1 STRESS AND STRAIN CALCULATION

To monitor the strain during deformation gold foils that acted as strain markers in X-ray radiographs were placed at the bottom and the top of the sample. The powder diffraction patterns gave access to the differential stresses sustained by lattice planes of a certain phase due to the distortion of the Debye rings in an anisotropic stress field. Hilairet et al., (2012) give further details on the strain and stress calculation. These differential stresses were calculated on the (-201), (111), (002), and the (-220) lattice planes of plagioclase using available elasticity data (Brown et al., 2006) and thermal expansion coefficients (Tribaudino et al., 2010) from literature. The mean stresses of each experiment were re-calculated using the average of the differential stress on the (002) and the (111) lattice planes of plagioclase and the confining pressure \((P_c)\). The confining pressures (see the table in Fig. 1) were estimated using the peak shift in the diffraction pattern taken at ambient conditions and after pressurization and heating. Because calculating stress using triclinic symmetry did not lead to reliable results, the calculation was performed with orthorhombic crystal symmetry. Prior to deformation, the powder samples were hot-pressed in-situ, at their respective confining pressures and their minimum temperatures (table in Fig. 1). After hot-pressing the samples for around one hour, deformation started at a controlled constant strain rate of \(\sim 5 \times 10^{-5} \text{ s}^{-1}\).

2 ANALYTICAL METHODS

All samples were investigated using the Zeiss Sigma field-emission scanning electron microscope (FE-SEM) at Ecole Normale Supérieure, Paris. Backscattered electron (BSE)
images were acquired with an acceleration voltage of 15 kV. For the energy-dispersive X-ray spectroscopy (EDS) element distribution maps, the acceleration voltage was lowered to 10 kV to obtain a higher resolution. The electron backscatter diffraction (EBSD) analyses were performed using an Oxford instruments EBSD detector installed on the same SEM at Ecole Normale Supérieure Paris. Analyses were conducted at an acceleration voltage of 15 kV and the EBSD data was generated using the Oxford Instruments AZtecHKL EBSD system. To investigate the nanostructure, a focused ion beam (FIB) section was cut using a FEI Strata DB 235 at IEMN at the University of Lille, France. The transmission electron microscopy (TEM) analyses were performed on a JEM 2011 at the Laboratoire de Réactivité de Surface at Université Pierre et Marie Curie Paris, France. The TEM images were taken in bright field (BF) mode with an acceleration voltage of 200 kV.

3 CALCULATION OF $E_a$ (EXPLANATIONS TO FIGURE 4)

To calculate the activation energy $E_a$, an Avrami type equation (Poirier, 1982)

$$X(t) = 1 - \exp(-kt^n)$$  \hspace{1cm} (1)

was used, with $X$, the advancement of reaction, $t$, the time in seconds, and $k$ the kinetics factor that can be written as an Arrhenius function

$$k = k_0 \times \exp(-E_a/RT)$$  \hspace{1cm} (2)

where $E_a$ is the activation energy term, $R$ the gas constant and $T$ the temperature in K. Assuming $n=1$ for nucleation at grain boundaries (Cahn, 1956), equations (1) and (2) derive into:

$$\ln(X(t)) = k_0 \times \exp(-E_a/RT) \times t.$$  \hspace{1cm} (3)

where $X$ is the reacted granulite volume over $t$ the finite duration of the experiments and is measured from microstructural observations. Considering that $dX/dt$, the instantaneous reaction rate is constant over the short duration of our experiments yields:
\[ \ln\left(\frac{X}{1-X}\right)/t = k_0 \times \exp\left(-\frac{E_a}{RT}\right), \]  

(4)

For the two experiments performed at constant temperature, NG\_2.5\_1023 and NG\_2.5\_1173, we plotted \( \ln k_0 \) over \( 1/(RT) \). The slope of the regression line between these two points is the activation energy with \( E_a \approx 215 \text{ kJ}\cdot\text{mol}^{-1} \). However, the reacted volumes cannot be estimated precisely and any change would affect the slope. The exact determination of \( E_a \) for anorthite breakdown in the presence of fluid exceeds the scope of the present study and since it lies in the same order of magnitude as \( E_a \) for other known transitions, e.g. 162 \text{ kJ}\cdot\text{mol}^{-1} \) for the quartz-coesite (Perrillat et al., 2003) and 259 \text{ kJ}\cdot\text{mol}^{-1} \) for the olivine-spinel transition (Poirier, 1981), we consider that for our purpose the calculated \( E_a \) represents a reasonable estimate of the activation energy.

Fig. DR1

A

- plagioclase

B

- epidote
- alkali feldspar
- plagioclase

C

- amphibole
- clinopyroxene
- clinopyroxene + kyanite
- biotite
- garnet
- corundum
- spinel
- magnetite
Fig. DR3
Fig. DR4
Fig. 2C

clinopyroxene

plagioclase

bright bands

Fig. 2C

FIB

NG_3_1225

10 μm