ESRF	**Experiment title:** The Fate of subducted slabs : an x-ray diffraction study at high pressures and temperatures	**Experiment number**: HS2329
Beamline: ID30	**Date of experiment**: from: 19/11/2003 to: 25/11/2003	**Date of report**: 28/02/2004
Shifts: 18	**Local contact(s)**: N. Guignot	*Received at ESRF:*

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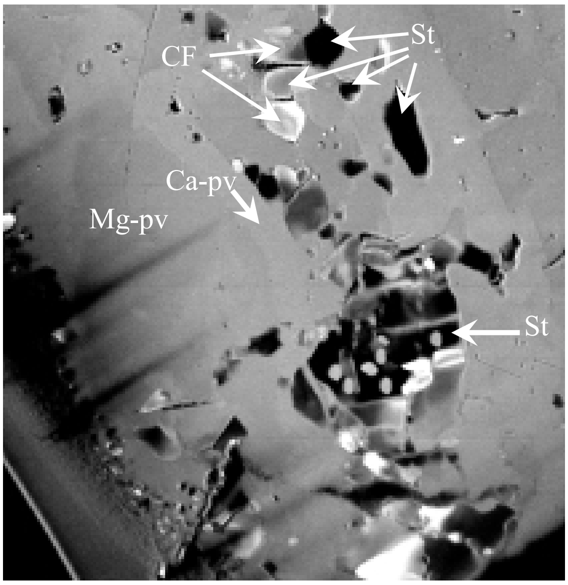
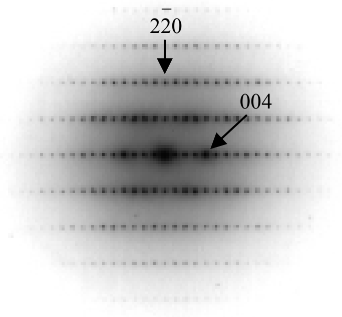
Report:

The penetration of subducted slabs in the lower mantle could have profond effects on the nature of mantle convection and the presence of chemical heterogeneities in the deep mantle. Thus, the mineralogical composition of the oceanic crust (for both MORB and sedimentary compositions) under pressures and temperatures relevant to the lower mantle, is of high interest. The density profile of oceanic crust as a function of depth should obviously play a major role in the dynamics of subducted slabs in the lower mantle.

Several attempts have been previously reported in the litterature to address that question but none of them could take into consideration possible variation of mineral compositions with depth nor measure the density evolution *in situ* at high pressure and high temperature of each single component of the complex mineralogical assemblage synthetised at these conditions.

Our experiments have been carried out on a natural glassy MORB sample from the East Pacific Rise and on a synthetic glass with a GLOSS composition (*i.e.*, global subducted sediments from Plank and Langmuir [1998] with no water and no carbon; we consider a sediment already subjected to dehydration and melting processes in the first kilometers of subduction). These samples were cut in thin slices and loaded in diamond-anvil cells using neon as pressure transmitting medium. These samples were then transformed and studied at high pressure and high temperature on the high pressure beamline ID30 at ESRF, using the *in situ* YAG laser heating system developed for this purpose. For MORB samples, X-ray diffraction patterns were collected at 28, 36 and 40 GPa during a first experiment (see report HS1881) and at higher pressures, namely, 49, 56, 80 GPa, and temperatures ranging from 1700 to 2700K. Quenched samples were recovered and prepared for TEM (transmission electron microscope) investigations with FIB technique (focused ion beam). On the STEM image shown below, all the phases present on the X-ray diffraction patterns of MORB at 48 GPa are visible (Mg-perovskite, Ca-perovskite, stishovite and a calcium ferrite type phase). An electron diffraction pattern taken close to this area confirmed this calcium ferrite type structure. Compositions obtained on these phases from ATEM are listed in table 1.





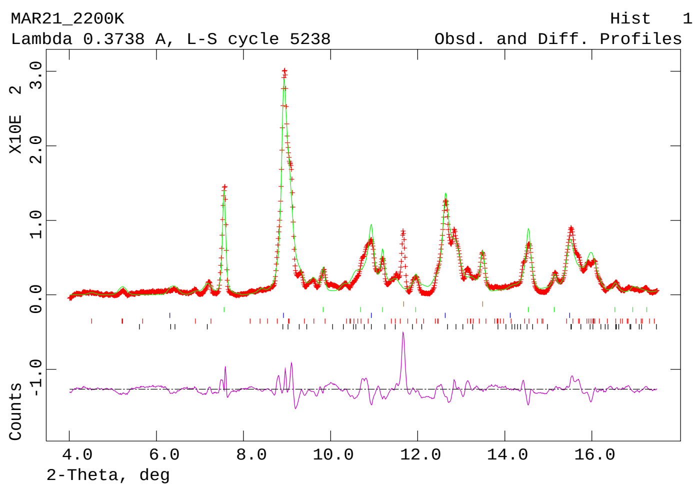
St: stishovite; Mg-pv: Mg-perovskite; Ca-pv: Ca-perovskite; CF: calcium

(Na, Ca, Mg, Fe)AlSiO4 with the CaFe2O4 structure, zone axis [110], space group Pbnm, a=10.1540Å, b=8.664Å, c=2.7385 Å

Table 1 Chemical composition of phases synthetised from MORB at 48 GPa

wt%	SM	St	CF	Ca-pv	Mg-pv
SiO2	49,89	96,38	30,10	66,27	48,02
TiO2	1,41	0,06	0,41	1,13	2,11
Al2O3	14,95	2,09	44,45	4,80	21,11
Fe2O3	10,42	0,63	9,78	4,70	13,28
MgO	7,92	0,11	8,08	3,17	11,02
CaO	12,04	0,72	4,21	19,90	4,29
Na2O	2,61	-	2,98	0,02	0,17
Total	99,24	100,00	100,00	100,00	100,00

These chemical compositions are subsequently taken into account in the Rietveld refinement procedure of X-ray diffraction patterns so that proportion and volume of each mineralogical phases can be estimated. An example of X-ray diffraction pattern collected at 2200K and 61 ±1 GPa (pressure obtained by stishovite and Ca-perovskite thermal equation of states) is shown below.

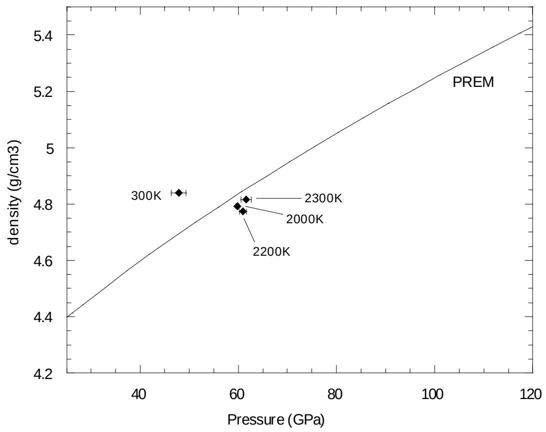


Proportion of phases obtained by Rietveld refinement:

Mg-pv:	44.41%
Ca-pv:	23.00%
St:	14.83%
CF:	11.55%

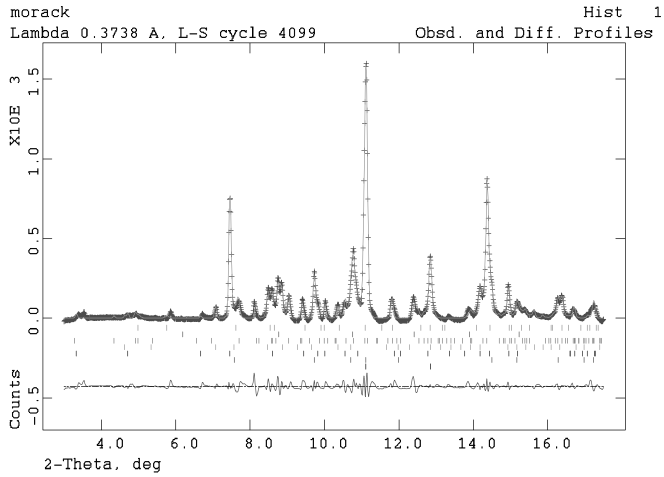
Neon (pressure transmitting medium): 6.20%

Mineralogical assemblages and phase fractions are in good agreement with previous studies made at 300K [Irifune and Ringwood, 1993; Ono et al., 2001; Kesson et al., 1994; Funamori et al., 2000]. In particular, we confirm that the aluminous phase present has a calcium ferrite structure.



With proportion and volume of each phases we obtained for this material a density of 4.77g/cm^3 at 61 GPa and 2200 K. Other Rietveld refinements made at 300K and temperatures of 2000 and 2300 K yield the densities reported in the figure below along with an average radial seismic model for the Earth [PREM, see Dziewonski and Anderson, 1981].

For sedimentary composition, X-ray diffraction patterns were collected at 22.5 and 31 GPa and temperature ranging 1650 to 2700K. Diffraction patterns show six different phases at relatively low pressure, namely NAL phase, Ca-perovskite, calcium ferrite type phase, majorite, hollandite and stishovite (see figure below of a pattern obtained at 22.5 GPa and 300K). TEM investigations on recovered samples will be made to check the presence of all the phases observed by X-ray diffraction and determine their chemical compositions.



In this report, we show that it is possible to:

- identify the different phases present in MORB and sedimentary composition samples transformed along a lower mantle geotherm, measure molar volumes and phase fractions.
- Recover these samples and analyse them by analytical transmission electron microscope.
- With such analysis in hand, we are able to calculate the average density of the high pressure-high temperature mineralogical assemblage and the density differentials between a normal mantle and one subducting oceanic lithosphere.

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