Biogeosciences Discussions, 2, S183–S186, 2005
www.biogeosciences.net/bgd/2/S183/
European Geosciences Union

Biogeosciences Discussions

BGD

2, S183–S186, 2005

Interactive Comment

Interactive comment on "Non-invasive diagnostics in pathological fossils by magnetic resonance imaging" *by* D. Mietchen et al.

D. Mietchen et al.

Received and published: 3 May 2005

General comments

First of all, the authors wish to thank the referees for their positive evaluation of the manuscript and for initiating the discussion. The referee's comments are in *Italic*.

Specific comments

(N. Clark): *A useful comparative study would have been to examine the same structures using CT scanning to see if shell density produces a similar image to that produced using MR imaging. This may help in interpreting the source of the nuclei resulting in the interpolated image using MR.*
We have not tried CT with these samples but preliminary experiments some years ago have failed to produce sufficient image contrast in belemnites. CT provides good contrast when it comes to major differences in mass density within a sample, as between

air and sandstone in the mouldic fossil study by Clark et al. (2004) or in ammonites where shell and filling materials typically have a different origin and, consequently, density (Keupp and Mitta, 2004). The case is different, though, in samples like belemnite guards where mass density variations are subtle.
However, one of the advantages of our MR imaging experiments is that - having left the samples intact - all other investigations are still possible to the same extent they were before, and catalogue numbers were provided to facilitate this process.

(N. Clark): *If a belemnite could be sacrificed to determine the organic content, water content, and composition, this may also be useful in determining the source nuclei.*
(B. Kröger): *What type of rock is best to investigate (clay/limestone/chalk)?*
The focus of this study was the proof of principle that MRI can be used for non-invasive diagnostics of pathological phenomena in fossils. Thus, the questions of the source of the signal and, correspondingly, the favourable rock types were addressed solely on the basis of the pathological investigations described in here. Sælen (1989) has determined the total organic carbon in belemnite guards as being in the order of tens to hundreds of ppm, which suggests the total organic contents to be of the same range. Orr et al. (2002) state that clay minerals are favourable for organic preservation. We further investigated these questions, using independent lines of evidence in belemnoids and beyond. The corresponding manuscript is currently under preparation.

(N. Clark): *One question that has been bothering me is whether the belemnites have undergone any conservation through preparation, in the past, that may have involved consolidants.*
While it is correct to point at chemical preservatives and consolidants as a potential source of MR artifacts and thus of false-pathological signal distributions in belemnite guards, this is not applicable here, as all samples were holotypes and neither glued nor, to our knowledge, otherwise chemically conserved after excavation.

(N. Clark): *On p242 line 8, the authors state that the work by Clark et al. 2004 was 'destructive', however the whole premise of our article was that this was a non-invasive,*

nondestructive means of looking at moldic fossils rather than the standard palaeontological technique of filling the cavity with liquid rubber and breaking the rock open to reveal the cast, thereby destroying significant parts of the fossil.
We agree that the technique used by Clark et al. is considerably less invasive than classical rubber castings with subsequent break-up of the matrix, and it definitely is much more useful in keeping spatial relations between different parts of the specimen intact. Yet filling the moulds with water is certainly invasive, even though it did not change their shape or size to an extent relevant to paleontological questions addressed in your article. Moreover, the contact of the matrix with water during your MRI experiments might impede potential future attempts to determine anything about their past organic contents. Finally, in order to fill the mandibular cavity in your specimen with water, you drilled a connecting channel of 4 mm diameter and 10 mm length into the block. This is the destructive aspect we were referring to, although, for the mouldic (i.e. negative) fossils you investigated, this channel might appear additive rather than destructive. Having clarified this, we removed the bracket containing the “destructive” notion from that sentence in our manuscript.

(B. Kröger): *What maximum /minimum dimension must have a sample. What are the resolution limits? Is it possible to investigate structures / cavities that have mm dimension or cm dimension? Is the porosity a factor that counts?*
The achievable image resolution depends on the relaxation constants and other NMR parameters (such as acquisition bandwidth, proton concentration, repetition time and signal averaging, which contributes to the overall measurement time), as discussed in the cited literature (Callaghan, 1991). Sample dimensions, moreover, depend on the type of spectrometer and on the dimensions of the gradient system as well as the probe. In our system, samples of up to 23 mm in diameter and up to 38 mm in length can be imaged, and structures, including cavities or pores, can be visualized as long as they come along with changes of either the concentration or the relaxation times of their hydrogen nuclei.

(B. Kröger): *The chapter 1.2 would profit from a scheme of a belemnoid guard with its features. The chapter 1.3 would profit from a general outline of the pathological phenomena in belemnoids and the value of the investigated specimens within this. Are the observed belemnoids representative of specific phenomena?*
Details of belemnoid guard anatomy have been described in Sælen (1989), and an overview of pathological phenomena was given by Keupp (2002). Both aspects are beyond the focus of this paper.

(B. Kröger): *Makes it a difference for the image quality if the sample is dry or wet?*
The presence of water makes a difference, which is the basis behind the MRI experiments of Clark et al. (2004).

References

Keupp, H. and Mitta, V. V.: Septenbildung bei *Quenstedtoceras* (Ammonoidea) von Saratov (Russland) unter anomalen Kammerdruckbedingungen. Mitt. Geol.-Paläont. Inst. Univ. Hamburg, 88, 51-62, 2004.

Orr, P. J., Kearns, S. L. and Briggs, D. E. G.: Backscattered Electron Imaging of Fossils Exceptionally-Preserved as Organic Compresions. Palaios, 17, 110-117, 2002.

Interactive comment on Biogeosciences Discussions, 2, 239, 2005.