

DEUTSCHES ARCHÄOLOGISCHES INSTITUT
ABTEILUNG KAIRO

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1993

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DEUTSCHES ARCHÄOLOGISCHES INSTITUT
ABTEILUNG KAIRO

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An Introduction to Ancient Egyptian Pottery

FASCICLE 1

Techniques and Traditions of Manufacture in the
Pottery of Ancient Egypt

BY DOROTHEA ARNOLD

with contributions by
Paul Nicholson, Colin Hope and Pamela Rose

FASCICLE 2

Ceramic Technology: Clays and Fabrics

BY HANS-ÅKE NORDSTRÖM and JANINE BOURRIAU



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Fascicle 2

Ceramic Technology: Clays and Fabrics

by Hans-Åke Nordström
and Janine Bourriau

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Acknowledgements

Above all the authors wish to thank their collaborators, Dorothea Arnold, Manfred Bietak and Helen and Jean Jacquet, who helped formulate the classification of Egyptian pottery fabrics presented here. They also supplied most of the material upon which it is based, and particular thanks go to Dorothea Arnold, who provided many of the transparencies used in the colour plates.

David and Barbara Aston, Peter French, Colin Hope, Karla Kroeper, Paul Nicholson and Pamela Rose all contributed to the final version of the text; however, all errors remain the sole responsibility of the authors.

The following institutions and individuals allowed the reproduction of copyright material: Dieter Arnold (Map); Manfred Bietak (Pls. II i, III d,g-h, VI f); Egypt Exploration Society (Figs. 26, 30; Pls. I d, III b, IV c-d,g-i, V d,h-j, VI c,g-h, VII b,e-f, VIII a,c,e-i); Fitzwilliam Museum, Cambridge (Figs. 9-11,14-15,17-18,20-21,24; Pls. I a, IV a); French Institute of Archaeology, Cairo (Pls. II d, IV e, VII a); German Institute of Archaeology, Cairo (Pls. I b-c,e-h, II a-c,e-h, III a,f, IV f, V a-c,e-g, VI a,d,i); Louvre Museum (Fig. 28); Museum of Fine Arts, Boston (Figs. 16, 25, 27; Pls. III c, VI b, VII d); Pelizaeus-Museum, Hildesheim (Pls. III e, VII c); Petrie Museum, University College, London (Figs. 8, 12, 13, 19,

22, 23); Staatliche Sammlung Ägyptischer Kunst, Munich (Pl. IV b); Victoria and Albert Museum, London (Fig. 29).

This fascicle of the Introduction to Ancient Egyptian Pottery has required an unusually large number of colour plates in order to reproduce the Colour Atlas of Pottery Fabrics. The printing of these has been made possible by the generous support of the Volkswagen Stiftung and the expert skill of Herr Bache at the von Zabern Verlag. The authors' grateful thanks are also due to Dr. Günter Dreyer of the German Institute of Archaeology in Cairo and to Peter French who helped in innumerable ways in the final preparation of the manuscript.

Special thanks for their skill are due to the two photographers who produced most of the transparencies used in the colour plates, Dieter Johannes of the German Institute of Archaeology, Cairo, responsible for all those credited to the DAI Cairo, and Gwil Owen of the Department of Archaeology, University of Cambridge. Drawings were contributed by Malcolm Payne (Map and Figs. 1-7), Andrew Boyce (Fig. 25), Kathryn Eriksson (Fig. 26) and William Schenck (Fig. 30).

Introduction

Long before pottery was invented man must have been familiar with the basic properties of ordinary clays. Plastic clays were readily available in the ecological zones used most frequently by hunters, gatherers, fishermen and early farmers, i.e. around lakes and drainage systems, on alluvial plains and in maritime coastlands.

Some knowledge of ceramic technology was already displayed some 25,000 years ago, for example, at Dolní Věstonice in Moravia. At this site, Upper Palaeolithic hunters made figures of animals and voluminous women from a mixture of clay and powdered bone with a possible addition of animal fat, and this paste was subsequently hardened by fire.

The earliest pottery vessels were developed by people who based their economy on food storage and organized distribution. This required some form of sedentary life but not necessarily food production in its more

conventional form of animal husbandry, cereal agriculture and horticulture.

The Fukui cave of the earliest Jomon phase in Japan (ca. 10,000 B.C.; KIDDER 1977, 26f.), the Mureybet site in Syria (ca. 8000 B.C.; OATES and OATES 1976, 39), the Faiyum and Merimda sites in Egypt and the Early Khartoum site in the Sudan (ca. 6000-5000 B.C.; ARKELL 1949) are a few selected examples of localities where the earliest pottery production is attested in different regions of the Old World. It appears that different technologies and ceramic traditions were invented and developed independently in various parts of the world during the period between 10,000 and 5000 B.C. The parameters of this technological development are of course determined by the basic chemical and physical properties of the clays and ceramic materials available. These properties are outlined in more detail below.

1. General properties of clays and ceramic materials

The term *clay* may be applied to all fine-grained soils and rock materials which are hard and brittle when dry but have the ability to develop some degree of plasticity when mixed with appropriate amounts of water. It is rather difficult, however, to provide a short definition that covers all varieties and physical aspects of clays. Instead, the general properties of clays are considered, firstly from the geological and secondly from the ceramological viewpoint.

1.1 THE GEOLOGY OF CLAYS

The geologist may regard a clay from several aspects: texture, textural composition, formation, structure and age.

1.1.1 TEXTURE

The term *texture* refers to the size of the particles present in a soil. This property is a diagnostic feature. In nature, most clays contain particles of several different size groups or fractions - clay, silt and various groups of sand. In some clay formations even coarser size fractions, gravels, may be present in small amounts.

The size fractions and their definitions are summarized in Fig. 1. There is differing practice among scientists as regards classification and terminology of soil texture, but certain common standards have been worked out through field experience and theoretical research in sedimentology. The most common of these standards is presented here (cf. PETTIJOHN 1957, 16 ff., SHEPARD 1968, table 5, 118).

The upper limit of the particle size in the so-called clay fraction is usually set at 2 microns (1 micron = 0.001 mm). In practice this means that a clay particle cannot be seen with the unaided eye or felt by the fingers or between the teeth (geologists may sometimes perform this kind of testing).

A silt particle has a size ranging between 2 microns and 60 microns (0.002-0.060 mm). The coarser silt grains, i.e. around 50-60 microns, can be detected under a low-power binocular microscope or with a good x10 hand-lens, provided that the light is satisfactory. Silt particles develop a characteristic "silty" feel when rubbed between the fingers or between the teeth. The upper limit of 60 microns is not set arbitrarily but has some functional meaning.

A sand particle has a texture between 60 microns (0.060 mm) and 2.0 mm, ranging from very fine through fine, medium-textured, coarse, to very coarse (Fig. 1). Individual sand grains larger than 100 microns (0.1 mm) can readily be seen without a lens. Sand grains may vary greatly in respect of mineralogy, shape and degree of roundness.

Gravels are composed of particles larger than 2 mm (granules, cobbles and boulders, the latter being larger than 256 mm according to the grouping used here).

Some boundaries between the textural classes are important from a practical point of view, since they affect the physical behaviour of different soils. The dividing lines of 2 microns and 60 microns between clay/silt and silt/sand fractions respectively are relevant in this respect. Soils composed of particles coarser than 250 microns let water through to a much greater extent

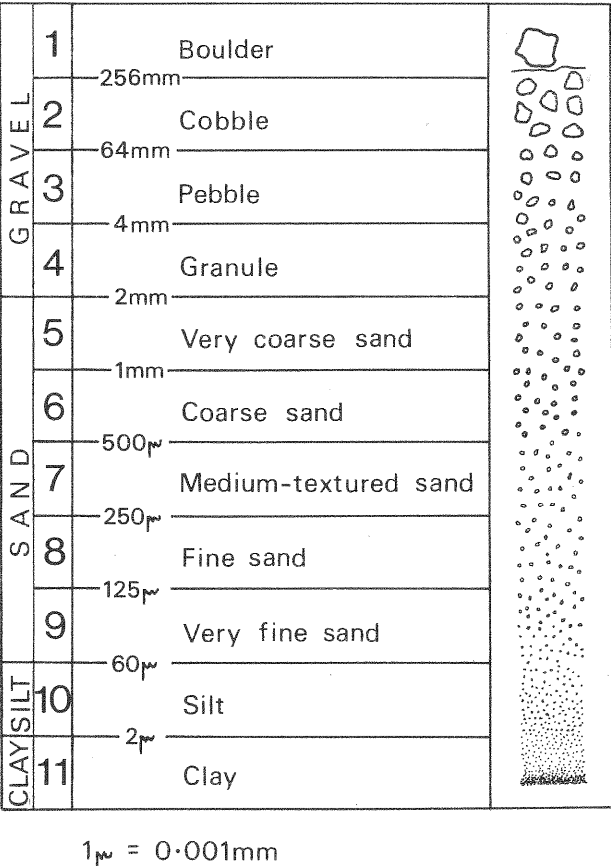


Fig. 1 Terminology and definition of size fractions (MALCOLM PAYNE after PETTIJOHN 1957, 19, table 5).

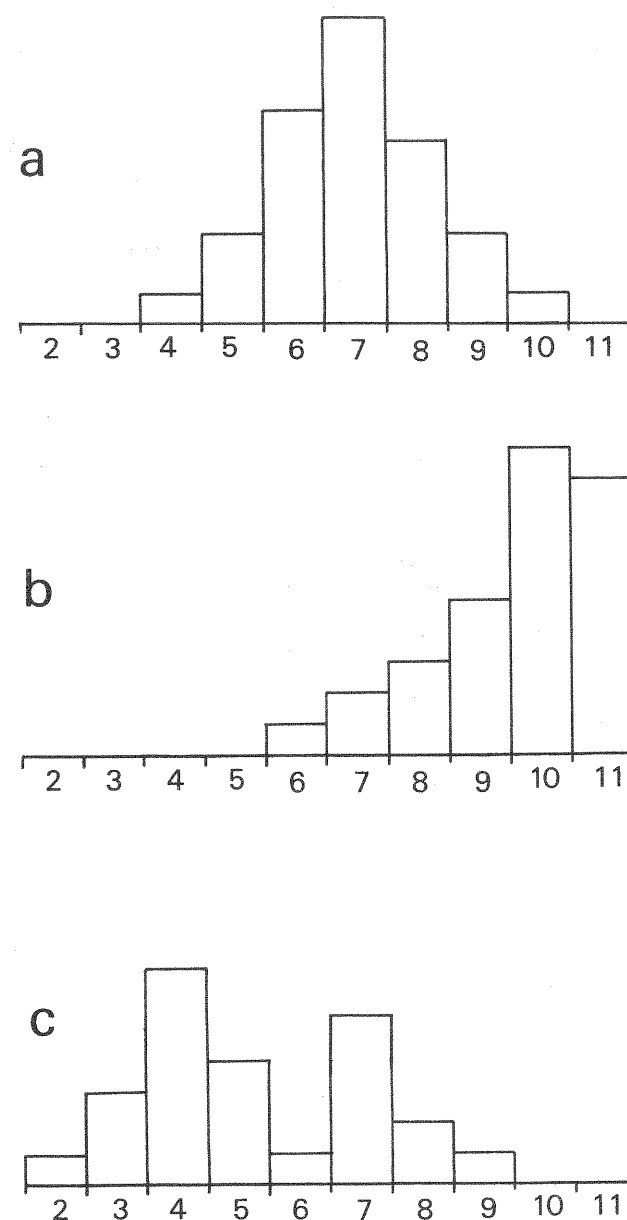


Fig. 2 Examples of texture distributions in soils. Numbered columns refer to size fractions shown in Fig. 1. (a) Unimodal: normal type with medium-textured sand (7) as the chief ingredient; (b) Unimodal but with a pronounced bias towards the finer fractions, silt (10) being the chief ingredient; (c) Bimodal: with two maxima (chief ingredients) in different size fractions, gravel (4) and medium-textured sand (7) (MALCOLM PAYNE after PETTIJOHN 1957, 35, fig. 19).

than the finer fractions. The capillary action of water in soils is practically negligible in fractions larger than 2 mm (gravels).

1.1.2 SIZE DISTRIBUTION AND TEXTURAL CLASSES

A soil assemblage is always composed of several size fractions. According to the modes of origin, formation and sampling, soils can display many different kinds

of sorting. Examples of common types of size distribution are shown in Fig. 2, a-c. Soils with only one maximum (chief ingredient of a specific fraction) are called unimodal. Sands often have an even, well sorted distribution of size fractions (Fig. 2a), while silts and clays may have a pronounced bias towards finer (or coarser) fractions (Fig. 2b). Gravels are often characterized by a bimodal texture composition with two maxima (Fig. 2c; cf. PETTIJOHN 1957, 34 ff.).

Most clay soils are composed of clay, silt and sand occurring in various proportions, the clay fraction forming at least 30–35% of the whole weight of each sample. The triangular diagram, Fig. 3, illustrates the various textural classes formed by these three components. The terminology used here conforms to the British System used by soil investigators in England and Wales (B.S. 1377; cf. LIMBREY 1975, 260 f., fig. 26a). The use of a three-component diagram is further illustrated in Fig. 4.

Practical tests on different soil types are useful in this context. A rich plastic clay can be rolled out into long, thin (1.5–2 mm) strings between the palms of the hands, while sandy or silty loams with a low clay content (5–15% clay) can form only relatively short, thick (3 mm) strings.

1.1.3 FORMATION OF CLAYS

It is common practice to differentiate between two major types of clay formation, residual and sedimentary.

Residual clays are formed *in situ*, usually by hypogenic actions, i.e. actions taking place at some depth below the surface of the earth – heat and corrosive chemical solutions are the chief agents in these processes. Residual clays may be difficult to reach without mining or advanced digging equipment.

Sedimentary or secondary clays are by far the most common and widespread. They have been transported and deposited in various ways through the action of water, ice or wind. SEARLE and GRIMSHAW (1960, 43 ff.) list six different classes:

- 1 Fluvial deposits, formed by sedimentation along the course of a river (if the river is large the deposits are called alluvial).
- 2 Glacial deposits, transported by large masses of ice.
- 3 Estuarine or deltaic deposits, found at the mouth of a river.
- 4 Lacustrine deposits, formed in freshwater lakes.
- 5 Marine deposits, formed in a sea or ocean.
- 6 Aeolian deposits, transported by air.

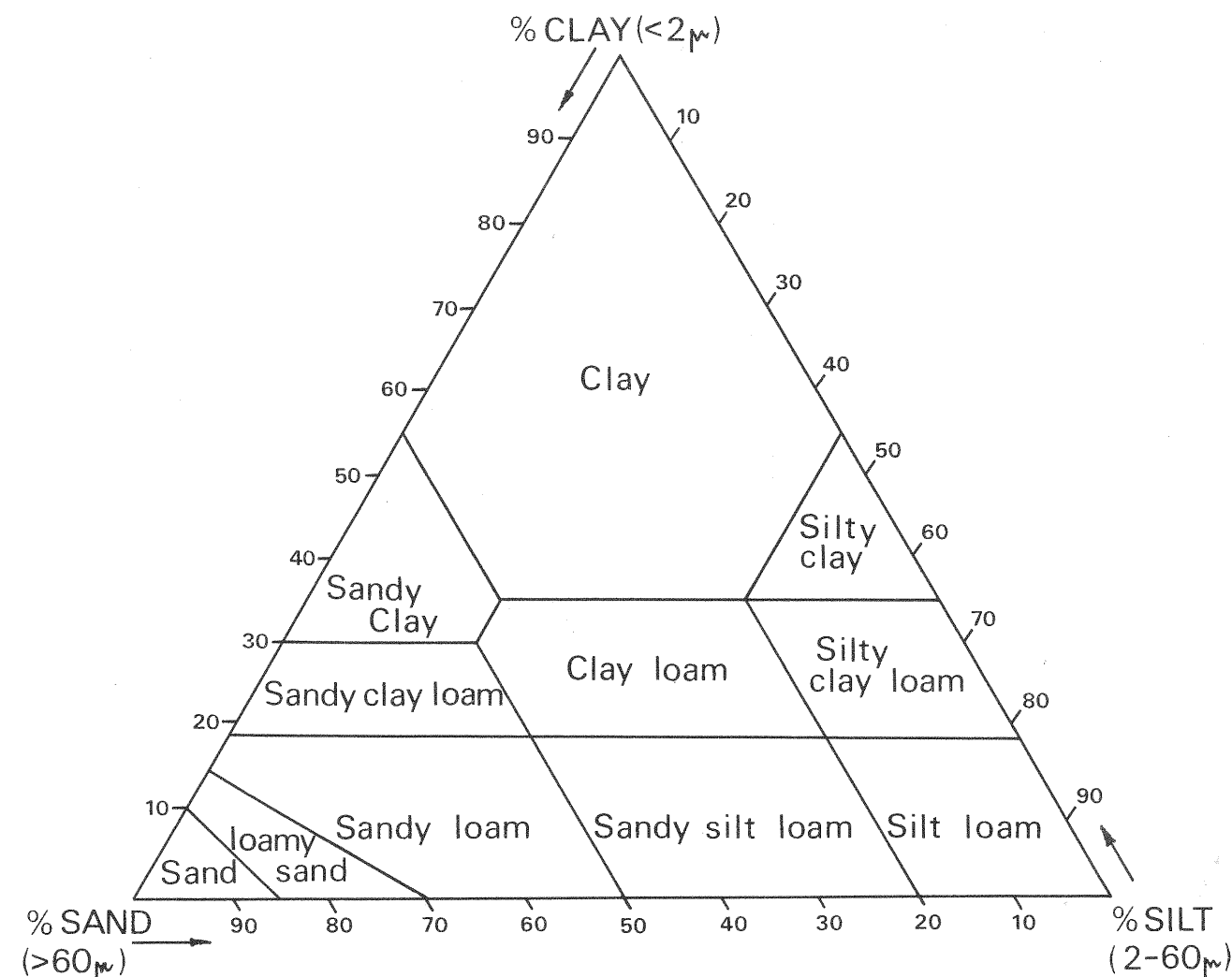


Fig. 3 Clay terminology and parameters according to the British Standard (MALCOLM PAYNE after LIMBREY 1975, fig. 26a).

1.1.4 STRUCTURE OF CLAYS

The environment in which clays aggregate (come together) and the manner in which they are deposited, as well as the subsequent geological history of the formation, are the principal factors which influence the structure of clays. Most clays found in nature are solid, but muds (often in a pasty form) and watery suspensions occur in some environments, for example along rivers and lake shores.

Most of the residual clays, and some of the sedimentary, form massive unstratified structures, often of a homogeneous character. These are today the most useful ceramic raw materials in the commercial pottery industry. Stratified masses are characteristic of sedimentary clays and may occur as dehydrated layers of mudstone or shale or as wet, plastic clays. Shales may sometimes develop an extremely flaky or laminated structure; these deposits are generally difficult to trans-

form into a homogeneous plastic paste suitable for pottery making.

1.1.5 AGE

As a decomposition product of rock material, clays have been formed during a major part of the earth's history and many of the important fire-clays and brick-clays originate from the Upper Palaeozoic and Mesozoic eras (400–70 million years ago) and the Tertiary period (70–3 million years ago). Some of the oldest of the preserved clay formations in Europe are associated with the Coal Measures of the Carboniferous period, which are 350 million years old (SEARLE and GRIMSHAW 1960, 45 and tables I–II; dates corrected according to HOLMES 1965, 156–157).

It is important to consider that many clays have been altered considerably through time, by, for example,

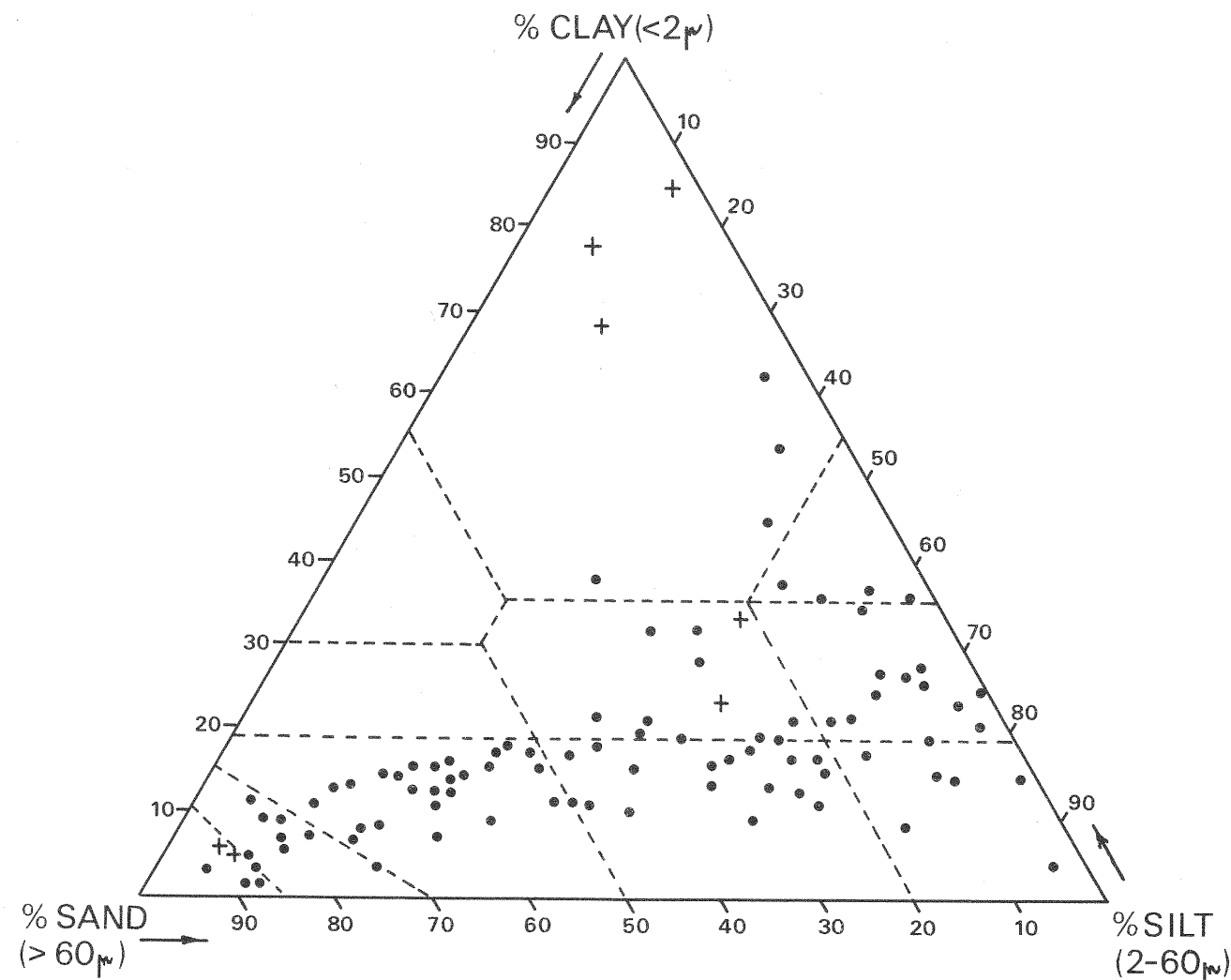


Fig. 4 Three-component diagram of soil textures in Lower Nubia (•) and Kurkur oasis (+) based on data in BUTZER and HANSEN 1968, Appendix A (MALCOLM PAYNE after NORDSTRÖM 1972, fig. 2).

numerous transportations and redepositions, folding, faulting and metamorphic processes. This applies also to the crystalline structure of one of the major components of clays, namely the clay minerals (cf. GRIM 1953, 356 f.).

1.2 THE PROPERTIES OF CLAYS IN RELATION TO POTTERY MAKING

From a ceramological point of view, clays are mainly considered in respect of certain physical properties such as plasticity, shrinkage, firing colour, hardness and porosity. A basic understanding of these properties can be acquired by studying the mineralogical and chemical composition of the clay mixtures used by potters.

A plastic clay is principally composed of three kinds of material:

Clay minerals form an important component. They consist of crystal fragments of hydrated silicates of aluminium, magnesium and iron and the fragments are generally much smaller than 0.001 mm.

Water in different chemical forms is an essential part.

Non-plastic inclusions of various kinds make up the third category.

1.2.1 CLAY MINERALS

The ultimate particle in most of the clay minerals is a crystal. The crystal is in turn built up of identical unit cells or layers, characterized by their chemical composition and by the inter-atomic arrangement within the lattice.

The principal clay minerals may be divided into four groups on the basis of their structural qualities (GRIM 1953, 27 ff.):

- 1 The kaolinite/halloysite group, including kaolinite, nacrite and halloysite, in which the crystals are built up of two-layer units consisting of one silica sheet co-ordinated with aluminium and hydroxyl ions.
- 2 The montmorillonite group in which the units are made up of a three-layer structure of silicon-oxygen linked with hydroxides of aluminium, magnesium or iron. The lattice can be expanded by water, which is able to penetrate between the layer units of the crystal.
- 3 The mica group (illite, hydrous micas), in which the basic structure is similar to that of the montmorillonite group. The lattice cannot be expanded by water. The unit cells are held together by potassium ions.
- 4 The chlorite group, characterised by a three-layer structure, in which the lattice is held together by sheets of magnesium hydroxide (brucite) or substitutes for these.

Common to all clay minerals is their softness, an often distinct cleavage pattern along the basal planes of the unit layers, and a significant reluctance to form large crystals, all of which may be explained by the weakness of the inter-atomic forces holding the crystals together (EVANS 1964, 255). A crystal of a clay mineral is rarely larger than 2 microns (0.002 mm).

Another property of importance to ceramologists is the cation exchange capacity of the clay minerals. The term refers to positively charged cations (for example, hydrogen H^+ , calcium Ca^{++} , magnesium Mg^{++}), which are often attracted to the external faces of the unit cells of the clay minerals. These ions can be exchanged with other cations in a solution – for example, calcium may replace magnesium. This reaction usually has no effect on the internal structure of the unit cell, but it has a certain bearing on the physical properties, such as plasticity and “green” (mechanical) strength, of the different clays. The montmorillonite clays, which are usually very plastic, generally have a high cation exchange capacity, while the less plastic kaolinite has a low one. Halloysite and illite clays seem to be intermediate in behaviour (SEARLE and GRIMSHAW 1960, 264 ff.).

1.2.2 CLAY, WATER AND PLASTICITY

The size and shape, the relative surface area and the chemical composition of the clay minerals including the exchangeable ions on the surfaces of the unit cells are all factors of fundamental importance as regards the properties developed by a clay suspension and by a plastic clay.

Due to their size, a large percentage of the clay minerals falls within the colloidal size fraction, i.e. between the submicroscopic and molecular ranges (between ca. 1 millimicron and 5 microns). A clay substance that is made up of particles of colloidal size is readily dispersed in a liquid medium, such as water. These colloidal particles are charged, and the charge their surfaces display is high in relation to the particle size. If all the particles have a similar charge they will repel each other, which will cause them to move about continuously in the dispersion liquid (Brownian movement). Thus, under stable conditions they will remain in suspension for an indefinite period.

A clay suspension may ultimately coagulate and settle to form a jelly-like mass called a gel. Such a gel displays some properties that are believed to be closely related to those developed by a plastic clay (SEARLE and GRIMSHAW 1960, 437 f.). The water related to a plastic clay belongs to three principal groups:

- 1 Combined water and hydrate water – chemical components in the form of hydroxyl units of the crystalline structures, which make up the clay minerals.
- 2 Adsorbed water – attracted to the surfaces of the clay minerals due to negative charges developed at the external faces of the crystals and at the fractured edges of the unit cells.
- 3 Free water – occurring in the pores and on the surfaces of the clay body.

The water molecules that are adsorbed into the surfaces and edges of each crystal fragment of the clay minerals will arrange themselves in layers of a more rigid configuration than that displayed by free liquid water. The clay particle and its shell (hydrosphere) of oriented water form a unit cell called the colloidal micelle, held together by inter-molecular charges that are most strongly developed at the surface of the solid.

Optimum plasticity of a clay mass will result when the largest possible quantity of oriented water is adsorbed by the hydrospheres. The micelles will tend to cohere and the combined cohesive forces between them will be large enough to prevent disruption of the clay. The solid particles may, at the same time, change position in relation to each other, due to a lubricant effect developed by water molecules with weak configuration in the outermost layers of the micelles.

From this it follows that the clay material can retain its optimum plasticity only within a narrow range of the clay/water ratio. A fully plastic clay has no sticky surfaces, i.e. the clay particles will not adhere to the fingers when the clay is kneaded, because all the water is employed. Water added in excess of that attracted by the hydrospheres will tend to cause stickiness. Viscous flow of the clay will develop at an increased rate, when the amount of excess free water separates the individual particles to such an extent that the potential bonding

forces between the micelles have only limited effect. On the other hand, when the water content is lowered below the point required for optimum plasticity, the hydrospheres will become thinner, with a resulting increase in the cohesion and rigidity and a decrease in the deformability (SEARLE and GRIMSHAW 1960, 416 ff.)

1.2.3. NON-PLASTIC COMPONENTS

Both residual clays (formed *in situ*) and secondary (transported) clays are made up of various compounds occurring in the free state or chemically combined with the clay minerals described above. The minerals and the organic compounds in the free state do not usually possess the properties of clay minerals within the colloidal size fraction and are therefore termed non-plastics. They display a wide range of shape, roundness and size, all factors that are dependent on the mineralogy and the provenance of the material, and the length and duration of the transportation prior to the sedimentation process (PETTIJOHN 1957).

The main forms of the non-plastics naturally occurring in clay sediments are as follows:

- 1 Quartz and related silica compounds. These have a reducing influence on the plasticity and shrinkage of practically all clays.
- 2 Feldspars. Usually more common in residual clays than in transported secondary clays.
- 3 Micas. Occurring in secondary clays. The main forms of mica are muscovite and biotite.
- 4 Iron compounds, chiefly oxides and hydroxides. The iron hydroxide, limonite, is very common in secondary clays, often finely disseminated in the material.
- 5 Calcium and magnesium compounds, mainly carbonates (calcite, dolomite) and sulphates (gypsum, anhydrite). The amount of carbonate is significant in marls, which may be formed in contact with limestones or as a result of precipitation.
- 6 Soluble salts, mainly sodium chloride (rock salt), sodium sulphate and potassium sulphate.
- 7 Organic matter, an important constituent of most secondary clays.

The heavy minerals, with a specific gravity greater than 2.85, form another group of importance for the study of different sedimentation phases. They occur in very small amounts, usually less than 1%, in most clays. Common minerals of this group are tourmaline, zircon, rutile, garnet, kyanite and hornblende (PETTIJOHN 1957, 129–130).

The presence of trace elements, occurring in minute amounts absorbed into the sedimentary minerals, is of great significance in the study of argillaceous deposits. Since these elements may be present in different proportions in different environments and may occur in the raw clay in about the same proportions as in the

corresponding ceramic product, it is possible to relate certain pottery fabrics and wares to specific geographic regions (MASON 1952, table 21, 171–174; cf. the analytical method [Neutron Activation Analysis] worked out by PERLMAN and ASARO [1970]. For its application to the Vienna System classification, see BELLIDO ET AL. forthcoming).

1.3 CHANGES AT ORDINARY TEMPERATURES

The drying process of a wet clay body can be divided into two stages.

During the first stage most of the free water and some of the water adsorbed around the clay particles is driven off at a fairly constant rate. The shrinkage which is the result of this process usually varies between 5 and 15%. A "critical point" is reached at the end of this drying stage, when the clay particles touch each other and the water begins to evaporate only through capillary pores. The amount of water then is about 7–10% of the fully dried weight. This point is called the leather-hard stage, which is of great importance for all pottery production. Modifications of the vessel shape, such as fitting different parts together and application of handles, spouts, knobs etc., are usually made at this stage. Furthermore, most of the surface treatments employed in antiquity, such as polishing, coating and decoration, were carried out during this phase.

The second and final drying stage is a rather slow process during which most of the adsorbed water evaporates. Shrinkage is usually limited. At the end of this stage the clay body is fairly hard and brittle, and the remaining water is confined to isolated pockets in the mass (SEARLE and GRIMSHAW 1960, 507 ff.).

1.4 CHANGES AT HIGH TEMPERATURES

When a clay is heated at temperatures above 100°C the materials present are subject to both physical and chemical changes, which are either permanent or reversible.

The free and adsorbed water which is still retained after drying evaporates in the temperature range from about 100° to about 150°C. In montmorillonite clays the interstitial water may be held until ca. 300°C. This exposure to high temperature permits a continuation of the drying process which takes place at an ordinary temperature.

The combined water, made of hydroxyl groups, which form a part of the clay mineral structure, is driven off in the temperature range between about 400° and 800°C. This latter process, dehydration, leads to a permanent and irreversible destruction of the plastic

properties of the clay, which then becomes a solid ceramic material. A phase of rapid dehydration, accompanied by shrinkage, occurs at temperatures that vary for the different clay minerals. The mean temperature for kaolinite is about 500°–550°C, for montmorillonite ca. 700°C, for illite ca. 600°C (GRIM 1953, 212–235).

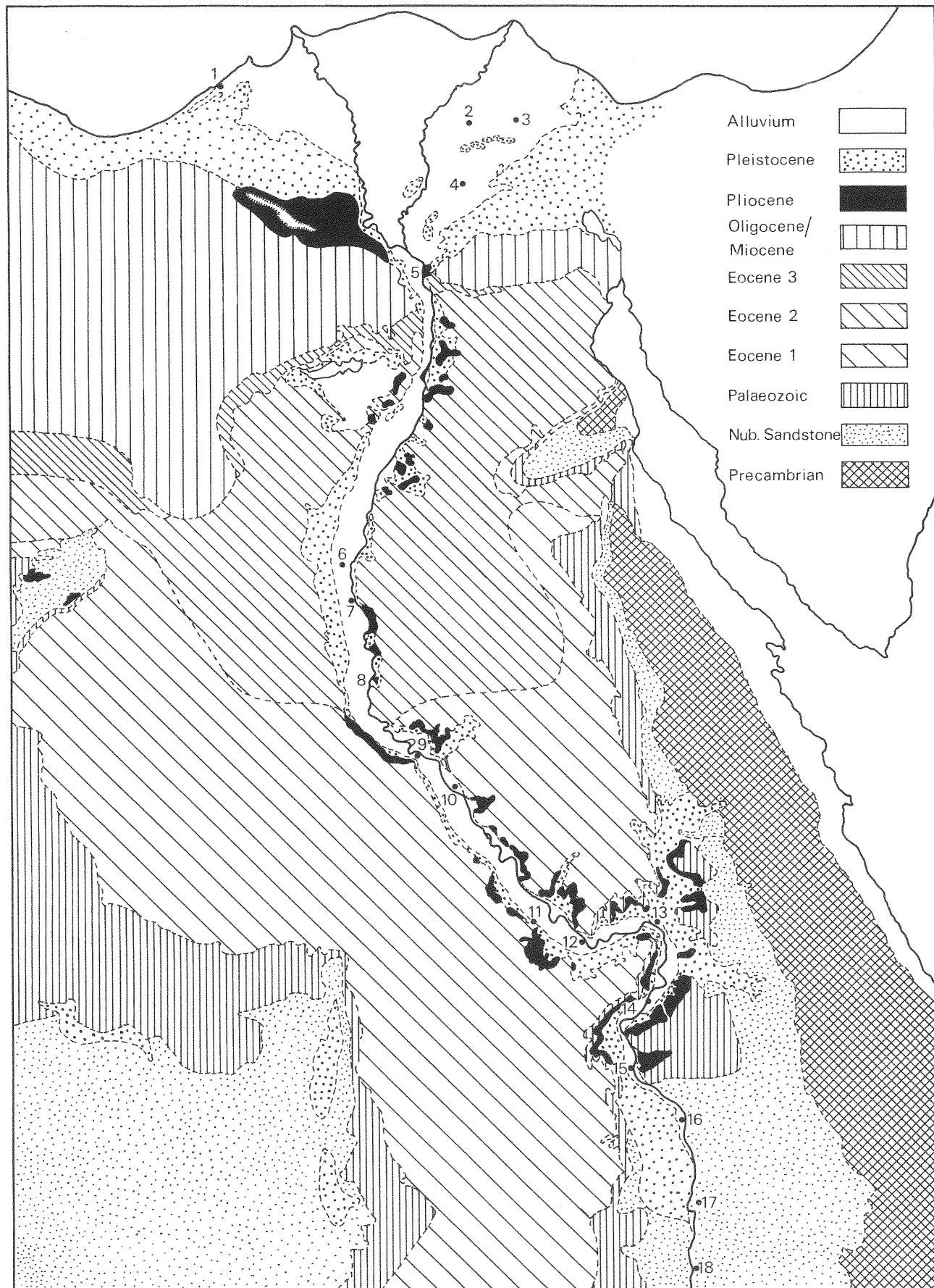
At higher temperatures, generally from about 900° to 1500°C, the clay material goes through complex structural changes, usually accompanied by a vitrification (glass formation) process, followed by a complete softening and melting. Of the non-plastic inclusions, quartz and feldspar change little externally at temperatures below 1000°, which is the upper firing limit for most ancient or primitive pottery. Muscovite mica and other hydrated silicates, such as serpentine or chlorite, lose most of their hydroxyl groups between 600° and 900°C, a process which is sometimes accompanied by structural alterations.

Hydroxides of iron (goethite, limonite), very common constituents of most clays, are dehydrated at temperatures between 300° and 400°C, forming ferric oxide in an oxidizing atmosphere. Limestone inclusions, such as carbonates of calcium and magnesium, are rapidly decomposed in the temperature range of about 800°–

900°C (ca. 880°C for pure calcite). Combustion of organic matter takes place in an oxidizing atmosphere at temperatures between 380° and 600°C (MACKENZIE (ed.) 1957).

The basic colour of a ceramic material which has been fired at temperatures between about 500° and 1000°C is largely dependent on three main conditions: (1) the amount, particle size and dispersion of iron oxides, calcium carbonate and organic matter, (2) the firing temperature, and (3) the kind of atmosphere dominating in the final stage of the firing. The atmosphere is related to the type of fuel, the kiln construction and the manipulations of the potter himself. A surplus of oxygen constitutes an oxidizing atmosphere. Hydrogen, carbon monoxide and sulphur dioxide are reducing agents, and a surplus of one or more of these develops a reducing atmosphere.

In primitive firing, without special kiln constructions, the atmosphere may change rapidly during the heating procedure, being reducing, oxidizing or neutral at different stages. Reducing conditions are, on the other hand, difficult to retain for a long period of time in primitive kiln structures (SHEPARD 1968, 220; LUCAS 1962, 375 f.).



Map showing the geology of the Nile valley.

1: Alexandria 2: Mendes 3: Tanis 4: Bubastis 5: Cairo 6: Samalut 7: el-Minya 8: el-'Amarna 9: Asyut 10: el-Badari 11: Abydos 12: Nag' Hammadi 13: Qena 14: Thebes 15: Esna 16: Edfu 17: Kom Ombo 18: Aswan

(Drawn by MALCOLM PAYNE after original by DIETER ARNOLD in DO. ARNOLD ed. 1981, 175, fig. 1).

2. Clays of the Nile Valley

The various ceramic wares produced in ancient Egypt display a complete technical range from low-fired, porous varieties to high-fired, dense fabrics with signs of incipient vitrification. The principal dividing line runs, however, between two ceramic families:

- 1 Pottery made of alluvial clays (Nile clays) rich in oxides of iron and organic impurities. The colour turns into a strong reddish-brown or dark brown when the firing temperature reaches the range between 1000° and 1100° C.
- 2 Pottery made of calceo-ferruginous clays (marls) with a high content of calcium carbonate and with additions of finely disseminated iron oxides. The colour turns into a pale grey or greenish-grey when the firing temperature reaches the same range as indicated above, and the clay softens and melts in temperatures not far above 1100° C.

To understand these basic differences we must now turn to the geology of the Nile valley and, more precisely, to the formation and structure of the old marls and the much younger alluvial sediments.

Below, there is a brief summary of the geological background to the various clay formations along the Nile, with emphasis on the Egyptian part of the Nile valley. For more detailed information the reader is referred to the standard geological text-books in this field (e.g. SAID 1962; BUTZER and HANSEN 1968; ABU AL-'IZZ 1971; EL-BAZ 1984).

2.1 GENERAL GEOLOGICAL BACKGROUND

The most prominent rocks and soils in Egypt originate from five principal groups of formations. The first four are:

- 1 The igneous and metamorphic rocks of the basement complex (granites, gneisses, etc.).
- 2 The sedimentary formations mainly of marine or estuarine origin (sandstones, limestones, shales and mudstones).
- 3 Pliocene deposits of estuarine and fluvial origin (clays).
- 4 Alluvial and fluvial formations connected with the drainage system of the Nile including the wadis (clays, silts and gravels).

These four are all of significance as regards the development and composition of the various clay deposits occurring in the Nile valley.

The fifth is the sand, mainly of aeolian origin, which covers the western plateaux and the wadi bottoms on both sides of the valley, sometimes accumulating into impressive dunes.

The spectacular Egyptian landscape that we admire today is the outcome of geological processes which evolved during an enormous time span – this is summarized on the diagram, Fig 5. Between the origin of the Precambrian basement complex and the formation of the Nubian sandstone in the lower Cretaceous period there are more than 500 million years. The sandstone is in turn more than 70 million years old.

2.1.1 THE BASEMENT COMPLEX (PRECAMBRIAN)

In Egypt the Precambrian rocks form the basic structure, an old, worn down block, cracked up by various faults, sloping slightly towards the north. On top of this block all other formations are deposited. The beautiful granitic outcrops in the Aswan area are visible parts of this block.

The oldest rocks of the complex are made up of hard granites, gneisses and schists, the latter transformed by metamorphism from granites of various kinds. Somewhat younger are the dense, basic, igneous rocks, e.g. diorite, which are thought to be intruded into the gneiss-schist complex.

A still later member of the basement complex is the igneous intrusions of granite forming the rugged peaks of the Red Sea mountains which reach a height of more than 2000 m above sea level. The mountains seen today are the result of a strong uplift during the Pliocene period, three million years ago. In the mountains there are volcanic dykes in which intrusions of igneous rock have been brought to the surface, e.g. basalt.

The igneous rocks contain rich resources of minerals, metal ore (such as gold, silver, copper and iron) and materials used in buildings, sculpture and other objects (marble, porphyritic rock, etc.). Both the igneous and the metamorphic rocks of the basement are important in the development of the clay minerals occurring in the Nile valley, such as kaolinite and illite.

2.1.2 THE SEDIMENTARY FORMATIONS (CRETACEOUS-MIOCENE PERIODS)

When the sedimentary rocks were deposited from the Cretaceous to the Miocene periods (100 to 38 million years ago), North Africa, the Mediterranean basin and part of S W Asia were covered by a vast sea which advanced its shores over the old and much eroded rock surface that formed N E Africa. The Tethys sea, as it is called, was shallow, fairly warm and rich in faunal life, including molluscs and shellfish of various kinds. The deposits that grew on top of each other along the shelves and in lagoons and bays on the Tethys coast are as follows:

- 1 Nubian sandstone of lower Cretaceous age (100 million years ago) consists of well stratified and variegated rocks accumulating to a thickness of up to 500 m. It now covers the basement complex throughout most of the land except the highland area between Korosko and Aswan and the Red Sea mountains (see Map). The rock is visible in the southern part of the western desert, in the el-Kharga oasis, and in the eastern desert along the western side of the mountains. It dominates the landscape in Lower Nubia.
- 2 Sediments of Upper Cretaceous and Palaeocene age consist of chalk, calciferous shales and mudstones (marls) lying on top of the sandstone – they are called the Quseir variegated shales, the Phosphate formation, the el-Dakhla shales, and the Esna shales. They are visible today in the southern part of the western desert, in the el-Kharga region, and below the limestone cliffs on the west bank in Upper Egypt. On the east bank there is a large plateau to the east of Esna and large outcrops to the east of Qena (see Map). Shales are found between Qena and Nag' Hammadi and along the west part of the sandstone bordering the Red Sea mountains in the north.
- 3 Eocene formations consist mainly of limestone, some having intercalations of shales and solid, calcareous clay (mudstone). There are three major deposits of the Eocene, the oldest and lowest being the Theban formation that dominates the southern part of Egypt from a line drawn to the north of Asyut (see Map). The middle and upper formations of this period are called the Lower Mokattam and the Ma'adi respectively, and are mainly visible on the west bank in the Dahshur-Cairo region.
- 4 Oligocene formations, called the Qatrani, consist of limestone with inclusions of shale. During the Oligocene the sea coast was located on a line running to the north of the Faiyum depression to Dahshur and the N slopes of the Mokattam hills. Numerous volcanic dykes with basalt have been recorded from this period along the Oligocene coastland. This period is also characterized by conspicuous faulting

and uplift of the Egyptian land, especially in the eastern part where the mountains and the Red Sea depression were beginning to be formed. This uplift, together with increased rainfall, also promoted the development of the pre-Nile drainage pattern of this corner of Africa; numerous streams, of which the Wadi Qena was the most important, were connected into a branch-like system which cut its way down into the soft sedimentary rocks.

- 5 The Miocene limestones are the youngest of the sedimentary rocks in Egypt. They are found in Lower Egypt to the west of Cairo, extending into the western desert, and between Cairo and Suez (see Map). In all probability they underlie the Pleistocene and recent deposits of the Delta and along the Mediterranean coast. In any case the entire Delta was under the sea during Miocene times, 38 million years ago.

The movements of the crust continued – the mountains in the east were building up and the Red Sea sinking. Concurrently, the drainage and the erosion of the soft rocks, especially of the eastern desert, was intensified: thus the embryo Nile was created.

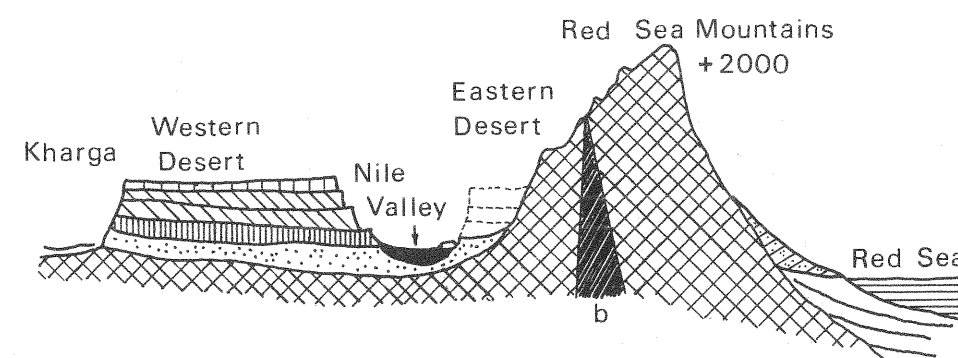
2.1.3 THE PLIOCENE FORMATIONS

During the Pliocene at the end of the Cenozoic era (the Tertiary, Fig. 5) the sea advanced again into Egypt, this time forming a narrow, deep bay that penetrated into the present Nile valley, up to the latitude of Kom Ombo. In this bay Pliocene deposits were formed, usually fine-grained sediments including plastic clays. These are visible today as numerous dissected remnants on the flood-plain of the Nile, adjacent to the sedimentary rocks, from Esna in the south to Cairo in the North. A large formation lies to the northwest of Cairo and some deposits of these plastic clays are found in the oases, for example at el-Kharga.

During the end of the Pliocene the marine bay disappeared due to new crustal movements in the area. The Red Sea mountains were raised up to a level of 2000 m. During the subsequent rearrangement of the local drainage system the present course of the Nile was formed. It was in its youth a local river, with its sources in the Sudan, which began cutting, in a south-north direction, through the sediments and erosion materials that filled the former estuary.

2.1.4 THE PLEISTOCENE AND HOLOCENE (THE QUATERNARY ERA)

This era, which is characterized by several ice ages and interglacial periods in the higher latitudes of the earth, started *ca.* one million years ago. The Nile, supported by



Geological framework			Major geological features in the Nile valley	Major clay formations
Million years before present	Quaternary	Holocene	Sand Alluvium and wadi formation	•Upper alluvium (Nile clay) •and Wadi clays (e.g.Qena) •Lower alluvium (Nile clay)
		Pleistocene		
	Cenozoic	Pliocene	Estuarine formation	•Pliocene "plastic clays"
		Miocene	Limestones with shales and clays	•Marl clays from limestone and shale formations
		Oligocene		
		Eocene		
		Palaeocene		
Mesozoic	Cretaceous	Shales (Quseir-Esna) Nubian sandstone	•Aswan clays in and under Nubian sandstone	
	Jurassic			
	Triassic			
Palaeozoic	Permian			
	Carboniferous			
	Devonian			
	Silurian			
	Cambrian			
Precambrian	Basement complex			

Fig. 5 Geological features of the Nile Valley and their date before present (MALCOLM PAYNE after diagram by HANS-ÅKE NORDSTRÖM).

numerous streams draining off the western side of the Red Sea mountains, continued its down-cutting through the limestone, shales and underlying sandstone layers. In the valley a canyon-like landscape was formed with prominent terraces intersected by various khors cut by the tributaries. The sediments along the river were generally of coarser fractions – the calm lagoonal waters needed for deposition of clays were evidently rare on the floodplain but could have developed in the Delta area, which was building up at this stage.

The present Nile was created during Upper Pleistocene times, when it was linked up with the Ethiopian and East African sources and drainage systems through the Blue and the White Niles and the Atbara river. After this linkage there followed a long period of aggradations and recessions of the river and various stages of wadi activity, all dependent on the rainfall regimes in Ethiopia and in the Red Sea mountains. This resulted in a complex series of fluvial formations of local and southern sediments along the flood plain of the Nile, in the lower parts of adjacent wadis and in the Delta.

The modern flood plain started to build up during the third millennium B.C., when the general parameters for the present climate were set: a river flowing through a fertile valley in an arid land, receiving the bulk of its water, especially during summer and autumn, from the Ethiopian highlands and only occasional torrents through some of the larger wadis in the eastern desert. Considerable amounts of sediment are transported along the valley and across the desert land through the action of water and wind. The climate regime of the Mediterranean basin, with some rainfall during the late autumn and winter, is however an influential factor in the Delta.

2.2 CLAYS USED FOR POTTERY MAKING IN EGYPT

A common opinion among Egyptologists in the past has been that the pottery clays used in ancient times originate either from the Nile mud or, as regards the marls, from a few special localities and pottery centres in Upper Egypt, namely Qena, Deir el-Ballas and Sohag (cf. REISNER 1923, 320–322; LUCAS 1962, 368).

This concept is now being changed due to a more comprehensive understanding of the geology of the Nile valley (see Map), combined with a more detailed study of ancient pottery fabrics and the various clays which are used today and could have been used in antiquity (cf. SAID 1962; BUTZER 1974; TOBIA and SAYRE 1974; RIEDERER 1981; DO. ARNOLD 1981; BRISSAUD 1982).

The most important of these clay formations, or groups of formations, are listed below, in roughly chronological order:

- 1 Kaolin clays occur in connection with Nubian sandstone and the basement rock, for example at

Aswan. Their dry colour is grey (MUNSELL 5YR 6/1). They contain finely disseminated hydroxides of iron and evidently no calcium carbonate (they show no reaction to HCl tests), firing to a light red or red colour in an oxidizing atmosphere. They appear to have been used from the Late Period onwards. Some red or whitish mudstone is also found in the Sudan in connection with Nubian sandstone, e.g. in the Shendi-Atbara reach. It may belong to this category and was possibly used for the light red or buff Meroitic fine wares.

- 2 Egyptian marl clays are found along the river valley between Esna in the south and the Cairo region in the north, and also in the oases to the west of the Nile. They originate in various calciferous shales and mudstones that were deposited together with the limestones between Upper Cretaceous and Miocene times (100–38 million years ago). Their dry colour is shades of grey. They have conspicuous amounts of calcium carbonate (always positive reaction with strong effervescence when tested with HCl), while the silica content is generally lower than in the Nile alluvial clays (see below). As a rule there are inclusions of finely disseminated oxides of iron, always in smaller proportions than the calcium carbonates. Organic material is generally absent in the raw clay. Foraminifera may be detected in thin-sections. Most of the marls fire to a pale red ('pink') or pale-to-light grey colour in an oxidizing atmosphere. They may become red (MUNSELL 10R 5/6) but never dark reddish-brown in an ordinary firing at temperatures above 800°C. They melt at temperatures not far above 1100°C, usually developing a greenish-grey colour. Egyptian marl clays were used from Predynastic times (Naqada II) onwards for both open vessels and storage jars.
- 3 Pliocene clays were deposited at the end of the Tertiary (3 million years ago) and occur today in dissected patches of fine-grained sediments between Esna and Cairo and also in the oases, for example at el-Kharga. The relationship between these clays and the ancient pottery is as yet unclear.
- 4 Nile alluvial clays were deposited on the floodplain in the Sudan and in Egypt during Upper Pleistocene and Holocene times. They usually have a fairly high content of silica and of finely disseminated hydroxides of iron. Mica and organic matter, including small, fragmentary plant material, are also significant constituents. The textural composition may vary according to deposition, from silty to very fine, with a high clay content (see Fig. 4). The Nile clays always fire to a reddish or brownish colour in an ordinary oxidizing atmosphere. Unlike the marl clays mentioned above, they always develop a dark red to very dusky red or dark reddish-brown colour (MUNSELL 10 R 5/2 to 2.5 YR 5/4) when fired at

temperatures of about 1000°C. At that temperature they may display signs of incipient vitrification and they probably melt in the range between 1100° and 1200°C. Nile clays were used for pottery making from prehistoric times (Faiyum Neolithic and Khartoum Mesolithic) onwards.

- 5 Mixed secondary deposits may occur along the flood-

plain, especially in Egypt. One such is the so-called Qena clay in Wadi Qena which is used by local potters today. BUTZER (1974, 377 ff.) has shown that this clay is not a typical marl but rather a later secondary deposit of washed-down and mixed sediments in which calceo-ferruginous marl is a constituent.

3. Ancient Egyptian pottery fabrics

The scope of pottery production in ancient Egypt must have been enormous, almost beyond imagination, even if we consider only the chronological range from prehistoric times to the end of the New Kingdom. Behind this production there was a complicated interplay of various social and economic factors. Variations, improvements and innovations were made within parameters established by material resources, technical conceptions, functional and social requirements, and aesthetic, religious, traditional and commercial demands.

The raw materials were generally of excellent quality and all the basic technical knowledge of clay treatment and firing had already developed by Late Predynastic times. The ability to transfer accumulated ceramic knowledge from one generation to the next was facilitated to a considerable extent by the traditional structure of society.

One would expect, therefore, that long-lasting conservative lines of development would be discernible in the technological data displayed by Egyptian pottery. The identification of these lines is essential for the understanding of the evolution of vessel shape, decoration and style.

Consequently, one important task for students in this field is to define the range in time and space of such technological trajectories, that is, the beginning and the end of a specific ceramic tradition in a given area.

A necessary preliminary to this work is the classification of ancient Egyptian pottery fabrics and a framework for it is presented here. What follows is essentially an enlargement of the brief description given by NORDSTRÖM in the *Lexikon der Ägyptologie* under "Ton", Band VI, 631-634.

3.1. THE FABRIC CONCEPT

3.1.1 DEFINITION

The term *fabric* was introduced by ADAMS (1962, 247) in the context of his classification of Nubian pottery, and it may be defined as a group designation for all significant physical and chemical properties of the clay and the non-plastic inclusions in a fired ceramic material, as well as all relevant technological features of the finished product (NORDSTRÖM 1972, 40). In this case the relevant technological features are taken to be firing

conditions and thickness of the vessel wall. One may add to the definition above that it is important to differentiate between the natural clays on the one hand and the potter's paste on the other. The latter is a product of the technological requirements and the ceramic tradition of the potter. *Paste* is a term for the plastic material from which the pots were made. Important constituents of a paste are the non-plastic inclusions, of mineral or organic origin, that the potter added in the form of a temper in order to improve the workability and strength of the clay and to reduce the shrinkage during drying and firing. The most common tempering materials in ancient Egypt were sandy soil, crushed limestone, ashes, cattle dung and straw. A further addition to the basic clay could be another clay having a different texture - mixtures of this kind have been attested by studies of modern potteries in Egypt (BRISAUD 1982). They are difficult to detect in a well-kneaded paste but were probably more common in ancient times than anyone has thought till now.

3.1.2 ANALYTICAL METHODS

The grouping of the fabrics is based on the study of freshly made fractures of numerous sherds selected from different sites and archaeological contexts in Egypt. A low-power binocular microscope (magnification x30), good lighting equipment, micro-chemical test procedures (FEIGL 1958), and a set of MUNSELL soil colour charts (see 3.1.3.6), have been used consistently in the basic analytical work. Comparisons have been made with the many petrological analyses of thin-sections carried out by, for example, FRECHEN (1981) and HOPE, BLAUER and RIEDERER (1981).

3.1.3 THE PROPERTIES OF FABRICS

NORDSTRÖM's classification of the pottery from Nubia began with a description of the major technological features that characterize each fabric (NORDSTRÖM 1972; NORDSTRÖM 1977). A similar scheme is followed here and to begin with there is a summary of each diagnostic feature.

3.1.3.1 Groundmass

This is a term used for the finest matrix of the paste, which is made up of particles smaller than 60 microns, i.e. particles of the clay and silt fractions (Fig. 1). These are usually not discernible with a low-power binocular microscope. The particle size (texture) of the groundmass varies considerably between different fabrics, and Fig. 3 shows how the different proportions of clay, silt and sand (non-plastic mineral inclusions over 60 microns) can be expressed.

3.1.3.2 Non-plastic mineral inclusions

These inclusions are larger than 60 microns, and they may occur naturally in the clay or have been added by the potter as a *temper* to make the clay easier to work. Potters prefer the term *filler*, but *temper* has become fixed in the archaeological literature. The quantity and size of the inclusions and their distribution through the paste help to determine whether or not they were a deliberate addition. As a working assumption, a small number of mineral inclusions of fine to coarse size may be thought to be natural components in the clay, but it does not follow that many large inclusions of a particular mineral must be tempering material.

Establishing the identity of many mineral inclusions is only possible by studying a thin-section of the fired clay through a petrological microscope, but some micas, limestone and particles of unmixed and crushed sherds (grog) can be identified under low magnification. Not all the components of sand, which correctly defined is all non-plastic mineral inclusions between 60 microns and 2 mm (see above, p. 149), can be identified at this level of magnification. The major constituents will be quartz and feldspar but a wide range of rare minerals and granitic rock material (e.g. flint, see Pl. III f), can occur (FRECHEN 1981, 89-95). For these unidentified minerals, the term *sand* is used in the fabric descriptions. The shape of mineral grains can be recorded with reference to geometric standards (NORDSTRÖM 1972, fig. 3) and together with colour, size (Fig. 1) and quantity help to characterize the paste even if the precise identity of the inclusion is unknown. An example of this is the numerous coarse rounded sand particles which are characteristic of Nile E fabrics (see Pl. III d-h).

3.1.3.3 Inclusions of crushed sherds

Ground up particles of fired pottery (grog) may be used as a tempering material. It has been noted in the New Kingdom in sherds which may be classified as Marl D (HOPE, BLAUER and RIEDERER 1981, 155) and Nile B2 (Pl. II d, in lower right hand corner). The particles are

large and their porosity and hardness make it possible to distinguish them from soft granules of red ochre, even under low magnification. Scattered particles of grog frequently work their way into the paste with the dust from the potter's workshop, so it is particularly difficult in this case to be certain that the inclusions are a deliberate addition.

3.1.3.4 Organic inclusions

Particles of organic matter in the paste may be visible only as voids which sometimes contain the impressions of plant fibres. If the material has completely burnt away in firing, the shape, quantity, size (texture), distribution and orientation of the inclusions are still recoverable. If the plant material is carbonised it may be difficult to identify under low magnification within a dark groundmass (Pl. I f). However, the plant material may be only partially consumed, leaving behind the silica skeleton of its structure. The most common organic inclusion in Egyptian clays is straw, and it occurs as a natural constituent in the clay as well as a tempering material in all Nile clay fabrics except Nile A. Straw occurs in marl clays only as an addition, either accidental, for example through the dung of an ox treading the dry lumps of marl into a paste with water, or deliberate, as in Marl E, a fabric which is tempered with straw (Pl. VII d; Fig. 25). If the straw particles are consistently < 2.0 mm long, finely divided, evenly distributed within the paste and orientated parallel to the vessel walls, it is likely that they derive from cattle dung (NORDSTRÖM 1972, 42). This is a characteristic of several Nubian fabrics (see below, p. 183) and some fabrics within the Nile B group (Fig. 10). The presence of quantities of particles of coarse straw, defined as over 5.0 mm in length (see Fig. 6), indicates that chaff has been added as a temper to the clay, which is usually but not invariably an alluvial clay (see Marl E), to improve its plasticity. In order to observe and quantify the rod-shaped particles of straw correctly it is essential, if the vessel is thrown or rotation-assisted, that the fabric be examined in a section cut parallel to the rilling lines, i.e. following the orientation of the straw particles. The "white cross-lined" ware sherd (Pl. I b) is cut at right angles to the mouth but the vessel is hand-made so the direction of the cut is correspondingly less important.

3.1.3.5 Shell inclusions

Abundant inclusions of crushed shells and sometimes fragments of foraminifera have been recognised in both Nile and marl clays (Nile C, Marl D, Marl A2 and A4). These particles may derive from fresh shells or they may originate from fossil shells found in limestone

E is an example of such a fabric (Pl. III d-h). The categories of porosity used here (Fig. 6) are as follows: open porous paste, moderately porous, dense (few open pores at all), and incipient vitrification in which closed pores, created by the melting of particles of the paste at high temperatures, are visible (Pl. V g).

3.2 GROUPING FABRICS

The rough classification of fabrics which follows uses all the properties listed above, but does not assign equal significance to each one. The primary characteristics of each grouping are those relating to the potter's paste – i.e. the clay/silt matrix and the inclusions in it, whether naturally occurring or added by the potter as temper (see Fig. 6). The other characteristics of colour, hardness, transverse strength and porosity all depend heavily on the firing conditions and are closely related to each other and sometimes to shaping techniques, so do not carry the same weight in this classification.

3.2.1 THE IDENTIFICATION OF NILE FABRICS

Nile clay fabrics can be identified as a group of fine ferruginous clays containing varying amounts of sand and usually (but not invariably) organic inclusions. Except for Nile D, which contains limestone particles, they show a negative reaction to hydrochloric acid. They fire from dark grey, through brown, to red with violet zones when close to vitrification. They are medium-hard to soft and crumbly but the porosity shows a considerable range from a loose, open appearance to a dense and homogeneous one with few pores.

3.2.2 THE IDENTIFICATION OF MARL FABRICS

Marl clay fabrics can be identified as a group of fine calcareous clays and calceo-ferruginous clays containing varying amounts of sand but few organic inclusions. Except in the case of Marl E (Pl. VII d) which is, so far, a rare fabric, the presence of organic inclusions, usually straw, is more likely to be accidental than a deliberate addition to the paste. Fabrics show a strong reaction to tests with hydrochloric acid but in highly fired (over 850°C) examples, identifiable also by their whitish-green colour, the limestone particles may have disintegrated, so producing a negative reaction. The fabrics show a considerable colour range, often on the same vessel, from pink/yellow through grey to olive green. Marl fabrics are generally harder and denser than Nile clay fabrics. They do not share their homogeneous character

but show a greater variety in range, quantity and size of mineral inclusions.

3.2.3 MIXED CLAYS

Mixtures of Nile and marl clays certainly existed in antiquity but so far it has proved difficult, on the basis of the simple analytical method used here, to identify them. The practice of modern potters (BRISAUD 1982) provides a model which suggests that a complicated process of importing and mixing clays from different regions may have taken place, in addition to the mixing of local clays; however, so far study of pottery itself from the period up to the end of the New Kingdom does not provide enough evidence to confirm this. Some scholars, however, maintain a category of mixed clays in their classification (see HOPE in HOPE, BLAUER and RIEDERER 1981, 159; HOPE 1989, 4–5, 88–90; ASTON and ASTON in press).

The problem of identifying a mixed clay is twofold. Firstly the characteristic properties of such a clay have to be established, and secondly criteria which can be applied macroscopically, using a hand lens or a low-power microscope, have to be set out. *A priori*, it is easy to discover fabrics which do not conform to the parameters laid down for a marl clay or a Nile clay, whether by visual examination or using laboratory techniques, such as thin-sections studied through a petrological microscope, chemical analysis or Neutron Activation Analysis. Understanding the differences we can observe in these fabrics is another matter. Each technique of examination shows up different properties: thin-sections show up the non-plastic inclusions in the clay, whereas chemical analysis and Neutron Activation Analysis combine clay matrix and tempering material to provide a chemical profile of the fabric based on the percentage of certain elements present. The number and character of elements quantified may vary between one analysis and another. Only rarely (HOPE, BLAUER and RIEDERER 1981; BOURRIAU and NICHOLSON in press; BELLIDO ET AL. forthcoming) have visual examination, thin-section and chemical analyses been applied to the same group of sherds so that the different properties defined by each method can be directly related to one another.

Another complicating factor is that the putative “mixed” marl/Nile group of fabrics may be completely heterogeneous because they are defined by what they are not, not by what they are, and we are thus still very far from being able to characterise them or to identify any with confidence by visual examination alone (NICHOLSON and ROSE 1985, 133). Distinctions between the marl and Nile groups of fabrics themselves may be blurred by the use of similar tempering material. Limestone diagnostic of a marl fabric occurs plentifully

in Nile D (Pl. III a-c) as well as occasionally in other Nile fabrics, sand occurs both naturally and as a tempering material in marl and Nile fabrics and straw temper, while characteristic of Nile fabrics (Pls. I–III), also occurs in the Marl E group (Pl. VII d).

The technology of pottery manufacture changes very much after the end of the New Kingdom and it is likely that the mixing of clays was one of the factors influencing the different appearance of fabrics from that time onwards.

3.2.4 FOREIGN FABRICS

Foreign fabrics are visible in the Egyptian pottery repertoire from the Predynastic period onwards. They

emerge clearly from the two major groupings of Egyptian fabrics by reason of the size, shape and character of their inclusions and their colours, hardness and porosity (see below, pp. 183–186) (Pl. VIII a-i). Included as foreign for the purposes of this classification are Nubian fabrics (Pl. VIII d). For most of the period up to the end of the New Kingdom, Nubian pottery clearly belongs to a distinctly different tradition of clay collection, preparation and firing. It therefore requires its own separate classification system.

On the other hand, enormous quantities of apparently Egyptian pottery have been found in Nubia, and while some of it was certainly made there, much of this appears to belong technologically to Egyptian ceramic traditions (HOLTHOER 1977).

4. The Vienna System

4.1 THE SCOPE AND AIM OF THE CLASSIFICATION

The "Vienna system" is the name, adopted for convenience of reference and because the discussions during which it was drafted took place in Vienna in 1980, given to a visual classification which defines the main groups into which fabrics may be placed and suggests some subdivisions of these groups. It has been conceived as a starting point only, providing a guide, in the form of a nomenclature, to the way fabrics may be described and classified in the field. The divisions are not to be considered binding, and it is hoped that archaeologists may test them so that they may be modified according to the character of the material being examined.

The archaeologists who together created the classification were DOROTHEA ARNOLD, MANFRED BIETAK, JANINE BOURRIAU, HELEN and JEAN JACQUET and HANS-ÅKE NORDSTRÖM. All brought sherds from excavations in which they were involved, and with a few exceptions this provided the sample upon which the classification was based. The sample sherds came from Tell el-Dab'a, Saqqara, Dahshur and Thebes (Asasif, el-Tarif and Karnak North). To these were added some unprovenanced Predynastic sherds from the Fitzwilliam Museum, Cambridge, Old Kingdom sherds from various sites, supplied by BARRY KEMP, and Badarian sherds from Matmar from the collection of the Museum of Archaeology and Anthropology in Cambridge. Since 1980, further work by the original group of archaeologists and the application of the system to samples of pottery from Deir el-Ballas, Manshiyet Abu 'Omar, Memphis (Kom Rabi'a), Lisht and Qantir has reinforced the original broad divisions, while emphasising that the classification provides a framework, not a rigid system.

The divisions were intentionally wide to avoid creating groups based solely on different firing conditions (NICHOLSON and ROSE 1985, 134) or on minor changes in the potter's paste. Such criteria might be relevant in the analysis of a particular body of material from a single site but are hard to apply in such a general classification.

This is an important point to bear in mind when we are trying to establish concordances between the Vienna system and site classifications, as will be seen below.

The chronological and geographical limits of the Vienna System were set by the range of samples

available. The Delta is represented by material from only a small area in the East and there is nothing from Middle Egypt beyond the Faiyum or Upper Egypt outside Thebes. The period best represented runs from the XIth to the end of the XVIIIth Dynasty. Earlier and later periods are represented by only a thin scatter of samples. The classification is not intended to be applied to the post-New Kingdom period, when profound changes began to take place in pottery technology and organization, about which we still know very little (see JACQUET-GORDON in press).

The analytical method used to create the fabric groupings was a visual one. The sherds, about 100 in all, were first submitted to HANS-ÅKE NORDSTRÖM, who examined under a microscope (up to x30 magnification), fresh breaks cut parallel to the vessel rim. It is important to stress that clean breaks were made using pliers, since sherds are sometimes cut in half using an electric saw (to create a flat profile to facilitate drawing), and the resulting section is used to identify the fabric. The action of a saw blurs the section and produces a cut at right angles to the vessel rim; consequently it is very difficult to identify the fabric from such a break. NORDSTRÖM described each sherd using the table of properties shown in Fig. 6, which covers the non-plastic inclusions, porosity and hardness, and adding details of the colour of the fracture, thickness of the vessel wall, transverse strength and character of the groundmass. He also prepared slides of the same fresh sections photographed at x30 magnification. Using NORDSTRÖM's descriptions as a starting point, the archaeologists grouped the sherds into fabrics or fabric groups and worked out a preliminary description of each one.

Reliance on visual criteria, identifiable with a x10 hand lens or a low-power microscope, was intentional since the aim was to provide a working classification which could be applied to pottery in the field and would not be dependent on petrological analysis of thin-sections or other laboratory-based techniques. Such analyses are necessary but were seen as a subsequent step intended to test and refine the groupings. For a comparison of the visually based classification with the results of thin-section analysis, see BOURRIAU and NICHOLSON (in press).

It may be useful to note that the articles which appeared in 1981 in *Studien zur altägyptischen Keramik*, edited by DOROTHEA ARNOLD, were already in press when the Vienna meeting took place, so that they

represent an earlier, not a later, phase of discussion. Much of the information in these studies and some of the sherds discussed there were submitted to NORDSTRÖM. Reference is given below to the illustrations and discussions of these sherds in *Studien zur altägyptischen Keramik* under the relevant fabric descriptions, so that they may be used in conjunction with this account. Two projects are currently under way using Neutron Activation Analysis (BELLIDO ET AL. forthcoming) and thin-section analysis (BOURRIAU and NICHOLSON in press) to test the divisions proposed among the marl clays.

4.2. A GUIDE TO THE DESCRIPTIONS

The description of the fabric groupings which follows is an extended version of the brief descriptions given by NORDSTRÖM under "Ton" in the *Lexikon der Ägyptologie*, Band VI, 631-634. Both supersede the preliminary description of Egyptian fabric groups given by DOROTHEA ARNOLD under "Keramik" in Vol. III of the *Lexikon*, published in 1980.

Fig. 6 shows how some of the information which provides the basis for the verbal descriptions was collected and tabulated. The properties analysed are the *non-plastic inclusions*, *porosity* and *hardness*. The most common *non-plastic inclusions* are sand, straw and particles of limestone, and each of these is subdivided into three groups according to size, as well as quantified. The mineral particles of sand (see above, pp. 149, 163) and limestone are subdivided into the same categories of fine (60-250 microns), medium (250-500 microns) and coarse (> 500 microns). For terminology, see Fig. 1. Straw is subdivided into fine (< 2 mm), medium (2-5 mm) and coarse (> 5 mm) according to length of particles.

The quantity of a particular inclusion present is indicated by numerals 1, 2 or 3. Number 1 means the particles are scarce and scattered through the fabric, 2 that they are conspicuous and common throughout, 3 that they are so abundant as to be touching each other. It should be admitted that it takes considerable patience to describe inclusions in as much detail as this using only a x10 hand lens, even if it is calibrated. A low-power microscope is a great help. The descriptions of larger mineral inclusions provide indications of size (a granule is 2-4 mm in length, see Fig. 1) and colour. Precise identifications can only be guessed at such low magnification. It should be noted, for example, that not all white particles are limestone, and a test with hydrochloric acid will show if they are but will not identify them if they are not.

The colour of the surface and the section of the sherd was recorded individually for each sample and in several cases refiring experiments were carried out by NORDSTRÖM to establish the original firing temperature.

The fabrics are divided into two main categories according to the naturally occurring clays employed: the Nile fabrics and the marl fabrics, respectively. The existence of mixed clays, produced by the potter from different clay sources, remains possible, and even, on analogy with modern Egyptian potters, likely, but it is at present difficult to detect by visual means.

At the end of each fabric description, concordances have been suggested with fabrics described in some recent publications. The number of publications which can be utilised is necessarily limited to those where fabric is described in detail and a terminology employed which can be related to the one used here.

These suggested "matches" need to be treated with caution. In most cases they are based on a visual comparison of sherds but sometimes on published description and illustration alone, as is the case for the pottery from Malqata, Hierakonpolis, Armant and the examples discussed in HOPE, BLAUER and RIEDERER (1981). A comparative study of the New Kingdom marl clays from Memphis/Saqqara and el-'Amarna, using thin sections as well as microscopic examination, has been carried out by BOURRIAU and NICHOLSON (in press), and some material from Qantir was included. The evidence for "matches" in this case is much stronger and the concordances suggested by this study are cited wherever possible.

The Vienna System classification and the field classification at an individual site are essentially different; this needs to be emphasised so that the reader may judge the value of any suggested concordances. The Vienna System was conceived as a framework, providing a method and a vocabulary for fabric description and a point of reference so that comparisons between sites could more easily be made. A field classification has to cover all the divisions in the material which the archaeologist thinks significant, and will necessarily contain more classes than the Vienna System. For example, in the Memphis/Saqqara field classification, H2 and H4 both belong to Marl A4, and H9 and H10 to Marl A2, and at Tell el-Dab'a, Nile E has three subdivisions, I-e-1, I-e-2, I-e-3 (BIETAK 1991, 326).

4.3 THE NILE FABRICS

These alluvial clays were first divided into three groups, Nile A, B and C, differentiated by the relative quantity and size of their most common inclusions - sand and straw.

Nile A (Pl. I a-c) contains a large amount of sand of all sizes, both coarse and extremely fine, but no straw, except for an occasional particle which may have occurred naturally in the clay or been picked up in the course of manufacture. NORDSTRÖM notes that finely divided straw is not naturally present in the alluvial

A — B	C	1	
A	B — C	2	
A	B	C	3

Fig. 7 Possible divisions in different assemblages (1–3) of Nile fabrics A, B and C. In 1, Nile C emerges clearly but differentiating between Nile A and B is difficult; in 2, Nile A is clear but Nile B and C merge; in 3, all three Nile clays, A, B and C, can be differentiated. In practice the situation most frequently encountered is that shown in 2 (drawing by MALCOLM PAYNE).

clays from Nubia. Nile B (Pls. I d–h, II a–d) contains varying amounts of fine to coarse sand, and fine to medium straw particles in sufficient number (B2 only) to suggest they were deliberately added to the paste by the potter. Nile C (Pl. II e–i) contains large quantities of fine to coarse sand and of fine to coarse straw. The coarse straw particles appear to dominate over other inclusions.

The groupings, it should be stressed, do not represent single fabrics but groups of fabrics which share certain properties. The demarcation between Nile A and C is the strongest, and visible even on the surface of a vessel or sherd. The boundary between Nile B and C, on the other hand, can sometimes be very difficult to observe and is not necessarily significant in all material (ARNOLD 1988, 126). Fig. 7 is an example of how the nature of the demarcation between Nile A, B and C may change in different collections of material.

Nile D (Pl. III a–c) and Nile E (Pl. III d–h) are much less widespread, both geographically and chronologically, than the other three groups. The diagnostic feature of Nile D distinguishing it from Nile A, B and C is the presence of limestone inclusions in conspicuous amounts in the paste, occurring either naturally or as temper. Nile E is distinct from the other Nile groups in colour, porosity and hardness as well as inclusions, of which the dominant one is fine to coarse rounded grains of sand. It seems to be typical of the Delta region.

4.3.1 NILE A (Fig. 8, Pl. I a–c)

The groundmass is composed of homogeneous fine clay containing a significant amount of silt (for definition of terms see Fig. 1). It contains abundant inclusions of fine sand with conspicuous amounts of medium-sized sand and occasional grains of coarse sand. Mica is common. A very few particles of fine straw may occur scattered

through the paste but they are uncharacteristic of this fabric. The even gradation in size among the particles of the groundmass (clay and silt) and the fine sand inclusions suggest that the sand is a natural constituent of the material and not added as temper. The original firing temperature of some sherds from the Scandinavian Joint Expedition to Sudanese Nubia analysed by NORDSTRÖM (1972, 50) has been estimated at 700°–750°C. The fracture colour is usually brown or greyish-brown without strongly defined zones, indicating a well controlled firing of relatively long duration. Porosity is moderate to dense, hardness medium and transverse strength medium to great.

The fabric is common through out the Predynastic to early Dynastic period in Egypt, from the Badarian period onwards (NORDSTRÖM 1972, 51). It is rare thereafter but occurs in the Eastern Delta (at Tell el-Dab'a) in the late Middle Kingdom to Second Intermediate Period (BIETAK 1991, 324). The fine to dense texture of the groundmass, the almost total absence of organic inclusions and the large quantity of sand inclusions are the diagnostic properties of this fabric. It has been suggested (FEKHRI HASSAN, personal com-

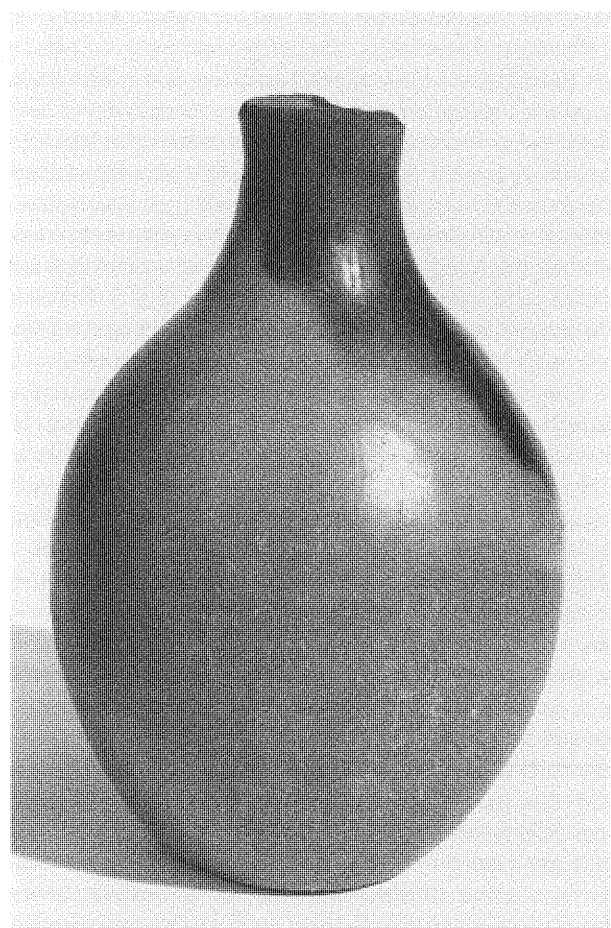


Fig. 8 Black-topped flask of Nile A, from Naqada grave 1449. Naqada II. University College 4129 (BOURRIAU 1981a, no. 4).

munication) that the fine texture is due to a process of natural levigation such as might derive from the use of clay collected from pools of water left behind after the inundation.

The fabric group may be compared with NORDSTRÖM's IE (1972, 50–51); the Untempered Plum Red Ware from Hierakonpolis (HOFFMAN 1982); MYERS' Nile-ware from Armant (MOND and MYERS 1937, 50); BIETAK's I-a fabric from Tell el-Dab'a (BIETAK 1991, 324), and possibly siliceous group Type I from el-'Amarna and Malqata (HOPE, BLAUER and RIEDERER 1981, 160, colour plate I f).

4.3.2 NILE B

This fabric is subdivided into B1 and B2. B2 is differentiated on the basis of conspicuous straw inclusions, colour of fracture indicating a range of firing conditions, and more open porosity.

4.3.2.1 Nile B1 (Fig. 9, Pl. I d–h)

The groundmass is relatively silty and not as fine as Nile A. There are abundant inclusions of fine sand, with scattered particles of medium to coarse sand. Micaceous particles are common. Scattered fine (< 2 mm) straw particles occur both as impressions in the clay and as silica skeletons of the plant structure. Surfaces and sections are often a uniform reddish-brown but black/grey or black/red zoning can occur (Pl. I d, f). The thicker vessel wall and short, intense period of firing account for the different colour of the fracture of the IIIrd Dynasty sherd from Saqqara (Pl. I d) compared with the Middle Kingdom B1 sherds (Pl. I e, g–h). Porosity is moderate to dense, hardness soft to medium and transverse strength low to medium. The appearance of the sherds (Pl. I d–h) suggests a well-mixed paste, fired for a long time at steady temperatures. This fabric is common from the Old Kingdom to the beginning of the XVIIIth Dynasty. It is the fabric of the hemispherical bowls, the ubiquitous drinking cups of the Middle Kingdom (ARNOLD 1982, fig. 17; ARNOLD 1988, 140–141) and particularly characteristic of the fine wares of the Delta and Memphis-Faiyum region at this time (BIETAK 1991, 324–325). Pl. I e shows a section from a hemispherical bowl and it is interesting to compare the fine fabric with the grains of sand which form the background of the photograph. Pl. I e.g show white threads scattered throughout the groundmass, measuring approximately 2 mm or less. These are silica skeletons of fine straw particles. Pl. I f comes from a Tell el-Yahudiya ware juglet made in Egypt and the fabric has been deliberately smoked in the kiln to achieve the desired black colour. Typically, vessels in B1 fabric have very thin walls and this feature helps to characterise the

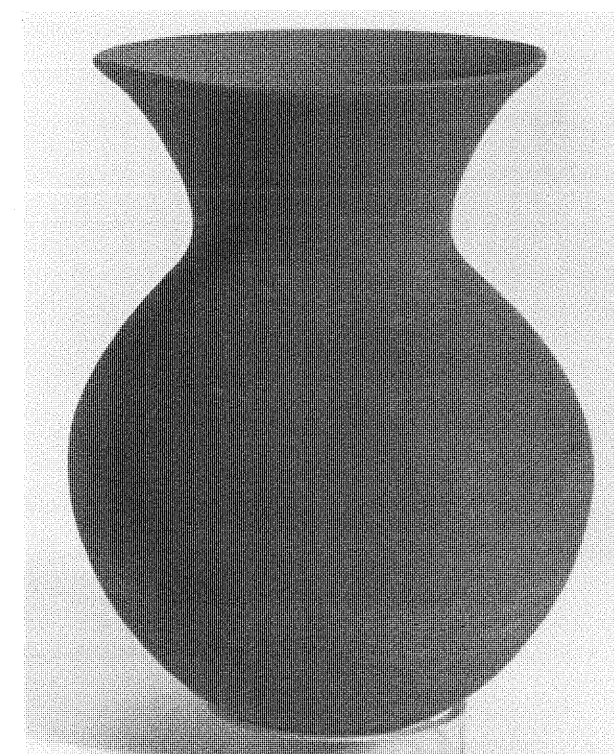


Fig. 9 Water jar of Nile B1, from el-Riqqa cemetery A, grave 180 or 183. Mid-XIIth Dynasty. Fitzwilliam Museum E.17.1913 (BOURRIAU 1981a, no. 96).

colour, porosity and hardness of the fracture (ARNOLD 1982, 44–48).

At Lisht South, in pottery of the early XIIth Dynasty, ARNOLD (1988, 126) has identified three variants: Nile B1 fine; Nile B1 with many organic particles; and ordinary Nile B1. The last named corresponds most closely to the description given here, and to the I-b-1 fabric of BIETAK from Tell el-Dab'a (BIETAK 1991, 324–325). ARNOLD's subdivisions illustrate how a more detailed classification of fabrics than the Vienna System provides is usually required for a site report but how it remains a useful starting point and makes the quoting of comparable material easier.

4.3.2.2 Nile B2 (Figs. 10–12, Pl. II a–d)

The groundmass is similar in character to Nile B1, but mineral and organic inclusions occur in larger sizes and in greater quantities. There are abundant inclusions of fine sand, and medium sand is common. Some rounded sand grains may occur, together with scattered particles of limestone, some of which show signs of decomposition (reaction rims, Pl. II b). BIETAK notes the occasional occurrence of fragments of mussel shell and limestone concretions, deriving from the Delta *geziras* (sand-

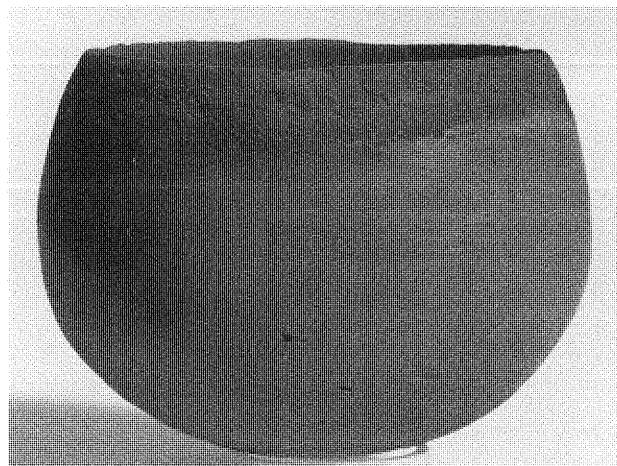


Fig. 10 Bowl of Nile B2, Badarian. Fitzwilliam Museum EGA.6385.1943 (BOURRIAU 1981a, no. 67). Note the fine (< 2mm) rods from the burning out of thinly divided straw particles, visible even on the surface.



Fig. 12 Spouted jar of Nile B2, XVIIIth Dynasty up to the end of the reign of Hatshepsut. University College 30223 (BOURRIAU 1981a, no. 138). The surface, compacted by burnishing, shows fewer straw impressions than Fig. 11, but the section shows they both belong to the same fabric group.

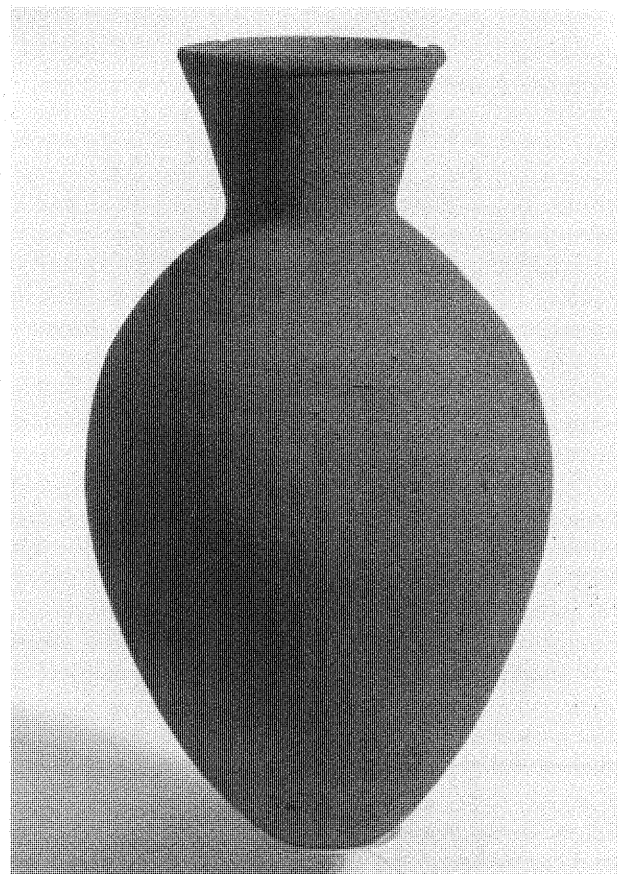


Fig. 11 Flask of Nile B2, from Tarkhan. Early XIIth Dynasty (redated). Fitzwilliam Museum E.52.1912 (BOURRIAU 1981a, no. 92). The red wash on the surface covers many of the rectangular impressions left by burnt out straw.

banks), in the Tell el-Dab'a equivalent of Nile B2 (BIETAK 1991, 325). Some samples of the later XVIIIth Dynasty from Karnak contain grog (crushed pot sherds, Pl. II d). These may be accidental inclusions in the paste, part of the dust from the potter's workshop, rather than a deliberate addition. There are conspicuous amounts of fine to medium straw with a few scattered coarse straw particles.

While the dividing line between B and C fabrics may sometimes be hard to make and maintain consistently, especially comparing B2 with C (Pl. II a-d, e-i), one guideline is that sand and not straw remains the dominant inclusion in B fabrics (ARNOLD 1988, 124).

Some examples of B1 and B2 fabrics in section may appear similar to the dung-tempered fabrics of Nubia (NORDSTRÖM 1972, 42, 51-52; NORDSTRÖM 1986, *passim*) owing to the numerous fine (< 2 mm) whitish rods of thinly divided straw which occur (Pls. I e.g., II a-d). However, there is some doubt that these white rods do derive in every case from dung. NOLL (1981, 114) has reported one analysis (by JUX) which identifies them as traces of fungi which derive from the natural decay of organic material in alluvial deposits.

The fracture is usually brown but narrow red cores with violet outer zones and black cores can occur. The porosity varies from loose and open to moderate; in hardness the fabric group varies from medium to hard and in transverse strength from medium to great. The fabric group is common in all periods and regions so, unlike B1 which is very homogeneous because of its limited distribution, B2 shows considerable variability, especially in those properties closely related to firing

conditions such as colour, hardness and porosity (ARNOLD 1982, 46-48; ARNOLD 1988, 126).

ARNOLD identifies four variants at Lisht South (ARNOLD 1988, 126): Nile B2 fine, which is close to B1; Nile B2, used mainly for hand-made vessels, with fewer sand inclusions than the standard B2 fabric described above; Nile B2 sandy, used for plates and bowls, in which the quantity of straw is reduced and fine to coarse sand inclusions increased; and Nile B, near C, which lies at the fine end of the range of variations which lead to a distinct Nile C fabric. It is important to note following her own observation (ARNOLD 1988, 126, note 314), that the pottery of Lisht South is of the early XIIth Dynasty, while the Vienna System's definitions of Nile B2 were mainly based upon samples from Dahshur, of the late XIIth-XIIIth Dynasties. BIETAK identifies a coarse variant which appears in the Second Intermediate Period at Tell el-Dab'a. It contains sand particles (500 microns to 1 mm) and medium straw particles (using the definitions used here, see above, p. 163). BIETAK describes them as coarse. The fabric characteristically shows a broad ash-grey core with narrow, sharply defined red zones on either side. BIETAK admits the difficulty of maintaining consistently the division between this variant and other examples of Nile B2 at Tell el-Dab'a.

Nile B2 corresponds to the fabric of Ware group W1 (NORDSTRÖM 1977, 60-61); fabrics IIC and IID in NORDSTRÖM 1972, 52-53; I-b-2 at Tell el-Dab'a (BIETAK 1991, 325); fabric G1 at Memphis/Saqqara (BOURRIAU and ASTON 1985, 33-34; JEFFREYS and ASTON in press); fabric I.1 at el-Amarna (NICHOLSON and ROSE 1985, 134); siliceous group Type II at el-Amarna and Malqata (HOPE, BLAUER and RIEDERER 1981, 160); fabric I at Karnak North (JACQUET-GORDON in press); the medium straw-tempered Nile fabric at Deir el-Ballas (BOURRIAU 1990a, 19); and I.B.02 at Qantir (ASTON and ASTON in press).

4.3.3 NILE C

(Figs. 13-15, Pl. II e-i; FRECHEN 1981, K3153 = here Pl. II f)

The material is made up of a fairly silty clay containing sub-angular to rounded sand grains varying from fine to coarse and in frequency from scarce to common. Medium-sized limestone particles may occur scattered thinly through the paste, but not as conspicuously as in Nile D. Other mineral inclusions such as mica, crushed sherds (grog) and medium-coarse rock particles may also occur.

There is a predominance of straw inclusions, visible in the section and on the surface, ranging from fine to coarse, with an abundance of coarse particles (> 5 mm) (Pl. II i). The straw survives as carbonised particles, as white or light grey silica skeletons of its cellular structure and as impressions in the paste. The rod-shaped particles usually become orientated parallel to the vessel

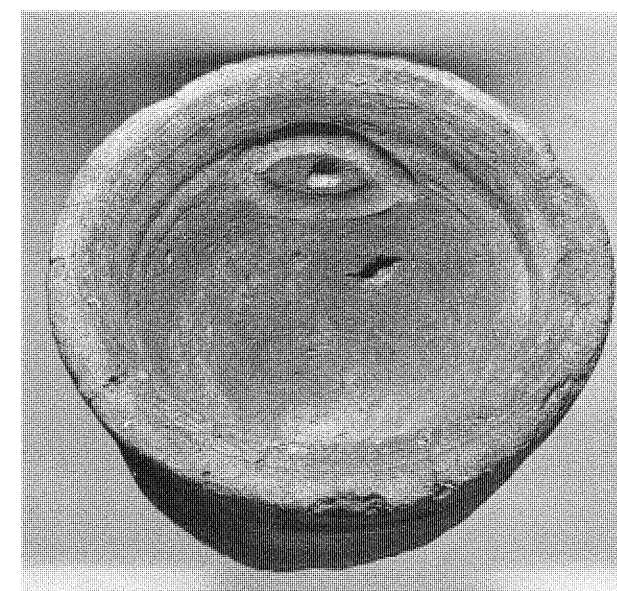


Fig. 13 Bread mould of Nile C, from el-Kab, stairway tomb 5, Old Kingdom. University College 17547 (BOURRIAU 1981a, no. 2).

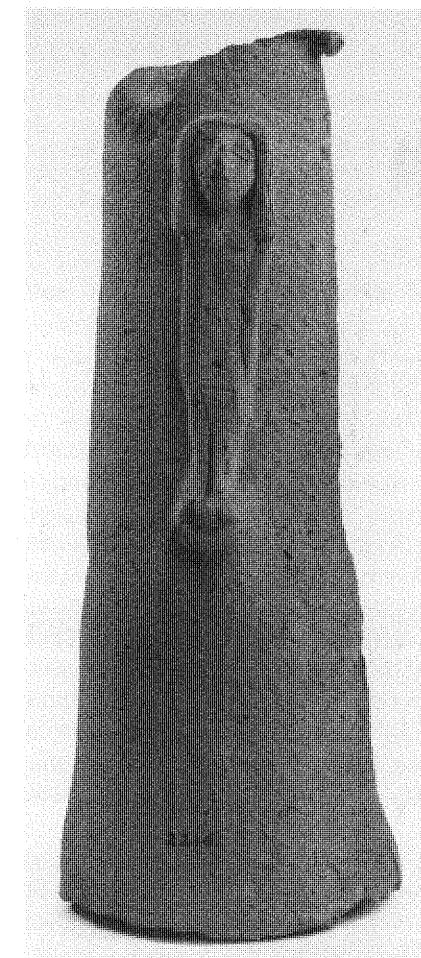


Fig. 14 Potstand of Nile C, from Beni Hasan. XIth-XIIth Dynasties. Fitzwilliam Museum E.180.1902 (BOURRIAU 1981a, no. 112).

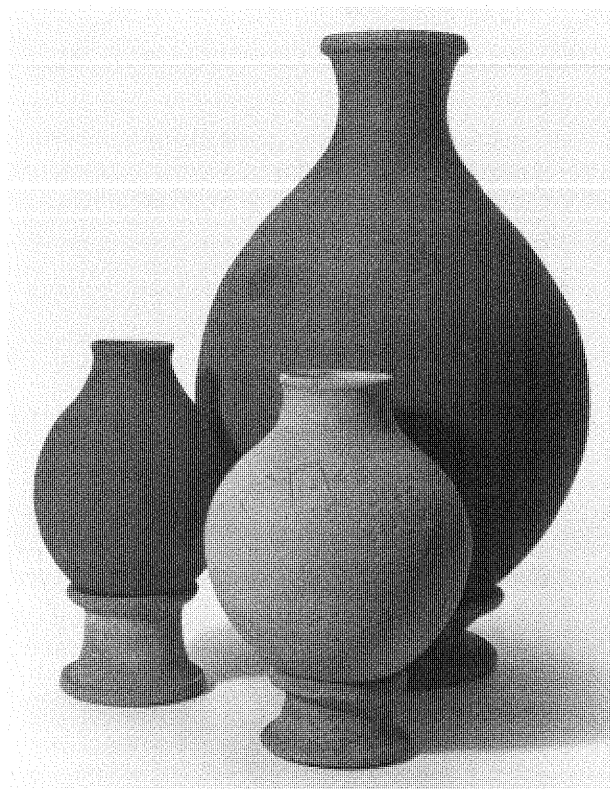


Fig. 15 Group consisting of jars of Nile C and Marl A₃ with potstands of Nile B₂ all, except E.P.261, from Hiw (Diospolis Parva). Early XIIth Dynasty. Fitzwilliam Museum E.250.1899, E.94.1902, E.105.1902, E.111-112.1902, E.P.261 (BOURRIAU 1981a, nos.131-133,135 a-c). Note that the medium-sized Nile C jar is on the borderline between Nile C and Nile B.

wall (Pl. II i) in the case of vessels thrown on the wheel or shaped on a turning device. This is why it is necessary to examine a sherd fractured parallel to the throwing lines, in order to identify the shape and frequency of the straw particles.

In some variants of this group, carbon particles, originating from ash, bone, shell and miscellaneous vegetable matter, may be observed (for example, Tell el-Dab'a I-c-2, here Pl. II i). The paste is frequently poorly mixed, with an open, porous texture. The fabric is often used for containers with very thick walls (up to 2 cm), and in these cases the core remains black. The colour of the fracture varies between grey-brown and reddish-brown. The firing temperature reaches a peak at 500° to 800°C and the surface often shows smoky patches from uneven firing conditions. The hardness ranges from soft and medium, and transverse strength from very low to medium.

Nile C occurs at all periods and in all regions and so includes potentially a wide range of variants. These have yet to be studied and in the present state of our knowledge it is difficult, using visual criteria of fabric alone, to differentiate a Nile C fabric of the Old Kingdom from one of the Middle or New Kingdoms.

In the Middle Kingdom, in the Delta and Memphis-Faiyum region, it is often difficult to differentiate between Nile B₂ and Nile C. They seem to represent the extreme ends of a continuum rather than two separate fabrics. This difficulty is reflected in ARNOLD's creation of categories Nile B₂ near C and Nile C near B₂ (ARNOLD 1988, 126) and in BIETAK's subdivision of Nile C into I-c-1 and I-c-2 (BIETAK 1991, 325-326). Both ARNOLD and BIETAK have looked at fabric variants in relation to other properties of the pottery, such as shape, size, technology or decoration, and so have been able to confirm the significance of their fabric subdivisions.

Nile C is often used for heavy containers such as bread trays or large storage jars (Pl. II g). The finer variant at Tell el-Dab'a (I-c-1) is used for model vessels (BIETAK 1991, 325-326). The fabric is described by ARNOLD (1982, 46; 1988, 124) and is equivalent to MYERS' Chaffware from Armant (MOND and MYERS 1937, 50); NORDSTRÖM's IIE fabric (1972, 53); HOFFMAN's Straw Tempered Ware from Hierakonpolis (1982, 68); BIETAK's I-c-1 and I-c-2 at Tell el-Dab'a (BIETAK 1991, 325-326); siliceous group Types III - IV at el-'Amarna and Malqata (HOPE, BLAUER and RIEDERER 1981, 160); fabric I.4 at el-'Amarna (NICHOLSON and ROSE 1985, 135); G₄ at Memphis (JEFFREYS and ASTON in press); the coarse straw-tempered Nile fabric at Deir el-Ballas (BOURRIAU 1990a, 18-19); and I.C. at Qantir (ASTON and ASTON in press).

4.3.4 NILE D

(Fig. 16, Pl. III a-c; ARNOLD 1981, 190, colour plate IIc, pl. 18a)

The diagnostic property of this Nile clay fabric is the presence of conspicuous inclusions of limestone, whether occurring as a soil admixture in the paste or as tempering material. If it were not for these conspicuous inclusions, the fabric would otherwise be classified variously from a Nile A (from Tell el-Dab'a, sometimes fired in a reducing atmosphere) to a low-fired Nile B₁ (from Dahshur, Pl. III a) and a Nile B₂ - Nile C (from Memphis, Pl. III b). This emphasises that Nile D represents a fabric group rather than a single fabric.

The "Nile A" variant within Nile D is the fabric of

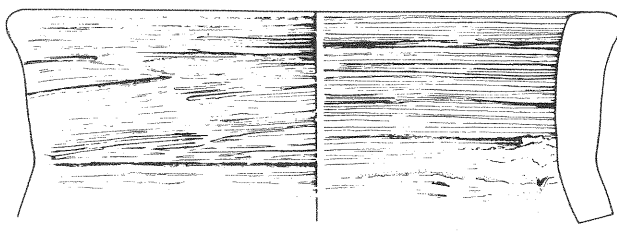


Fig. 16 Rim sherd of storage jar of Nile D, cf. ARNOLD 1981, colour pl. II c; pl. 18, a. From Deir el-Ballas, excavations of Museum of Fine Arts, Boston, XVIIth-XVIIIth Dynasties (drawing by ANDREW BOYCE. Courtesy of PETER LACOVARA).

a group of Tell el-Yahudiya ware juglets and (at Tell el-Dab'a only) related vessels of the Middle Bronze Age culture (BOURRIAU 1981a, no.59; BIETAK 1991, 326). In the case of the juglet described by BOURRIAU, it was not possible to test whether the coarse white inclusions were limestone, or grains of quartz or feldspar. Neutron Activation Analysis by MAUREEN KAPLAN, however, classed the fabric as a Nile clay (KAPLAN 1980, 60 note 34, 229, 238, fig. 5e).

The "Nile B₁" type (Pl. III a), contains conspicuous inclusions of fine to medium sand and varying amounts of fine to coarse limestone particles. Fine straw may also be present in small amounts.

Nile D occurs in XVIIIth and XIXth Dynasty levels of the settlement at Kom Rabi'a at Memphis, where it exhibits rather different properties and is used for large vessels with thick walls - up to 2 cm wide (Pl. III b). The conspicuous limestone particles, both medium and coarse, are well distributed through the paste, but a test with hydrochloric acid produces a strong reaction in which it is possible to observe that the inclusions and not the groundmass are reacting. In addition to conspicuous fine sand and mica, there are abundant fine straw, scattered particles of medium straw and conspicuous silica formations. The fracture usually shows outer zones of red and even violet, with a black core, but sometimes the fracture and the surface are the same red colour. Signs of incipient vitrification and the reaction rims from burnt out limestone may be observed. The porosity varies from loose and open to moderate, but the fabric is characteristically hard and firm with great transverse strength, in part due to the high firing temperature.

Recent Neutron Activation Analysis of pottery from Deir el-Ballas (BELLIDO ET AL. forthcoming), which had been tentatively identified in the report (BOURRIAU 1990a, 21) as a Marl D, has grouped it with Nile D sherds from Memphis (Pl. III c). In the Deir el-Ballas publication the possibility was raised that the fabric was alluvial clay to which limestone temper had been added, so the result is perhaps not so surprising. The Deir el-Ballas fabric also occurs at Thebes, el-Tarif (ARNOLD 1981, 190, colour plate II c) and at Karnak North (seen by BOURRIAU in December 1991 courtesy of HELEN JACQUET). In both cases the contexts were of the Second Intermediate Period and the fabric was used for large hand-made storage jars. As ARNOLD pointed out, the distinctive shapes and technology of the jars have parallels among the late Middle Kingdom-Second Intermediate Period pottery from Dahshur, but the fabric used at Dahshur is different, being Marl C not Nile D. The distinctive inclusion common to both fabrics is limestone, naturally occurring in one clay (Marl C) and added as temper to the other. It is hard to escape the conclusion that, as in Marl E, there is a link here between tempering material and function.

In addition to the Deir el-Ballas and el-Tarif occurrences already mentioned, Nile D is recorded by BIETAK at Tell el-Dab'a (1991, 326); HOPE at Malqata, used for amphora group AI (HOPE 1978, 66); in the New Kingdom necropolis at Saqqara as G₃ (BOURRIAU and ASTON 1985, 37) and at Memphis as G₅ (JEFFREYS and ASTON in press). It corresponds to I.D.01, I.D.02 at Qantir (ASTON and ASTON in press).

4.3.5 NILE E (Pl. III d-h)

The appearance of this fabric group is very distinctive. The fracture and the surface are dominated by conspicuous to abundant fine, medium and coarse rounded sand grains. Apart from this diagnostic inclusion, fabrics in this group may exhibit the properties of either Nile B (Pl. III d-e) or Nile C (Pl. III g-h). This range is reflected in BIETAK's division of the group into I-e-1 (here Pl. III d), I-e-2 (here Pl. III g-h), I-e-3. He notes that I-e-2 and I-e-3 were first placed in a separate category in the Tell el-Dab'a field classification until Neutron Activation Analysis demonstrated that they were Nile clays (BIETAK 1991, 326).

Other mineral inclusions are angular and sub-angular particles of fine-coarse sand in small quantities, and micaceous inclusions, which are common.

Firing temperature appears generally to be low, leaving a brown or black fracture. The fabric is soft and crumbly with an open, porous texture and low to medium transverse strength.

Nile E has so far been identified within restricted geographical limits, and is found in the Eastern Delta and in the Memphite region as far south as the Faiyum. It is used in the Eastern Delta (Qantir and Tell el-Dab'a) for a wide range of vessels (95% of the Nile clay vessels at Qantir belong to this fabric group according to DAVID ASTON, personal communication), but in the Memphite region its use is more specialised, and it occurs most often used for bread moulds and cooking vessels (Pl. III f, from Dahshur). The date range so far known is Middle Kingdom to New Kingdom.

Nile E corresponds to ARNOLD's Sandy Nile clay (ARNOLD 1982, 45, fig. 10:6) and the same cooking vessel type in the same fabric occurs in the XIIIth Dynasty levels at Memphis, Kom Rabi'a. At Tell el-Dab'a BIETAK has subdivided the group into I-e-1, I-e-2, I-e-3 and at Qantir, DAVID ASTON has added one more, I.E.04 (BIETAK 1991, 326; ASTON and ASTON in press).

4.4 THE MARL FABRICS

Finding visual criteria with which to separate one marl clay from another, and which can be applied consistently, appears to be easier than discovering a dividing

line between some Nile clays, for example Nile B and Nile C. Most of the marl clays in this classification have different chronological ranges, so criteria based on technology of preparation and firing may also play a role in defining character. Marl A (Pls. IV-V) exhibits a dense, homogeneous groundmass with varying amounts of sand and limestone in a well-mixed paste. Marl B (Pl. VI a-c,g-h) is characterised by the variety, quantity and size of sand inclusions, which account for 40% of the paste and must have been added as temper. Marl C (Pl. VI d-f,i) shows a porous fracture dominated by medium to large, often decomposed limestone particles in a grey/red groundmass containing fragments of unmixed marl. Marl D (Pl. VII a-c,e-f) displays a homogeneous groundmass containing quantities of fine limestone temper up to 25% of the mass. Marl E (Pl. VII d) is distinctively characterised by an abundant chaff temper.

4.4.1 MARL A

This fabric group has been subdivided into four variants, on the basis of their physical properties. These variants have also been observed to have specific chronological and sometimes geographical distributions. The unifying characteristic of Marl A is its dense, homogeneous groundmass containing fine mineral inclusions and very little organic matter. It fires from pink to pale grey or olive. Wares of group W₃ discussed in NORDSTRÖM (1977, 65) belong to this fabric group.

4.4.1.1 Marl A₁ (Fig. 17, Pl. IV a-c)

The groundmass is made up of a relatively fine and homogeneous clay tempered with conspicuous particles of fine-medium crushed limestone distributed evenly through the paste. These dominate the fracture and are also clearly visible on the surface. The particles are angular and vary in size from 60 to 400 microns with occasional particles of larger size. Fine sand is common and there are a few larger sand grains scattered throughout. Dark micaceous particles are also common. Few organic inclusions (straw) are present. The firing temperature has been calculated at about 800°C, so the limestone particles normally show little sign of decomposition. However a few examples show reaction rims and incipient vitrification resulting from a higher firing. The fracture is usually pale to light red, sometimes with a greyish core. The texture is dense but with distinctive elongated voids orientated parallel to the wall surfaces. The fabric is hard and firm and the transverse strength is great, so it breaks sharply when struck.

The fabric is common throughout Egypt from Naqada II to the Old Kingdom, and is one of the fabrics used for Maidum ware bowls (BOURRIAU 1981a, 18, 52-53;

ARNOLD and ARNOLD 1979, 32-33). It is equivalent to NORDSTRÖM's IVA fabric (1972, 54-55) and MYERS' Desert-ware (MOND and MYERS 1937, 50) from Armant. The relation of Desert-ware to PETRIE's classification of Predynastic pottery is discussed by MYERS, and by CROWFOOT-PAYNE (in press). BOURRIAU (1981a) divided PETRIE's D ware between Marl A₁ and Marl A₄, using the presence or absence of straw as a guide. The distinction is not one that can be maintained, based as it was on whole pots without freshly broken sections available for examination. It is perhaps necessary to admit a wider range of properties for Marl A₁, including organic inclusions which may have got into the clay during the preparation of the paste, at least until further research on the fabric grouping can be carried out. The catalogue was written (BOURRIAU 1981a, 14) at the same time as the Vienna system was being formulated and all the fabric identifications in it should be considered preliminary.

4.4.1.2 Marl A₂

(Fig. 18, Pl. IV d-i; ARNOLD 1981, colour plate II d)

In this variant of Marl A the mineral inclusions are much finer and scattered evenly through the paste. Fine sand and limestone particles and some fine angular particles of unmixed marl are present but no one inclusion dominates. Dark micaceous inclusions are also present in small quantities. The surface fires from pale red to grey-white and the fracture usually appears pale red without zones. Examples are usually fired at high temperatures (around 1000°C) under controlled conditions. The fabric is very dense without conspicuous pores, and extremely hard with great transverse strength; the surface feels distinctly grainy to the touch. It occurs from the Middle Kingdom onwards (ARNOLD 1982, 46, figs. 8:9,11,13; 11:13; ARNOLD 1988, 124) but is most common in the late Second Intermediate Period and XVIIIth Dynasty, and is more plentiful in Upper than in Lower Egypt. Vessels belonging to this fabric are discussed by BOURRIAU (1981b, 25-41), although the description of the fabric, based on whole vessels not freshly broken sherds, is not consistent. Some of the vessels, those containing chaff and (?)grog for example, may belong to Marl A₄. It should be remembered that the articles in *Studien zur altägyptischen Keramik* were all written during the period when the parameters of the fabric groupings, later called the Vienna system, were becoming defined. For the same reason, it is only probable that calcareous Type I (HOPE, BLAUER and RIEDERER 1981, 160, colour plate I d) belongs to the Marl A₂ group. Memphis/Saqqara fabrics H₉ and H₁₀ (Pl. IV g-i) belong to this group, together with Amarna III.4 and V.6 and possibly Qantir II.A.04.02 (BOURRIAU and NICHOLSON in press; ASTON and ASTON in press). The fabric also occurs at Deir el-Ballas (BOURRIAU 1990a,20).

4.4.1.3 Marl A₃

(Figs. 15, 19, Pl. V a-c,g-h; ARNOLD 1981, colour plate II a-b; FRECHEN 1981, K2339 = here Pl. V a, K2889 = here Pl. V c)

This fabric appears to the eye to be closest to the modern Qena clay although we cannot assume that clay was mined in this region in antiquity. Few mineral inclusions show up in the fracture under low magnification and there is no sign that any were added as tempering material. The paste is exceptionally fine and homogeneous and this may be due to careful preparation, perhaps including levigation, by the potter. Occasional straw particles may occur as accidental inclusions in the clay.

The fabric is fired at around 1000°C, when signs of incipient vitrification (melting of the groundmass) may become visible together with numerous pores from burnt out limestone and other mineral inclusions. Elongated, roughly rectangular pores (caused by pockets of air) are a distinctive characteristic of the fabric. Apart from these voids, porosity is dense, hardness medium to firm and transverse strength great. The high firing explains why there is often no reaction when the fracture is tested with hydrochloric acid – the limestone has already been burnt away. The surface and fracture are pale greenish-grey in the most highly fired examples, but there are sometimes pink spots or zones, due to uneven firing conditions.

The fabric occurs from the early Middle Kingdom through into the New Kingdom and seems to originate in Upper Egypt, where it is common, and to occur rarely and in only a limited range of forms in the Eastern Delta (at Tell el-Dab'a, BIETAK 1991, 327, and in Ramesside levels at Qantir, DAVID ASTON, personal communication) and the Memphis-Faiyum region. It corresponds to NORDSTRÖM's VA-B fabric (1972, 55-56; 1977, 66-67); calcareous Type VI at el-Amarna and Malqata (HOPE, BLAUER and RIEDERER 1981, 161, 163, colour plate 1e); and type Bb. I at Malqata (HOPE 1978, 68). It has been tentatively identified at Deir el-Ballas (BOURRIAU 1990a, 20); at Tell el-Dab'a it corresponds to II-a (BIETAK 1991, 327) and at Qantir to II.A.03 (ASTON and ASTON in press). It is described in detail in ARNOLD 1981, 169-171; FRECHEN 1981, 89-94; ARNOLD 1982, 46, fig. 11:14-16; ARNOLD 1988, 124, 126.

4.4.1.4 Marl A₄ (Fig. 20, Pl. V d-f,i-j)

Of all of the variants of Marl A this is the one with the coarsest texture and the greatest quantity of fine to coarse sand inclusions. Scattered micaceous inclusions are also present and, conspicuously in some examples, particles of straw. It shows a considerable range of colour, porosity and hardness. In low-fired versions (800°-850°C) there is a strong reaction to hydrochloric

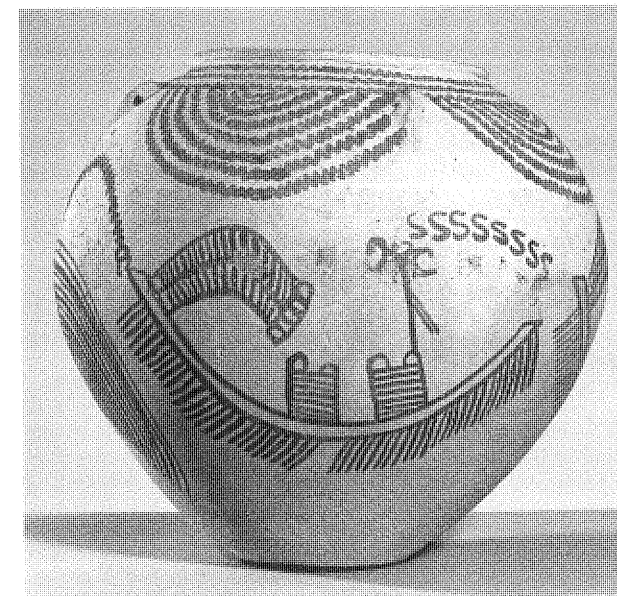


Fig. 17 Jar of Marl A₁ (surface fired pink, MUNSELL 7.5YR 8/4). Naqada II. Fitzwilliam Museum EGA.4571.1943 (BOURRIAU 1981a, no.31, incorrectly captioned 32). This is an example of PETRIE's D (Decorated) ware.

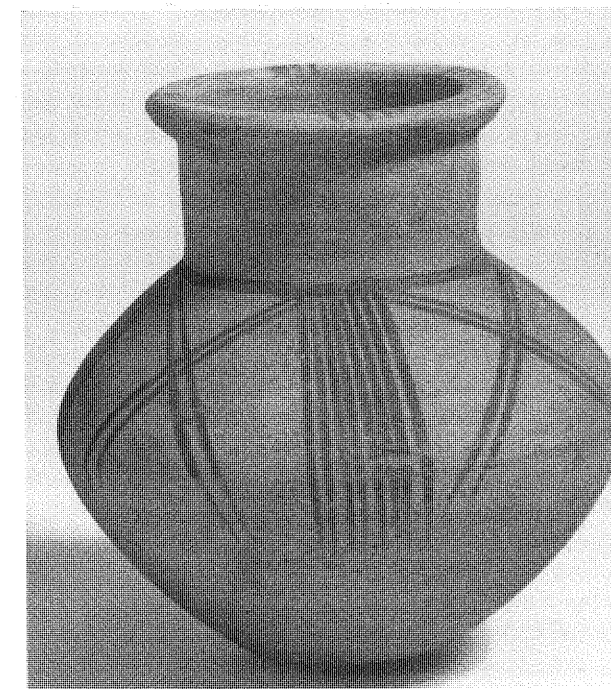


Fig. 18 Squat jar of Marl A₂. Due to uneven firing conditions the surface colour varies from pale yellow (MUNSELL 5Y 7/3) to red (MUNSELL 2.5YR 5/6). From Hiw (Diospolis Parva) grave W 43, early XVIIIth Dynasty. Fitzwilliam Museum E.63.1899 (BOURRIAU 1981a, no.264, where incorrectly described as Marl A, variant 1).



Fig. 19 Squat jar of Marl A3, surface pale yellow (MUNSELL 5Y 7/3) to reddish-yellow (MUNSELL 5YR 6/6). From el-Kab, early XIIth Dynasty. University College 18385 (BOURRIAU 1981a, no. 123).



Fig. 20 Storage jar of Marl A4, surface fired pale yellow (MUNSELL 5Y 7/3). From Hiw (Diospolis Parva) grave Y 177, reign of Tuthmosis III. Fitzwilliam Museum E.202.1899 (BOURRIAU 1981a, no. 143).

acid but in samples fired at around 1000°C there is no reaction. An open, porous texture due to burnt out limestone characterises the fracture of highly fired examples. At low magnification inclusions of limestone are visible, but at x45 magnification it becomes clear that the limestone is calcareous material in the clay matrix and therefore naturally occurring and not added by the potter (BOURRIAU and NICHOLSON in press). The fracture varies between light red and greenish-grey and is often zoned. Hardness varies between crumbly and soft, and hard and firm, and transverse strength from medium to great.

The fabric occurs in the Middle Kingdom but is most common in the New Kingdom. It corresponds to NORDSTRÖM's IVB fabric (1972, 55); Ba.I and Ba.II at Malqata (HOPE 1978, 67-68; HOPE 1989, 4-5); the calcareous Type V fabric at el-'Amarna and Malqata (HOPE, BLAUER and RIEDERER 1981, 161, colour plate 1a); H2 fabric at Saqqara in BOURRIAU and ASTON 1985, 39, here Pl. V d; H4 at Memphis (JEFFREYS and ASTON in press; BOURRIAU and NICHOLSON in press); fabric III.1 at el-'Amarna (NICHOLSON and ROSE 1985, 136; BOURRIAU and NICHOLSON in press); and II.A.04.01 at Qantir (ASTON and ASTON in press; BOURRIAU and NICHOLSON in press). It has been tentatively identified at Deir el-Ballas (BOURRIAU 1990a, 20).

HOPE has suggested that his type V may be a mixed clay, i.e. a mixture of desert (marl) and alluvial clay (HOPE, BLAUER and RIEDERER 1981, 162-163) and his discussion illustrates our present difficulty in determining this. At the present stage in our knowledge we cannot rule out the possibility that these examples represent a separate fabric group, and that what we currently call Marl A4 contains several fabric groupings (see HOPE, 1989, 4-5, 88-90).

4.4.2 MARL B (Fig. 21, Pl. VI a-c, g-h)

The groundmass is homogeneous and very dense. The voids so distinctive of Marl A3 and Marl A4 do not occur. The diagnostic property of the fabric is that it contains abundant quantities of sand, around 40% of the paste, added as a temper (ARNOLD 1988, 126). The particles are angular to sub-angular, and fine to coarse in size. As with Marl A4, at low magnification, inclusions of limestone are visible, but at x45 magnification these appear clearly as calcareous material in the clay matrix (BOURRIAU and NICHOLSON in press, comment on H8, which corresponds to Marl B).

The surface is always gritty to the touch and only the groundmass will react to hydrochloric acid, not the quartz and the feldspar which are the main constituents of the sand temper. Micaceous particles, usually dark, and the occasional straw particle may occur. Examples

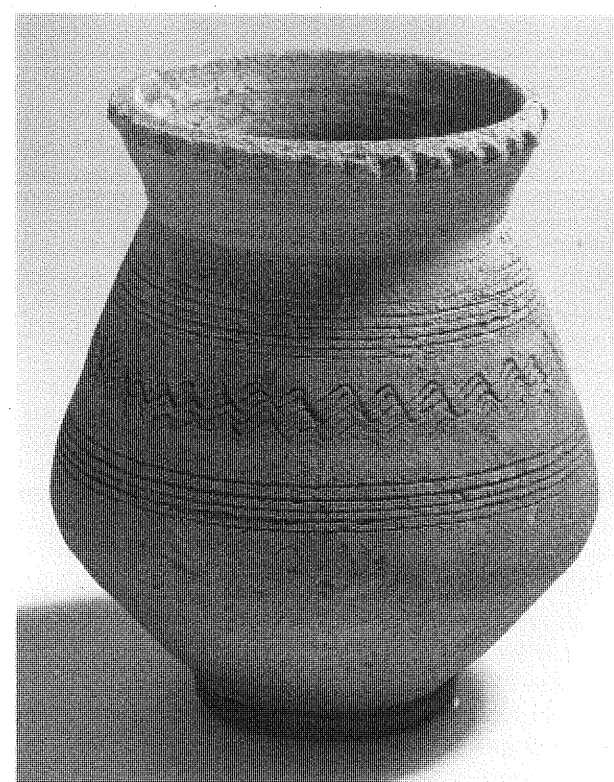


Fig. 21 Jar of Marl B, surface fired pale yellow (MUNSELL 5Y 7/3). From Hiw (Diospolis Parva) grave Y 343, Second Intermediate Period. Fitzwilliam Museum E.161.1902 (BOURRIAU 1981a, no. 22).

are often fired over 800°C, burning out limestone in the groundmass. The fracture, or at least the core, is usually pink with outer zones of grey-white to green. Porosity is dense, sometimes showing incipient vitrification. The fabric is normally hard and firm, but its extreme sandiness makes it crumbly and soft in highly fired examples. Transverse strength ranges from low to medium.

Marl B is used exclusively for large to medium-sized vessels, and seems to have a relatively short distribution in time and space. It occurs in the Second Intermediate Period and XVIIIth Dynasty and is most common in Upper Egypt. Neutron Activation Analysis (BELLIDO ET AL. forthcoming) has shown good agreement between samples from Deir el-Ballas (BOURRIAU 1990a, 20-21), where it is very plentiful, and samples from Memphis, Kom Rabi'a, where it is rare except in contexts of the early XVIIIth Dynasty. This suggests that it may be imported into the North from the South.

It corresponds to fabric II.B at Qantir (ASTON and ASTON in press) and fabrics III.8 and V.3 (?) at el-'Amarna (NICHOLSON and ROSE 1985, 137; BOURRIAU and NICHOLSON in press) although the fabrics are rare at both these sites. It corresponds to H8 in the Memphis/Saqqara classification (BOURRIAU and NICHOLSON in

press) and to the sandy marl clay at Deir el-Ballas (BOURRIAU 1990a, 20-21).

This marl fabric group is one of the easiest to identify even at low magnification, because of its sandy appearance and its texture, and at el-'Amarna the visual criteria for defining the group established by ROSE were well supported by the thin-section analysis carried out by NICHOLSON. A similar result was obtained at Memphis by BOURRIAU and NICHOLSON (in press).

4.4.3 MARL C (ARNOLD 1981, colour plate III c-e)

The fabrics in this group show a considerable range of texture and of firing conditions, accounting for an equal range of colour and porosity (ARNOLD 1981, 171-174, 183-191; ARNOLD 1988, 126-127, 129, 135, 144, fig. 74; BIETAK 1991, 327-328). The consistent and diagnostic property of the group is the abundant, more or less decomposed limestone particles of medium to coarse size embedded in the groundmass. These give the fabric a distinctive speckled appearance. The groundmass itself is fine and dense. Fine and medium sand particles, added as temper, are always present. Particles of unmixed marl clay, visible sometimes even on the surface, are also common (Pl. VI e). Micaceous inclusions, both light and dark, are also present. The dominant limestone inclusions ensure

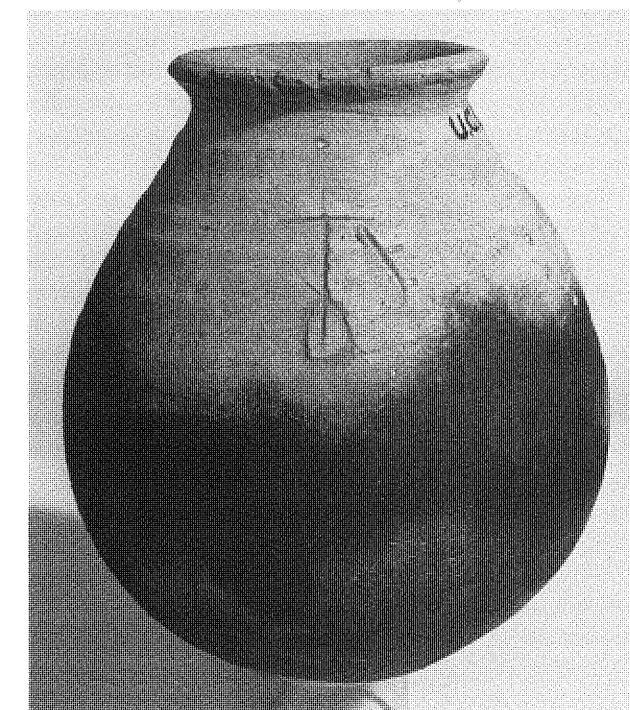


Fig. 22 Cooking pot of Marl C1, unsmoked area of surface fired pinkish-white (MUNSELL 7.5YR 8/2). From Kahun, XIIth Dynasty. University College 18636 (BOURRIAU 1981a, no. 119).

that there is almost always a strong reaction to hydrochloric acid. Examples fire from 750° to 1000°C, and the low-fired examples (750°–850°C) with their distinctive pale red/brown fracture seem to represent a distinct variant, Marl C₂ (see below). Most examples exhibit a grey-white surface (ARNOLD 1981, 172 quoting MATSON 1974, 129 ff.) and a dark/pale grey core with red outer zones. The appearance of the fracture is influenced by the fact that most vessels for which the fabric is used have very thick walls (0.5–1.0 cm). Porosity may be dense (in low-fired examples), or open due to voids from burnt out limestone, or exhibit patches of vitrified paste, but hardness and transverse strength are always very great.

The example shown in ARNOLD 1981, colour plate IIIc, which is from Dahshur, was examined in thin-section by JOSEF RIEDERER (personal communication) and he found fragments of the calcareous shells of large fossils in addition to the usual abundant limestone and sand particles. At the low magnification of the photograph, about x₃, the fossils are not visible.

The fabric group seems at present to have a clear pattern of distribution and use. It possibly occurs as early as the IVth Dynasty (it was identified by BRIDGET CROUWELL [personal communication] at Giza, excavations of the Oriental Institute of the University of Chicago, and by DINA FALTINGS at Dahshur, excavations of the German Institute of Archaeology). ARNOLD (1988, 144–145, note 342) has identified at Sidmant a marl fabric which is close to Marl C. This occurs in graves of Cemetery N, datable, she suggests, to early in the reign of Senwosret I. It should be emphasised that these early examples have not yet been fully studied and ARNOLD has already noted that the Sidmant Marl C is different in texture, colours and consistency of inclusions from the typical Marl C fabric (Marl C₁).

Thereafter the fabric group occurs in quantity throughout the Middle Kingdom and Second Intermediate Period in the Delta and Memphis-Faiyum region. Evidence from Lisht South confirms that at least one of the sources of this clay was close by, since Marl C was used to make, by hand, a drain-pipe in the priests' bath (DI. ARNOLD 1988, 29–30, fig. 4). Vessels made of Marl C are traded into Upper Egypt and Nubia (BOURRIAU 1991, and most recently confirmed by the discovery of storage jars in late Middle Kingdom settlement contexts at Karnak North [HELEN JACQUET, personal communication]).

It is used mainly for large and medium-sized cooking and storage vessels. The paste is heavy and frequently poorly mixed, unsuitable for small, thin-walled vessels. The technology of manufacture of the vessels for which it is used is as distinctive as the paste itself. The vessels are not usually thrown on the wheel but made by hand, primarily by coiling and shaping on a turning device (see ARNOLD, 1981, 171–174, 183–191; ARNOLD 1982, 95–96,

figs. 4: 4; 8: 1–8, 10, 12; 9: 12, 15; 11: 1–12; 19: 1–5; 20; ARNOLD 1988, 135; ARNOLD in this volume). Memphis, Kom Rabi'a, has provided examples of relatively thin-walled bowls with ring-footed bases in Marl C which have been thrown on the wheel, but they appear only in the latest contexts in which the fabric occurs, datable to the Second Intermediate Period.

At present we can recognise three variants within the Marl C fabric group, based upon firing temperature, colour of fracture, porosity and quantity and character of the sand temper.

4.4.3.1 Marl C₁ (Fig. 22, Pl. VI d,i)

This variant of Marl C is defined by the mass of contiguous fine and medium decomposed particles of limestone (NORDSTRÖM 1986, 633; ARNOLD 1988, 126; BIETAK 1991, 327–328). The fracture is almost always zoned, red with a grey or black core, and sometimes shows signs of incipient vitrification. NORDSTRÖM has estimated firing temperatures as 850°–1000°C. There are large quantities of fine and medium sand particles but the limestone predominates. This is the most common variant in the Memphis-Faiyum region.

4.4.3.2 Marl C₂ (Pl. VI f)

Lower firing, estimated at 750°–850°C by NORDSTRÖM, accounts for the different appearance of this variant. Many of the limestone particles remain intact and the fracture is not zoned but a uniform colour ranging from red (MUNSELL 10R 4/6) to brown (MUNSELL 5YR 6/6). Neutron Activation Analysis (BELLIDO ET AL. forthcoming) has confirmed that a further difference between Marl C₁ and Marl C₂ lies in the sand temper. Samples of Marl C, when analysed, fell into two sub-groups, which became indistinguishable once a dilution effect, reducing the concentrations of elements being measured, was taken into account. This dilution effect was thought to be due to increased amounts of silica (sand particles) in one of the groups. All the samples identified by ARNOLD as Marl C₂ fell into this latter sub-group and one of these samples, from Tell el-Dab'a, is illustrated on Pl. VI f. Further visual examination under low magnification confirms that sand is present in larger quantities than limestone, and coarse rounded sand grains are conspicuous. BIETAK describes a coarse variant of Marl C which corresponds to Marl C₂ (BIETAK 1991, 327–328).



Fig. 23 Double vase of Marl D, fired pale yellow (MUNSELL 5Y 8/4). Probably from Saft el-Hinna, grave 55, late XVIIIth–XIXth Dynasties. University College 19043 (BOURRIAU 1981a, no. 148).

4.4.3.3 Marl C compact (Pl. VI e)

ARNOLD has suggested the existence of this variant (ARNOLD 1988, 127, 129) and defines it as follows: it contains much less sand than Marl C₁ or Marl C₂; it is much denser (hence the name); the limestone particles show signs of decomposition; and conspicuous flakes of unmixed marl are visible in the fracture. The variant has so far been associated principally with a single pottery type, large egg-shaped bottles with grooved necks (ARNOLD 1988, fig. 74, nos. 122, 123).

4.4.4 MARL D (Figs. 23, 24, Pl. VII a-c, e-f)

The groundmass is fine and homogeneous, and the distinctive visual characteristic of the fabric is the limestone particles, probably added as temper to the clay. They are smaller in size than those in Marl C, varying from fine to coarse and sub-rounded to sub-angular. They constitute up to 25% of the mass of the fabric, so less than the limestone temper of Marl C. There are also fine to coarse sand, micaceous particles and dark rock material, in a quantity at least equal to that

of the limestone. Organic inclusions are extremely rare, and the surface feels distinctly gritty.

The surface usually fires light grey to green and the fracture is pale greyish-brown. More highly fired examples show red-brown outer zones or a uniform red-brown core. In these cases there are usually signs of decomposed limestone particles. The porosity is usually dense and the fabric is hard and firm with great transverse strength.

This fabric is very common in XVIIIth–XIXth Dynasty contexts in the Delta and the Memphis-Faiyum region, and seems to occur in the south only as imports from the north. The illustration, Pl. VII a, comes from one such import, a wine amphora.

The fabric corresponds to II.D.01, II.D.02 (ASTON and ASTON in press), and possibly II.F.02 at Qantir (BOURRIAU and NICHOLSON in press); calcareous Type IV from Malqata and el-'Amarna (HOPE, BLAUER and RIEDERER 1981, 161–164, colour plate I, b and c); Ba.I from Malqata (HOPE 1978, 67–68); H1 from Memphis/Saqqara (BOURRIAU and ASTON 1985, 38; BOURRIAU and NICHOLSON in press; JEFFREYS and ASTON in press); III.2, III.3, III.5 and III.6 at el-'Amarna (NICHOLSON and ROSE 1985, 136–138, 145–147; BOURRIAU and NICHOLSON in press). In Nubia it corresponds to NORDSTRÖM's IVA-B (1972, 54–55; 1977, 65).

As these descriptions show, Marl D is not a homogeneous grouping but shows considerable variation in firing conditions and in number and size of inclusions; see the discussion in BOURRIAU and NICHOLSON (in press) concerning fabric H14, common at Memphis/Saqqara and Qantir, and related to H1 (= Marl D). It is used frequently for amphorae (BRACK and BRACK 1977, pls. 15, 63 nos. 2/28, 2/29) some of which carry dockets giving date, contents and place of origin (HAYES 1951;

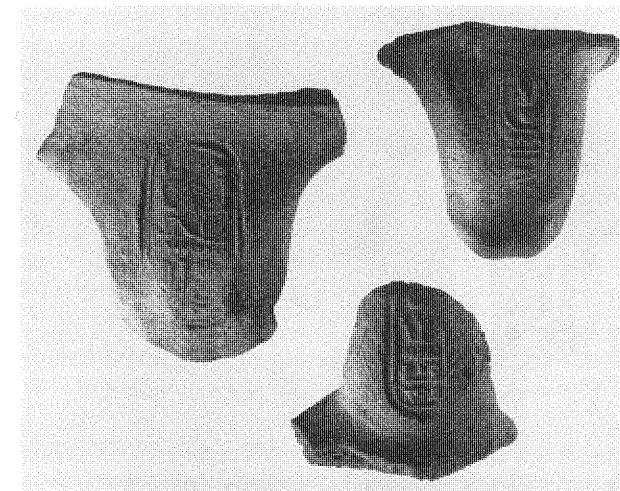


Fig. 24 Vetricle handles of amphorae of Marl D, stamped with the king's name. Reigns of Seti I and Ramesses II. Fitzwilliam Museum EGA.4157–8.1943, EGA.4160.1943 (BOURRIAU 1981a, no. 245).

HOPE 1978) and/or stamps with royal names on the handles (Fig. 24). When the information from the docketts and stamps is finally integrated with the classification of the shapes, technology and fabric of the amphorae, we will have a powerful tool for the study of commodity distribution in the Nile Valley and beyond.

4.4.5 MARL E (Figs. 25, 26, Pl. VII d)

This fabric appears similar in most respects to Marl B, except for the presence of abundant particles of medium to coarse straw. These have been added to the paste as temper. In addition to straw, there are abundant inclusions of medium to coarse sand, micaceous particles and particles of unmixed groundmass material.

The surface fires from yellowish-white to greenish-grey and in fracture from pink to greenish-grey. The green, highly fired examples do not react to hydrochloric acid, and show an open, porous texture dominated by the voids or impressions left behind by the burnt out straw. These particles lie parallel to the throwing lines, so a fracture needs to be made along these lines for the straw to be clearly seen. The fabric is hard with great transverse strength.

It is commonly used for thick-walled vessels, often hand-made "bread trays" (Fig. 26). This suggests that the deliberate addition of straw by the potter was related to this special function. The fabric is relatively rare, but has now been identified at Memphis as well as in Upper Egypt (Koptos and Deir el-Ballas, BOURRIAU 1990a, 21-22). It seems, so far, to occur for a short time from the Second Intermediate Period to the early XVIIIth

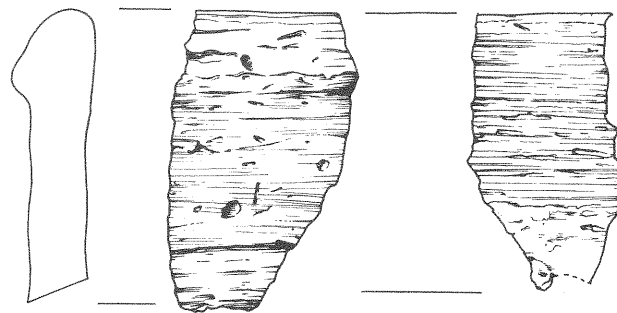


Fig. 25 Rim sherd of a basin (?) of Marl E; the fracture is illustrated as Pl. VII d. From Deir el-Ballas, excavations of Museum of Fine Arts, Boston, XVIIth-XVIIIth Dynasties (drawing by ANDREW BOYCE. Courtesy of PETER LACOVARA).

Dynasty, and to originate in the Deir el-Ballas region, since it occurs there in the widest range of open and closed forms. It corresponds to HII at Memphis (BOURRIAU and NICHOLSON in press) where it is present in only one form, the "bread tray" (Fig. 26).

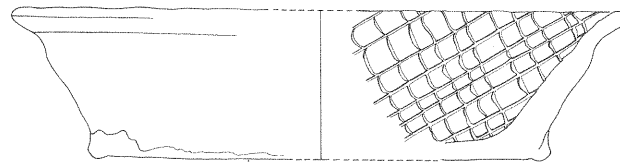


Fig. 26 "Bread tray" of Marl E. From Memphis, Kom Rabi'a, RAT 308/334:1247, early XVIIIth Dynasty (drawing by KATHRYN ERIKSSON).

5. Foreign Fabrics

Our intention is not to survey all the fabrics of pottery imported into Egypt. To do this for even a single period would be a large undertaking and well beyond the scope of this fascicle. Instead some readily available examples have been selected to indicate the range of material and to illustrate how the imported pottery differs in appearance from the Egyptian. The differences are not hard to see even if the Egyptian potter is setting out to imitate an imported pottery type. He relies upon his treatment of the surface, using paint or slip, or upon shape, to achieve his purpose and does not seek to reproduce, even visually, the raw material of the original.

5.1 NUBIAN

The pottery styles of Nubia are distinctive but we know very little of the processes of manufacture and organisation of the industry except for what we can infer from an examination of the pottery itself. In the Christian period the situation is better, thanks largely to the pioneering work of W. Y. ADAMS (ADAMS 1986). From the beginning of pottery making until the early New Kingdom, all Nubian pottery is hand-made and the raw material is Nile clay. The manufacture of black-topped red wares continued in Nubia for over 1500 years after it had ceased in Egypt.

5.1.1 CLASSIC KERMA BEAKER WARE (Fig. 27, Pl. VIII d)

The sherd illustrated on Pl. VIII d is from a beaker dating to the Classic period of the Kerma culture, ca. 1750-1500 B.C. The completely black section, which is the result of firing in a reducing atmosphere, makes it difficult to recognise inclusions in the paste. For this reason it is reproduced at roughly x4 magnification, i.e. double the size of the sherds shown in Pl. VIII a,b,c. At x10 magnification, abundant fine sand, fine mica and scattered fine (< 2 mm) particles of straw can be seen. The straw suggests dung temper (see above, p. 163). Porosity is dense and the fabric is medium-hard with an exceptionally thin (2 mm wide) vessel wall. Transverse strength is low. It is described by NORDSTRÖM (1972, 65) as his IIB fabric, red-and-black ware H4.15. It is interesting that the only Egyptian fabric which it

resembles is Nile A (Pl. I a-c) most commonly used for black-topped red wares in the Predynastic period.

5.2. AEGEAN

From the early Middle Kingdom until the Ramesside period, Minoan followed by Mycenaean pottery occurs in Egypt and Nubia (KEMP and MERRILLEES 1980, *passim*; BELL 1985, 61). Minoan pottery is found in much smaller quantities than Mycenaean and the latter is most plentiful in the late XVIIIth Dynasty. It cannot be assumed *a priori* that all the Mycenaean pottery from Egypt is from Greece itself since it was manufactured also in Palestine and that country often served as an intermediary in the trade with Egypt.

The surviving corpus of Mycenaean material consists almost entirely of small, closed, painted vessels, used to contain scented oils. Large coarse ware stirrup jars for the import of olive oil were shipped to Egypt (BOURRIAU 1981a, no. 248; MERRILLEES 1972, 125-127), but sherds have so far been identified from only two sites, el-'Amarna and Deir el-Medina (MARTHA BELL, personal communication). Sherds from other examples almost certainly went unrecognised by early excavators.



Fig. 27 Spouted vessel, Classic Kerma Beaker ware. From Kerma, Second Intermediate Period. MFA.13.4102 (photo Museum of Fine Arts, Boston).

5.2.1 MYCENAEAN FINE WARES (Pl. VIII a,g)

The hardness, dense porosity and fine texture of the groundmass are the distinctive properties of this group of fabrics. At x10 magnification (Pl. VIII g) a scatter of inclusions of fine red-brown particles (ochre or grog?) and straw can be seen, and rounded air-holes are conspicuous. Only at over x20 magnification do other mineral inclusions such as sand become visible. The vessel wall is usually thin, 2–4 mm, and the section rarely shows zoning, being a uniform light brown to cream yellow.

The fabric corresponds to P4 in the Memphis/Saqqara classification (BOURRIAU and ASTON 1985, 40).

5.3 CYPRIOTE

Cypriote pottery appears in Egypt from the late Middle Kingdom until at least the end of the XVIIIth Dynasty (MERRILLEES 1968, *passim*). The greatest variety and quantity has so far been found at Tell el-Dab'a (MANFRED BIETAK, personal communication) but two classes, Base Ring I/II Wares and Red Lustrous Ware, have a wide distribution in Egypt and Nubia. They are common enough in contexts of the early XVIIIth Dynasty to help to characterise the period in Egypt in ceramic terms. The precise origin of Red Lustrous Ware is at present under discussion (KATHRYN ERIKSSON, personal communication) and it may be a product of the Levant and/or Cyprus. The characterization of the fabric of Base Ring Ware is also currently being debated by Cypriote archaeologists (VAUGHAN 1991, *passim*).

5.3.1 BASE RING I/II WARES (Fig. 28, Pl. VIII e)

These fabrics are very hard and dense and all vessels are thin-walled, 3–4 mm, but in contrast to Mycenaean fine wares, reveal fine mineral inclusions (abundant sand and scattered limestone particles) and a few impressions from fine straw, even at x10 magnification. Elongated air holes are distinctive as is the zoning of the sherd fracture—grey-black on the inside and light brown (MUNSELL 7.5Y 6/4), which is also the outer surface colour, on the outside. In examples from Memphis, Kom Rabi'a, Base Ring II seems to contain more and coarser mineral inclusions than Base Ring I and to be more highly fired, judging by limestone particles which show traces of decomposition. The colour zoning of the fracture, grey core with red outer zones, is also more pronounced than in Base Ring I.

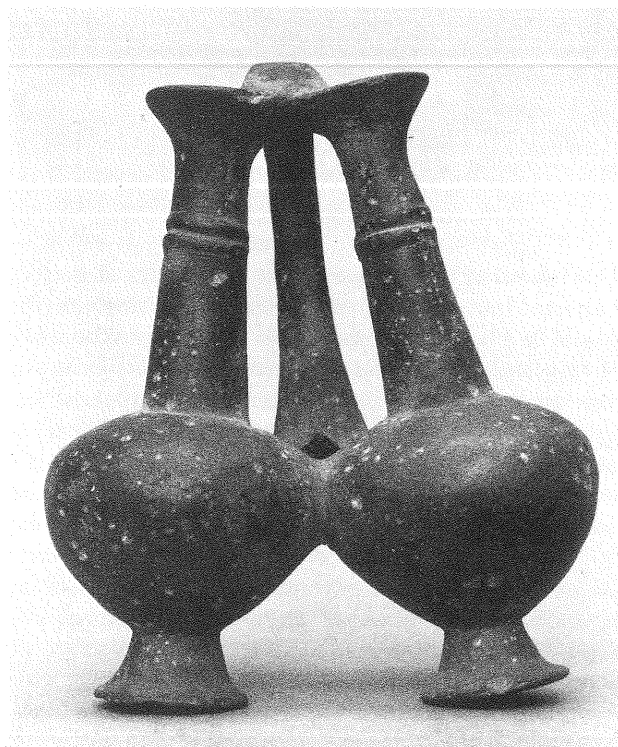


Fig. 28 Double juglet of Cypriote Base Ring I ware from Egypt. Louvre Museum, AF.6.441 (photo Louvre).

Small juglets are the most common shapes in which the fabrics appear in Egypt (Fig. 28). The fabrics correspond to P7 in the Memphis/Saqqara classification (BOURRIAU and ASTON 1985, 40–41).

5.3.2 RED LUSTROUS WARE (Fig. 29, Pl. VIII f)

In Egypt this fabric occurs most commonly in one form, the "spindle bottle" (Fig. 29; MERRILLEES 1968, *passim*), used probably for the importation of scented gums and resins. The example shown on Pl. VIII f, from Saqqara, is a fine variant of the usual fabric. The density and homogeneity of the groundmass is striking. At x10 magnification only a scatter of small round air-holes and a little fine sand are visible. Examination at higher magnification suggests mineral inclusions are generally below 200 microns in length. The surface and the fracture are both red, MUNSELL 2.5YR 5/8. Porosity is dense and the fabric is extremely hard with great transverse strength.

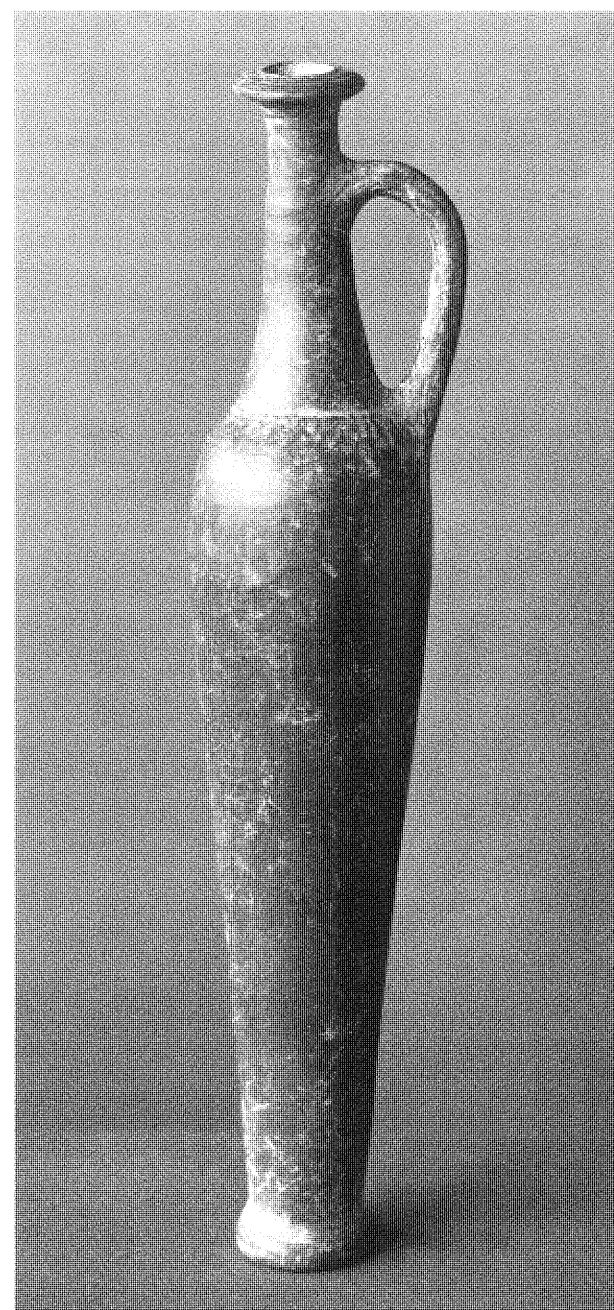


Fig. 29. Red Lustrous ware "spindle bottle" from Egypt. Victoria and Albert Museum (photo Victoria and Albert Museum).

5.4 PALESTINIAN

The three fabrics illustrated as Pl. VIII b,c,h,i are all fabrics of "Canaanite jars", the term given to large amphorae made in the Syria-Palestine region during the Bronze Age (GRACE 1956, 80–109; AMIRAN 1969, 140–142, pl. 43). They were imported into Egypt in large quantities as containers for wine and olive oil. They are

under-represented in early excavation reports, either because they were not recognised as imports, or because they survived only as sherds and were not kept for study (BOURRIAU 1990b).

Properties shared by all three "Canaanite jar" fabrics illustrated here are: the large size, quantity and character of their mineral inclusions; the absence of straw temper; their dense porosity; and the thickness of the vessel wall (10–19 mm). This combination of properties sets them apart from both the Nile and the marl fabrics of Egypt.

5.4.1 "CANAANITE JAR" FABRIC WITH COMBED SURFACE (Pl. VIII b)

For the distinctive treatment of the surface, see ARNOLD 1982, fig. 13: 1. This example is from Lisht North and is of Middle Kingdom date.

The groundmass is almost invisible between the abundant fine, medium and coarse, irregularly shaped mineral particles. Sand and limestone, both medium and coarse, dominate and grog (visible in the photograph, upper right) is definitely recognisable, together with rounded sand grains and dark rock particles. Despite the numerous reaction rims from burnt out limestone, visible also on both surfaces of the sherd, the porosity is dense and hardness and transverse strength, great. There is a band of paler colour in the fracture, otherwise the colour is a uniform deep reddish-brown.

In addition to occurrences at Lisht and Dahshur, this fabric is common in the late Middle Kingdom to Second Intermediate Period levels at Tell el-Dab'a where it corresponds to IV-2 (BIETAK 1991, 329).

5.4.2 "CANAANITE JAR" FABRIC WITH FINE MINERAL INCLUSIONS (Fig. 30, Pl. VIII c, h)

The sherds shown as Pl. VIII c, h derive from amphorae of late XVIIIth–XIXth Dynasty date from Saqqara and Memphis. The fabric, while still dominated by numerous mineral inclusions, is noticeably more homogeneous than the previous one. This is seen most clearly in Pl. VIII h. The numerous limestone particles and both irregular and rounded sand grains are all fine, but the eye is taken by the even more plentiful fine dark rock particles, which are characteristic of this fabric. The fracture shows no zones and its colour is that of the outer surface, reddish-yellow (MUNSELL 5YR 6/6). The hardness and transverse strength are great, porosity is dense and the vessel wall approximately 1 cm thick.

The fabric corresponds to P11 at Saqqara and Memphis (BOURRIAU and ASTON 1985, 40; BOURRIAU 1990b, 21–22, ill. 1–2) and IV.07.11 at Qantir (ASTON and ASTON in press).

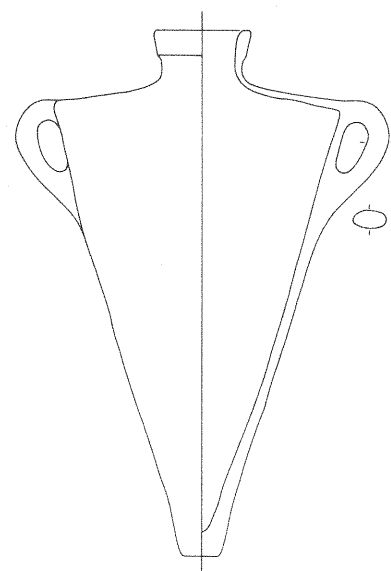


Fig. 30 "Canaanite Jar" of fabric illustrated as Pl. VIII c and h. From Saqqara, Tomb of Horemheb (drawing by W. SCHENCK).

5.4.3 "CANAAHITE JAR" FABRIC WITH SHELL
(Pl. VIII i)

The example on Pl. VIII i comes from Memphis, Kom Rabi'a. It is illustrated at high magnification in order to show the shell inclusions clearly.

The distinctive properties of this fabric are the colour and zoning of the fracture—reddish-brown outer bands with a grey-black core; very large (> 5 mm) irregular and intact particles of limestone (visible in photograph, top left) scattered throughout and breaking the surface; shell, which is identifiable even at $\times 10$ magnification; and low transverse strength due to the relatively low firing temperature and the large friable limestone inclusions. Porosity is moderate and hardness is soft to medium.

"Canaanite jars" in this fabric are found throughout the New Kingdom deposits at Memphis, Kom Rabi'a, and the fabric corresponds to P31 in the Memphis/Saqqara classification (BOURRIAU 1990b, 23–24). It has also been identified as Qantir IV.07.10 (ASTON and ASTON in press).

6. Colour Atlas of Pottery Fabrics

Describing pottery fabrics so that examples of the same fabric can be recognised from verbal description alone is difficult. Colour photographs are still an indispensable tool used in conjunction with a clear and consistent descriptive terminology. Plates I–VIII provide illustrations of the range within the major fabric groupings described above, and should be used in conjunction with the illustrations on colour plates I, II in *Studien zur altägyptischen Keramik*, edited by DOROTHEA ARNOLD, published in 1981. To clarify the relationship between the appearance of the section of a sherd and the surface of a complete vessel, a selection of vessels is shown as Figs. 8–30. Most of these have been taken from *Umm el-Ga'ab. Pottery from the Nile Valley before the Arab Conquest*, written by JANINE BOURRIAU in 1980 while the Vienna System was being formulated.

All photographs credited to the DAI Cairo are of

sherds used in the discussions during which the fabric classification was created. The photographs are of sections of sherds freshly broken parallel to their throwing lines, taken in bright sunlight by DIETER JOHANNES. The sherds photographed by GWIL OWEN were taken in strong artificial light. Most of the sections are reproduced at roughly twice original sherd size. Pls. IV g-i, V h-j, VI g-h, VII e-f, VIII e-i were taken by JANINE BOURRIAU through a microscope, mostly at $\times 10$ magnification. All are intended to show how the fabric appears when seen through a $\times 10$ pocket lens, the ceramicist's indispensable tool. The fabric descriptions are based upon examination of fractures at between $\times 10$ and $\times 30$ magnification.

All the sherds described in the captions as from Dahshur come from the excavations of the German Institute of Archaeology in the Pyramid complex of Amenemhet III.

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COLOUR PLATES I-VIII