

Experimental study of the Ultra High Temperature metamorphism of a restitic metapelitic granulite: role of a previous partial melting event on the UHT metamorphism and influence of the redox state.

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Experimental study of the Ultra High Temperature metamorphism of a restitic metapelitic granulite: Role of a previous partial melting event on the UHT metamorphism and influence of the redox state

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Experimental Mineralogy, Petrology and Geochemistry

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This poster (and the abstract) is online:http://christian.nicollet.free.fr/page/Publications/Communications.html#78

Introduction

The origin of UHT metamorphism in the continental crust is still matter of debate. Partial melting probably plays a key role. UHT metamorphism occurs at temperatures above the fluid-absent melting of most crustal rocks. Partial melting is an endothermic process that consumes heat and buffers the temperature at around 750-850°C. Thus, partial melting prevents a fertile crust to attain UHT. Conversely, UHT conditions can be more easily reached upon refractory / restitic rocks and occur preferentially in terranes that underwent previous partial melting event and melt loss..

UHT metamorphism in the Gruf complex (Central Alps)

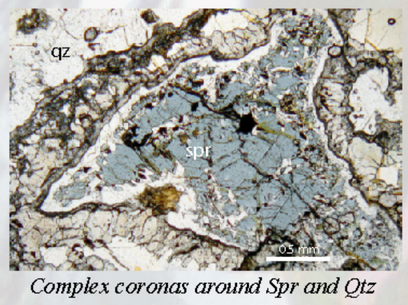


UHT granulite paragenesis and complex retrograde evolution.

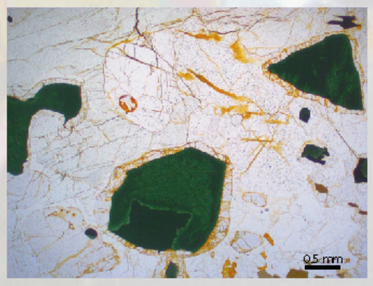
The Gruf complex in the Lepontine Alps could confirm this scenario; it is one of the rare occurrences of Eocene UHT metamorphism in the world. This terrane has also suffered the post Hercynian high-thermal regime responsible of the widespread formation of granulites in the Austro-alpine domain and Southern Alps and consequently of the crust differentiation. We propose that the typical UHT parageneses of the Gruf complex crystallised from refractory/ restitic lithologies. The refractory character was acquired by fluid-absent melting reactions during this post Hercynian metamorphic event and allowed reaching and recording UHT conditions during the Alpine cycle.

Spr + Qz versus Spl + Qz assemblages

The typical mineral assemblage diagnostic of UHT metamorphism Spr + Qtz is sometimes replaced by Spl + Qz under similar P-T conditions. The reason for this dichotomy is not yet understood. These assemblages could be sensitive to $f(O_2)$.



Complex coronas around Spr and Qtz Andriamena formation, N Madagascar



Coronas of Crd around Spl in contact with Qz according to the retrograde reaction Spl + Qz = Crd Beraketa formation, S Madagascar

Experiments

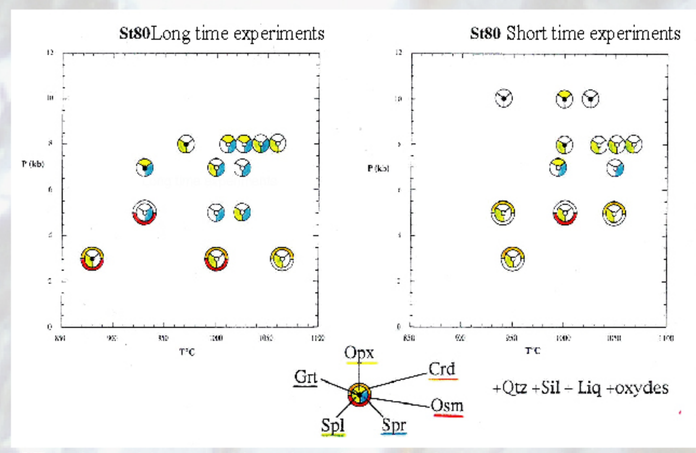
In order to bring new insights to this discussion, we conducted experiments in an internally-heated pressure vessel (BBL) (except 2 runs in a piston cylinder apparatus) on a metapelitic granulite of the Ivrea zone (STR80) composed of Qz-Grt-Sil-Kf±Pl±Bt±Rt (typical **"stronalite"**). This rock is considered to be representative of the lower crust after extraction of a significant melt proportion. It would represent a restite associated with the process of differentiation of the crust leaving a restitic lower crust.

Starting material:
Qz-Grt-Sil-Kf±Pl±Bt±Rt

Nom Echant.	STR-80
SiO2 %	58,37
Al2O3 %	21,26
Fe2O3 %	10,85
MgO %	3,31
CaO %	0,57
Na2O %	0,92
K2O %	2,50
TiO2 %	1,47
MnO %	0,10
P2O5 %	0,07
Ba %	0,0625
Sr %	0,0119
H2O+ %	0,03
H2O- %	0,18
Total %	99,71

Run	P (bars)	T°C	Duration (days)	Minerals (o: inclusions; -: rare) Melt	Qz	Sil	Oxides Ti-Mag	Ilm	Spl	Spr	Grt	Opx	Crd	Osm	KFsp	Pl	notes
A111	8000	970	13 d.		+	+	+		+		-				+		no Melt
		1025		+	+	+	+		o	-		+					Spl included in Opx
		1035		+	+	+	+		o	-		+					and Spr
A119	7000	995	7 d.	+	+	+	+		0 -	-		+			+		Spl included in Spr
		1050		+	+	+	+	+	0	-							Spl included in Spr and Qz
A154	7000	930	13 d.	+	+	+	+			-	0 +	+			+		Grt included in Opx and KFs
		1000		+	+	+	+		0 -	-							Spl incl. in Spr; zones a Spr /Spl/Spr+Spl
		1025		+	+	+	+		0	-							Spl included in Spr
A155	5000	930	16 d.	-	+	+	+	+		-				+		+	few melt
		1000		+	+	+	+	+	0	-						+	Spl included in Sil and Qz
		1025		+	+	+	+	+	0 +	-							Spl incl. in Spr; zones a Spr /Spl/Spr+Spl
A158	3000	880	14 d.	+	0 +	0 +	0 +		0 -		+		+	+		+	Qz, Sil, oxydes, Spl included in Crd
		1000		+	0 +	0 +	0 +	0 +	0 -				+	+			Qz, Sil, oxydes, Spl included in Osm
		1065		+	0 +	0 +	0 +	0 +					+		+		Qz, Sil, oxydes, Spl included in Crd
A161	10000	940	4 d.	+	+	+	+				+				+	+	
		1000		+	+	+	+				+	+			+	+	
		1025		+	+	+	+				+						
A107	8000	1000	7 d.	+	+	+	+		+		-						
		1055		+	+	+	+	+	+								
		1060		+	+	+	+		+								
PC1-91-16	8000	1035	7 d.	+	+	+	+	+	+								
PC1-91-20	8000	1035	14 d.	+	+	+	+	+	+								
A157	5000	940	5 d.	+	+	+	+		+				+				
		1000		+	+	+	+	+	+					+			
		1050		+	+	+	+	+	+				+				
A116	3000	950	4 d.	+	0 +	0	0 +	0 +	0 +				+				Qz, Sil, Spl, oxydes included in Crd

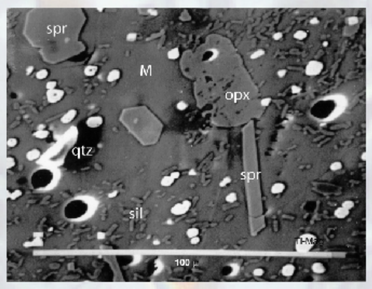
The **P and T intervals** considered during these experiments were **0.3-1.0GPa and 950-1050°C**; their duration lasted between 4 and 14 days.
Between 0.8-0.6 GPa, the paragenesis is dependent on the duration of the run. For the *long-time experiments*, the paragenesis is Spr-Qz-Sil - with or without Opx -TiMag-Melt. Grt is present at T less than about 950°C. For *short-duration experiments* (same, P, T, and X), the paragenesis is Spl-Qz-Sil-TiMag-Melt.



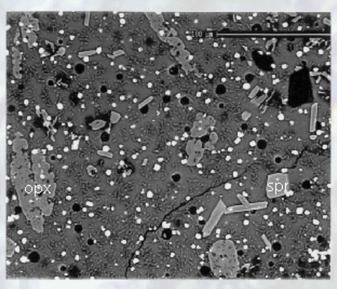
At 0.3GPa, the stable assemblage is Spl-Qz-Sil-TiMag-Ilm-Melt-Crd and/or Osm and Grt at T>900°C, whatever the duration of the experiment.

At 1.0GPa, the stable assemblage is Grt-Qz-Sil-oxides (-sometimes Opx and Fsp).

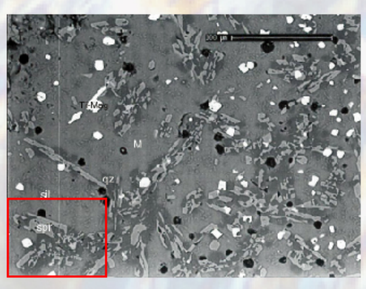
BSE images of different experimental products



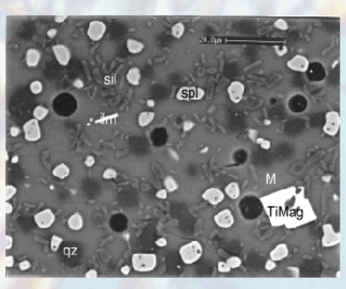
A111-1025°C-8kb-13d. Qz-Spr-Sil-Opx-(Spl)-TiMag-M



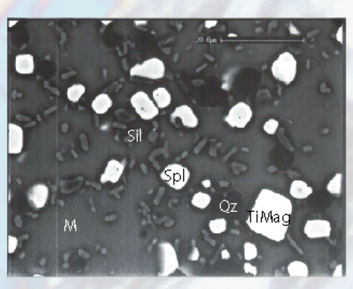
A111-1035°C-8kb-13d. Qz-Spr-Sil-Opx-(Spl)-TiMag-M



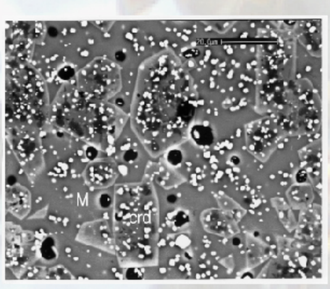
A104-1035°C-8kb-13d. Qz-Spr-Sil-(Spl)-TiMag-M enlarge-ment below



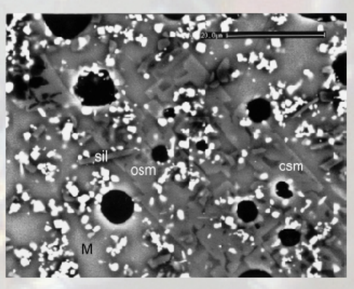
PC1-91-20-1035°C-8kb-14d. Qz-Spl-Sil-Ilm-TiMag-M



A107-1055°C-8kb-7d. Qz-Spl-Sil-Ilm-TiMag-M



A116-950°C-3kb-4d. Qz-Crd-(Sil)-Spl-TiMag-M

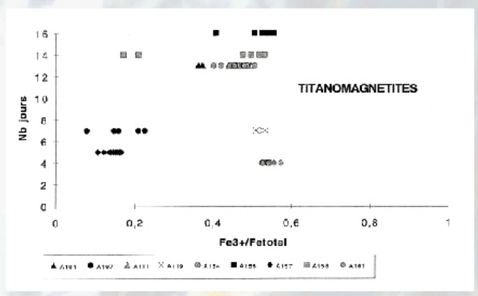


A158-1000°C-3kb-14d. Qz-Osm-Crd-Sil-Spl-TiMag-Ilm-M

Influence of the redox state :

There is a clear relationship between mineralogical assemblages (Spr + Qz or Spl + Qz) and the duration of the experiment conducted in an internally-heated pressure vessel. Similarly, oxidation conditions prevailing during a run is also function of the duration of the experiment as demonstrated by the composition of some minerals.

This is the case of spinel and especially titano-magnetite (see figure on right). We ascribe this increase in the oxydation state along time, due to progressive loss of hydrogen during the experiments at very high temperatures through the gold capsule.
It should be noted that in piston cylinder experiments (PC1-91-xx) the duration of the experiment had no influence on the oxidation state and the nature of the mineralogical assemblage, probably because f(O2) was buffered by the graphite furnace surrounding the capsule.

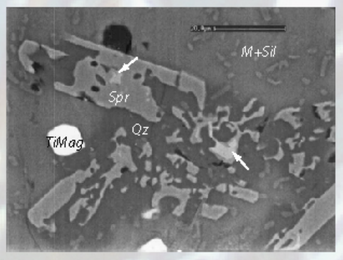


Fe3+/Total Fe versus Duration of the experiments of the Ti Magnetite (Fe3+ calculated by mass balance)

Spl + Spr is observed in run A154;

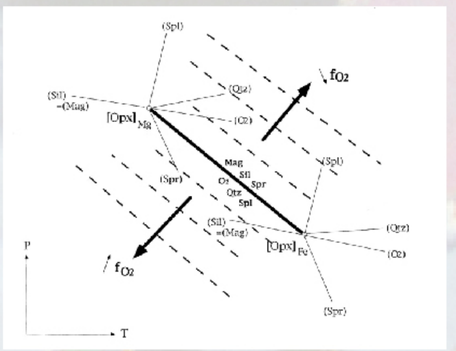
Spl is sometimes included in Spr (figure on right), Sil and Opx.

This suggests a gradual transformation over time of Spl + Qz assemblage (in short-duration experiments and reduced conditions) to Spr + Qz assemblages (in long-duration experiments and oxidized conditions.)



Enlargement of fig. A104 (above) showing Spl included in Spr (arrows)

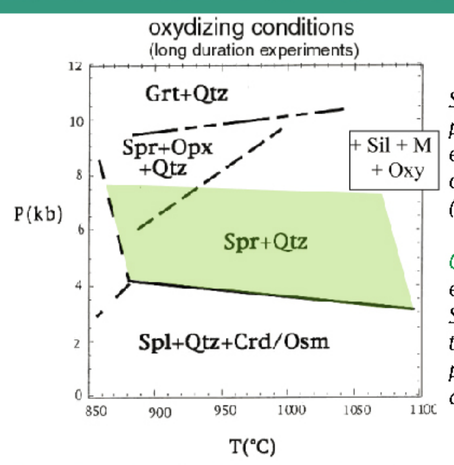
Phase relations in the system FeO-MgO-Al_2O_3-SiO_2-O allow writing the reaction:
Spl + Qz + O_2 = Spr + Qz + Mag.
This reaction moves toward high pressures when $f(O_2)$ which increases the Spl+Qz stability field.



In Conclusion,

our experiments show that UHT conditions applied to a restite from the lower crust produce parageneses typical of UHT metamorphism. These results strengthen our interpretation that the short-lived Eocene UHT metamorphism of the Gruf complex developed on a Hercynian refractory lower crust formed by crustal differenciation.

These experiments also suggest that, under similar P-T conditions, Spl-Qz assemblages are indicative of reducing conditions while Spr-Qz assemblages prevail under more oxidised conditions.



Stability fields of the parageneses of our experiments in oxidizing conditions (long duration)

Green field: enlargement of the Spl+Qz stability field towards high pressure as $f(O_2)$ decreases.