SUPPLEMENT: Analytical Methods

EBSD methods

Detailed EBSD analyses were carried out on six representative samples and eight distinct symplectitic textures within them using a JEOL 6500 FEG-SEM at the College of Science and Engineering's Characterization Facility at the University of Minnesota. Analyses were carried out using a 20 keV accelerating voltage an ~80 nA sample current. Orientation indexing was achieved using Channel™ software and EBSD detector of Oxford/HKL technology. The fine-grained nature of the symplectitic textures along with the optical dominance of spinel precluded a detailed analysis of the grain-scale structure of the textures. As a result, EBSD maps were collected using a 0.7 µm step size.

HRXCT methods

    Three-dimensional imaging on OCG was conducted at the HRXCT facility at the Department of Geological Sciences at the University of Texas-Austin. The ultra-high-resolution (UHR) subsystem using a 225-Kv microfocal source (maximum spatial resolution of 5µm) was used for analysis of mm-scale samples of single symplectite textures and the High-energy subsystem using a 450-Kv tungsten X-ray source was used to obtain 3D data on larger samples of OCGs. HRXCT data were collected on three samples (02-2.03, 06ET-2B, and 06ET-2H). Ultra-high-resolution (UHR) data were collected on single reaction textures cut from 02-2.03 and 06ET-2B as well as a three-inch long by one inch diameter core taken from 06ET-2B to investigate corona- and intermediate-scale textural relationships. Hand sample sized specimens of 02-2.03 and 06ET-2B were scanned in the high-energy system to characterize bulk-rock textures.

        Data collected from HRXCT analysis are in the form of a series of grey-scale images. The grey-scale distribution approximately correlates with density (Denison et al., 1997). As a result, large discontinuities in the density of phases present in a rock volume must be present to efficiently visualize the phases individually. Garnet and other relatively large and high-density phases, are typically easy to identify and therefore their three-dimensional characteristics (e.g. spatial distribution, size, shape etc.) can be quantified (Hirsch et al., 2000; Whitney et al., 2008)

    Even when using the UHR system on the smallest possible diameter samples, imaging the three-dimensional structures of spinel vermicules within the symplectitic assemblages was not possible. The spinel vermicules range in size from a few to tens of microns in diameter, putting them at the edge of the spatial resolution of the technique. This fact, along with the relatively high-density of spinel obscured the fine-detail of the morphologies due to beam hardening (Denison et al., 1997). These two factors also had the added affect of obscuring phase contrast between whether spinel was intergrown with either cordierite or plagioclase. However, general details related to the total thickness and textural heterogeneity of samples can still be determined.

Estimates of Material Transport

Calculation of apparent material transport from outside of the reaction zone (termed *boundary fluxes* for convenience of discussion) was developed following calculations presented by Johnson & Carlson, (1990) and Carlson & Johnson, (1991) to allow for the systematic investigation of the effect of textural heterogeneity on estimating the location of the original interface between reactants as well as the apparent material transport into and out of the reaction zone. This was achieved by systematically changing the relative thickness (or presence/absence) of the two-phase symplectitic layers as well as the identity and composition of the matrix reactant. We assumed constant volume and utilized the reactant and product phase compositions and product phase modal distribution within the reaction zone. The position of the original reaction interface and the degree of component conservation (or transport) is determined by systematically varying the ratio of the reactants participating in the reaction. Modal proportions of the two-phase assemblages and the cordierite moat and their respective phase compositions were integrated to determine a representative bulk composition (normalized to 24 oxygens) of the entire thickness of the reaction zone. The relative proportion of each of the layer assemblages was varied systematically. The bulk composition of the entire reaction texture was then compared with an inferred reactant assemblage to determine the net molar change necessary to achieve the product bulk composition. We assumed that Si and Al would be conserved during reaction. Therefore, the position of the original interface correlates where Si and Al curves crossover near the mass conservation line (Fig. 3).

Movie Caption

Movie DR1. Movie composed of stacked HRXCT data of a representative core of Orthoamphibole-Cordierite gneiss from the Thor Odin dome to illustrate the full 3D nature of the interpreted pathways composed dominantly of relatively fine-grained cordierite linking reaction textures associated with Grt and Als porphyroblasts. Cored sample is 2.54 cm in diameter.

References for supplementary material

Carlson, W. D., and C. D. Johnson (1991), Coronal Reaction Textures in Garnet Amphibolites of the Llano Uplift, American Mineralogist, v. 76, no 3, p. 756–772.

Denison, C., Carlson, W., and Ketcham, R., 1997, Three-dimensional quantitative textural analysis of metamorphic rocks using high-resolution computed X-ray tomography .1. Methods and techniques: Journal Of Metamorphic Geology, v. 15, no. 1, p. 29-44.

Hirsch, D.M., Ketcham, R.A., and Carlson, W.D., 2000, An evaluation of spatial correlation functions in textural analysis of metamorphic rocks: Geological Materials Research, v. 2, no. 3, p. 1-42.

Johnson, C.D., and Carlson, W.D. (1990) The origin of olivine-plagioclase coronas in metagabbros of the Adirondack Mountains, New York. Journal of Metamorphic Geology v. 8, no. 4, p. 697-7 17.

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Table DR1. Representative microprobe analyses of orthoamphibole, cordierite, spinel, sapphirine, plagioclase, and biotite

Phase	Orthoamphibole	Orthoamphibole	Cordierite	Cordierite	Cordierite	Spinel	Spinel	Plagioclase	Biotite	Biotite		Garnet	Garnet
Texural Placement	Core	Rim	After Orthoamphibole	Coronal	w/Spl	w/ Pl	w/ Crd	w/Spl	Adjacent to Symplectite	Grt-Corona		Core	Rim
SiO_2 wt%	45.72	54.53	48.77	48.12	49.26	0.57	0.20	44.06	37.43	37.55		38.47	38.76
TiO_2	0.20	0.07	0.00	0.01	0.00	0.95	0.05	-	0.46	1.77		0.01	0.00
Al_2O_3	15.56	4.50	34.15	34.46	34.50	62.88	65.08	36.59	19.75	19.46		22.58	22.83
FeO	14.43	16.04	3.57	4.94	5.43	22.34	22.79	0.37	13.22	11.68		26.48	26.54
MnO	0.13	0.14	0.06	0.11	0.14	0.05	0.06	-	0.06	0.02		1.74	1.45
MgO	19.27	22.39	11.61	10.71	10.52	11.77	12.36		15.99	16.52		6.16	8.25
CaO	0.51	0.45	0.01	0.11	0.04	-	-	19.30	0.02	0.00		4.99	2.50
Na_2O	1.52	0.46	0.16	0.05	0.05	-	-	0.52	0.52	0.74			
K_2O	0.01	0.00	0.00	0.01	0.01	-	-	0.01	8.19	8.23			
Total	97.36	98.58	98.31	98.51	99.94	98.57	100.54	100.85	95.74	96.04		100.41	100.33
											Grt endmembers xMg	0.29	0.35
											XAlm	0.58	0.58
X_{Mg}	0.70	0.71	0.85	0.79	0.78	0.48	0.49	-	0.68	0.72	XSps	0.04	0.03
X_{An}	-	-	-	-	-	-	-	0.95			XPyp	0.24	0.32
											XGrs	0.14	0.07

Cr_2O_3 content was below detection limits in all phases

Table DR2. Measurements of symplectitic layer assemblages

Total thickness of reaction texture (μm)*

Average	s.d.	n
678.64	57.92	30.00

Thickness of cordierite moat

Average	s.d.	n	number of textures
168.07	20.47	30.00	22.00

Thickness of Sp+Cd**

Average	s.d.	n	number of textures
253.50	19.09	30.00	17.00

Thickness of Sp+Pl**

Average	s.d.	n	number of textures
174.62	55.56	30.00	15.00

*Variation in thickness is also a function of 2D limitations on measureing 3D structures
**Thickness measurements were conducted only where a single two-phase assemblage was present in the layered structure

Representative estimates of two phase product assemblage in equivalent square area

Crd+Spl	
Spl	0.37
Crd	0.63

An+Spl	
Spl	0.361
An	0.639

Crd+Crn	
Crn	0.3
Crd	0.7