Rapport d'expérience ES-335 sur la ligne ID27:

Viscosity-impeded ascent of carbonated silicate melts at the lithosphere-asthenosphere boundary.

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We recall here that the aim of this study is to determine the viscosity of a type of magmatic liquids that are intermediate between carbonatites and basalts, that is, intermediate between carbonate and silicate melts.

On total 23 experiments were conducted during experiments ES-335. These aimed at monitoring the falling velocity of a metal sphere in a melt at pressure and temperature. The fall of the sphere were successfully monitored for 6 experiments.

The results obtained in terms of viscosity are listed in table 1. The viscosity of pure carbonate end-member (Dolom) is well resolved and compares fairly well with recent literature data from Kono et al (2014). The viscosity of the silicate melt (TA0) is also in excellent agreement with literature data. The viscosity of the intermediate melts indicate a surprising behaviour. As illustrated on figure 1, it is most likely that the viscosity behaviour is not monotonic between the high-viscosity silicate melts and the low-viscosity carbonate melts. We clearly see a positive deviation in viscosity for melt composition having a silica content lower than 30 wt%.

Table 1: Summary of the successful runs.

Sample	SiO_2	CO_2	H_2O	P (GPa)	T (°C)	η (Pa.s)	Error (Pa.s)	Remarks and ramp used
TA6 H	20	19	2	2,09	1525	0,5	0,1	possibly crystallised
								1118°C -> 1525 °C = 150 s
TA0	56	0	0	1,7	1650	1,02	0,04	
TA10 dry	28	15	0	?	1350	0,26	0,1	η estimated from high velocity speed
								700°C -> 1350°C = 180 s ?
TA12 VF	44	0	0	2,12	1700	0,2	0,03	700°C -> 1700°C = 120 s ?
Dolom	0	49	0	2,1	1400	0,012	0,002	
TA10 H	28	16	2	1,7	750W	?		viscosity too high = partially crystallized ?
TA12 D	42	7	0	-	-	-	-	

Additional runs were conducted at ISTO, Orleans, in order to complete and/or confirm the data collected at ESRF. These were not in-situ measurements, but we have a single observation on quenched run-products, that is, the position of the metal sphere at the end of the run. These results are called post-mortem experiments in figure 1 and while most of them are in agreements the in situ

measurements at ESRF, we have mixed feelings for the sample TA6H. Our interpretation is that for the run done at ES-335, the sphere was falling in a mush, that is, a solid-liquid mixture containing a fraction of solid that significantly increases its viscosity. We also suspected the presence of such a mush during another experiment at ESRF in which, the sphere was not continuously falling but was rather moving by "steps" (TA10dry). This experiments was corrected (considering only the steps) which yield viscosity results being very similar to the post-mortem data point.

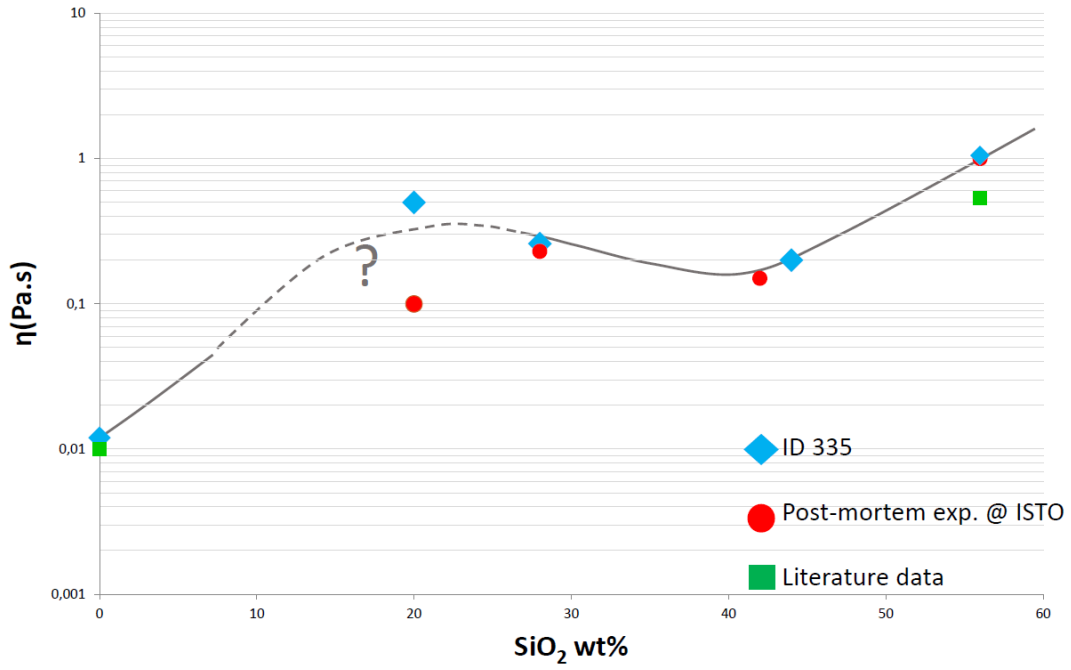

Fig. 1. Viscosity vs chemical composition of the melt from carbonatite (low SiO2) to basalt (55% SiO2).

For the future of this project, we recommend the following improvements:

- Large volume assemblages constitute an interesting setup that was regretfully discovered too late. We had to use MgO capsule for such assemblages and a high number of experiments produced a blowout (at 350 watts systematically). We retain that this type of large assemblage will make our measurements much easier but can be improved.
- The fall of spheres in a mush (crystal+liquid) is an issue related to the heating rate, being too slow and favouring crystallization during the heating stage. We think that an activity focusing on the possibility of increasing the heating rate would be mandatory.
- We found that working without thermocouple is difficult. An interesting long term effort would consist in introducing a thermocouple in the assemblage allowing a continuous monitoring of temperature.

On our side at ISTO, we are about the complete a set of data with post-mortem observations. These give interesting first-order clue, but it is clear that one or two successful in situ experiments at ESRF are needed to make a paper in a high profile journal. In brief, the positive deviation in viscosity at low SiO2 needs to be corroborated by 1 or 2 complete experiments.

END.