JOHN GILLIS

The Fadden More Psalter: De-Watering the Vellum Text

Fig. 1. The Faddan More Psalter after its retrieval from the bog.

INTRODUCTION

The Faddan More Psalter is a late 8th century codex discovered buried in a peat bog in North Co. Tipperary in the summer of 2006. It was reported as one of the most significant archeological discoveries in Ireland and among the "top ten" of the National Museum of Ireland's[1] treasures. Its unearthing was reported by the World's media and it is the first Insular[2] manuscript to be discovered in Ireland in over 200 years. Significantly in relation to this paper, it is also the first known early manuscript to be discovered in a wetland environment world wide as far as the author is aware. The following describes some of the more specific conservation aspects of this project, in particular the 'de-watering' techniques used to help facilitate access to its historical origins and provenance. The focus of this paper requires much to be omitted in the way of codicological information, and indeed many other aspects of the conservation and identification. The preservation of this unique 'bog book' has opened up many interesting areas of collaborative archaeological, historical and conservation research, and its world interest continues.

HISTORICAL DESCRIPTION

The Psalter is part of the Old Testament from Christianity. It contains Hebrew prayers and poems. Traditionally much of the content is attributed to King David. In Ireland the Psalter played an important role in monastic life as part of the divine office; a series of daily prayers and readings to be recited. The Psalter is also recorded as a teaching aide when instructing a young novice (often as young as seven) how to read and write before entering the monastery as a novice.

The explanation of how this particular copy found its way into a bog in Tipperary is un-clear. Archeologist Maeve Sikora from the National Museums staff carried out detailed excavation work at the find spot. The results of this work combined with fragments of associated material located in the same area give us some very interesting clues as to the last days above ground for the Psalter. We have the remains of a bag, manufactured from some form of collagen-based material. Also found were deposits of hair like material, which after analysis have been identified as an animal pelt, possibly calf and strongly suggests the manuscript was covered with this material during deposition. From the outset there was speculation that the Manuscript was concealed in this location. This in turn led to evocative stories of a fleeing monk burying his precious book while being pursued by marauding Vikings, such raids being recorded at the monastery in Birr, in neighbouring County Offaly. Fascinating speculation, and hopefully the continuing investigation may help us fill in some of the gaps, of which there are many.

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PHYSICAL DESCRIPTION

MANUSCRIPT

The manuscript is calfskin vellum, and allowing for trimming, it is likely that one skin would have provided two bifolia. Contemporary animal husbandry suggests that animals were smaller than they are today, so somewhere around fifteen calves would have been required to produce the Faddan More Psalter. There are approximately 31 to 32 lines to a page and the text block is approximately 305 X 226mm In its original form the text block contained 5 quires of varying folio counts and layout, with two quires containing 10 leaves and a twelve, a thirteen, and a fifteen for the remaining three quires, giving a total of 60 folios; no flyleaves although the last folio of the 5th quire is blank. The layout follows neither the Insular practice with hair side of one folio facing flesh side of another nor is it consistent in having the hair side on the outside of the quire as found in the Western tradition[3]. Likewise it ignores the continental or Gregory's rule of like facing like, it is more accurately described as ad-hoc, in the best Irish tradition!

THE COVER

The manuscript is contained in a semi-limp leather cover similar in execution to early Coptic structures[4] although in the case of Faddan More there is no clear evidence to suggest the gatherings were mechanically attached in any way. However we did find evidence of the use of quire tackets[5].

CONDITION ASSESSMENT, INCLUDING SCIENTIFIC ANALYSIS

Conservation measures were considered and evaluated as soon as the codex was excavated from its twelve hundred year archaeological environment and brought to the Conservation Department of the National Museum of Ireland. Much time was spent in assessing preservation needs with respected experts in the field[6].

To gain a better understanding of the components of the codex, specifically the vellum, and their condition, a selection of analytical procedures were embarked upon including the level of degradation and shrinkage the vellum had suffered over the years. In the first instance we employed non-destructive techniques such as MRI scanning and multi spectral imaging, which were for the most part unsuccessful, and High Definition filming including close ups[7]. CT scanning and X-ray were ruled out on the basis of reports of X-rays accelerating vellum degradation. Analysing how far the irreversible state of gelatinisation[8] had gone, as a second phase of analysis, we sent two small samples under licence to The Royal Danish Academy of Fine Arts School of Conservation. Here Rene Larsen, (Rector, Associate Professor, PhD) put the samples through the range of tests developed for the IDAP programme (Improved Damage Assessment of Parchment)[9] with an additional amino acid test to establish levels of oxidation of the vellum. The results of the Danish tests confirmed the much of the visual evidence in relation to gelatinization and severe damage to the collagen fibres. Levels of oxidation were quite low however, no doubt due in the most part to the generally anaerobic environment in the bog. Surprisingly, shrinkage temperatures remained very high and comparable to that of good quality new parchment, this possibly due to the partial tanning of the vellum from organic tannin in the bog material.

SEPARATION OF VELLUM LAYERS

The first major conservation challenge was that of separating the remaining vellum fragments from both each other and the mass of bog material surrounding the manuscript. Even a casual glance at the "as found" image of Faddan More will tell you that the typical approach to "pulling"[10] of the manuscript did not apply here. There was severe trauma and disturbance throughout the structure and indeed the find was said to resemble over-cooked lasagna more so than a medieval manuscript!

As we are aware, the nature of conservation can be said to be destructive in so much as disturbing material from its as found position results in the loss of information and this was particularly emphasized in the case of the Faddan More Psalter. With this in mind much time was given over to recording position and orientation of fragments before separating from the mass.

The use of backfolds is, as we know a basic aide to working out the collation of a bound volume, given that the survival of this feature equated to an average of 5mm, this combined with the complete book block being split across the book, spine to fore edge and the long period spent in this hostile and fluid environment, resulting in much movement between the leather covers. Again an emphasis on recording became central to the early stages of the hands on work. A Perspex® bridge was constructed, onto which a grid with x and y-axis was inscribed. Work would commence by sliding the entire manuscript, which sat on a Corex® base board under the bridge. After establishing which fragment was to be removed, the piece in question was mapped and recorded with a grid reference and also recorded photographically. During this stage, which continued for over 18 months, the manuscript was maintained in its saturated state and stored in a cold room at 4°C. The requirement to keep everything wet restricted the working time for any given session and while out of cold storage the moisture levels were maintained by spraying with an atomizer filled with de-ionized water. There was concern during this stage of the project that problems may arise with microbiological growth occurring once the organic material is removed from the protective and largely anaerobic environment of the

Fig. 2. A view of some surviving backfolds in-situ.

bog. Also, typically organic material survives better here than in soil, research suggesting that sphagnum moss, a component part of a peat bog plays a major role in this process. It has the ability to immobilise microorganisms and according to Terence Painter[11], produces an antibiotic substance called sphagnan that bind with proteins on the surface[12]. The concern was that by maintaining the saturated levels by spraying with de-ionized water the effectiveness of the bog water was diluted each time. Fortunately we saw no such growth during any stage of the work (fig. 2).

The first task prior to removal was to study the small area of extant backfolds. As these were in-situ they gave some clue to the original make-up of any given quire, also some codicological detail could be extracted such as the use of singletons or inserted folios. This proved to be a difficult and time consuming task but essential if we were to successfully establish a collation map of the manuscript. It should be remembered that even though we had a well-known and recorded text in the Psalms, we had several folio fragments where no writing had survived and only its position in the quire gave any clue to its identification. The physical position of the text block very much dictated the order of dismantling, and it was approached layer by layer, searching for natural divisions between the clumps of material, this usually occurring between quires. A thin slip of printers plate, cut to approximate the width of the piece in question was covered with a fold of silicone Mylar® and slowly eased between, the spraying with deionized water of the separation point assisted the transmission and reduced surface friction. This process continued until the delineation between the layers was no longer in evidence, and at this point the material, which was at a more advanced stage of deterioration, had become a single mass of gelatinised vellum, surviving letters and bog material, containing plant roots, seed pods and degraded plant material.

Fig. 3. Bifolia of quire two separated and ready for cleaning.

The intact folio fragments were lifted away and in a separate operation the associated mass material was removed. The task of separating out the intact fragments was achieved by facing with Bondina®, which adhered to the saturated vellum through surface tension. The individual fragment could then be lifted away and prepared for cleaning. (fig. 3).

CLEANING

The now separated and supported larger fragments were prepared for cleaning excessive dirt and debris that hindered the script, whilst it was saturated. The obvious advantage of the saturated state of the Psalter was the possibility of employing water as the main cleaning agent. The cleaning process proceeded more or less as follows:

1. The fragment on its Bondina® support was laid out on a sheet of glass, another sheet of Bondina® was laid on top and the fragment sprayed with deionized water. This allowed the piece to be manipulated to lie as flat as possible.
2. The top sheet of Bondina® was lifted away, and this in fact started the cleaning operation as it had the effect of lifting way some of the looser debris. A fine Japanese brush was dipped in deionized water and used to brush more material from the centre towards the edge of the fragment and from here onto the glass. This allowed examination of the material for matter other than bog and plant contamination.
3. For the next stage a piece of chemical sponge cut to a convenient size was first soaked in denatured alcohol and then in deionized water before being wrung out. It was rolled across the surface where it picked up smaller loose material missed by the brush. A second method of placing the sponge on the surface and allowing the water on the surface draw towards the sponge bringing with it even more debris. This proved a useful approach where the fabric of the vellum was very degraded and unable to withstand any

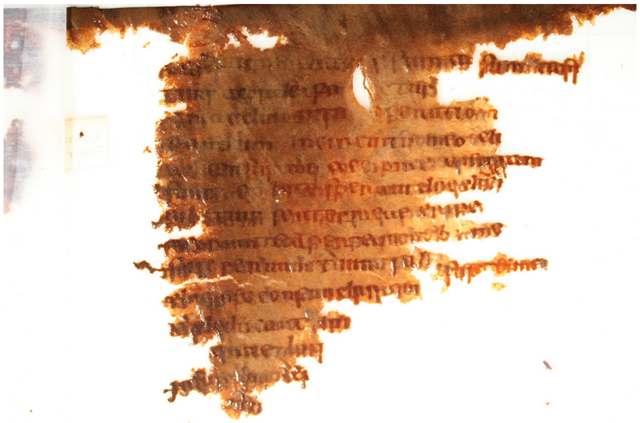

Fig. 4. Folio 13r after cleaning still saturated.

direct contact. When nearing the end of a wet stage cleaning, denatured alcohol would be introduced in solution in order to introduce the vellum to the solvent that would later be employed in the de-watering process

4. The final stage involved the use of a fine stainless steel tweezers and the picking off from the surface, what at this stage were mostly seedpods, of which there were thousands! They proved particularly difficult as when saturated they are quite transparent. All the above stages were carried out under a 3dioptre illuminated magnifier lamp.
5. In areas where the condition of the vellum was considered "robust" a further method that proved very successful was employed on occasion. Here a Dahlia® atomized sprayer was used to spray across the surface and by adjusting the angle, at which the unit was held, usually almost parallel to the fragment, much of the debris was pushed off, the intensity of the spray could be further modified by allowing the pressure in the sprayer to drop before use (fig. 4).

The clean fragment was faced with a new sheet of Bondina® and turned over to allow the operation to be repeated on the verso. It was imperative to maintain the saturated condition of the vellum throughout due to the further risk of instability if the drying process was not controlled effectively. After cleaning, a sheet of Mylar was placed over the fragment and the piece mapped using a permanent pen. Some datum points were measured and marked as was the centre fold line given that this feature was not always easy to locate once the bifolium fragment was dry. At this stage surviving edges consisting of narrow strips of vellum no more than a few millimeters in width were aligned to their correct position.

The quantity and variety of information produced, as each fragment was processed required particular attention. To this end a database was devised using File Maker Pro® as a platform. This proved an essential tool allowing as it does additional information to be inserted as it comes to light. Each record contains information such as the grid reference for location as mentioned above, folio number, psalm number (where applicable), general observations and the removal or addition of any newly discovered related fragments. A tag number was designated to each fragment as the folio number often changed as new evidence came to light effecting collation. This method allows any given piece to be tracked through the aforementioned changes.

DEWATERING TRIALS

Having established the condition of the Psalter vellum at a microscopic/cellular level it was decided that there was a need to understand the reactive condition of the material in comparison to the expected behavior of vellum that has not been subject to the long-term exposure of the extreme environment of Faddan More. It is commonly understood that the fibre structure of vellum retains much tension through its manufacture, which makes it sensitive to adjustments in relative humidity and temperature due to a low hydrothermal stability[13].

A small un-locatable fragment with no marking on the surface was selected for testing. This was flattened out and traced, then allowed to air-dry at normal room conditions. The result was difficult to access such was the change in physical condition. The fragment was very brittle and had shrunk to less than half its original dimensions, it was also very dark and almost unrecognizable as vellum. Although this is the same reaction we would expect from modern vellum in the case of the Faddan More each feature appeared exaggerated (fig. 5).

One of the difficulties of trying to discover how best to dry out the vellum was the lack of material on which to test any possible solutions. The unique nature of the problem also meant there was little to nothing in the way of previous published material on the subject. In order to address the first issue some discarded vellum flyleaves from a late 18th century binding were prepared by hydrating between saturated

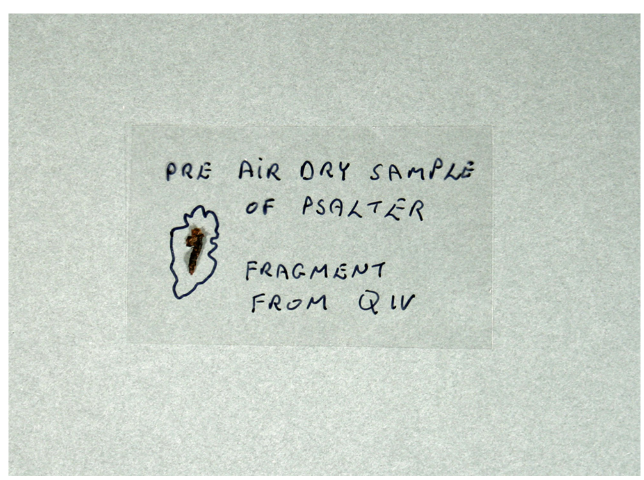

Fig. 5. Air dried fragment showing level of shrinkage.

blottings. The vellum sandwich was then placed into a large ziplock® bag under glass weights and left for a month at ambient temperatures. The end result was thoroughly saturated vellum with evidence of microbiological growth and dramatic change in appearance and handling characteristics. This did replicate some of the physical properties of the Faddan More vellum, and likely some of the conditions at an individual fibre level, but in most respects was still quite a different material. Nonetheless given the unique nature of Faddan More combined with the variation in manufacture methods between early Medieval vellum and that of the later centuries, we were always expecting a high degree of compromise. During trials the test vellum was maintained at the same conditions as Faddan More, 4°C and saturated.

As a basic principal, it was agreed that no chemical be added to the vellum that would remain after the completion of the drying process. This principal was established primarily because of concern over the possible long-term effects of chemicals such as polyethylene glycol and glycerol on the inks and pigments present in the manuscript, and as such ruled out some possible archaeological conservation techniques[14]. Central to these concerns was how these chemicals may obstruct future non distructive pigment analysis.

It was clear from the outset that one of the major issues was the physical restraining of the vellum as it moved from its saturated state to a dry one as the un-bound water was removed, regardless of the method chosen to achieve this. We know as a result of the manufacturing process of vellum that the cell structure is drawn into a low angle of weave and any uncontrolled removal of the un-bound water would result in a loss of this tension and unacceptable levels of shrinkage and irreversible gelatinisation of the vellum as the fibres stuck to each other. Normally this is avoided by physically restraining the vellum around its circumference as the drying process proceeds. This was not an option for Faddan More due to the degraded nature of the material. As an alternative, the methods listed below were chosen for trial in this aspect of the operation:

- The use of a suction table.
  - Sample places on double layer of Bondina® and surface of table masked off as required. Table set at 28" H_2O with ambient values of 20°C and 57% R.H. In order to reduce cupping as the sample dried layers of Bondina® masking were placed around the circumference of the sample. As drying of the samples neared completion the table setting was reduced to 13" H_2O
- The use of a vacuum machine.
  - Vellum samples placed between 100% cotton blotting papers and into an Archipress vacuum bag®. Vacuum pulled for 35 seconds and bag heat sealed for 5 seconds. The bag remained sealed for 24hours before opening to observe results.
- Vacuum freeze-drying.
  - Sample placed in unit for three days.
- Under glass weights at ambient values.
  - Vellum samples placed between 100% cotton blotting papers, under weight. After two to three hours the blotting was replaced with dry pieces. This process continued until the vellum reached ambient values.

The principle was to establish which of the four methods would best serve our needs in relation to controlling shrinkage, after which we would trial how best to remove the excess water from the saturated vellum. The best in each category would then be combined to deliver a working drying process. This somewhat simplifies what actually took place but in principle it was a successful approach. In deciding on how to proceed with the second phase of water removal, it quickly became apparent that some form of solvent exchange system, as practised in archaeological conservation, particularly in relation to saturated timbers might prove useful. This is based around the different surface tension properties of solvents including water, which has a high value. The higher the value the more likely it is to collapse cell walls as it is evacuated resulting in shrinkage of the velum. The selection of solvents was short listed for trialing based on properties such as their working characteristics, polarity, and health and safety issues, assuming that the conservator would be working in close proximity with quite high volumes of the chosen solvent over a lengthy period of time. An example of a rejected solvent was petroleum ether (H_3C O CH_3), because of its very fast evaporation rate, which allowed no working time with the solvent saturated fragment. The short list was as follows:

1. De-ionized Water (of course the vellum was already saturated with water, but trials drying straight from water were included)
2. I.M.S Industrial Methylated Spirit 95% (denatured ethanol)
3. Acetone (propan-2-one)
4. Acetone/H_2O 80:20

The criteria for comparison were partly associated with the IDAP results and its methodology of collection condition assessment, the following is the complete list of comparisons made:

1. Dimensional change: judged by measuring around the circumference of the sample.
2. Thickness: three measurements were taken at different points on the sample using a dial micrometer
3. Flexibility test: Using the four I.D.A.P discs of varying thickness to allocate a flexibility value to the test sample

4. Colour Value: A value was allocated to each test sample based on the Colour Atlas 96, Natural Colour System. A value was recorded for both hair and flesh side. A viewing box was constructed @1000lux to maintain consistency in recording before and after values.

The samples were prepared by cutting the vellum into triangular pieces that enabled, a high number of trial pieces out of a limited supply of material. It was also considered that this shape would represent the different tensions asserted by the different areas and direction of a skin (figs. 6–7).

Once the trials commenced we were quickly able to eliminate the suction table because of the difficulty it had in holding the sample in place once evaporation had begun, regardless of the solvent in use. We tried various settings and masking of the base, all proved unsatisfactory. Freeze-drying through water was also eliminated at an early stage due to the following observations: No distortion, an average of 3.5% shrinkage, opacity maintained, but critically the sample has "pulped up" with a spongy feel and noticeable increase in thickness and loss of natural pigmentation on the hair side, becoming almost white.

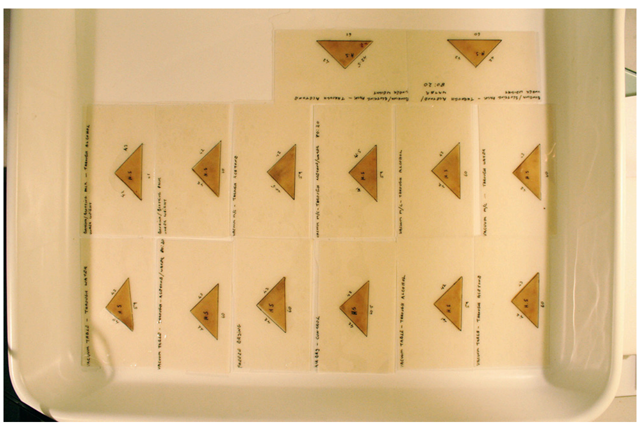

Fig. 6. Trial vellum pieces.

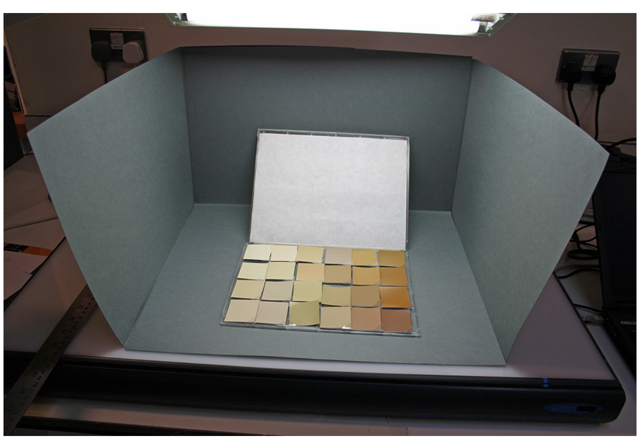

Fig. 7. Colour value station.

Due to the fast evaporation rates of all the other solvents it was not deemed worthwhile to test these through vacuum freeze-drying.

The basic format resulted in four trial pieces, each with a different solvent, tested through the three systems. By way of a control an additional four trial pieces with the four solvents were also allowed air dry. The results of the criteria listed above were then compared to the before and after values. Obviously the goal was to try move from the wet to the dry state with the minimum change in values, particularly in relation to the dimensions.

When we had promising results from different combinations, then we would compare the two against each other and repeat the test with new trial samples. An example of this was: solvent- H2O, mechanism- vacuum M/C, compared with solvent- H2O, mechanism- glass weights. Other results sometimes encouraged us to try a variation on our standard criteria. We had for example achieved good results through the Acetone/H2O method, however during the solvent exchange process a level of "activity" was noted in the solution in the form of bubbles in the solution and eventually a fine film forming on the surface. As an alternative we then tested denatured ethanol/H2O at a lower 98:2, given that denatured ethanol already contains a fractional percentage of water. Keeping in mind the limited supply of trial material we focused on only the most promising results.

SOLVENT EXCHANGE PROCESS

The trial vellum was placed in a bath of the solvent in question and covered. It remained here for an average of 12 hours after which it was changed for a fresh bath. The specific gravity of the solution was recorded before and after in an attempt to gauge any water content in the solution. Given the small size of the trial fragment and quantity of solution this did not prove to be a definitive method for the trials, but was useable when it came to the larger fragments of the Psalter vellum itself.

FINAL TEST RESULTS

The *vacuum machine* showed great promise from early on as it delivered the required criteria in a controllable fashion. The main advantage proved to be the ability of the blotting sandwich inside the vacuum bag to begin the drying process by the transfer of solvent from vellum to blotting while maintaining the integrity of the vellum[15].

For dewatering we settled on drying through *denatured ethanol* although the denatured ethanol /H2O 98:2 ran a very close second place and may even be preferable where the saturated vellum is less degraded.

From here a small piece of the Psalter vellum was chosen, with no writing and no clear evidence of its correct location. It was processed through denatured ethanol and vacuum machine after first recording the same information as for the trial pieces. On successful completion of this fragment, we repeated the process, this time with a larger fragment of Faddan More that also displayed some writing. Again this satisfied the criteria laid down. The procedure was put before the Faddan More Steering Committee and approval was given to proceed with the complete remains of the vellum text block (fig. 8).

DEWATERING PROCEDURE

Remembering that processing began with the removal and cleaning stages already documented, from here the dewatering procedure was as follows:

1. The cleaned and saturated fragment was transferred into a bath of denatured ethanol while still supported between Bondina® sheets. The top of the bath was then covered. After 12 hours the solution was changed for a fresh bath. A graduated cylinder filled with denatured ethanol from each bath was taken and the specific gravity measured. The process was repeated after the time period had elapsed. The change in value indicated the take up of water (fig. 9).
2. The bath was drained and the Bondina® interleaved fragment laid out on a sheet of glass. The top sheet was removed and the any distortion of the vellum, particularly the long ribbon like edges were manipulated into position.
3. The top sheet of Bondina was replaced and the fragment placed between four sheets of 100% cotton blotting. This sandwich was then placed into an Archipress® vacuum bag and from here in the vacuum machine[16].
4. The bag and contents was placed parallel to the sealing bar with the open end of the bag resting on the bar. A large pressing board was placed on top with some additional loose weights. This prevents the fragments shifting before the expulsion of gas from the chamber. The weight does not affect that expulsion. A vacuum was pulled over a 40 second period and the sealing bar for 5 seconds. It was essential there was no delay between step 3 and 4 as the solvent began to evaporate (fig. 10).
5. After three to four hours, depending on the size of the fragment, the sealed bag was opened and the blottings changed. The pack was put back into the bag and the procedure repeated, this time for a 20 second vacuum. This stage only proved necessary for the larger fragments, due to the higher volume of denatured alcohol required to be displaced.
6. The vacuum bag was opened and the fragment removed. The Bondina was replaced for fresh sheets and everything placed between new dry cotton blottings, under a pressing board and lightweight. After three to four hours the blottings were replaced and weight reduced. The concept here was to acclimatise the vellum to ambient conditions[17].

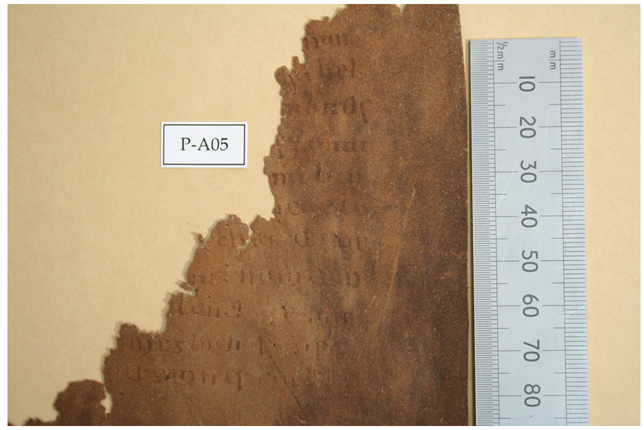

Fig. 8. First successfully de-watered fragment of the Psalter vellum.


Fig. 9. Solvent exchange bath containing with f47v-56r to view.


Fig. 10. Audionvac 401H vacuum m/c.

Fig. 11. Smaller fragments of vellum under conservation treatment.

The end product is stable and reasonably robust but with no fold endurance. Although in appearance the stabilised fragments with their muddy brown colour and ragged edges might tempt you to believe that it is no longer vellum. I was reminded on one occasion that this is not the case[18].

At this point a mention should be made in relation to the areas of the vellum where the integrity of the skin did not survive apart from the surface onto which the iron gall ink was applied. This resulted in a very different and unique level of survival and required a different approach in how to stabilise the matrix of words and letters. There is no space in this paper to examine our approach but it became even more time consuming than dealing with the major surviving fragments and as such needed to be noted here (fig. 11).

CONCLUSION

The end result of the drying process has allowed us for the first time in over a millennium to examine the content of the remaining Psalter fragments. This achievement should not be underestimated given the dearth of manuscript material from this period in early Medieval Ireland. The Faddan More Psalter, as an early Irish manuscript retaining most of its original features, is beginning to play an important role in improving our knowledge in areas such as Palaeography and Insular Psalters. This paper documents just one aspect of an engaging project, which also included challenges in relation to display and housing, identifying and relocating dislocated text fragments and extensive recording throughout the project.

The Faddan More Psalter is now stable and on display but it is far from finished, with both actual conservation and follow-up research outstanding. I continue the latter as part of my PhD in tandem with delivering lectures on all aspects of this extraordinary book to anyone interested in hearing about it. Financial restrictions due to a severe economic downturn in Ireland's economy have slowed me down somewhat due to lack of available funding but my commitment to the Faddan More Psalter remain

Although I was the "bench conservator" for Faddan More, the only reason I was able to bring the project to its current level of completion was the support and advice that was available to me at a moments notice. The generosity of my fellow conservators in the National Museum was a resource I accessed often over the four years and there is little doubt both the Faddan More Psalter and I are the better for it.

NOTES

1. www.museum.ie/
2. "of or pertaining to an island or islands" Diringer, D. *The Book Before Printing* (New York 1982), 215.
3. Bischoff, B. *Latin Palaeography* (Cambridge 2008), 20–23.
4. The principle of a limp single piece of leather with internal linings with a flap on one fore edge extending onto the front of the cover. The majority contain single quire codices attached directly to the cover through the spine.
5. Used as a temporary method of keeping the bifolia of a quire together prior to binding. They often take the form of vegetable fibre or twist of vellum inserted through the backfold. These sometimes remain even after binding has taken place.
6. I engaged with many lengthy conversations at the early stages of the project with, Chris Clarkson, Tony Cains, Michael Gullick (Paleaography) and others, all who offered their valued observations and suggestions.
7. Filming involved the use of an articulated stage and a high-resolution camera on a track positioned over the subject.
8. Hansen, E. F., Lee, S. N. and Sobel, H. 1991. The Effects of Relative Humidity on Some Physical Properties of Modern Vellum: Implications for the Optimum Relative Humidity for the Display and Storage of Parchment. *The Book and Paper Group Annual* 10, http://cool.conservation-us.org/coolaic/sg/bpg/annual/v10/bp10-09.html
9. The aim of this project is to assess damage in historical parchments at the macro, micro and molecular levels
10. A book conservation term relating to the dis-binding of a book.
11. The late professor Terence J. Painter (Department of Biotechnology, NTNU, Trondheim, Norway)
12. Lindow man, tollund man and other peat-bog bodies: The preservative and antimicrobial action of Sphagnan, a reactive glycuronoglycan with tanning and sequestering properties. *Carbohydrate Polymers Vol.15 issue2 1991* (Journal) P. 123–142
13. The Hydrothermal Stability of Parchment Measured by the Micro Hot table Method Rene Larsen, Dore V Poulsen and Marie Vest *Microanalysis of Parchment*, 2002, Book. P. 55–58
14. Gillis, J. and Read, A. The Faddan More Psalter, A Progress Update, *ICON News issue 11 2010*, p.25–28
15. Chris Clarkson prompted the concept of using a vacuum machine during a visit to the Museum; he mentioned that he had been discussing the possibilities of drying parchment with Stuart Welch, formally of Conservation by Design, who had established the vacuum machine

as a conservation tool, particularly in the area of disaster recovery. It was Stuart in fact who organised the loan of a vacuum machine for our trials.

16. Audionvac 401H

17. Climatic conditions where the dry vellum fragments could be examined in a conditioned area where values are maintained to recommended levels e.g. 55% R.H and 20°C

18. Whilst documenting a fragment of processed vellum one cold December morning, a phone call had distracted my attention briefly. Upon my return I witnessed it curl up towards the hair side in reaction to the dry air, in exactly the way a new piece of vellum might, proof positive!

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