

Petrology of tonalitic rocks of Dehnow (Northwest of Mashhad, Iran)

R. Samadi

Student of Ph. D., Science and Research Branch, Islamic Azad University, Tehran, Iran.

E-mail: rsamadi@hotmail.com

Ph.D. H. Mirnejad

Department of Geology, University of Tehran, Tehran, Iran.

N. Shirdashtzadeh

Science and Research Branch, Islamic Azad University, Member of Young Researchers Club,

Tehran, Iran.

Ph.D. H. Kawabata

Institute for Research on Earth Evolutions of Japan, Japan

Abstract

Tonalites are mineralogically comprised of quartz, plagioclase (mainly bytownite), garnet (almandine-pyrope), biotite (annite), amphibole (ferro-hornblende), and accessory minerals of chlorite, epidote, calcite, and ilmenite. Based on the geothermobarometrical investigations, the tonalitic melt have had an average temperature and pressure of up to 680°C and 6.4 kbar and the contact metamorphic rocks produced by its intrusion show lower metamorphic degrees (Albite-epidote to hornblende hornfels facies) in compare to schists of area (green schist to amphibolite facies). Thus the by effect of this intrusion, compared to the regional metamorphism of area, is just seen around the intrusive mass of tonalite. Petrography and geochemistry of tonalites and their garnets composition revealed that the parental magma of Dehnow tonalitic rocks was an I-type granitoid, belonged to calcalkaline series and related to CAG tectonic setting.

1.Introduction

Dehnow is located in the northeast of Iran, in 15 km from the northwest of Mashhad. This area is in E59° 22' to E59° 26' and N36° 20' to N36° 22' and it is belonged to the structural zone of Binalood, along with the eastern mountain range of Alborz (Fig. 1). Hornblende-biotite tonalites are the most aged igneous rocks of the area that intruded into the metamorphic rocks and flisch. Many workers have studied the petrology of igneous and metamorphic rocks of Mashhad. Based on chronological studies of Alberti et al. (1973) on granites of Mashhad, they have formed in Mesozoic but another research by Lammerer et al. (1983) related them to an earlier age, in Permian. In addition, intrusive mass, metamorphic rocks and metamorphic contact in the area are considered by Alavi and Majidi (1972), Alberti and Moazez-Lesco (1974), Majidi (1978), Amini and Karimi (1991), Hatefi (2003), and Samadi (2009). In addition, Samadi (2009) studied the contact metamorphism produced by tonalites intruded into the schists that were forming by an extended regional metamorphism. This intrusion consequently caused to formation of a thin layer of hornfels around the tonalitic mass. The regional metamorphism occurred in Triassic period, and the granitoid body were

simultaneously replaced in the produced metamorphic rocks. Compressional phases caused by plutonism and metamorphism made schistosity in metamorphic rocks and mylonitized the granitoids (Alavi, 1991; Hatefi, 2003). This paper will consider the petrography, mineral chemistry and whole rock analysis data of tonalitic intrusions of Dehnow.

2. Analytical Methods:

Representative specimens were selected for geochemical analysis after macro- and microscopical observations. A quantitative chemical analysis of minerals was carried out by wavelength-dispersive EPMA (JEOL JXA-8800R) at IFREE (Japan). The analysis was performed under an accelerating voltage of 15 kV and a beam current of 15 nA. The ZAF program was performed for data corrections. Natural and synthetic minerals of known composition are used as standards. Representative analysis data of 229 points of minerals (plagioclase, garnet, biotite, amphibole, and ilmenite) are available in table 1.

3. Discussion

3.1 Petrography and mineral chemistry

Tonalitic rocks of Dehnow area containing quartz, plagioclase (mainly bytownite), garnet (almandine-pyropes), biotite (annite), amphibole (Ferro-hornblende) and accessory minerals of chlorite, epidote, calcite and ilmenite (Fig. 2). EPMA analysis of minerals conducted in order to discover the chemical nature of minerals (Table 1). Mean analysis data of 30 points of feldspars display an average composition of $Ab_{0.39}Or_{0.01}An_{0.60}$ which is correlated with mainly bytownite composition (based on feldspar classification of Deer et al., 1992). Garnet composition is almandine-pyropes as it is $Alm_{63.12}Sps_{4.83}Pyr_{16.21}Grs_{14.38}$ (Table 1). According to discrimination diagram of garnets (Fig. 2), the garnets composition displays a composition near to phenocryst garnets (Fig. 3).

3.2 Geochemistry

Application of whole rock geochemical data (taken from Samadi, 2009) indicated that tonalitic rocks have an I-type granitoid origin, belonged to calcalkaline series and related to CAG tectonic setting (Fig 4).

3.3 Thermobarometry

Application of different methods of geothermobarometry (from Schmidt (1992) and Holland and Blundy (1994)) indicated a P-T condition of 6.4 kbar and 679.4 °C for the formation of tonalites. Since the garnets are phenocryst type, formed from the tonalitic magma originally, thus P-T condition of their formation can be assumed as the P-T condition of tonalitic melt crystallization. Studies done by Samadi (2009) proved the similar P-T condition of tonalitic rocks with their garnets.

4 Conclusions

Petrography and geochemistry of tonalites revealed that the parental magma of Dehnow tonalitic rocks was an I-type granitoid, belonged to calcalkaline series and related to CAG tectonic setting. In addition, they contain garnet phenocryst occurred by igneous condition, based on their composition.

Acknowledgements

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Table 1: Representative mineral compositions of minerals (in wt%) from Dehnow tonalites (average data of 18 points of amphiboles, 37 points of biotite, 30 points of plagioclase, 142 points of garnets, and 2 points of ilmenites) and their structural formula (in a.p.f.u.).

Mineral Type	18 Amphiboles	37 Biotites	30 Plagioclases	2 Ilmenites	142 Garnets
SiO ₂	40.50	35.80	52.23	0.44	38.22
TiO ₂	0.77	2.31	0.01	51.48	0.30
Al ₂ O ₃	16.10	16.93	29.64	0.28	21.34
Cr ₂ O ₃	0.01	0.01	0.00	0.02	0.00
FeO	17.61	21.71	0.37	45.12	29.02
MnO	0.54	0.38	0.02	0.56	2.18
MgO	6.25	8.27	0.02	0.68	4.16
CaO	12.26	0.09	12.35	0.12	5.62
Na ₂ O	0.77	0.09	4.46	0.01	0.02
K ₂ O	1.18	9.22	0.10	0.01	0.01
Total	95.99	94.82	99.20	98.71	100.87
Structural formula					
Si	6.21	2.78	2.388	0.983	2.999
Ti	0.09	0.13	0.000	0.008	0.013
Al	2.91	1.55	1.599	0.000	1.974
Cr	0.00	0.00	0.000	0.958	0.000
Fe	2.30	1.41	0.014	0.012	1.897
Mn	0.07	0.02	0.001	0.026	0.151
Mg	1.46	0.96	0.002	0.003	0.534
Ca	1.98	0.01	0.606	0.000	0.431
Na	0.23	0.01	0.395	0.000	0.002
K	0.23	0.91	0.006	0.000	0.000
Ni	0.00	0.00	0.000	2.002	0.000
Total	15.48	7.78	5.012	0.983	8.002
Oxygen	23	11	8	3	12
End members					
Anorthite			0.60		
Albite			0.39		
Orthose			0.01		
Spessartine					4.83%
Pyrope					16.21%
Almandine					63.12%
Grossular					14.38%

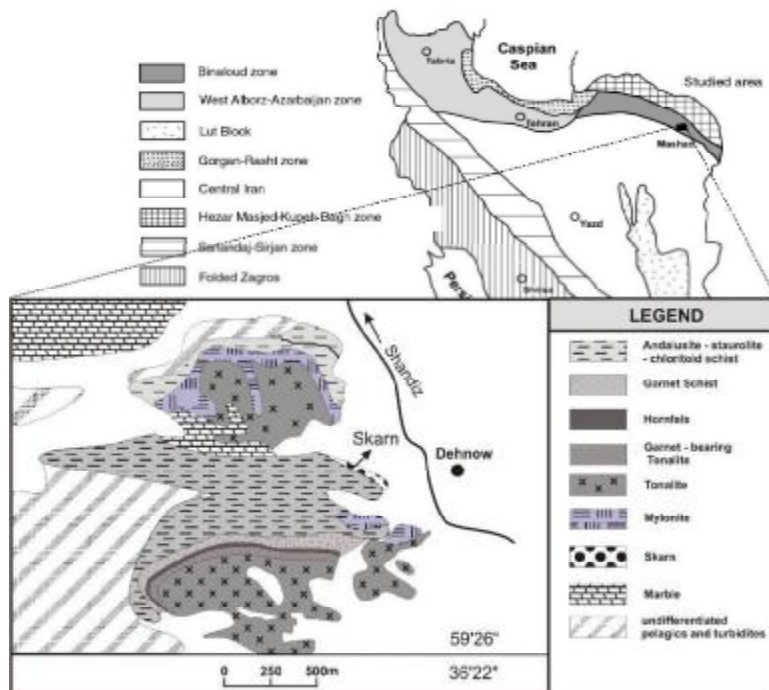


Fig. 1: Simplified geological map of Iran. Geological map of Dehnow adopted from Torghaba 1:100'000 map sheet, by Geological Survey of Iran, 2001).

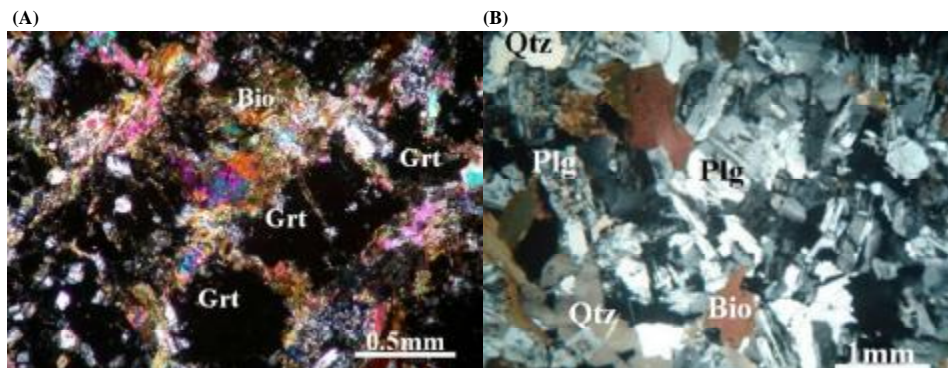


Fig. 2: Microscopic thin section of biotite, plagioclase, quartz, and garnets in tonalites in (A) XPL and (B) PPL views.

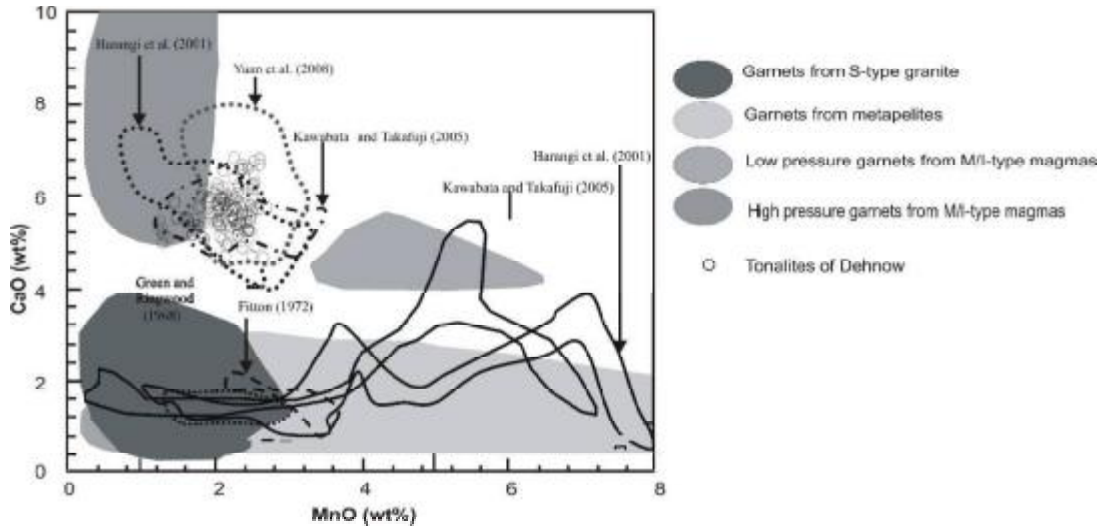


Fig. 3: Comparison of garnets of Dehnow tonalites with pheno- and xenocrysts of garnets from the other areas in the world (dashed lines are for garnets studied by Green and Ringwood (1968), Fitton (1972), Kawabata and Takafuji (2005), Harangi et al. (2001) and Yuan et al. (2008); and solid lines are belonged to garnets investigated by Harangi et al. (2001) and Kawabata and Takafuji (2005)).

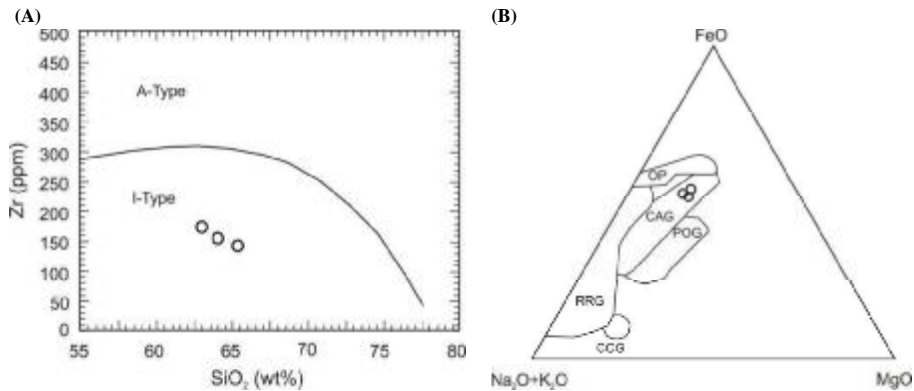


Fig. 4: (A) SiO₂-Zr diagram of Chappell et al. (1998); (B) AFM diagram of Bowden et al. (1984).