THE CLIMATE BEHIND PICTURES MOUNTED AGAINST THE OUTER WALLS OF THE CHAPEL OF LEDREBORG, DENMARK

Tim Padfield and Annabel Robinson

Abstract

The climate behind oil paintings on canvas, mounted in shallow recesses in the outer walls of the Baroque chapel of a country house, Ledreborg, near Roskilde in Denmark, is rather more stable and scarcely more humid than the climate in the room. The climate in the chapel is typical of a building which is seldom heated. The average relative humidity, about 70%, is higher than would be considered acceptable in a museum but is similar to the climate in many churches and historic houses in which paintings and woodwork survive in reasonable condition.

An experimental painting was protected with polyester foil stretched over the back of the stretcher. This provided an even more stable microclimate with a hygrometric half life of about a month. There is no real need for special protection of the paintings against damp but the screening is effective against large insects and nesting bats. If permanent heating were installed, the climate behind the pictures would be quite different, because of the permanent temperature difference that would be established between the painting and the wall surface behind it.

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The climate behind pictures mounted against the outer walls of the Chapel of Ledreborg, Denmark

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Abstract
The climate behind oil paintings on canvas, mounted in shallow recesses in the outer walls of the baroque chapel of a country house, Ledreborg, near Roskilde in Denmark is rather more stable, and scarcely more humid than the climate in the room. The climate in the chapel is typical of a building which is seldom heated. The average relative humidity, about 70%, is higher than would be considered acceptable in a museum but is similar to the climate in many churches and historic houses in which paintings and woodwork survive in reasonable condition. An experimental painting was protected with polyester foil stretched over the back of the stretcher. This provided an even more stable microclimate with a hygrometric half life of about a month. There is no real need for special protection of the paintings against damp but the screening is effective against large insects and nesting bats. If permanent heating were installed, the climate behind the pictures would be quite different, because of the permanent temperature difference that would be established between the painting and the wall surface behind it.

Keywords
Microclimate, relative humidity buffering

Introduction
Conservators are generally rather anxious about the welfare of pictures that hang on the outer walls of houses. Various strategies have been proposed, and used, for securing a gentle climate at the back of the picture: boards mounted across the back of the frame made of some material that buffers RH, or that is inert to moisture, air gaps, thermal insulation. This article is a quantitative contribution to the debate. We present no general solution: just an analysis of the microclimate in a particular place, which suggests that an analysis of the microclimate in each particular place is a reasonable, though time consuming, route to choosing a rational action, or inaction.

The climate measurements
Ledreborg house has hardly altered since the eighteenth century. The chapel (fig.1) is a baroque room with stone floor and painted wooden panelling covering the walls. The room occupies the full width and height of the west end of the main house. The construction is massive brick, cement rendered on the outside and lime plastered on the inside. The main rooms are wood-panelled.

The chapel has oil paintings set in shallow recesses in the outer walls (fig.2). The conservators who have responsibility for the paintings were worried about the development of a damaging microclimate behind the pictures. The urgency of a climate study was reinforced when a large fruiting body of the dry rot fungus, *Serpula lacrymans*, was found clinging to the back of a canvas that was removed for conservation. We used this stimulus, and the availability of the wall niche, to measure the climate in the room and behind two paintings which were made to replace the original while it was under restoration.

The two pictures were set side by side in the recess, as shown in Fig.2. One of the paintings had polyester foil stretched across the back of the stretcher to prevent water vapour transfer (but not heat transfer) from the wall. Temperature and humidity sensors were placed in front of these pictures and in the air space between the canvas and the wall. The outside climate was measured in a shaded spot on the flat roof of the west wing, just outside the chapel.

The microclimate around the pictures

The climate measurements are summarised in three graphs. Figure 3 shows the outside (dotted) and inside temperature and relative humidity (RH) for a 15 week period starting on the 14th. March 1994. The inside relative humidity is generally a moderated version of the outside RH. The daily cycles of RH are caused mainly by the daily temperature cycle acting upon room air that is rapidly exchanging with outside air. The outer door has no lobby, the door at the balcony level is poorly fitting and the windows are not particularly airtight. The room is high and open, encouraging convective air exchange (the "stack effect").

The temperature and humidity cycling is not effectively damped out by the room. The abundant wood panelling is a fairly good thermal insulator, reducing the stabilising influence of the thermal inertia of the wall. The paint on the wood prevents moisture movement which would stabilise the relative humidity.

Figure 4 shows the microclimate around the paintings. The upper curves show the RH in the room (dotted) and at the back of each of the two experimental paintings. Both the polyester-protected canvas (bold line) and the unprotected canvas (thin line) had been stored for several weeks in a room at about 40%RH. The unprotected canvas came rapidly to equilibrium close to the running average of the RH in the chapel, while the protected canvas came slowly to equilibrium with its new surroundings over a period of about two months. At the end of the measuring period the two RH traces have converged. The RH behind both canvases is more stable than that in the room.

A detailed study of figures 3 and 4, with a close up of a shorter period, shown in fig.5, suggests that the canvas of the screened picture is stabilising the RH of the air trapped behind it but that the wall is actively stabilising the RH behind the unprotected picture, and therefore behind all the other pictures in the room.

The lowest line in fig.5 is the temperature difference between the pictures and the wall surface (the two pictures have identical thermal environments). Notice that the RH behind the unprotected canvas (thin line) is cycling up and down with minimum values that coincide with maximum values of the temperature difference between the picture and the wall (the picture surface is warmer than the wall surface). At first glance this could be attributed to air exchange with the room, because the RH in the room goes up and down in the same pattern. However, a closer look at fig.3 shows that the relationship between RH in the room and behind the painting is not easily explained by this theory. Around day 130 the RH behind the picture is varying more than that in the room but the peaks in room RH on days 105, 137 and 145, when the temperature was rather stable, do not penetrate behind the canvas.

These observations can be explained by assuming that the wall is controlling the RH to a constant value *at the wall surface*. This air then convects away from the wall to the back surface of the painting, keeping the exact water content it acquired when it came to equilibrium with the wall surface. Because the picture canvas is at a higher temperature than the wall, the air warms up and therefore drops in relative humidity.

This explanation may seem very indirect and speculative but it is supported by a consideration of what happens at the back of the protected painting (thick line in fig.5). Here the wall plays no part in the moisture transfer, because of the impermeable polyester sheet which separates the wall from the air space behind the picture. The air trapped behind this picture exchanges water vapour only with the canvas of the picture itself, so the RH at the back of the screened picture is much more constant. There is just a slight increase of RH as the temperature rises, which is a known property of cellulosic fibres in a confined, nearly airtight space.

The opposite pattern of the RH cycle behind the unscreened painting confirms that the reasonable RH stability cannot be due to poor air circulation, because this would allow the canvas to buffer the RH just as it does for the screened picture. The wall is actually such a powerful stabiliser of RH that it overrides the influence of the canvas.

We have used many words to describe this apparently minor phenomenon because it is not generally appreciated by architects and building engineers (maybe not even by conservators) that porous walls confer considerable climatic stability on the rooms which they enclose (1). The modern practice of sealing porous walls with plastic paint prevents them from exerting this beneficial influence on house interiors. The painted and varnished baroque panelling of Ledreborg unfortunately has the same effect of screening the wall from the air in the room. The wall can therefore only influence the climate behind the panels and the paintings.

Conclusions

The climate measurements are unexpectedly reassuring: the climate behind the pictures is actually more stable than the climate in the room and is not significantly moister. The fungus which formed such a dramatic, baroque embellishment to the back of the original painting had not significantly attacked the painting or its frame: the observed damage can be attributed to the moisture oozing from the fruiting body. The dried residue on the back of the picture was the fruiting body of mycelium that was probably digesting the lower part of the roof construction, which is not far above the level of the top of the picture. There is no evidence that the wall is unusually damp at the level of the paintings and panelling in the chapel but there are constructional details at the edge of the roof which have caused dry rot within the roof timbers.

The climate in the chapel can be described as far from ideal for preservation of the splendid interior but not acutely dangerous. In particular there is no ground for special anxiety over the microclimate around the pictures mounted on the outside walls. They have the best climate in the room!

The best way to secure the stability of the paintings is to improve the climate in the chapel by reducing air leakage and heat flow. The sealing around doors and windows can be improved. The daily temperature cycle can be reduced by minimising heat flow through the windows, by the use of heat reflecting curtains or, more controversially and expensively, by adding a layer of coated, though colourless, glass to reflect radiant energy.

Biological deterioration is a more urgent problem. The danger from dry rot in the roof timbers migrating to the back of the picture while trying to disperse its spores in free air will continue as long as damp conditions prevail where the roof springs from the walls. This matter is at present being attended to. There remains one other biological threat: The protected bats of Ledreborg should be dissuaded from setting up home behind the pictures. A permeable but tightly woven polyester cloth stretched over the back of the paintings' frames should serve this purpose without causing unexpected side effects.

Technical details

The temperatures were measured with type K thermocouples. These are better than the more usual type T, recommended for climate measurements, because of the lower thermal conductivity of type K. The surface temperature measurements were made with the thin thermocouple wires lying on the surface for about 20 mm from the metal junction. The relative humidity was measured with resistive polymer sensors from the General Eastern Company. The pulsed excitation was provided by a Campbell Scientific CR10 data logger, which collected all the data. The calibration of the RH sensors was done with saturated salt solutions, before and after the investigation. Sensors were screened against radiant heat by polished stainless steel shields. The outdoor sensors were in a double shielded enclosure with convective air circulation. The indoor room measurements were made at a point 200 mm in front of the experimental paintings. This position has the same climate as in the centre of the room, within experimental error and natural variation.

Acknowledgements

We thank the Holstein Ledreborg family and their staff for their help in this investigation.

Reference

1. Bent Eshøj and Tim Padfield, 'The use of porous building materials to provide a stable relative humidity', Triennial meeting of the International Commission of Museums, Committee for Conservation, Washington 1993, pp 605-609.

Captions

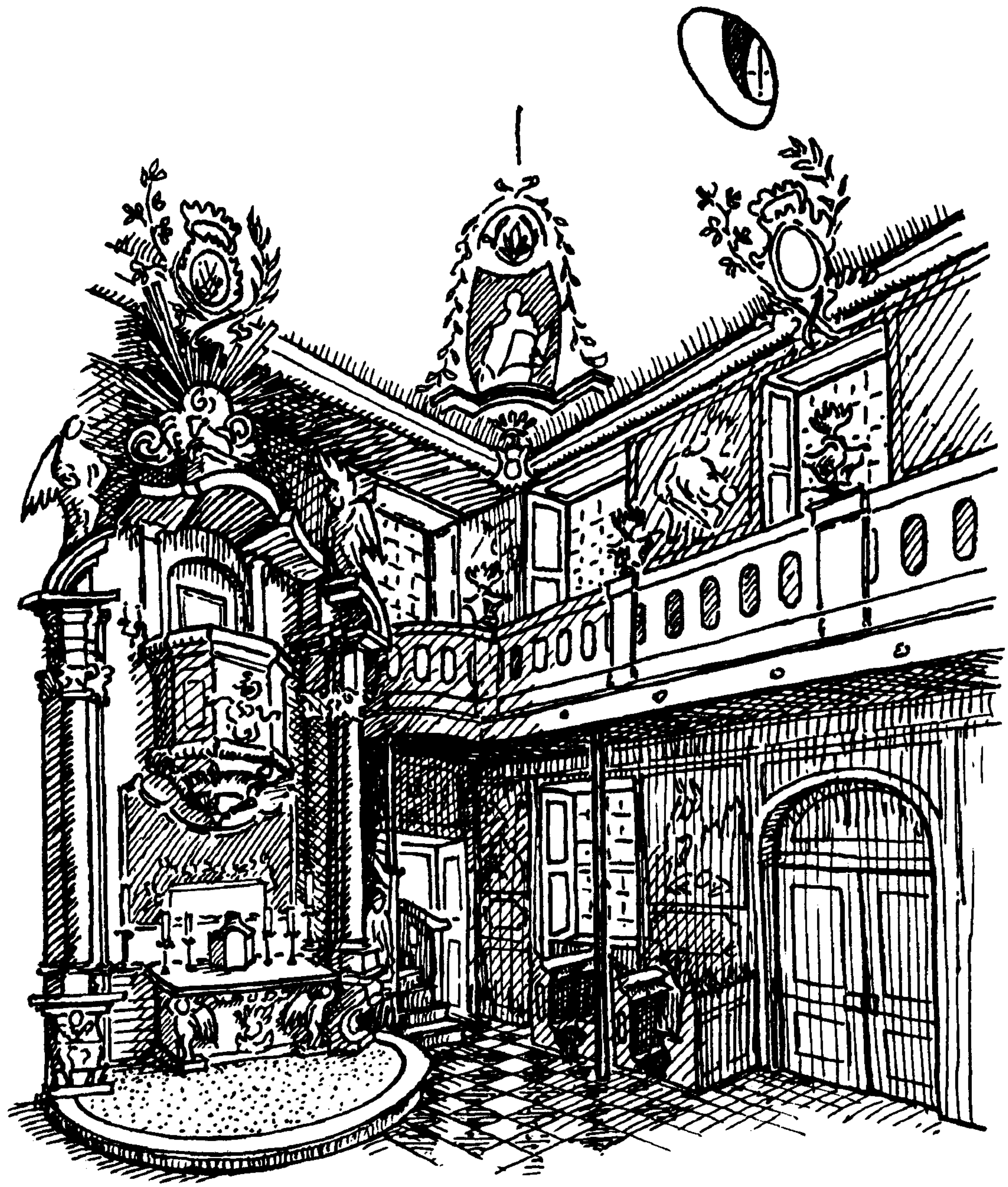
Fig.1 The chapel of Ledreborg, looking north west. Notice the outside door opening directly into the chapel and another outside door on the balcony. The windows are large and single glazed: There is relatively free air circulation to the loft through the holes made for the oval ceiling windows. The furniture is varnished wood, the floor is stone. The room is poorly sealed against air exchange, uninsulated and poorly buffered against RH variation.

Fig 2. A diagram showing a section of the wall and the positions of the climate sensors. The room temperature and relative humidity are measured at the end of a post sticking 200 mm out in front of the paintings. Behind each painting are two temperature sensors (thermocouples) touching the surface of the canvas and the surface of the wall respectively. Temperature and relative humidity sensors are enclosed in a radiation shield in the middle of the air space behind each picture.

Fig.3 Temperature and relative humidity inside the chapel (bold line) and outside (dotted line). Notice the relatively poor relative humidity buffering of the room air, due to rapid air exchange through windows and doors, combined with varnish on the woodwork, which prevents humidity buffering.

Fig.4 Relative humidity in the chapel (dotted line) and behind the two pictures. The bold line is the RH calculated for the canvas back surface of the picture screened from the wall by polyester foil. Notice the slow climb in RH from the value in the conservation laboratory, about 40%, to equilibrium with the chapel after about two months. The dips at the beginning of the record are instument failures. The thin continuous line is the RH calculated for the canvas of the unscreened picture. It follows the running average of the room RH, with a noticeable buffering, caused not by the canvas itself but by the wall, as shown in fig. 7.

Fig.5 The two traces at the top are the RH behind the two pictures. At the bottom is the temperature difference between picture and wall. The screened picture (bold line) has small RH peaks that approximately coincide with temperature peaks at the canvas. This RH pattern is characteristic of a closed container filled with abundant buffer, in this case the canvas. The unscreened RH (thin line) has larger RH peaks when the temperature difference is at a minimum. This can be attributed to buffering of RH by the wall *at the wall temperature.* This buffered air warms up to the canvas temperature with consequent fall in RH.



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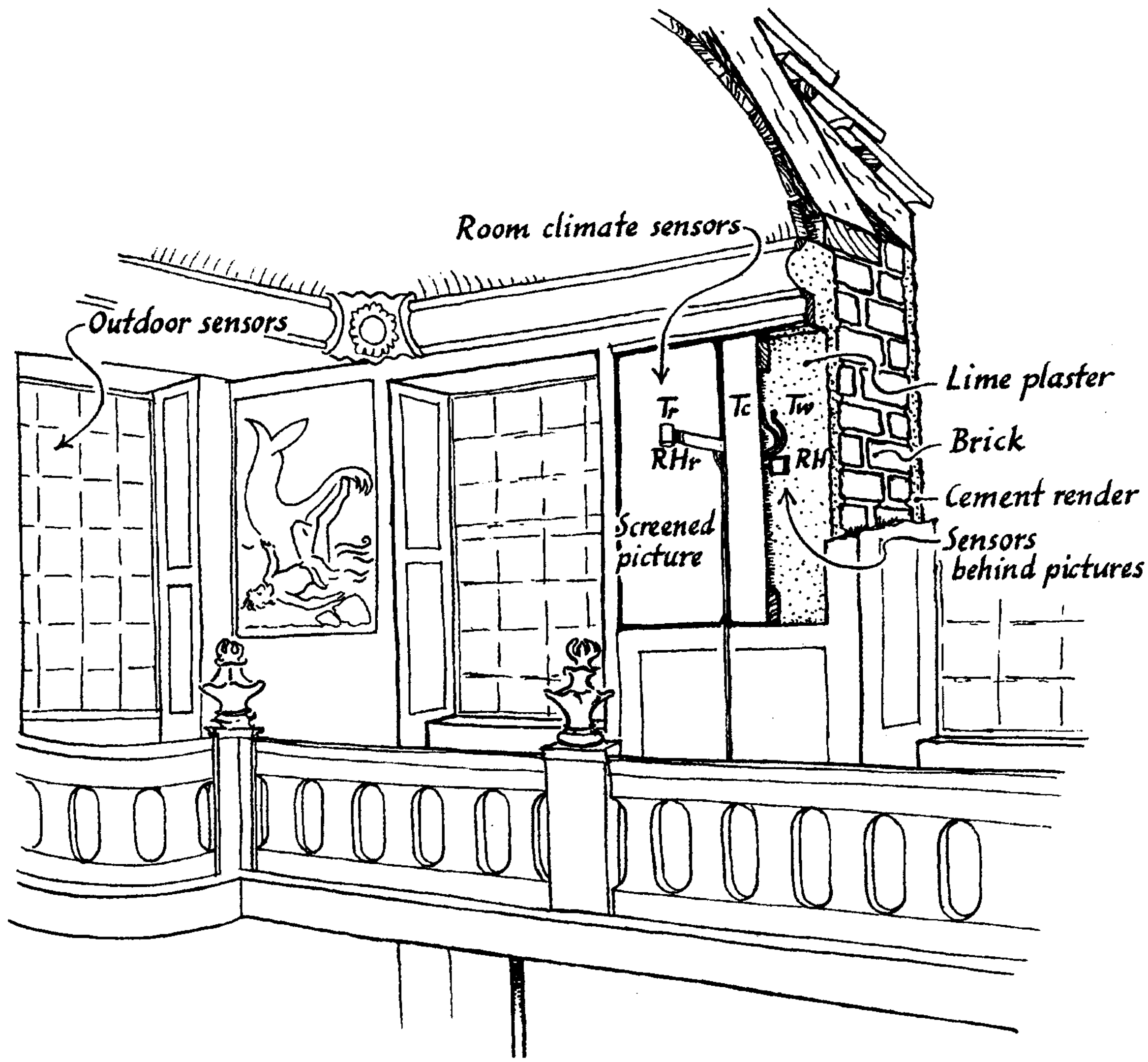

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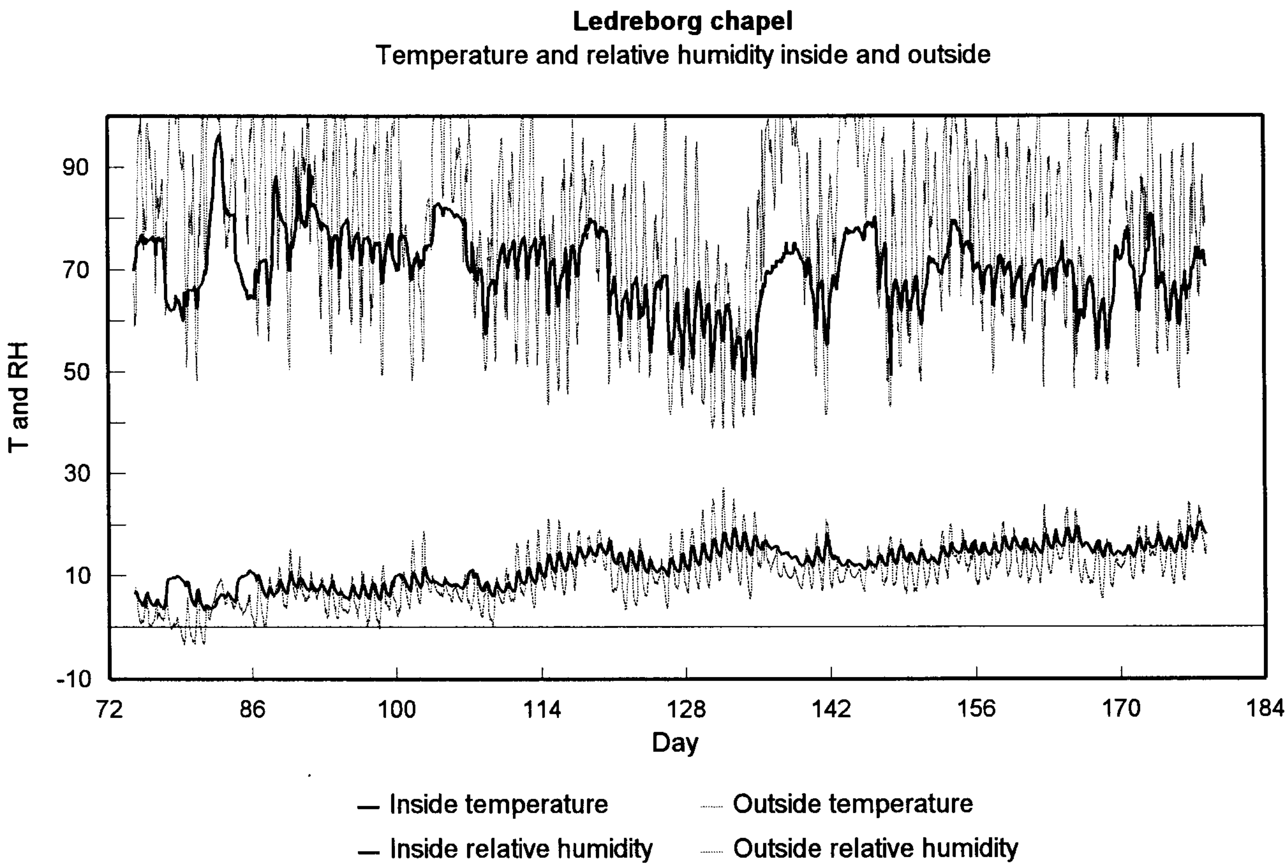

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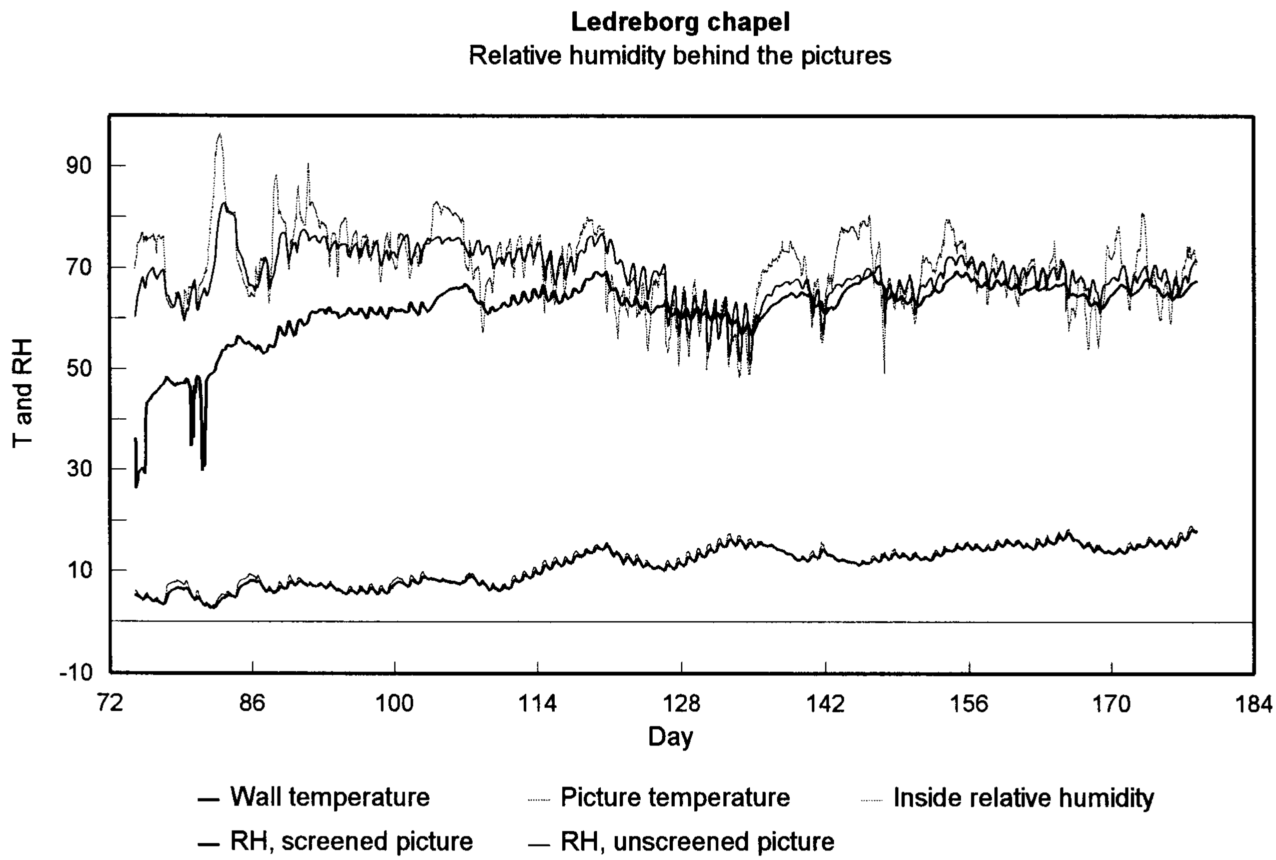

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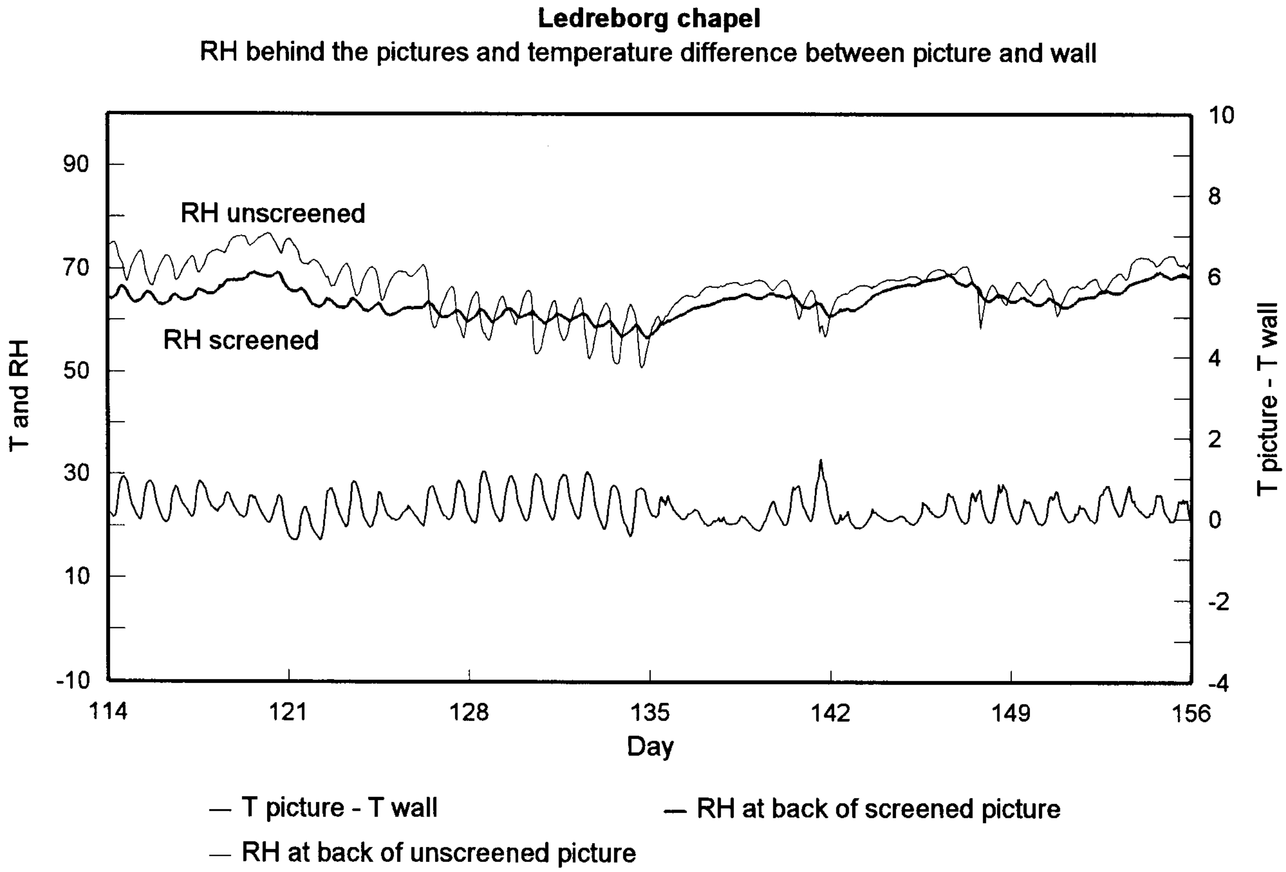

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