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Salt damage at Cleeve Abbey, England
Part I: a comparison of theoretical predictions and practical observations

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Abstract

The use of environmental control as an indirect means of reducing salt damage has long been proposed, but is only now becoming more feasible with the availability of new information on the thermodynamics of salt behaviour. Recent research has led to the development of a computer program Environmental Control of Salts (ECOS), which utilises a thermodynamic model to predict which solid minerals will exist in equilibrium at any given temperature and relative humidity, given the ionic composition of the contaminating salts. This, in turn, permits the prediction of the range of ambient relative humidity under which the salt-contaminated object is less at risk of salt damage.

This paper discusses the application of the ECOS program to provide an insight into the salt deterioration problems affecting the C13th wall paintings in the Sacristy at Cleeve Abbey, Somerset. The work was realised through a combined process of sampling and analysis, condition assessment and documentation, and environmental monitoring. Analytical data were input into the ECOS program to obtain predictions for the phase transition behaviour of the salts present. By drawing together the different investigative strands of the project, the source of significant discrepancies between observed and predicted salt behaviour was identified. Once this had been addressed, the resulting thermodynamic calculations not only correlated well with the in situ observations and recordings, but also offered a plausible explanation for the dynamic deterioration processes taking place.

Keywords: Salts; Wall paintings; Stone; Environmental control; Thermodynamic behaviour

1. Introduction

The damage caused by soluble salts is a frequently encountered problem in the field of conservation, and particularly affects porous materials such as stone and wall paintings. Changes in relative humidity and temperature play a key role in the activation of salt damage, and so environmental control has been increasingly cited as a desirable means of reducing salt deterioration [1–3]. However, this form of passive amelioration is difficult to get right, and carries the risk that if applied incorrectly the damage to the object could be exacerbated. So, it is highly important that the environmental conditions for limiting the damage are selected on the basis of predictions that accurately reflect the real situation.

Recent advances have now made it possible to predict the thermodynamic behaviour of soluble salt mixtures derived from the Na^+–K^+–Mg^{2+}–Ca^{2+}–Cl^-–NO_3^-–SO_4^{2-}–H_2O system in relation to relative humidity and temperature, using the Environmental Control of Salts (ECOS) software program [4]. This new technique was employed to interpret the results of investigations into the salt deterioration problems of the thirteenth century wall paintings in the Sacristy at Cleeve Abbey, Somerset, to gain insight into the processes of deterioration and the options for remedial action.

The aim of the investigations at Cleeve was to assess the salt damage behaviour in relation to the environmental conditions experienced within the Sacristy, in order to inform the future conservation strategy for the wall paintings. This was achieved through the application of the ECOS thermodynamic modelling programme, to predict environmental conditions under which the wall paintings are less at risk of salt damage. This paper constitutes the first instalment of a two-part publication, and is primarily concerned with the use of

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the ECOS program for environmental control calculations. Other aspects of the investigations included the improvement of site investigation methods, and the degree to which the salt distribution within such objects can change both spatially and over time, which are discussed in part II [5].

2. Historical background

The Cistercian Abbey at Cleeve was founded in the 1190s, and is significant not only because of its early date, but also for the extent of the survival of its monastic buildings, many of which retain fragments of their original decoration. The wall paintings at Cleeve comprise schemes from the early 13th to the late 15th centuries and collectively form the most significant survival of Cistercian painting in the British Isles [6]. Since its dissolution in 1536, the Abbey was leased for domestic and agricultural use until the late nineteenth century. The most comprehensive analysis of the documentary records relating to the use of the Abbey during this period is given in [7]. In 1950, the Abbey was sold to the Commissioners of Crown Lands, and in 1951 it was transferred to the Ministry of Works, which in 1984 became English Heritage [8].

This study was conducted in the Sacristy, a single-celled barrel-vaulted chamber, located on the ground floor of the east range of the cloister, dating from 1230 to 1250 (Figs. 1 and 2). The painted decoration in the Sacristy is coeval with the building, and is extremely simple, executed on a lime-wash ground overlying lime plaster, with a restricted palette of red and yellow earths, black and white. The decorative schemes mainly comprise a single line masonry pattern in red ochre, with bands of wavy-line pattern and floral scroll-work accentuating the few architectural details ([6], p. 193) (Fig. 3).

3. Conservation history and current condition

Detailed references to the condition of the Sacristy paintings are only available post 1951, and without exception all refer to the extremely poor condition of the paintings in the Sacristy, and their ongoing deterioration by salts. The current condition of the paintings is little altered from that described in the condition audit undertaken by English Heritage in 1996 [9]. Both the plaster and paint layers suffer disruption and decohesion due to the action of soluble salts, resulting in numerous losses and pitting of the painted surface. Salt efflo-

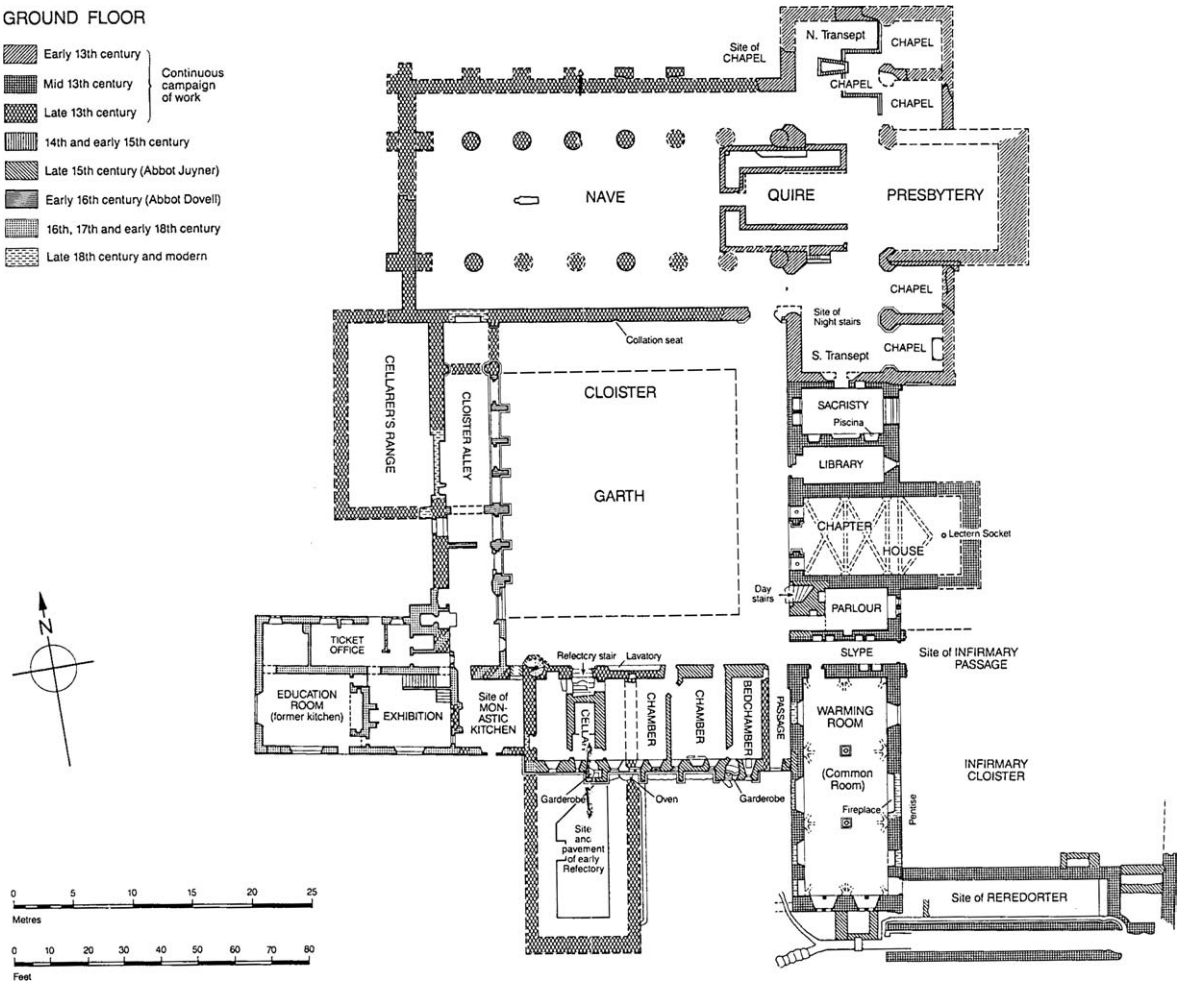

Fig. 1. Ground floor plan of Cleeve Abbey (after Gilyard-Beer 1990, p. 26).