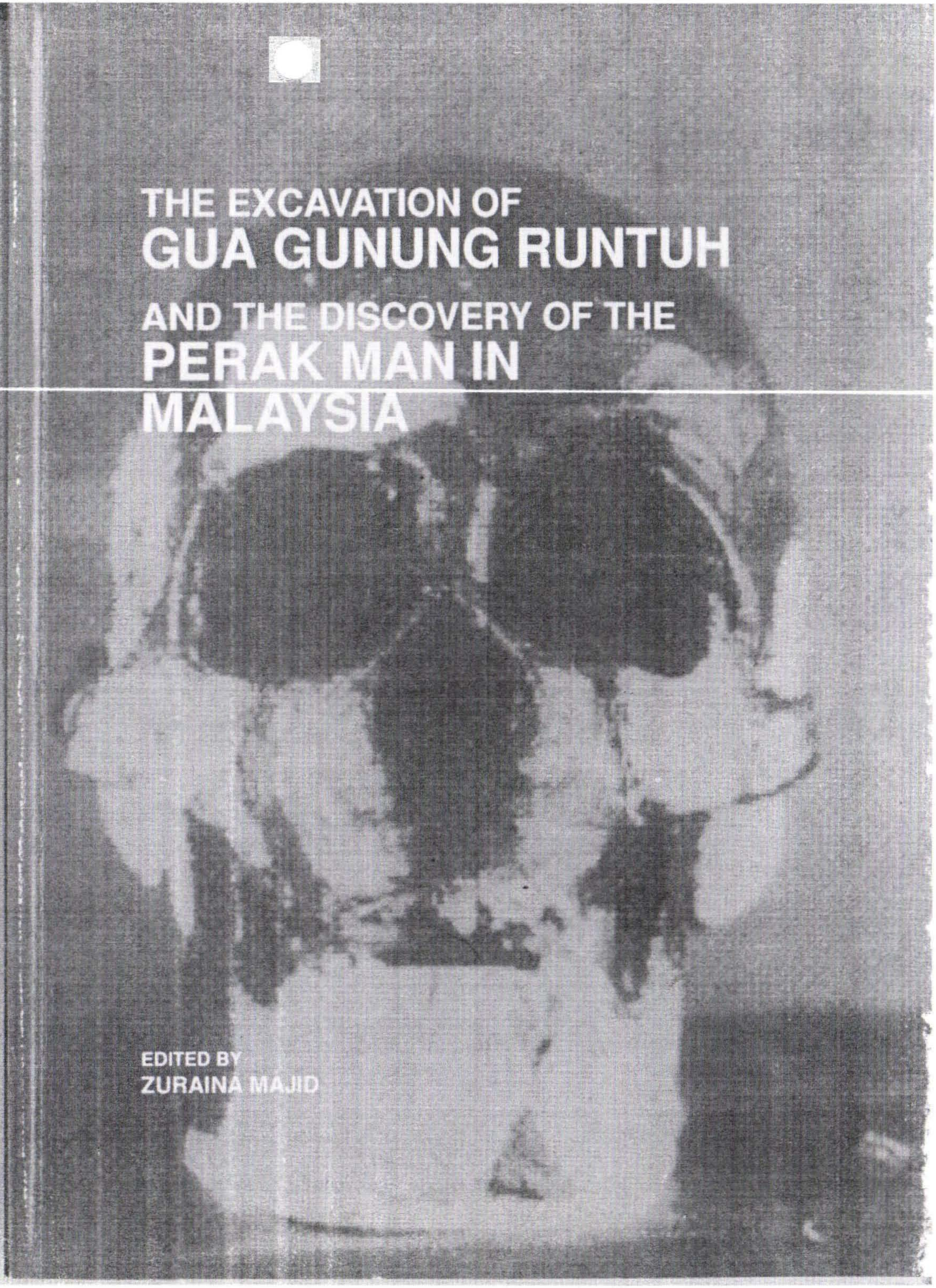
THE EXCAVATION OF GUA GUNUNG RUNTUH AND THE DISCOVERY OF THE PERAK MAN IN MALAYSIA



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CHAPTER 7

THE REMOVAL, RECONSTRUCTION AND CONSERVATION OF THE GUA GUNUNG RUNTUH SKELETON: A PRACTICAL GUIDE

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INTRODUCTION

Bone consists of collagen, a proteinous (organic) substance, and a mineral, principally a form of calcium phosphate, called apatite, together with water. The bones in a body have different functions and this difference is reflected in the degree of mineralisation. Such differences in mineralisation also give rise to the differences in properties between the same bone from individuals of different ages. During life, limb bones can also alter their shape to respond to the load placed upon them. For example, the bones on the racquet arm of a professional tennis player are likely to be thicker than the other side. Wear and tear on teeth indicate diet. Therefore, an expert examination of skeletal remains can give vital clues not only to age but also to occupation, diseases, and diet of the living person.

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However, the proteinous material is subject to decay so only the highly mineralised parts of the skeleton stand a chance of preservation for posterity to uncover. Normal chemical reactions with ambient minerals aided by damp conditions can alter the structure of the remaining apatite edifice and the bone may crumble. It is therefore rare to find ancient and well-preserved human

remains in the the tropics and when one is uncovered, it is extremely important to conserve it for the clues that it can offer about the prevalent society of that time.

An archaeologist who uncovers such human remains therefore needs the additional skills of the forensic scientist to remove, transport, reconstruct and eventually to conserve those remains. This situation was precisely the problem we had with the skeleton from Gua Gunung Runtuh in Lenggong. Based upon our experience with this skeleton, we have developed a general procedure which may be useful for the recovery of ancient human remains in tropical regions.

PRELIMINARY SITE MEASUREMENTS

It is important to acquire information about the site such as temperature and humidity, soil composition and condition, and their variations in order to assist in subsequent removal, conservation, and analysis. Perak Man was buried 0.8 metres below the surface in a limestone cave. The floor was composed of fine chalk silt and roof debris from a relatively recent cave-in. A patchy layer of guano was evident over the site. The moisture content of the top soil was determined as 2.0% by drying to constant weight. The moisture content of a bone fragment was similarly measured as 2.7%. Thus a measurement of the water content of the immediate soil should give an approximate value for the moisture content of the skeletal remains. This level of moisture content may be considered dry. Ambient humidity was relatively constant over one week at 89% while the cave temperature averaged a cool 24^{o}C (maximum 24.5^{o}C, minimum 23.5^{o}C). These relatively constant environmental conditions must have contributed to the preservation of the remains. Wider deviations would lead to deterioration.

The pH of the soil, measured with a digital pH meter (Cole Palmer, Beckman model 3500) was slightly alkaline at 8.15 units. Acid conditions would have destroyed the mineral components (Nakahashui and Nagai 1985).

Fluoride ions were low in abundance and precluded extensive conversion of bone apatite into fluoroapatite which could contribute to a weakening of the structure and loss of form (Baer 1978). As the burial was relatively high, about 75 metres above the estimated level of the lake at the dated period (see chapter 2) it was not subjected to periodic inundation with groundwater containing dissolved salts. Thus the remains were relatively free from salt encrustations and the form was well preserved.

REMOVAL

The skeleton was first exposed by standard established techniques. The observed integrity of the remains then allowed a decision as to which of the two methods should be used for removal and transport. If the remains are sufficiently intact and largely in an undeteriorated condition then they can be removed as a block with the soil especially if the site is accessible. However, the rather frail condition of the skeleton, and the inaccessibility of the cave required that the *in-situ* position of every fragment be recorded and photographed for individual removal (Plate 7-1). Half the jaw was recovered away from the skeleton probably as a result of a boulder falling on the skull.

Each fragment was next identified and carefully cleaned while in place with wooden skewers and soft hair brushes. Fragments which did not need consolidation were carefully removed and labelled. Attention was given particularly to whether the skeletal parts belonged to the left or right side. Left and right parts were separately packed and labelled. Small breaks (for example finger bones) were mended with a polyvinyl acetate cement such as UHU (Ligner & Fischer GmbH) before packing. Cancellous (spongy) bones such as the shoulder blade were fragile and were carefully removed with the aid of a shaped block of plasticine (Plate 7-2).

The bones were wrapped in bubble paper, placed into boxes packed with styroform beads for added protection during transport. Precise labelling is important for the reconstruction (Plate 7-3). In this manner, the skeleton was evacuated from the cave to Lenggong, Ulu Perak where it was washed and reassembled. The reassembled skeleton was then packed with styroform beads and old newspapers into a wooden box lined with styroform sheets (Plate 7-4) and transported back to Universiti Sains Malaysia in Pulau Pinang.

CONSOLIDATION

The skeleton was in a fragile condition, especially the rib cage, the spinal column and the pelvic region and needed consolidation for removal. Consolidation means coating the fragment with a supporting polymer to hold the surface together. No animal or natural polymers such as shellac or animal glue should be used as this might interfere with dating and DNA studies that are to be conducted later. Epoxies should be avoided as they cannot easily be unbonded from the bone without serious damage.

We found that a moderately low molecular weight polyvinyl acetate e.g. UHU or a polymethacrylate (Acryloid B72/Polaroid B72) as a 3% - 5% solution in acetone was appropriate. The degree of dilution depended upon the porosity of the bone. A more dilute solution would be suitable for a dense and nonporous bone whereas very porous bone would need a thicker solution. This was arrived at empirically by observing the seepage of consolidant solution into the surface. The consolidant solution was brushed on layer by layer with a 2.0 cm brush to assure that it was absorbed into the bone. Toluene can replace acetone as the solvent. The bone was thoroughly cleaned by using a bamboo skewer or stick to minimise scratching and scarring of the bone. It was air dried carefully. Drying can also be done with an ordinary hair dryer. If the bone is not dry, the consolidant would not adhere to the bone.

An attempt can be made to consolidate wet or damp bones with an emulsion of PVA or the polymethacrylate (1 part polymer to 4 parts water). Use of a hydrophobic polymer without substituents permitting crosslinking is essential to prevent strong bonding to the mineral in the bone, deep seepage into the structure and formation of a hard irremovable film. However, a disadvantage arising from the use of a relatively low molecular weight polymer such as UHU PVA is its tendency to become tacky during hot weather. This can be messy and care should be exercised during the packing. Consolidation treatment should therefore be carried out under cover if the site is exposed.

A different type of consolidation was used to remove larger assemblage of bones such as the partially intact vertebral column. Cotton wool was liberally wrapped round the whole large fragment to protect it from the plaster of Paris to be used (Plate 7-5). The vertebral column was then wrapped up with several layers of bandages coated with plaster of Paris (Plate 7-6) as in the casting for a broken limb in a hospital.

UNPACKING AND CLEANING

Unpacking should be carried out systematically on a large table. The remains usually require further cleaning to remove stubborn adhering soil, encrustation and consolidation material. The fragments can be handled as one would excavated sherds. Loose material may be dislodged mechanically with wooden sticks, steel needles, dissecting blades and soft bristle brushes (tooth brushes are perfect). Fragments protected by a consolidant may be washed with acetone or toluene to redissolve the surface polymer film if necessary. However in our case, since the consolidant was used on the very fragile pieces to prevent crumbling and disintegration, we left it in place. Subsequent analyses were not carried out on fragments so consolidated unless the surface film was removed. Work involving organic solvents should be done in a fume cupboard and away from all flames.

Chemical methods are required for the more tenacious material. Soluble salts can be dissolved by immersion and washing with water (warm water, if necessary) assisted by gentle scrubbing with a soft tooth brush (Plate 7-7).

Insoluble inorganic encrustations such as calcium carbonate (limestone) require digestion by a weak acetic acid solution (10%-15%)

which will not affect the bone apatite. Strong mineral acids such as hydrochloric acid or nitric acid should never be used as they will attack the bone apatite. The bones were placed in a fine plastic sieve which was dipped repeatedly into the acid solution contained in a larger bowl (Plate 7-8). Scrubbing and cleaning was carried out between immersions. Immersion for at least half an hour may be necessary. Longer periods may be used for stubborn encrustations. Thorough rinsing after acid treatment is imperative. This was done by repeated rinsing in fresh water.

After cleaning, the bones should be air dried (in the open with only a very gentle draught). Oven drying should be avoided as rapid drying can cause cracks and splintering. After drying, the consolidant mixture can be used to rejoin fragments according to the site record. Such temporary bonding can be undone with acetone solvent. Again, natural glues or gums should never be used for this reconstruction as they will interfere with future analyses such as amino-acid dating and elemental analyses. Synthetic polyamides such as nylons should also be avoided as they might similarly interfere in tests or form permanent bonds which will restrict subsequent analyses of the bones.

STORAGE AND CONSERVATION

Initially, the reconstructed skeleton was stored in a wooden box lined with styroform sheets which was then placed in a room with intermittent air-conditioning. Slight shrinkage was observed. This was most obvious in the skull and jaw where some of the teeth became more exposed and loose. Some bone powdering and peeling was also observed in some joints. This could be caused by the fluctuating relative humidity (RH). Residual inorganic salts have a complex chemistry. At high RH these salts may hydrate to acid forms that can react with the bone while a low RH could lead to crystallisation of salts. Both these acid and salts could be responsible for the powdering and peeling (Colin Johnson, British Museum pers. comm. 1992). Some of the UHU consolidant also peeled off probably as a result of application to the bone when it was still damp. This took away some of the underlying bone. This deterioration in condition was largely due to the wide temperature variation (and consequently a distressing variation in humidity also). Perak Man had remained largely intact for more than 10,000 years because it had lain in a naturally controlled environment. We had disturbed this harmony of the elements. The solution was obviously to return as closely as we could to the cave conditions.

This was achieved by 24 hour air-conditioning and a humidity controlled cabinet. Up to now (1993) no further deterioration has been observed. This air-conditioning has maintained the room temperature at a constant 20°C. The use of an air-conditioner also kept the relative humidity at 45% - 55%. (somewhat drier than in the original site at Gua Gunung Runtuh; but this was considered necessary to prevent fungal infection). This airtight glass storage facility is a constant temperature/constant humidity controlled cabinet as used by professional photographers for storing their equipment.

We recommend also constant visual monitoring of the container and the remains for insect, fungal or other organism infestations. A relatively dry environment should prevent fungal spores from germinating. An insect repellant (e.g. moth balls) should be adequate protection against most common insects (nesting ants, cockroaches, borers, silverfish etc.).

CONCLUSIONS

The human remains from Gua Gunung Runtuh has been stored for about two years now at Universiti Sains Malaysia, Pulau Pinang without any visible deterioration. The methods we have developed for the removal, transport, reconstruction, and conservation use simple tools and easily available chemicals. They do not require a high degree of skill. The method of storage and conservation also allows easy access to the remains for further study. Ideally, we would be happier with a purpose-built room for the storage and conservation but it is not easy to meet the cost and space demands of such a facility. Our procedure is a viable alternative for long term storage and conservation of such ancient remains.

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1986-87 "Preservation of Human Bone in Prehistoric and Historic sites of western Japan", *Asian Perspectives*, vol. XXVII, No. 1, 15-27.

Plate 7-1: Important details of the skeleton e.g. its *in-situ* position and associated artifacts were recorded, sketched and photographed before removal.

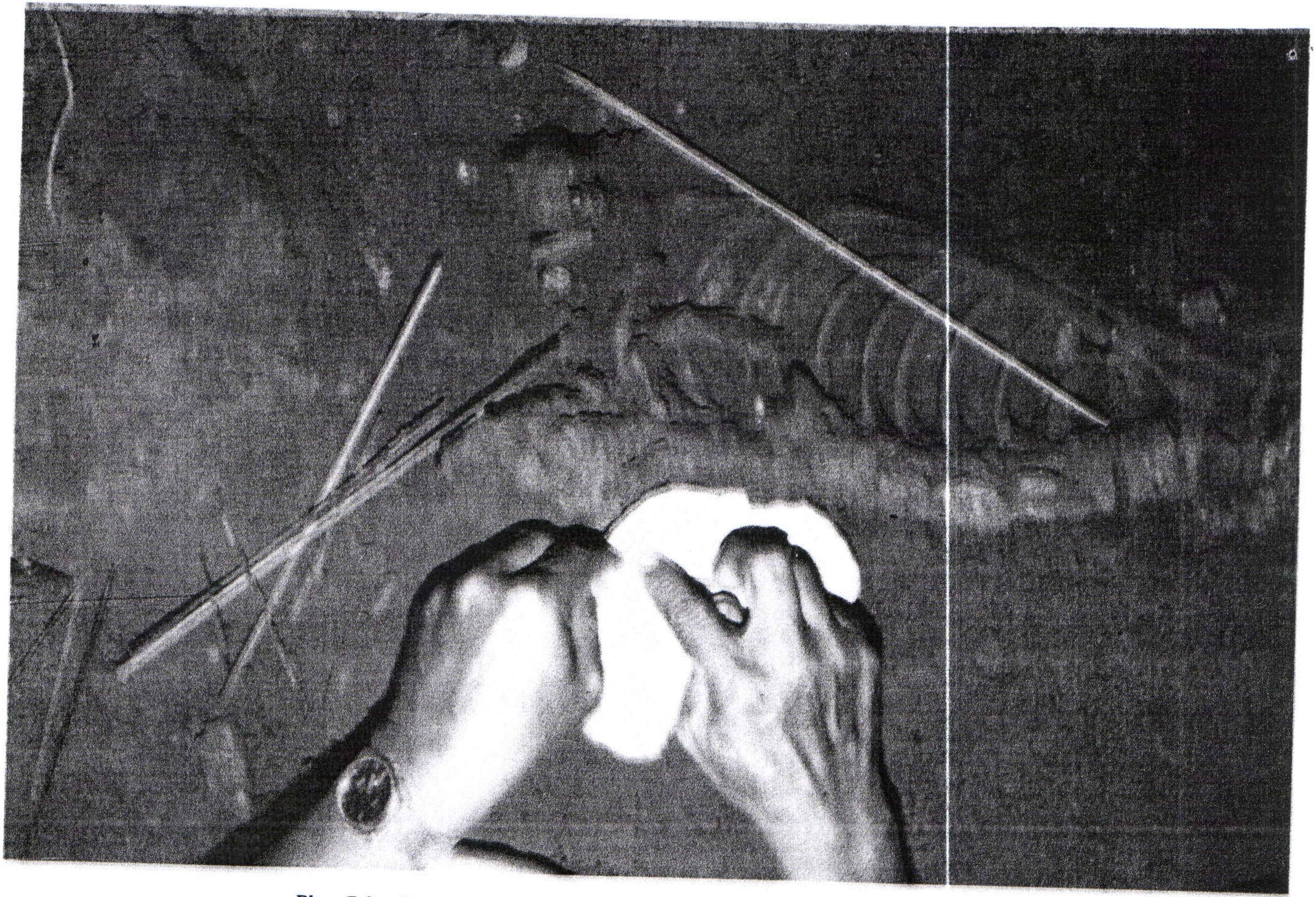

Plate 7-2: Removing the fragile and fragmentary shoulder blade using plasticine

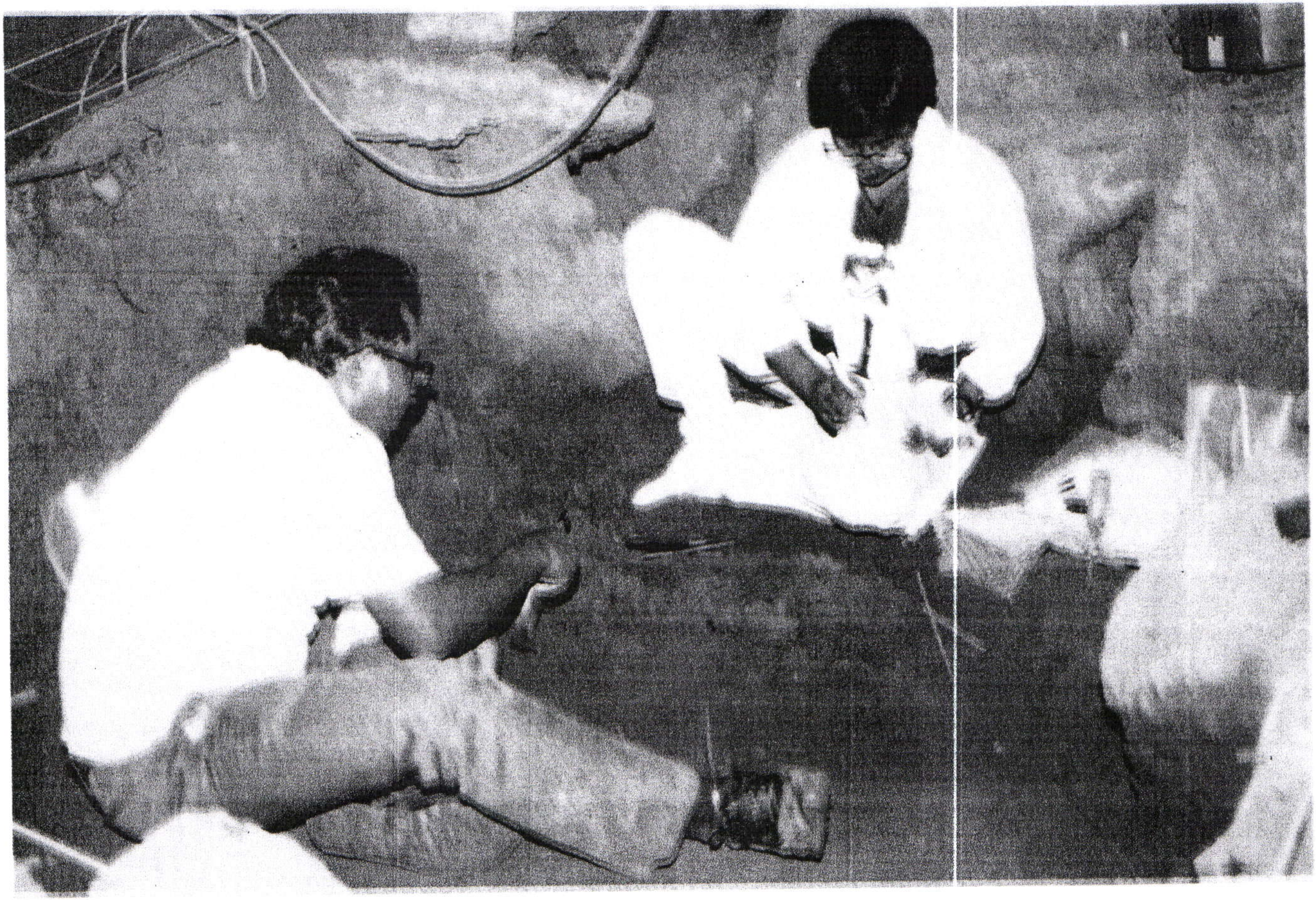

Plate 7-3: Each bone was lifted separately, carefully wrapped with bubble paper an labelled. The bone was labbeled accordingly to facilitate skeletal reassembling in the laboratory.

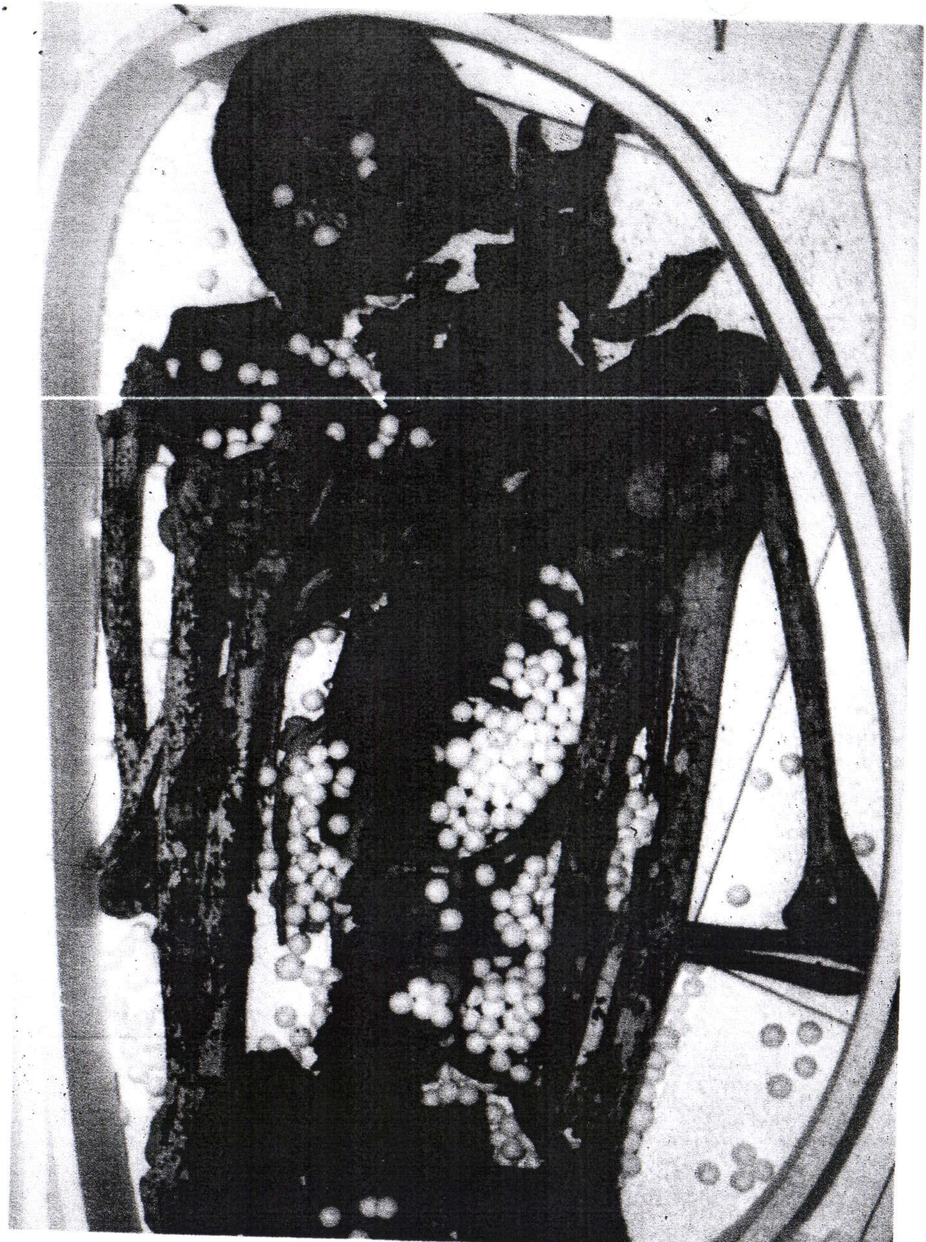

Plate 7-4: Styrofoam sheets and beads were used to protect the fragile skeleton against breakage during transportation.

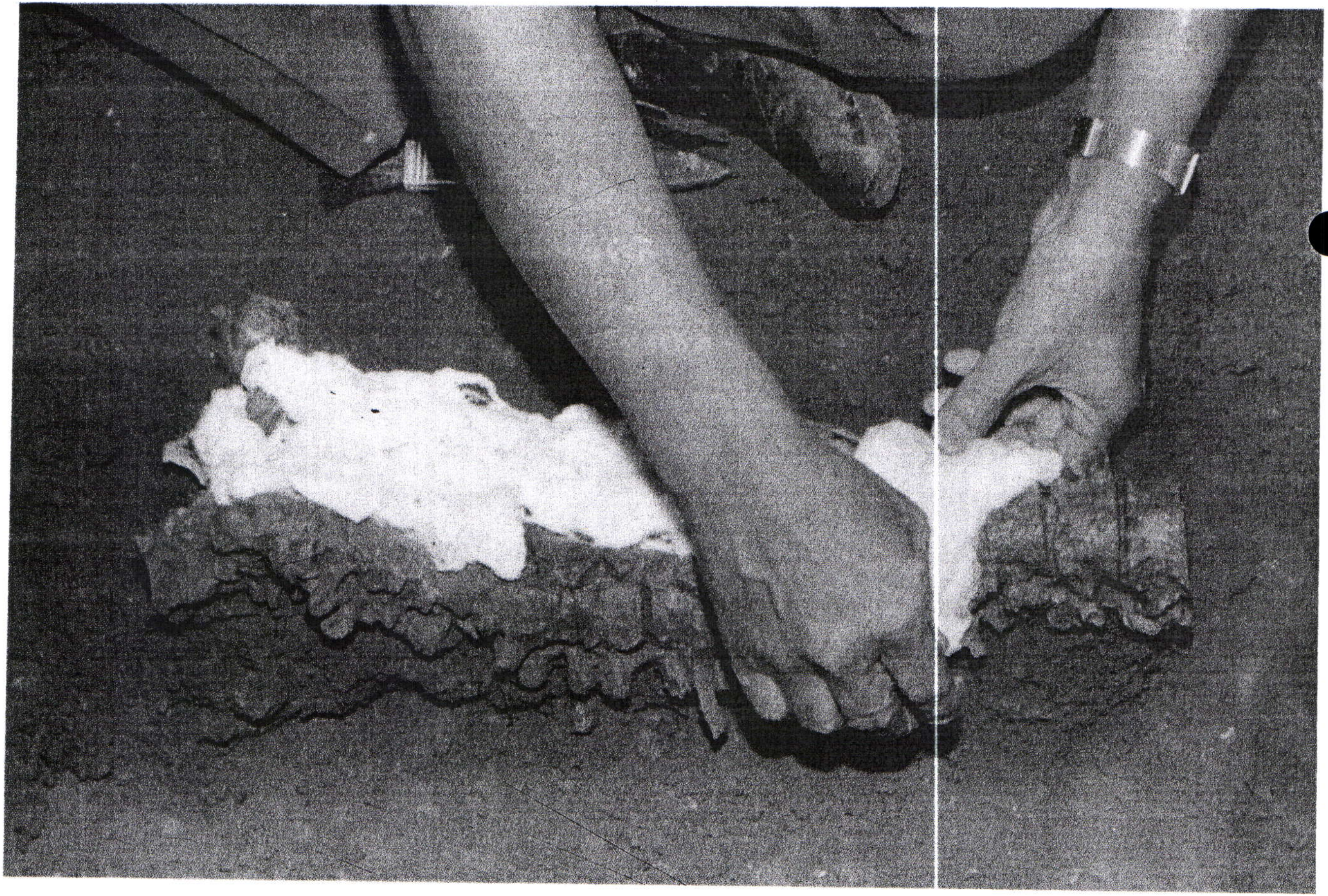

Plate 7-5: Cotton wool was used as separating layer to prevent direct contact between the plaster of Paris and the vertebral column.

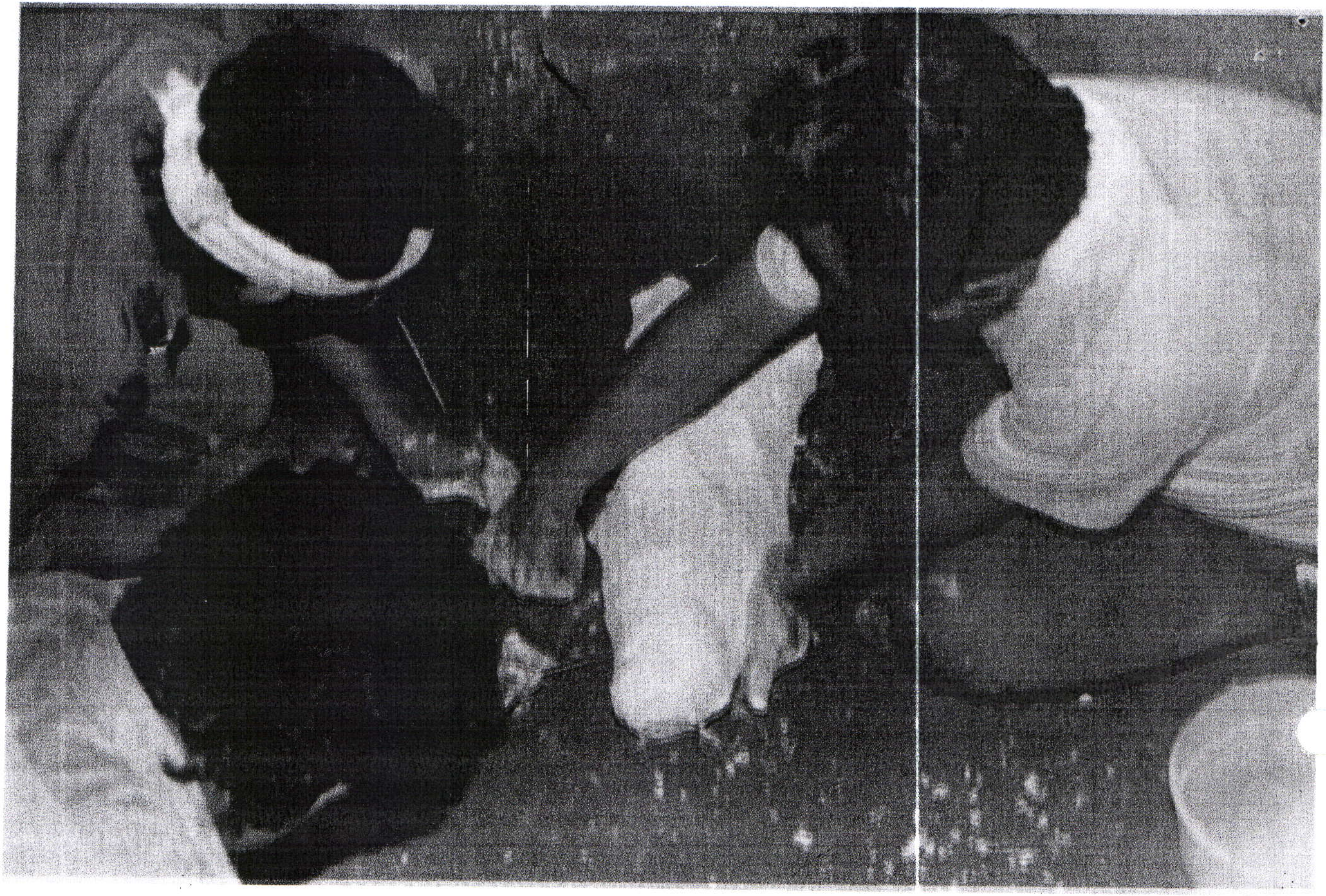

Plate 7-6: Cosolidation of the vertebral column prior to removal by wrapping it with several layers of bandages coated with the plaster of Paris.

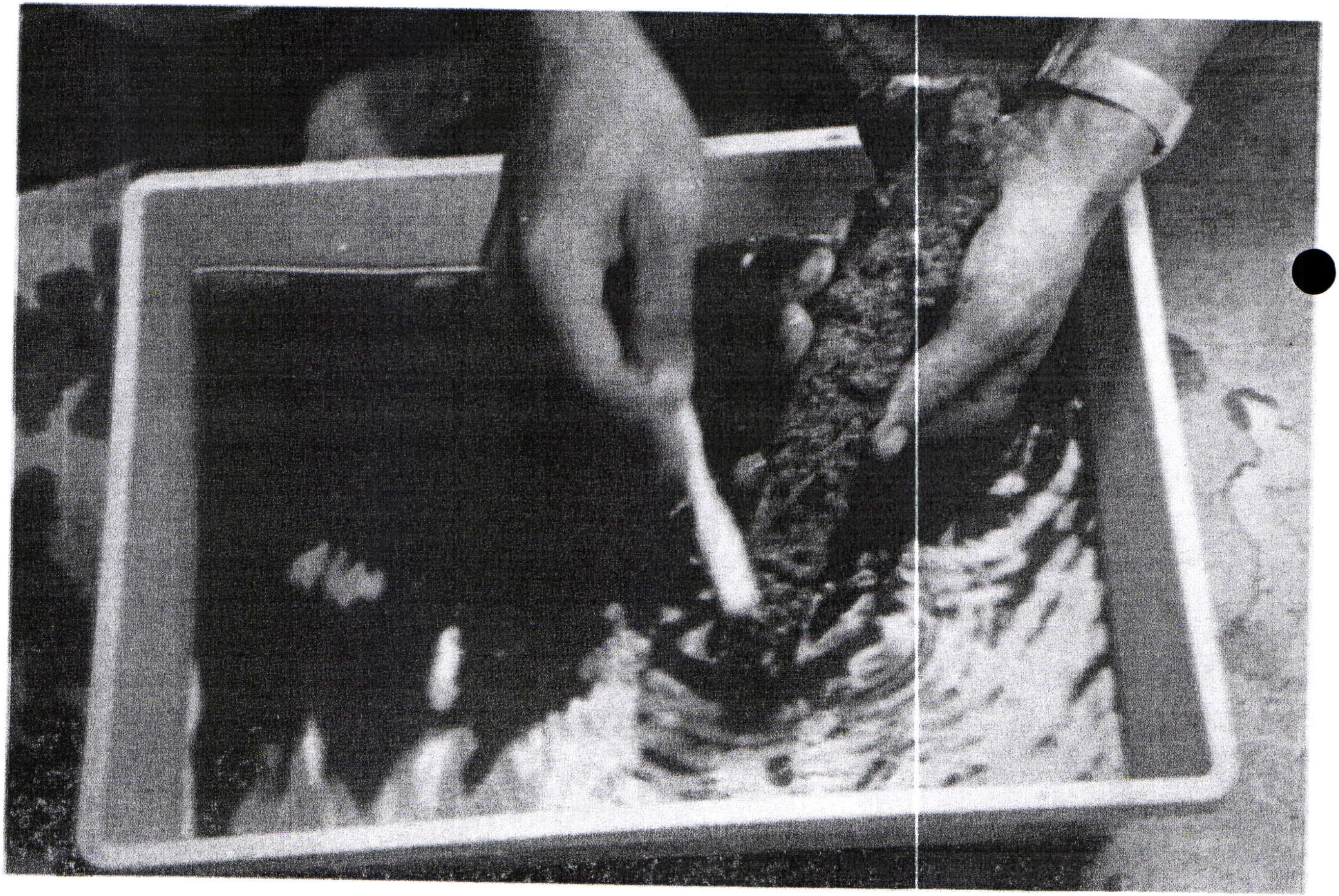

Plate 7-7: Removal of dirt and soluble salts was done by washing the bone with water and brushing it gently with a soft toothbrush.

Plate 7-8: Plaster sieves should be used for small and fragile bones to facilitate handling during immersion in acid and water.