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(G*) Direct 2D Imaging of Water Penetration In Clay Using Low Field MRI

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Introduction:
Magnetic resonance imaging of short signal-lifetime samples comes with several challenges¹, namely lower signal and the need for short acquisition windows. The apparent transverse relaxation time (T_2^*) of water-content in cement paste has been measured² to be <0.3ms at 3T: this suggests imaging at low field (<0.5T) where T_2^* is expected to be longer, permitting 2D imaging of water penetration in a clay sample. However, proton imaging at low field prohibits the use of low flip-angles if high signal is desired, so a short echo-time (TE) pulse sequence using 90° flip angles was implemented with a water and clay sample at 74mT.

Method:
The x-centric pulse sequence³ consists of acquiring each half of every k-space line separately, from the centre outwards in the readout/*k_x* direction: this halves the acquisition duration and ensures the centre of k-space is acquired first, minimizing signal decay caused by T_2^* relaxation. This pulse sequence was used to image water distribution in a 12mL bentonite clay sample on a 74mT MRI system and compared with the traditional gradient echo (GRE) sequence. Eight T_2^*-weighted images were obtained using 8 different TEs=0.5ms$\cdots$10ms. Bulk relaxation measurements of the longitudinal (T_1) and apparent transverse relaxation times were also performed for increasing water content (1mL increments).

Results:
The T_1 relaxation was around 10ms and was largely independent of water content; the T_2^* relaxation was proportional to the amount of water in the clay (3 to 5ms). The x-centric pulse sequence was 2.5 times more efficient than GRE. A 2D T_2^* map was generated from eight T_2^*-weighted x-centric images: the global mean T_2^* value was 6.4$\pm$3.2ms.

Conclusion:
We have shown that x-centric was able to image the water content in the bentonite clay with minimal T_2^*-weighting. To our knowledge, this is the first attempt to image water-content in bentonite clay⁴. The T_2^* dependence on water content suggests that a T_2^* map also represents a regional water absorption/content map. The short T_1 measured here should allow for rapid real-time 2D and 3D imaging of water penetration in porous materials, and the significantly longer T_2^* at this field strength alleviates the imaging issues caused by this fast signal decay.

References:
1 Muir et al. MRC (2013); **2** Sakai et al. OJCE (2017); **3** Ouriadov et al. MRM (2015); **4** Fagan et al. MRI (2005)

Keyword-1

MRI

Keyword-2

Clay

Keyword-3

Water Absorption

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