Spinel composition in pillow lavas from Mesozoic ophiolites of Nain and Ashin (Central East Iranian microplate)

Shirdashtzadeh N.[1], Torabi G.[1], Samadi R.[2]
[1] Department of Geology, Faculty of science, University of Isfahan, Isfahan, Iran; [2] Department of Geology, Science and Research Branch, Islamic Azad University, Tehran, Iran
nshirdasht@gmail.com

The Mesozoic ophiolitic mélanges of Nain and Ashin are located in the west of the Central East Iran Microplate, along the major faults of Nain-Baft and Dorouneh. It is a relict of Neotethys Ocean, covered by Paleocene-Eocene sediments. It has emplaced before the Paleocene at Upper Cretaceous [1], [2], [3], [4].

They comprises a wide range of rock units including peridotites, amphibolitic rocks, schists, marbles and quartzites, sheeted dikes and pillow lavas, limestone and radiolarian cherts that all have tectonically mixed up together.

Pillow lavas and the overlying pelagic sediments (Radiolarian cherts and Glaubotruncana limestones) indicate a sub-marine volcanism system. They have experienced spilitization and sub-sea floor metamorphisms [5] [7].

Our investigated rocks are green, dark green to brown spherical and elliptical pillow lavas ranging between 40 cm to even 2 meters in diameter. The spaces between pillows are occupied with volcanoclasts and marine sediments. Polygonal fractures, made by sudden cooling, observed on their surface while they are radial in the pillows sections. These fractures led the spilitization rate to speed up.

Pillow lavas of Nain and Ashin composed of plagioclase and chloritized olivine as the main minerals and accessory minerals of clinopyroxene, chromian spinel, chlorite, pumpellyite, calcite, amphibole and magnetite, with common microtextures of intersertal, variolitic, and porphyric.

Pillow lavas from Ashin are mainly made up of plagioclase and olivine, but clinopyroxene, chlorite, pumpellyite, chromian spinel, calcite and magnetite are present in minor amount. In Nain samples, clinopyroxenes and chromian spinels have not strongly affected by metamorphism, while olivines entirely chloritized. Clinopyroxenes surrounded with plagioclase laths. This mineral assemblage show a low-grade sub-sea metamorphism correlated with green schist facies. In fact, they just have undergone spilitization and low-grade sub-sea metamorphism to some degrees.

Spinels were analyzed by wavelength-dispersive electron probe micro analyzer (EPMA, model JXA-8800R) at the Cooperative Centre of Kanazawa University and under an accelerating voltage of 15 kV and a beam current of 15 nA. JEOL software made ZAF corrections for data reduction.

Spinels have been considered as petrogenetic indicators by many workers (i.e. [7], [8], etc.). They are refractory and high resistance to alteration phases reported from a wide variety of mafic and ultramafic rocks. In pillow lavas of Nain and Ashin, chromian spinels occurred as micro phenocrysts or as inclusions in other phenocrysts minerals.

According to [9], this mineral occurs in very small amount (possibly up to 0.5 vol%) in MORBs and it seems to be restricted to the most primitive olivine-rich basalts with picritic character and other Cr-rich primitive melts. It has a typically low FeO/(FeO+MgO) ratios [10], which have not undergone significant fractionation during the ascent of the magma [8]. Spinels of MORBs appear to be Al-rich [9] and with a range of Cr# of 0.2 to 0.6 in a not wide range of Mg# and low Ti content [11].

In samples from Ashin, they have Cr # of 0.40 to 0.44, and it is 0.39 to 0.47 for spinels in Nain samples. Mg# of spinels is 0.79 for Ashin and 0.070 to 0.75 for Nain samples.

[12] also presented an equation for the degree of melting (in per cent) as a function of the spinel Cr# as F=10 lnCr#+24, calibrated for spinel Cr# values between 0.10 and 0.60. The fractional melting (F) calculated based on this formula is 14.8 to15.8 for Ashin samples and 14.6 to 16.4.

Chromian spinels in pillow lavas of Nain and Ashin ophiolites are compared on Cr# versus Mg# diagram. This illustration shows that spinels from two areas are similar in chromian spinels composition with a signature of MORB affinity.

Therefore, spinels composition approves that pillow lavas from Nain and Ashin have been produced in a similar tectonic setting recognized as mid oceanic ridges with a tholeiitic nature. Moreover, according to occurrence of pelagic sediments of Radiolarian cherts and Glaubotruncana limestones, the start of a new ocean spreading phase could be in Upper part of Lower Cretaceous in both areas, over the massive basalts and pillow lavas.

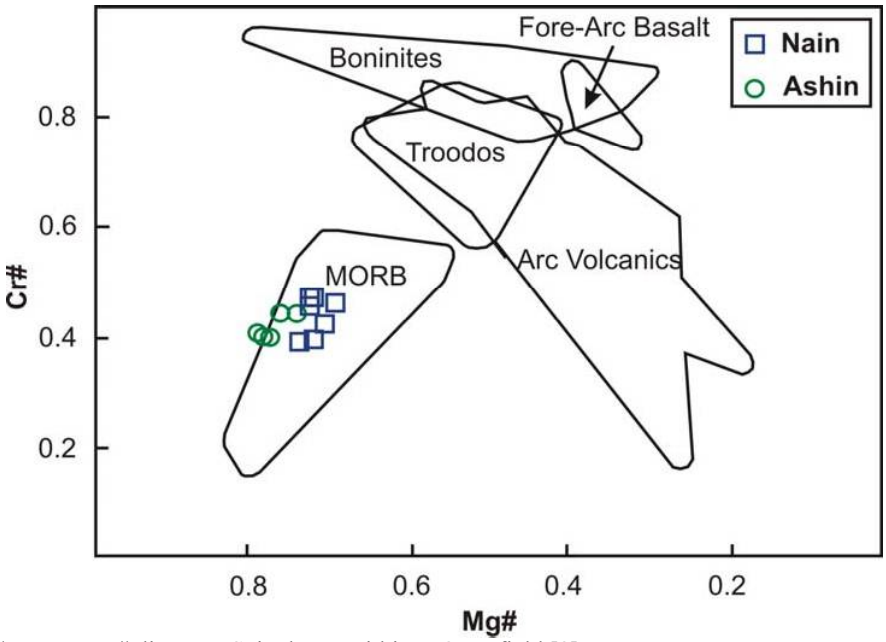

Fig. M Cr# versus Mg# diagram. Spinels are within MORB field [8].

References:

1. Stocklin J. (1974). Mesosoic-Cenosoic orogenic belts data for orogenic studies. Geological Society of London. 4: 213-234.
2. Stoneley R., 1975. On the origin of ophiolite complexes in the Southern Tethys region. Tectonophysics, 25: 303-322.
3. Hassanipak A.A., and Ghazi A.M., 2000. Petrochemistry, 40Ar-39Ar ages and tectonics of the Naein ophiolite, Central Iran. GSA Annual meeting, Reno, Nevada, 237-238.
4. Ghasemi A. and Talbot C. J., 2006. A new tectonic scenario for the Sanandaj-Sirgan zone, Iran, Journal of Asian Earth Science 26, 683-693.
5. Abdullahi E., 2007. Petrology of Nain ophiolite pillow lavas (Isfahan Province). M.Sc. Thesis in Petrology, Department of Science, Islamic Azad University of Khorasgan, I.R. Iran, 133 pp.
6. Torabi Gh., Abdollahi E., and Shirdashtzadeh N., 2008b. Application of Mineral and whole rock analysis in identification of petrogenesis of pillow lavas in the Nain ophiolite, Iranian Journal of Crystallography and Mineralogy, 16(2): 295-312.
7.Arai, S. (1992) Chemistry of chromian spinel in volcanic rocks as a potential guide to magma chemistry, Mineralogy Magazine, 56: 173-184.
8. Yong, I.L. (1999) Geotectonic significance of detrial chromian spinels: a review. Geosciences Journal, 3(1): 23-29.
9. Sigurdsson H., and Schilling J.G., 1976. Spinels in Mid-Atlantic Ridge Basalts: Chemistry and occurrence. Earth Planet Scientific Letters, 29: 7-20.
10. Schrader E.L., Rosendahl B.R., Furbish W.J. and Meadows G., (1980) Picritic basalts from the Siqueiros transform fault. In: Rosendahl. B.R., Hekinian, R. et al. (eds.), Initial Reports on the Deep Sea Drilling Project 54: 771-778.
11. Dick H.J.B., and Bullen T., 1984. Chromian spinel as a petrogenetic indicator in abyssal and alpine-type peridotites and spatially associated lavas. Contributions to Mineralogy and Petrology, 86: 54-76.
12. Hellebrand E., Snow J. E., Hofmann A. W (2001) Coupled major and trace elements as indicators of the extent of melting in midocean-ridge peridotites", Nature 410(6829) 677-681.