Journal of Petroleum and Gas Exploration Research (ISSN 2276-6510) Vol. 2(1) pp. 017-026, January, 2012
Available online http://www.interesjournals.org/JPGER

Full Length Research Paper

Evaluation of some natural ores from Egyptian eastern desert to be utilized in producing of paint materials

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Accepted 11 January, 2012

The Eastern desert possess a numerous natural ores with sufficient quantities can be ground to a very fine grain size and used as a component of decorative and protective paint materials necessary for protection of steel structure components. In this present study an investigation is carried out to search for the appropriate of local natural ores can be utilized in producing paint pigments, samples collected from different localities in the Eastern desert (Zafarana "Abu El Darag", Um Greifat, Wadi Ghadir, Wadi Um Ghazal), the sample includes silica white sand, Iron oxide 'Ochre", Barite, Graphite. The collected specimens were crushed and ground to powder varying in size between "5 - 50 um" for laboratory testing. The evaluation techniques for the various ore samples incorporated laboratory work for measuring the material quality control together with laboratory testing including specific gravity, moisture content, pH value, oil absorption, X-Ray analysis, microscopic studies and others to prove that the selected local ores possess the required characteristics for pigments that can be utilized in producing the paint material in Egypt. The study indicates that the following local ore materials "Silica white sand of Zafarana, , Iron oxide of Um Gerifat, Graphite of Wadi Ghadir, and Barite of Wadi Um Ghazal " can be utilized as extender and colored pigments to produce paint. The estimated reserves of the studded ores give an indication of presence the sufficient quantities for stream production of the some paint pigments needed for Egyptian market.

Keywords: paint composition, paint pigment, extender pigment, color pigments, microscopic studies, x-ray analysis, chemical analysis, Eastern Desert, Egypt.

INTRODUCTION

All coatings used for decorative and corrosion protection, or for any other purpose will contain a film-forming material. This material may be organic or inorganic and, after application, may form a hard, impervious film, a soft porous film, or combinations in between.

The present study will concern to extender pigments which used as reinforcing pigments and flow control pigments, they are important in coating formulation. As a class, these pigments called extender pigments because they are relatively inexpensive compared to most other pigments; they are used in conjunction with more expensive pigments to reduce costs. The use of extender pigments reduces shrinkage stresses within the paint film, giving it strength, and "extending" the pigment volume content at relatively low cost.

Extender pigments include those based on silicates, barites. Each of these types of pigments is somewhat different, but they all are relatively low cost materials that can be added in finely divided form to a paint to aid in its rheological properties (viscosity and flow control) and to reinforce the dry film strength.

The other pigments, studied in details in this article is called colored pigments "Iron oxide and Graphite" frequently are used in combination with titanium dioxide to add color (Gaber.M.AW, 1999).

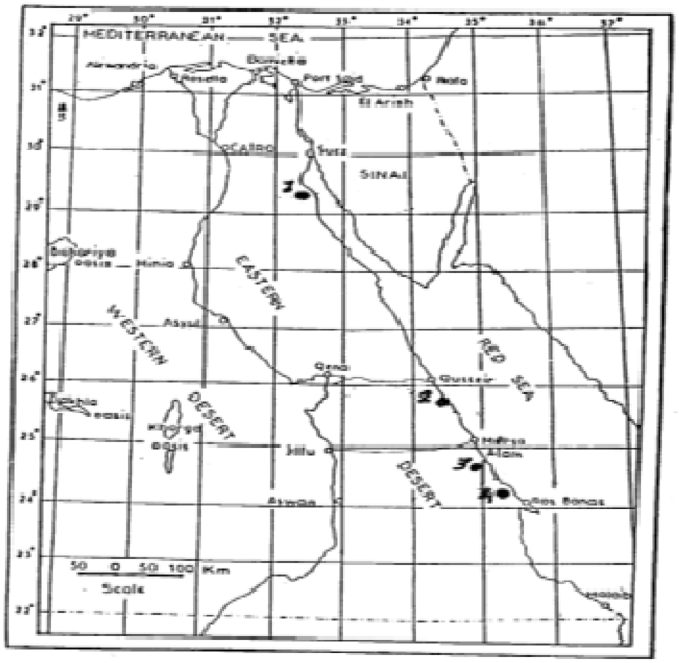

Figure 1. Location map of studied areas (•)
1- Zafarana area (Abu El Darag)
2- Um Gerifat
3- Wadi Ghadir
4- Hamata (Wadi Um Ghazal)

Figure 2. Silica white sand of Zafrana area at Gulf

Figure 3. Crushing of silica sand at zafrana are of Suez

Evaluation method and techniques

In the present study, a total of 40 collected samples were studied, the following is a brief description and techniques of the studies ores “Silica white sand of Zafarana, Iron oxide of Um Gerifat, Graphite of Wadi Ghadir, and Barite of Wadi Um Ghazal

Zafarana silica white sand

Zafarana white silica ore reserves are huge, and exceed billions of tons and the deposit has little or no overburden, and it’s exposed in extensive areas. Many active quarries operated by public and private sector firms are operating in Abu Darag and Wadi Dakhal near Zaafarana on the Red Sea coast. The sands satisfying for production of paint pigment belong to the Malha formation of Cretaceous age and the content of SiO_2 is ranging from 99.2 to 99.5 % (Hussein, 1990) and (Geological survey report of glass sand, 1994). Figure 2 and 3.

Iron oxide

Yellow and red ochre have been mined from Um Greifat, about 50 km south of Quseir on the Red Sea coast (Figure 1 location map). The deposit occurs in Middle Miocene sediments including conglomerates,

Figure 4. Iron oxide (ochre) at Umm Greifat , Eastern Desert.

Figure 5. Mining the iron oxide from Umm Greifat for industry

Figure 6. Graphite ore at Wadi Ghadir , the ore overburden with thin layer of weathered materials

marl, sandstone and green clay, resting on peneplaned basement rocks. It appears in the form of lenticular bands about 2 m thick, capped with green clay. The yellow ochre contains 46.5 % Fe and the red Ochre, 58.7 % Fe. (Hussein, 1990 and Dardeir et al, 1992). Also small occurrences of red and yellow Ochre are found, beneath the hematite bed in Wadi EL Negebawi, Kab El Lulia in sedimentary rocks. Figure 4 and 5.

Graphite

Graphite is a black, lustrous mineral crystallizing in the hexagonal system, with rhombohedral symmetry. The natural graphite's are divided into three classes according to the nature of the mineral. These three divisions comprise disseminated flake, crystalline or plumbago, and amorphous or black lead. Graphite was formed as a result of metamorphic processes and the first discover in Egypt was in 1938 at Gabal Um Selim in the Barramiya area and later, in 1943, at Wadi Ghadir (Figure 1 location map) (Geological Survey, metallic and non-metallic map, 1979). In all these occurrences, graphite is present in thin seams of graphite schist intercalated with other paraschists. The graphite schist is strongly foliated and has a soapy feel and is composed of chlorite and tremolite with finely dispersed graphite dust.
Chemical analysis of graphite schists from Wadi Ghadir showed graphitic carbon in the range of 1.6 to 1.84 %, and ash content between 92 and 94 %. The origin of graphite is believed its result from low to medium grade metamorphism of the carbonaceous matter contained in the original sediments. Figure 6.

Barite "barium Sulphate"

Barite is frequently associated with lead ores such as galena. The purity of barite varies considerably according to its locality in which it is found. Seams of barite are obtained in the same mine, some of which are of a pure white color whereas others are of a yellowish or greyish - red hue, due to the presence of iron. Owing to its cheapness, it forms an ideal " extender " or adulterant for use in conjunction with other pigments , especially white lead, on account of its high gravity and low oil consumption .

Barite or barium sulphate ($BaSO_4$) is used in various quantities in the paint trade as an adulterant or "extender" for mixing with other pigments where by their cost is considerably reduced. Its value is dependent on the whiteness of its color and the fineness of its texture or grinding. It is one of the heaviest white pigments known, and has a specific gravity up to 4.48. Its oil absorption is very low, and it only requires about 8 - 15

Table 1. Chemical and Physical properties of local ores forming pigments

Ore Type	Chemical Composition	Physical Properties						
		Specific Gravity	Moisture %	Oil Absorp. at 100gm	pH	Matter Soluble	Hardness	Brightness
White sand	99.5 SiO_2	2.60	0.15	25	9	0.20	7	86
Barite	94.2 $BaSO_4$	4.38	0.24	22	8	0.13	3	88
Iron oxide	48.80 Fe_2O_3	3.25	0.14	27	8	0.27	4.5	red
Graphite	3.7 C	2.25	0.10	33	8.5	0.70	1.5	black

% of oil to grind it into a paste form and the particle size range from 10 to 40 um.

It is used in high grade paint and supplied as a finely ground, white powder containing 98 - 99 % of $BaSO_4$, but a slightly brown or pink variety may be used for lower grades of paint. Barite function as a true pigment in water - paints, and as an extender in oil - type paints. For use as pigment and extender the crude barite mineral must be sorted, crushed, wet - ground, levigated to remove coarse particles, washed with acid to remove colored impurities, again levigated and fractionated into grades of particle size. Special grinding machinery is used to obtain the finest degree of grinding (Paint Technology manuals, 1966).

Laboratory tests

Fourthly ditch samples were collected from different localities at Eastern Desert represent to silica white sand, iron oxide 'ochre", graphite and barite, the representative sample used for laboratory testing, chemical analysis, microscopic studied, X-ray and scanning electron microscopic studies.

All samples were subjected to another number of tests to determine their suitability for application as pigments to be utilized in manufacturing of paints.

These tests are explained and discussed in a number of text books and standard including; Introduction to paint chemistry and principles of paint technology (1991), Encyclopedia of the chemical "Inorganic pigment" (1992), Paint Handbook (1981), Paint technology manuals part six pigments dyestuffs and lakes (1966), Handbook of paint raw materials (1989), The American Standard for Testing Materials (ASTM), Jotun coating manual, 1994 and El Sawy, 1994. The tests may be summarized in the following Specific gravity – ASTM D 153, Moisture content – ASTM D 280, Oil absorption – ASTM D 281 and D 234, Particle size, Particle shape, ASTM E 70 of Hydrogen ion concentration (pH value) – ASTM D 2196, Matter soluble in water, Hardness, Color of powder, Brightness, and Performance application tests of paint products (Fineness test "Hegman scale" - ASTM D 1210), Viscosity test- ASTM D 562, Flow time - ASTM D 1200, Wet film thickness, Dry film thickness, Opacity or hiding power ASTM D 2805, Gloss ASTM D 523, Flexibility or bend test, Adhesion, Pinhole or porosity test ASTM D 3891) as per indicated in evaluation sheet of studied ores illustrated in (table 3, 4 5 and 6).

RESULTS AND DISCUSSIONS

In Eastern Desert area there are numerous ores that can be utilized in producing pigments powder forming paint types as indicated in (table 1, 2, 3, 4,5 and 6) .

Zafarana silica white sand

Powder silica is produced by grinding natural deposits of white sand. The white silica used to produce the paint material of wood fillers, undercoat or priming paints, house paints, and floor paints, where their hardness and crystalline structures give finishes which dry rapidly and possess good rubbing properties. It is chemically inert and gives good "tooth "to priming coats (Paint technology manuals, 1961).

Iron oxide

The red ochre of Um Greifat is containing of iron oxide ranging from 15 to 50 per cent. The red ochre is wholly or partially present as anhydrous ferric oxide "Fe_2O_3". The chemical composition of Um Greifat red ochre show that the Fe_2O_3 is (48.86 %), SiO_2 (25.45 %), CaO (8.41 %), MgO (4.41 %) and (3.15 %) Al_2O_3 with traces of TiO_2 (0.20 %). The Fe_2O_3 content of samples collected from Um Greifat is comply with Domestic ochre produced in Georgia "USA" and (ASTM D 85, 1987). This ratio of iron oxide satisfies the paint manufacturing of anticorrosive primer.

Graphite

The ore consist of (31.40 %) SiO_2, (12.65 %) Al_2O_3, (8.53 %) Fe_2O_3, (9.40%) CaO, (22.40%) MgO, (0.50 %) TiO_2, (0.16 %) K_2O and (3.7 %) carbon content as indicated in (Table, 1), the carbon content is small and

Figure 7. Crushing of large size of studied ores to fine sizes

Figure 8. Ball Mill for grinding of ores to very fine grain size (10 – 50 um)

should be increased to obtain the required ratio of black carbon. Meanwhile the mixing of coal with graphite to obtain the required percentage of carbon is necessary for producing standard black pigment.

Barite “barium Sulphate”

Barite is the densest and has the highest refractive index of the extender pigments, insoluble in water, and

good chemical and corrosion resistance, it provides good holdout in undercoats and primers and shows wear resistance in traffic paints, also adding the barite as a filler to ethyl silicates zinc rich paints improve the paint performance (Fragata et al., 1993) .

The results of chemical analysis of Wadi Um Ghazal indicate that the $BaSO_4$ content is (94%), SiO_2 (2.50%), Al_2O_3 (0.60 %), Fe_2O_3 (1.8 %) and CaO (0.7%), this chemical composition is suitable for paint pigments and comply with (ASTM D 715 and ASTM D 602) requirements necessary for manufacturing of paint extender and colored pigments .

The following tests were carried for the studies ores as follows and the results illustrated in the following tables.

Chemical and physical properties of studied ores

The paint, when applied to steel substrate, is usually exposed to the destructive effect of light, moisture, UV and severs environmental conditions. Therefore, the chemical composition of pigments should be stable, inert and free of chloride and sulfur.

The chemical analysis of samples collected from the Eastern Desert areas were accomplished to ensure that the ores used in pigments are inert, stable and not contain detrimental impurities. The following results were obtained and illustrated in (table. 1).

Particle size

Pigments for paint manufacturing occurs in the form of a fine powder or lumps by using crushing and ball mill equipment’s as shown in (Figure 7 and 8). The final condition in the finished paint must be such that there are no particles greater than a certain size limit. For example if a paint film has a thickness of say, 50 microns it is desirable that the largest pigment particle in range of 10 microns in size. The vast majority of particles are much smaller in size than 10 microns; there is some evidence that a mixture of particle sizes is desirable for increased durability, reduced absorption and reduced permeability of the film.

Particle shape

The particle shape also plays a part in these features; for example, plate-like particles which form an over lapping laminar structure in the film offer greater resistance to water permeation.

Particle size in conjunction with specific gravity influences the rate of the settlement in the liquid paint. The smaller the particle size the slower the rate of settling for specified specific gravity. On the other hand it appears that a proportion of extremely fine particles

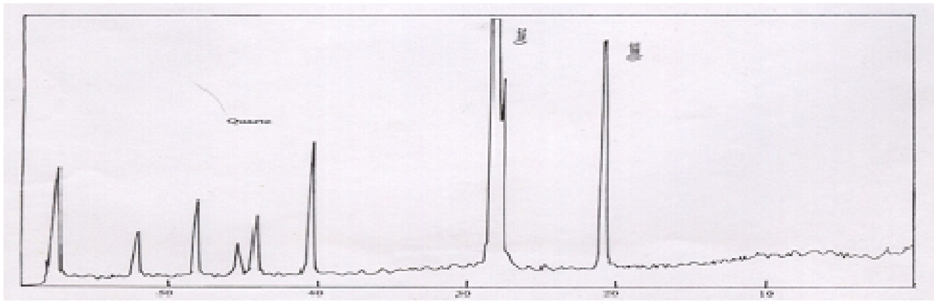

Figure 9. X-ray diffraction pattern for white sand of Zafarana

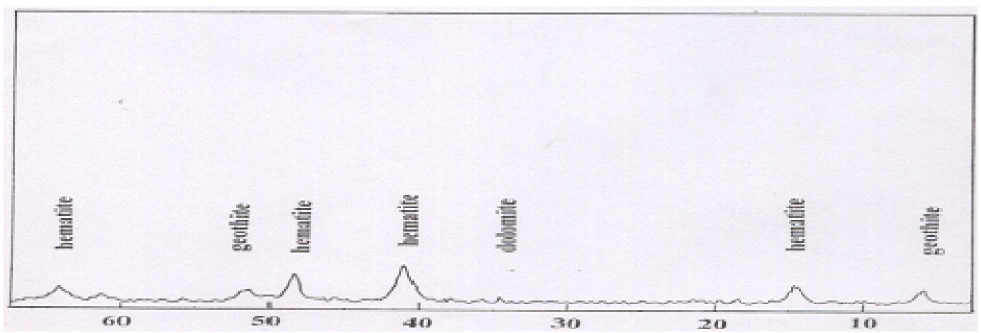

Figure 10. X-ray diffraction pattern for iron oxide of Um Gerifat

can result in the phenomenon of flotation in the applied film of paint.

Particle size, size distribution and shape have also an influence on other properties of the paint such as hiding power, consistency, oil absorption and the formation of absorbed layers as well as on such application properties as flow and brush ability.

The particle shape for local ores was examined thoroughly by taking photographs of the powder pigments using high magnification.

The Particle shape for the white sand of Zafarana is granular and ranges in shape from sub-rounded to rounded as shown in (Figure 13), Graphite of Wadi Um Ghazal is foliated in shape (Figure 15), Barite of Wadi Ghadir indicate that the grain shape are massive as shown in (Figure 16).

X- Ray Diffraction

The identified minerals from powdered samples are as follows.

Silica white sand

The XRD of studied samples were collected from Zafarana area indicate that the SiO_2 is the major element with 99.5 % as shown in (Figure 9).

Iron oxide

XRD (Figure 10) of Um Greifat ochre shows that the samples are composed of hematite, geothite and dolomite, this analysis complies with chemical composition results.

Graphite

XRD of Wadi Ghadir graphite indicate that the major element is quartz, calcium oxide and carbonaceous graphite as shown in (Figure 11).

Barite

The result obtained from XRD (Figure 12) indicates that the sample collected from Wadi Um Ghazal, South of Eastern Desert of $BaSO_4$ by more than 95 %.

Microscopic studies

Thin section

White sand

Photograph shows that white sand has a clear

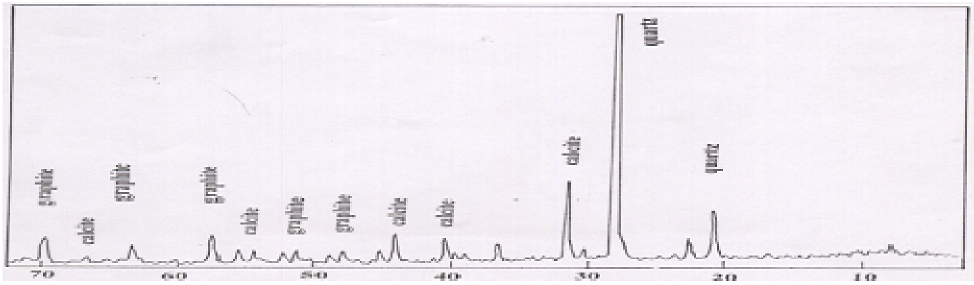

Figure 11. X-ray diffraction pattern for graphite of Wadi Ghadir

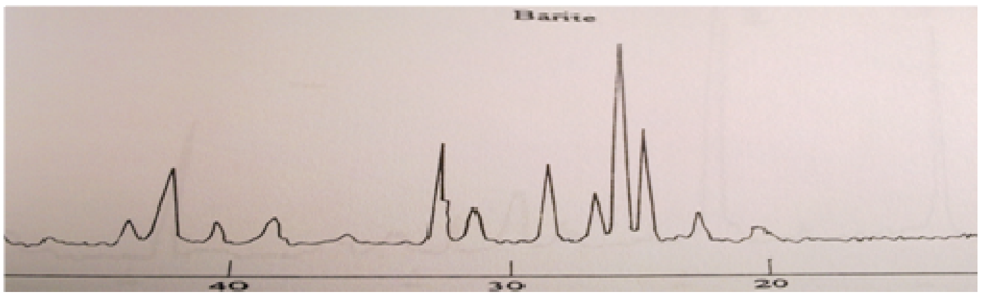

Figure 12. X-ray diffraction pattern for Barite of Wadi Um Ghazal

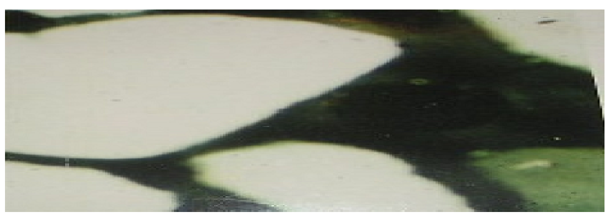

Figure 13. White sand of Zafarana (The quartz grains are predominant, sub- rounded to round, carbonate cement and clay matrix XN - X100)

Figure 14. Ochre of Umm Greifat

appearance, lack of cleavage, sharp extinction and white to yellowish white interference color in thin section. The quartz grains are predominant and ranges from sub-rounded to rounded. Clay matrix and carbonate cement the quartz grains. Figure 13.

Ochre

The photograph shows that ochre of Um Greifat is reddish to black in thin section, massive with some scattered grains of silica and carbonate that characterize the ochre or hematite. Figure 14

Graphite

Photograph shows that most of the sample is thin flaky and disseminated grains which characterize the schist's

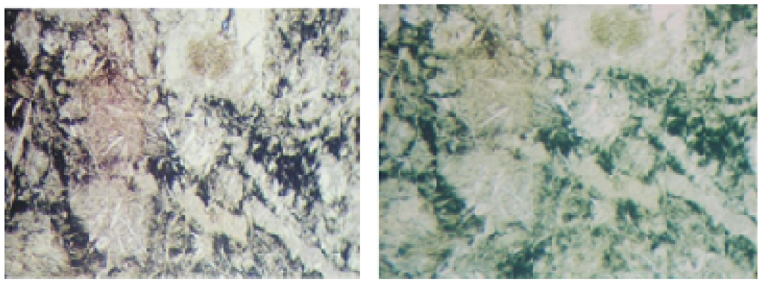

Figure 15. Graphite of Bent Abu Geraya

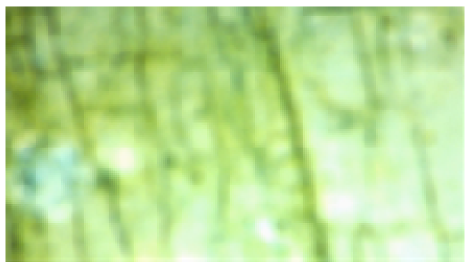

Figure 16. Barite of Wadi Ghadir

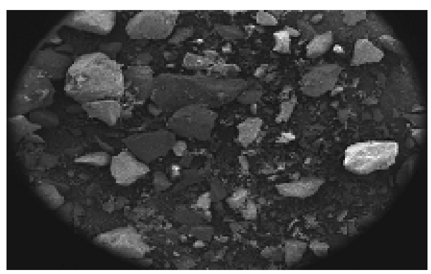

Figure 17. SEM of white sand

rock, slate and metamorphic limestone. The finely opaque particle ‘carbonaceous matter ‘is a major constituent of graphite samples. Figure 15.

Barite

Photograph shows mainly anhydrite massive, crystals are rare, cleavage in three directions at right angles, few iron oxide and silica (+ 125). Figure 16.

Scanning Electron Microscope

The electron microscope investigation provides a good mean in identifying the main characteristics of the studied rocks including “grain size, grain shape, matrix, and pore geometry; the SEM investigation of the studied samples was carried out on the following ores.

White sand

The photograph (Figure 17) shows that the white sand of zafarana composed mainly of SiO_2 with angular to sub-angular grains. It is abundant in sandstone, quartzite, and granites. The grain size ranges from zero to 3 um in diameter

Iron oxide

The photograph (Figure 18) shows that the ochre of Um Greifat is composed mainly of colloidal or masses

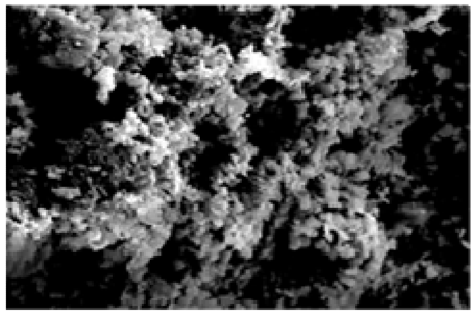

Figure 18. SEM of Um Greifat ochre

Table 2. Viscosity of studied ores forming pigments

Rock name	Test Name	Pigment	Ratio	
		20 %	**40 %**	**60 %**
White sand	Apparent viscosity	50	60	80
Barite	Apparent viscosity	42	49	53
Iron oxide (ochre)	Apparent viscosity	40	50	61
Graphite	Apparent viscosity	65	83	102

Table 3. Silica sand evaluation sheet after mixing with paint formulation

Ore type	White sand
Paint name	Anti corrosive primer
Pigment or filler %	7 % in paint formula
Oil absorption	29 mil / 100g
Color of ore before mixing	white
Fineness	35 um
Flow time viscosity	175 sec./Ford cup 4
Wet film thickness	150 um
Drying time	1-2 hours
Opacity or hiding power	Very Good
Paint color	Red
Gloss	Flat (< 15 / 60º)
Hardness	Accept
Flexibility or bend test	no flaking or cracking of coating
Adhesion	GT0 (no lifting of paint other than cutting)
Pin hole or porosity	No pin hole
Dry film thickness	75 um
Corrosion resistance	Very good

Table 4. Iron oxide (ochre) evaluation sheet after mixing with paint formulation

Ore type	Iron oxide (ochre)
Paint name	Primer based on long alkyd
Pigment or filler %	12 % in paint formula
Oil absorption	27 mil / 100g
Color of ore before mixing	Red
Fineness	55 um
Flow time viscosity	180 sec./Ford cup 4
Wet film thickness	Up to 150 um
Drying time	1 – 2 hours
Opacity or hiding power	Good
Gloss	flat (< 15 / 60º)
Hardness	Accept
Flexibility or bend test	no flaking or cracking of coating
Adhesion	GT0 (no lifting of paint other than cutting)
Pin hole or porosity	No pin hole
Water resistance	Very good

Table 5. Graphite evaluation sheet after mixing with paint formulation

Ore type	Graphite
Paint name	Primer based on long alkyd
Pigment or filler %	12 % in paint formula
Oil absorption	33 mil / 100g
Color of ore before mixing	Black
Fineness	50 um
Flow time viscosity	145 sec./Ford cup 4
Wet film thickness	100 um
Drying time	3 - 4 hours
Opacity or hiding power	Good
Gloss	flat (< 15 / 60º)
Hardness	Accept
Flexibility or bend test	no flaking or cracking of coating
Adhesion	GT2
Pin hole or porosity	No pin hole

Table 6. Barite evaluation sheet after mixing with paint formulation

Ore type	Barite
Paint name	Enamel based on long alkyd
Pigment or filler %	25 % in paint formula
Oil absorption	20 mil / 100g
Color of ore before mixing	white
Fineness	55 um
Flow time viscosity	175 sec./Ford cup 4
Wet film thickness	90 um
Drying time	2 - 3 hours
Opacity or hiding power	Good
Gloss	Semi gloss (30-60 / 60º)
Hardness	Accept
Flexibility or bend test	no flaking or cracking of coating
Adhesion	GT0 - GT1 (no lifting of paint other than cutting)
Pin hole or porosity	No pin hole
Corrosion resistance	Very good

hematite grains with few grains of silica and carbonate. The grain size is very small satisfies for anticorrosive paints

Viscosity of ore powder mixed with linseed oil

The viscosity of the studied samples were measured by mixing the different proportions of pigment powder 20%, 40% and 60% with linseed oil, the viscosity results were increased with the high pigment ratios as indicated in (table 2).

Paint products of studied ores

The studied samples were mixed with paint formulation and the final paint product was determined and the results illustrated in (table 3, 4, 5 and 6)

CONCLUSIONS

There are some ores (white sand, iron oxide, graphite and Barite) located in the Eastern Desert of Egypt that can be utilized in producing various types of extender and colored paint pigments. These are considered a part of paint constituents which applied to protection of steel structure facilities and building decoration. The investigated ore deposits are the following:

1- The white sand of Zafarana area results indicate that the powder used with 7 % of anticorrosive primer and non skid materials, Iron oxide with 12%, Graphite with 12 % and Barite with 25 % of paint components.

2- The evaluation techniques of the ore types incorporated laboratory work for material quality control together with laboratory testing in Eastern Desert to producing the extender paints material e.g. white silica sand, iron oxide "ochre", graphite and Barite.

3- Applied studies of these ores white silica, barite and iron oxide may be utilized in producing anticorrosive primer based on long alkyd, Enamel based on long alkyd (Koktal blue) , primer based on long alkyd (Comando) consequently. The graphite powder used to produce Enamel based on long alkyd (Borodora) but the opacity not comply with the required standard; and need to remove the contamination associated with the ore or mixing with coal to increase the carbon content and giving high opacity of paint materials.

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