1. THE GEOLOGICAL BACKGROUND TO THE GENERATION OF THE ARTIFACT MATERIALS AND THEIR TRANSPORT TO THE VICINITY OF THE SITE.

The principle primary source for the igneous rocks that dominate the artefact assemblage is the Troodos ophiolite, a slab of Cretaceous ocean floor that forms the highest part of Cyprus. It is well exposed around the headwaters of the Dhiarizos catchment. (See Fig.1)

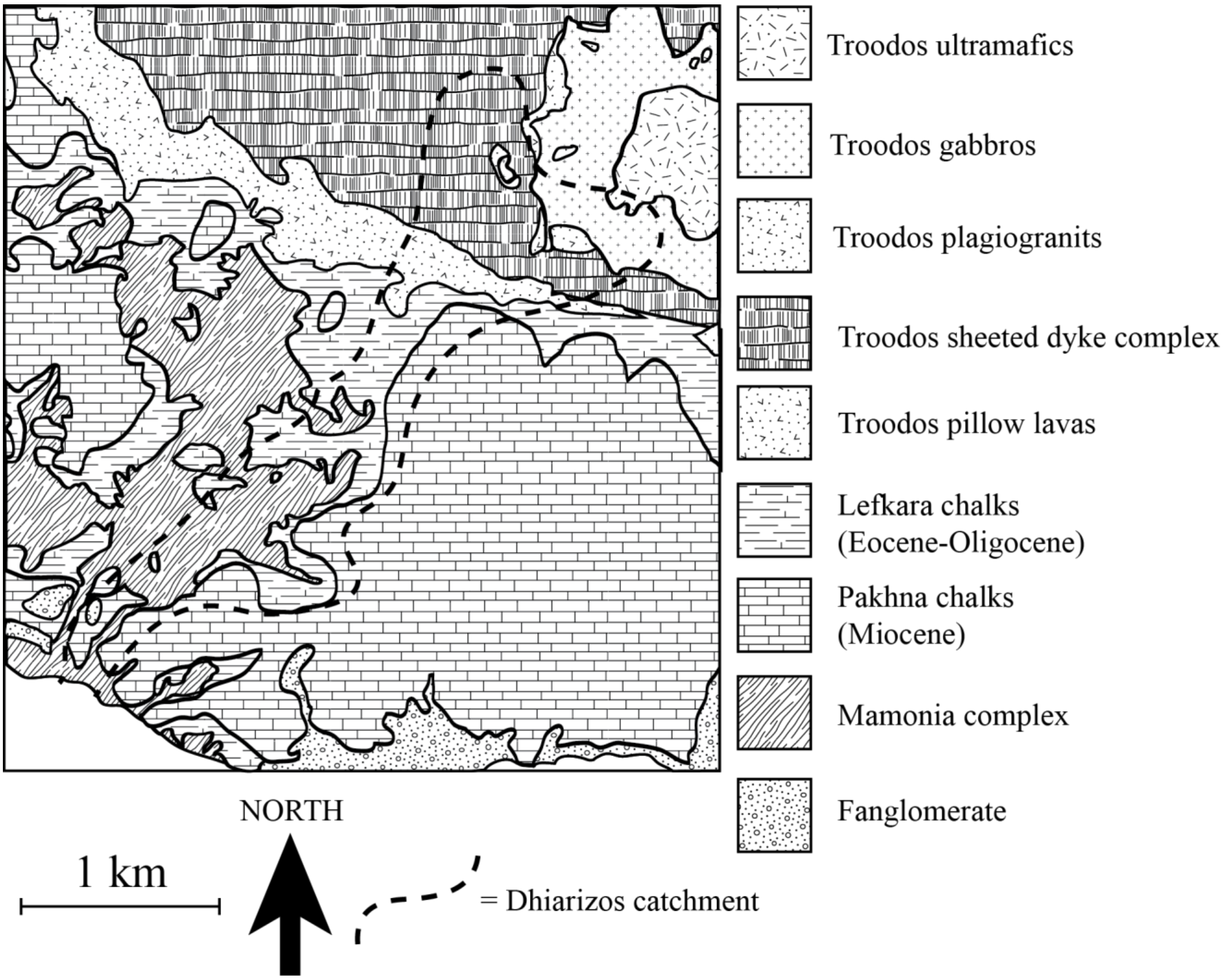

Fig 1: A simplified geological map of the underlying geology around the Dhiarizos catchment.

The oceanic crust is formed by basaltic melt separating and rising up from the Earth's peridotite mantle as it wells up into the gap created by the separation of the lithospheric plates at a spreading centre. The magma that reaches the sea floor rapidly cools to form basalt pillow lavas, sheet flows and breccias. Feeding the lavas from below are intrusive sheets of basaltic dykes that cool more slowly to dolerite, a fine-to-medium grained basaltic rock. The Sheeted Dyke Complex is 100% dykes, each one intruding earlier ones. Individual dykes are 1-1.5 m wide, on average. Lower down in the section are gabbros and ultramafic cumulates that are the coarsest grained products of the basaltic melt formed by slower cooling in deeper magma chambers. Below the gabbros is peridotite, now mostly serpentinised, the hydrated remnant of the upper mantle from which the basalts were extracted as a partial melt. The whole crustal section is approximately 5km in thickness.

In south-west Cyprus a more complex geological terrain known as the Mamonia Complex is exposed. This is the deformed remnant of a Mesozoic aged continental margin and deeper marine sequence of sedimentary rocks and subsidiary volcanic rocks of Triassic, Jurassic and Early to Mid-Cretaceous age. This terrain collided with the Troodos sea floor in the Late Cretaceous and is juxtaposed with it along a NW-SE suture zone marked by slivers of serpentinite and occasional metamorphic rocks crossing the Dhiarizos Valley.

After this collision the whole area was covered by deep water in which the pelagic chalks of the Lefkara and Pakhna Formations were deposited. The Mamonia Complex thus contributes a varied assemblage of sandstones, siltstones and limestones, and occasional volcanics to the present Dhiarizos River, mixed in with Troodos material from further upstream, and chalk and calcarenites from the cover sequence.

The peculiarity of Cyprus geology is that the deepest part of the Troodos oceanic crustal section, the serpentinite and relict peridotite, is now exposed at the highest point on the island, Mount Olympus, because of several kilometres of geologically recent uplift centred on this area. The higher parts of the sequence, gabbros, sheeted dykes, lavas and the covering deep-sea sediments are arranged in concentric bands around Mount Olympus, dipping away from the centre. The recent uplift created considerable topographic relief and caused enormous quantities of Troodos material to be eroded and transported radially away from the centre in major rivers. This material was deposited on the flanks as overlapping alluvial fans that blanketed the underlying bedrock. The alluvial deposits – sands, gravels and boulder beds – are known as “fanglomerates”.

The continuing uplift of the Troodos and the periodic falls in global sea-level through this interval caused the fanglomerates to be progressively uplifted relative to sea-level and incised, as the rivers cut down to successive new base-levels. The effect of this is that the oldest fanglomerate surfaces are now left stranded on the tops of the low hills as in the area around the Souskiou site and for some distance to the north. The very highest point on the ridge into which the burial chambers are cut is a patch of the highest and oldest (F1) fanglomerate. This surface can be seen to line up with a gently sloping regional depositional surface on adjacent hills. The graves themselves are cut into an old erosion surface in the chalk beneath which would have been the riverbed itself at the time. Lower, younger surfaces (F2, F3 etc.) can be recognised in various places on both the south and the north sides of the Troodos but are much less well-developed further to the west and south-west towards Paphos where there are fewer major river valleys extending up into the Troodos.

It is likely that the present topography has not changed greatly in the c.5000 years since the site was occupied. At least three alluvial terraces are recognisable in the vicinity of the site that are above the level of the present river bed but the exact correlation with the dated terrace sequence is not yet known and needs further work.

In summary, the site is right beside an important river that has cut through virtually the entire range of major lithologies exposed on Cyprus, and carries material re-worked from the fanglomerates with their similar wide range of content. This processes has resulted in the local availability of virtually every possible usable rock type in useful cobbles and boulders, already pre-selected by the river itself for coherence and toughness.

2. How rock properties and geological processes interact to affect the availability of suitable material in the river bed.

To fashion a robust axe, particularly the larger examples, requires a cobble of a size that will encompass the finished product. This in turn implies that the source of cobbles must be exposed rock with natural joints sufficiently widely spaced, on average, to generate the blocks that will be rounded by abrasion in the rivers to cobbles and boulders, without breaking up. This condition is well met by the Troodos Sheeted Dyke Complex. This unit also provides abundant tough, fine-to-medium grained rock that can be worked to an edge and polished. Most of the axes and pestles are made of dolerite from the Dyke Complex.

The individual dykes are generally 0.5 m to 1.5 m wide and were intruded sufficiently infrequently within the spreading centre zone of injection for earlier dykes to have already cooled, possibly by several hundred degrees centigrade, causing each subsequent dyke to chill against its host. It is this chilled zone a few cm wide that has the finest texture with the smallest crystal size, and occasionally verges on a glass. Apart from scattered crystals that were in the magma when it was intruded, the individual crystals in the chill zone groundmass are often too small to see even under the binocular microscope. The grain-size in a typical dolerite from the main body of a dyke, in contrast, has feldspars and occasional pyroxenes up to 4mm in length, and a texture recognisable as igneous to the naked eye. The chill zone tends to be tougher than the normal dolerite and takes a fine edge. This is in part due to the extremely fine-grained texture and probable preserved glass that actually inhibits the penetration of hot sea-water during the cooling of the dyke so limiting the transformation to low-temperature hydrous alteration products that reduce the strength of the rock.

This inherent toughness of chill zones and the general scarcity of joints more closely spaced than a few centimetres in the dykes means that small fragments consisting almost entirely of chilled dolerite can survive river transport to become pebbles and small cobbles. The chill zone material makes up only a fraction of one percent of the dyke material as a whole.

Nevertheless it is these rare pebbles that were selected to make the small chisels.

The basaltic lavas above the Sheeted Dyke Complex have cooled even more rapidly on average than the chilled dyke contact zones. Why do they not feature prominently in the artefact suite? There are three reasons: joint and fracture spacing, alteration and vesicularity.

Most of the lavas erupted under water occur as pillows, the result of "budding" of extruded magma as it emerges from fissures. The pillows inflate to a size around 1 m on average and then detach and may roll down the slope. They have a chilled carapace but are clearly flexible enough to fit themselves into depressions in underlying pillows. As they cool on the move or with later pillows landing on them, and their outer layers contract on cooling while the interior is still partly liquid, they develop closely spaced, often radial, joints and fractures. When erupted on steep submarine slopes they may break up completely producing pillow breccia. Other submarine lavas that erupt too rapidly to form pillows and so form sheet flows, cool while moving, often on irregular substrates and so very rarely develop the widely spaced columnar jointing that arises when terrestrial lavas are ponded and freeze undisturbed. The net result is that although such lavas may develop extremely fine-grained or glassy textures, they do not erode into large enough coherent fragments to form suitable artefact material after river transport.

In addition, the lavas are immediately subject to hydrothermal alteration from seawater as they erupt and typically show the greatest development of secondary minerals. This alteration continues down to lower temperatures than is the case in the sheeted dykes where the pervasive hydrothermal activity appears to largely cease at temperatures around 300˚C. Only the true glass on pillow rims escapes alteration as it is effectively impermeable having no crystal grain boundaries, but it is never in large enough lumps to be useful. Finally, the volatiles in the magma separate out as steam bubbles on eruption and rise up to the tops of the pillows while they are still liquid. Many are then frozen in creating a vesicular texture. The vesicles are often later filled with low-temperature alteration minerals such as calcite. Vesicles also occur rarely in some dyke margins. In either case vesicular lavas do not make good artefacts, as homogeneity and strength are both reduced.

Gabbros and other coarse-grained intrusive rocks that are the product of slower crystallisation of larger magma bodies more than 2 km below the sea-floor were mostly below the limit of contemporaneous hydrothermal circulation and so retain their high-temperature igneous mineralogy, albeit with hydrous minerals such as hornblende as important constituents because of the inherent water content of the original basaltic magma. They crystallised largely undisturbed, with strong bonding between the crystals. Joints are widely spaced and if there is late alteration by circulating fluids it tends to work inwards from the joints and faults and leaves kernels of unaltered gabbro. The large joint bounded blocks and the unaltered kernels are then eroded into material for the subsequent river to transport. The larger ones were probably only moved downstream during periods of the highest discharge and so would have spent most of the time inert on the riverbed. They would not have suffered as much continuous abrasion as smaller pebbles and so frequently retain an angular outline.

3. Litholological Identifications. Guide to the Rock Terms used in the Spreadsheet and the reasons for earlier Mis-identifications.

A large proportion of the artefacts are made up of fine to medium grained altered dolerite. The alteration of the original igneous rock has converted black shiny pyroxenes and hornblendes, occasional green glassy olivines, to softer, green hydrous minerals like actinolite (another amphibole), chlorite, and grew new yellowish-green minerals like epidote in the rock. The originally clear, sharply outlined feldspars re-crystallised and changed composition and lost some but not all, of their outlines. We define dolerite as an igneous-textured, hydrothermally altered, epidote-amphibolite grade, basaltic-to-andesitic, fine-to-medium-grained minor intrusive.

The coarser-grained igneous intrusive lithologies, are identified as **gabbro** when the mean grain size is around 5 mm or more. There is a continuum between coarse dolerite and fine-grained gabbro, essentially reflecting a continuum in the dimensions and cooling histories of different magma bodies, from very thick dykes, to parts of a complex magma bodies at greater depth. Where the gabbroic or coarse doleritic rock is very feldspar-rich and ferromagnesian-mineral-poor there is no doubt that it is a slowly cooled equivalent of the andesites and the term **micro-diorite** is adopted as it would be perverse to persist with gabbro, which applies to plutonics with c.50% plagioclase and the rest mafic minerals, down to rocks with only 10% feldspar (“**mafic gabbros**”).

The one additional igneous intrusive rock-type that appears in the suite as a rare member is **plagiogranite**. This is a rock that is the product of continued fractional crystallisation of a body of basaltic magma to the point where the remaining melt has lost almost all its iron and magnesium, a lot of its aluminium in calcic plagioclase and has a composition close to that of a granite. It will crystallise quartz, sodic plagioclase feldspar and often-scattered needle-like crystals of hornblende. These ocean-floor basaltic liquids are generally very low in potassium so that these final fractions do not crystallise potassium feldspar, hence the term plagiogranite, which is more or less confined to ophiolitic occurrences. These liquids tend to get squeezed out of the mass of crystals in the magma chamber and are injected as small intrusive bodies, a few 100 m across, in the zone near the top of the gabbros and the base of the Sheeted Dyke Complex. They are a very small but distinctive component of the ophiolite suite and consequently an extremely minor component of the cobble and boulder assemblage.

5.9 The older limestones of Triassic age exposed in the Mamonia Complex are much tougher rocks, in shades of grey or pink, as well as white, and some are thoroughly crystalline. They are clearly different from the much less well-consolidated softer chalky limestones of the Pakhna Formation.