks(WIP). Also Muller& Groves (2000) introduced binary and ternary diagram for separation tectonic environment in potassic rocks. These diagrams are on base non- mobility elements like Y, Al, Zr, Ti (Pearce& Cann 1973) and REE Pearce 1982).

With using Y-Zr (Fig4 ) and $TiO_2$-$Al_2O_3$ (Fig5) diagrams, can separated related arc patassic rocks with within plate potassic rocks, that in mentioned diagram all samples located in related arc section.

For separation, related arc rocks, using from $Zr/Al_2O_3$-$TiO_2/Al_2O_3$ (fig6) and
/ 100- Hf*100 diagrams (Fig7). That all samples located in continental arc La-TiO2
And Postcollisional arc area. At the end for separation of Continental arc from postcollisional arc, use from $Ce/P_2O_5$ - $Zr/TiO_2$ diagram, that all samples placed in
Area of Continental arc potassic rocks

## Conclusions

In study area, Karaj Dam Sill, intruded to the pyroclastic rocks of Karaj formation and made contact metamorphism and hydrothermal alteration. The composition of the Sill changes from gabbro and monzogabbro to monzodiorite and in lower contact with country rocks, Cu, Au, Mo mineralization occurred.

Mentioned rocks having high value of K2O (Max 3/63), $TiO_2$ less than 1/3weight more than 5 weight percent, ($Na_2O$+$K_2O$ (percent, ratio of alkaline element
$Al_2O_3$ Concentration is between 11/91-14/98 that this features placed them in potassic igneous rocks with shoshonite nature group.

Geochemistry features of study rocks are similar with subduction-related tectonic settings and have high value of LILE and LREE respect to HFSE. Also on the base of Potosi igneous rocks Special geochemistry diagrams, Karaj Dam sill igneous rocks placed in Continental arc group.

Geochemistry pattern' Samples of sill rocks is similar with some potassic igneous rock hosted base and precious metals in other part of world. On base of field observation and geochemistry, there is direct relationship between potassic igneous rocks with mineralization around ore body. Existence of this relationship is very important factors for exploration in other part of intrusive boby.

## References

Atapur, H., Aftabi, A., 1380, Study of calcoalkaline polotunism, potassic calcoalkaline and shoshonite evolution withporphyry copper mineralization in granitoid intrusive body.20 th conference of earth science

Bergman SC., Dunn D.P., Krol L.O. 1988 : Rock and mineral chemistry of the Linhaisai minene and origin of Borneo diamonds, central Kalimantan*, Indonesia ,Can mineral***26**: 23-44

Blevin P.L. 2002 : The petrographic and compositional character of variably K-enriched magmatic suites associated with Ordovician porphyry Cu-Au mineralization in Lachlan Fold Beld, Australia, *Mineralium Deposita* **37**: 87-99

Collins L.G., 1997: Contrasting characteristics of magmatic and metasomatic Granites and Myth that Granite Plutons Can be only magmatic, Internal report

Foley SF. 1992 : Petrological characterization of the source components of Potassic magmas, geochemical and experimental constraints. *Lithos***28**, 187-204

Foley SF., Peccerillo A. 1992: Potassic and ultrapotassic magmas and their origin, *Lithos***28**

:181-185

Foley SF., Wheller GE. 1990: Parallels in the origin of the geochemical signatures of island arc volcanics and continental potassic igneous rocks, the role of residual titanates, *Chem Geol***85**:

1-18

Holiday J.R., Wilson A.J., Blevin P.L., Tedder I.J., Dunham P.D., Pfitzner M. 2002 : Porphyry gold-copper mineralisation in the Cadia district, eastern Lachlan Fold Beld, New south wales, and its relationship to shoshonitic magmatism. *Mineralium Deposita***37**: 100-116

Joplin G.A. 1968 : The shoshonite association- a review. *I Geol Sco Austr***15**: 275-294

Kroll T., Muller D., Seifert T., Herzig P.M., Schneider A. 2002 : Petrology and geochemistry of the shoshonite-hosted Skouries porphyry Cu-Au deposite, Chalkidiki, Greece,

*Mineralium Deposita***37**: 137-144

Morrison O.W. 1980 : Characteristics and tectonic setting of the shoshonite rock association.

*Lithos* **13**: 97-108

Muller D., Franz L., Herzig P.M., Hunt S. 2001: Potassic igneous rocks from vicinity of epithermal gold mineralization at Lihir Island, Papua New Guinea. *Lithos* **57**: 163-186

Muller D., Groves D.I. 2000 : Potassic igneous rocks and associated gold-copper mineralization. Springer, Berlin Heidelberg New York. 252p

Muller D., Rock N.M.S., Groves D.I 1992 :Geochemical discrimination between shoshonitic and potassic volcanic rocks from different tectonic setting, a pilot study. *Mineral Petrol***46**: 259-289

Pearce J.A. 1982 : Trace element characteristics of lavas from destructive plate boundaries

IW Thorpe RS Andonesites Wiley.New York.P. 548

Pearce J.A., Cann J.R. 1973 :Tectonic setting of basic volcanic rocks determined using trace element analyses. *Eartb planet Sci Lett***19**: 290-300

Peccerillo A., Taylor S.R. 1976 : Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastomonon area, northern Turkey. *Contrib mineral petrol***58**: 63-81

Rock N.M.S. 1991: Lamprophyres Blackie,Glasgow.285p

Shelly D. 1993 : Igneous and metamorphic rocks under the microscope, Chapman and Hall. Landon, 445p

Sillitoe R.H. 2002 : Some metallogenic feature of the gold and copper deposite related to alkaline rocks and consequences for exploration. *Mineralium Deposita***37**.4-13

Smith J.V., Brown W.L. 1988 : Feldspare minerals . crystal structure, physical, chemical & microstructure properties. Springer. Berlin

Thompson R.N., 1982: Magmatism of the British Tertiary volcanic province.*Scott J Geo***193:**

603-608

Wilson M. 1989.: Igneous petrogenesis, a global tectonic approach, unwin by longman,Landon.466p

**Table 1: Result of XRF analysis of Karaj Dam sill' rocks**

| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $Al_2O_3$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $Fe_2O_3$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| MgO | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| CaO | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $Na_2O$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $K_2O$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $TiO_2$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| MnO | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $P_2O_5$ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Rb | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Y | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Cr | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Ni | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Ba | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| La | ۱۷ | ۱۷ | ۲۵ | ۱۷ | ۱۹ | ۲۳ | ۱۵ | ۲۲ | ۱۰ |
| Ce | ۵۲ | ۴۹ | ۵۸ | ۴۲ | ۱۵۹ | ۱۴۹ | ۱۲۵ | ۸۵ | ۱۵۷ |
| Nd | ۲۲ | ۲۱ | ۲۲ | ۲۲ | ۲۳ | ۲۱ | ۲۵ | ۲۲ | ۱۸ |
| Sm | ۸ | ۵ | ۸ | ۷ | ۶ | ۹ | ۶ | ۶ | ۷ |
| Tb | ۱ | ۱ | ۱ | ۱ | ۴ | ۴ | ۴ | ۴ | ۴ |
| Yb | ۲ | ۲ | ۲ | ۲ | ۷ | ۷ | ۷ | ۶ | ۷ |
| Hf | ۸ | ۲ | ۶ | ۲ | ۱۱ | ۱۸ | ۱۹ | ۱۳ | ۲۴ |
| Ta | ۲ | ۱ | ۲ | ۱ | ۱ | ۱ | ۱ | ۱ | ۱ |
| Eu | ۲ | ۲ | ۲ | ۲ | ۲ | ۴ | ۲ | ۳ | ۲ |
| V | – | – | – | – | ۹۷ | ۱۱۵ | ۹۰ | ۸۳ | ۸۴ |
| Pb | – | – | – | – | ۵۸ | ۳۷ | ۲۳ | ۲۵ | ۲۴ |
| Cu | – | – | – | – | ۶۳ | ۱۱۲ | ۱۲۲ | ۷۸ | ۱۵۴ |
| Co | – | – | – | – | ۱۹ | ۲۹ | ۲۱ | ۱۹ | ۱۹ |
| Zn | – | – | – | – | ۱۱۱ | ۸۴ | ۶۴ | ۸۵ | ۷۰ |
| Cs | ۱ | ۱ | ۱ | ۲ | ۴۸ | ۳۱ | ۹ | ۳۶ | ۱۸ |
| Ga | – | – | – | – | ۲۱ | ۲۰ | ۲۱ | ۲۱ | ۲۱ |
| Mo | – | – | – | – | ۴ | ۴ | ۴ | ۴ | ۴ |
| Sn | – | – | – | – | ۶ | ۶ | ۶ | ۶ | ۶ |
| Th | – | – | – | – | ۶ | ۶ | ۶ | ۷ | ۷ |
| Sc | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

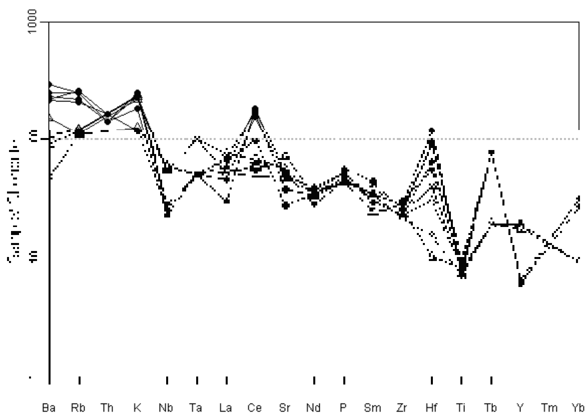


**Fig3- - chondrite-normalised 'spidergrams' (Thompson 1982). all samles show patterns of enrichment and depletion typical of magmas from subduction-related tectonic settings**

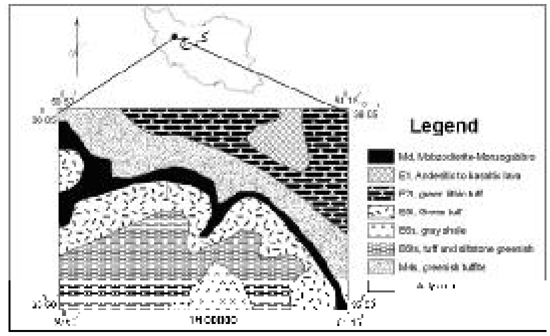


**Fig1:Geological map of study area 1/100000 scale**

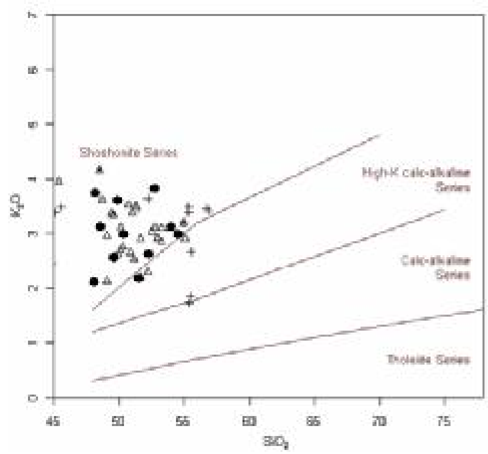


**Fig2- K2O-SiO2 diagrams,more samples**

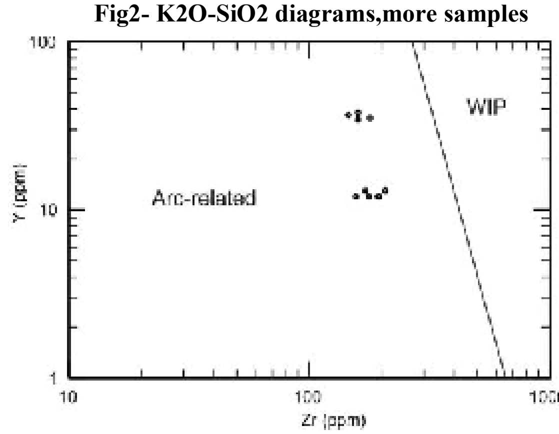


**Fig4- Y-Zr diagrams,All samples located in Arc-related part**

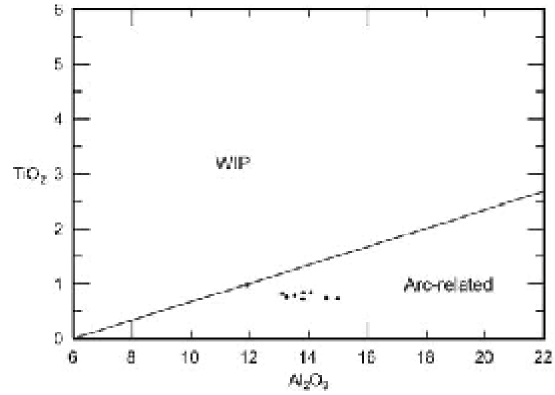


Fig5- TiO2-Al2O3diagrams,All samples located in arc- related part

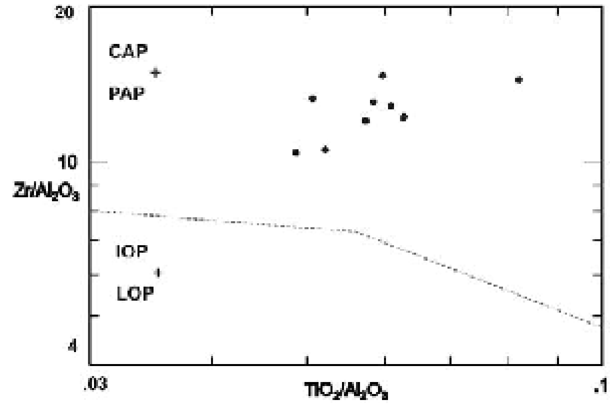


Fig6- Zr/Al2O3- TiO2/Al2O3diagrams,All samples located in PAP+CAP area

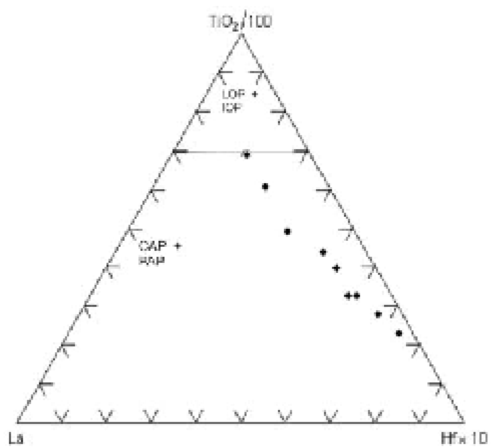


Fig7-TiO2/100-La-Hf*10diagrams,All samples located in CAP+PAP part

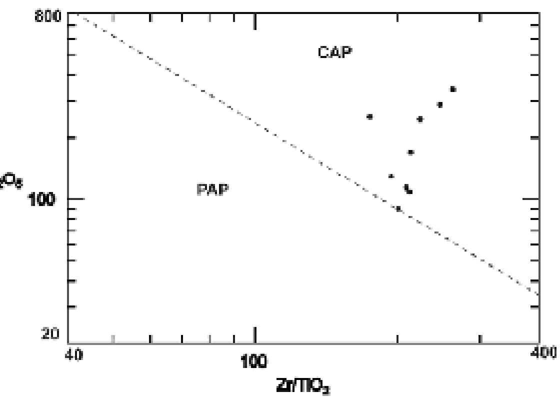


Fig8-Ce/P2O6-Zr-TiO2diagrams,All samples located in Continental arc group