Very-low- to low-grade metamorphism of mafic and felsic volcanic rocks in Avalonia of SE Cape Breton Island (Nova Scotia; Canada) as a result of collision

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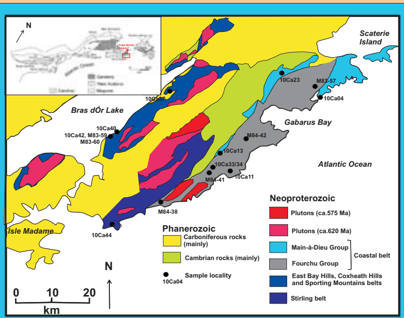

Introduction

To better understand geodynamic processes in late Neoproterozoic to Cambrian times which resulted in metamorphism of volcanic rocks in the Avalonian Mira terrane of SE Cape Breton Island (CBI;protolith ages: 680-560 Ma), we have studied 17 white-mica-bearing mafic and felsic metavolcanic rocks. As yet McMullin et al. (2010) have shown by chemography and calculation of multivariant reactions that these rocks were metamorphosed at very low grade conditions and relatively low pressures in the transitional field between greenschist, pumpellyite-actinolite and prehnite-actinolite facies.

The metarhyolitic rocks are invariably sheared and mylonitized with a blastoporphyric relict fabric. They show the assemblage epidote – chlorite – phengite – albite – quartz – titanite ± stilpnomelane ± K-feldspar. By contrast, many metabasic rocks are relatively undeformed and display relict porphyritic and amygdaloidal textures. They contain the assemblage epidote – chlorite – phengite – albite – quartz - titanite ± actinolite ± pumpellyite ± prehnite ± calcite ± K-feldspar. Inhomogeneous equilibration is partly indicated by local relicts of magmatic clinopyroxene and plagioclase

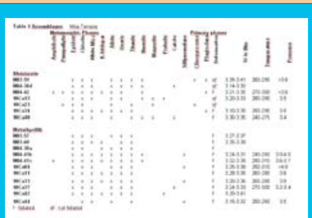

Table 1. Observed assemblages of all studied metabasite and metarhyolite samples in CBI, their Si-contents in white mica and their calculated maximum PT -conditions.

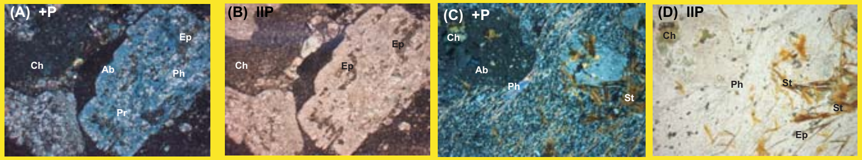

Fig .2. Photomicrographs of metabasite 10Ca13 (A, B) and metarhyolite M8441B (C, D). Image lengths are 2 mm. Abbreviations: Ch = chlorite, Ep = clinozoisite-epidote, Ph = phengite, Pr = prehnite,St = Stilpnomelane, Ab = Albite

Fig.3

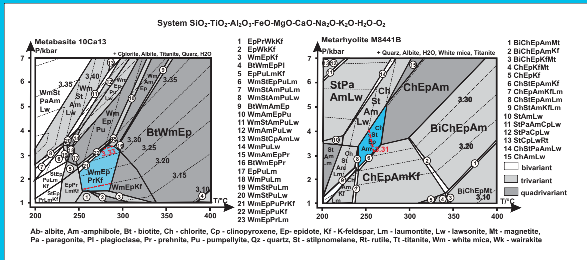

Table 2

	XRF Analyses of CBI Rocks			Compositions for PERPLE_X Calculations	
	10Ca13	M8441B		10Ca13	M8441B
SiO_2	53.08	74.04	SiO_2	51.90	70.05
TiO_2	0.73	0.38	TiO_2	0.71	0.36
Al_2O_3	18.80	14.70	Al_2O_3	18.38	12.78
Fe_2O_3	8.93	1.92	FeO	8.02	1.90
			O_2	0.04	0.04
CaO	4.83	0.41	CaO	4.56	0.39
MgO	4.29	1.10	MgO	4.19	0.96
MnO	0.16	0.02			
K_2O	1.60	1.17	K_2O	1.56	1.10
Na_2O	3.77	5.66	Na_2O	3.68	5.36
P_2O_5	0.05	0.13			
H_2O	3.50	0.15	H_2O	6.96	6.96
SUM	99.79	98.77	SUM	100.00	100.00

Method

PT-pseudosections were calculated for the range 200-400°C, 1-7 kbar with the PERPLE_X software (Connolly 2005) using the thermodynamic data set and solid solution models of Holland and Powell (1998, 2003) with supplements by Massonne and Willner (2008). The peak metamorphic assemblages occupy PT-fields consistent with the position of isolines for corresponding maximum Si-contents in white mica within the calculated stability field of the observed assemblage (Fig. 3).Thus, the obtained results suggest that equilibrium conditions were reached at very-low grade metamorphism. This method leads to better constrained PT results than the calculation of multivariant reactions.

References:

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Holland, T.J.B. and Powell, R., 2003. Contrib. Mineral. Petrol., 145, 492–501
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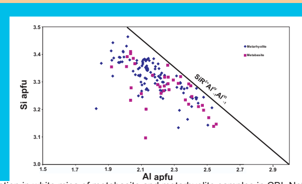
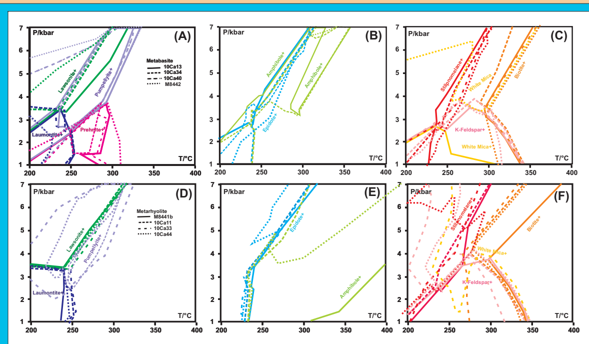


Fig. 4. Si-Al variation in white mica of metabasite and metarhyolite samples in CBI. Note that most white mica is phengite (>3.2 Si apfu). Grains with Si contents < 3.3-3.4 grew during the prograde PT path. There is partly a strong deviation of the white mica composition from the line of the ideal Tschermak substitution due to elevated Fe3+ content



PT fields of metamorphic minerals

The calculated PT fields for metamorphic phases are shown in Fig. 3 for four metabasite samples (A-C) and four metarhyolite samples (D-E). Except for prehnite, all calculated phases may occur in both principal CBI lithologies. PT conditions in CBI are above the stability fields of lawsonite and laumontite (>250°C), within the one of epidote (>240°C) and below the one of biotite (<300-340°C). Note that the stability fields of prehnite and pumpellyite hardly overlap (250-280°C, 3-3.7 kbar). These conditions were mostly realized in CBI. At these pressures K-feldspar is still stable in some metabasite and metarhyolite samples, but stilpnomelane in metabasite only up to 250°C, in metarhyolite up to 280°C. Hence this mineral is only observed in metarhyolite in CBI.

Geodynamic consequences

Peak PT-conditions of 3.4-4.0 kbar, 260 ± 30°C result for the Mira terrane samples. These conditions appear to be relatively homogeneously distributed. They suggest burial to at least 12-16 km depth under a low metamorphic geotherm of 18-25°C/km. In contrast to previous studies (McMullin et al. 2010), the detected medium pressure metamorphism in the Mira terrane is compatible with collisional processes and related crustal thickening. Most likely burial occurred in the deepest part of a foreland fold-and-thrust belt. The timing of this metamorphism predated deposition of overlying Cambrian sedimentary sequences which contain white mica with $^{40}Ar/^{39}Ar$ ages of ca. 550 Ma and older (Reynolds et al. 2009) and was probably related to the assembly of Avalonia in Late Neoproterozoic times