Helen Lloyd, Carlota M. Grossi and Peter Brimblecombe

Low-technology dust monitoring for historic collections

Keywords
dust; identification; particles; fibres; area coverage; deposition rate

In historic houses and museums dust is a nuisance. It obscures surfaces, reduces their artistic worth and gives the impression that a place is not well cared for. Visitor reactions are fairly clear on this, although they suggest too that dust can also convey a sense of historicity.1 Dust is also an economic problem because research in historic properties has demonstrated that removing it imposes considerable costs and may consume some 75% of housekeeping and preventive conservation budgets.2 In addition, dust should be removed reasonably quickly as under humid conditions it can cement to the underlying surfaces, becoming difficult and more damaging to remove.3 These potential risks and costs suggest that it is better to prevent the deposition of dust rather than to clean it off, and a number of simple management techniques are available to achieve this.4 Such management plans are inevitably assisted by understanding the sources of dust and this is the relevance of the simple identification techniques explained within this article. Although this article discusses research undertaken in historic properties, the dust atlas presented, and the approach to dust management, are applicable in museums, archives and libraries.

The dust atlas
In a joint project with input from English Heritage, Historic Royal Palaces and the National Trust, a collection of photographs and other materials was assembled as an electronic file that can be printed or viewed on screen as an aid to the study of deposited dust. The Identification of Dust in Historic Houses, by P. Brimblecombe and C.M. Grossi, will be available free by downloading from the National Trust website at http://www.nationaltrust.org.uk/main/w-collections-dust.5 This booklet provides guidance on sampling, examination and interpretation of dust in historic houses and museums. The contents include:

1 instructions for collection of samples, preparation and exposure of sticky sampling surfaces;
2 guide to examination with a hand lens and to estimating coverage;
3 guidance in quantifying dust;
4 an atlas of typical dust components and their identification (can be printed as reference cards);
5 some examples of dust analysis and scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) examination;
6 information about suppliers, contacts, websites and references.

Dust monitoring kit
It is relatively easy to create a basic dust monitoring kit. The simplest kit might contain items such as:

1. hand magnifying lens (10×);
2. slide case for storage;
3. slide frames (for making sticky samplers);
4. adhesive labels;
5. microscope slides;

Details of equipment and suppliers are given at the end of this paper. A more sophisticated kit might include these additional items:

1. light loupe 10×/15×, or monocular 24× on stand with Light Emitting Diode (LED) lamp;
2. slide storage case or box (hard);
3. slide mount—paper;
4. Tyvek, vinyl or Teflon labels;
5. adhesive labels—paper, sheet or roll;
6. microscope slides;
7. Biotec Microslides;
8. graph paper with 1mm squares;
9. binocular microscope.

Collection of dust
Dust deposits are easily collected by gently touching the deposit with a sticky surface and picking up a sample. Ordinary paper labels will work, but Teflon labels are better as they have a finer structure and enable easier observation of the dust particles. Alternatively the label can be left sticky side upwards for several weeks until a deposit accumulates. The samples can be retained and stored by attaching the label to the back of a microscope slide, taking care not to include too many air bubbles. This requires the labels to be quite small or to be cut into smaller strips. The particles can then be observed through the slide.

Examination
The task of examining the particles is easy with a microscope—an inexpensive one will be quite sufficient. However, a high quality hand lens (approximately 10× magnification) of the kind used by geologists will allow some progress to be made in identifying major particles. The lens is brought close to your eye (approximately 20mm between eye and lens) and then, for a clear image, focused by bringing the sample towards the lens. This examination should be done in bright light. It is also possible to use an illuminated or digital magnifier, although some illuminated magnifiers provide insufficient magnification.

Textile conservators will already be familiar with the identification of fibres, and conservators in other disciplines may find it easy to recognize some other materials. During examination, the particles can be compared with those shown in the atlas to establish their possible origin. Identification is not always easy, but the source of some particles is self-evident, for example fibres and insects. Even where the type of particle is not entirely clear, some possibilities can be eliminated (for example, it is not a fibre). Table 1 provides some indication of the relative ease of identification of a variety of particle types.

It may be useful to create a reference collection of particles for a particular site or place. For example, if it is suspected that a deposit is breadcrumbs,
looking carefully at a sample from a kitchen table can aid identification. Large particles are easier to classify, while small particles may have to be placed together under a simple heading such as ‘many fine particles’.

More detailed characterizations can be achieved through higher magnification examination and other analyses, although these require specialist equipment and personnel and can be more expensive. Scanning electron microscopy (SEM) allows the observation of dust at much higher magnifications than are possible with a standard lens. Energy dispersive X-ray spectroscopy (EDS) provides chemical elemental analysis of dust but can be laborious to perform. The dust atlas includes some images from SEM-EDS analysis. The use of different microscopy techniques, and advanced analytical methods for the identification of vegetable textile fibres, are described in ‘Identification of Selected Vegetable Textile Fibres’.6

Observation chart (fiche)
The characteristics of each sample can be noted and filed in a chart or fiche, divided into several sections. The first section should record sampling details, such as start and finish dates, building, location, sampling method, number of visitors, weather and other details about the context. The second and main section should provide a general description of the sample, including type of dust, dominant component, relative size, shape, colour, percentage coverage and so forth. The fiche may include a final section to record further comments of interest, such as characteristics or events that affect dust deposition, such as draughts, cleaning frequency, any unusual deposits, problems with the sampling, and building works.

Dust atlas
The atlas can be used as a series of detachable pages (perhaps printed out on card), showing micro-photographs of the different types of particles often found in historic houses and museums. Pages can be laid out separately, or housed in a ring binder or folder. The cards include photographs of particles of soil dust, combustion materials (soot), insects, plant fragments, hair, skin, paint/plaster, clothing fibres, paper, food and mould, as well as mixtures of dust particles and fibres collected from historic houses and from vacuum cleaners.

Most pages consist of two binocular microscope photographs: one shows the characteristics that can be seen with a 10 × magnification hand lens and the other a more detailed image of the dust. A ruler was photographed under the binocular microscope, to provide scale for comparisons between photographs on the atlas pages. The lower magnification picture, when printed on A4 size paper or card, represents magnifications of 8 ×, while the more detailed image may vary between 12 × and 40 × magnification.

Observations and analysis
When examining particles it is important to consider their relative size, weight and location. Heavy particles are generally found on the floor, deposited by people’s shoes, although some may drop from the ceiling, walls or clothing. Biological particles (insects, pollen, leaves) and clothing particles may have a seasonal pattern, with noticeable differences in prevalence between summer and winter.7

The following sections summarize the characteristics of common components of dust.

1 Soil—mineral dust
Soil is an important component of indoor dust. The coarser particles (larger than 30 μm) are likely to have been brought in on shoes and are typically

found on the floor or just 10–20 cm above it.\(^8\) Soil includes rock, brick, tiles, concrete and other particles from building materials, as well as quartz and other mineral grains, such as calcite, clays and salts, for example gypsum and halite. Soil particles vary widely in size (1–300 μm), in shape (from irregular to rounded conglomerates) and in colour, depending on the original material. For instance, granite dust consists mainly of transparent or greyish quartz grains, shiny—sometimes dark—sheets of mica and possibly whitish feldspars (Fig. 1a). Dust from a red sandstone or brick is usually red due to the iron content. Common salt (sodium chloride—halite) is characterized by whitish transparent cubes.

2 Combustion products—soot

Typical sources of modern soot are traffic emissions, but older deposits accumulated over century-long time-scales can indicate historic coal burning. Today, oil soot can be found from heating boilers. Soot is typically very dark, varying from black to brownish, fine grained with round to irregular shapes. Particles often join to form loose clusters of rounded to angular or elongated agglomerates (Fig. 1b).

3 Insects

Insects are typically found when temperature and humidity are high (as more rapid breeding and growth occurs during warmer months) (Fig. 1c). Seasonality may be an important feature of their presence. Some of these insects may be considered pests in historic collections; detailed descriptions can be found in *Insect Pests in Museums* and images of common insects are shown in *A Helpful Guide to Insect Pests found in Historic Houses and Museums*.\(^9\)

4 Plant fragments

Plant fragments are often relatively large and can be coloured or show evidence of fibres or cells (Fig. 1d).

<table>
<thead>
<tr>
<th>Table 1 Relative ease of identification of dust components.</th>
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<tbody>
<tr>
<td><strong>Component</strong></td>
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<tr>
<td>Fibres</td>
</tr>
<tr>
<td>Soil dust: mineral grains</td>
</tr>
<tr>
<td>Soot</td>
</tr>
<tr>
<td>Insects</td>
</tr>
<tr>
<td>Skin</td>
</tr>
<tr>
<td>Food</td>
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<tr>
<td>Plants</td>
</tr>
</tbody>
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8 Yoon and Brimblecombe, ‘Clothing as a Source of Fibres’.

5 Hair
Human hair samples are usually long. Animal hairs can be less than half the diameter of human hair; colour varies from white to black and from transparent to opaque (Fig. 1e).

6 Human skin, dandruff, dander
These particles are not necessarily common in historic houses open to visitors, except in places where people spend a lot of time and skin is exposed (bedrooms, bathrooms) or where animals shed dander. Skin particles can be shed from clothes.

7 Paint fragments
Paint fragments are opaque and present irregular shapes. Colour will vary according to local decorative schemes, and coloured flakes that do not relate to a room’s interior decoration can be indicators of local building work and draughts in the building or from outside.

8 Plaster
Gypsum plaster has a whitish colour and very fine grain size.
9 Clothing fibres
These are very common components of dust in historic houses and can occur alone or in clusters. Fibres derive from different fabrics and, therefore, vary in colour, thickness and length. Acrylic and cotton fibres are characteristically thinner than wool fibres (Fig. 1f). White semi-transparent clothing fibres may be difficult to differentiate from plant and paper fibres. Clothing fibres are helpfully indicative of sources of dust and valuable for pointing towards potential management solutions.

10 Paper
In historic properties, it is more usual to find a single fibre, which may derive from abraded wall paper. Paper fibres can be difficult to differentiate from vegetable fibres or even clothing fibres. Where the colour of the background contrasts with the fibre colour, paper fibres are easier to identify, for example on black sticky labels.

11 Food
Food is sometimes found as relatively large particles, such as chocolate or bread crumbs, which have rather angular grains.

Dust deposits from Knole
Household dust is usually a mixture of the most common particles found in rooms, including abundant differently coloured fibres. As a case study, dust samples from Knole, near Sevenoaks in Kent, were collected during cleaning by house staff and textile conservators.

Knole, a medieval palace-cum-Renaissance mansion, was furnished by the 6th Earl of Dorset with perquisites (‘perks’) from Stuart royal palaces. Because of the high relative humidity and cautious ‘hands-off’ care for rare seventeenth-century textiles, dust generated by visitors forms grey ‘mudpacks’ on bedspreads and seat furniture. It was the need to protect Knole’s newly conserved silk bed hangings from dust that provoked recent research into the sources and distribution of dust, and causes of ‘cementation’.

Dust vacuumed from a James II stool in the Venetian Ambassador’s bedroom (Fig. 2a) consisted mainly of blue, red and golden fibres from the stool, and fine small mineral grains, irregular and variable in size, the exact composition of which proved hard to assign. SEM-EDS analyses confirmed the presence of plaster (calcium sulphate; degradation of plaster ceilings) and sand (silicon; wind-blown soil dust).

A sample of carpet dust from the Brown Gallery (Fig. 2b) contained a mixture of many particles commonly found in rooms at Knole, i.e., different coloured fibres, sand (quartz and other mineral grains) and skin. SEM-EDS examination revealed a mainly silicate composition and sulfur was also detected.

Quantification of deposits
In addition to undertaking a qualitative description of dust, it is possible to quantify the coverage of a surface by particles, using simple approaches to measuring size and coverage. Where there are not too many particles, the number can be counted using a grid as a background. The measurements will probably be sufficiently accurate to enable comparison of coverage in one room with that in another. It is also possible to estimate the area of surface that particles cover.

1 Estimating size using a graticule
Size, for example the lengths of fibres, can be estimated using a primitive graticule (a network of fine lines, vertical and horizontal, enabling size to
be measured in optical instruments. Fine (1mm square) graph paper can be used as a background surface on which to work during examination of particles (if graph paper is printed with blue or light-coloured ink, it can be photocopied before use (Fig. 3)).

2 Estimating percentage coverage
Calibration charts are sometimes used during microscopic examination to estimate the percentage coverage of grains or minerals. These charts have been added to the atlas, to enable a rough estimate to be made of the percentage of the surface covered by particles. The chart used in the atlas was extracted from Basic Petrography. Fig. 4 shows a sample of limestone powder, compared to a calibration chart, suggesting that the percentage coverage in this case is between 2% and 5% (results vary slightly according to the opinion of different observers).

Observations from measurements
Even simple observations are revealing. For example the comparative size, density and weight of individual particles, and the height at which they are found, may determine whether floor-level soiling has been agitated by cleaning techniques and foot traffic, or airborne dust from above has settled on surfaces at higher levels. More than three fibres in every 100 particles might suggest that the source of dust is visitor clothing, whereas a higher proportion of particles might indicate sources of dust unrelated to visitor activity. Fine fibres may be dislodged from clothing through the activities of staff, live interpreters or visitors, whereas thick coarse fibres may derive from entrance matting, underlay, carpets or drugget. A wide range of types and colours of fibres may come from the clothing of visitors, whereas the prevalence of a particular type and colour of fibre suggests that the source might be uniforms worn by local staff or visiting school groups, or jeans worn by students or tourists. Short wool and paper fibres might fall from deteriorating flock wallpaper, whereas textile wall hangings might generate short silk and cotton fibres. During dry weather, a high proportion of one colour of mineral particle could come from garden path surfaces, brought in on visitors’ shoes, whereas one colour of vegetable fibre might suggest wind-blown chaff from harvested crops, or deteriorating entrance matting. Accumulations of stone dust may indicate that visitors are brushing against vulnerable architectural features. Gypsum plaster dust may
have descended from ceilings, for example where there is visitor access to the floors above causing vibration and displacement of the building structure. Crumbs of leather in a library might indicate that book bindings are deteriorating or being mishandled, while elsewhere in the house they might suggest that visitors are using fragile leather-seated chairs.

The dust atlas is designed to provide helpful indicators but it cannot supply an answer for every situation. Its use requires plenty of common sense, simple processes of deduction, and realistic expectations of outcomes. By comparing collected dust particles and fibres with examples of particular materials found in different parts of the building and its collection, it is possible to build up a picture of likely sources of dust. It may be helpful to assemble a reference collection of local materials—such as pollen, straw, grass, leaves, mortars, plaster, path surface materials, reed,
jute, animal hair and coir fibres (used in rush matting, underlay and entrance matting). Having identified the sources of dust, it then becomes feasible to devise simple management solutions\textsuperscript{15} to protect vulnerable surfaces from dust deposition, or to reduce the rate or extent of dust coverage.

Knowledge of the sources of dust, and an estimation of the amount that deposits over a given time span in a defined area, enable calculation of the rate of deposition. From studies in a variety of historic contexts where collections are on open display, it appears that up to 2–3% dust coverage of surfaces can be tolerated without complaint but further accumulations of dust attract attention and prompt suggestions by staff and visitors that cleaning is necessary.\textsuperscript{16} However, in libraries, where the dusty tops of books are partially concealed by bookshelves, 6–7% dust coverage may be tolerated by visitors and staff before prompting the need to clean.

**Aid to good practice and economical use of resources**

Over the past decade, these low-technology methods of sampling, identification and assessment have been used to support research into the sources and distribution of dust in historic interiors. Collections care staff are now being encouraged to use these techniques to establish how often cleaning is necessary in individual furnished historic interiors on open display to visitors—to paraphrase the Burra Charter, the objective is ‘as much [cleaning] as necessary ... as little as possible’.\textsuperscript{17}

Collections care staff will rarely have the capacity to conduct comprehensive sampling campaigns. Instead, they can use these monitoring techniques in specific locations where the characteristics of dust and its distribution give cause for concern. For example, this may be where fibrous dust spoils the appearance of shiny surfaces, where gritty dust abrades gilt materials or demands too frequent vacuuming of decaying silk textiles, or where the rate of dust coverage attracts adverse comments from visitors. As an alternative to setting up long exposures of sticky samplers, instantaneous sampling of dust accumulations arousing particular concern can be taken and analysed immediately for instant results.

These techniques can be used to inform the fine-tuning of housekeeping programmes, ensuring that cleaning of individual items is undertaken only when necessary, and not as a matter of habit, whether that may be daily, weekly, occasionally, annually or less often. These methods are also valuable during building works and renewal of services, when they can be used to gauge the effectiveness of dust prevention and protection measures, and lend weight to negotiations with site contractors for more effective controls on dust generation at its source, whether indoors or outdoors.

The results from dust monitoring also contribute to effective management of resources during periods of economic recession, and when assessing the need for additional housekeeping time in response to extended opening and increased visitor numbers. Monitoring results inform decisions to target resources where they are most needed, and ensure that precious time is not wasted on repetitive cleaning, when it might be spent more constructively on proactive care for historic collections, or in demonstrating the benefits of housekeeping and preventive conservation practice to the visiting public.

**Way forward**

Experience of pilot-testing these techniques among preventive conservators and historic house staff suggests that it takes some time for individuals to develop the confidence to identify correctly different particles and fibres, and that they can become frustrated if they cannot identify everything immediately. In the early stages, users of these techniques should be willing to seek specialist advice, recognizing that learning to analyse dust

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\textsuperscript{17} Australia ICOMOS, The Burra Charter. The Australia ICOMOS Charter for Places of Cultural Significance, http://www.icomos.org/burra_charter.html (accessed February 11, 2011), 1. ‘The Burra Charter advocates a cautious approach to change: do as much as necessary to care for the place and to make it useable, but otherwise change it as little as possible so that its cultural significance is retained.’
takes time, and even experts find it difficult to identify everything. Feedback from a group of English Heritage and National Trust staff using a prototype dust atlas has stimulated improvements in the selection, magnification and scaling of images. The inclusion of several particles or fibres in one image helps users to differentiate one type from another and to recognize their distinguishing features.

After publication of The Identification of Dust in Historic Houses, there remains a need to expand the range of dust materials commonly found in historic houses, museums, galleries and other heritage sites. Images matching the specification described in the dust atlas above, with comparable magnification and scale, would be most welcome, and contributions can be sent to dust@nationaltrust.org.uk. Over time the dust atlas will become a more comprehensive tool, including advice and case studies showing how it was used to solve particular problems, and an increasingly useful resource for conservators and conservation technicians in the heritage sector.

Acknowledgements
The development of the dust atlas would not have been possible without the initial efforts of Young Hun Yoon during his PhD and post-doctorate work at UEA Environmental Sciences, and the ideas contributed by conservators and scientists at English Heritage and Historic Royal Palaces, including David Thickett, Kathryn Hallett and Victoria Richards. Thanks are also owed to English Heritage and National Trust conservators and house staff who attended a Dust Study day in Birmingham, and whose feedback has helped to improve the dust atlas.

Abstract
A qualitative understanding of the particles in dust and their sources helps to identify ways to reduce the accumulation of dust within historic houses. Knowing the possible sources of dust helps to suggest preventive steps. Simple low-technology methods enable rapid identification of dust deposits and require little specialist equipment. Dust samples can be collected on sticky surfaces for examination with a hand lens or microscope. The size of particles and fibres, and amount of surface coverage, can be estimated roughly using a graticule or coverage chart. An atlas of common dust components aids identification of soil dust, soot, insects, plant fragments, hair, skin, paint/plaster, clothing fibres, paper, food and mould. A mixture of fine dust is resolvable into a range of particle and fibre types. Long exposures of sticky samplers, with an estimate of the area covered by dust, indicate the rate of deposition and suggest the cleaning frequency necessary to prevent negative visitor reactions. The atlas lists suppliers and sources of information.

Résumé
«Surveillance de la poussière sur les collections historiques à l’aide d’une base technologie»
Une connaissance qualitative des particules présentes dans la poussière et de leurs sources aide à identifier les moyens de réduire l’accumulation de la poussière dans les maisons historiques. Connaître les sources possibles de la poussière aide à suggérer des étapes préventives. Des méthodes simples de base technologie permettent une identification rapide des dépôts de poussière et requièrent un équipement léger de spécialiste. Des échantillons de poussière peuvent être collectés sur des surfaces collantes afin d’être examinés avec une loupe ou un microscope. La taille des particules et des fibres ainsi que la quantité couvrant la surface peuvent être grossièrement estimées en utilisant un compteur de colonies ou une carte de couverture. Un atlas des composants communs de la poussière facilite l’identification des salissures, poussières, suies, insectes, fragments de plantes, cheveux, peau, peinture/plâtre, fibres de vêtements, papier, nourriture et moisissures. On peut classer un mélange de la poussière fine dans un éventail de types de particules et de fibres. De longues expositions des échantillons collants, avec une évaluation de la zone couverte par la poussière, indique le taux de dépôt et suggère la fréquence de nettoyage nécessaire pour prévenir les réactions des visiteurs. L’atlas énumère une liste de fournisseurs et de sources d’informations.

Zusammenfassung
„Low-Tech Staub-Kontrolle für historische Sammlungen“

Resumen
“Mínima tecnología para el control de polvo en colecciones históricas”
Para identificar las formas de reducir la acumulación de polvo en propiedades históricas se necesita un entendimiento cualitativo de las partículas de polvo y de su procedencia. El saber los posibles orígenes del polvo ayuda a sugerir medidas preventivas. Los métodos sencillos y con poca tecnología facilitan la identificación rápida de depósitos de polvo y requieren poco equipamiento especial. Para su examen con lupa o microscopio las muestras de polvo se pueden recolectar en superficies pegajosas. El tamaño de las partículas y las fibras y la cantidad de superficie cubierta, pueden ser calculadas aproximadamente usando una grafica de cobertura. Un atlas de los componentes del polvo común ayuda a la identificación del polvo de tierra, hollín, insectos, fragmentos de plantas, pelo, piel, pintura/yeso, fibras de ropa, papel, comida y moño. En una mezcla de polvo fino se puede identificar una amplia gama de partículas y fibras. El ritmo de deposición y la frecuencia de limpieza necesaria para prevenir reacciones negativas de los visitantes, está indicada a través de las muestras pegajosas junto con una estimación del área cubierta por el polvo. Se incluye en el atlas una lista de proveedores y otras fuentes de información.

Biographies
Helen Lloyd is Deputy Head Conservator and Preventive Conservation Adviser (Housekeeping) to the National Trust. Her consultancy
role focuses on strategies for achieving a sustainable balance between visitor access and conservation, and preventive conservation training for house staff, managers and conservators. Helen coordinates research into physical agents of deterioration and damage predictions for historic collections, and its publication in conservation journals. She publishes housekeeping guidance online on National Trust web pages, and in the *National Trust Manual of Housekeeping*. Helen is an accredited conservator (ACR), Trustee of Icon and Fellow of IIC.

Carlota M. Grossi Sampedro has been a senior research associate in the School of Environmental Sciences at the University of East Anglia since 2002. Previously she worked as a research scientist at the University of Oviedo (Spain), Building Research Establishment (Garston, UK) and STATS Consultancy (St Albans, UK). Her main area of expertise is historic stone decay and conservation and she has participated in many research projects on conservation and the impact of pollution and climate on historic buildings. This includes stone decay and durability, effects of pollution on building stone, conservation and cleaning treatments for stone, non-destructive techniques applied to stone, aesthetics of soiling of historical buildings and the effects of climate change on cultural heritage.

Peter Brimblecombe was awarded a PhD by the University of Auckland, New Zealand. He is professor of atmospheric chemistry in the School of Environmental Sciences of the University of East Anglia, UK, and was appointed senior editor of *Atmospheric Environment* in 1990. He has written extensively on museum atmospheres and has a continuing interest in the process of damage control to cultural materials by air pollutants. He has also studied the history of air pollution and more recently has been interested in the influence that urban air pollution has had on architectural design in late Victorian England.

### Equipment and suppliers

- **10× hand magnifying lens:** Gowlland Optical Limited
  71 Beechwood Road
  Sanderstead
  Surrey CR2 0AE
  UK

- **10× Peak light loupe:**
  Peak Optics
  GWJ Company
  2117 Weeping Willow Lane
  Hacienda Heights
  California 91745-4148
  USA

- **CLE Design Ltd**
  69–71 Haydons Road
  Wimbledon
  London SW19 1HQ
  UK

- **24× Opticron Gallery Scope monocular, microstand and LED lamp:**
  Sherwoods Photographic Ltd
  North Court House
  Greenhill Farm
  Morton Bagot
  Studley
  Warwickshire B80 7EL
  UK

- **Slide storage case or box (hard), slide mount—paper:**
  Gepe Produkte AG
  PO Box 4313
  CH-6304 Zug
  Switzerland

- **UK distributor of Gepe products:**
  Johnsons Photopia Limited
  Hempstalls Lane
  Newcastle under Lyme
  Staffordshire ST5 0SW
  UK

- **Adhesive labels—paper, sheet or roll:**
  Systems Print Media Limited
  Unit 2, Willan Enterprise Centre
  Fourth Avenue
  Trafford Park
  Manchester M17 1DB
  UK

- **Microscope slides:**
  Chance Propper Ltd
  PO Box 53 – Spon Lane South
  Smethwick
  West midlands B66 1NZ
  UK

- **Scientific Laboratory Supplies Ltd**
  Nottingham South and Wilford Industrial Estate
  Ruddington Lane
  Wilford
  Nottingham NG11 7EP
  UK

- **Biotec Microslides**
  Little Lower Ease
  Cuckfield Road
  Arnsy
  West Sussex RH17 5AL
  UK

- **Graph paper with 1mm squares:**
  ESPO Catalogue
  Eastern Shires Purchasing Organisation
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