

# LYOPHILIZATION IN MICRO-GRAVITY

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Abstract - Freeze-drying of waterlogged wood in a pre-lyophilized state is discussed, with emphasis upon the problems of scale. The possibility of miniaturizing artifacts to expedite treatment is introduced. The potential of space as an infinitely large chamber for freeze-drying is explored and a shipwreck delivery system detailed.

## 1 Introduction

The freeze-drying of waterlogged wood has been shown to be the most useful technique of lyophilization of waterlogged wood so far devised (1). With this in mind, or even without it, the construction of chambers or other environments in which to perform the technique has been the major challenge in the treatment of larger objects. Early results with small, laboratory-sized chambers have produced many encouraging early results. The questions remaining, therefore, are: how may a whole ship be treated; how can we progress from a barrel stave to a dugout; to a *Wasa* or a vaster *Wasa*, or vice versa? Is the chamber yet devised in which to treat the *Mary Rose*? No.

These challenging ideas have been very challenging to the conservation community at large and many ingenious ideas have been put forward for study, as shown in Fig. 1:

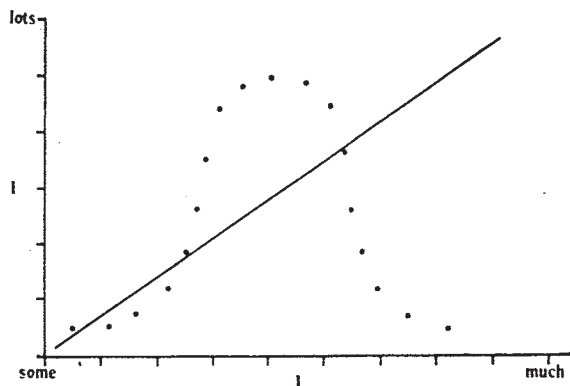


Figure 1 Ingenuousness (I) plotted against Ideas (I) shows a basic straight line relationship as shown in Figure 1.

Early experiments with models have shown that small model ships may be placed in small freeze-drying chambers (or lyophilizers). This suggests that larger models may be inserted into larger chambers, and leads to the supposition that full-sized or over-sized, or large, vessels may be placed in larger chambers, as shown in Fig. 2:

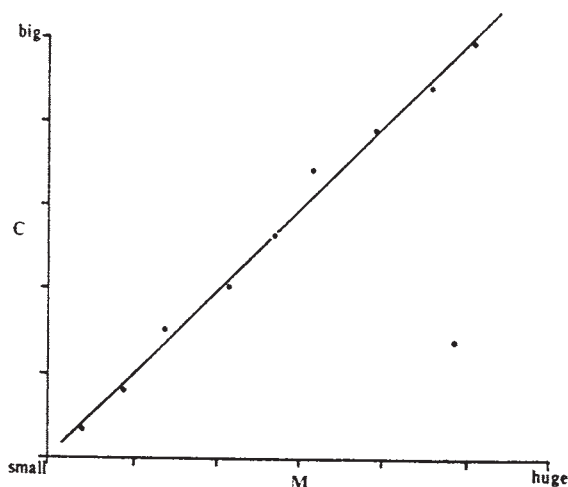


Figure 2 Chamber Size (C) plotted against Model Scale (M).

## 2 Larger Chambers or Smaller Artifacts?

A cheaper alternative to the construction of very large chambers is the use of smaller artifacts. Since all waterlogged wood objects shrink on drying, one way in which they can be reduced in size before freeze-drying (lyophilization, or just plain lying) is to allow drying to take place. Unfortunately this shrinkage is not normally more than 50% tangentially, 40% radially and 2% longitudinally and is, of course, non-linear. This makes for awkward shaped tanks for those used to working in feet and inches. Experiments in increasing shrinkage - or, as we now refer to it, miniaturization - by soaking for long periods in a solution of chloro alkyl ortho silicate (CHAOS) in weak tea have not been able to increase shrinkage very greatly or uniformly (Fig 3.).

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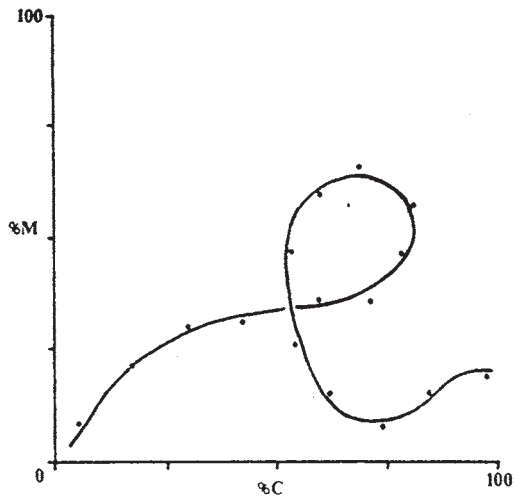


Figure 3 % Miniaturization (M) against % CHAOS (C).

### 3 Possible Large Chambers

Rather than encompassing the expense of building vast chambers specifically for the purpose of freeze-drying, we looked into the possibility of utilizing existing facilities for this purpose. With the unfortunate delay in the completion of the domed stadium in Montreal, we have been unable to carry out one significant test, namely - could the Stadium hold vacuum? Calculations showed that approximately 121.7 km of Home Hardware's *Blo Eez* weather stripping would be required to caulk the major sites of ingress. This might have proved an expensive solution anyway. As an alternative, *Maple Leaf Gardens* in Toronto was considered a more likely venue since the arena has fallen out of use and has freezing equipment already installed. However, the roof structure was found to be unsuitable and would likely implode on evacuation.

With this in mind, or even without it, the obvious venue for carrying out vacuum freeze-drying of whole shipwrecks is outside the earth's atmosphere. All that is necessary is to pre-treat the waterlogged ship, boost it into orbit, and recover it on completion of the treatment. There are several advantages:

- Suited-up conservators would be able to "space walk" around the ship, rendering gloves-on attention - a facility at present denied.
- The object could be placed in a geo-synchronous orbit such that it is always exposed to solar radiation, rotating slowly

- every 24 hours to give an even exposure.
- Weighing would be easily carried out by attaching small vernier jets to each end of the object and measuring the time taken to accelerate it with one jet to a certain velocity with a given force. Once the measurement was made the jet at the opposite end would return the object to its correct orbit and also provide a calibration check of the equipment.
- Cheapness - no costly tanks.

The obvious vehicle in which to transport shipwrecks into orbit would be the NASA Space Transportation System, or Space Shuttle. For larger wrecks the Shuttle would have to be scaled up in size, but no great problems are envisioned since the technique is well established.

## 4 Practical Considerations

### 4.1 Pre-Treatment

In recent studies PEG 400 has been shown to be a perfect chiroprotector for wood (2). Thus normal pre-treatment in a 15% solution of PEG 400 would be satisfactory, but since weight is an economic consideration this can be reduced to a 10% solution of PEG 300. To further reduce weight, phenolic micro-balloons could be introduced into the solution. It is normal procedure to perform this pre-treatment in a tank but this is what this author wishes to avoid. However, studies have shown that if PEG had been poured into the water over the resting place of the *Wasa* in Stockholm Harbour, rather than raising the wreck and treating it at its present site, impregnation would have been just as effective. In this light *in situ* pre-treatment is a possibility. (It is also just possible that arrangements could be made with the Swedish government to dunk wrecks into Stockholm Harbour which must be about 50% PEG by now.)

### 4.2 Packing and Pre-Freezing

On completion of the pre-treatment phase the wreck should be wrapped in bubble pack. (Each bubble should be provided with an air-escape mechanism to allow slow adjustment to vacuum conditions.) The wreck should then be frozen for a month in the Canadian North and carefully packed in the bay of the Shuttle. Further packing with polystyrene granules might be worth while since these would be easily removable once the doors of the Space Shuttle were opened.

### 4.3 Placing in Orbit

Once in orbit the Canadarm could move the wreck from the bay and space-walking conserv-

ators could remove the bubble pack (Fig.4). Booster rockets would be required to place the wreck into its higher, geo-synchronous orbit. These and the wreck itself should be insured through Lloyd's of London.

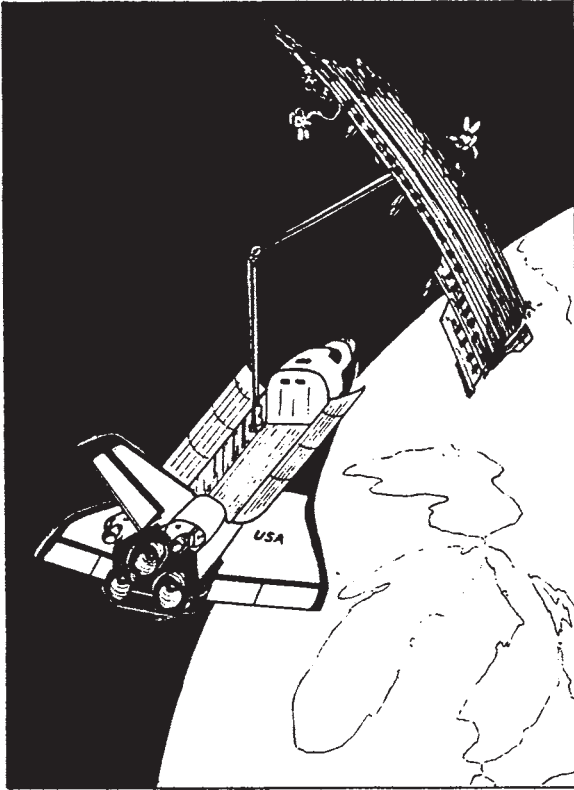


Figure 4 Artist's depression of the Space Shuttle delivering a wreck to the micro-gravity environment.

#### 4.4 Monitoring

Regular Shuttle missions should be maintained during treatment for examination, monitoring, brushing PEG onto the surface, joy riding, etc. Canadian astronauts should be given preference for these missions cos it's our idea in the first place.\*

#### 4.5 Return to Display Environment

Splash down is a definite no-no since this might cause some loss of PEG and the possibility of the wreck being sunk again in a historically inappropriate location. Also

\* Problems may be encountered with scheduling of such a space voyage. It is conceivable that somebody in the U.S. Congress might consider other missions of more importance. Obviously, intense lobbying would be a necessary first step. It goes without saying that only ships from American waters would receive this treatment, although other countries may be able to make deals by offering to trade the bodies of drowned U.S. mariners for cargo commitments.

re-waterlogging might occur which would be a shame. It would be important to return the wreck to the Earth in the bay of the Shuttle packed as for ascent. Retrieving the polystyrene granules might be tedious. Once the wreck had been returned it could be maintained in the Shuttle, loaded on top of the Boeing 747 transporter using the mate-demate device, and flown to any museum in the world. This would be the ultimate expression of a de-centralization policy.

#### 4.6 RH Control

It would be important to maintain RH within the Space Shuttle Bay to within 50%. The Shuttle, since it is an air-tight environment and covered with insulting tiles, would be, with the introduction of environmental controls, an ideal environment for the creation of an ideal environment. Thus the Shuttle could be used as a treatment vehicle, a display vehicle and, by the same reasoning, as a pre-treatment tank for the introduction of a cryopractor such as PEG 200 or less.

#### 5 Conclusion

To sum up, one can conclusively say in conclusion that there exist possibilities for a quantum leap that will make thermoluminescence look like washing potsherds in a refrigerator. There is undoubtedly no doubt that that the frontier of space can be used to expedite doubtful existing techniques. Go for it, space fans.

#### 6 References

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JEAN BAS-CULOTTE Refuses to provide any biographical information despite repeated attempts to contact him through his drop box in a hollow tree. Listen, Bas-Culotte, we know you're out there reading this, you fairy! This is just to let you know we don't give a hoot about your mean, sordid little existence and if you send any more papers we'll treat them with the contempt they deserve - we'll publish them! Author's address: we don't know....

*Lyophilisation in microgravity*

Résumé - On décrit la lyophilisation du bois imbibé d'eau qui est dans un état pré-"freeze-dried", en soulignant tout particulièrement le problème d'échelle. La possibilité de rétrécir les objets afin d'accélérer le procédé est introduite. On explore aussi le potentiel de l'espace comme une chambre de lyophilisation infiniment grande. Les détails d'un système de livraison pour les navires submergés sont présentés.

Auszug - Das Gefriertrocknen von wassereingeschlossenen Holz in "prelyophilisiertem" Zustand wird besprochen, wobei Probleme der Grossen verhältnisse besonders hervorgehoben werden. Möglichkeiten der Ausnutzung von Raum als eine unendliche Kammer für den Gefrierprozess werden erforscht, und ein Bergungssystem für Schiffwrecks wird eingehend behandelt.