1. INTRODUCTION

Before a pot reaches restoration, the stage to be described in this paper, it is assumed that it will have received before careful conservation treatment in the field and laboratory to remove encrustations, salts and stains, without damaging the basic constituents of the pot (e.g. lime temper) or delicate decors. Patches of the surface will not be missing in tape-shaped rectangles, and it will not have received treatment which might prejudice future analysis, such as destruction of content residues, or overheating (above about 100°C) or radiography which could affect thermoluminescence dating. For E1, a sample is generally best preserved in its earthen matrix. It will also have been consolidated if necessary, with a suitable material on the surface or in depth.

The reader is referred to Dowson [11], Gedge [21] and Lazenby [31] as basic texts.

2. MENDING

This is generally best carried out by starting at the base of the pot (or at the top if there is no base), and building up one shred at a time. It will be easier to find the correct shred if they have been sorted out on the bench by position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations. The position (tens, hundreds, bases), orientation (from inner throw lines and other edges), and colour variations.

Sufficient, but not excessive adhesive is applied lightly to the centre of the broken edge on both shreds. They are then joined, 'wagged' slightly to settle them, and dried in equilibrium at 70°C for at least 48 hours. If the mend is judged satisfactory, the edge of a fingernail can be drawn across the joint in either direction to ascertain further cleaning of the fracture. In cases where the pot has sprung, or where many supporting pieces are moving, I found pink plaster, string bindings, and other devices easy to be required.

3. GAP-FILLING WITH PLASTER

The use of plaster is an art which requires experience. A.J.K. dough can also be extremely useful by itself, or to build a supporting framework for plaster reconstructions. The advantages of plaster are that it is inexpensive, quick and easy to make up, and heavy enough to act as a counter-balance when half of a heavy pot is missing. The filled area can be sculptured precisely to irregular shapes following the lines of the extent patterns. The disadvantages of plaster, 'ghosting' (traces of plaster left in surface irregularities) and fragility, can largely be overcome by proper working techniques. Plaster is not recommended when the finished product will not be handled incorrectly handled. 'Ghosting' can be minimized by careful workmanship, by using pre-treated plaster, and by the application of a coat of PVA solution to the surface around the area filled. This is removed afterwards by careful rolling with a solvent-soaked swab. Plaster can be strengthened by mixing it up with very dilute PVA emulsion instead of water.

Other materials can be added to plaster to make it more plastic or to change its colour. These additives must not exceed a total of 25-30% dry weight, or the plaster will be weakened. Plasticizing materials include kaolins, bentonitic clay or bentonite, calcium carbonate, marble powder, barium sulphate, and marble dust. Carbon black, modelling clay, carborundum, PVA, polyvinyl alcohol, and other binding agents can be used. Other materials can be used to change the texture of the plaster. Pre-coloured plaster to easier to work with than white plaster, but the colour is weaker and more difficult to remove in some cases. The proportions of the pre-coloured plaster used may be varied to obtain the desired colour effect. The proportions of the pre-coloured plaster used may be varied to obtain the desired colour effect. The proportions of the pre-coloured plaster used may be varied to obtain the desired colour effect. The proportions of the pre-coloured plaster used may be varied to obtain the desired colour effect. The proportions of the pre-coloured plaster used may be varied to obtain the desired colour effect. The proportions of the pre-coloured plaster used may be varied to obtain the desired colour effect.
shape produced during manufacture. Plastocene is useful if the support shape must be created ex novo, but dental wax gives a less easily deformed shape, and is likely to drop out at a critical moment.

2. Attach the support inside the pot by pressing the perimeter of the plastocene against the pot (being careful not to deform it or push it into the area to be filled), or by attaching the wax form on the inside with masking tape.

3. Wet the fracture surfaces with water (if the ceramic has not been made impermeable by consolidation), so that the ceramic will not leave water from the plaster. PVA emulsion can be used if additional strength seems necessary.

4. Soft dry plaster into water until the plaster forms a cone-shaped mound protruding slightly above the surface of the water. (The author has always done this the other way round, using a medium-sized beaker built as a conveniently balanced and controllable water dispenser. This method makes it easier to judge the amount of dry plaster needed, but does not work for everyone.) Mixing is most conveniently done in a bowl, half-sphere bowl. Hold the container in the palm of one hand and mix the plaster into the water with a plaster spatula, gently at first to avoid bubbles, then by crushing the mixture against the bottom with a sideways motion. When the plaster no longer feels gritty and has begun to set, it is applied first around the edges of the gap and then in the middle until the entire area is slightly proud.

5. Any manipulation of the plaster after it has set prior to setting will weaken it. This may be compensated by using PVA emulsion in the water, if proper consistency is needed, but this is never satisfactory.

6. When the plaster has set but is still damp, use a straight-sided, toothed plaster tool, held perpendicular to the surface, to cut the filled area to its final shape. This is more easily controlled than a straight blade.

7. While the plaster is still damp, remove finishing marks and rework the surface of the filled area with sandpaper, medium grade 'wet or dry' paper, followed by fine grade. Do not use excessive water or pressure. Manual sensitivity is critical at this point. A hard brush should be used as a finishing brush for final template.

8. Any small hollows or pockmarks can be filled at this point by using some of the damp, slaked plaster used for the gap filling. Small amounts can be crushed into a little more water and applied with a fine paint brush. If a new batch of plaster is mixed and added on, the old plaster will absorb water from the new, causing a difference in colour and making the new plaster much harder. Finishing will wear away the outer plaster around the new area, leaving bumps and valleys. It is usually easier to remove insufficiently filled area and start again, than to patch.

9. Final surface texturing to match a course surface is done while the plaster is damp. Smooth finishing is done dry with fine emery paper, avoiding dust. At no time must tools or emery paper touch the original ceramic.

10. Cracks can be filled with coloured plaster, acrylic gesso, or Polyluta. They should be trimmed while damp.

5. RECONSTRUCTION USING POLYSTYRENE IN MOLD FORM AND POLYESTER PASTE

This method of restoration, which was devised by Mr. R.W. Archer, is normally only employed when the pot is either massive in size with few fragments remaining, or when the pot is smaller but has only one or two disjointed fragments. It is based on the use of layers of polystyrene foam sheet to make the inner form.

A full-scale archaeological drawing of the pot is first prepared, as in Section 4. On this, horizontal lines are drawn across the pot from one inside contour to the other, at one or two inch intervals, according to the thickness of foam sheet available. From the length of these lines the diameter of each individual circular layer of polystyrene is calculated. One has a polystyrene cut with a cutting knife, it may be possible to cut the circles to the largest diameter of each layer. These are then placed on top of the other to resemble the interior shape.
of the pot. If the edges have been cut vertically to the largest diameter, it will be necessary to trim down the edges with a knife and heated spirals. If they have been cut to the minimum diameter of each layer, it will be necessary to fill in the angles between one layer and the next with plaster or similar material. This has, in fact, some advantages, as one can give the inner form a slightly more characteristic angular shape than would be possible by cutting alone.

When the plaster on the polystyrene has dried thoroughly, a very thin coat of brown shellac or other suitable varnish should be applied. The fragments of the pot can then be sorted and positioned on the contoured form. It may be possible, by examining the contour of each fragment, to fit it in an approximate position. The individual fragments are held in place by bent pins pushed into the form down the edge of each shard. It may be necessary to fill some of the small gaps between neighbouring sherds with plaster. This should certainly be considered when the pottery is very friable, as the plaster is perhaps more easily removed than polystyrene paste. (In the case of a much harder body, it may be considered permissible to butt the polystyrene paste right up against the fragment.)

Reinforcement should now be placed around the inner form. This can be plastic mesh, galvanized wire net, or aluminum rod or tube, whose diameter is not more than half the thickness of the sherds. This reinforcement should be bent around the entire exposed surface of the form, and between the individual fragments. It should occupy no more than half the depth of the sherds.

At this stage the polystyrene paste may be applied. (Most of the commercial polystyrene body filler pastes have proved satisfactory for this use, and are more convenient than making one’s own.) The paste should be applied all over the form, covering the reinforcing material. It should still be left lower than the outer surface of the original sherds. It will help if the polystyrene paste is not made too smooth, as it will be necessary to apply the finishing plaster over this layer. Two or three days should now be allowed for the polystyrene paste to set. It is essential that it be allowed to set thoroughly before the finishing plaster is applied.

Immediately before the plaster is applied to the polystyrene form, a thin coat of PVA emulsion should be applied, as plaster will not adhere directly to the polystyrene. The finishing plaster layer is applied in the conventional manner, covering all of the polystyrene and bringing the restoration up to the level of the existing fragments.

It now only remains to remove the core from the interior of the pot. This may be achieved by cutting with a hot spiral, or, if all else fails, acetone can be poured carefully into the pot to reduce the polystyrene to a 'goopy' mass.

It is of course possible to debate these methods of reconstruction on the grounds of fidelity to the original, but they may be the only means of showing the public, in a conventional display, what the pot may have looked like before it was broken, since it is possible by these methods to reconstruct an entire pot when very few individual sherds are in actual contact with each other.

6. FINISHING

The ethics and aesthetics of degrees of imitation of the original depend largely on individual opinion and the use for which the finished pot is intended. The author’s personal opinion is that the ‘six feet—six inches’ rule is a good one, i.e. that restoration should not be noticeable at a viewing distance of six feet, but should be clearly distinguishable at six inches. It should be remembered that the idea of reconstruction is to present an idea of the pot as it once was, and that restoration should not distract from the object by presenting a visual pattern of contrasting geometric shapes which have nothing to do with the object.

In many cases, pre-tested reintegration (a shade lighter, not darker, than the basic colour, so as not to create an optical ‘hole’) may be sufficient. If painting is required, acrylic paints, or dry pigments in Acrylic B72, are to be preferred to varnish, oil, or water-colour paints. Test samples should be matched after drying. Gluey paints can be adjusted with a matching agent such as arachid oil; a vernis mat color can be stippled in over the base colour; texture can be added with pigments and glue. Final adjustment can be made by rubbing on paste colours or dry pigments with a finger.

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REFERENCES


Other references

Clark, C. D., Molding and Casting, John D. Lucas Company, Baltimore, Maryland.
UHU (yellow tube)
Mixture of different grades of PVA, or may be cellulose nitrate, depending on country of manufacture, good working characteristics; stable.
Available from hobby shops.

MOWILITH 60
Supplier: Canadian Hochez Ltd
40 Lesmilion Road
Dons Mills, Ontario, Canada
Farbwerke Hochez AG
45 Bruningstrasse
Frankfurt am Main, West Germany

VINAVIL K60
Adhesive
Make thick stock in industrial nitrilethiodiglycol spirits (powder dissolves easily) and dilute with same as needed
Particularly useful degree of plasticity.
Supplier: Montecasimil Edison SpA
Via F. Tucat 18
Milan, Italy

PVA EMLUIONS ('WHITE GLUES')
Often used for convenience, especially on porous ceramics. Formula subject to change without notice, tend to give way in damp climates or storage. Form better optical bridge across cracks than solvent glues.

RESISTOL 850
Adhesive
Starch included in formulation; almost impossible to remove on fragile ceramics.

ELMER'S GLUE-ALL
Adhesive
It appears that the formula has been changed; this may now become irreversible.
Available in hobby shop.

LE PAGES BONFAST
Adhesive
Not very strong; very flexible (shards tend to sag); durability unknown.

BULLDOG GRIP WHITE GLUE
Adhesive, consolidant
Good working characteristics; dibutyl phthalate plasticizer; information on other additives not available; implication is that it should be fairly stable.
Supplier: Canadian Adhesives
420 Marcon
Montreal East, P. Q., Canada

PROMATCO A1023
Adhesive, consolidant
Vinyl acetate homopolymer; plasticized with dibutyl phthalate; 65% solids; 16,000-18,000 cps viscosity; emulsion; pH 5.6, protective colloid, stabilizing agents, dextan and added. Preliminary experience with promising; high strength adhesive, excellent aging characteristics claimed. Ivory colored paste; can be diluted to full-strength (e.g. with Japanese tissue fibres as reinforcement) will redissolve in cold water.
Supplier: Process Materials Corp
Carlstadt, New Jersey 07072, USA

EASTMAN 910
Adhesive
Cyanocrylate; appears to break down fairly rapidly; useful, like epoxies, in dots to hold heavy ceramics in place while other glues set.
Supplier: Eastman Chemical Prod. Inc., Chemicals Division
Kingsport, Tennessee 37662, USA
Armstrong Cork Co.
Kingsbury
London NW9, England

GE SILICONE RUBBER ADHESIVE
May remain too flexible, difficult to remove (requires hot water and force), primarily useful for modern wa which find their way into the laboratory; will withstand dish-washers.
Supplier: Canadian General Electric Ltd
Chemical and Metallurgical Section
1025 Lansdowne Avenue
Toronto, Ontario M6N 2C5, Canada
POLYFILLA
Calcium sulphate plus cellulose powder. Useful additive to plaster.
Available from hardware stores or: Niagara Chemicals, Burlington, Ontario, Canada

DENTAL PLASTER (calcium sulphate)
Available from dental suppliers.

MOULDING PLASTER (calcium sulphate)
Available at less cost from construction firms.

STAYBRITE COLOURS
Colours intended for tinting concrete; used with plaster
Supplier: W. R. Grace and Co. of Canada Ltd
Construction Products Division
Toronto, Ontario, Canada
(branches in Montreal and Edmonton)

GRUMBACHER POWDERED EARTH PIGMENTS
For tinting fillers and for final retouching
Available from art supply stores or: M. Grumbacher Inc.
New York, N. Y. 10001, USA
M. Grumbacher Inc.
723 King Street
Toronto 213, Ontario, Canada

HYPLAR ACRYLIC COLOURS
For retouching
Available from art supply stores or from Grumbacher.
EPOXY RESINS
Usually reversible by swelling in methylene dichloride, if pot geometry allows this; can be used where high strength is required (e.g. handles) to avoid need for Dowelling, or with filler as putty.

ARALDITE AY 103 with HARDENER AY 951 or AY 956
Supplier: Ciba (A.R.L.)
Duxford
Cambridge, England

EPO-TEK 301
Supplier: Epoxy Technology Inc.
65 Grove Street
Watertown, Massachusetts 02172, USA

DEVCON 5-MINUTE EPOXY
LE PAGES 5-MINUTE EPOXY
Results not entirely predictable.

EPOXY PUTTY
Convenient two-part paste system, excellent working characteristics.
Supplier: Ralph E. Baute (Manufacturer’s Representative)
143 Telford Road
Somerdale, New Jersey 08081, USA

POLYESTER RESINS
Can be excellent on heavy pots or where there are gaps between pots. Filled versions shrink less; may discolor slightly.

AKEMI TRANSPARENT
AKEMI ORIGINAL (filled)
Supplier: Jaeger and Condino Inc.
P.O. Box 592, 35-44 61st Street
Woodside, New York 11377, USA

SINTULIT TRANSPARENT STRAW
SINTULIT FILLED
Supplier: A. Pitani and Co.
41 14 Fifth Avenue
Brooklyn, New York 11212, USA
or:
Carrara Wharf, Ranelagh Gardens
London SW6, England

CAR BODY FILLER
Distributed nationwide in Canada by Canadian Tire Corp.

BONDAFILLA
Supplier: Bondaglas
55 South End
Croydon, Surrey, England

OTHER MATERIALS

DENTAL WAX (toughened)
Available from dental suppliers or.
Amalgamated Dental Co.
132 St Patrick Street
Toronto 2E, Ontario, Canada

PLASTICINE
Available from art supply or hobby stores.

ACRYLIC MODELLING CLAY
Considerable shrinkage; may be useful for succumbing cracks.
Available from art supply stores.

APPENDIX: ADHESIVES AND OTHER SUPPLIES FOR CERAMIC RESTORATION

A wide range of adhesives is used in conservation laboratories for different aspects of ceramic restoration. Ideally, a standard adhesive should satisfy several criteria: correct degrees of plasticity and viscosity for the work in hand, physical and chemical stability, rapid drying, reversibility. This last will affect the ease of removal of any excess adhesive, but reversibility itself will often depend on the type and condition of the individual pot.

NATURAL ADHESIVES

SHELLAC
Strong; darkens and embrittles with age. Becomes very difficult to remove; thick — often remains as a visible layer between joints; use of flame may singe pot or prejudice TL dating.

ANIMAL GLUES
Yellow; inconvenient to use; shrink, tend to embrittle in time.

CELLULOSIC SOLUTIONS

HMG (cellulose nitrate) adhesive
In general use: experience has shown it to be useful, durable, and lasting reversibility.
Supplier:  
Marcel Guest
Collyhurst
Manchester 9, England

AMBROID (cellulose nitrate) adhesive
Does not stick very well; amber colour may remain visible.
Supplier:  
Ambroid Inc.
Boston, Massachusetts, USA

DUCO (cellulose nitrate) adhesive
Dries quickly, also breaks down quickly, may exert contractile forces. Deficient in plasticizer?

UHU HART (blue tube) cellulose adhesive
Model makers' glue; very strong (has been used to mend an iron cauldron); quick-drying; ageing characteristics unknown.
Available from hobby shops.

HOME-MADE CELLULOSIC FORMULATIONS

As with consolidants, solvent combinations can be varied according to resin solubility, working characteristics desired, and ambient temperature and relative humidity.

CELLULOID (cellulose nitrate) adhesive
See Dawson [11] p. 71. Dissolve celluloid in acetone and amyl acetate (1:1); add dibutyl phthalate 0.5-1% v/v.

MOTORCYCLE WINDSHIELDS adhesive
Cut up and dissolve in acetone and alcohol. For emergency field use when no other supplies are available. Adhesion poor.

CELLULOSE DIACETATE adhesive
Less adherent than cellulose nitrates, but may be more stable; ethyl acetate is a good solvent. Suggested by Mr R. M. Ogden* (with note that adhesive plastecisers tend to be lost in time). Use diacetate, not mono-acetate; triethyl phosphate (5%) or dianethyl phosphate (20%) are recommended in this case rather than dibutyl phthalate. Incorporation of an acid acceptor (magnesium acetate 0.5%) is suggested, as is addition of a U.V. absorber (resorcinol benzoate or Tinuvin T). [4]

PVA SOLUTIONS

BAKELITE AYAF (V/5) consolidant, adhesive
BAKELITE AYAF (V/2.5) adhesive (somewhat brittle if used alone)
We have used the following with some success: 25% v/v PVA resin (equal parts AYAF and AYAT); 63% v/v methanol; 8% v/v ethyl acetate; 4% v/v acetone.