Potential sources of iron oxides found in Mesopotamia

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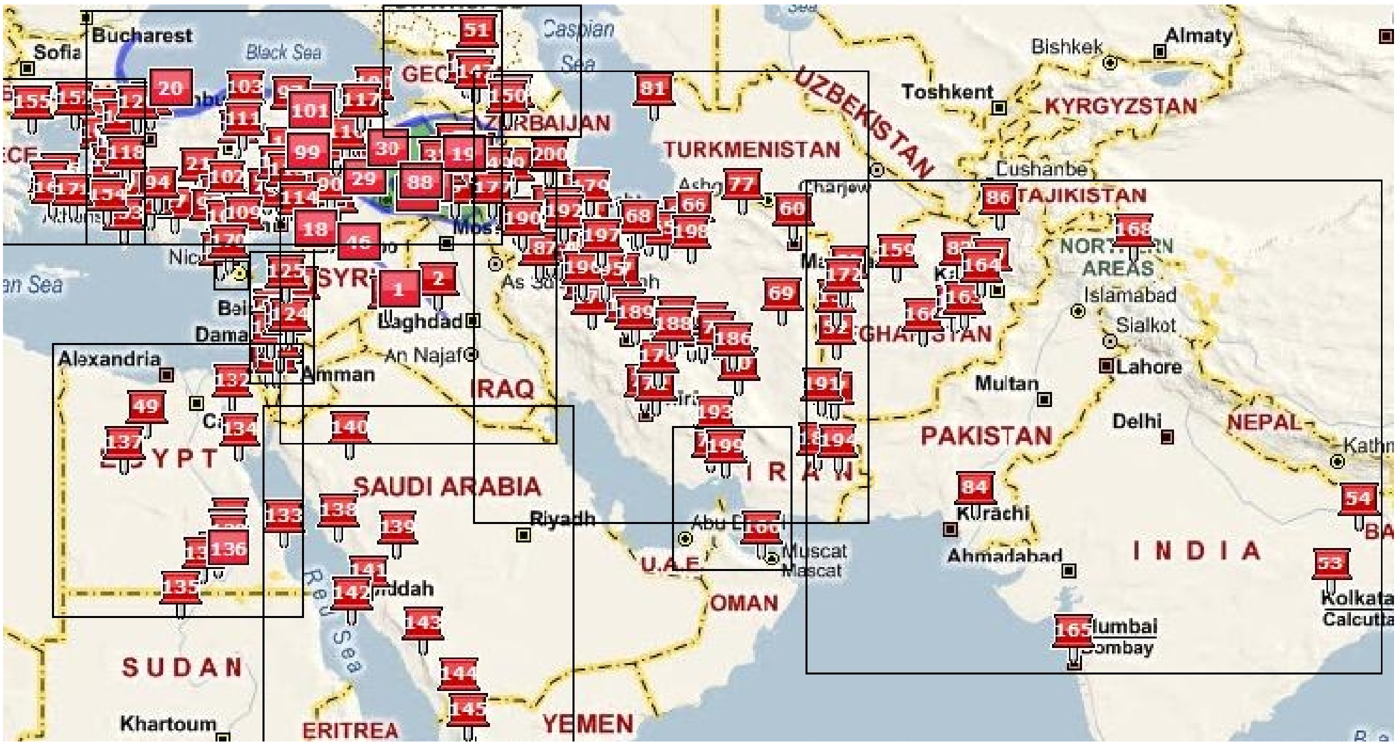

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Abstract

In Mesopotamia a sudden increase of seals made of iron oxide can been seen in the Old Babylonian Period. Also other artefacts like beads and weights were made of iron oxide. The material was obtained from outside of Mesopotamia, but it is not known from were it was obtained. The aim of this research is to find potential sources of iron oxides which could have been used for making artefacts in Mesopotamia in the Old Babylonian Period. In this research potential sources of haematite, goethite, magnetite and iron in general were collected by making an inventarisation of the occurrence of these iron oxides in the regions around Mesopotamia. The potential sources were selected on the basis of the quality of these materials to make artefacts and the logistic factors. These sources are presented in tables and maps. The most likely potential sources appeared to be the South-East of Anatolia, the Western Iran and the Levant.

Chapter 1: Introduction

This thesis is a literature survey about the provenance of haematite and other iron oxides which have been found in Mesopotamia. The aim of this study is to find potential iron oxide sources from which the material was used for making artefacts. This is done by a geoarchaeological approach. Geoarchaeology is important for this study, because geology, mineralogy and archaeology are combined to make this thesis.
In this chapter first the framework of the study will be presented, than the research questions are given and the material, geographical and temporal boundaries are outlined. After that the acknowledgements and the reading guide of the whole thesis can be seen.

1.1 Framework

This study was carried out the framework of the PhD research of Martine de Vries about haematite objects in Mesopotamia. Mesopotamia is the region which include present-day Iraq and Syria. In excavations seals, weights and other small artefacts are found. During certain periods many of these artefacts were carved from iron oxide stones.
Cylinder seals (fig. 1) are a typical Mesopotamian artefact (De Vries-Melein et al...). The seals were pressed in soft clay and they were used for example for signing clay tablets or sealing doors. Cylinder seals have been made of all kind of material. Mostly they were made of stone, like calcite, carnelian, chalcedony, chlorite, jasper, lapis lazuli, marble and steatite, but they have also been made of faïence, glass, baked clay, wood, bone, shell, ivory and metal (Roaf 1990). In the Old-Babylonian Period (circa 2000-1600 B.C.) a lot of seals were made of iron oxide stones. Up to 70% of the cylinder seals from that period were made of haematite, goethite or magnetite. Before that period hardly any seals were made of iron oxide stones.
When it is stated in archaeological studies that an artefact is made of haematite is does not necessarily mean that it is truly made from haematite, because goethite and magnetite look very much like haematite. In Mesopotamia haematite was called *šadānu*, which means “stone from the mountain”.
An important part of the PhD research is the study of provenance. Haematite, goethite and magnetite do not occur naturally in Mesopotamia. It is generally thought that the materials were imported from Anatolia, but no evidence for that theory is found. So it is not yet known where they were imported from. The aim of my research is to find potential locations using geoarchaeology.

Fig. 1: A cylinder seal at the right with its imprint at the left (British Museum http://www.britishmuseum.org/explore/highlights/highlight_objects/me/h/hematite_cylinder_seal.aspx).

1.2 This thesis

This thesis is part of the first half of my geoarchaeological course. Geoarchaeology is particularly

suited for provenancing studies, because through the combination of geology, mineralogy and archaeology many data can be taken into account.
This survey was carried out to find where potential iron oxide stones that were used for making artefacts were located.
The main questions of my research are:

- Where does haematite occur?
- Are there differences in composition of haematite in the different areas? What are those differences and where do they occur?
- What is the provenance of haematite found in Mesopotamia?

With the answers of these questions I have tried to recognize what iron oxide stones were most suitable for making artefacts. In order to do this a literature survey was performed on how haematite forms. Then the iron oxides from different locations were classified according to suitability for making artefacts. With the result of that research the remaining potential iron oxide stone sources are presented.
Mainly the minerals haematite, goethite and magnetite were studied, because these are the most common iron oxides.
Only the area around Mesopotamia was studied. Beginning with the area of Mesopotamia itself, which include Iraq and Syria. Than Persia: Iran, Afghanistan and the Persian Gulf. India. Anatolia. The Levant, which comprise Israel, Jordan and Lebanon. Than Egypt and also the northern part of Sudan. Caucasia and Transcaucasia. And finally Cyprus and Greece. Iron oxides were probably not obtained from other parts of the world, because the areas which were studied contain probably enough iron oxide and could be reach more easily. So the rest of the world was not studied.
With regard to the archaeological literature this research concentrates on the circumstances in the Old-Babylonian Period, because most of the cylinder seals made of iron oxides are from that period.

1.3 Acknowledgements

I would like to thank Henk Kars and Martine de Vries for supervising me in writing my thesis. And Dave van der Brugge for helping with some computer programs. I would also like to thank him and other people for giving moral support.

1.4 Reading guide

In the *introduction* the framework of the thesis, the research questions, the material, geographical and temporal boundaries of this study are outlined.
In *chapter two* the formation processes of haematite, goethite and magnetite are described. Also information about the characteristics of these iron oxides is presented.
In *chapter three* an inventory of all the natural occurrences of haematite, goethite and magnetite found in the literature is given. Paragraphs are made according to the different regions mentioned above. As much as possible information about the characteristics of the iron oxides found at the locations was added. With every paragraph a map of all the natural occurrences of the iron oxides in the area is given.
The locations are discussed in *chapter four*. At first the material properties presented in chapter two are discussed. The iron oxides which formed in different ways and occur in different rocks are judged on their suitability for making artefacts. Than the logistic factors are weighted.
In *chapter five* the remaining locations which can be seen as potential sources of iron oxides are enumerated and presented in maps.
Chapter six consist of the conclusion and the summery. In this chapter the research questions are answered.

Chapter 2: The natural formation of iron oxide stones

2.1 Introduction

Many minerals contain iron. Iron is the third most abundant cationic element, after silicon and aluminium. Iron is often bound into iron oxides (Cornell and Schwertmann 2003). About 0,2% of the crust of the earth consists of iron oxides and hydroxides (Wenk and Bulakh 2006). 16 different iron oxides are discerned (Cornell and Schwertmann 2003). The most common are haematite, goethite and magnetite (Wenk and Bulakh 2006). Up to 70% of the cylinder seals in the Old Babylonian Period are made of haematite, goethite or magnetite (De Vries-Melein et al...). The formation processes of these minerals are discussed below.
Rocks are divided in three groups according to their formation process: magmatic, metamorphic and sedimentary rocks. Iron oxides occur in all of these three groups. For every iron oxide I first present an inventory of the magmatic rocks, then the metamorphic rocks and then the sedimentary rocks in which they occur. In addition to there are all sorts of iron oxides in soils, at groundwater level, as coatings, at the deep sea etc. and these are formed in many ways. However these minerals are generally too small to use for making artefacts. Therefore those formation processes will not be discussed here.

2.2 Haematite (Fe_2O_3)

Fig. 2: Kidney ore, a compact variety of haematite (Floyd R. Getsinger/EB Inc.).

Haematite (fig. 2) is a mineral with a metallic grey to earthy red colour, it can make a bright red to dark red streak (de Vries-Melein et al...). It consist of crystals of iron and oxide. In every molecule are two iron atoms and three oxygen atoms (fig. 4), the chemical formula is Fe_2O_3. In fig. 4 the iron atoms are indicated with dark blue spheres and the oxygen atoms with light blue spheres (www.webmineral.com). Haematite belongs to the Corundum group. It has a trigonal symmetry (Wenk and Bulakh 2006).
The crystal form is Trigonal - Hexagonal Scalenohedral (fig. 3) (www.webmineral.com). The morphology of the mineral is platy. The hardness of haematite is 6.5 on Mohs' scale and the density is 5.2 g/cm^3 (Wenk and Bulakh 2006).

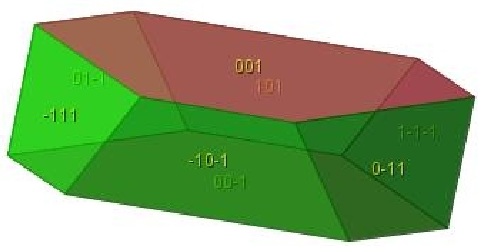

Fig. 3: Haematite crystal form (http://www.webmineral.com/data/Hematite.shtml).

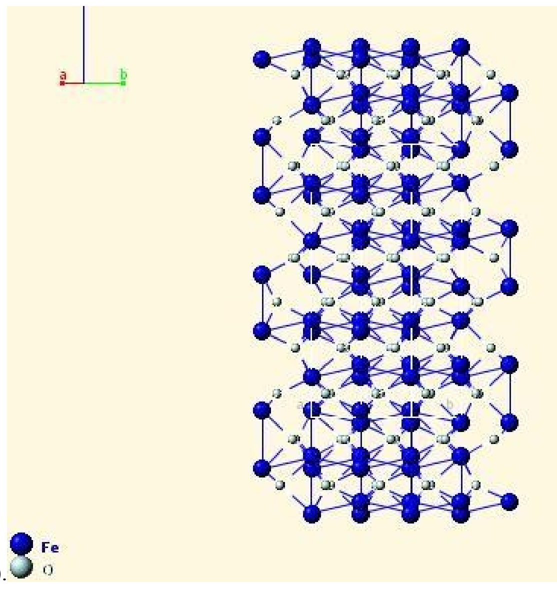

Fig. 4: Haematite crystal structure (Blake et al. 1996).

Haematite occurs in magmatic, metamorphic and sedimentary rocks (Cornell and Schwertmann 2003). It forms in oxidizing environments (Wenk and Bulakh 2006).

Magmatic rocks

Haematite is the only iron oxide of importance that occurs in magmatic rocks, together with titanomagnetites and ilmenites, which occur in lesser extent. The factors which determine the composition of the minerals are the composition of the melt, the rate of cooling and the oxygen fugacity (Cornell and Schwertmann 2003). The fugacity is a measure of the tendency of a gas to escape or expand (Weisstein, 1996-2007). Stable phases can be formed by the decomposing of titanomagnetites by exsolution, all kind of Ti-rich and Ti-poor phases can be formed. The end member of Ti-poor phases: haematite. Ti-haematite can exsolve, it can separate into two minerals: rutile (TiO_2) and haematite. Exsolution is more pronounced as the cooling is slower (Cornell and Schwertmann 2003). So haematite can in this case more easily form with intrusive than with extrusive formation.

Metamorphic rocks

Haematite is, with magnetite and ilmenite, also the main Fe-(Ti) oxide in metamorphic rocks. It is found in metamorphized iron-formations, metabasites with low grade metamorphism, aerobic clay rocks and metamorphosed rocks containing manganese. The haematite often contains Ti and so it often is titanohaematite (Cornell and Schwertmann 2003). Haematite from iron-formations can be very pure, with almost no MgO and TiO_2 in it. Haematite from oxidizing Mn-rich metasediments may have 1 to 4% Mn_2O_3 in it (Frost 1991). Enriching of haematite in banded iron formations can occur through metamorphism (Skinner et al. 2004).

Sedimentary rocks

Haematite occurs in three main types of sedimentary rocks: Red beds, Banded iron formations and Ironstones. Besides that haematite can also form in skarns and at the margins of a basin. These types of formations are explained below.

- Red beds

Haematite occurs in Red beds. The haematite crystals can have different sizes. A large size and euhedral shape of the crystals points towards diagenetic formation (Cornell and Schwertmann 2003). That means that the deposited sediment is going to be conversed to rock.

Aggregates of haematite can be formed from a primary material by Ostwald ripening (Cornell and Schwertmann 2003). Ostwald ripening is a phenomenon in which small crystals, that are more soluble than large ones, dissolve and precipitate as larger particles. These aggregates can occur in sandstones and consist of authigenic and idiomorphic haematite crystals of several µm (Cornell and Schwertmann 2003). Authigenic means here that the haematite has not been transported, but has been formed in place. Idiomorphic indicates that the haematite is part of the rock, but appears in distinct crystals. Haematite aggregates can also form as pseudomorphs of goethite, biotite, or pyrite. Authigenic haematite can be formed by oxidation from magnetite, biotite and ilmenite. Haematite forms by a pseudomorph transformation of goethite by a temperature increase of 47ºC to 105ºC with increasing burial depth of 550m to 2500m. The haematite in the Red beds is detrital or authigenic. Detrital haematite comes from eroded red soils. The conditions for the formation of these continental sediments are a semi-arid climate with a wet-dry cycles and a low-carbon environment. Such climate is good for the formation of haematite via ferrihydrite. In such formation process Fe has to be mobilised during diagenesis. The mobilisation supplies Fe for authigenic haematite formation (Cornell and Schwertmann 2003).

- Banded iron formations

Banded iron formations (BIF's) consist of layers of haematite or magnetite of a millimetre in thickness between layers of quartz or chert. After the material sedimentates, it will metamorphose and the haematite crystals will increase. Then there can form specular haematite (Cornell and Schwertmann 2003), which is a variety of haematite with a blue-grey colour and bright metallic lustre.

Two types of banded iron formations exist. The first one is the Algoma-type ore. It formed when iron-rich hydrothermal solutions were discharged by submarine hot springs into sedimentary basins. The second type is the Superior-type ore. These are younger than the Algoma-type ore and contain more

iron. They are also more uniformly bedded. It is thought that this type is formed by accumulation of ferrous iron in the deep ocean which was transported to shallow water near coasts. (Wenk and Bulakh 2006). The deposits, which are interbedded layers of chert and various iron minerals, precipitated chemically (Skinner et al. 2004). Limestone occurs near this type of ore (Wenk and Bulakh 2006). This ore is found in sedimentary basins on every craton (Skinner et al. 2004), which is an old part of a continental plate which has for long time not been disturbed.
It is supposed that for the formation of the BIF, the solutions with for instance the iron is supplied to a shelf zone, lagoons or lakes in which siderite, haematite, magnetite, FeII silicates, pyrite and chert were formed by seasonal precipitation. Which of those minerals is exactly formed depends on the redox potential and the composition of the aqueous phase. Haematite can be formed by conversion of ferryhydrite. Ferryhydrite absorbs silicate and conversed to haematite by diagenesis and metamorphism. Then it will release the Si. The Si will precipitate. It is also proposed that haematite forms by biogenic formation. Concentrated haematite layers may have been formed from magnetite by post-sedimentary processes together with leaching of chert (Cornell and Schwertmann 2003).
The Superior-type can only be used as good iron ore when an other process is applied to it. Normally the deposit only contains 15 to 30 % iron by weight and the deposits are to fine grained to separate. The first process that can occur is leaching of silica during weathering. That can lead to secondary enrichment, so the deposit will contain 66% of iron. The second process that can make the deposit richer in iron is metamorphism. Then the grain sizes increase, so the minerals can more easily be separated from the gangue. Also new minerals will form and iron silicates and iron carbonates can be replaced by magnetite or haematite. Iron ores which are enriched by metamorphism are called taconites (Skinner et al. 2004).

- Iron stones

Haematite is present in iron stone, which is a Fe-rich, hard sedimentary rock of supergene origin. It is one of the main minerals. Ironstone has probably Fe content because of terrestrial weathering products rich in Fe^{III} oxides, for example lateritic ferricretes. These products were eroded into the sea and then transformed into Fe minerals by reduction or reoxidation (Cornell and Schwertmann 2003). Ironstone can be formed by chemically weathered parent rocks, which are transported by rivers en deposited. These parent rocks can be metamorphic rock, igneous rock and sediments. For example in the Hussainiyat Formation, the fragments were derived from lateritized rocks (Al-Bassan and Tamar-Agha 1998), so rocks that have formed to a red soil by the leaching of silica and enrichment of for example iron oxides. The lateritized rocks could have been al kind of rocks, igneous, metamorphic and sedimentary rocks. The mixing of iron oxyhydroxides with kaolinite was also caused by laterization. Intermediate and basic rocks might have been contributed to the iron enrichment in source rocks. Bacterial build-up in swamps and marshes form iron concretions. Thicker ironstone sections are formed in former depressions (Al-Bassam and Tamar-Agha 1998).
Fe ooids are ironstones with a perfectly rounded body. They are formed in a terrestrial or in a marine context. For the formation there are required mobile Fe^{2+} ions as an Fe source. Fe^{III} oxides will accumulate because of the redox potential, that is low where the Fe^{II} is and higher where the Fe^{III} oxides form. Detrital Fe^{III} oxides from higher parts are transported to wet areas, which lay lower. There the Fe precipitates as ooids (Cornell and Schwertmann 2003). Oolites (sedimentary rocks of ooids which are cemented together) and pisolites (which are something langer and less regular than oolites) can form in situ in kaolinitic soil at the upper limit of the fluctuating water table (Al-Bassam and Tamar-Agha 1998).
As magnetite is not in equilibrium with the atmosphere, haematite can form when in contact to the surface (Cornell and Schwertmann 2003).

- Other sedimentary iron ores

Haematite can precipitate during the formation of a skarn. A skarn is a certain gangue formation. It is produced by replacing the carbonate rocks by solving them and precipitating solutions. If the solutions are rich in Fe, haematite and magnetite can precipitate (Cornell and Schwertmann 2003).
Haematite can be formed at the margin of a basin via ferrihydrite, if hydro-thermal solutions associated with submarine volcanic activities have transported Fe (as $FeCl_3$) into a marine environment (Cornell and Schwertmann 2003).

Copper is diffused in iron oxide minerals. Copper irregularities occur in interrupted iron oxide veins, containing haematite. Those irregularities are usually adsorbed on the iron oxide minerals, they don't form distinct copper minerals. In those veins are also metals found like As, Zn, Ni, Mo, V and Co (Ilani et al. 1987).
Haematite can be formed by dehydration of goethite (Hradil et al. 2003).
The dissolution of magnetite is probably related to its transformation to haematite by oxidation of Fe^{2+} to Fe^{3+}. That transformation occurs along planes and so haematite domains develop along the planes parallel to the foliation and lineation (Lagoeio 1998). So in that case haematite occurs at places where tectonic activity has taken place.
On burning iron (Fe) with sulfuric acid (H_2SO_4), iron oxide with an ochre to red collar will form (Goltz 1972). Haematite can be formed by heating goethite. In the past people produced haematite in that way (Cornell and Schwertmann 2003). Because haematite forms by heating goethite, haematite can also form during bush fires (Pidgeon 2003). At the surface, so with no influence of pressure, goethite transforms to haematite at 240-400°C (Weinstein-Evron and Ilani 1994).

2.3 Goethite (FeO(OH))

Fig. 5: Goethite (http://www.mii.org/Minerals/photoiron.html).

The colour of goethite (fig. 5) is metallic grey to dark brown, the mineral can make a brown, brownish yellow to orange yellow streak (de Vries-Melein et al...). The chemical formula of goethite is FeO(OH). The crystal exists of molecules with iron and oxygen atoms and OH groups (fig. 7). In fig. 7 the dark blue spheres are iron atoms, the light blue spheres are oxide atoms and hydrogen atoms. The crystal form is Orthorhombic – Dipyramidal (fig. 6) (www.webmineral.com). The symmetry is Orthorhombic and the morphology of the mineral is fibrous. The density is 4.3 g/cm^3. The hardness of goethite is 5-5.5 on Mohs' scale (Wenk and Bulakh 2006), so on average it is less hard than haematite.

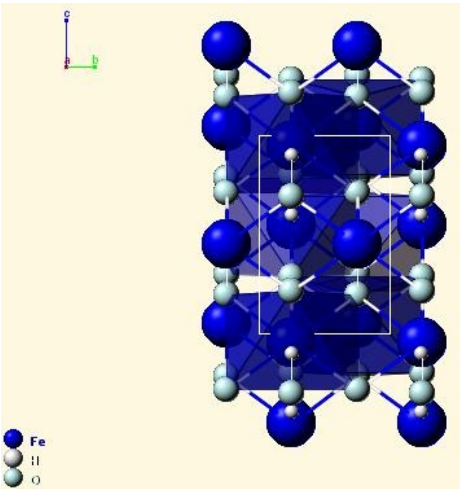

Fig. 7: Goethite crystal structure (Gualtieri et al. 1999).

Goethite hardly ever forms in magmatic and metamorphic rock, so it is only important in sedimentary rock (Cornell and Schwertmann 2003). Like haematite it forms in oxidizing environments (Wenk and Bulakh 2006).

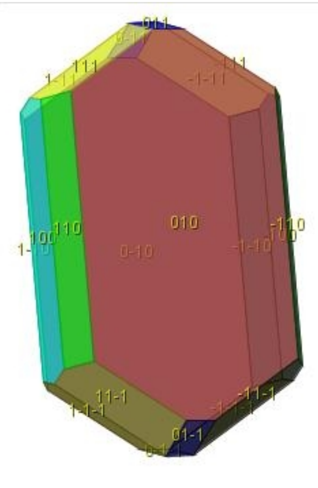

Fig. 6: Goethite crystal form (http://www.webmineral.com/data/goethite.shtml).

Goethite is the most commonly found oxyhydroxide in soils. Usually it is poorly crystallized and it often contains isomorphous substitutions for Fe, for example Al (Vandenberghe et al. 2000). Goethite has usually been formed at lower temperature in comparison with haematite and magnetite and it has

usually been formed in the presence of water. Goethite originated in various environmental conditions. The formation of goethite predominates over the formation of haematite, if there is a low rate of iron supply, a higher water activity, lower temperatures, and with values of pH that are higher and lower than the natural range of the conditions at the earth surface (Nayak et al. 2004).
Goethite or goethite/haematite mixtures that are free of clay minerals can be formed by oxidation of pyrite. That happens in most cases with formation of brownish limonite (Hradil et al. 2003). The name Limonite is used for all kind of iron oxides. It's colour is brown and it's hardness is 4-5,5, so it is generally something softer than goethite, haematite and magnetite (www.mindat.org). Goethite is a phase of brownish limonite. Well-crystalline particulate goethite is for example formed when basic or neutral rocks are intensely chemical weathered in humid climates. A high water activity is necessary to make the goethite/haematite ratio bigger in the weathering products (Hradil et al. 2003). Because goethite forms better with high water activity than haematite does (Nayak et al. 2004).
Olivine is also an example of a goethite parent mineral. It is weathered to a mixture of smectite or kaolinite and goethite. Other sources of Fe are sufficient to form well-crystalline goethite are augite, biotite and hornblende (Hradil et al. 2003). Goethite can be formed from biotite when biotite is weathered and the Fe, which came from the biotite, will be oxidated (Cornell and Schwertmann 2003).
Goethite was formed by goethitization, so conversion of haematite or magnetite to goethite. Goethites have probably mostly formed by natural weathering and it may be assumed to have formed by inorganic chemical precipitation from various kinds of solutions (Nayak et al. 2004).
There is also goethite present in ironstone (Al-Bassam and Tamar-Agha 1998). It is one of the main minerals. Goethite in iron stones may have formed primarily in coastal zones that have been oxygenated, so goethite occurs in coastal zones. Formation may also be secondary, for example oxidation of siderite or other FeII minerals. The formation of goethite ooids is the same as for haematite ooids. Iron stones can change if they make contact to the surface. Pyrite, siderite and biotite weather easily in the atmosphere, and by oxidation of Fe, which is released, goethite can form. If magnetite is not in equilibrium with the atmosphere, goethite can form. Specular haematite can transform in goethite in an aqueous system, by dissolution and reprecipitation (Cornell and Schwertmann 2003).
Laterization also helps to form goethite (Al-Bassam and Tamar-Agha 1998). Like haematite, goethite occurs in copper containing iron oxide veins (Ilani et al. 1987).

2.4 Magnetite (Fe_3O_4)

Fig. 8: Magnetite (http://www.mii.org/Minerals/photoiron.html).

Magnetite (fig. 8) is metallic grey to black in colour and its streak is black (de Vries-Melein et al...). The mineral consists of molecules of three iron atoms and four oxide atoms (fig. 9). Its chemical formula is Fe_3O_4. In fig. 9 the iron atoms can be seen as dark blue spheres and the oxide atoms as light blue spheres. The crystal form is Isometric – Hexotahedral (fig. 10) (www.webmineral.com). The symmetry of the mineral is Cubic and the morphology is granular. The density is 4.9 g/cm^3. The hardness of magnetite is 5.5-6 on Mohs' scale (Wenk and Bulakh 2006), so its average is a slightly harder than that of goethite and a slightly softer than that of haematite.
Magnetite occurs in magmatic, metamorphic and sedimentary rocks (Cornell and Schwertmann 2003) and in contrary to haematite it forms in reducing, oxygen poor environments (Wenk and Bulakh 2006).

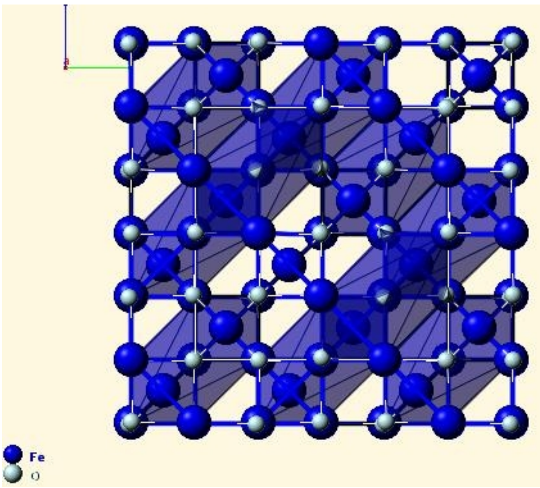

Fig. 9: Magnetite crystal structure (Haavik et al. 2000).

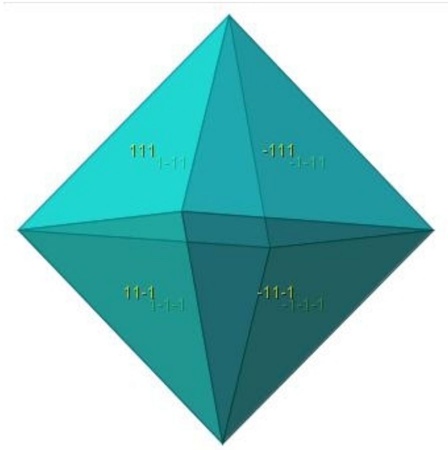

Fig. 10: Magnetite crystal form (http://www.webmineral.com/data/Magnetite.shtml).

Magmatic rocks

Magnetite can occur in magmatic rocks. Magnetite is an titanomagnetite ($Fe_{3-x}Ti_xO_4$) with x=0. The factors which determine the composition of the minerals are the composition of the melt, the rate of cooling and the oxygen fugacity (Cornell and Schwertmann 2003). Magnetite has been formed in the upper zone of Precambrium shields. That magnetite is chromium-bearing. Precambrium shields occur for instance at the West of Saudi-Arabia and at the South-East of Egypt (Wenk and Bulakh 2006).

Metamorphic rocks

Magnetite, ilmenite and haematite are the most important Fe-(Ti) oxides in metamorphic rocks. Magnetite is found in metaperidotites, metabasites, iron-formations, gneisses and metapelites. In high-grade metamorphosed rocks magnetite occurs together with ilmenite and then it contains some Ti (Cornell and Schwertmann 2003). Magnetite in metaperidotites may contain Cr_2O_3 (Frost 1991). Enrichment of magnetite in banded iron formations also occurs by metamorphism (Skinner et al. 2004).

Sedimentary rocks

Magnetite in soils is usually formed lithogenic (related to rock processes), but it can also be fine-coarse pedogenic (related to soil processes) (Vandenberghe et al. 2000).
Magnetite forms if goethite is heated to 500°C (Weinstein-Evron and Ilani 1994). As haematite magnetite also occurs in BIF's. The magnetite is formed by biogenic formation.
Magnetite can precipitate by the formation of a skarn in the same way haematite does. And it occurs rarely in ironstone. Ironstones can metamorphosed. Then magnetite can recrystallize (Cornell and Schwertmann 2003).

2. 5 Conclusion

An overview of the three minerals with characteristics and formation types can be seen below (table 1).

	Haematite	Goethite	Magnetite
Colour	Metallic grey to earthy red	Metallic grey to dark brown	Metallic grey to black
Streak	Bright red to dark red	Brown, brownish yellow to orange yellow	Black
Chemical formula	Fe_2O_3	FeO(OH)	Fe_3O_4
Crystal form	Trigonal-Hexagonal Scalenohhedral	Orthorhombic-Dipyramidal	Isometric-Hexotahedral
Symmetry	Trigonal	Orthorhombic	Cubic
Mineral morphology	Platy	Fibrous	Granular
Hardness (Mohs' Scale)	6.5	5-5.5	5.5-6
Density (g/cm^3)	5.2	4.3	4.9
Formation in magmatic rocks	Yes, more in intrusive than in extrusive formations.	No	Yes, in Precambrium shields. Often titanomagnetite.
Formation in metamorphic rocks	Yes, in metamorphized iron-formations, metabasites with low grade metamorphism, aerobic clay rocks, metamorphosed rocks containing manganese and BIF's. Often Mg, Mn or Ti in the haematite.	No	Yes, in metaperidotites, metabasites, iron-formations, gneisses, metapelites and BIF's.
Formation in sedimentary rocks	Yes, in red beds, BIF's, ironstones, skarns and margins of basins.	Yes, in soils, ironstones in coastal zones and iron oxide veins.	Yes, in soils, BIF's, skarns and ironstones.

Table 1: Overview table of the characteristics and formation types of haematite, goethite and magnetite.

Chapter 3: The natural occurrences of haematite, goethite and magnetite in the Near East

3.1 Introduction

In this chapter all natural occurrences haematite, goethite or magnetite I found in my literature study are presented. Also locations containing iron oxide or iron are added, because probably haematite, goethite or magnetite can be found there, since these the most common iron ores. (Wenk and Bulakh 2006). The natural occurrences are ordered according to the regions that existed in Antiquity: Mesopotamia (Iraq and Syria), Persia (Iran, Afghanistan, Turkmenistan and the Persian Gulf), Pakistan and India, Anatolia, the Levant (Lebanon, Israel, Palestinian Territories and Jordan), Egypt, the Arabian Desert (Saudi Arabia and Yemen), Caucasia and Transcaucasia, Cyprus and at last Greece. The locations which were found are presented on maps. The numbers between brackets behind the locations refer to locations on the maps. Figure 11 displays an overview map of whole the region around Mesopotamia. The areas in the squares can be seen on other individual maps. Some locations mentioned in literature were too obscure to put on the map. As much as possible information about the deposits was added in the text.

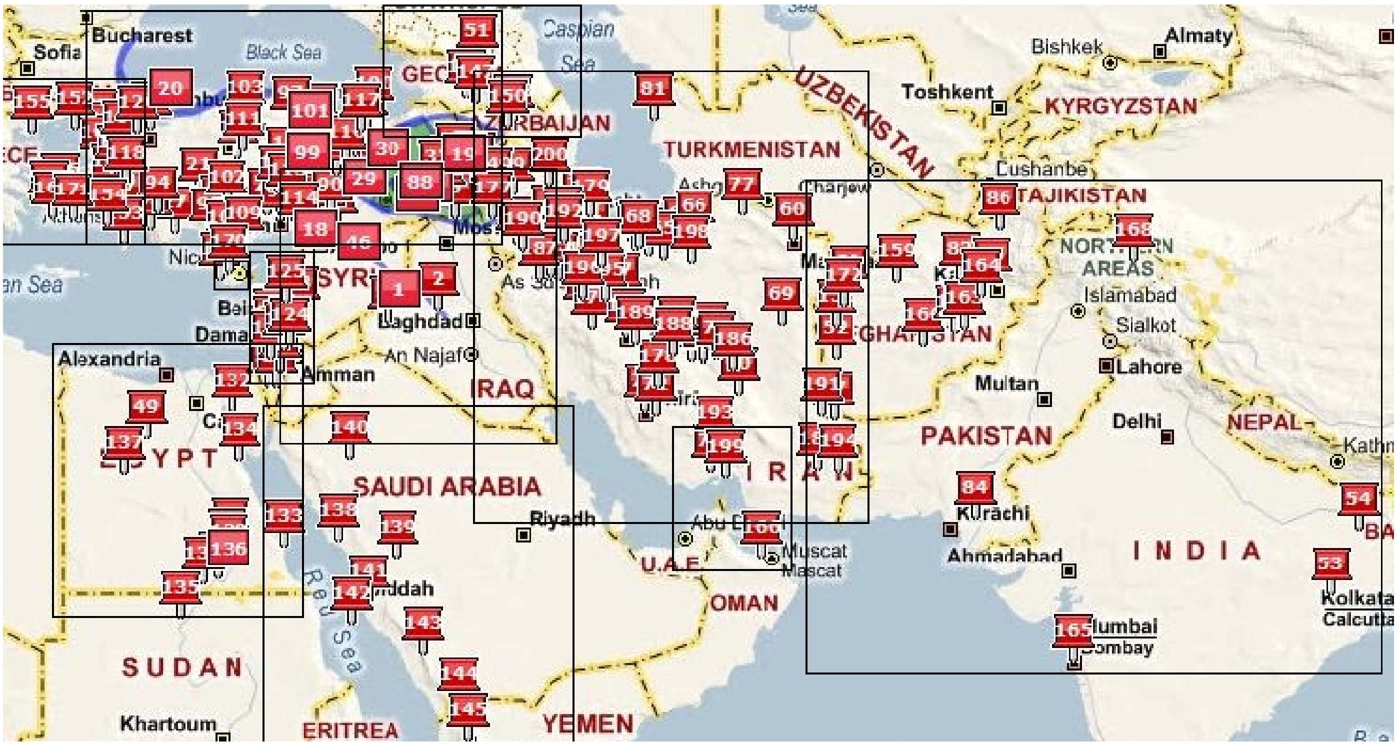

Fig. 11: Overview map of the region around Mesopotamia with all natural occurrences of haematite, goethite, magnetite and iron or iron oxide in general on it. For the areas in the black squares see below.

3.2 Mesopotamia

The name Mesopotamia means 'between rivers', referring to the Euphrates and the Tigris. It comprises Eastern Syria, South-Eastern Turkey and most of Iraq are included in that name (www.britannica.com/eb/article-9108642). The enumeration of natural occurrences of iron oxide stones is subdivides in Iraq and Syria. In figure 12 a map of Mesopotamia can be seen showing the natural occurrences of iron oxides in the area.

Iraq

It is possible that there was exploitation of local iron ores in Assyria in Antiquity. There are iron mines in the Wadi Hassainiyat, North-East of Rutba (no. 56), in Western Iraq, but it is not sure whether they have been exploited in Antiquity. No documentation or archaeological evidence is found about the exploitation of these mine (Moorey 1994), so the mines are difficult to date. The Hussainiyat ironstone deposit, where the mines are in, contains mainly goethite and also haematite. The deposit is 15km long and 2-3 km wide. The ironstone is sedimentary and mainly pisolitic to oolitic and there are parts that are massive and concrete (Al-Bassam and Tamar-Agha 1998).

The Middle Euphrates region (no. 1) contains a potential iron source in Neo-Assyrian times (Moorey 1994). Near Hit (2), brown haematite is found.
In Kurdistan iron mines are exploited in the Bawari Valley (5) (Moorey 1994).

Fig. 12: Map of Mesopotamia showing the natural occurrences of iron oxides in that area.

Syria
The Middle-Euphrates (1), the Khabur region (Laqe) (46) and Damascus (48) are mentioned as potential iron sources in Neo-Assyrian times. However Damascus may have been only a distribution centre (Moorey 1994). Near Alexandria are rich iron ore deposits (Forbes 1972).

3.3 Persia

The ancient name of Iran and Afghanistan is Persia. It lies West of Mesopotamia across the Zagros mountain range.

Iran
The Greater Iran is a potential source for haematite (Moorey 1994). On the map of figure 17 all the natural occurrences of iron oxide in Iran can be seen. In figure 13 to 16 provide more detailed maps. Figure 13 shows the natural occurrences of iron oxide in the provinces of Gilan, Mazandaran, Semnan, Tehran, Qazvin and the Northern part of the province of Markazi. Figure 14 is about the iron oxides of the provinces of Esfahan, Fars, Lorestan and Markazi. Figure 15 about the provinces of Hamadan, Kermanshah, Kordestan and Zanjan and figure 16 gives the Yazd province.
The ground mass of the dehaj-type rocks North-West of Kuh-el-Mosahim contain Fe-oxide (Ministry of Economy 1973). Dehaj is a phase of volcanic activity (Ranjbar 2004). Iron deposits occur near the Zagros Thrust, South-West of Tehran (Derry 1980). Iron is found at the East of Lake Urmia (Roaf 1990). Mines and smelting sites existed in the past near Tabriz (59) (Forbes 1972). Near Kashan (67) are magnetite and haematite found (Forbes 1972). Deposits of raw iron are found in Tappe Sialk (80) (Denk 1990). In the plain of Persepolis and between Kerman (70) and Shiraz (71) remains of early iron working have been found. There are iron ore deposits in Chorassan near Semendeh (72) and Ilak (Forbes 1972). There are old mines near Resht (78) (Forbes 1972), deposits of raw iron are found there (Denk 1990). Iron is also found on the main land of Iran North of the island of Hormuz, (Roaf 1990). Iron deposits occur in the South of Iran in the region of Kerman (Derry 1980). Yellow and brown ochre and limonite occur in Carmania (70) (Forbes 1972). Yellow and brown ochre and limonite can be found in the Kuh-i-Benan region (69) (Forbes 1972), in the Khorasan province. Deposits of raw iron are found at Reżāābād (77) (Denk 1990). Iron is also found on the North-East of Iran near Mashhad (60) (Roaf 1990). Deposits of raw iron are found in the province of Lorestan (fig. 14) in Šamsābād (79) (Denk 1990). In the Mazandaran province (fig. 13) near Massula in the Elburz mountains are old mines. On the foothills of Mount Demawend (no. 63) occur haematite and limonite.

Fig. 13: Detail map of area South of the Caspian Sea with natural occurrences of iron oxides. This map comprises the provinces of Gilan, Mazandaran, Semnan, Tehran, Qazvin and the North of the Markazi province.

There is magnetite and haematite near Kohrud (68) (Forbes 1972). Deposits of raw iron are found in the province of Semnān (no. 198) (Denk 1990). At the mountains near Damghan (64), Semnan (65) and Sharud (66) are rich strata of haematite and deposits of limonite and yellow ochre (Forbes 1972). 12 km North of Semnan (65) is an iron mine where magnetite is found (www.mindat.org/). In the Tehran province (fig. 13) to the East near Firuzkuh (no. 62) is haematite and limonite found (Forbes 1972). West of Teheran and near Kazwin (61) is much haematite (Forbes 1972). Iron is found in the Yazd province (fig. 16) (Roaf 1990). In the Yazd province (no. 34) are haematite deposits known (Cowell). Near Bafq are some iron mineralization. Volcanogenic magnetite-apatite lenses are in the Bafq district and at Čoġart (74). The lenses contained 100 to 250 million tonnes of 60% Fe (Sillitoe 1979). Deposits of raw iron are found at Čādar malu (75) and the Northern Anomaly (76) (Denk 1990). Goethite is found in Ardakan (169) (www.mindat.org/).

The following information is mainly based on the website of the National Geoscience Database of Iran (www.ngdir.ir/MiningInfo.asp). It has to be mentioned that the mines below are modern mines. Iron oxides are obtained from them nowadays, so in ancient times at least not everything was mined. In modern times material can be obtained from locations which are more difficult to reach, for example minerals deep in the ground. In the past people probably could not reach all minerals in these mines. However it is good to know the locations of the iron oxide deposits. They are potential ancient iron oxide sources.

Iron occurs in Muil in the Ardebil province (no. 200). In the province of East-Azerbaijan (around no. 59) is the ore body of Ali kandi Hashtrud formed by metamorphic processes as a vein between volcanic rocks. Magnetite is the main ore type. At the Khams ore body in the same province occurs haematite. It is formed by igneous-metamorphic processes. In the Zakleak Ahar mine in East-Azerbaijan (near 59) ironstone occurs.

In the Balestan (no. 177) mine in West-Azerbaijan are magnetite and haematite found in ironstone. The ore purity is 61 to 73 %. In West-Azerbaijan (near no. 177) lies the Eskandarian mine where haematite and mainly magnetite are found in ironstone. The minerals are lens shaped and of igneous genesis. Ironstone occurs also in the Safu mine and the Qareh Baq Qalqachi mine. Ironstone with haematite and mainly magnetite in it can be found in the mine of Qatur Ironstone of Shahindezh in West Azerbaijan (near 177). The genesis is metamorphic and the mineral shapes are lenses.

The Mohamad Abad iron ore body (no. 189) in Esfahan contains haematite and mainly magnetite. They occurs in schists as veins. The texture is scattered and massive. They are formed by igneous processes. The igneous formed iron ore bodies of Darreh Mustan and Darreh Rahim in the Esfahan province (183) are skarn types. In the Ab Pooneh mine in the city Fereydunshahr (174) are haematite and magnetite found in ironstone. Haematite and magnetite occur in Niasar. They are in lens shapes and their genesis is metamorphic. The natural occurrences of iron oxides can be seen on figure 14.

At Shiraz (no. 71) in Fars province is the ore body of Kueh Sefid. It contains among others haematite, magnetite and goethite. It's genesis is metamorphic. Near the city Dehbid (178) occurs an iron ore body which is called Band-e-No Bavanat. It is also formed by metamorphic processes. The Ushan Piry Bavanat ore body lays there too. Ironstone occurs at Hanshak in the Fars province (near 71). In the Kan Gohar mine is iron found that is formed by igneous processes and occurs in veins, it appears together with manganese. Igneous formed ironstone can be found in the Soleymanpor mine. Also for the Fars province can the iron oxide occurrences be seen in figure 14.

Fig.14: Detail map of the Central-West of Iran with natural occurrences of iron oxides. This map comprises the provinces of Esfahan, Fars, Lorestan and Markazi.

In the Gardoysheh mine and the Garmab Dasht Rudsar mine in the Gilan province (near no. 78) (fig. 13) is also ironstone. The ore body of Ahandan-e-Lahijan (179) in that province is formed by metamorphic processes and it appears in veins.

The iron ore body Golali occurs in the province of Hamedan (no. 184). The main ore is magnetite, but also haematite occurs. The ore body is 850 m in length and 60-150 m wide, it is a lens type and it's genesis is sedimentary-metamorphic. In Asad Abad (182) occurs the Chenar-e-Olya ore body, the ore mineral type is magnetite and the ore occurs in lenses. An other iron ore body which also occurs in the Hamadan is Hameh Kasi (185). It's genesis is metamorphic, it is lens shaped and it is 700 m long. It's main ore type is magnetite. At Shaleh abad (175) is ore body Baba Ali found. The main ore type is magnetite, but haematite does also occur. The ore is lens shaped and is formed by igneous and metamorphic processes. The ore is 250 m long, 25-30 m wide and 40-45 m thick. In the Alvand Baba Ali mine near Saleh Abad (175) is magnetite found in ironstone. It occurs in veins. The natural occurrences of iron oxide of Hamedan can be seen in figure 15.

Fig. 15: Detail map of Iran, of the natural occurrences of iron oxides in the provinces of Hamadan, Kermanshah, Kordestan and Zanjan.

Near Haji Abad (193) in the Hormuzgan province is the ore body of Tang Zagh. It contains magnetite and mainly haematite in ironstone. They are formed by sedimentary processes and appear in veins. The thickness of the ore body is 40 m. Ironstone also found in the Guri sheikh mine (73).

In Ravar (no. 186) lays an iron ore body with magnetite in veins. Ironstone occurs at the Cheshmeh Sefid mine and the Gazdaru mine in the Kerman province (70). In the Iron Golgohar sirjan mine and the Jalal Abad Zarand mine is iron found.

In Sonqor (187) in the province of Kermanshahan (fig. 15) is the Kanishireh ore body. Haematite, goethite and mainly magnetite occur in it. It is 350m. long, 0,5m. wide and 20m. thick. It's genesis is magmatic-metamorphic. Also near Sonqor is the Khosru Abad ore body. It contains metamorphic formed magnetite in lenses.

An iron ore body occur at Saheb (no. 3) in Kordestan (190) (fig. 15). Ironstone is found in the Shahrak Bijar mine.

In the Kuh-e-Pank mine in the province of Markazi (no. 173) is haematite found. The haematite is formed by submarine volcanism and is found in sandstone, marl and shale. In the mine of Delijan (no. 196) occurs ironstone. The main ore is haematite, but goethite is also found. The iron is formed by erosion of igneous rock deposits between sedimentary layers. The ore body is 50 m in length, 20 m wide and 10 m thick. In the Gazal Dar mine near the city Arak (195) is also ironstone found. The main ore is limonite, but also goethite occurs. In the Mamoniyeh mine (197) is also ironstone. Also goethite and mainly haematite occur in it. They have a sedimentary genesis. The ore body is 50x20x6 m. The ore purity grade is 2%. In the Shams Abad 1 mine near Arak (196) is also ironstone. Goethite occurs as paragenesis. The natural occurrences of iron oxides can be seen in figure 14. The most Northern iron oxide occurrence (197) can also be seen in figure 13.

At the mine at Damghan (64) is haematite found in ironstone. Ironstone also occurs in the Hamirud mine, the Hashdeh Robai mine, the Lojneh1 mine, the Shomale Semnan mine and the Sheykhab mine. At the Chalu mine also occurs ironstone. That ironstone contains magnetite and mainly haematite. The minerals are in veins. In the Panjkuh mine near Damqan (64) in the Semnan province is ironstone

formed with haematite and mainly magnetite in it. Their genesis is metamorphic and the minerals occur in veins. Ironstone occurs in the in Semnan province (199) (fig. 13).
An iron ore body occurs in Shvin near Zahedan (191) in Sistan va Baluchestan province. The Zaboli (194) (Garnak) ore body in that province contains metamorphic formed haematite in veins. In Iranshahr (180) does the Bakhtar-e-Rodkhaneh-e-Maki ore body occur. The main ore type is oligist. which is some sort of haematite. It is formed in veins by metamorphic processes and the body is 100 m in length and 1-6 m thick.
In the mine of Chushalu in the Qazvin province is haematite found. It can be seen on figure 13.
The iron oxides found in the Yazd province are presented in figure 16. The Kazab ore body (188) in Yazd province has mainly magnetite and oligist occurring in veins. The Chah Gaz iron ore body, near Bafq (58), contains haematite, goethite and mainly magnetite. It is formed by metasomatic processes, which means that the composition of the rock is changed by interaction with fluids. At the Chadormalu mine, 80 km of Ardakan city (169) is ironstone found with mainly magnetite, but also haematite in it. They are found as lenses and massive stones from igneous genesis. The grade of iron is 55%. Ironstone occurs in Cogart (74). Iron occurs in the Se Chahun mine near Bafq (58) in the Yazd province. North of Bafq (58) is also an iron ore body. The main ore is magnetite, but haematite also occurs. It's genesis is igneous-metamorph. In the Yazd province (34) is an ore body with magnetite, it is formed by metasomatic processes. It is 500m. long, 5-6m. wide and 15-18 m thick. It occurs in veins.

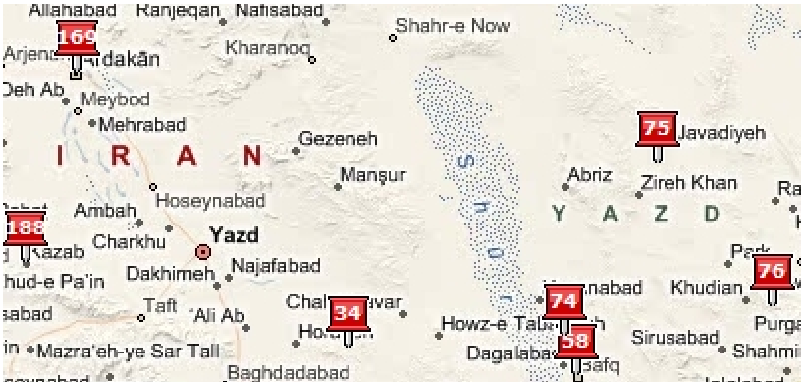

Fig. 16: Detail map of the Yazd province in Iran with natural occurrences of iron oxide in that area on it.

In Bonab in the Zanjan province (181) occurs an ore body probably of magnetite which is formed in veins by metamorphic processes. In the Argin mine in Abhar (176) is ironstone found containing magnetite. The ore is for 70% magnetite and the material is formed as result of infiltration of granite mass in side host stone and by metasomatism processes. An iron ore body occurs in Shah Bolagh (55). The Shah Bolaghi mine contains ironstone with haematite in it. The ore purity grade is about 60%. The ore body is 50m. in length and 16m. wide. In the Goljik mine (4) and in the Gozlodre mine is also ironstone. The main ore mineral in these mines is magnetite, but haematite also occurs. The minerals occur in veins and are formed by infiltration in rocks and metasomatism. Magnetite and haematite ore are found in the ironstone of the Hosein Abad mine (50). The ore purity grade is 90%. The genesis is metamorphic and the minerals occur in veins. The ironstone in the Kuse Lor mine contains haematite. The ore purity grade is about 75%. The ore occurs in veins and is formed by infiltration in rocks and metasomatism. The ore body is 50x10 m. The Morvarie mine contains ironstone with goethite and mainly magnetite in it. The minerals are formed by metasomatism and they occur in veins. The ore body of Sorkh dizej (192) contains metamorphic formed magnetite in veins. In the Sorkhe Dizaj mine occurs ironstone. The main ore mineral is magnetite. 60% of the ore is Fe_2O_3 (haematite and limonite). The minerals occur in veins. In the Zakar mine in Zanjan province (181) occurs ironstone with haematite and mainly magnetite in it. The ore purity grade is 58%. The minerals are formed by metasomatism, they occur in veins. The natural occurrences of iron oxide of Zanjan province can be seen in figure 15.

Turkmenistan
In Persian times haematite came from Khwarizm (no. 81), that is East of the Caspian (Campbell-Thompson 1936), in Turkmenistan.

Fig. 17: Overview map of Persia, showing the natural occurrences of iron oxides and black squares which refer to other maps of Iran in this chapter.

Afghanistan

Iron ore deposits have been found in Juwain (no. 52), Herat (82) and Bamian (83) (Forbes 1972). Iron deposits occur in Afghanistan West of Kabul (Derry 1980). Deposits of raw iron are found at Šiwa (86), Kōtal-e Hāğğigak, Paġman (which is just South-West of Kabul) (85) and Haği-Alam (Denk 1990). In Afghanistan is also haematite found in the Faryab (Fariab) province (158), in the Ghazni province (162), in the Uruzgan province (163) and in the Zinda Jan province (164). Magnetite is found in the Herat province (172). Both haematite and magnetite are found in the Badg(h)is province (159) and in the Kandahar province (160), in the Zabol province (161), in the Ghazni province (162) and in the Uruzgan province (163) (www.mindat.org/). On figure 18 and 19 can the natural occurrences of iron oxide in Afghanistan be found.

Fig. 18: Overview map of Afghanistan with natural occurrences of iron oxides. The black square refers to map 19.

Fig. 19: Detail map of Afghanistan with natural occurrences of iron oxides.

Persian Gulf
Red ochre and other iron ores have been found at the islands of the Persian Gulf (fig. 20) (Forbes 1972). About the time of the second world war it was mined in the Hormuz island (no. 33) by the Persian Government (Campbell-Thompson 1936, Geographical handbook…, Denk 1990), the haematite occurs in solution caverns (www.mindat.org/). Goethite, magnetite and massive haematite occur in Fanja (166) in Oman (Wilde et al. 2002). Ironstone occurs at Larak (199) (http://www.ngdir.ir/MiningInfo/MiningInfo.asp).

Fig. 20: Map of locations in the Gulf with natural occurrences of iron oxides in that region.

3.4 Pakistan and India

The natural occurrences of iron oxides in both Pakistan and India can be seen in figure 21.

Pakistan
Haematite is found in Pakistan in Alchori in the Baltistan province (168) (www.mindat.org/). There were old mines in Alexandria and Caucasum in Kohistan (84) (Forbes 1972). Deposits of raw iron are found at Saindak (87) (Denk 1990).

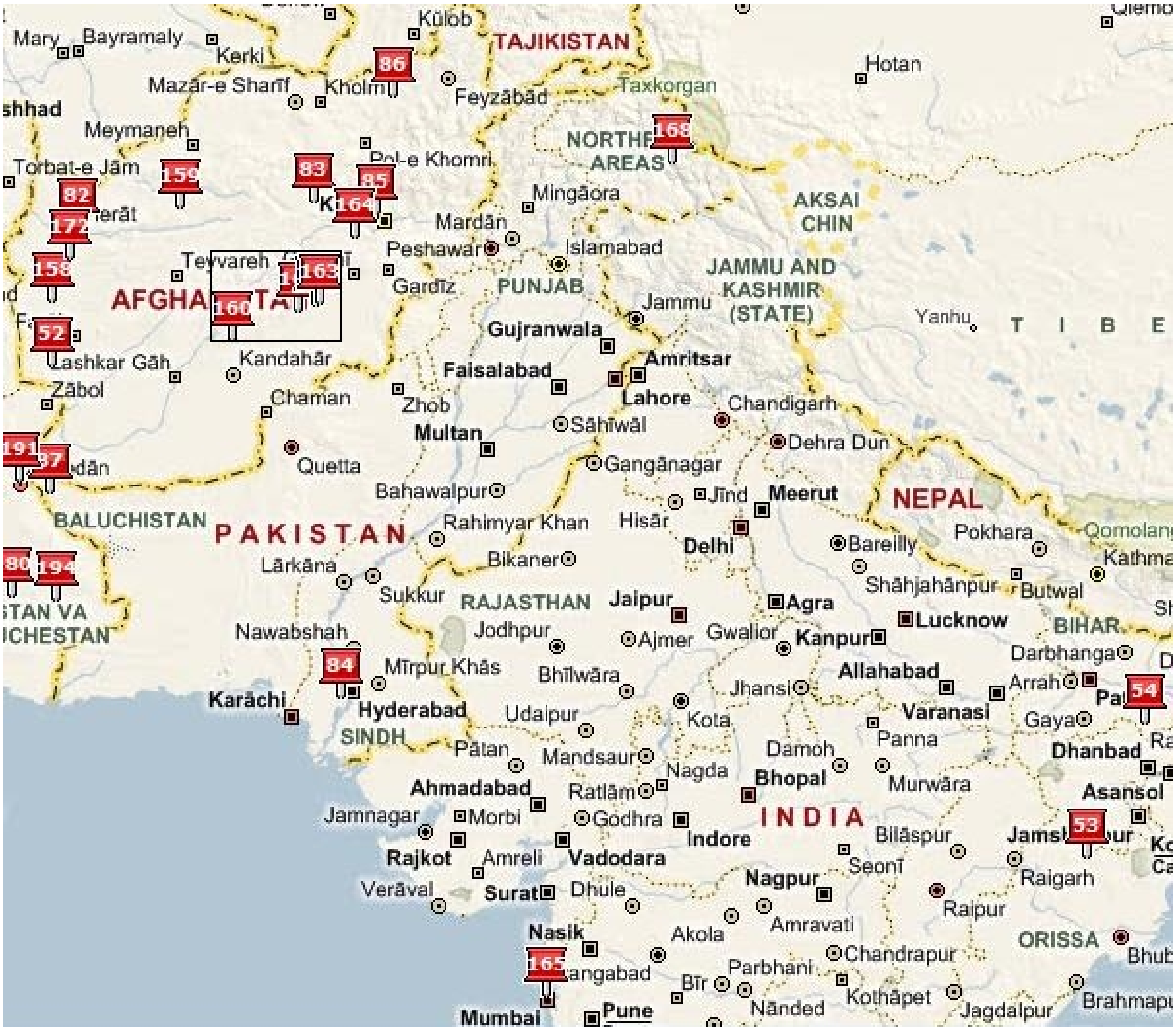

Fig. 21: An overview map of Afghanistan, Pakistan and India with natural occurrences of iron oxides in those countries.

India

Iron ores are found in the Singhbhum Granite massif in North Orissa (no. 53) and South Bihar (54) in India (Nayak et al. 2004). There are soft haematites found in Jauli, in India (Campbell-Thompson 1936). Iron deposits occur at the South-West coast of India (Derry 1980). Haematite is found in the Khandivali quarry (165) near Bombay in Western India (www.mindat.org/).

3.5 Anatolia

In Turkey, haematite is a fairly common mineral. It is often associated with granitic rocks and hydro-thermal deposits (Cowell). An overview map of Anatolia with the natural occurrences on it is presented in figure 22. A more detailed map of the Western part of Anatolia in figure 23 and the Eastern part in figure 24.

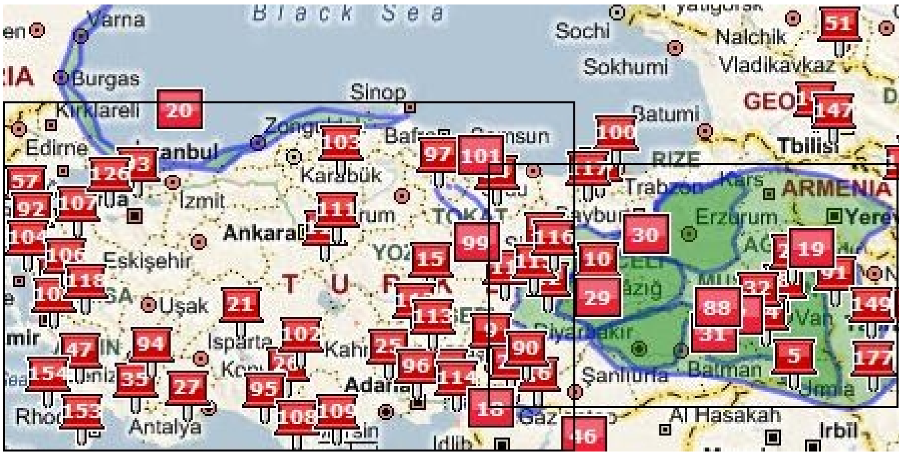

Fig. 22: Overview map of Anatolia with natural occurrences of iron oxides in that area. The black squares refer to the two following maps, to the figures 22 and 23.

Iron ore is found in East Turkey. About 1100 BC iron ore and haematite are obtained from for example Nairi (no. 88), that is at the West and South of Lake Van. In the area South and South-West of Lake Van is found evidence of ancient ironworking. That region has possibly been essential for the iron of Assyria and Urartu (Moorey 1994). Nairi is the name for the land and for the people. The capital of Nairi was Tushpa, which is now the city Van. The area Nairi was the region around Lake Van. It existed from about 2000 BC till the 8th century BC (Nev 2007). In that same region were three rich deposits of iron ore intensively exploited in Urartian times (about 13th to 6th century B.C.). The largest is the area of Bingöl, Tunceli, Elaziğ and Malatya (no. 29). The second largest is that of Divriği, Erzincan, Erzurum (30). And the smallest of the three is the area of Diyarbakir (Hani), Siirt, Bitlis, Van and Hakkari (31). Also iron mines existed in Mağara Tepe (now called Pero-Tarlasi) and Balaban (32). Near the settlement Ernis (28) was probably a small iron smithery (Merhav 1991).
Also the iron containing sands of the Black Sea region in Turkey might have been a iron source (Moorey 1994). In the past a high quality of haematite was shipped from the Sinope at the Black Sea to Crete and Egypt (Cornell and Schwertmann 2003). Iron is also found South-West of Euxine (the Black Sea) (20) (Campbell-Thompson 1936).

In Kestel (no. 25) a probable tin mine was found. In nearby Göltepe haematite artefacts were found, e.g. weights. The Kestel and Göltepe finds date to the third millennium B.C. Haematite ore nodules were found in Göltepe during excavations, they resemble the ore from Kestel (Yener 2000). A nodule is an irregular rounded to spherical concretion. They are typically solid replacement bodies of the iron oxides, they are formed during diagenesis of a sedimentary rock. In the region of Kestel there have been two main phases of mineralization. The first was a tin bearing mineralization and the second was a haematite bearing mineralization with weak tin in it. The tin-rich haematite ore is grey and glittering, the haematite without the tin is matte. Haematite-quartz veins occur along the tin mineralization. The extensive mineralization occurs near the subduction zones in the area. In the area plate tectonic activity has been quite intensive. There are rich haematite veins, which measure 58 cm x 2.7 m where left intact. Yener states the mine was a tin mine, not a haematite mine. However there are found third millennium mace heads and hammer stones shaped from haematite ore for example in Göltepe, near the Kestel mine (Yener 2000).

To continue with other occurrences of iron oxide ores: most iron came from the West and North-West of Mesopotamia, from modern Anatolia and Syria. Some came from the North, Urartu (no. 8). Potential iron sources in Neo-Assyrian times were Marash (9), the Elazig region (10), the Gurun (11) and Malatya (12) areas, the Divriği deposits (13), which are between Sivas and Erzinca, the Amanus region (14), Carchemisch (16), Tabal (15) in the anti-Taurus region and Que (Cilicea) (17). The Divriği deposit is the largest and most important iron-producing area in modern Anatolia. An haematite source can be found in the central Taurus range between the Euphrates and the Cilician Gates (no. 18). There are iron oxides that came from the volcanic regions of Anatolia near the Upper Euphrates (19) (Moorey 1994). Iron is also found in the Taurus, and Anti-Taurus. Iron was smelted at Siliski, near Diurik (Dumbugh Dagh) (Campbell-Thompson 1936), so we don't know whether there are iron deposits. Iron oxide is found in Tura duri (Tiyari) (24) (Campbell-Thompson 1936). In the Tiyari mountains (91) are found iron mines. (Moorey 1994) In the Bolkardağ area (26) is iron present as haematite of magnetite. It has a high lead and sink percentage (Yener 2000). Knowing that is useful for doing analysis on it. Umber, a clay pigment which contains iron oxide, comes for example from Turkey (Hradil et al. 2003). There was an iron-working centre near Germanicia North of Doliche (90). There is magnetite at Mons Ida (92) near Andeira and near Magnesia (89), iron ore in Bythinia (93), Caria near Latmus and Cibyra (94). The last one is probably an haematite deposit. There were ancient mining centres in Phrygia and Lycia. In Phrygia Maior are several deposits of high-grade haematite. Near Alaya (95) and Silinti (Adana) (96) is much haematite and iron pyrites. There are iron mines in Amaxia (97) in upper Cilicia. Near Jünik Tepessi is iron ore which contain up to 53% of iron. There are iron ore deposits in Pontus (98) and the neighbouring districts, up to Kighi near Erzerum. Near Amasia, Tokat and Sivas (99) is magnetite and iron pyrites. There are traces of ancient mines West of Trapezus (100). There are bog-ore deposits (Forbes 1972), which is limonite (www.mindat.org), in the valleys of the Thermodon and Iris (101). There are other deposits on the lower slopes and foothills of the ranges between the modern Yešil Yarmak up to Batum (102) (Forbes 1972) Deposits of raw iron are found in Kuşşayiri (103), Altinoluk, Ayazmant (104), Hortuna (105), Sakarkaya (106), Şamli (107), Camdağ, Mellec (108), Bűyűkeceli (109), Kesikkőprũ (110), Celebi (111), Kősedag, Karamadazi (112), Mansurlu (113), Payas (114), Akdağ, Pinargőzű-Davutağlu, Uzunpinar, Karakalkar, Deveci/Hekimhan (no. 115), Divriği/Cürek (13), Bizmişem (116), Aşvan, Avnik and Ertabil (117). In Sart (Sardeis) (118) and Gaziantep (22) are deposits with processing of raw iron (Denk 1990). West of Feke in the Adana Province (near Mansurlu (113)) is haematite (specularite) still mined (http://www.mindat.org/). 13 ironmines were located in the area near the border of the provinces of Isparta and Konya (no. 21). Near the coast at the South of Antalya (27) did 6 ironmines exist. At the East of the Muğla coast (35) are 3 ironmines found, at the West (47) are 4 ironmines found. Also at the coasts of Çanakkale (no. 57) and Bursa (126) are a few more ironmines found (Sasson et al. 1995).

Fig. 23: Map of the middle and West of Anatolia with natural occurrences of iron oxides.

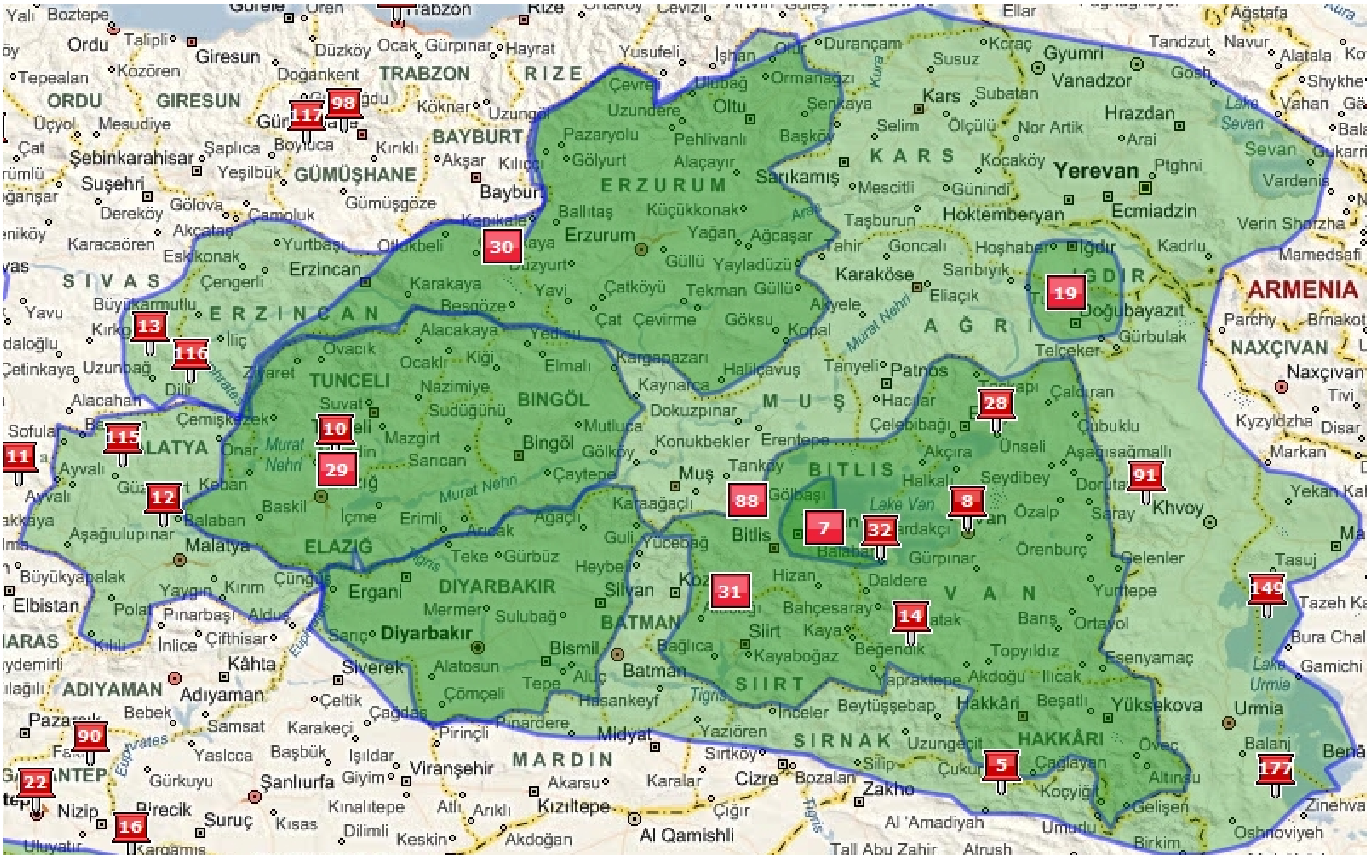

Fig. 24: Map of Eastern Anatolia with natural occurrences of iron oxides.
The green areas are regions were occur a lot of iron oxide.

3.6 Levant

The natural occurrences of iron oxides that have been found in this survey are situated in Israel, Jordan and Lebanon. An overview of these countries and there iron oxide occurrences can be seen in figure 25. A more detailed map of Northern Israel can be found in figure 26.

Israel
In Israel copper containing iron oxide veins are found along the Ramon fault (no. 36) in the central Negev desert, where they mostly contain haematite and goethite, in the Qalqilya Horst (no. 119), where they mostly contain goethite, in the Zur Natan horst (120), where they mostly contain goethite, in En Boqeq (121), where goethite was found, in Latrun (122) at the Western foothill of the Judean mountain range, where they mostly contain goethite. In En Yahav (no. 37) are also iron oxide veins found. There are iron oxides in the Samarian mountains (38) (Ilani et al. 1987).
There are several iron oxide mineralizations found in the range of 1-10 km of el-Wad in the Mount Carmel area (no. 39). They are found in Cenomanian-Turonian limestones and dolomites in the Judea Group, close to volcanic rocks. The 7 sites are: lower and upper Nahal Meárot (no. 41 and 40), Kerem Maharal (42), Ofer (43), Tavasim (44), Shefeya and Raqefet Valley (45). The iron oxide mineralizations mostly fill joints and fractures in carbonates. These joints and fractures are along faults which link the carbonates with the volcanic material. The iron oxides occur in veins, lenses and concretions. The veins and lenses are 1 or 2 to tens of meters in length, they are a few millimetres to 20 cm in thickness. The veins and lenses are often discontinuous. There also are irregular bodies of iron oxides, which have lengths of tens of centimetres. In the alluvium or wadi terraces of Mount Carmel are sometimes pebbles of iron oxides found (Weinstein-Evron and Ilani 1994).

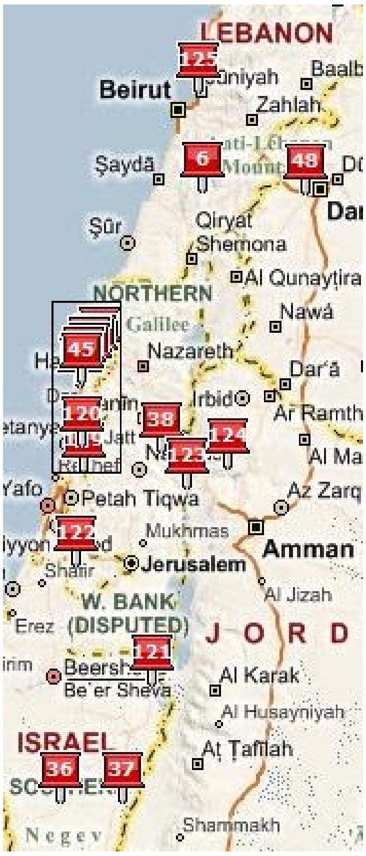

Fig. 25:Overview map of the Levant with natural occurrences of iron oxides.

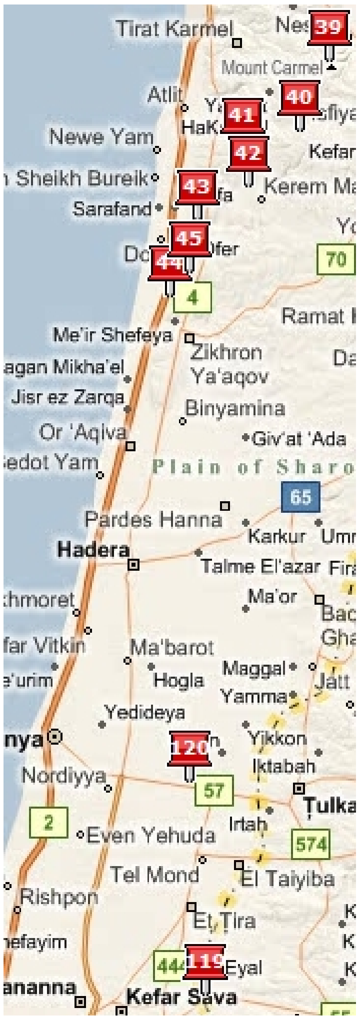

Fig. 26: Detail map of Northern Israel with natural occurrences of iron oxides.

At an excavation in the el-Wad cave, one of the Mount Carmel Caves, are ochres found. Sample analyse of these ochres shows that there are three main types found. One type contains goethite, the other haematite and goethite and the other rock containing iron as Fe_2O_3. In the area goethite is very common, haematite is much more rare. Haematite ochre does occur in rocks that have been pushed above the soil (Weinstein-Evron and Ilani 1994). In an olive-yard behind Shefeya (boulders) is limonite and magnetite (Vroman 1938). There are old mines near Ikzim on Mount Carmel (Forbes 1972). Deposits of raw iron are found at Wādī al-Fāri`a, Warda, Ğabal al-Manāra and Wādī Samun (Denk 1990). Also iron is found between the Dead Sea and the coast of the Mediterranean Sea (Roaf 1990).

Jordan

In Wadi Araba (no. 123) is copper mineralization with 1,5% Fe_2O_3 in it. In other parts there is even less % iron oxides. That is to small to be useful for this research. In the Dolomite-Limestone-Shale formation is a manganese ore of 3m. thick. It contains among others haematite and goethite. The Fe-contents of that ore is between 6,13% and 16,3%. The natural resources authority separates the Mn, Cu and Fe in the area for industrial use (Bender 1974). About 35 km NNW of Amman, about 7 km West of the village Burma (no. 124), in the Southern Ajlun District is according to Bender the only iron ore deposit of Jordan which offers certain, limited possibilities for exploitation situated. It was massive iron ore. They mined it in the time of the crusaders. The ore body is about 300 m long, 200 m wide and 0.80 to 9.80 m thick. The main components of the ore are Compact, hard, and dense aggregates of haematite, and limonite which is here an unconsolidated, earthy mass. Rare are calcite, quartz and chalcedony. The average Fe2O3-content is 67% (Bender 1974b).

Lebanon
There are a few deposits of limonite and weathered haematite near Nahr el Kelb (no. 125) and Beyrout. They may have been worked in Antiquity. There are also a few deposits near the sources of the river Jordan. There are old mines near Merdjiba (Nahr el Kelb), but we don`t know how old they are (Forbes 1972). A few iron mines were located between Byblos and the Sea of Galilee (6) (Sasson et al. 1995).

3.7 Egypt

Magnetite is quite common in the mountains of Egypt (Forbes 1972). There are iron-ore deposits in East Aswan (no. 127), in the Eastern Desert, at the Bahariya Oasis (49), in the Western Desert, and in several locations in the Eastern Desert near the Red Sea coast (Nakhla and Shehata 1967). An overview map of Egypt with natural occurring iron oxides is presented in figure 27. A more detailed map of Southern Egypt en Sudan is shown in figure 28.

The Aswan Iron ore deposits (127) consist of two parts. The first is a band of 32 to 40 cm thick and the second consist of 1, 2 or 3 bands of 28cm. to 1.48m. The bands lie in the Nubian Sandstone Formation. In the sandstone are sometimes particles of haematite, goethite or magnetite found. The iron ores of East Aswan consist among other things of cryptocrystalline hydrated haematite (turgite) ($Fe_2O_3 \cdot nH_2O$), that is the mineral in the oolites and in the matrix, microcrystalline haematite, which does occur more in the matrix, goethite and hydrogoethite and less in the oolites. Oolites form the greater part of the East Aswan iron ores. The shell of the oolite contains the most iron. The core is mostly composed of quartz (Nakhla and Shehata 1967).

The iron ore deposits of the Bahariya Oasis (no. 49) in the Western Desert occur in the form of beds which are capped with a band of goethite of 1 to 15 cm thick. The deposit at Gebel Ghorabi are 6.30 to 10.60 m thick in average. The deposit consist of hard goethite and manganiferous haematite or conglomerate and pisolitic en oolitic goethite. In the El-Heiz area has the deposit the form of ochre. The hard goethite is sometimes transformed to haematite, especially at the boundaries between quartz and goethite (Nakhla and Shehata 1967).

The banded iron ore deposits in the Eastern desert are mainly composed of magnetite, specular haematite and a bit goethite and martite. The iron ores of the Um-Ghamis El-Zarqa Area consist of lamellae of magnetite, quartz and/or jaspar. Aggregates of magnetite can form. There is much martite in it and there are also a few grains of goethite. The iron-ore of the Um-Shaddad Area consist of 5 main bands and several smaller bands. There is more aggregation of the magnetite than with the Um-Ghamis ore, but less martite. The iron-ore of Wadi El-Dabbah area is much less massive and it is composed of very fine ferruginious material. The iron-ores of the Wadi Kareim Area contains aggregates of magnetite and sometimes octahedral crystals. There is martite and particles of specular haematite in it. In the iron-ores of the Gebel El-Hadeed area are two types of ores. The first one contains well developed magnetite crystals and martitization at the border and cleavage planes. The second contains small martitized magnetite crystals in a groundmass of silica and ferruginous material (Nakhla and Shehata 1967). In a tin section study of peridotites found along the qift-quseir road in the Eastern desert in Egypt, the most common ore minerals in the medium-grained variety were magnetite, titomagnetite and chromite. Also ilmenite, pyrite, rutile and goethite do occur. In a tin section of normal gabbros there was found ilmenite, titanomagnetite, rutile and a bit of haematite. Pyrite crystals have partially been changed to goethite and lepidocrosite (Nasseef et al. 1980).

Oolitic haematite deposits are found along the Nile valley at Kalabsha’(no. 128), Garf Hussein (129), Kurusko (130), Abu Simbil (131) and other locations (Said 1962). Haematite is found in Wadi Baba (132)and other valleys in the Sinai, also in Wadi Dib (134), on the road to Qosier near Abu Gerida, near Ranga (near Ras Benas (133)). The haematite near Ranga is titaniferous. Between Assuan and Shellal (136) is magnetite. The alluvial Nilesand contains magnetite. In Wadi Marwat and in the oases of the Western desert is limonite. There are exhausted iron-mines in Wadi Hammamat. There were iron mines in Meroë (Forbes 1972). Iron deposits occur near Qaşr al Farafirah (137) and Aswan (Derry 1980).

Sudan

In the Northern Red Sea hills of Sudan hydrothermal deposits of magnetite-haematite are present. The mineralization have the form of dipping lenses. They are up to a few hundred metres long. They occur in greenschist assemblage rocks. It are small bodies and the exploitation that is taking place there is small in scale. There are iron ore deposits South South-West of Halaib (Vail 1979). Near Wadi Halfa (no. 135) are banks of oolitic ironstone (Forbes 1972).

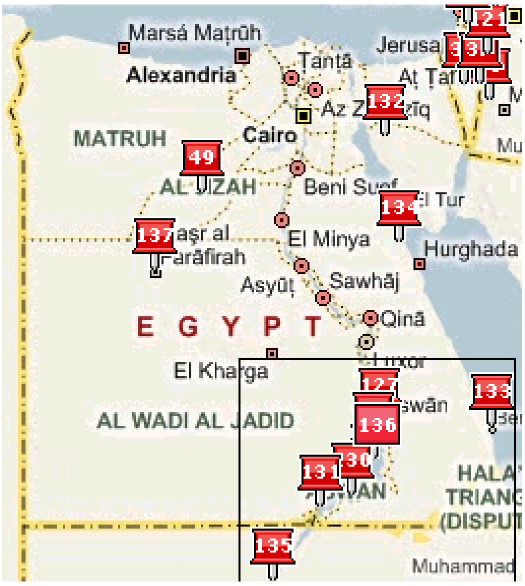

Fig. 27: Overview map of Egypt with natural occurrences of iron oxides. The black square refers to the map of figure 28.

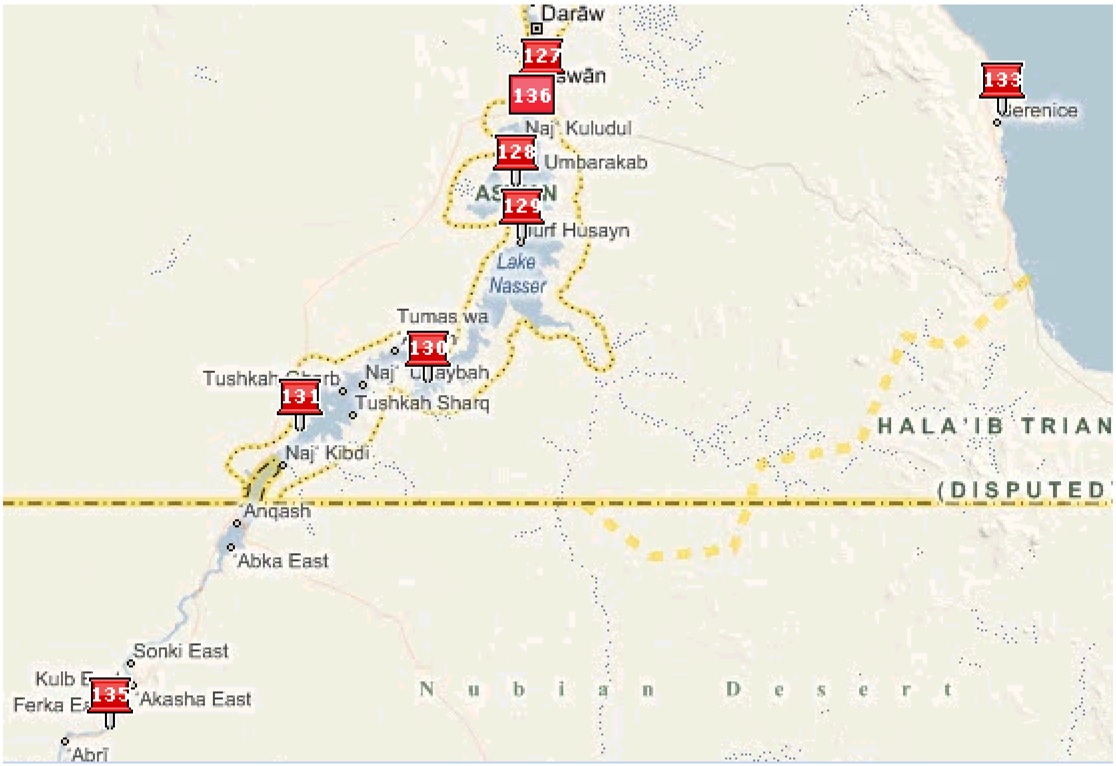

Fig. 28: Detailed map of Southern Egypt with natural occurrences of iron oxide on it.

3.8 Arabian Desert

Fig. 29: Map of Saudi Arabia and Yemen with natural occurrences of iron oxides on it.

In figure 29 are the natural occurrences of iron oxide found in Saudi Arabia and Yemen presented.

Saudi Arabia

Fe-Ti deposits are found in layered gabbros, for example the ilmenite-magnetite deposits of the Wadi Hayyan gabbros in Saudi Arabia (Al-Shantiand and Roobol 1979). In Wadi Wassat and Wadi Qatan is a gossan of haematite and goethite, which is formed by the continued oxidation of the material which lays under it (pyrite-pyrrhotite) (El-Shatoury and Al-Eryani 1979). At Wadi Wassat, Wadi Qatan, North of Yanbu at Bahr (no. 138), South of Mahd adh Dhahab (139), South of Nuqrah and South of Khnaiguiyah is Fe-Ti-pyrite (Rye et al. 1979). At Nuqrah there can also be found traces of magnetite and ilmentite. At Mahd adh Dhahab there can also be found traces of magnetite and and haematite (Sabir 1979). Magnetite and haematite occur in Khaiguiyah in the Halaban Group (Rye et al. 1979). At Jabal Sayid in the Hulayfah (Halaban) Group, there can be found e.g. magnetite as a massive deposit (Sabir 1979). According to research at samples at Maha adh Dhahab the total of Fe (Fe_2O_3) ranges from 2.96 to 25.76. The FeO ranges from 0.07 to 3.87 and the FeO/Fe2O3 from 0.006 to 0.63 (Hakim 1980). In Khnaiguiyah the Fe mineralization consist of crystallised haematite, magnetite and pyrite and commonly muschketovite, which is a replacement of haematite by magnetite. There is a magnetite band of about 10 to 20 m thick, 70 m wide and 240 m long (Testard et al. 1980). In the radioactive pegmatitic zone at Jabal Sayid haematite is found in all rock types. It occurs mostly as fine, metallic black grains (Turkistany and Koyama 1980). In Midian are many deposits of haematite and magnetite (Forbes 1972). Fe deposits occur near Tayma` (no. 140) and between Jidda and Mecca (141). Fe mineralizations is being formed today in the red sea (142) (Derry 1980). Deposits of raw iron are found at Bilād Bāqim (143), Ğabal Nuqum, Wādī l-Hādina and al-Qani` (Denk 1990).

Yemen

In Sa`ada (no. 144) in Yemen and probably in other locations around that place is the same type deposit as in Wadi Wassat and Wadi Qatan in Saudi Arabia, a gossan of haematite and goethite (El-Shatoury, Al-Eryani 1979). There are iron ore deposits near Usala and Sana (145) (Forbes 1972).

3.9 Caucasia and Transcaucasia

Iron ores are found in Caucasia (no. 51) and Transcaucasia (Moorey 1994). The locations of the ores are presented on figure 30. The iron deposits are rich in Caucasia, Transcaucasia and Armenia. In Kuban on the banks of the Kotscharka river are 30 m. thick magnetite strata, which contains 62 to 68 % iron. They were worked from the Persian period. There is haematite near Damyrtash, on the river Bolnis (no. 147), near Tamblut an Tshatash (146), near Sizimadini and along the Dyblaki pass near Miskan. The haematite found in the valley of the Bojan and near Elisavetpol (148) is very pure. In the Eastern Karabagh district are magnetite and ilmenite found. Near Talori and Karadagh are iron pyrites

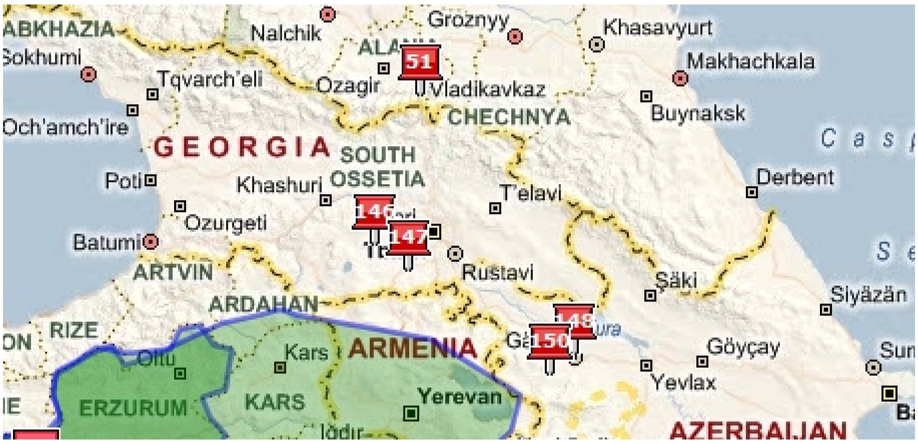

Fig. 30: Map of Caucasia and Transcaucasia with natural occurrences of iron oxides on it.

and other iron ores found. Other iron ore outcrops are found near Lake Urmia (149) and North of Tabriz, smaller outcrops occur in the Tiyari mountains and near Chorsabad. Magnetite is quite common in the mountains of Armenia (Forbes 1972). Deposits of raw iron are found in Daškesan (150) (Denk 1990).

3.10 Cyprus

Iron ores are available in Cyprus (Moorey 1994) (fig. 31). Umber, a clay pigment which contains iron oxide, comes for example from Cyprus (Hradil et al. 2003). In Soli, Paphos (no. 151) and Tamassos are also iron ore deposits. The deposits are mainly haematite and limonite. Traces of ancient mines appear (Forbes 1972). Magnetite is found at Skouriotissa (170) (www.mindat.org/).

Fig. 31: Map of Cyprus with natural occurrences of iron oxide on it.

3.11 Greece

Iron ore deposits are found on Samothrakè (no. 152), Rhodes (153), Cos (154) (Forbes 1972), Ormylia (155), Andros (156), Kéa/Keos (157) and Moutoula (Denk 1990). At the island Serifos (167) are goethite and aggregates of haematite found (www.mindat.org/). Haematite quartzites occur on the island of Kythnos (between 157 and 167). They have been formed under oceanic hydrothermal activity (Chrysanthaki and Baltatzis 2003). The locations of the deposits are shown on figure 32.

Fig. 32: Map of Greece with natural occurrences of iron oxide on it.

3.12 Conclusion

In this chapter are 357 locations are described which are potential iron oxide sources. Most potential sources were found in Anatolia and Persia. Unfortunately not a lot information was found about the material that was found in the individual locations. In the next chapters we will define which locations remain as being potential iron oxide sources when the material and logistic factors of these locations are considered.

Chapter 4: Suitability and attainability of iron oxides for making artefacts

4.1 Introduction

To pinpoint the locations which possibly could have been in use as an iron oxide source in the past, one has to consider both the material properties of the ore and of their occurrences.

For example cylinder seals, beads and weights were made of iron oxides. To make artefacts, the material has to be hard enough and compact enough to carve it. The material has to be homogeneous, since inclusions what could seriously affect the workability of the material. The stone has to be big enough to make an artefact from it. The average height of a cylinder seals is 2,5 cm and the average diameter is 1,5 cm (Roaf 1990). Therefore the material has to be slightly bigger than this size, because also the loss of material while making the object has to be accounted for.

For the locations the logistic factors should be considered. To transport the material to Mesopotamia, the location must not be too far away. If for example a mountains range is between the location and Mesopotamia, it is much harder to reach it. If there was a trade transporting way between that location and Mesopotamia, it was much easier to transport the material. You should also consider politic strategic factors. If the region where the location is in and Mesopotamia or two regions between that were in war, trade may have been severely affected. Also you have to discern between nowadays mines and ancient mines especially from the Old Babylonian Period, because this research tries to locate potential sources from that period. Many routes were not located in the past, I have written down the routes I found in the literature. An inventory of major trade routes of the Old Babylonian Period and some centuries before was made. It is clear that the routes continue to be in use during long periods of time.

For most locations detailed information on the composition of the deposit is lacking. It is unclear how the material formed and whether it has been found among magmatic, metamorphic or sedimentary rocks. However since they still may contain haematite, goethite or magnetite these locations could not be rejected. Haematite and magnetite are the two most frequent occurring iron ores, goethite is also an important one (Wenk and Bulakh 2006), so if it is stated in an article that iron ore was found in an area, there is a reasonable change that the deposit contains haematite, goethite or magnetite. Locations that had material that was certainly good enough for making artefacts or locations that didn't have enough information to determine whether artefacts can be made artefacts of the material or not are in chapter five. The numbers in italics refer to the trades routes of the maps of figure 34 and 35 in this chapter.

4.2 Material Properties

In the introduction several properties have been mentioned that make the iron stone suitable for making the artefacts. The properties are the size of the material, the compactness, the hardness and the homogeneity. These properties are defined by the geological genesis of the material. In this paragraph will be discussed which rocks that contain haematite, goethite and magnetite are unsuitable for making artefacts.
For making an artefact the haematite has to be stable, so this process must have taken place. Haematite that has been formed in magmatic rocks can reach a stable phase by decomposition of titanomagnetites by exsolution. Formation of haematite by exsolving of Ti-haematite or titanomagnetites can only occur during formation of magmatic rock at a low temperature (Cornell and Schwertmann 2003). Haematite can only be formed in magmatic rocks when they are formed at a low temperature. Magnetite also occurs in magmatic rocks.
Magnetite, ilmenite and haematite are the main Fe-(Ti) oxides in metamorphic rock (Cornell and Schwertmann 2003). When the iron oxide layers are banded or broken they are unsuitable for the production of artefacts, since it is impossible to obtain blocks from it which are big enough. When

before the metamorphism the iron oxide content was high enough and through metamorphism the iron oxide was only compacted, it may yield suitable material to make an artefact from.
If in Red beds the sediment is well enough converted into rock, you probably can make artefacts of it. If it is not compacted into rock it is unsuitable. The haematite aggregates occur in other rock, the Red beds are not massive haematite (Cornell and Schwertmann 2003).
In Banded Iron Formations are the layers of haematite or magnetite only a millimetre thick (Cornell and Schwertmann 2003). That is to small to make artefacts from (Wenk and Bulakh 2006).
Ironstone is a hard sedimentary rock (Cornell and Schwertmann 2003). It can be so hard that blocks can be made of them, which can be used as construction material (Skinner et al. 2004). Probably also other artefacts can be made of it. However I am not sure whether ironstones which consist of oolitic iron oxides are suitable for making artefacts. They might consist of too small particles.
From iron oxide veins that are big enough can probably be made artefacts. The iron oxides in sands and soils are too small and incoherent to make an artefact from.

4.3 Logistic factors

The logistic factors that have to be considered are the employability of the ore, the difficulty of reaching it, political/strategic factors and the perception. Perception is what people in the past liked, so which material people wanted to have to make an artefact from. That is very difficult to determine, so it will not be discussed in this thesis.

Exploitability of the ore
One of the main factors that influences the exploitability of the ore in Antiquity is the depth from the surface. For most locations the only information that is available is that iron oxide was found in that location. Data about how deep it lays under the surface lack. For some locations it is stated that the ore was mined in ancient times, so possibly in the Old Babylonian period that ore could have been reached. When ore is found in modern mines the ore might not have been reachable in the past. With modern technology much deeper laying ores can be mined.

Geographical influences of reachability
- The environment

Mountain ranges highly effect transport. In the region under discussion mountain ranges run from the South of Persia to the West of Persia to the South of Anatolia. Other mountain ranges run from the South of Anatolia to the South, through Lebanon and along the border of Israel and Jordan (Roaf 1990) (fig. 33). South and South-East of Mesopotamia lie deserts, which are also difficult to travel through, because in the Old Babylonian period camels were not yet in use (Roaf 1990).

Fig. 33: Relief of the Middle-East (maps.google.com).

- Trade in general

In the Middle-East area transportation was done by boats and by animal caravans. Most places in Mesopotamia could be reached by the water (Roaf 1990). North-Eastern Mesopotamia and Northern Syria could be reached with the Euphrates and Assyria could be reached with the Tigris (Sasson et al. 1995). Parts of the Tigris could not be travelled, because the water flows to fast (Martine de Vries: personal communication). Ships couldn't go through the Euphrates Canyon across the Taurus. The most economical way to travel the rivers was by sailing downstream and returning by land. The ships were dismountable (Sasson et al. 1995). Ships were sailing the Gulf and the Mediterranean Sea. Donkeys and mules were the most used animals for transportation (Roaf 1990). Donkeys could walk on narrow mountain paths. Also oxen-drawn wagons, donkey-drawn light carts and pack donkeys were used. In Babylonia wagons were not often used, they were more important in the North in the Middle Euphrates region (Sasson et al. 1995).

Until the 20th century B.C. trade was centralized and ruled by the state, after that the trade was organised by wealthy citizens (Roaf 1990). Merchants usually travelled in caravans, because of safety reasons. When travelling through the desert or in mountains, they had to hire guides and armed escorts. So travelling through desert and in mountains was more difficult than for example travelling along a river (Sasson et al. 1995). But along rivers taxes had to be paid, so it was expensive to travel along the rivers (Martine de Vries: personal communication). The routes depended on locations of watering places, food supply, mountain passes and ferries. The rise of a new political centre could bend the routes (Sasson et al. 1995).

- Trade routes in the period before the Old Babylonian Period

Trade was done long before the Neolithic period. In the Neolithic period people used materials that came from more than 800 km from where they lived (Roaf 1990), but most information in this paragraph is from 4000-2000 BC. The trade routes from the period before the Old Babylonian Period can be seen on figure 34 and in more detail in figure 35.

Since the late 4th millennium B.C. the Sumerians went from Mesopotamia to Badakhshan (*no. 5*) in Afghanistan and back to obtain lapis lazuli (Sasson et al. 1995). Badakhshan could be reached by a Northern (*no. 14*) and a Southern route (*10*). Those two routes are connected with other routes (*no. 15, 20, 21*) (Roaf 1990). The Sumerians also went from Susa (*29*) to North-Western India to get carnelian (*route: no. 37*) (Sasson et al. 1995). Also ships were sailing through the Gulf to North-Western India (*19*) (Roaf 1990).

Nineveh (*31*) lay close to the river Tigris route (*4*) (Roaf 1990). From Nineveh routes led to the Diyala valley (*38*) and and to Kermanshah (*40*) (Sasson et al. 1995). To the West and North-West were also routes (*no. 4, 45, 51*). Anatolia could be reached. From Mesopotamia Anatolia could also be reached by travelling along the Euphrates (*30*) (Roaf 1990, Sasson et al. 1995), but the Euphrates Canyon across the Taurus was impassable, so merchants had to go by land and take a road more to the East (*50*), which also led to Anatolia (Sasson et al. 1995).

The Levant could be reached by taking the route along the Euphrates (*no. 30*) and than going to the West to the coast. Different routes to the West led to various locations to the North or the South (*27, 23, 52*) (Roaf 1990, Sasson et al. 1995).

From the Mediterranean Sea the North of Egypt could be reached (*no. 28, 52*) (Roaf 1990, Sasson et al. 1995). From Damascus a route led to the South to the Red Sea (*27*) (Roaf 1990). So Egypt and the Red Sea area could be reached from Mesopotamia by travelling first to the North, than to the South and get around the desert.

Fig. 34: Overview trade routes before Old Babylonian Period. The numbers in italic belong to this map.

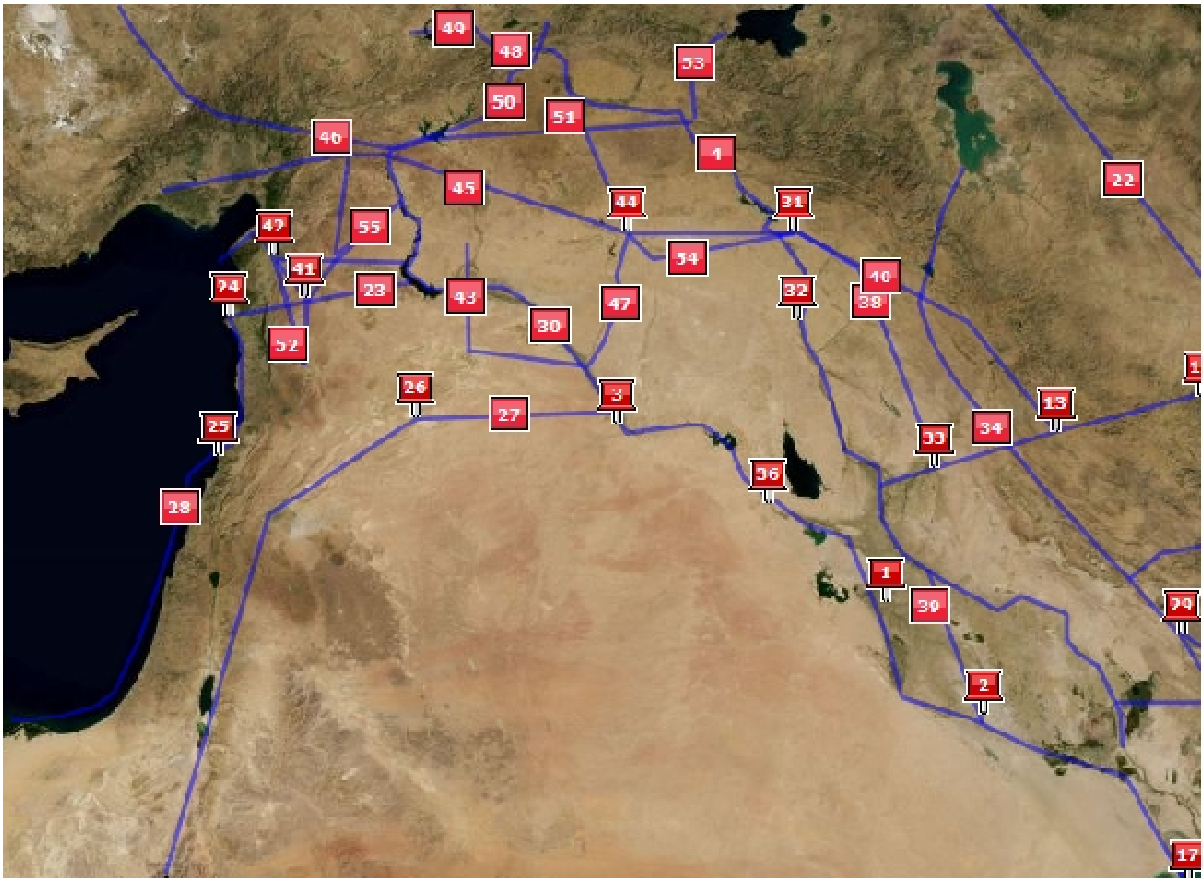

Fig. 35: Detail map trade routes before Old Babylonian Period. The numbers in italic belong to this map.

- Trade routes in the Old Babylonian Period

Merchants still traded between Mesopotamia and the Gulf. Through the Gulf was a maritime trade route, it went through the state of Dilmun, which included the islands of Failaka and Bahrain and the Eastern coast of Saudi Arabia, the state of Magan, which is Oman, and the state of Meluhha, which was located in the Indus valley. Another route was from Shusharra in the mountains at the East of Assyria to Iran and possibly Afghanistan. The Assyrians traded with Hattians, who lived in Anatolia, Hurrians and Indo-Europeans, for example Hittites and Luwians. It is suggested that Mesopotamia had trading links to the Far East (Roaf 1990).

Assyria and Anatolia traded with each other. Hurrians, who lived in Northern Mesopotamia and the regions at the East of the Tigris, traded with Assyrian merchants in Anatolia. An important trade route ran along the Tigris and passed the city of Ashur. The road from Ashur to Kanesh was a steep mountain pass through the Taurus mountains. Donkeys could travel there. Ashur traded with Kanesh between ca. 1880 and 1820 B.C. and between ca. 1800 and 1740 B.C.. Two routes were used to reach Kanesh from Ashur. The first route went first to the West and than to the North-West and passed the cities Urshu and Mamma. The second route went first to the North-West and than to the West and passed the cities Nikhriya (Diyarbakir) and Khakkhum (near Elâziğ) (Sasson et al. 1995). Kanesh was the centre of trade (Roaf 1990). From Kanesh started also major routes to the North and to the West (Sasson et al. 1995). Kanesh was an Assyrian merchant colony. The Assyrian merchants lived in the merchant suburb with merchants from other cities in Mesopotamia and Anatolia. Other important Assyrian trade centres were in Hattusas (Boghazkoy), Alishar (possibly Ankuwa), and Acemhuyuk (possibly Purukshanda (Roaf 1990), Burushkattum, near Aksaray). Also in Nikhriya (Diyarbakir), Khakkhum (near Elâziğ), Urshu, Khurama and Mamma trading colonies were established (Sasson et al. 1995). The Assyrian trade routes can be seen on figure 36.

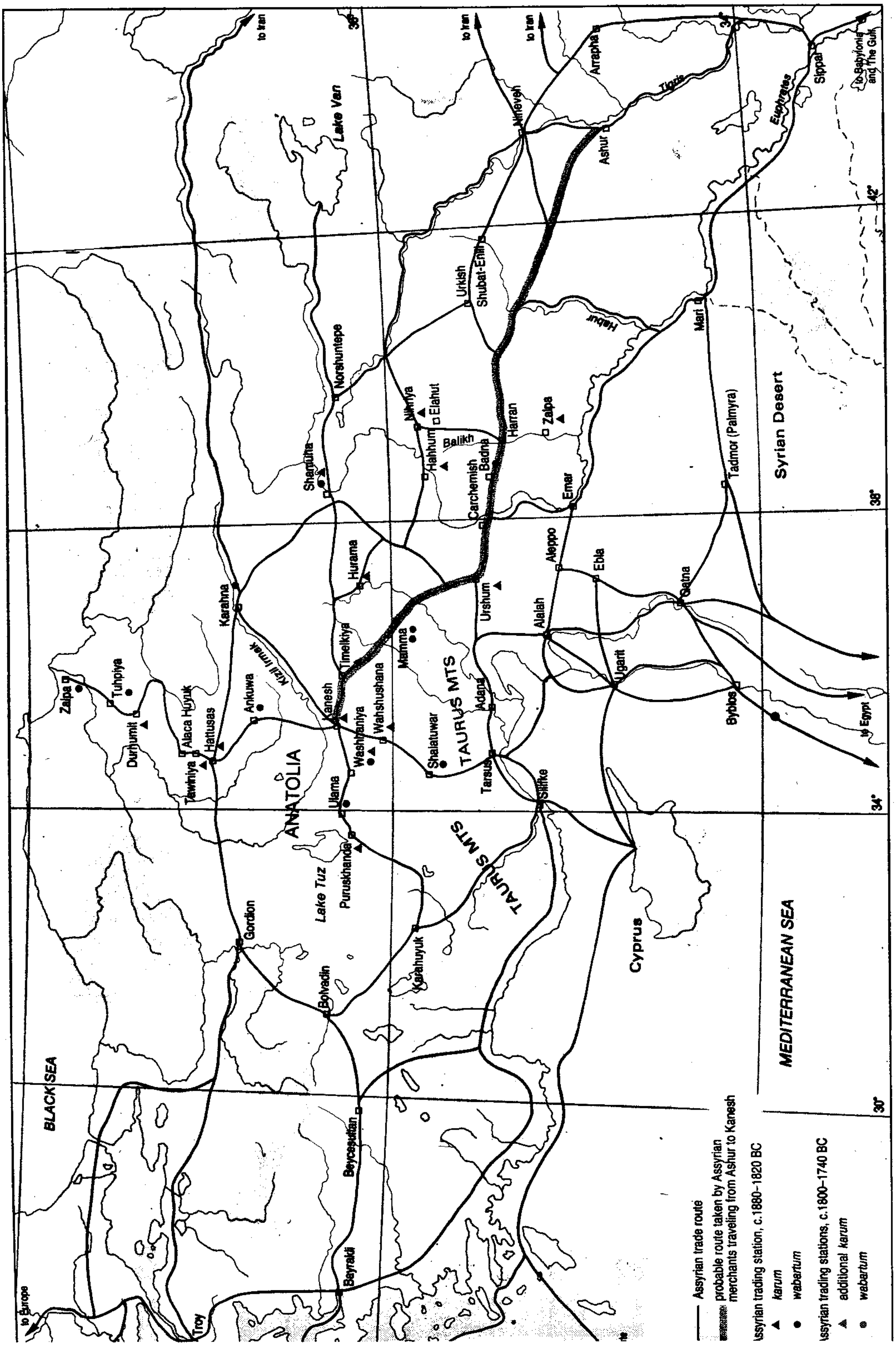

Fig. 36: Map of Assyrian trade routes (Roaf 1990).

Also another trade route ran between Elam and Mari and then to the West. Near Mari was a trade route along the Euphrates. The cities Megiddo, Quatna, Ugarit and Byblos in the Levant had contact with Egypt. In the beginning of the 17th century B.C. North Egypt was ruled by the Hyksos, who had contact with the inhabitants of Palestine (Roaf 1990).

Politic Strategic factors
During the first two two centuries of the Old Babylonian period two big dynasties lived in Mesopotamia: Isin and Larsa. They were rivals of each other, which probably had an influence in trade. So at the borders of Mesopotamia the situation was fairly unstable. Gungunum, the king of Larsa between 1932 and 1906 B.C., gained control over the trade with the Gulf and dictating any trade from Isin to the Gulf (Roaf 1990). So because Larsa was the rival of Isin, Isin could probably not trade with the Gulf. Shamshi-Adad (ca. 1813-1781 B.C.) ruled the area from the Euphrates to the Zagros mountain range (Roaf 1990). In the middle of the 18th century B.C. a foreign prince began to rule over Assyria, in Anatolia a new centralization was occurring and a new state was formed in Babylonia by Hammurabi. All the access to goods was cut off to the Assyrian merchants and the Old Assyrian trading system collapsed (Sasson et al. 1995). In 1763 B.C. Hammurabi conquered Larsa. In 1761 B.C. he conquered Mari and in 1757 he destroyed it. The cities Mari, Tuttul, Ashur, Nineveh, Ur, Eridu and Girsu were all his allies (Roaf 1990). Hammurabi wanted to control the city Id (modern Hit), because it had famous bitumen wells, which were important for building ships (Sasson et al. 1995). In 1739 B.C. an economical crisis occurred in Southern Mesopotamia, probably caused by Rim-Sin II of Larsa, who in 1742 B.C. occupied Nippur in the South. In 1737 B.C. Rim-Sin was defeated. In 1740 B.C. the city Ur was destroyed. (Roaf 1990).
Usually trees were brought from Mount Amanus (modern Nur range) to Mari and Babylonia. Shamshi-Adad I (1813-1791 BC) conquered Northern Syria and barred access to the Amanus, so merchants had to take another route. The wood was brought from the mountain range on the border of Lebanon and Syria, now the route was twice as long (Sasson et al. 1995).

Conclusion about the reachability of the locations
In the Old Babylonian Period Iran, Afghanistan, the North-Western India and the Gulf could be reached. No evidence was found they also reached the East of India. A lot of evidence was found about trade routes in Anatolia. It were Assyrian trade routes and it is said that in the middle of the 18th century B.C. the Assyrian trading system collapsed. So maybe after that Anatolia was much more difficult to reach, but before that a lot of trade happened between Mesopotamia and Anatolia. The Levant could be reached. The coast of Egypt could be reached via the Levant. Probably people could also obtain material from the South of Egypt, at least Egyptians themselves could trade along the Nile. Cyprus and Greece could be reached via Anatolia, via the Assyrian trade routes. The Red Sea could have been reached before the Old Babylonian Period, so probably also during it. And because people could go to the Red Sea they also could go to the cities around it. No evidence is found about trade between Mesopotamia and the Caucasus, the area around the Caspian Sea and Northern Pakistan.

Now the material properties and logistic factors of the locations found in chapter three will be considered. Only the locations that are not suitable for making artefacts are mentioned in the paragraphs below. The locations are ordered on the same regions as in chapter three.

4.4 Mesopotamia

The iron mines in the Wadi Hassainiyat, North-East of Rutba (no. 56), in Western Iraq probably were not exploited in antiquity, because they lie in a desert and no evidence of trade routes to it is found. The other locations could be reached. Information about material found in the other locations is unavailable.

4.5 Persia

Iran
I think all location in Iran could have been reached. Not all locations are exact of the trade routes, but the trade routes are roughly drawn and the iron oxides could have reached the merchants which traded along the trade routes by trade in Persia itself. The two biggest routes through Persia are route *10, 14* and *37* on figure 34 and 35. They lead from the West to the East of Iran. The routes *16, 20, 21, 22, 34* and *35* are routes in Iran which are connected to the main routes mentioned before.

Remains of early iron working have been found at the plain of Persepolis and between Kerman (no. 70) and Shiraz (71), but that doesn't necessarily say that there is also an iron mine at that place. The iron could also have been transported to these locations, so we don't consider them as potential iron oxide sources.
In the Mamoniyeh mine (197) in the Markazi province (173) is the ore purity grade only 2%. That is too little.

Afghanistan
Trade routes existed to Eastern Afghanistan, so probably every location in Afghanistan could have been reached. The two biggest routes are again route *10* and *14* (fig. 34 and 35), which lead from Mesopotamia through Iran to Badakhshan in North-Eastern Afghanistan. Route *15* connects route *10* and *14* and lays in Western Afghanistan.

Turkmenistan
Khwarizn (81) in Turkmenistan are probably too far to reach. No trade routes are found leading to Turkmenistan.

Persian Gulf
Trade routes ran from Mesopotamia through the Persian Gulf to India (*route no. 19*), so locations in the Gulf area were easy to reach.

Red ochre isn't suitable for making artefacts, but also other iron ores have been found at the islands of the Gulf.

4.6 Pakistan and India

Trade routes existed to Western India (*routes 19 and 37*). Alchori in the Baltistan province (no. 168) in North-Eastern Pakistan was probably not reached, because no evidence was found that the trade routes were going further than Eastern Afghanistan and the area lays high in the mountains, so is probably difficult to reach. Also the Singhbhum Granite massif in North Orissa (53) and South Bihar (54) in Eastern India is probably too far to reach.

The soft haematites of Jauli in India are too soft to use for making artefacts.

4.7 Anatolia

All locations could have been reached, especially because of the Assyrian trade routes (fig. 36). These locations might have been more difficult to reach after the Old Assyrian trade system collapsed in the middle of the 18^{th} century B.C..

Near the settlement Ernis (28) was probably a small iron smithery. That will not necessarily say that also iron oxide was found there. So Ernis is not a potential iron oxide source. The same is valid for the iron-working centre near Germanicia North of Doliche (90) and Siliski, near Diurik (Dumbugh Dagh).
The sands of the Black Sea are too incoherent to make an artefact from, so the South-West of the Black Sea (20) can be rejected as a potential iron oxide source.

Umber, a clay pigment which contains iron oxide, is also not suitable.

4.8 Levant

All of the Levant can be reached, because a trade route is going from the Euphrates river to Damascus to the Red Sea (*route 27* on fig. 34 and 35) and an other route is going along the Levant on the Mediterranean Sea (*route 28*). On the map about the Assyrian trade routes (fig. 36) are also routes through the Levant presented.

The ochres in the el-Wad cave in Israel are not useful. The iron content of Wadi Araba (no. 123) in Jordan is too small to be useful.

4.9 Egypt

Trade routes are known from the Levant to the North coast of Egypt (*route 28* in fig. 34 and 35 and the map of fig. 36). Trade was also done along the Nile. Also a trade route ran from the Levant to the Red Sea (*route 27* on fig. 34 and 35). So also Wadi Dib (no. 134) and Ras Benas (133), which are lying at the Red Sea coast, could be reached. The Bahariya Oasis (49), in the Western Desert and the iron deposits near Qaşr al Farafirah (137) were much more difficult to reach than the locations along the Nile, because merchants had to travel through a desert. So people were probably not going to these locations to obtain haematite. People probably didn't obtain iron oxides from Sudan, because it was too far away.

The Aswan Iron ore deposits consist mostly of oolites with a quartz core. These oolites are not useful for making artefacts. So the most of the Aswan Iron ore deposits is not useful. When only grains of iron oxides occur in the Eastern desert, it is also not useful. The Nilesand is also not useful. I am not sure whether oolitic iron oxide is useful for making artefacts.

4.10 Arabian Desert

Mesopotamia could probably obtain the material from Saudi Arabia and Yemen, because the people who lived near those locations could transported the material to the Red Sea. The locations are not too far from the Red Sea. Trade routes existed from Mesopotamia to the Levant to the Red Sea (*route 27*).

The iron ore deposits found in gabbros in Wadi Hayyan are too small to make artefacts from. We are not looking for the Fe-Ti-pyrite found in Wadi Wassat, Wadi Qatan, North of Yanbu at Bahr (no. 138), South of Mahd adh Dhahab (139), South of Nuqrah and South of Khnaiguiyah. The traces of magnetite and haematite found in Nuqrah and Mahd adh Dhahad are probably also too small. In Jabal Sayid are only fine grains of haematite found. The iron mineralizations in the Red Sea is formed today, so maybe it was not there yet in the past, or not completely formed. And the people probably didn't know it was there, because it existed beneath the water and they couldn't obtain it from the bottom of the Red Sea.

4.11 Caucasia and Transcaucasia

Iron oxides were probably not obtained from this area. To reach this area you had to go through Anatolia, through mountain ranges which were difficult to pass. In Anatolia were also a lot of iron oxide sources, so they didn't had to go further to obtain iron oxide.

4.12 Cyprus

Cyprus could be reached through trade routes (fig. 36).

Umber was not useful.

4.13 Greece

Greece could be reached (fig. 36), although it was not very close by Mesopotamia and a lot of other countries had to be passed.

Chapter 5: The remaining potential useful iron oxide sources

5.1 Introduction

In this chapter are the locations described that can be made potential sources of haematite, goethite and magnetite of which can be made artefacts. This chapter is the result of the last chapter where the materials which were not suitable for making artefacts were rejected. The suitability of the material and the locations was determined by considering the properties of the material per locations and the logistic factors, which include the exploitability of the ore, the geographical reachability, politic-strategic factors and the perception.
Looking at the information that was found a lot of information is not available about the potential sources. That is why in this chapter an optimistic and pessimistic view are presented. The optimistic view include all the potential sources that are found in chapter three and are not rejected in chapter four. The materials from which is only known that they are some sort of iron or iron oxide are also included. It is a big change the material will be haematite, goethite or magnetite, because most iron ore is haematite, goethite and magnetite. In the pessimistic view are the iron and iron sources not presented, because it is also possible that they are not haematite, goethite or magnetite.
In the maps in this chapter (fig. 37 t/m 72) are the purple numbers haematite sources, the light green numbers are goethite sources, the black are magnetite sources, the yellow are iron oxide sources and the red numbers are iron sources of which is no further information available. Maps of both the optimistic and pessimistic view are presented.

5.2 Mesopotamia

Optimistic view

Material	Number	Name
Haematite	2	Hit
Iron	1	The Middle Euphrates
"	5	Bawari Valley
"	46	Khabur region
"	48	Damascus
"	-	Alexandria

Table 2: Optimistic view of occurrences of potential iron oxide sources in Mesopotamia.

Fig. 37: Map of Mesopotamia showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	2	Hit

Table 3: Pessimistic view of occurrences of potential iron oxide sources in Mesopotamia.

Fig. 38: Map of Mesopotamia showing potential sources of iron oxide occurrences according to the pessimistic view.

5.3 Persia

Iran and Afghanistan

Optimistic view

Material	Number	Name
Haematite	59	Khams ore body in East-Azerbaijan
"	189	Mohamad Abad iron ore body
"	174	Ab Pooneh mine in the city Fereydunshahr
"	67	Naisar in Esfahan
"	67	Kashan in Esfahan
"	71	Shiraz
"	184	Golali iron ore body in Hamedan
"	175	Baba Ali ore body at Shalah abad
"	193	Tang Zagh ore body near Haji Abad
"	187	Kanishireh ore body in Sonqor
"	173	Kuh-e-Pank mine in the Markazi province
"	173	Mine of Delijan in the Markazi province
"	63	On the foothills of Mount Demawend
"	68	Near Kohrud
"	64	The mine at Damghan
"	64	The Panjkuh mine near Damqan
"	198	The Chalu mine in the Semnān province
"	64	The mountains near Damghan
"	65	Semnān

"	66	Sharud
"	194	Zaboli
"	180	Iranshahr
"	62	Near Firuzhuh
"	61	In the mine of Chushalu in the Qazvin province
"	61	West of Teheran and near Kazwin
"	34	Yazd province
"	188	Kazab ore body
"	58	Chah Gaz iron ore body near Bafq
"	169	The Chadormalu mine 80 km of Ardakan city
"	58	Ore body North of Bafq
"	55	Shah Bolagh
"	4	Goljik mine
"	181	Gozlodre mine in the Zanjan province
"	50	Hosein Abad mine
"	181	Kuse Lor mine in the Zanjan province
"	181	Zakar mine in the Zanjan province
"	158	The Faryab (Fariab) province
"	162	The Ghazni province
"	163	The Uruzgan province
"	164	The Zinda Jan province
"	159	The Badg(h)is province
"	160	The Kandahar province
"	161	The Zabol province
"	163	The Uruzgan province
Goethite	189	Mohamad Abad iron ore body
"	71	Shiraz
"	187	Kanishireh ore body in Sonqor
"	196	Mine of Delijan
"	195	Shams Abad 1 mine near Arak
"	195	Gazal Dar mine near Arak
"	58	Chah Gaz iron ore body near Bafq
"	169	Ardakan
"	181	Morvarie mine in Zanjan province
Magnetite	59	Ali kandi Hashtrud in East-Azerbaijan
"	174	Ab Pooneh mine in Fereydunshahr
"	67	Niasar in Eshahan
"	67	Kashan
"	71	Shiraz
"	184	Golali iron ore body in Hamedan province
"	182	Chenar-e-Olya ore body in Asad Abad
"	185	The Hameh Kasi iron ore body
"	175	Baba Ali ore body and mine at Shaleh abad
"	193	Tang Zagh ore body near Haji Abad

"	186	Ravar
"	187	Kanishireh ore body near Sonqor
"	187	Khosru Abad ore body near Sonqor
"	68	Near Kohrud
"	65	Chalu mine, 12 km North of Semnān
"	64	Panjkuh mine near Damqan
"	188	Kazab ore body
"	58	Chah Gaz iron ore body near Bafq
"	169	Chadormalu mine, 80 km of Ardakan city
"	58	Ore body North of Bafq
"	181	Bonab in the Zanjan province
"	176	Argin mine in Abhar
"	4	Goljik mine
"	181	Gozlodre mine in the Zanjan province
"	50	Hosein Abad mine
"	181	Morvarie mine in the Zanjan province
"	192	Sorkh dizej
"	181	Zakar mine in the Zanjan province
"	74	Čoġart
"	172	The Herat province
"	159	The Badg(h)is province
"	160	The Kandahar province
"	161	The Zabol province
"	162	The Ghazni province
"	163	The Uruzgan province
Iron oxide	59	Zakleak Ahar mine in East-Azerbaijan
"	177	Balestan mine
"	177	Eskanderian mine in West-Azerbaijan
"	177	Safu mine in West-Azerbaijan
"	177	Qareh Baq Qalqachi mine in West-Azerbaijan
"	177	Qatur Ironstone mine of Shahindezh in West-Azerbaijan
"	71	Hanshak in the Fars province
"	71	Soleymanpor mine in the Fars province
"	78	Gardoysheh mine in the Gilan province
"	78	Garmab Dasht Rudsar mine in the Gilan province
"	73	Guri sheikh mine
"	70	Carmania
"	70	Cheshmeh Sefid mine in the Kerman province
"	70	Gazdaru mine in the Kerman province
"	190	Shahrak Bijar mine in Kordestan province
"	198	Hamirud mine in the Semnān province
"	198	Hashdeh Robai mine in the Semnān province
"	198	Lojneh1 mine in the Semnān province
"	198	Shomale Semnan mine in the Semnān province

"	198	Sheykhab mine in the Semnān province
"	191	Shvin near Zahedan
"	74	Čoġart
Iron	200	Muil in the Ardebil province
"	59	East of lake Urmia near Tabriz in the East-Azerbaijan province
"	177	West of lake Urmia in the West-Azerbaijan province
"	183	Darreh Mustan in the Esfahan province
"	183	Darreh Rahim in the Esfahan province
"	80	Tape Sialk
"	71	Ushan Piry Bavanat in the Fars province
"	178	Band-e-No Bavanat near Dehbed
"	72	Chorassan near Semendeh
"	71	Ilak in the Fars province
"	71	Kan Gohar mine in the Fars province
"	73	The mainland North of the Hormuz island in Hormuzgan province
"	179	Ahandan-e-Lahijan
"	78	Resht
"	70	Iron Golgohar sirjan mine in the Kerman region
"	70	Jalal Abad Zarand mine in the Kerman region
"	77	Reżāābād
"	69	Kuh-i-Benan region
"	60	Near Mashhad
"	3	Saheb
"	79	Šamsābād
"	198	In the Semnān province
"	74	Čoġart
"	75	Ĉādar malu
"	76	Northern Anomaly
"	52	Juwain
"	82	Herat
"	83	Bamian
"	86	Šiwa
"	-	Kōtal-e Hāğğigak in Afghanistan
"	85	Paġman
"	-	Haği-Alam in Afghanistan

Table 4: Optimistic view of occurrences of iron oxide sources in Iran and Afghanistan.

Fig. 39: Overview map of Iran showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 40: Map of the area South of the Caspian Sea showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 41: Detail map of Iran, of the locations in the provinces of Hamadan, Kermanshah, Kordestan and Zanjan, showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 42: Map of the Yazd province in Iran showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 43: Map of Central-West Iran showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 44: Map of Afghanistan showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 45: Detail map of Afghanistan showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	59	Khams ore body in East-Azerbaijan
"	189	Mohamad Abad iron ore body
"	174	Ab Pooneh mine in the city Fereydunshahr
"	67	Naisar in Esfahan
"	67	Kashan in Esfahan
"	71	Shiraz
"	184	Golali iron ore body in Hamedan
"	175	Baba Ali ore body at Shalah abad
"	193	Tang Zagh ore body near Haji Abad
"	187	Kanishireh ore body in Sonqor
"	173	Kuh-e-Pank mine in the Markazi province
"	173	Mine of Delijan in the Markazi province
"	63	On the foothills of Mount Demawend
"	68	Near Kohrud
"	64	The mine at Damghan
"	64	The Panjkuh mine near Damqan

"	198	The Chalu mine in the Semnān province
"	64	The mountains near Damghan
"	65	Semnān
"	66	Sharud
"	194	Zaboli
"	180	Iranshahr
"	62	Near Firuzhuh
"	61	In the mine of Chushalu in the Qazvin province
"	61	West of Teheran and near Kazwin
"	34	Yazd province
"	188	Kazab ore body
"	58	Chah Gaz iron ore body near Bafq
"	169	The Chadormalu mine 80 km of Ardakan city
"	58	Ore body North of Bafq
"	55	Shah Bolagh
"	4	Goljik mine
"	181	Gozlodre minein the Zanjan province
"	50	Hosein Abad mine
"	181	Kuse Lor mine in the Zanjan province
"	181	Zakar mine in the Zanjan province
"	158	The Faryab (Fariab) province
"	162	The Ghazni province
"	163	The Uruzgan province
"	164	The Zinda Jan province
"	159	The Badg(h)is province
"	160	The Kandahar province
"	161	The Zabol province
"	163	The Uruzgan province
Goethite	189	Mohamad Abad iron ore body
"	71	Shiraz
"	187	Kanishireh ore body in Sonqor
"	196	Mine of Delijan
"	195	Shams Abad 1 mine near Arak
"	195	Gazal Dar mine near Arak
"	58	Chah Gaz iron ore body near Bafq
"	169	Ardakan
"	181	Morvarie mine in Zanjan province
Magnetite	59	Ali kandi Hashtrud in East-Azerbaijan
"	174	Ab Pooneh mine in Fereydunshahr
"	67	Niasar in Eshahan
"	67	Kashan
"	71	Shiraz
"	184	Golali iron ore body in Hamedan province
"	182	Chenar-e-Olya ore body in Asad Abad

"	185	The Hameh Kasi iron ore body
"	175	Baba Ali ore body and mine at Shaleh abad
"	193	Tang Zagh ore body near Haji Abad
"	186	Ravar
"	187	Kanishireh ore body near Sonqor
"	187	Khosru Abad ore body near Sonqor
"	68	Near Kohrud
"	65	Chalu mine, 12 km North of Semnān
"	64	Panjkuh mine near Damqan
"	188	Kazab ore body
"	58	Chah Gaz iron ore body near Bafq
"	169	Chadormalu mine, 80 km of Ardakan city
"	58	Ore body North of Bafq
"	181	Bonab in the Zanjan province
"	176	Argin mine in Abhar
"	4	Goljik mine
"	181	Gozlodre mine in the Zanjan province
"	50	Hosein Abad mine
"	181	Morvarie mine in the Zanjan province
"	192	Sorkh dizej
"	181	Zakar mine in the Zanjan province
"	74	Čoġart
"	172	The Herat province
"	159	The Badg(h)is province
"	160	The Kandahar province
"	161	The Zabol province
"	162	The Ghazni province
"	163	The Uruzgan province

Table 5: Pessimistic view of occurrences of iron oxide sources in Iran and Afghanistan.

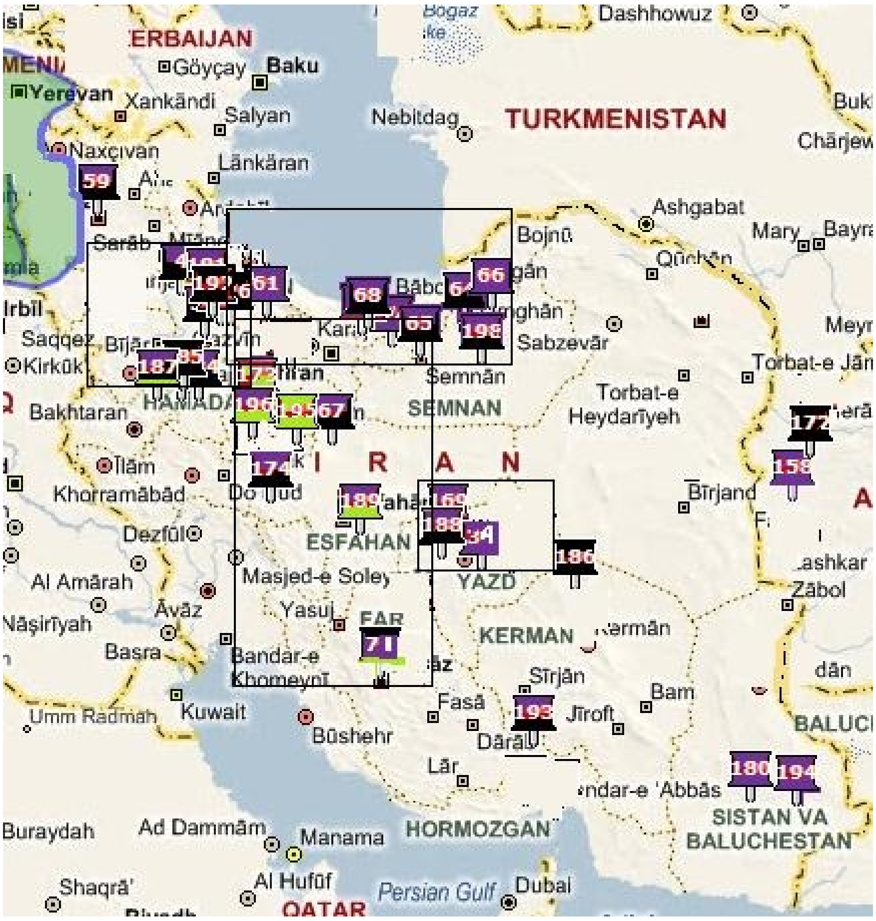

Fig. 46: Overview map of Iran showing potential sources of
iron oxide occurrences according to the pessimistic view.

Fig. 47: Map of the South Caspian area in Iran showing potential sources of
iron oxide occurrences according to the pessimistic view.

Fig. 48: Detail map of Iran, of the locations in the provinces of Hamadan, Kermanshah, Kordestan and Zanjan, showing potential sources of iron oxide occurrences according to the pessimistic view.

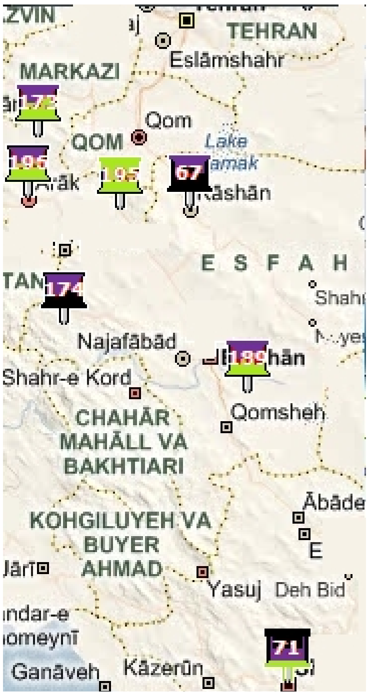

Fig. 49: Detail map of the Yazd province in Iran showing potential sources of iron oxide occurrences according to the pessimistic view.

Fig. 50: Map of Central-West Iran showing potential sources of iron oxide occurrences according to the pessimistic view.

Fig. 51: Map Afghanistan showing potential sources of iron oxide occurrences according to the pessimistic view.

Fig. 52: Detail map of Afghanistan showing potential sources of iron oxide occurrences according to the pessimistic view. This map is the same as the detail map of Afghanistan which shows the optimistic view about the occurrences.

Persian Gulf

Optimistic view

Material	Number	Name
Haematite	33	Hormuz island
"	166	Fanja in Oman
Goethite	166	Fanja in Oman
Magnetite	166	Fanja in Oman
Iron oxide	199	Larak island
Iron	-	Islands of the Persian Gulf

Table 6: Optimistic view of occurrences of iron oxide sources in the Persian Gulf.

Fig. 53: Map of the Persian Gulf showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	33	Hormuz island
"	166	Fanja in Oman
Goethite	166	Fanja in Oman
Magnetite	166	Fanja in Oman

Table 7: Pessimistic view of occurrences of iron oxide sources in the Persian Gulf.

Fig. 54: Map of the Persian Gulf showing potential sources of iron oxide occurrences according to the pessimistic view.

5.4 Pakistan and India

Optimistic view

Material	Number	Name
Haematite	-	Alexandria in Pakistan
"	84	Kohistan in Pakistan
Iron	87	Saindek in Pakistan
"	165	Khadivali quarry near Bombay in Western India

Table 8: Optimistic view of occurrences of iron oxide sources in Pakistan and India.

Fig. 55: Map of Pakistan and India showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	-	Alexandria in Pakistan
"	84	Kohistan in Pakistan

Table 9: Pessimistic view of occurrences of iron oxide sources in Pakistan and India.

Fig. 56: Map of Pakistan and India showing potential sources of iron oxide occurrences according to the pessimistic view.

5.5 Anatolia

Optimistic view

Material	Number	Name
Haematite	88	Nairi
"	25	Kestel
"	18	The central Taurus range between the Euphrates and the Cilician Gates
"	26	The Bolkardağ area
"	94	Cibyra
"	-	Phrygia Maior
"	95	Near Alaya
"	96	Near Silinti (Adana)
"	113	West of Feke in the Adana province (near Mansurlu)
Magnetite	26	The Bolkardağ area
"	92	Mons Ida
"	89	Near Magnesia
"	99	Near Amasia, Tokat and Sivas
Iron oxide	8	Urartu
"	19	The volcanic regions of Anatolia near the Upper Euphrates
"	24	Tura duri (Tiyari)
"	101	In the valleys of the Thermodon and Iris
Iron	29	The area of Bingöl, Tunceli, Elaziğ and Malatya
"	30	The area of Divriği, Erzincan, Erzurum

"	31	The area of Diyarbakir (Hani), Siirt, Bitlis, Van and Hakkari
"	-	Mines of Mağara Tepe (now called Pero-Tarlasi)
"	32	Mines of Balaban
"	9	Marash
"	10	Elazig region
"	11	Gurun area
"	12	Malatya area
"	13	Divriği deposits
"	14	Amanus region
"	16	Carchemisch
"	15	Tabal
"	17	In the anti-Taurus region and Que (Cilicea)
"	-	In the Taurus and anti-Taurus
"	91	Tiyari mountains
"	93	Bythinia
"	-	Caria near Latmus
"	-	Lycia
"	97	Amaxia
"	-	Jűnik Tepessi
"	98	Pontus and the neighbouring districts
"	-	Up to Kighi near Erzerum
"	100	West of Trapezus
"	102	On the lower slopes and foothills of the ranges between the modern Yešil yarmak up to Batum
"	103	Kuşşayiri
"	-	Altinoluk
"	104	Ayazmant
"	105	Hortuna
"	106	Sakarkaya
"	107	Şamli
"	-	Camdağ
"	108	Mellec
"	109	Bűyűkeceli
"	110	Kesikkőprũ
"	111	Celebi
"	-	Kősedag
"	112	Karamadazi
"	113	Mansurlu
"	114	Payas
"	-	Akdağ
"	-	Pinargőzű-Davutağlu
"	-	Uzunpinar
"	-	Karakalkar
"	115	Deveci/Hekimhan
"	13	Divriği/Cürek

"	116	Bizmişem
"	-	Aşvan
"	-	Avnik
"	117	Ertabil
"	118	Sart (Sardeis)
"	22	Gaziantep
"	21	In the area near the border of the provinces of Isparta and Konya
"	27	Near the coast at the South of Antalya
"	35	East and West of the Muğla coast
"	57	At the coastsof Çanakkale
"	126	At the coast of Bursa

Table 10: Optimistic view of occurrences of iron oxide sources in Anatolia.

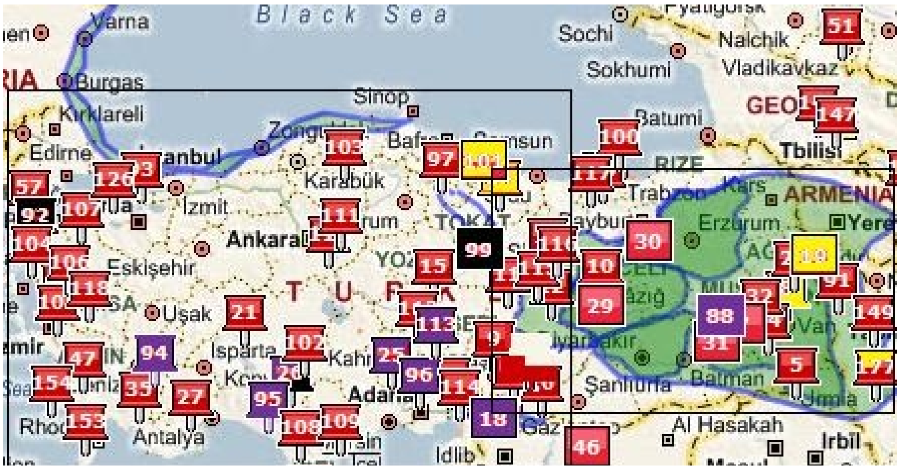

Fig. 57: Overview map of Anatolia showing potential sources of iron oxide occurrences according to the optimistic view.

Fig. 58: Map of Western Anatolia showing potential sources of iron oxide occurrences according to the optimistic view.

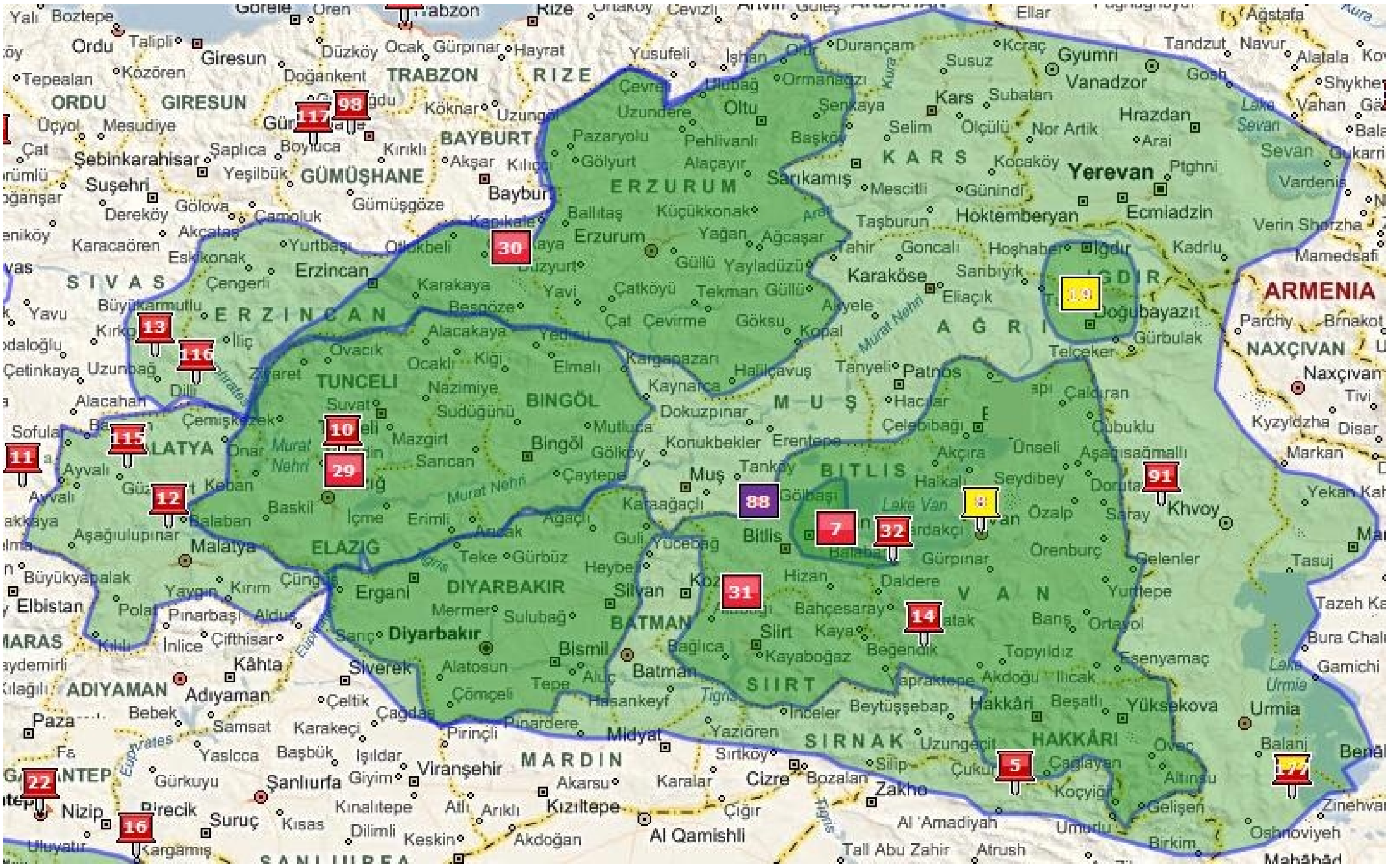

Fig. 59: Map of Eastern Anatolia showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	88	Nairi
"	25	Kestel
"	18	The central Taurus range between the Euphrates and the Cilician Gates
"	26	The Bolkardağ area
"	94	Cibyra
"	-	Phrygia Maior
"	95	Near Alaya
"	96	Near Silinti (Adana)
"	113	West of Feke in the Adana province (near Mansurlu)
Magnetite	26	The Bolkardağ area
"	92	Mons Ida
"	89	Near Magnesia
"	99	Near Amasia, Tokat and Sivas

Table 11: Pessimistic view of occurrences of iron oxide sources in Anatolia.

Fig. 60: Map of Anatolia showing potential sources of iron oxide occurrences according to the pessimistic view.

5.6 Levant

Optimistic view

Material	Number	Name
Haematite	36	Along the Ramon fault in Israel
"	124	About 35 km NNW of Amman, about 7 km West of the village Burma, in the Southern Ajlun District in Jordan.
"	125	Near Nahr el Kelb and Beyrout in Lebanon
"	-	Near the sources of the river Jordan in Lebanon
"	6	Between Byblos and the Sea of Galilee in Lebanon
Goethite	36	Along the Ramon fault in Israel
"	119	Qaliqilya Horst in Israel
"	120	Zur Natan Horst in Israel
"	121	En Boqeq in Israel
"	122	Latrun in Israel
Iron oxide	37	En Yahav in Israel
"	38	The Samarian mountains in Israel
"	39	Near el-Wad in the Mount Carmel area in Israel
"	41	Lower Nahal Meárot in Israel
"	40	Upper Nahal Meárot in Israel
"	42	Kerem Maharal
"	43	Ofer
"	44	Tavasim
"	-	Shefeya
"	45	Raqefet Valley
"	-	Ikzim on Mount Carmel
"	-	Wādī al-Fāri`a
"	-	Ǧabal al-Manāra
"	-	Wādī Samun
"	122	Between the Dead Sea coast and the Mediterranean Sea

Table 12: Optimistic view of occurrences of iron oxide sources in the Levant.

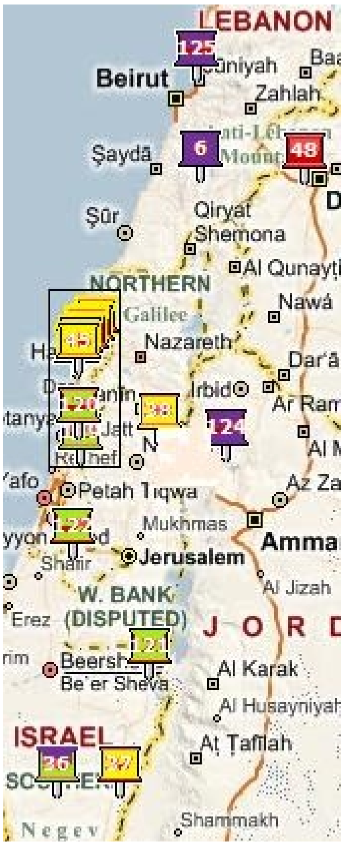

Fig. 61: Map of the Levant showing potential sources of iron oxide occurrences according to the optimistic view.

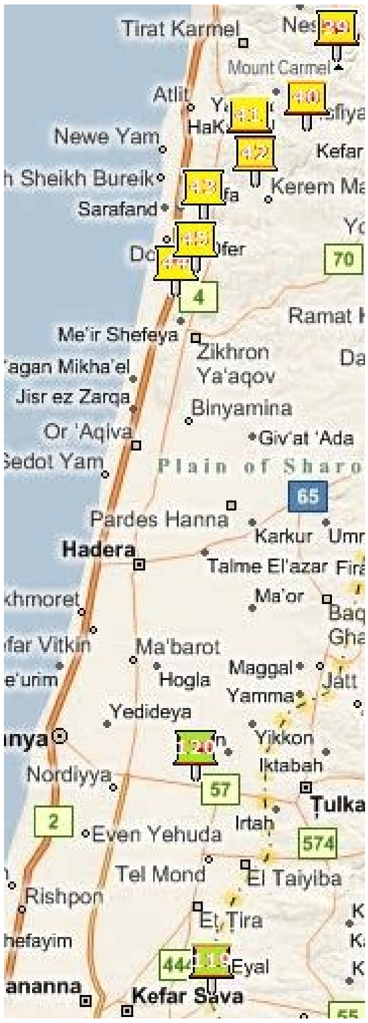

Fig. 62: Detail map of Northern Israel showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	36	Along the Ramon fault in Israel
"	124	About 35 km NNW of Amman, about 7 km West of the village Burma, in the Southern Ajlun District in Jordan.
"	125	Near Nahr el Kelb and Beyrout in Lebanon
"	-	Near the sources of the river Jordan in Lebanon
"	6	Between Byblos and the Sea of Galilee in Lebanon
Goethite	36	Along the Ramon fault in Israel
"	119	Qaliqilya Horst in Israel
"	120	Zur Natan Horst in Israel
"	121	En Boqeq in Israel
"	122	Latrun in Israel

Table 13: Pessimistic view of occurrences of iron oxide sources in the Levant.

Fig. 63: Map of the Levant showing potential sources of iron oxide occurrences according to the pessimistic view.

5.7 Egypt

Optimistic view

Material	Number	Name
Haematite	128	Along the Nile valley at Kalabsha'
"	129	Garf Hussein
"	130	Kurusko
"	131	Abu Simbil
"	132	Wadi Baba and other valleys in the Sinai
"	134	Wadi Dib
"	133	On the road to Qosier near Abu Gerida and near Ranga (near Ras Benas)
"	-	The Northern Red Sea hills of Sudan
Magnetite	-	Um-Ghamis El-Zarqa Area
"	-	Um-Shaddad Area
"	-	Wadi El-Dabbah area
"	-	Wadi Kareim Area
"	-	The Gebel El-Hadeed area in the Eastern desert
"	136	Between Assuan and Shellal
"	-	The Northern Red Sea hills of Sudan
Iron oxide	-	Wadi Marwat
"	-	In the oases of the Western desert

Table 14: Optimistic view of occurrences of iron oxide sources in Egypt.

Fig. 64: Map of Egypt showing potential sources of iron oxide occurrences.
The maps of the optimistic and the pessimistic view are the same.

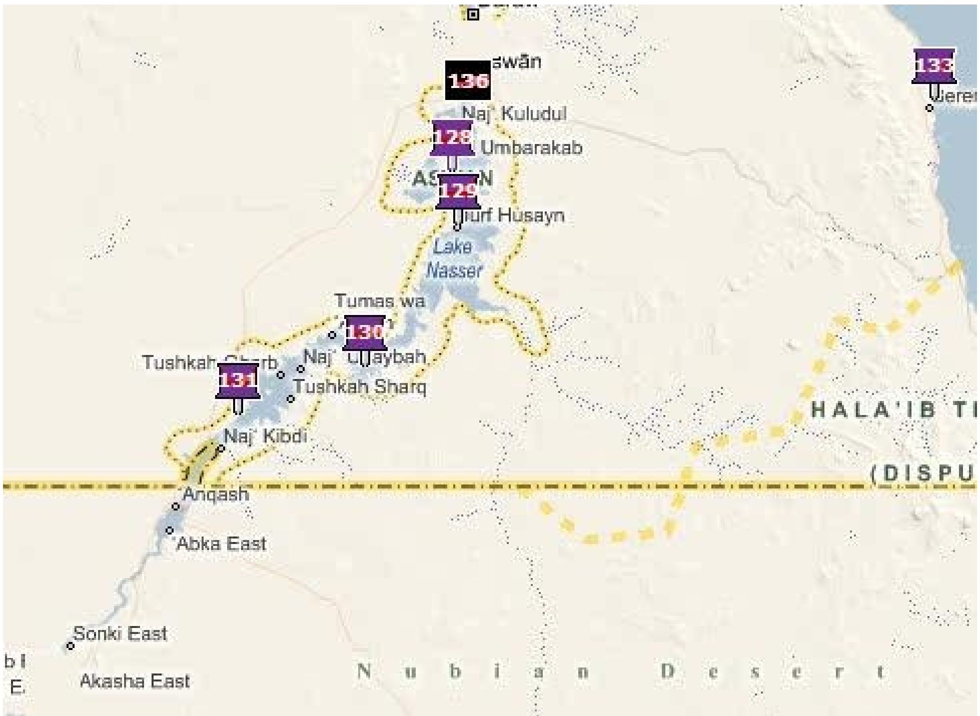

Fig. 65: Detail map of Pakistan and India showing potential sources of iron oxide.
The maps of the optimistic and the pessimistic views are the same.

Pessimistic view

Material	Number	Name
Haematite	128	Along the Nile valley at Kalabsha'
"	129	Garf Hussein
"	130	Kurusko
"	131	Abu Simbil
"	132	Wadi Baba and other valleys in the Sinai
"	134	Wadi Dib
"	133	On the road to Qosier near Abu Gerida and near Ranga (near Ras Benas)
"	-	The Northern Red Sea hills of Sudan

Magnetite	-	Um-Ghamis El-Zarqa Area
"	-	Um-Shaddad Area
"	-	Wadi El-Dabbah area
"	-	Wadi Kareim Area
"	-	The Gebel El-Hadeed area in the Eastern desert
"	136	Between Assuan and Shellal
"	-	The Northern Red Sea hills of Sudan

Table 15: Pessimistic view of occurrences of iron oxide sources in Egypt.

5.8 Arabian Desert

Optimistic view

Material	Number	Name
Haematite	-	Wadi Wassat in Saudi Arabia
"	-	Wadi Qatan in Saudi Arabia
"	-	Khaiguiyah in the Halaban Group in Saudi Arabia
"	-	Midian in Saudi Arabia
"	144	Sa'ada in Yemen
Goethite	-	Wadi Wassat in Saudi Arabia
"	-	Wadi Qatan in Saudi Arabia
"	144	Sa'ada in Yemen
Magnetite	-	Khaiguiyah in the Halaban Group in Saudi Arabia
"	-	Jabal Sayid in the Hulayfah (Halaban) Group in Saudi Arabia
"	-	Midian in Saudi Arabia
Iron	140	Tayma' in Saudi Arabia
"	141	Between Jidda and Mecca in Saudi Arabia
"	143	Bilād Bāqim in Saudi Arabia
"	-	Ǧabal Nuqum in Saudi Arabia
"	-	Wādī l-Hādina in Saudi Arabia
"	-	Al-Qani` in Saudi Arabia
"	-	Near Usala in Yemen
"	145	Near Sana in Yemen

Table 16: Optimistic view of occurrences of iron oxide sources in the Arabian Desert.

Fig. 66: Map of a part of Saudi Arabia and Yemen showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	-	Wadi Wassat in Saudi Arabia
"	-	Wadi Qatan in Saudi Arabia
"	-	Khaiguiyah in the Halaban Group in Saudi Arabia
"	-	Midian in Saudi Arabia
"	144	Sa'ada in Yemen
Goethite	-	Wadi Wassat in Saudi Arabia
"	-	Wadi Qatan in Saudi Arabia
"	144	Sa'ada in Yemen
Magnetite	-	Khaiguiyah in the Halaban Group in Saudi Arabia
"	-	Jabal Sayid in the Hulayfah (Halaban) Group in Saudi Arabia
"	-	Midian in Saudi Arabia

Table 17: Pessimistic view of occurrences of iron oxide sources in the Arabian Desert.

Fig. 67: Map of a part of the Arabian Desert showing potential sources of iron oxide occurrences according to the pessimistic view.

5.9 Cyprus

Optimistic and pessimistic view

Material	**Number**	**Name**
Haematite	-	Soli
"	151	Paphos
"	-	Tamassos
Magnetite	170	Skouriotissa

Table 18: Optimistic and pessimistic view of occurrences of iron oxide at Cyprus. The optimistic and pessimistic view are the same.

Fig. 68: Map of Cyprus showing potential sources of iron oxide occurrences. The maps of the optimistic and pessimistic views are the same.

5.10 Greece

Optimistic view

Material	Number	Name
Haematite	167	Serifos
"	157/167	Kythnos (between Serifos and Kéa/Keos)
Goethite	167	Serifos
Iron	152	Samothrakè
"	153	Rhodes
"	154	Cos
"	155	Ormylia
"	156	Andros
"	157	Kéa/Keos
"	-	Moutoula

Table 19: Optimistic view of occurrences of iron oxide sources in Greece.

Fig. 69: Map of Greece showing potential sources of iron oxide occurrences according to the optimistic view.

Pessimistic view

Material	Number	Name
Haematite	167	Serifos
"	157/167	Kythnos (between Serifos and Kéa/Keos)
Goethite	167	Serifos

Table 20: Pessimistic view of occurrences of iron oxide sources in Greece.

Fig. 70: Map of Greece showing potential sources of iron oxide occurrences according to the optimistic view.

5.11 Conclusion

In chapter three are 357 natural occurrences of iron oxide found. In the optimistic view are of these 357 locations 307 left. In the pessimistic view are only 148 locations left. In figure 71 the overview map of all the region can be seen through the optimistic view and in figure 72 the overview map can be seen through the pessimistic view.

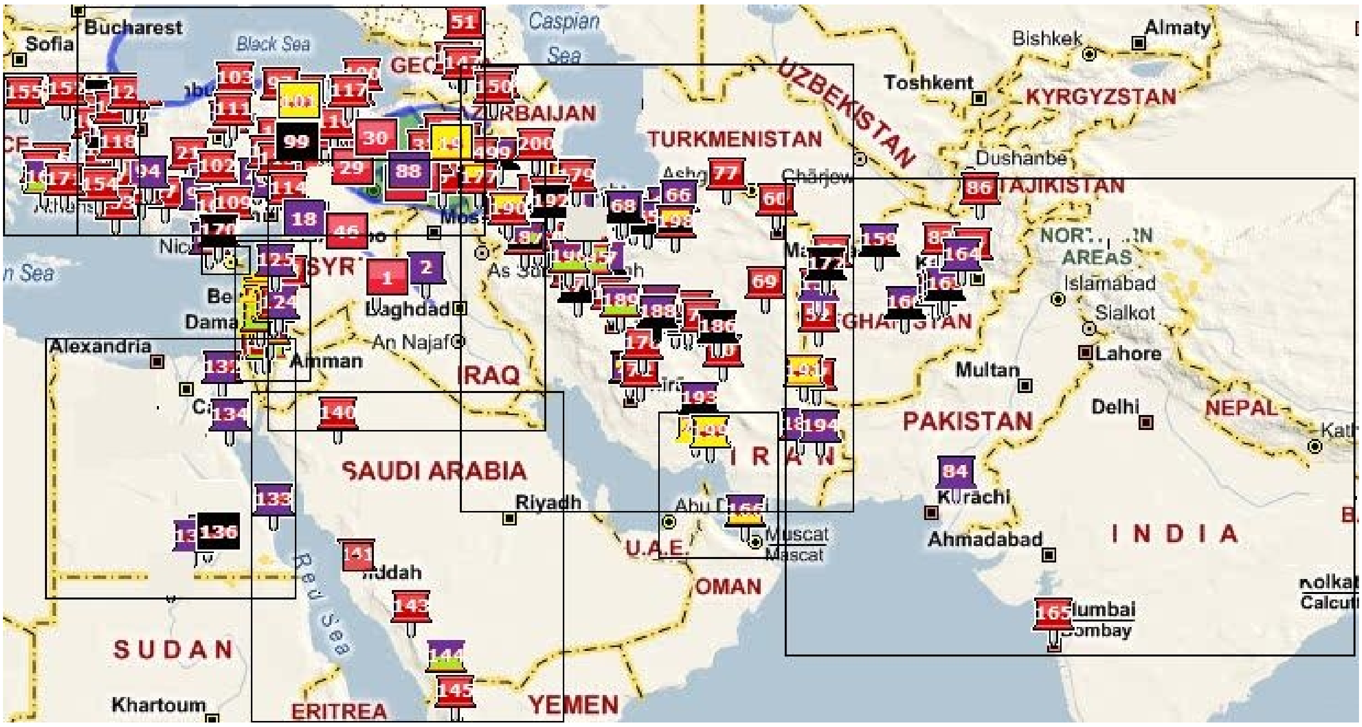

Fig. 71: Overview map of potential useful iron oxide sources according the optimistic view.

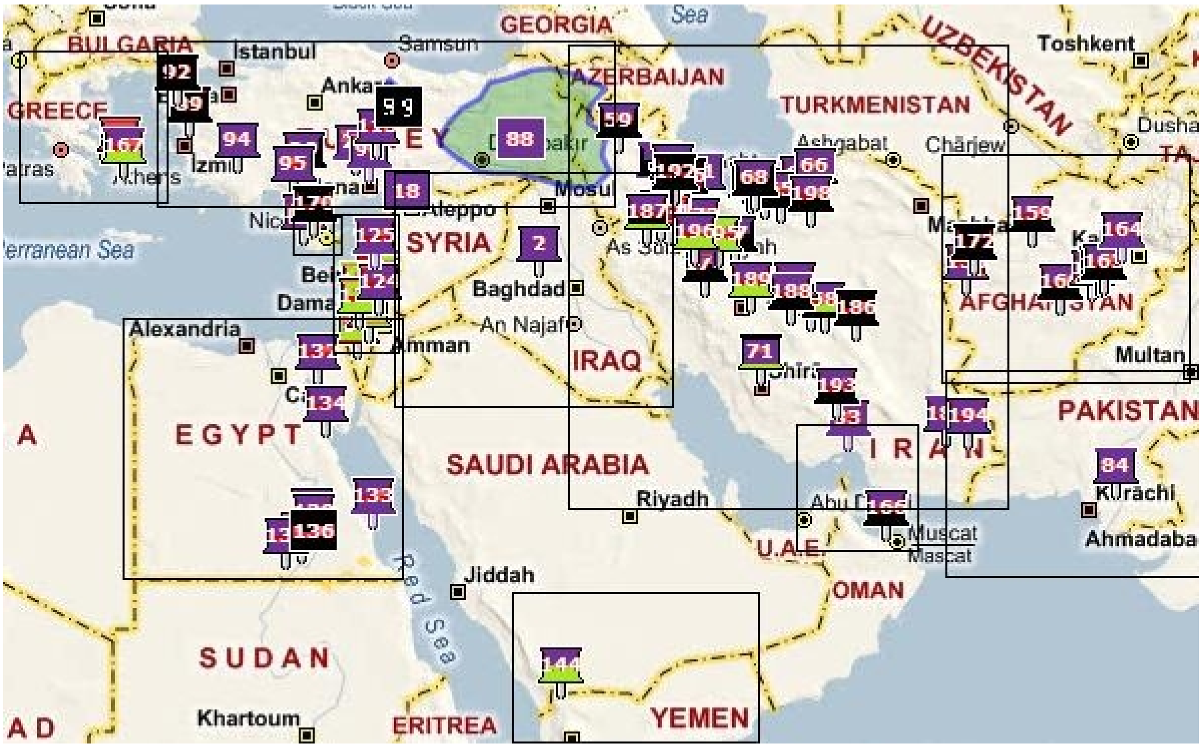

Fig. 72: Overview map of potential useful iron oxide sources according the pessimistic view.

As you can see in figure 72, goethite occurs mainly in the Levant, but also some goethite appears in Iran. Magnetite and haematite mostly occur together. No clear difference in locations between magnetite and haematite can be made. If you compare figure 71 and 72 you can see that especially in Anatolia a lot of iron occurs from which is not known what kind of iron it is. Unfortunately not enough information was available to find out what iron oxide occurs in these locations.

Chapter 6: Conclusion

After studying the formation processes of iron oxides, looking for iron oxide sources and criticizing them 307 potential sources of iron oxide are found according the optimistic view and 148 potential sources of haematite, goethite and magnetite are found according the optimistic view. When also considering logistic factors Anatolia, the Levant and Persia are the most likely potential sources of iron oxides. The material from which the artefacts, for example the cylinder seals, are made was probably obtained from those areas.

Now the research questions will be answered. The main questions of my research were:

- Where does haematite occur?
- Are there differences in composition of haematite in the different areas? What are those differences and where do they occur?
- What is the provenance of haematite found in Mesopotamia?

I have answered the first question. In chapter 5 you can see where haematite, goethite, magnetite and iron in general are located. Because some information was not found, not with every location is known whether haematite, goethite, magnetite or another form of iron could be found.

Unfortunately I couldn't answer the second question. In the sources I used I have not found much information about the exact composition of the rocks. Mostly I just found that haematite, goethite or magnetite occurred at the locations. Sometimes the only information that was available was the occurrence of iron at that place.

In contrary to what in general was thought, that the iron oxides came from Anatolia, in this thesis is proved that the material could also be obtained from other locations like the Levant and Persia. The South-East of Anatolia, the Western Iran and the Levant are the most likely sources. They are the sources which lie the closest to Mesopotamia and trade routes are going to these places.
The rest of Persia and Anatolia, Egypt, the area around the Red Sea, Afghanistan and India could also be reached and it is possible that people were obtaining iron oxides from those locations. For example when they were passing those locations while they were going to get another material which was not available in Mesopotamia and the area around it. But I don't think people were travelling that far while they could obtain the iron oxides from a much closer location.
I don't think they travelled to Sudan, the Caucasus, Turkmenistan, Northern Pakistan and Eastern India. Because no evidence of trade routes to those locations is found and those places are too far away or too hard to reach.

For knowing the exact source of a specific seal found in Mesopotamia, samples should be taken from different potential sources and the compositions of these samples should be determined. The composition of the seal should also be known. The question could be answered by comparing these compositions.

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Appendix: map legends

Table 21: Legend of the location maps of chapter three and five.

No.	Name location	Name location	No.
1	Middle Euphrates	Abhar	176
2	Hit	Abu Simbil	131
3	Saheb	Adana (Silinti)	96
4	Goljik	Alaya	95
5	Bawari Valley, North-East of Amadiya	Alchuri in Baltistan province	168
6	Between Byblos and Sea of Galilee	Amanus region	14
7	The region South-West of lake Van	Amasia: near Amasia, Tokat and Sivas	99
8	Van/Urartu/Tushpa	Amaxia	97
9	Marash	Andros	156
10	Elazig region	Antalya: coast South of Antalya	27
11	Gurun area	Arak	196
12	Malatya area	Ardabil	200
13	Divrigi deposits	Ardakan	169
14	Amanus region	Asad Abad	182
15	Tabal	Assuan: between Assuan and Shellal	136
16	Carchemish (Karkemis)	Aswan	127
17	Cilicea (Que)	Ayazmant	104
18	Central Taurus between the Cilicean gate and the Euphrates	Badgis	159
19	Volcanic region of Anatolia near upper Euphrates	Bafq	58
20	South-West of Euxine (Black Sea)	Bahariya Oasis, Western Desert	49
21	Isparta and Konya	Balaban	32
22	Gaziantep	Balestan	177
23	Payas	Bamian	83
24	Tiyari (Tura duri)	Batum	102
25	Kestel	Bawari Valley, North-East of Amadiya	5
26	Bolkardag	Between Assuan and Shellal	136
27	Coast South of Antalya	Between Byblos and Sea of Galilee	6
28	Ernis	between Jiddah and Mecca	141
29	The region of Bingol, Tunceli, Elazig and Malatya.	Bilad Baqim	143
30	The region of Divrigi, Erzincan and Erzurum.	Bingol, Tunceli, Elazig and Malatya region	29
31	The region of Diyarbakir, Siirt, Bitlis, Van and Hakkari.	Bitlis, Diyarbakir, Siirt, Van and Hakkari region	31
32	Balaban	Bizmişem	116
33	Hormuz	Black Sea: South-West of Euxine (Black Sea)	20
34	Yazd / Jezd province	Bolkardag	26
35	Eastern Mugla coast	Bolnis	147
36	Ramon fault	Burma	124
37	En Yahav	Bursa Coast	126
38	Samarian Mountains	Bűyűkeceli	109

83	Bamian	Goljik	4
84	Kohistan	Guri Sheikh	73
85	Pagman	Gurun area	11
86	Siwa	Haji Abad	193
87	Saindak	Hakkari, Diyarbakir, Siirt, Bitlis and Van region	31
88	Nairi	Hamadan	184
89	Magnesia	Hameh Kasi	185
90	Doliche	Hekimhan / Deveci	115
91	Tiyari mountains	Herat	82
92	Mons Ida	Herat	172
93	Bythinia	Hit	2
94	Cibyra	Hormuz	33
95	Alaya	Hortuna	105
96	Silinti (Adana)	Husein Abad	50
97	Amaxia	Iranshahr	180
98	Pontus	Iris and Thermodon valleys	101
99	Near Amasia, Tokat and Sivas	Isparta and Konya	21
100	Trapezus	Jezd / Yazd province	34
101	Valleys of the Thermodon and Iris	Jiddah: between Jiddah and Mecca	141
102	Batum	Juwan	52
103	Kuşşayiri	Kalabsha	128
104	Ayazmant	Kandahar	160
105	Hortuna	Karamadazi	112
106	Sakarkaya	Karkemis (Carchemish)	16
107	Samli	Kashan	67
108	Mellec	Kazab	188
109	Bűyűkeceli	Kazwin	61
110	Kesikkőprũ	Kéa/Keos	157
111	Celebi	Keos / Kéa	157
112	Karamadazi	Kerem Maharal	42
113	Mansurlu	Kerman / Carmania	70
114	Payas	Kesikkőprũ	110
115	Deveci/Hekimhan	Kestel	25
116	Bizmişem	Khabur region (Laqe)	46
117	Ertabil	Khandivali quarry	165
118	Sart	Khwarizm	81
119	Qalqilya Horst	Kition-Larnaka	55
120	Zur Natan horst	Kohistan	84
121	En Boqeq	Kohrud	68
122	Latrun	Kordestan	190
123	Wadi Araba	Kuh-i-Benan	69
124	Burma	Kurusko	130
125	Nahr el Kelb	Kuşşayiri	103
126	Bursa Coast	Lahijan	179

127	Aswan	Lake Van: the region South-West of lake Van	7
128	Kalabsha	Larak	199
129	Garf Hussein	Latrun	122
130	Kurusko	Lower Nahal Me`arot	41
131	Abu Simbil	Magnesia	89
132	Wadi Baba	Mahd adh Dhahab	139
133	Ras Benas	Malatya area	12
134	Wadi Dib	Malatya, Bingol, Tunceli and Elazig region	29
135	Wadi Halfa	Mamoniyeh	197
136	Between Assuan and Shellal	Mansurlu	113
137	Qaşr al Farafirah	Marash	9
138	Yanbu at Bahr	Markazi	173
139	Mahd adh Dhahab	Mashhad	60
140	Tayma`	Mecca: between Jiddah and Mecca	141
141	between Jiddah and Mecca	Mellec	108
142	Red Sea	Middle Euphrates	1
143	Bilad Baqim	Mohamad Abad	189
144	Sa`ada	Mons Ida	92
145	Sana	Mount Demawend	63
146	Tshatash	Mugla: Western Mugla coast	47
147	Bolnis	Nahr el Kelb	125
148	Elisavetpol	Nairi	88
149	Near lake Urmia	Naxos	171
150	Daškesan	Near Amasia, Tokat and Sivas	99
151	Paphos	Near lake Urmia	149
152	Samothrakè	North Orissa	53
153	Rhodes	Northern Anomaly	76
154	Cos	Ofer	43
155	Ormylia	Ormylia	155
156	Andros	Pagman	85
157	Kéa/Keos	Paphos	151
158	Faryab	Payas	23
159	Badgis	Payas	114
160	Kandahar	Pontus	98
161	Zarbol	Qalqilya Horst	119
162	Ghazni	Qaşr al Farafirah	137
163	Uruzghan	Que (Cilicea)	17
164	Zinda Jan	Ramon fault	36
165	Khandivali quarry	Raqefet Valley	45
166	Fanja	Ras Benas	133
167	Serifos	Rast / Resht	78
168	Alchuri in Baltistan province	Ravar	186
169	Ardakan	Red Sea	142
170	Skouriotissa	Resht / Rast	78

		Tshatash	146
		Tunceli, Bingol, Elazig and Malatya region	29
		Tura duri (Tiyari)	24
		Tushpa/Van/Urartu	8
		Upper Nahal Me`arot	40
		Urartu/Tushpa /Van	8
		Urmia: near lake Urmia	149
		Uruzghan	163
		Valleys of the Thermodon and Iris	101
		Van, Diyarbakir, Siirt, Bitlis and Hakkari region	31
		Van/Urartu/Tushpa	8
		Volcanic region of Anatolia near upper Euphrates	19
		Wadi Araba	123
		Wadi Baba	132
		Wadi Dib	134
		Wadi Halfa	135
		Wadi Hassainiyat, North-East of Rutba	56
		Western Mugla coast	47
		Yanbu at Bahr	138
		Yazd / Jezd province	34
		Zaboli	194
		Zahedan	191
		Zanjan	181
		Zarbol	161
		Zinda Jan	164
		Zur Natan horst	120

Table 22: Legend of the maps of the trade routes before the Old Babylonian Period (Fig. 32 and 33).

No.	Name location	Name location	No.
1	Babylon	Alalakh	42
2	Uruk (Erech, Warka)	Ashur	32
3	Mari	Babylon	1
4	Route along the Tigris (3000-2350BC)	Badakhshan	5
5	Badakhshan	Byblos	25
6	Shahr-i-Sokte	Diyala	33
7	Kerman	Elba	41
8	Fars	Failaka	17
9	Khuzistan	Fars	8
10	Southern route Afghanistan-Near East (3000-2350BC)	Gulf route (3000-2000BC)	19
11	Khorassan	Hamadan	12
12	Hamadan	Hit	36
13	Kermanshah	Kerman	7

14	Northern route Afghanistan-Near East (3000-2350BC)	Kermanshah	13
15	Trade route (3000-2350BC)	Khorassan	11
16	Trade route (3000-2350BC)	Khuzistan	9
17	Failaka	Mari	3
18	Tarut	Nineveh	31
19	Gulf route (3000-2000BC)	Northern route Afghanistan-Near East (3000-2350BC)	14
20	Trade route (3000-2350BC)	Palmyra	26
21	Trade route (3000-2350BC)	Route along the Euphrates (4000-2350BC)	30
22	Trade route (3000-2350BC)	Route along the Khabur river (3500-2000BC)	47
23	Trade route (3000-2350BC)	Route along the Tigris (3000-2350BC)	4
24	Ugarit	Route from Nineveh to the South (4000-3100BC)	38
25	Byblos	Route from Susa to Gujarat Peninsula, India (since 3400-3100BC)	37
26	Palmyra	Shahr-i-Sokte	6
27	Trade route (3000-2350BC)	Southern route Afghanistan-Near East (3000-2350BC)	10
28	Trade route (3000-2350BC)	Susa (Shush)	29
29	Susa (Shush)	Tarut	18
30	Route along the Euphrates (4000-2350BC)	Tell Brak (Azukhinnum)	44
31	Nineveh	Trade route (2600-2350BC)	34
32	Ashur	Trade route (2600-2350BC)	35
33	Diyala	Trade route (2600-2350BC)	45
34	Trade route (2600-2350BC)	Trade route (3000-2350BC)	15
35	Trade route (2600-2350BC)	Trade route (3000-2350BC)	16
36	Hit	Trade route (3000-2350BC)	20
37	Route from Susa to Gujarat Peninsula, India (since 3400-3100BC)	Trade route (3000-2350BC)	21
38	Route from Nineveh to the South (4000-3100BC)	Trade route (3000-2350BC)	22
39	Trade route (Since 4000-3100BC)	Trade route (3000-2350BC)	23
40	Trade route (Since 4000-3100BC)	Trade route (3000-2350BC)	27
41	Elba	Trade route (3000-2350BC)	28
42	Alalakh	Trade route (3000-2350BC)	46
43	Trade route (Since 4000-3100BC)	Trade route (3500-2000BC)	55
44	Tell Brak (Azukhinnum)	Trade route (4000-3100BC)	48
45	Trade route (2600-2350BC)	Trade route (4000-3100BC)	49
46	Trade route (3000-2350BC)	Trade route (4000-3100BC)	50
47	Route along the Khabur river (3500-2000BC)	Trade route (4000-3100BC)	51
48	Trade route (4000-3100BC)	Trade route (4000-3100BC)	52
49	Trade route (4000-3100BC)	Trade route (4000-3100BC)	53
50	Trade route (4000-3100BC)	Trade route (4000-3100BC)	54
51	Trade route (4000-3100BC)	Trade route (Since 4000-3100BC)	39
52	Trade route (4000-3100BC)	Trade route (Since 4000-3100BC)	40
53	Trade route (4000-3100BC)	Trade route (Since 4000-3100BC)	43
54	Trade route (4000-3100BC)	Ugarit	24
55	Trade route (3500-2000BC)	Uruk (Erech, Warka)	2