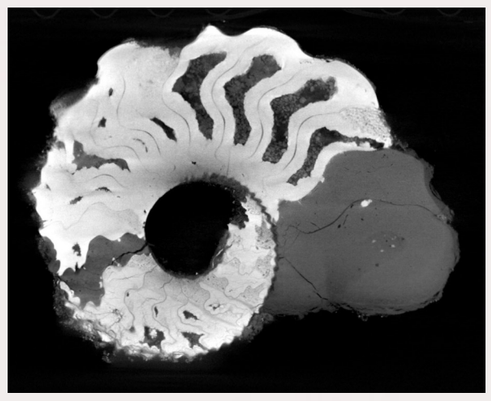
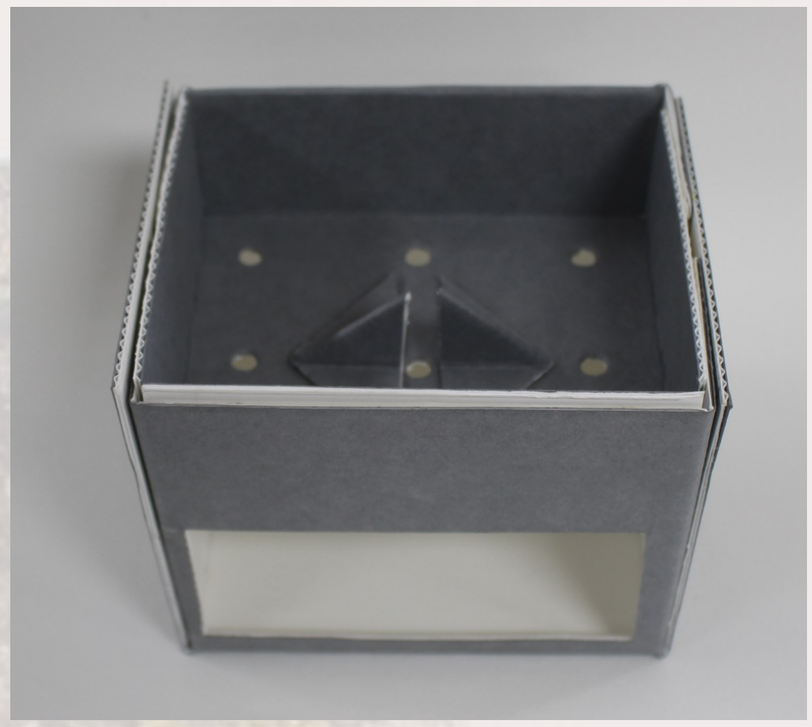
X-ray micro Computed Tomography as a tool for measuring deterioration: a case study on pyritic fossils

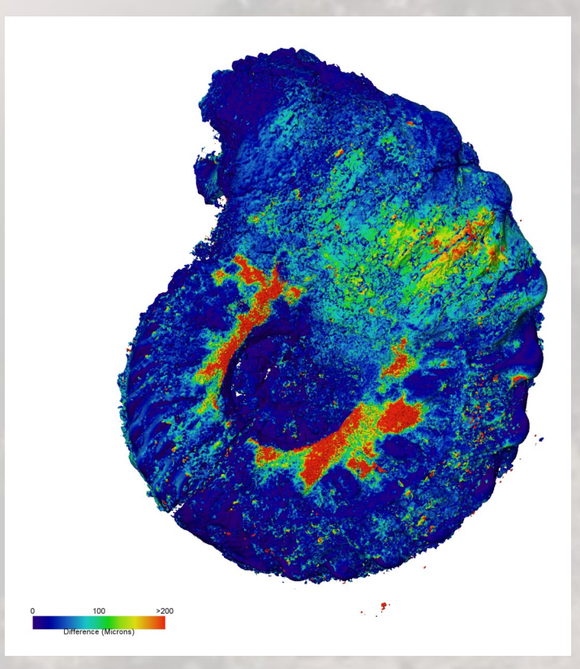


Virtual slice through a pyritic ammonite

X-ray micro Computed Tomography (XCT) was used to record deterioration of pyritic ammonites over a 15 month period. The specimens were stored in microenvironment enclosures of varying levels of relative humidity (0-70% RH) and oxygen (0-21%). XCT enabled both the specimen's external and internal state to be recorded at 3 month intervals. Three dimensional renders from the scanned slices were constructed with CTPro 3D XT 3.1.12 software and maps of surface alteration were created by overlaying the time-lapsed scans of each ammonite using Avizo Lite 9.2.0 software. Surface distance calculations were made to enable empirical comparisons and evaluation of the different microenvironments. The study concluded that the most effective conditions for limiting deterioration is 40% RH and 0% oxygen (or 40-60% RH and 0% oxygen if specimens are pre-treated with ammonia vapour). XCT allowed production of unprecedented quantifiable data but there were, however, several limitations to the technique.



One of the trays constructed to hold the ammonite sample (in position at the top) with the environmental control chamber in the base, distanced from the X-beam



A colour contour map of one of the samples. This was created by overlying the original scan with a scan taken after 15 months. The dark purple areas signify no change and the red areas signify >200 microns alteration.

Advantages

- Quantifiable results
- Ability to map and compare surface change empirically
- Visual comparison of internal structures
- Identification of timing of deterioration, to help identify the cause
- Samples can be scanned without the need to compromise the microenvironment

Practical Notes

Parameters of scan: Nikon HMX ST 225 X-ray tube set at 190 kV and 180 µA; filtration with 0.25mm of copper to reduce the artefacts generated by the high iron content of the samples; 3142 projections of 500 ms with 2 frames per projection over a rotation of 360°, totalling 53 minutes for a complete XCT acquisition per ammonite.

Construction of enclosures: the samples were held upright and in the same position in card brackets with Plastazote® chocks. The acid-free card platform holding the ammonite formed the upper level of a deeper tray, housing the environmental control method; heat-sealed Escal™ Neo barrier film.

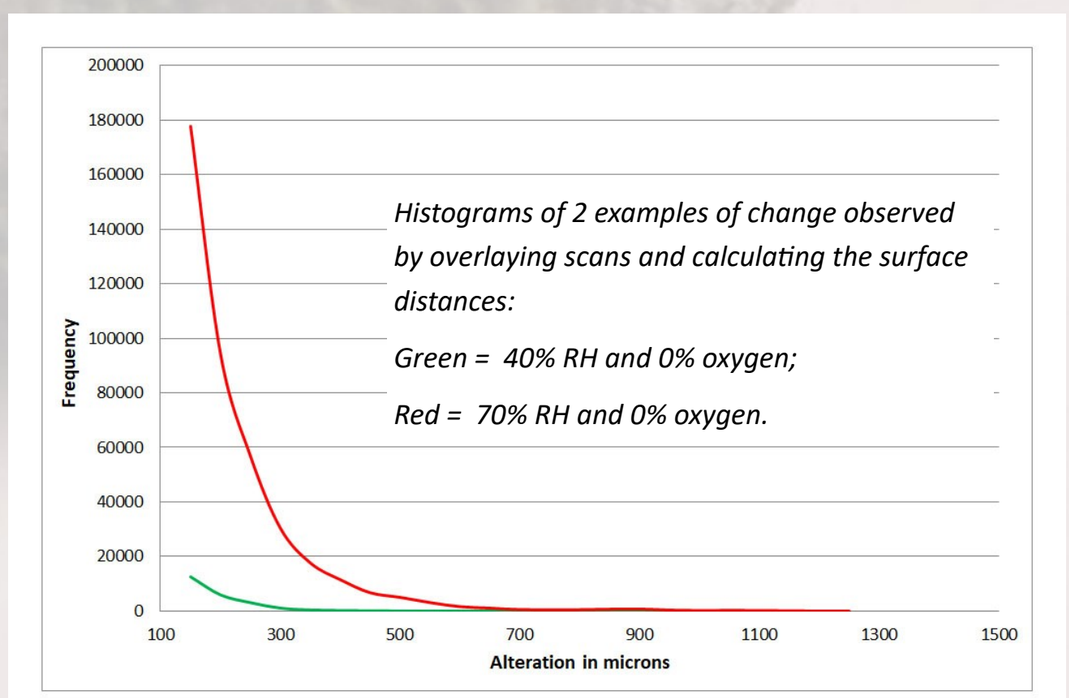
Environmental control: RP System® scavengers; conditioned silica gel sheets and beads

Environmental monitoring: cobalt chloride impregnated humidity indicator cards; Ageless Eye indicators.

Some of the enclosures showing environmental control with different methods

Limitations

- Long scanning (~I hour) and processing times (~12 hours)
- Unable to identify the deterioration products
- Unable to map and compare internal changes empirically
- Data sets so large that they had to be exported as histograms with automatically assigned bin ranges, requiring significant processing time to enable comparison
- Necessary to construct complex trays to ensure that the oxygen scavenger sachets did not interfere with the x-beam.



Conclusion

CT scanning is a very useful tool for studying deterioration over time and a valuable technique for quantifying the effectiveness of microenvironments.

Reference: Allington-Jones, L., Clark, B. and Fernandez, V. 2020. Fool's gold, fool's paradise? Utilising X-ray micro Computed Tomography to evaluate the effect of environmental conditions on the deterioration of pyritic fossils. *Journal of the Institute of Conservation* **43**

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