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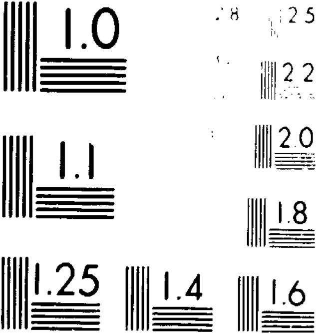
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Distr.
LIMITED

ID/WG.379/8
16 September 1982

ENGLISH

United Nations Industrial Development Organization

Interregional Cement Technology Forum

Benghazi, ~~The Socialist People's~~ Libyan Arab Jamahiriya
11-20 April 1982.

PRESENTATION OF THE OOLITIC LIMESTONE

USED IN THE CEMENT INDUSTRY

IN NORTH AFRICA*

by

A.R. Marei**

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V.82-30431

The economy of any cement plant is affected by the chemical, physical and mineralogical properties of the raw materials used to produce cement clinker, as each plant has its unique raw materials. The raw material serving the clinker production are key considerations to the success of any cement plant as well as the principal factors to be considered in designing, layout, choosing process and selecting the equipment. They also affect the raw material mix design, physical - chemical reaction of the kiln feed, fuel cosumption, refractory linings, and the quality and grindability of the clinker. So it is recommended to give great care and much study to the raw materials before selecting the area upon which a new cement project has to be erected. Microscopic and petrographic examinations, X - ray analysis, thermal analysis, complete chemical analysis and physical properties are the most essential tests to be carried out to characterise the raw materials.

As all of us know the limestone is by far the most impertant and common raw material used in cement raw mix plus clay, accordingly we will concentrate here in our paper upon such a well known type of lime stone widely distributed in areas of vecently geologically deposited ages (Pliestocene) along sea shores, great lakes and lagoons. One of these fantastic deposits the same origin, chemical and physical properties is the Oolitic limestone ridges which any of the Egyption, Libyan, Tunisian, Algerian and Moresque citizen can meet along the Mediterranian sea shore (more than 6000 km). So we can say with great proud that Nature fulfilled through the last geological age, the unity of our widely stretched and distributed Arab Lands, and we hope to fulfill the unity of our countries through our sincere feeling which means for us full independency, richness and much development for our Arab Countries.

First of all one can ask what is meant by limestone? The term was first used in the literal sense as it indicates a stone from which lime could be produced. In modern geologic usage, however, limestone has come to refer to a large group of rocks, some of which would be of indifferent value for the production of lime. The term limestone includes those sedimentary rocks made up of 50% or more of the minerals calcite and dolomite in which calate is more abundant than dolomite. Carbonates constitutes some 10-15% of the sedimentary rocks of the earths crust, as well as contributing to some important igneous and metamorphic rock types. The purest grades of limestone are calcite and aragonite. The hardness of limestone depends on its geological age, usually the older the geological formation, the harder the limestone. The hardness between 1.8 : 3.0 of the Moh's scale of hardness, its specific gravity is 2.6 to 2.8. Only the purest varieties of limestone are white. When contaminated with other admixures - like clay substance or iron compounds, its colour is influenced. In cement raw materials the lime component is generally represented up to an amount of 76 - 80%. Therefore the chemical and physical properties of this component are of decisive influence, when it comes to selecting a method of cement manufacturing as well as the type of production machinery.

GEOMORPHOLOGICAL FEATURES:

The area stretching mainly along the southern Mediterranian sea shore displays many examples of land forms characterized in most of its parts by a comparatively gentle topography and a low relief which rarely exeeds 100 m. Most of the lanforms represented in the area typical of desert conditions e.g the development of real pavement plains, accumulation of sand dune deposits, the presence of deal water shed areas, degradation of the surface and eventually by the domination of saline deposits and crust formations. Associated with such features the surface is locally imprinted with a number of old drainage lines which may reflect the past climatic conditions. Fluviatile processes created wide and flat to slightly undulated deltaic plains in the eastern portion of the North african Mediterranian sea shore. The landscape in the most northernportion is developed due to the action of shore processes connected usually several eustatic movements of the Mediterranian sea, into coastal landforms including elevated and elongated vidges alternating with shallow depressions. This plain extends parallel to the Mediterranian shoreline. In some places these plains does not appear due to the influence of geologic structure, differential weathering and the differentbase levels of erosion. The plain vary greatly in width from few meters to 10 km or more. The coastal plain reflects several examples of landforms indicating coastal geomorphology. These include the modern beaches with its 100 dune accumulation and swales in between, the foreshore lagoons, the wave out cliffs, the off shore elongate ridges mostly stretching subparallel to the Mediterranian Seal shorelines. Theseridges represent ancient shore lines of the sea in pliestocene times, each of which has been associated with a certain phase of sea regression. Alternating with and parallel to these ridges a series of shallow depressions are present mainly covered with loamy marl deposits. In our paper will will not deal with the other geologic features as mentioned before.

METODS OF INVESTIGATION

To locate and investigate a limestone deposit, starting from a scratch, is sometimes a job of quite a magnitude and not a ways a job crowned with success.

In our present investigation we used the classical plus the up to date methods of investigation taking into sonsideration that this type of limestone dominates along the Mediterranian Sea shore and along other sea shores or takes and accordingly it can be selected as a main material in cement production whether in Egypt, Libya, Tunisia, Algeria, Morraco. These methods are classical and X - ray analysis, microscopic examination, grain size analysis, x - ray diffraction, thermal analysis ...etc.

Most of the oolitic limestone forming the coastal ridges reveals that it is quite fit for cement industry. As a matter of fact the SiO_2, MgO and Fe_2O_3 content increase suddenly at the underground water level which means that the underground water plays a significant action on the limestone constituents by adding or leaching some special elements.

Another fact is that the cementing material (calcareous) binding the oolites dominates also above the underground water level white it is always leached from the limestone dominating under the water level and according the oolitic limestone is friable in character.

PETROGRAPHIC STUDY

It is worthy to state that the petrography and the origin of the oolitic limestone attracted the attention of the author and many others before of whom Hilmy (1951) Shukri, Philip and Said (1956) El Shasly (1941), Paver (1954), Zeuner (1952), Schwegler (1948), Picard (1943), Sandford and Arkell (1939), Ball (1939), Cuvillier (1938), Hume and Little (1928), Hume (1925)

The oolitic limestone is represented by rounded, oval elongated carbonate grains similar in shape and size to ova of fish (plate I Fig A) it is called ooltic limestone. These oolites as studied and investigated by the author are distinguished by the possession of an outer cortex of concentrically lammeller, crypto crystalline aragonite.

These concentric layers reaches up to 42 in number in case of true oolites and are only two or three layers in case of the superficial oolites (Shukri, philip and said 1956). In our study the number of the concentric layers vary in number from two or three up to thirty (plate I).

Within the coat or in the centre of the ooids a detrital nucleus can be recongnised. Commonly this nucleus is represented by a broken piece of an old ooid, a fragment of calcite, a grain of quarts (sand), forminefera or shell fragment (Plate I Fig A), however the shape of the nucleus is reflected on the shape of the ooids itself.
Some ooids have more than one nucleus and in this case the nucleus may be small oolitic grain (Plate I, Fig. A)

The concentric lameller pattern of the ooids is traversed by a more or less well - developed fabric of radially arranged calcite or argonite (Plate I, Fig B).

The ooids are poorly cemented with fine needly like cystals of aragonite in a wide space pattern leading to the friability of the limestone. The amount of such binding medium usually increased by aging (Plate II, Figs. A,B,C & D). The ooids grave 0.15-1.5 mm for the long diameters. Our study for great number of ooids show that 90% of their diameter lie in the ranges 0.2 - 0.5 mm.

The investigated samples show seattered quarts(sand)grains which are noramlly sub-angular to sub-rounded in shape. Organic and fossil remains are usually detected in few percentages. These shell remains are represented by different kinds of Pliestocene foraminefera, segmented calcareous, algae, Pelecepod, Gastropod shell fragments and Echinoid spines, (PlateII, Fig. D and Plate III. Figs A-D).

Clayey material is fenely disseminated in the investigated samples. In some ooids the clayey materials form their nucler as dispersed material (Plate I, Fig. A)

The diameter of the oolitic grains is always large in the young oolitic deposit i.e. the oolites decrease in size by aging (Plate II.) The older oolites are usually subordinate pseudo - olites and rare superficial and normal oolites (Plate II Fig. C&D) The cementing material binding the ooids is of microcrystalline or macrocrystalline mosaic texure matrix. This matrix is maily formed of crystalline calcite or aragonite (Plate II, Fig C&D). The percentage of this cementing material ranges between 20 to 30 % of the total rock forming the upper oolitic limestone bed.

ORIGIN & FORMATION OF THE OOLITES.

All the previously mentioned authors discribed the origin of the oolites forming the ridges occuring along the Mediterranian coast due to:-

1 - Wind Borne Origin Theory
2 - Ageous Origin Theory

We shall deal with the two theories independently as follows:-

1 - Wind Borne Origin Theory:-

Hilmy (1951) and others believe that the carbonate sands are not true authigenic oolites, but represent wind borne elastic carbonate sands derived from the cretaceous - Eocene limestone formation of the nearby exposures in the western Desert according to the following facts:-

a - The oolites are formed of cryptocrystalline calcium carbonate, highly polished, irregular in shape, tending to be ellipsoid, rodlike or rounded ranging from one half to one millimeter in diameter.

b - Concentric structure of thesse oolites uncommon and the nuclei are mostly absent and when a quarts fragment is met with, it is near the margin.

c - The pressnce of microfossils of tertiary and recent Gastropeds possessing the same size and polishing characteristic as the oolites.

d - Lack of microfossils inside the oolites.

e - The rounded carbonate sands are absent in the beach of Dekhela and present to the west. There is gradual change into fairly consolidated oolitic limestone ridges away from the sea water.

2 - Agueous Origin Theory:-

Philip (1955) supported by many other authors beleives that the origin of the oolites are of true marine origin based on the following criteria:-

a - The oolites commonly show concentric structure and they may be rounded, oval, elongated, ellipsoidal or irregular.

b - The oolites mostly possess nuclei made of cacite, quartz, crystalline carbonate or foraminifera, surrounded by concentric layers of carbonate which vary in umber from two or three concentric layers for the superficial oolites to 42 concentric layers of carbonates for the true oolites.

c - The true ooolites are recorded only in the Monasterian ridges but there is a majority of superficial oolites. The oolites are cemented usually by calcite, the amount of which increases by age.

d - Pliestocene foraminifera is present in the oolitic limestone.

According to the results of our work, we can state the following facts:-

1 - The oolites commonly show concentric structure, vary in their shape between rounded, oval, elongated, ellipsoidal and irregular, the brownish more oval.

2 - Most of the oolites contain a nuclei made up of calcite, quarts grain and or foaminifera surrounied by concentric lamellar pattern which is traversed by a more or less well-developed fabric of radially arranged calcite or aragonite fibres.

These lamellar pattern varies in umber from two or three up to thirty.

3 - The ooids are cemented together with fine needle like crystals of calcite or aragonite which increase by aging.

4 - The presence of aragonite is confirmed by X-ray analysis.

5 - Aragonite percentage decrease by aging as shown by X-ray diffraction investigation.

6 - Pockets, lenses of well sorted friable sands which vary in size are always met with in oolitic limestone ridges.

7 - The oolites possessing the concentric layers are recorded in all the ridges ranging between millasian and the Late Monasterian but mostly abundant and well developed in the late Monasterian ridge(foreshore ridge) i.e. the concretic layers of the oolites diminish in number by aging.

On the basis of the past work concerning the two mentioned theories and our present work results as stated in the preceding pages, the matter of the ooid origin and grwoth can be further developed. Further thoughts on the growth of the ooids, the control of aragonite crystal precipitation and orientation around the nuclei, the origin of radial fibrous calcite characteristic of ooids, the transformation of aragonite to calcite by aging, the limitation of grain size and the presence of fri able sand pockets or lenses associated with the oolitic limestone will occupy the remaining pages under the heading of the Tidal Range Origin (Third Theory)

THIRD THEORY

TIDAL RANGE OR SEA SHORE ORIGIN OF OOLITIC LIMESTONE

Dr. A.A. MAREI

Specialitsts of the subject of ooid formation have been few but it has been dealt with since 1877 by Sorby. Regarding the growth process of ooids we believe that the local detritus were trapped among algal filaments found near the seashore which roll by the action of tide currents over the bottom. This

rolling action can produce the radial concentric layers surrounding such detritus (quarts or sand grains, foramini fera, older broken limestone pieces ... etc).
Polishing of ooilites may be attributed to the action of abrasion of ooids when moving against each other. Aragonite found as co-lloodal nuclei suspended in the sea water migh become adsorbed by the action of chemical deposition on the ooid with their longest axis parallel to the ooid surface, so giving a tangential ar - rangement of c-axis(Bathurst 1971). We may well beleive that the mechanical accumulation of minute prismatic crystals, with their longer axis parallel to the surface of growth was going on at the same time.

The sphericity and the orality of the oolites can be attri buted to the balance between precipitation of orgenite and abra-sion over different parts of the ooid surface of the ooid nuclei which favours more rapid net growth on the less sharply convex and on the concave surface.

The origin of vadial fibrous calcite represented in the ooids is due to the fact that the detrial nucleus presumably once aragonite, has been replaced by calcite cement, yet the oolitic coat which was also aragonite, retains its original concentric structure upon which has been superimposed a pattern of radial fibrous calcite crystals.

It is worthly to state that the different investigated samples (aragonite and calcite percentages) decrease and increase respectively by aging as confirmed by X - ray diffraction. We beleive also that this may be due to the transformation of aragoni-te to calcite. It is known that a temperature of about 400C° is required for aragonite to invert rapidly to calcite by adry solid state reaction. Below 400C° the inversion still goes on but at rates that can be slow even judged against the geological time scale. Fyfe and Bischoff (1965) showed that below 100C° the time required for completion of the dry reaction is of the order of tens of millions of years. Wet transformation of aragonite to calcite in water lacking free Mg^2, is much more rapid than dry transformation. Rose (1958) has shown that carbonate of lime is deposited in the form of aragonite from hot solutions. Sorby (1879) found that - heat far below boiling will give vise to it but since under certain conditions like shell and corals. Aragonite shell material (most pelecepods, may Gastropods) inverts to calcite with time at ordinary temperature and the original delicately fibrous or prismatic structure of the shell is replaced by a structureless inter - locking semi - equigranular mosaic of anhedral sparry calcite. Some algae also recrystallise or invert to sparry calcite easily. It can be stated that inversion of aragonite to calcite is generally regarded as a function of time.

Why there is a high degree of sorting in the ooids forming the Late Monasterian ridge (fore shore ridge)?. Why there is limitation of grain size of the ooids?

After an ooid has reached a critical size, it can no longer be moved by the local currents and so it ceases to grow. The more a grain moves the faster it will grow i.e the rate of growth of ooid is proportional to the amount of time spent by the ooid in motion Carozzi, (1960). Small ooid rapidly become larger because, being the most mobile they spent more time in motion than the larger grain. The growth of larger ooid is slower because, as they grow they spend a progressively smaller proportion of time in motion. Bathrust, (1971). The fact that the foreshore ridges ooid is more larger in size than the other riiges can be attributed to the fact that the more rapid the oolites accumulation, the the quicker the burial, and the smaller the grain size. The coar coarser the oolites the longer it has been exposed in a growth enviroment, other thing equal.

The presence of the friable sand pockets or lenses associated with the oolitic limestone ridges may be due to the sand dunes that had been accumulated at the time of formation of the oolites along the sea shore. These sand dunes had been buried under the sea water in the tidal range. Buriel of sand under the sea water in the tidal range and its exposure to the atmosphere alternatively reflect the fact of alternate deposits of oolitic limestone and sand strata.

Finally it can be stated that the origin of this type of limestone (oolitic limestone) may indicate the original deposition of calcite, quarts, Foraminifera, broken shell.....etc, forming the oolitic nuclei along the sea shore which was then gently drifted along in the tidal range by currents of ordinary temperature. These nuclii caught more or less of the surrounding aragonite crystals chemically or mechanically to form the concentric layers, assisted by the sea currents in the tidal range to form at the end the ooids in its fantastic shape and texure. Due to the variation and the oscillation of the sea water level at that period it was possible to such ooids to be acted upon by wind.

EXPLANATION OF PLATE I

Photomicrographs of the Oolitic Limestone

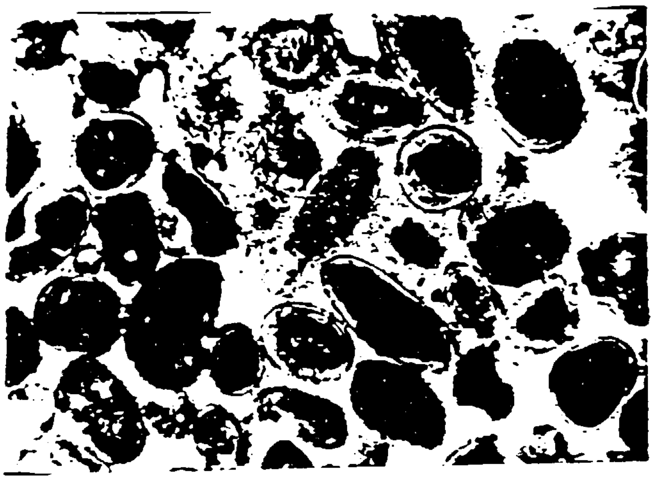
Fig. A- Brownish oolitic limestone, notice the outer crystalline concentric lamellar coat of the ooids embeded in sparry calcite groundmass and the ovality of the ooids. Carbonate, quartz and clayey material nuclei are observed. More than one nucleus are also detected (ooids marked a, b, & c)- cementing material marked "d".
Brownish oolitic limestone, P. P. L., X 300.

Fig. B- White oolitic limestone, more than 30 concentric layers are observed.
+ nicols, X 200.

Figs. C White oolitic limestone- from two to about 5 concentric layers (notice Fig. A also) of some deformed ooids embeded in authogenic sparry calcite.

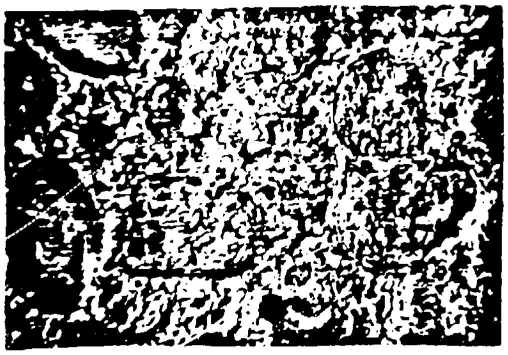
(+ nicols), X 200.
(notice the sphercity of the ooids)

PLATE I



A

B



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EXPLANATION OF PLATE II

Photomicrographs of the OOlitic Limestone

Figs. A and B- Poorly cemented limestone, notic the voids which are free from cementing material.

...................(Young oolitic limestone), + nicols, Fig. A (X 200), Fig. B (X 80).

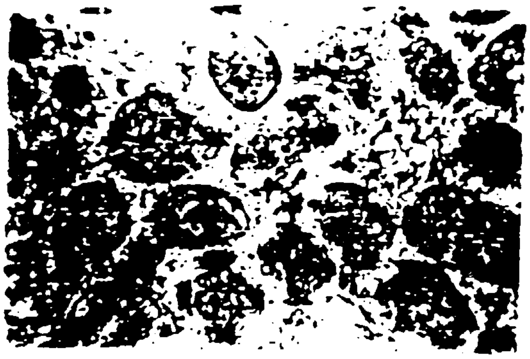
Figs. C and D- Fairly cemented oolitic limestone, the oolities are mainly superficial. Fossils debris are shown (Fig D). Notice the difference in grain size of this limestone and that of the young oolitic limestone (company with Figs. A and B).

.... (Old oolitic limestone), + nicols, Fig. C (X 200), Fig. D (X 80).

PLATE II

A

B



C

D

EXPLANATION OF PLATE III

Photomicrographs of the Oolitic Limestone

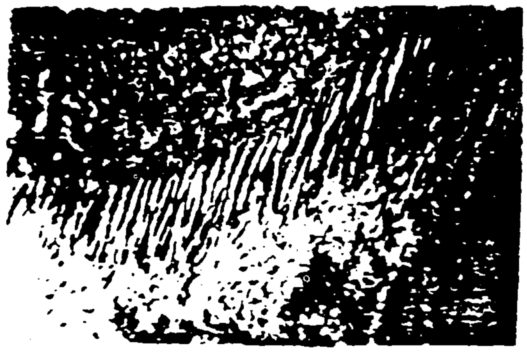
Figs. A and B- Poorly cemented limestone, acicular aragonite crystals are observed in the Pelecepods debris, some superficial oolites are also noticed.

Fig. A- Young ridge, + nicols, X 80
Fig. B- Old ridge, + nicols, X 200.

Figs. C and D- Good cemented limestone, notice the oolities and the fossils debris.

PLATE III

A



B

C

D