Profiling the temperature dependent frequency of an open-magnet for outdoor applications

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Profiling the temperature dependent frequency of an open-magnet for outdoor applications

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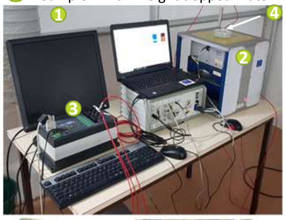
The open geometry of the single-sided NMR-MOUSE® sensor results in a powerful spectrometer to characterize arbitrarily sized samples. This inhomogeneous magnet is designed in such a way that it generates a highly flat sensitive slice, i.e. the measurement volume, at a given distance (25 mm for the PM25 system) parallel to the scanner surface [1]. It is well known that low field magnets have a strong dependence between the magnetic field and the magnet temperature. For the NMR-MOUSE® it leads to a dependence between the magnet temperature and the position of the sensitive volume [2].

As our aim is to use this portable device under unstabilized temperature conditions, we anticipate variations in the measurement position. This study aimed at characterizing the relationship between changes in the magnet temperature and the position of the measurement volume. Measurements were performed at two sites with two different PM25 NMR-MOUSE® spectrometers.

Materials

1. Climate room with temperature regulation between 10 and 25°C (Team 1)
   FITOCLIMA 1200 with temperature ranging from 15 to 35°C (Team2)
2. NMR-MOUSE® with Kea spectrometer (Magritek®, Aachen, Germany)
3. Fiber optic temperature sensors (LumaSHIELD®, Lumasens Tech, France)
4. Sample = 1-cm height dopped-water in a Petri dish



Experimental set-up Team 1:
- Two temperature cycles were used : 10 to 25°C and 25 to 10°C
- Sample profiles were acquired from 6 to 0 mm of the magnet surface with a slice thickness of 50 µm. The experimental time to record one profile was 8 min. A 2 min gap was left after each profile leading to a profile resolution of 10 min
- Room, sample and magnet temperatures were logged every 2 min

Experimental set-up Team 2 :
- Temperature set points were advised by successive plateaus : 15°C, 18°C, 25°C, 30°C, 32°C and 35°C
- Sample profiles were acquired from 4 mm to 0.5 mm of the magnet surface with a step of 90 µm. 5min 30s were necessary to record one profile

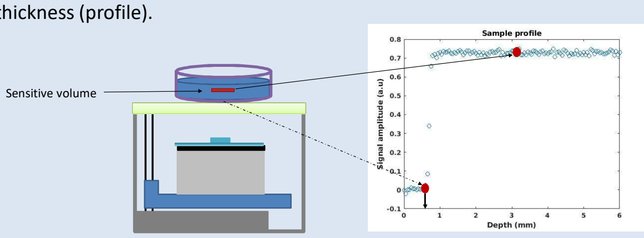
Methods

Principle

Magnet temperature change ➡ Change in B_0 ➡ Shift in the position of the sensitive volume

How ?

Sample profiles were recorded during the room temperature change and until it stabilizes. We followed-up the evolution of the signal intensity at different depths for a specific slice thickness (profile).



Results

Team 1

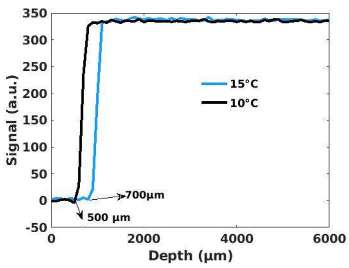


Figure 1: Sample profiles recorded at a magnet temperature of 10 (black) and 15°C (blue). A shift of 200 µm is observed for this 5°C difference.

Team 2

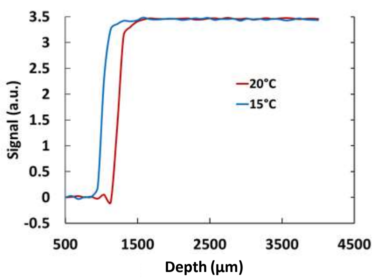


Figure 2: Sample profiles recorded 2 hours after the temperature stabilization of the magnet at 15 (blue) and 20°C (red). A shift of 241 µm is observed.

Figures 1 and 2 show the profile acquired at different temperatures by using the experimental set-up of team 1 and 2, respectively. Both figures highlight the fact that a relatively limited temperature change induces a significant variation in the position of the measurement slice. For a 5°C difference, the slice shifts by approximatively 200-250 µm.

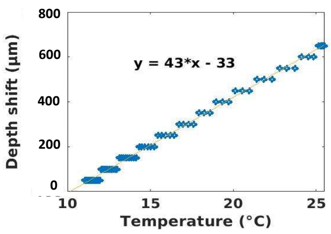


Figure 3: Shift of the measurement slice determined from the interface between the petri dish and the water as a function of the magnet temperature.

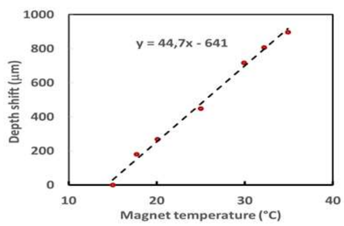


Figure 4: Shift in the measurement depth as a function of the magnet temperature.

Figures 3 and 4 summarize the relative shift of the slice position (reference at the lowest temperature) as a function of the magnet temperature. Team 1 reported the shifts during the magnet temperature evolution. Similar depth shifts were recorded for different magnet temperatures due to the profile resolution (50 µm).

Both experiments lead to the same conclusion: it exists a linear relationship between the shift in the slice position and the magnet temperature. The measurement slice will shift by 45 µm/°C.

Discussion and Conclusions

The relationship between the temperature of the NMR-MOUSE® magnet and the position of the sensitive volume was characterized in the range of 10 to 35°C and that in two different laboratories with two spectrometers. For both measurements, a shift of the measurement slice of 45 µm/°C was observed.

Two solutions can be implemented to take into account the possible slice measurement depth shift during the experiment:

1. The magnet can be insulated to limit its temperature change during the experiment
2. An automatic correction method, based either on the NMR signal or on the magnet temperature measurement, can be developed

(1) [1] J. Perlo, et al. J. Magn. Reson. 176 (2005).
(2) R. Lu et al. CJME. 26 (2013)