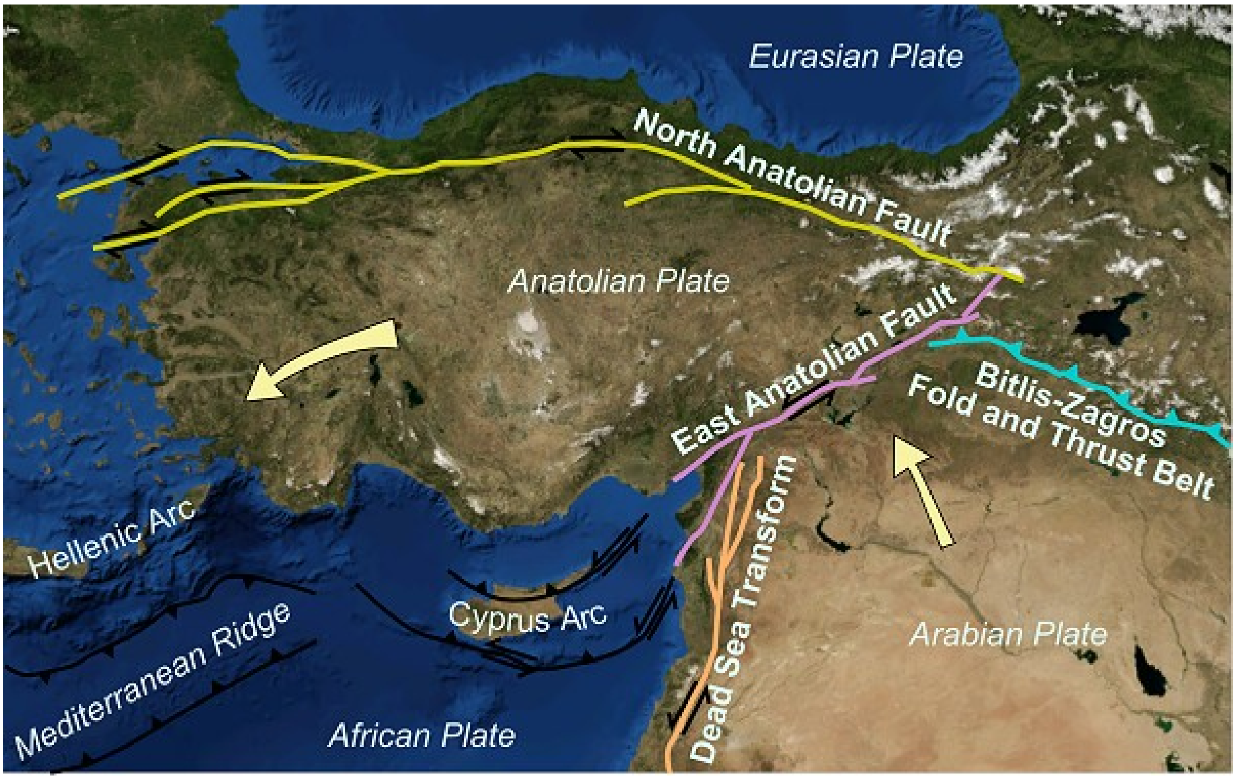
# *The Geology of Cyprus*

Cyprus is situated in the easternmost part of the Mediterranean, around 80 miles from Turkey in the north, around 100 miles from the coasts of Syria and Lebanon to the east and, to the south, around 300 miles from Egypt and Israel.

The regional geology of the eastern Mediterranean is highly complex and the area itself is generally thought to be a relic of the Mesozoic Tethyan Ocean. The region is composed of two separate tectonic domains, the northern Alpine orogenic belt, and the southern Eastern Mediterranean basin, with the two linked by subduction and plate collision. Cyprus forms part of the eastern Mediterranean basin, although the suture between the two separate domains runs across the island, marked, as it is to the east of Cyprus, by a series of ophiolites and related nappe sequences (Garfunkel, 1998).



The area itself consists of a juxtaposed series of fragments of oceanic and continental crust generated during the later stages of the Tethyan Ocean's history. This concept, of a major Mesozoic ocean separating the Eurasian and Afro-Arabian plates, is still controversial, but is now the generally accepted method of formation of the constituents of the Alpine-Himalayan orogenic belt. Oceanic crustal fragments are preserved as ophiolite sequences seen in various localities in and around the eastern Mediterranean (Dilek and Moores, 1990). These ophiolite sequences are found widely across the eastern section of the Mediterranean, including ophiolites in Bosnia, Croatia, Greece (e.g. Othris, Pindos ophiolites), Oman (e.g. Semail ophiolite), Syria (e.g. Hatay, Baer-Bassit ophiolites), Turkey (e.g. Lycian, Armutlu ophiolites,) and Cyprus, with its Troodos ophiolite and associated, but still controversial, Mamonia complex. Continental fragments composed of Palaeozoic and older metamorphic basement and overlying Mesozoic carbonate sequences separate these ophiolitic units of Triassic, Jurassic and Cretaceous emplacement and formation ages (Robertson, 2002).

Ophiolite sequences in the Eastern Mediterranean can be split into northern and southern groupings. Typically, northern ophiolites, found in Croatia, Bosnia, and Greece, etc. are usually highly deformed, dismembered and are commonly associated with metamorphic soles and tectonic melanges. Southern ophiolites are relatively undeformed, and are in many cases thought to be almost 'complete' sequences through the ocean crust. Examples of this are seen in the well-preserved ophiolites of Cyprus (Troodos), southern Turkey (Kizildag), and the Baer-Bassit ophiolite of Syria (Dilek and Moores, 1990).

The well-preserved nature of the Troodos ophiolite and its surrounding and adjacent units has made it a target for study over a number of years. However, the history of the exploitation of the geology of Cyprus, for copper and other metals and minerals, has been far longer than any study of the processes that formed the geology. The earliest workings for copper, gold and other metals date back to Bronze age times, as long as 5000 years ago or longer, with later Phoenician and Roman smelting shown by the extensive slag heaps that are visible on the island today. Ancient surface and underground workings are also numerous on the island, with shafts, galleries, timbering and other manifestations of small-scale underground workings visible across the island. Exploration, via the excavation of small untimbered shafts, was also widespread in Roman times, with many of the characteristic gossans that mark underlying sulphide bodies having been explored or prospected at one or more times in the past. Indeed, the word 'copper' may have been derived from the Greek for Cyprus, or vice versa (Bear, 1963).

Scientific investigation of the Troodos can be split into three main phases. The first occurred in the 1950's and 60's, with the (incomplete) mapping of the Troodos massif by members of the Cyprus Geological Survey, and the publication of a number of memoirs. The identification of the massif as an ophiolite sequence by Moores and Vine (1971) triggered another phase of investigation. This period culminated in 1979 with the International Ophiolite Symposium, held on Cyprus. The third period of investigation started with deep drilling through the ophiolite by the International Crustal Research Drilling Group (ICRDG) and the Cyprus Geological Survey Department (GSD), in the form of the Cyprus Crustal Project. This work was intended to resolve some of the outstanding issues and problems posed by the previous work. All these efforts and labours have made the Troodos one of the most studied, if not the most studied, ophiolite sequence in the world (Robinson and Malpas, 1990).

A centralised range or massif - the Troodos - dominates the topography of the majority of Cyprus, with the massif, and its surrounding hills and plains, formed of units belonging to two main geologically distinct 'groups' of rock types. The stratigraphically lower of the two is the Troodos ophiolite complex, with the upper grouping forming the circum-Troodos sedimentary succession, partially covering the topographically lower, but stratigraphically higher, parts of the ophiolite complex. However, the island actually comprises four discrete tectonic units, each with its own distinct geological history.

The main 'terrane' is the more or less central Troodos ophiolite complex, with its in-situ sedimentary cover. The Troodos itself is an Upper Cretaceous ophiolite, overlain by in situ, upper Cretaceous to mid Tertiary deep sea deposits, and Neogene shallow-marine to continental sediments. The Mamonia terrane, situated to the west of the Troodos, is a structurally complex amalgamation of Palaeozoic and Cretaceous igneous, sedimentary and metamorphic rocks. The third discrete terrane is seen in the north of the island; the distinctive Kyrenia, or Pentadaktylos, range of hills and mountains running close to the northern coast of the island, formed from a sedimentary succession of Late Palaeozoic to Recent rocks, with minor metamorphic units present (Robertson and Xenophontos, 1997). The final terrane, the Southern Troodos, or Arakapas, Transform Fault Zone, located to the south of the Troodos, is considered to be a fossil oceanic transform fault zone, separating the Troodos from the 'Anti' Troodos Plate, (Robertson, 2000). Initial accumulation of the three major terranes, the Mamonia and the Kyrenia with the already amalgamated Troodos, Anti-Troodos and Arakapas Transform, began in the Cretaceous, with final juxtaposition occurring before the Eocene, shown by the sealing of boundaries by the undeformed Upper Lefkara chalk formation. All three terranes were probably juxtaposed during the same convergent period (Robertson, 2002). Kyrenia range

The Kyrenia Range, or Pentadaktylos, consists of an East-West running series of hills and mountains parallel to the northern coast of Cyprus. These hills are all of sedimentary origin, and therefore entirely unprospective for copper. The Kyrenia Range contains a series of rocks formed from the Permian to the early Tertiary, and is divided into eastern and western sections. The lower eastern Kyrenia Range contains the oldest rocks on Cyprus, Permian olistostromes, along with the Kantara Limestone formation. Thrust sheets make up the higher western Kyrenia; made up of steeply dipping shallow water carbonates ranging from Triassic to mid-Cretaceous in age (Robertson and Xenophontos, 1997).

The Kyrenia range developed in four main stages, with the Kyrenia range Permian to mid-Cretaceous rifted passive margin sedimentary development being superseded by Upper Cretaceous - Early Tertiary deformation associated with the Troodos ophiolite microplate. Eocene compression and thrusting then formed the western Kyrenia range thrust sheets and 'docked' the Kyrenia units with the Troodos to the south, with Africa-Eurasia plate convergence in the Plio-Quaternary causing the range of hills and mountains seen today to develop (Robertson, 2000). Mamonia complex

The Mamonia complex is currently considered the most controversial aspect of Cyprus geology, consisting of two major and one minor litho-tectonic components. The first and lowermost is made up of Mesozoic sediments and volcanics predating genesis of the Troodos ophiolite, known as the Dhiarizos Group (Robertson, 1990). The second upper component is comprised of Upper Cretaceous Ophiolitic rocks, with minor slivers of metamorphic rocks and serpentinite of unconfirmed origin. These Mamonia complex units are overlain unconformably by several hundred metres of debris flows, known as the Kathikas Melange or Formation (Swarbrick, 1980).

The Mamonia complex is thought to have formed in three distinct periods, before final submarine compression, thrusting, and erosion, which formed the Kathikas Formation. Firstly, the Dhiarizos Group was formed as crust generated during the opening of the Mesozoic Tethys. The Upper Cretaceous Ophiolitic rocks are interpreted as remnants of oceanic crust and mantle of very similar type to those seen around the Arakapas, or Southern Troodos Transform Fault Zone (STTFZ). Minor metamorphic units are interpreted as being of similar origin to the metamorphic soles of other Tethyan ophiolites, e.g. Oman. These soles are presumed to have formed during plate convergence, with the metamorphic units underplating the overriding hot upper mantle. However, no such sole is exposed beneath the Troodos, possibly due to later disruption due to strike-slip and/or thrust faulting (Robertson and Xenophontos, 1997). Arakapas Transform Fault and Anti-Troodos Fault

The Arakapas, or Southern Troodos, Transform Fault Zone (STTFZ) marks the southern edge of the Troodos ophiolite. This area is interpreted as a fossil oceanic transform fault zone, separating the Troodos ophiolite from the so-called 'Anti' Troodos Plate, a section of ophiolitic crust around 3-5km thick (Gass, MacLeod et al., 1994). This STTFZ itself comprises a chaotically juxtaposed and distributed variety of lithologies that bears little resemblance to the classic ophiolite sequence as seen in the Troodos. Two main sequences of lithological units associated with the transform fault have been identified by Gass and co-workers (1994) - the older Axis sequence of lithologies similar to the Troodos and Anti-Troodos plates, and the Transform sequence, consisting of plutonic and hypabyssal rocks of mafic and ultramafic composition, and a volcanic sequence of pillow lavas, massive lavas and volcaniclastic sediments.

The STTFZ comprises tectonised harzburgites, with high-level trondhjemitic gabbros and dykes, including wehrlites, with masses of sheared serpentinites and zones of fragmented sheeted dykes. Covering this is a succession of alternating volcanics and sediments, including boninitic lavas similar to those exposed in the higher levels of the Troodos (Robertson and Xenophontos, 1997). The Anti-Troodos Plate (ATP), found to the south of the Transform Fault Zone, is a section of ophiolitic crust that formed coevally with the Troodos plate, and indeed closely resembles sections of the axis-generated Troodos ophiolite (Gass, MacLeod et al., 1994). The only major difference is that the ATP lithological units have suffered disaggregation, block rotation and intrusion by the products of a later magmatic episode within the transform domain (Gass, MacLeod et al., 1994). The main units found in the ATP are Upper and Lower Pillow lavas, the Sheeted Dyke Complex, gabbros, wehrlites and leucogabbros containing small lenses of plagiogranite, and a small lens of mantle sequence rocks, consisting of highly tectonised harzburgitic and dunitic rocks, showing no difference from the similar rocks found as a part of the Troodos Massif (Robertson, 1978). Troodos Ophiolite and Sedimentary Cover Sequences.

Figure 2 shows the outcrop of the three major terranes on Cyprus with the highest point of the island, Mount Olympus (1951m) of the Troodos range, marked for reference. The Troodos itself is considered by many to be an ophiolite formed above a subduction zone, much the same as the present day Mariana-Bonin arc, seen in the southern Pacific. However, this view is not accepted by all - some workers favour the concept that Troodos formed at a mid-ocean ridge, such as the present day Mid-Atlantic ridge, where the TAG mound shows some similarities to the Troodos, or in a back-arc marginal basin (Robertson and Xenophontos, 1997).

# *The major geological terranes of Cyprus*

The ophiolite itself consists of a trio of subdivided units - the structurally deepest but topographically highest Plutonic Complex, the overlying and surrounding Sheeted Dyke Complex, and the stratigraphically highest Pillow Lava Series, which forms a discontinuous ring around the Troodos massif. This can be further simplified into a two-sequence division - a lower mantle sequence, and an upper crustal sequence, separated by the petrological Mohorovicic discontinuity. This division has been applied to most ophiolites around the world, and is considered the standard way to partition coherent ophiolites such as the Troodos, to enable comparison of these ophiolites (Gass, 1990). However, some confusion can arise from using the two different nomenclatures, especially when considering that the mantle sequence is considered to be part of the plutonic complex, along with part of the crustal sequence. Table 1 tries to summarise the stratigraphy of the Troodos ophiolite sequence, along with the relative naming systems. Table 1: Generalised schematic stratigraphy and associated nomenclature of the Troodos ophiolite, Cyprus In Situ Sedimentary Cover Umbers Crustal Sequence Pillow Lavas Upper Pillow Lavas Lower Pillow Lavas Sheeted Dyke Complex Basal Group Plutonic Complex Plagiogranites Mantle Sequence Gabbros Ultramafics.

Depleted mantle rocks in the Troodos are exposed at the highest levels of the Troodos massif, around the Mt. Olympus peak, and form the highest ground on the island. Around 1km of succession is exposed, mainly composed of tectonised harzburgites, dunites, lherzolites, wehrlites, and gabbroic rocks. The majority of this sequence is harzburgitic, forming around 80% of the total outcrop of the mantle sequence, with pods of dunite forming the majority of the remaining 20% (Robertson and Woodcock, 1980).

Field relations and the chemical and mineralogical homogeneity of the depleted mantle sequence units suggests that these rock types formed from the residues of a plagioclase lherzolite mantle, from which basaltic material has been extracted. This is supported by the presence of gabbroic pods within the tectonised sequence, thought to be batches of basaltic melt that crystallised before they could escape the mantle sequence. Localised patches of plagioclase lherzolite are also seen, thought to represent mantle that had escaped the depletion effect of partial melting, and from which little or no basalt melt had been extracted (Gass, 1980).

The crustal sequence, as mentioned before, overlies the petrological Moho, the dividing line between the crustal and mantle sequences. Crustal sequence rocks are formed or derived from one or more magma chambers that were presumed to have originally formed beneath the ophiolite spreading axis. Moores and Vine (1971) originally suggested that the plutonic sequence of the Troodos ophiolite was formed from multiple magma chambers, an idea that was borne out by the Cyprus Crustal Study Project's drilling results from deep (over 2km) boreholes such as CY-4, which drilled through sheeted dykes, and plutonic rocks, penetrating at least two fossil magma chambers (Robinson and Malpas, 1990).

Crustal sequence rocks form several distinct units, as seen in Table 1. These units can be further broken down into smaller classes, but for the present the more generalised unit descriptions of Gabbros, Plagiogranites, Basal Group, Lower and Upper Pillow Lavas will be sufficient. The lowest unit, the Gabbros, also known as the Layered Sequence, is predominantly formed of cumulate gabbros with dunite and wehrlite, formed in a series of spreading axis magma chambers (Gass, 1980). The gabbroic sequence is overlain in places by a unit of high level intrusives, forming a series of plagiogranite intrusions, derived from the residual melts of the magma chamber, and forming the final members of the evolution of basic magma in the spreading axis chambers (Bebien, Dautaj et al., 1997).

Overlying the plutonic complex, the Sheeted Dyke Complex forms a 1-1.5km thick unit above the high level intrusives, consisting entirely of vertical, or near vertical 'diabase' dykes, with lava and gabbro 'screens' close to the upper and lower contacts of the complex, where sheeted dykes give way to either the Basal group, high level gabbros or plagiogranites, or, in atypical situations, layered gabbros (Gass, 1990). These dykes provide direct evidence for formation in an extensional environment, and Varga and Moores (1985) identified three separate domains of fossil spreading, seen as three structural grabens on the northern flank of Troodos (Solea, Ayios Epiphanios and Larnaka grabens), which also may be linked with the formation of major mining districts in Cyprus.

The sheeted dyke complex represents the conduits for lava transport from the underlying source to the seafloor. This implies that the dykes should record the same range of compositions found in the extrusive sequence. The dykes do span the same range of compositions, but sharp breaks in composition - observed in the lavas - are not recorded in the dykes. This fact, combined with the fact that no consistent relationships are evident between age and composition, suggests that within each individual spreading axis, dykes were intruded at a number of spreading centres, possibly overlapping (Robinson and Malpas, 1990). The dykes also have been metamorphosed, ranging in grade from zeolite to greenschist facies, with 'epidosite' (epidote-quartz-sphene) zones marking the base of hydrothermal recharge systems (Richardson, Cann et al., 1987).

Above the Sheeted dykes complex is the Basal Group, sandwiched between the dykes and the overlying pillow lavas. The Basal Group consists of both dykes and lavas, with lava screens and pillows filling inter-dyke spaces. This combination of both intrusive and extrusive factors means that this group does not fit neatly into either the sheeted dyke complex, or the pillow lavas - it instead forms a middle ground, having characteristics of both (Robertson and Xenophontos, 1997).

The Basal Group covers the gap in the stratigraphy covered by the outgoing dykes, and the incoming pillow lavas. The mixed unit that emerges is somewhat arbitrarily defined, and should possibly be considered to cover anything with less than 100% dykes, but not entirely composed of pillow lavas and feeder tubes (Gass, 1980).

The Pillow lava sequence is split into Upper and Lower Pillow Lavas (UPL and LPL) according to their place in the stratigraphy. This original division of the pillow lava sequence was based on the colour, mineralogy, abundance of dykes and relationship to massive sulphide orebodies - with the majority of massive sulphide bodies being mapped as forming between the two pillow lava sequences. However, this boundary, in the majority of places, was poorly mapped, or arbitrarily assigned to a local unconformity or intercalated sediment band. Robinson and Malpas (1990), in their review of the Troodos ophiolite, and its origins and emplacement, describe a threefold geochemical division of the entire pillow lava sequence, with 3 suites of pillow lavas - named A, B and C. Suite A comprises a relatively evolved island-arc tholeiitic suite, occurring at the base of the lava pile on the northern and southern flanks of the Troodos. Suite B, a depleted arc tholeiite suite, occurs at the top of the lava pile on the northern flank of the Troodos, whilst suite C, a highly depleted boninitic suite, is associated with the southern Arakapas fault zone. The relatively enriched lavas of suite A, and the depleted lavas of suites B and C correspond approximately to the Upper and Lower Pillow Lava suites respectively, however, the boundaries between the suites and the upper and lower lavas rarely do. In addition, interfingering of the depleted and enriched lava suites occurs in several localities. This all casts doubt on the validity of the UPL and LPL classifications, which has ramifications for cupriferous sulphide exploration within these units (Robinson and Malpas, 1990).

The presence of suite C, the highly depleted boninite-type lavas, also has significance for the tectonic setting. Such a high MgO, high $SiO_2$ but generally depleted lava could not be generated at a 'normal' mid-ocean spreading ridge. The formation of boninitic lava appears to require a combination of melt-depleted thermally anomalous mantle, an extensional tectonic regime, and relatively high $PH_2O$ conditions, providing evidence for the original formation of Troodos as a supra-subduction zone spreading ridge, such as the present-day Bonin arc (Flower, Russo et al., 2001). The location of the Suite C lavas, around the Arakapas Transform fault zone, implies that extension within the transform zone is inferred to have induced melt separation and emplacement - of the boninitic lavas - as products of remelted depleted upper mantle (Robertson, Dixon et al., 2003).

Directly overlying the ophiolite sequence are iron-manganese sediments, known as umbers, and the probable products of seafloor weathering of sulphide deposits, the gossans and ochres commonly seen on Cyprus. These metallogenic sediments mark the start of the in-situ sedimentary sequence that covers a large part of the island of Cyprus. The sedimentary sequence itself describes much of the development of Cyprus after the formation of the ophiolite sequence. The sequence describes a general progression from deep marine Turonian sediments through to later shallow marine and later alluvial ophiolite derived clastic sedimentation. This records the uplift and emergence of the ophiolite from deep marine conditions to the mountainous setting seen today, with the highest parts of the island reaching over 1900m. The actual uplift of the Troodos can be ascribed to one or a combination of three factors. Firstly, the Troodos ophiolite may have been emplaced onto a continental fragment in the Late Cretaceous. Secondly, the continental crust below Cyprus is effectively an extension of the Eratosthenes seamount (to the south of the island, and currently undergoing subduction), and was emplaced beneath Cyprus in Neogene-Holocene times. The final possibility is that the uplift of Cyprus was due to a diapiric serpentinisation of the underlying mantle sequence, causing a change in density, and therefore uplift. All these can be considered as possibilities; however, within the context of this tutorial, we need not go into much detail here. All that needs to be said is that the sedimentary sequence overlying the Troodos, as shown in Table 2, records the uplift, as can be clearly seen from the lithologies present. Table 2: In-Situ sedimentary cover of the Troodos ophiolite, Cyprus (modified from Robertson et al, 2003) Age (Ma) Formation Lithology 2.0 Pleistocene 'Fanglomerate' Apalos Kakkaristra Athalassa Conglomerates and Sandstones, Calcarenite, Sandstones, Conglomerates 5.2 Pliocene Nicosia Marls, Silts, Muds, Sandstones, Conglomerates Kalavasos Evaporites 23.3 Miocene Upper Pakhna Reefal and Bioclastic Limestone Pelagic Chalks, Marls, Calcarenites, Conglomerates Middle Lower Reefal and Bioclastic Limestone 35.4 Oligocene Upper Lefkara Pelagic Chalk and Marls 56.5 Eocene Middle Lefkara Massive Pelagic Chalks 65.0 Palaeocene Pelagic Chalks, Replacement Chert 74.0 Maastrichtian Lower Lefkara Pelagic Chalks 83.0 Campanian Kannaviou Volcaniclastic Sandstones, Bentonitic Clays 90.4 Turonian Perapedhi Umbers, Radiolarites Ophiolitic Basement Mineralisation

Over time, Cyprus has been a major exporter of various mineral commodities, from copper exports in ancient times, to salt exports (probably from the large salt lake near Akrotiri) in the Middle Ages, and more recently large amounts of asbestos were exported in the early to mid 20th century (Mobbs, 2000). Copper exports began again in the early part of the last century, and have been active for much of the last 100 or so years. Gypsum, gold, silver, chromite, umber, ochre and terra verte (mineral pigments) and building stone have also been produced over time.

The Troodos ophiolite is the major host of mineralisation on the island. The major deposits explored forand worked on Cyprus are the copper-bearing massive sulphide bodies, worked for many thousands of years. However, other resources have also been worked from the Troodos, including asbestos, chromite, iron-copper-cobalt-nickel sulphide mineralisation, and gold-bearing umbers. The diagrammatic stratigraphic column shown in Figure 3 displays the general outline of ore deposits within the Troodos Ophiolite.

# *General ore deposits within the Troodos Opholite.*

The asbestos deposits on Cyprus are found in the core of the Troodos plutonic complex, in the form of serpentinised ultramafic material. A total outcrop area of around 35km$^2$ is present, with the transition from the serpentinite to unaltered dunite at the edges of the deposit defined by faults. The deposit area coincides with a negative gravity anomaly, interpreted as the top of a diapiric low-density body extending to around 11km (Constantinou, 1980).

The eastern part of the body of serpentinised rocks was subjected to a more intense serpentinisation than the rest of the affected ultramafic rocks, described as the 'Bastite Serpentinite Zone' in Cyprus Geological Survey memoirs (Wilson, 1959). On the eastern slopes of this zone, in the area around Amiandos, asbestos was extracted from 1904 to 1988 over a 10km$^2$ mining lease area with huge resource potential, although ancient extraction undoubtedly predated modern extraction. Indeed, the area is named after the natural resource - with *Amiandos* in Greek meaning asbestos (Stelios Nicolaides, personal communication, 2003). However, the site is now considered to form a potential health hazard and steps to restore and remediate the site are being taken.

The Troodos ophiolite is moderately rich in chromite when compared to other ophiolite sequences (e.g. the Lizard, Cornwall), with the chromite occurring as an accessory mineral in several ultramafic rock types of the mantle sequence. However formerly economic chromite deposits in the Troodos are rare, only being found in podiform orebodies within dunites and harzburgites. These deposits were worked by small-scale operations, often mining very selectively and the overall production of chromite from the Troodos was low (Constantinou, 1980). Some minor platinum group elements have also been found, associated with a copper-zinc alloy in the Troodos chromitites, but again at sub-economic levels (Constantinides, Kingston et al., 1980).

Iron-copper-cobalt-nickel sulphide deposits on Cyprus are found in the Limassol Forest complex, a plutonic complex associated with the Arakapas transform fault, to the south of the main body of the Troodos ophiolite. A shattered serpentinite body, thought to have originally been an olivine-rich dunite or peridotite but now highly deformed and serpentinised, hosts the mineralisation. The entire mineralised area is around 6km long and around 200m wide, with the ore forming pods, lenses, veins and disseminations within this zone. The ore was worked from Roman times onwards, but the irregular nature of the mineralisation has precluded any modern extraction. The orebody itself is unusual in the high levels of copper it contains, not a usual characteristic of orebodies associated with ultramafic rocks. One suggestion is that the sulphides were segregated as an immiscible liquid during magma differentiation produced by melting of the upper mantle at depth (Panayiotou, 1980).

The only other major mineralisation on Cyprus, apart from the massive sulphide deposits and associated stockwork mineralisation covered in more detail elsewhere in this dissertation, are the interstitial and overlying sedimentary umber and ochre deposits. Ochres are manganese poor ferruginous sediments generally associated with sulphide ores, whilst umbers are manganese rich ferruginous mudstones. Umbers have been worked since pre-Roman times on Cyprus, for use as dyes and as a flux for copper smelting (Boyle, 1990). Some umbers, such as those around the Skouriotissa mining district, were also worked for gold, with soft, friable deposits known as 'devil's mud' often containing economic amounts of gold, but in small quantities (Prichard and Maliotis, 1998). Ochres, often mined for pigments and also gold, were also worked at various times in history, and are still worked today for pigments, albeit in small amounts (Robertson and Degnan, 1998)

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