

## **Petrology, geochemistry and Ti-Fe – vanadium oxide mineralization in the NW of Rivash area**

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### **Abstract**

*Fe-Ti vanadium placer ore deposit of Rivash with thousands tons of ore grading up to 63% Fe, 6.8 TiO<sub>2</sub> and more than 10000 ppm Vanadium is located at the north margin of the Darouneh great Fault. The Titanium and vanadium mineralization in the area is originated from ophiolitic complex of cretaceous age which consist of peridotites (dunite, lherzolite) and serpentized peridotites, gabbros, sheeted dikes, pillow and massive lava. The hydrothermal alteration of the host rocks can be recognized by a distinct colour change at the surface of the field and is distinguished by serpentization and rodingitization zones. The main ore zones (titaniferous magnetite and magnetite) contain elevated abundances of Fe > Ti > Cr > V.*

*The geochemical studies showed higher anomalies of Fe in the southern part of the area, while with increasing V, an elevated trend of Ti, and Fe elements were observed in the area of the study. The source of ore metals can be attributed to the magmatic activities and host rocks which were leached by water-rock interaction during the hydrothermal circulation of fluids in the system.*

*The mineralogy of the placers are simple, with only trace impurities, and magnetite constituting about 95% of metallic minerals in the area of the study. Other sulphide minerals present are pyrite and chalcopyrite.*

*The ore deposit originated from intrusive complexes which typically were emplaced at deeper levels in the crust. Progressive differentiation of liquids residual from gabbroic magma leads to late enrichment in Fe and Ti. Typically plagioclase crystallization results in concentration of Fe and Ti in residual magmas which typically crystallize to form ferrogabbros. Layers form by crystal settling and accumulation on the floors of magma chambers and the disseminated deposits are believed to have formed in-situ. Two genetic models have been suggested, remobilization of the crystal cumulates into cracks or fractures or emplacement as Fe-Ti-oxide-rich immiscible melt with little silica.*

*The key control was the development of a late, separate Ti and Fe-rich liquid from a fractionating magma under stable conditions. The deposit occurred in elongate belts of intrusive complexes emplaced along deep-seated faults and fractures.*

**Keywords:** immiscibility, Rivash, titaniferous magnetite.

### **Introduction**

The Rivash ore deposit is located in the Kashmar region, 75 km southwest of Neyshabour city (Fig. 1). It is a placer type deposit which mineralization occurs along a series of fluvial terraces trending NW–SE. In addition to Fe, contain elevated concentrations of Cr, Ti, and V as well.

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Fe-Ti vanadium placer ore deposit of Rivash is located at the north margin of the Darouneh great Fault. The Titanium and vanadium mineralization in the area is originated from ophiolitic complex of cretaceous age. The ore deposits are accumulations of heavy minerals on the middle regions of rivers. They form by mechanical concentration of resistant heavy mineral particles of high specific gravity by the action of water currents, and winds. In this paper, we present, petrographic and mineralogical data

## Results

In the Rivash ore deposit, ilmenite and titaniferous magnetite are dominant ore minerals. Proportions of ilmenite and magnetite generally can be correlated with petrology of host rock. Silicate minerals, especially plagioclase, orthopyroxene, clinopyroxene and olivine, with minor spinel are present as gangue minerals. Heavy mineral concentrations of titaniferous magnetite in placer deposits of the area can be acted as an exploration guide.

Fe-Ti vanadium placer ore deposit of Rivash with thousands tons of ore grading up to 63%. Fe, 6.8 TiO<sub>2</sub> and more than 10000 ppm Vanadium is located at the north margin of the Darouneh great Fault. The Titanium and vanadium mineralization in the area is originated from ophiolitic complex of cretaceous age which consist of peridotites (dunite, lherzolite and harzburgite), serpentinized peridotites, gabbros, sheeted dikes, massive and pillow lava. The hydrothermal alteration of the host rocks can be recognized by a distinct colour change at the surface of the field and is distinguished by serpentinization and rodingitization zones. The main ore zones (titaniferous magnetite and magnetite) contain elevated abundances of Fe > Ti > Cr > V.

Both grade and tonnage vary considerably in the source rocks and placers. In the source rocks, the grade of titaniferous magnetite deposit varies between 5.75 to 7.54% Fe, 0.1 to 0.53% TiO<sub>2</sub>, with V contents averaging 0.05% but in the placers varies between 60 to 63% Fe, 5 to 7% TiO<sub>2</sub>, with V contents averaging 1% (Table 2).

The geochemical studies showed higher anomalies of Fe, Ti, Cr, and vanadium in the southern part of the area, while with increasing V, an elevated trend of Ti, and Fe elements were observed in the area of the study. The source of ore metals can be attributed to the magmatic activities and host rocks which were leached by water-rock interaction during the hydrothermal circulation of fluids in the system.

The mineralogy of the placers are simple, with only trace impurities, and magnetite constituting about 95% of metallic minerals in the area of the study. Other sulphide minerals present are pyrite and chalcopyrite.

Cr is controlled by fractionation and accumulation of chromite. But Co is controlled mainly by fractionation and accumulation of olivine, these elements correlate with SiO<sub>2</sub> and show trends typical of fractional crystallization in ultramafic and mafic magmas. V correlates positively with SiO<sub>2</sub>, and ranges from 54 to 934 ppm but surprisingly in chromite increase to 1400 ppm and in placers to 10014 ppm.

(Figs. 2 to 5).

The ore deposit originated from intrusive complexes which typically were emplaced at deeper levels in the crust. Progressive differentiation of liquids residual from gabbroic magma leads to late stage intrusions enriched in Fe and Ti oxides. Typically plagioclase crystallization results in concentration of Fe and Ti in residual magmas which typically crystallize to form

ferrogabbros. Layers form by crystal settling and accumulation on the floors of magma chambers and the disseminated deposits are believed to have formed in-situ. Two genetic models have been suggested, remobilization of the crystal cumulates into cracks or fractures or emplacement as Fe-Ti-oxide-rich immiscible melt with little silica.

The key control was the development of a late, separate Ti and Fe-rich liquid from a fractionating magma under stable conditions. The deposit occurred in elongate belts of intrusive complexes emplaced along deep-seated faults and fractures.

### Conclusion

As V<sup>5+</sup> will not readily substitute for Fe<sup>2+</sup>, and substitution of V<sup>5+</sup> for Fe<sup>3+</sup> introduces a charge imbalance in the magnetite structure which can only be offset by substitution of a small monovalent cation for Fe<sup>3+</sup>, It is likely that the vanadium in magnetite is trivalent, not pentavalent

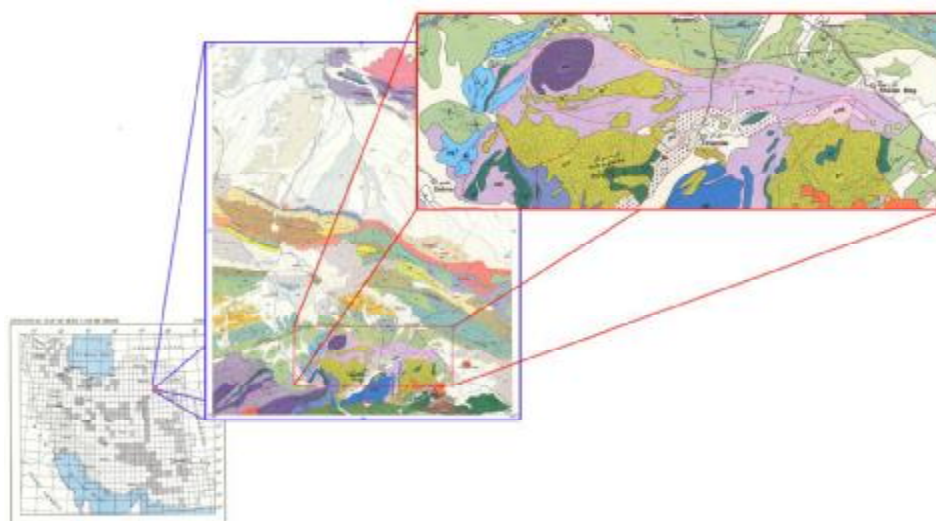
The mineralogical and geochemical relationships of titanomagnetite indicate that their genesis is related to fractional crystallization processes that were responsible for the formation of their silicate host rocks. Elementary modelling of the geochemical data indicates that remanent magnetisation and vanadium and Ti substitutions in titaniferous magnetite are responsible for a significant part of the observed anomalies.

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**Table 1. Chemical analysis of Ti-Fe – vanadium oxide mineralization in the NW of Rivash area**

	<b>peridotite</b>	<b>Gabbro</b>	<b>Chromite</b>	<b>Placer</b>	
SiO <sub>2</sub>	40.65	48.66	7.11	2.08	
TiO <sub>2</sub>	0.03	0.25	0.13	6.58	
Al <sub>2</sub> O <sub>3</sub>	1.33	16.66	9.54	1.38	
Fe <sub>2</sub> O <sub>3</sub>	9.09	8.75	13.83	83.03	
MgO	36.10	9.41	24.64	1.24	
MnO	0.14	0.17	0.17	0.77	
CaO	2.55	13.35	0.43	0.33	
Na <sub>2</sub> O	0.10	1.11	0.16	0.02	
K <sub>2</sub> O	-	0.30	-	0.08	
NiO	0.30	-	0.20	-	172 ppm of Ni in gabbro
Cr <sub>2</sub> O <sub>3</sub>	0.49	0.05	40.81	-	29815 ppm of Cr in placer
V <sub>2</sub> O <sub>5</sub>	0.01	0.02	0.14	-	10014 ppm of V in placer
LOI	9.08	1.016	2.73	0.16	



**Fig. 1. A geological map of the Rivash showing distribution of Ti-Fe – vanadium oxide mineralization in the NW of Rivash area.**

