1. Introduction

Block samples (135 x 6.5 x 8 cm) containing stratigraphic sequences of architectural materials have been removed from excavated buildings at three archaeological sites in the Near East: Çatalhöyük in Turkey (figures 1) and Tappeh Sheikh-e Abad, and Tappeh Jani in Iran (figure 10). These sites are important because they were occupied during the Neolithic as hunter-gatherer societies were undergoing the transition to agriculture and the domestication of crops and animals. All three are the subjects of investigation by multi-national inter-disciplinary teams. Thin sections of the block samples are being subjected to analysis by Infrared Microscopy using the new instrument in the Chemical Analysis Facility (CAF) at Reading. A case study of one imaging experiment on a sequence of wall plaster layers from Building 53 (figure 2) at Çatalhöyük is presented here as an example of the effectiveness of this instrument in archaeological analysis.

2. Site Background

Çatalhöyük was inhabited between 7400-6000 BC and is now the focus of an archaeological excavation begun in 1993 and led by Professor Ian Hodder. At this site there are many examples of multiple plastering layers on the walls and floors of buildings (figure 3). There is often a lower quality foundation layer which was probably applied annually, followed by one or more fine white plaster layers, applied annually or intra-anually if more than one. This is often repeated many times to build up a plaster sequence.

3. Aims

The aim was to trial the use of infrared imaging on thin sections of archaeological materials to yield results which would answer questions about the sites. Key qualities of any infrared maps recorded would be the ability to distinguish between deposits and inclusions on a micrometre scale, based on their infrared spectra and for those spectra to be readily interpreted.

Archaeological questions associated with this work include the identification of possible uses of space within and between different buildings, the detection of potential natural sources for architectural materials and evidence for different technological choices in materials such as mudbricks, mortars and plasters.

4. Method

The block samples show layers of occupation deposits from the buildings which are characteristic of the activities that were carried out in the different parts of a structure. These blocks were impregnated with resin and cut, ground and polished into thin sections (30μm thick) on glass slides, which were not cover slipped so that chemical microanalysis could be carried out (Figures 4-7). A Perkin Elmer Spotlight 400 FT-IR Imaging System with a Spectrum 100 FT-IR Spectrometer as the source of infrared radiation was used to record the infrared maps. Once the area was mapped the SpectrumIMAGE software was used to conduct a Principal Component Analysis (PCA) to identify the different spectral regions of interest. Specific bands of interest in the spectra could then be mapped across the image as a "Chemimap".

5. Results and Discussion

A visible image was recorded of the plaster layers and inclusions using the optical microscopy settings of the instrument. An infrared map of this area was then measured (pixel size is 2.5μm) and PCA applied to show which areas of the map were the most significantly different spectrally. The map here shows an overlay of the calculated factors 1, 2 and 3 (figure 8).

Reflectance spectra were chosen from two distinctly different regions of this map. Spectrum 1 shows strong peaks due to carbonate from the mineral dolomite in the fine white finishing layers. This is more easily seen in the carbonate peak at 899cm⁻¹ than the peak that is between 1550 and 1435 cm⁻¹ as the latter is showing strong reflectance effects. The shift in this peak to 888cm⁻¹ in spectrum 2 indicates that the carbonate present in the foundation plaster layers is calcite (figure 8).

A Chemimap of the plaster layers was produced showing the regions where the 890 – 915cm⁻¹ band (carbonate present in the mineral dolomite) is strongest (white regions) through progressively darker shades of blue to regions where it is not present at all (figure 9a and b).

6. Conclusions

The results obtained from mapping one small area of interest from the thin section is remarkable. The boundaries between the plaster layers after PCA are clear and allow the relevant spectra to be easily selected and compared. Chemimaps may then be produced, showing how each identified mineral is distributed across the mapped area. Additional areas of thin sections have already been analysed and these show further distinct differences dependent on the material present.

7. Further Work

The Central Zagros Archaeological Project (CZAP) began excavations in Iran (figure 10) in 2008, directed by Yaghob Mohamadifar, Roger Matthews, Wendy Matthews and Abbas Motarjem. Thin sections have already been made of some block samples brought back from this site and IR microscopy will help to answer many questions surrounding these recent discoveries. Furthermore, analysis of clay tokens found at Tappeh Sheikh-e Abad, which can only be analysed using non-destructive techniques, is hoped to yield answers about whether they were produced locally or involved in trade, possibly with societies in what is now Iraq.

References