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Comparative study between zircons from the Rosetta beach sand and wadi al arish, Egypt

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ABSTRACT

A comparative study between the zircons of Wadi Al Arish and beach sand from the placer deposits along the Mediterranean costs of Egypt (Rosetta) was done. More than two hundred zircon grains from each area were examined. The different features of zircon including; typology, internal structures, inclusions and EDX analyses were investigated.

The microscopic investigation revealed that zircons from wadi Al Arish are markedly coarser than zircons from the Rosetta beaches. Zircons from Al Arish area have high elongated with pencil like crystals and typically displaying oscillatory concentric zoning. These zircons were probably derived from an igneous source. On the other hand, the zircons from Rosetta have moderate elongation, weakly zoned, homogeneous or patchy, this indicates that they were derived from a metamorphic source.

The grain size, typological distribution, inclusions and mineral associations clearly discriminate between zircon from the Rosetta beaches and Wadi Al Arish. These phenomena leads us to the conclusion that Wadi Al Arish is the main source for the placer deposits in Al Arish coastal area while beach zircon may be attributed to upper reaches of Nile. Zircons from both areas show the imprints for their provenances from host rocks. Granitoid rocks in southern Sinai are the main source for zircon of Al Arish, while the metamorphic zircon represents considerable amount in the Nile sources especially the Blue Nile.

KEYWORDS

Zircon including;
Typology;
Internal structures;
Inclusions and EDX
analyses were investigated.

INTRODUCTION

It has been established that the heavy minerals in the northern beach sands along the Egyptian Mediterranean coast, extending from Rafah to the east till Abu Quir in the west including Rosetta, Baltim, Gamassa and Damietta can be considered as forming economic placer deposits (Figure 1).

The beach deposits along the north Sinai at Mediterranean coast from El Bardwell Lake to Ghaza are due to the eastward drifted Nile sediments by Mediterranean long shore currents with additions of local material by torrents coming from the south especially those passing through Wadi Al Arish[21]. El-Shazly et al. (1982) mentioned that the beach sediments in El Massaid area west of Al Arish are derived from either the drifted Nile sediments or by Wadi Al Arish floods during rainy seasons. The black

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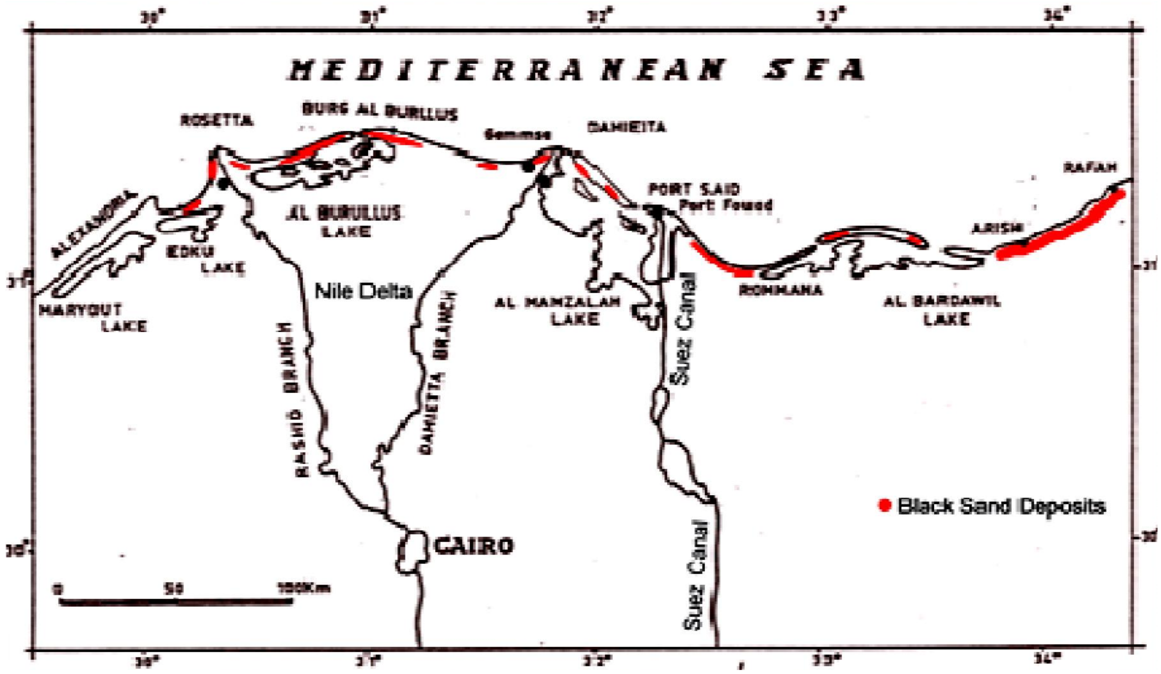

Figure 1 : Location map of the study area showing the location of the main black sand deposits

sand include zircon on the other sides of the mouth of the Nile near Rosetta and Damietta were derived originally from the disintegration of rocks especially in the upper reaches of the nile and carried by Nile waters then deposited at the Mediterranean coast.

Zircon is one of the common economic heavy minerals in these beach placers as well as in the coastal sand dunes. Generally, zircon is used as discriminant marker of the source-rocks since, in most igneous rocks; it crystallizes with specific morphological and chemical characteristics that remain unchanged during sedimentary processes[14]. Furthermore, zircon is a ubiquitous accessory mineral that forms in a wide range of geologic environments and rock types. Identifying the origins of detrital zircons requires the recognition of characteristics that are useful for discriminating between different petrogenetic environments. The most common primary occurrence of zircon is igneous rocks of acidic and intermediate compositions. Zircon can precipitate, dissolve, or recrystallize during metamorphic and/or hydrothermal processes[9], and can survive many cycles of melting and precipitation.

The typological and geochemical characteristics of zircons from igneous metamorphic and sedimentary rocks were first developed by Pupin and Turco (1972 a and b) and by Pupin (1980 and 1992). Zircon crystallizes in most plutonic rocks (from gabbros to granites), intermediate to differentiated lavas, and is also recrystallizes in high-grade metamorphic rocks[13]. The chemical composition, morphology and certain internal features of zircon (canaliculi, anatectic cores, overgrowths, etc.) of zircons are partly controlled by temperature, aluminium/alkali antagonism and magmatic emplacement conditions.

Many works were done on Al Arish and Nile by Al Far (1966), Shukri and Philip (1961), El Hinnawi (1964), Zaghloul and Kamel (1966), El-Shazly et al. (1981), El Balakssy (2003) and Barakat (2004). The aim of the present study is to characterize and identify the source areas of the studied zircons from Rosetta and Wadi Al Arish areas.

METHODOLOGY

Field sampling method

The collected samples were acquired by using spiral bar manually rotating for one meter depth. The samples were distributed along profiles perpendicular to the beach and the distance between them is about 10 to 15 km. Each profile includes from one to three samples. The distance between the samples along each profile ranging from 200 to 500 m. The site of each samples were determined using GPS system. The collected samples are 70 samples, 19 samples were taken from the beach, 22 samples from the coastal dunes, 29 sample from Sabkha areas. Their weight collected ranging between 10 to 15 kg.

Sample preparation and laboratory treatment

The obtained samples were dried and quartered to obtain representative parts weighting from 120 gm to 200 gm from each one. The representative samples were subjected to the decantation processes, where most of the silts and all of clay were removed. A hand magnet with suitable strength was used to separate magnetite mineral. Then the free magnetite sample was subjected to the conventional heavy liquid separation using bromoform (sp. gr. of 2.85 gm/cm^3). The heavy part was subjected to the magnetic fractionation using the Frantz Isodynamic Magnetic Separator (0.2A, 0.5A, 1.0, A, 1.5A). Portions of these separated zircons were further purified under the binocular microscope and studied under the polarizing microscope. Zircon grains were sized using +100 μm sieve size grains were mounted in epoxy resin, polished and etched with HF to show internal structure. Zircon internal structures were also investigated by preparing a polished thin section and carefully examined under the Environmental Scanning Electron Microscope (ESEM) using Philips apparatus model XL, 30. All analyses were achieved in the labs of the Nuclear Materials Authority (NMA).

3-Morphological studies

There is a close relation between zircon morphology and the petrogensis of enclosing rocks[14, 15, 18], while others suggests that morphology of zircon is related to physical and chemical conditions of the magma[22, 3]. The characteristics features comprise the crystal form, colors, shape, inclusions, overgrowth, zoning, fracture, and elongation.

Color of zircon

Generally, two main types of the zircon were identified, the colorless and the colored zircons. The colorless zircon is more frequent in the non-magnetic fraction at 1.5A. The first type is called water clear zircon while the second type of zircon is colored and rare or slightly encountered in the magnetic zircon. Their colour varies from yellowish, purple and cloudy zircons.

Al Arish Zircon display color ranges from purple to pinkish (Figures 2A, B and C). Only some samples contain the colorless grains (Figure 2A). On the other hand, Rosetta zircons mostly range from colorless to pale pink (Figure 2B, D, E and F). El Hannawi (1964) reported that, the colorless zircon is less radioactive than the colored ones. The trace elements are more enriched in the colored zircons which have high Hf/Zr ratio and Th and U contents.

Shape of zircon

The studied Al Arish zircons are classified according to its crystal dimensions and in turn the environmental conditions affecting the shape of the crystals, into three groups. The first group is characterized by strongly elongated (representing the original crystal (Figure 2A). The second group is characterized by moderately elongated crystal (Figure 2B) (referring to gentle environmental affecting conditions). The third group is characterized by rounded equi-dimensional (Figure 2C), referring intrusive conditions. The euhedral forms are essentially the result of mineral growth in a space that is occupied by melt and that they achieve their saturation in a relatively early stage of the crystallization history.

On the other hand, Rosetta zircons form subhedral elongated crystals (Figure 2D), surrounded and angular grains of zircon most often occur. Rosetta grains can be classified into four groups. The first group is characterized by needle form if compared to the Al Arish zircon (Figure 2D) representing the original form. The second and the third groups are moderately and slightly elongated with variable degrees of deformation (Figure 2E). The fourth group is characterized by equi-dimensional and rounded crystals (referring to intrusive condition of deformation (Figure 2F). The majority of Rosetta zircon behaves as nonconductors, diamagnetic, prismatic to elongated shapes with inclusions of different colors, shapes, types, and arrangement.

Inclusions

Inclusions are one of the characteristics features of zircon. These inclusions can be detected under the transmitting polarizing light microscope. The nature and type of some of these inclusions were identified under the ESEM. Apatite (Figures 3A&B),), barite (Figures 3C&D). Baddeleyite (Figures 3E&F) and zirconium-rich ilmenite are com-

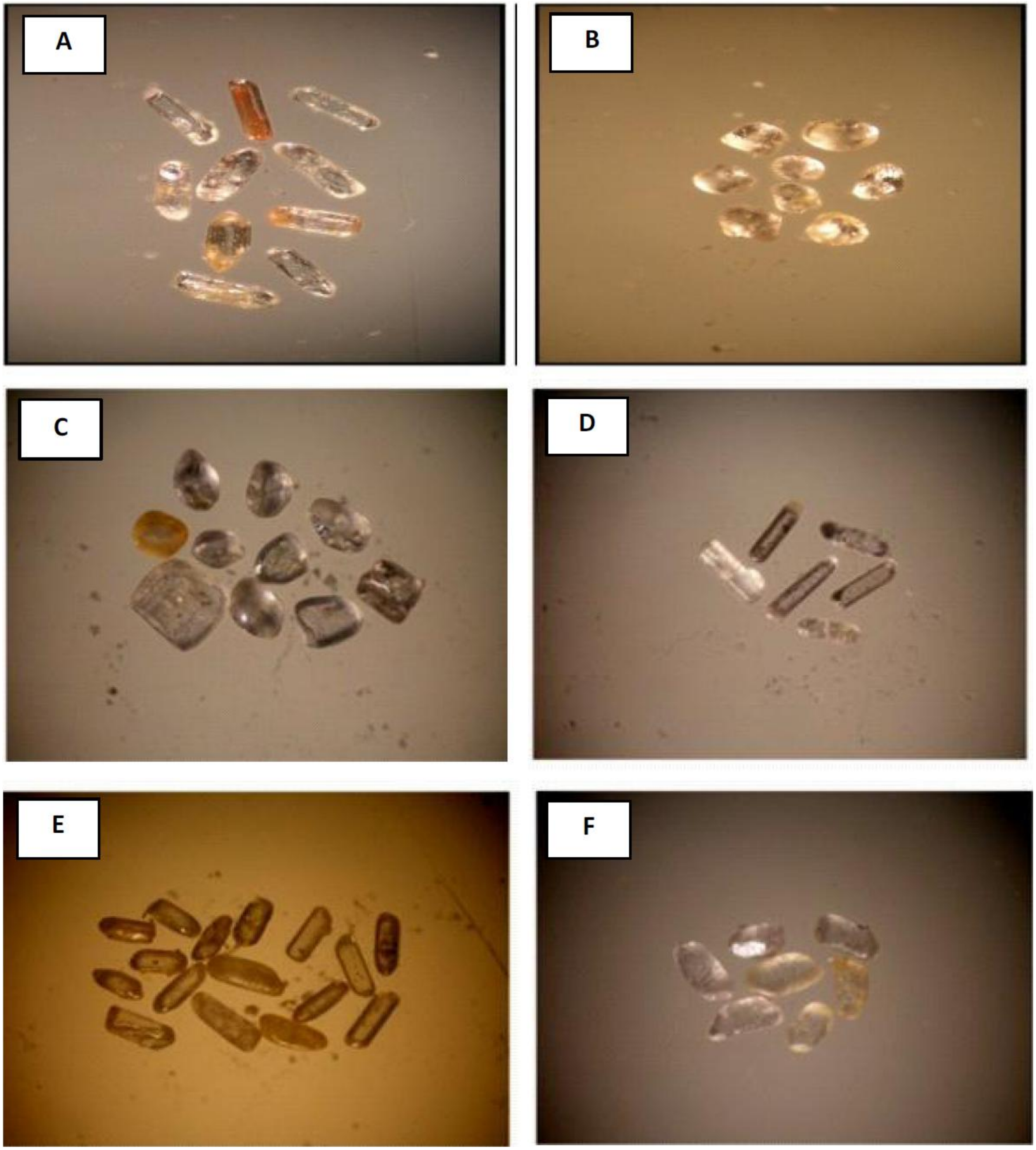

Figure 2 : Color and grain size of El arish and rosetta El Arish- A, B and C. Rosetta- D, E and F.

monly associated with Rosetta zircon. Uranothorite and silica are common inclusions within Al Arish zircons (Figures 3G&H), while rutile (Figure 4A), and iron (Figure 4B) are the dominant inclusions within the Rosetta zircon.

Over growths, zoning and fractures patterns

Overgrowths are observed in zircons separated from Al Arish and Rosetta zircons (Figures 4C and D) respectively. Overgrowths may be due to magmatic crystallization or may be due to alpha decay radiation[1]. Another form of growth is termed parallel growth. In such parallel growth, two zircon crystals are in parallel contact showing essentially parallel extinction. The formation of parallel growth

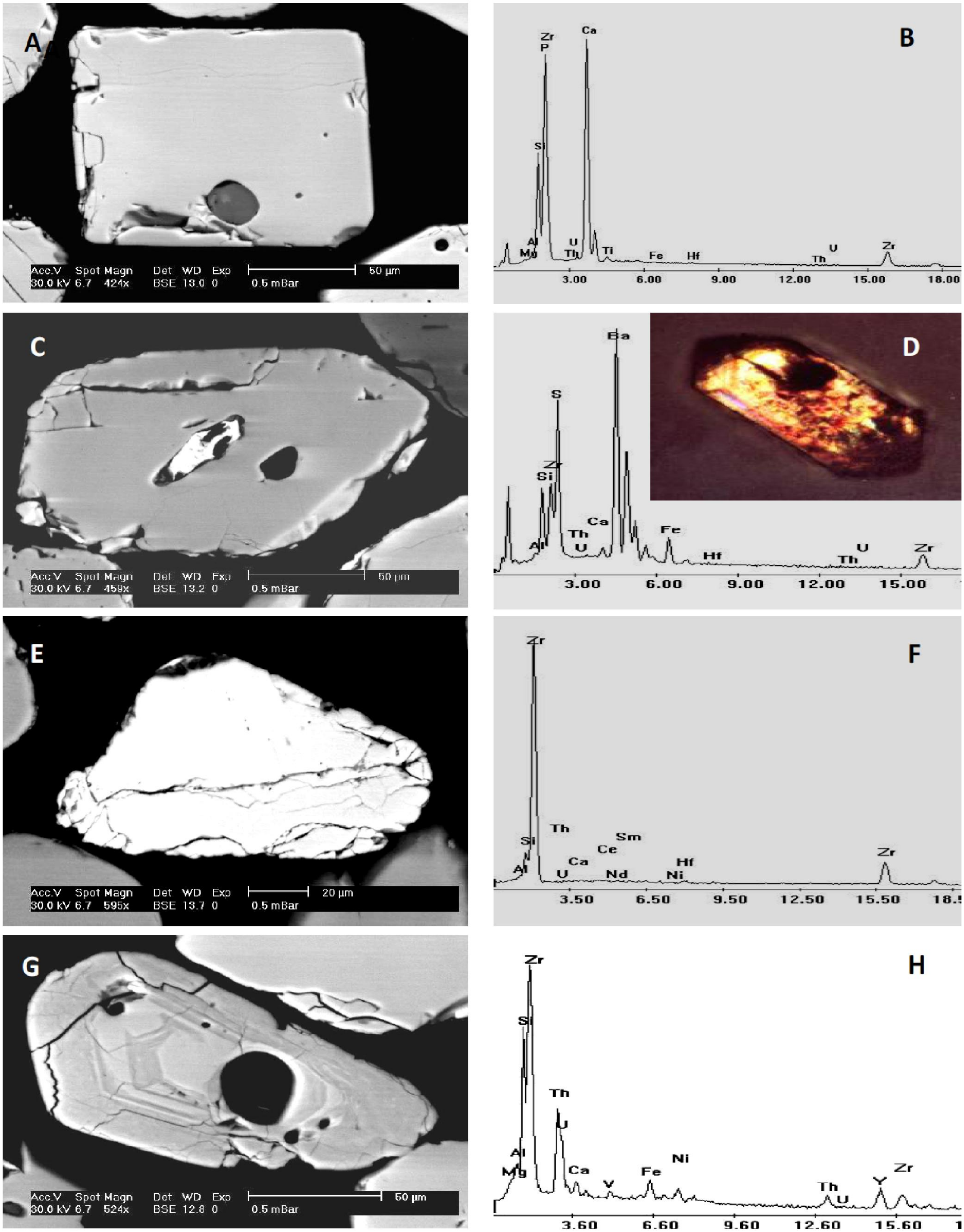

Figure 3 : Inclusions in zircon; A&B-Inclusion of apatite in zircon of El Arish; C&D- Inclusion of barite in zircon of El Arish; E&F- Inclusion of Baddeleyite in zircon of Rossetta; G&H- Inclusion of uranothorite in zircon of El Arish

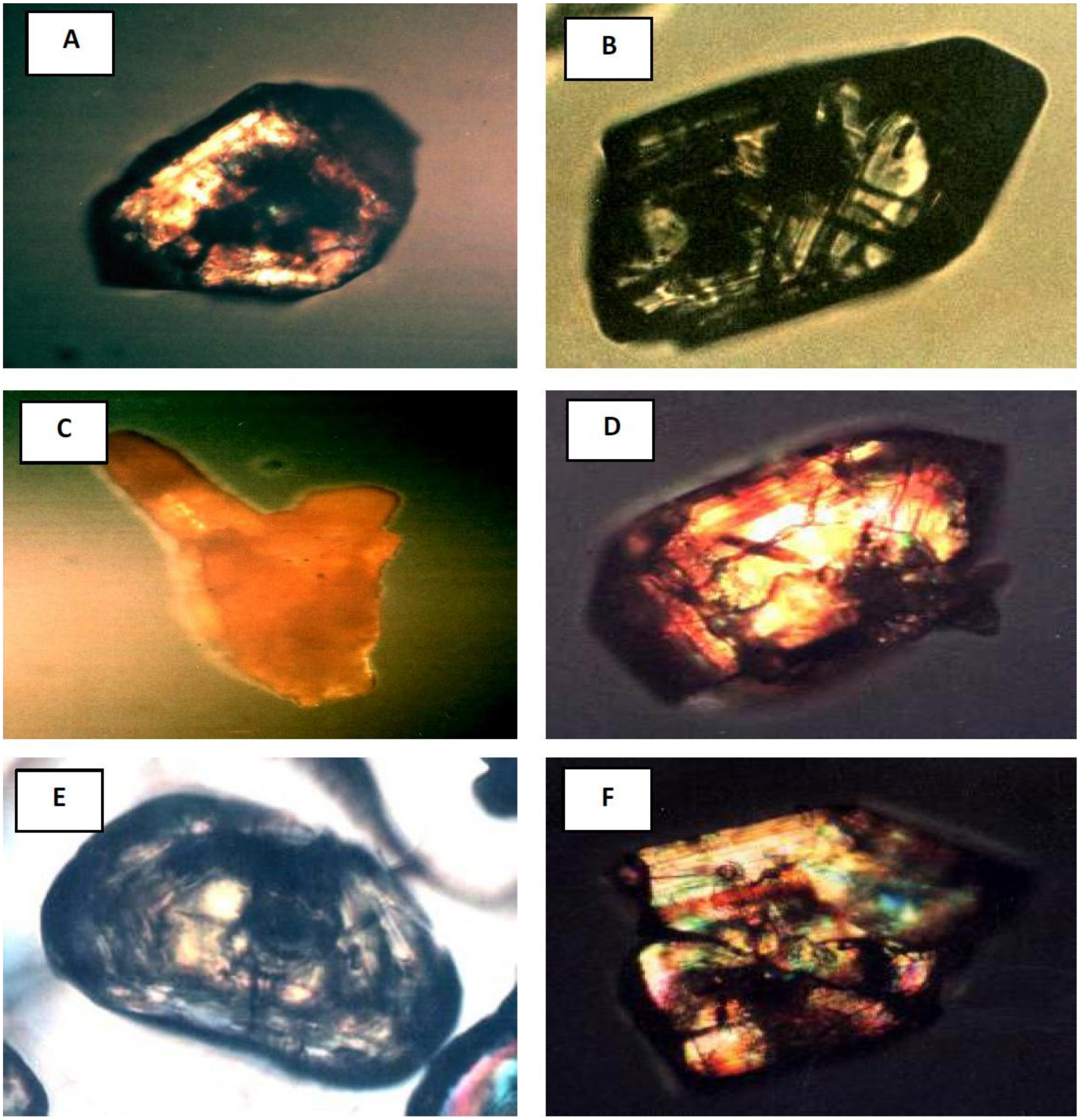

Figure 4 : A-Metamicted core zircon) Rutile inclusion in zircon) in Rosetta, B-Opaque inclusion in zoned zircon alteration, Rosetta; C- Outgrowth zircon, Rosetta; D- Outgrowth zircon, El Arish; E-Zoned zircon from Rosetta; F- Regular zoning in pure zircon of El Arish

suggests that zircon crystals crystallized early from a melt of growing zircon.

Zoning is a rather common feature in the zircon separated from Al Arish and Rosetta zircon (Figures 4E &F) respectively. It is clear that the zoning is more abundant in the dark zircon variety. Some of the grains are clearly zoned, but some others show no visible zoning. The oscillatory concentric zoning is more common in Al Arish zircon, and some of the zircon crystals from Rosetta containing uranothorite inclusion exhibit some radial fractures that may be ascribed to differential expansion of the main mineral constituents caused by metamictaization (crystal damage) (Figures 5A-F).

Elongation ratio (L/B) of rosetta and al arish zircon

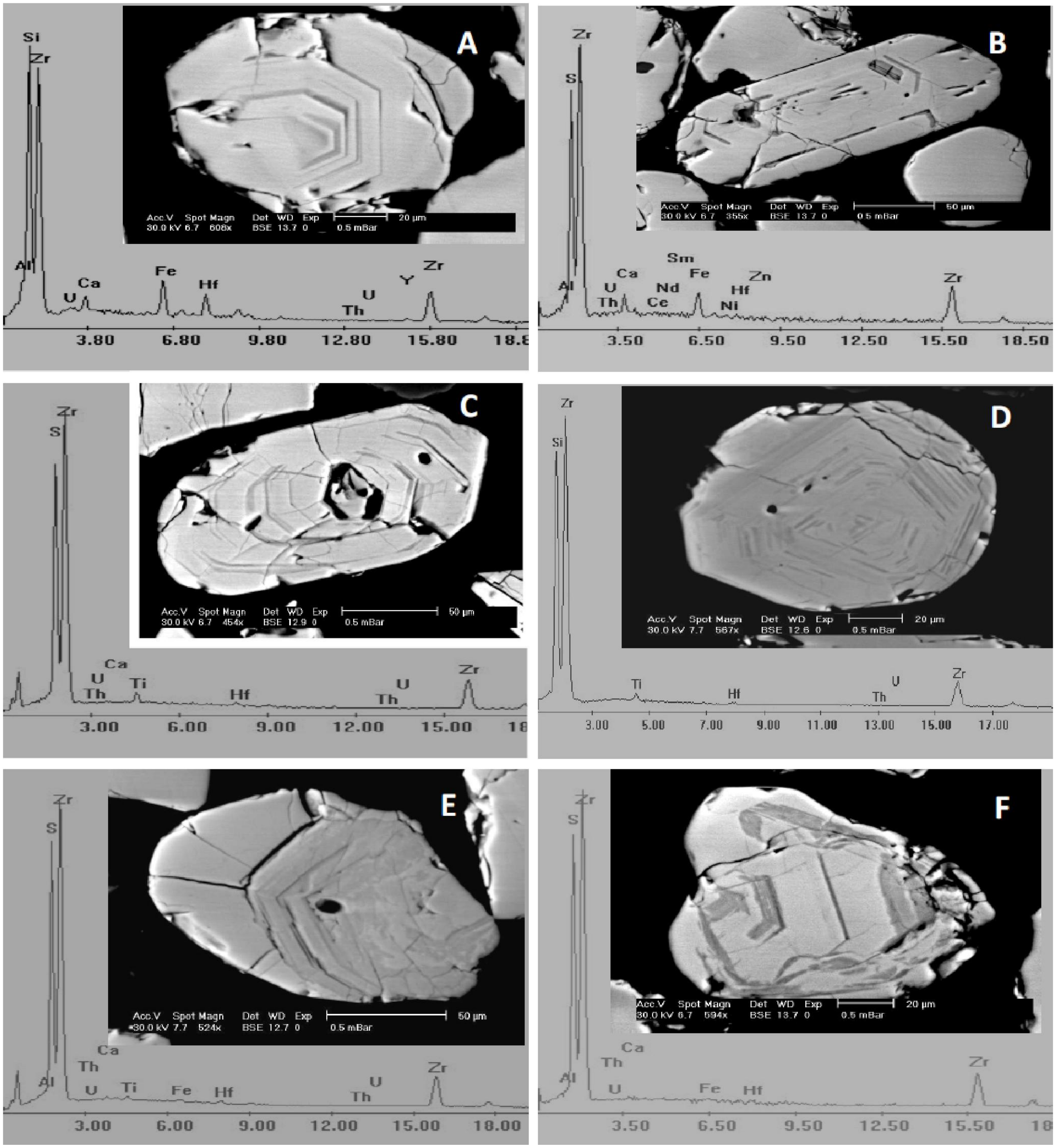

Figure 5 : EDX and BSE images showing the different verities of zircon; A-: Hf-rich Rounded zoned zircon (show concentric zoning) Rosetta; B-: Elongated zoned zircon of Rosetta; C-: Elongated zoned zircon of El Arish; D-Regular zoning in pure zircon El Arish; E- Radiated fracture in zoned zircon Rosetta; F- Cracked zoned zircon El Arish

The elongation ratio (L/B) and the shape of particles are two important factors in their hydraulic equivalence. This ratio for the Egyptian beach zircon was previously measured by El Hinnawi (1964), El Shazly et al. (1980) and El Balakssy (2003). The preceding prepared slides for the grain size classes were used in the measurements of the length and breadth randomly selected zircon grains. The length and breadth of about 200 zircon grains in each slide were measured which are statistically sufficient. The elongation ratio (L/B) was calculated for all measured particles. The minimum, maximum and aver-

TABLE 2 : Frequency of the three types of zircon in rosetta and al arish

Sediment	Al Arish			Rosetta		
Elongation ratio	Low elongated <2	Moderately elongated 2-4	Highly elongated > 4	Low elongated <2	Moderately elongated 2-4	Highly elongated >4
Frequency %	29.3	53.4	17.3	25.5	65.8	8.7

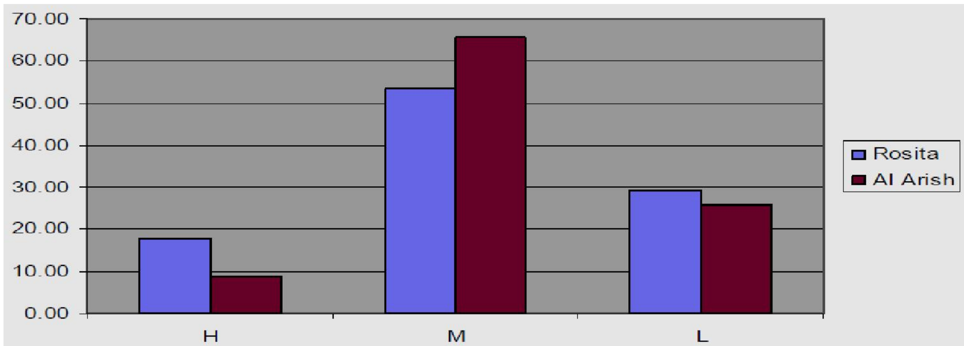

Figure 6 : Distribution of length, breadth and elongation of zircons from Rosetta and Al Arish black sands

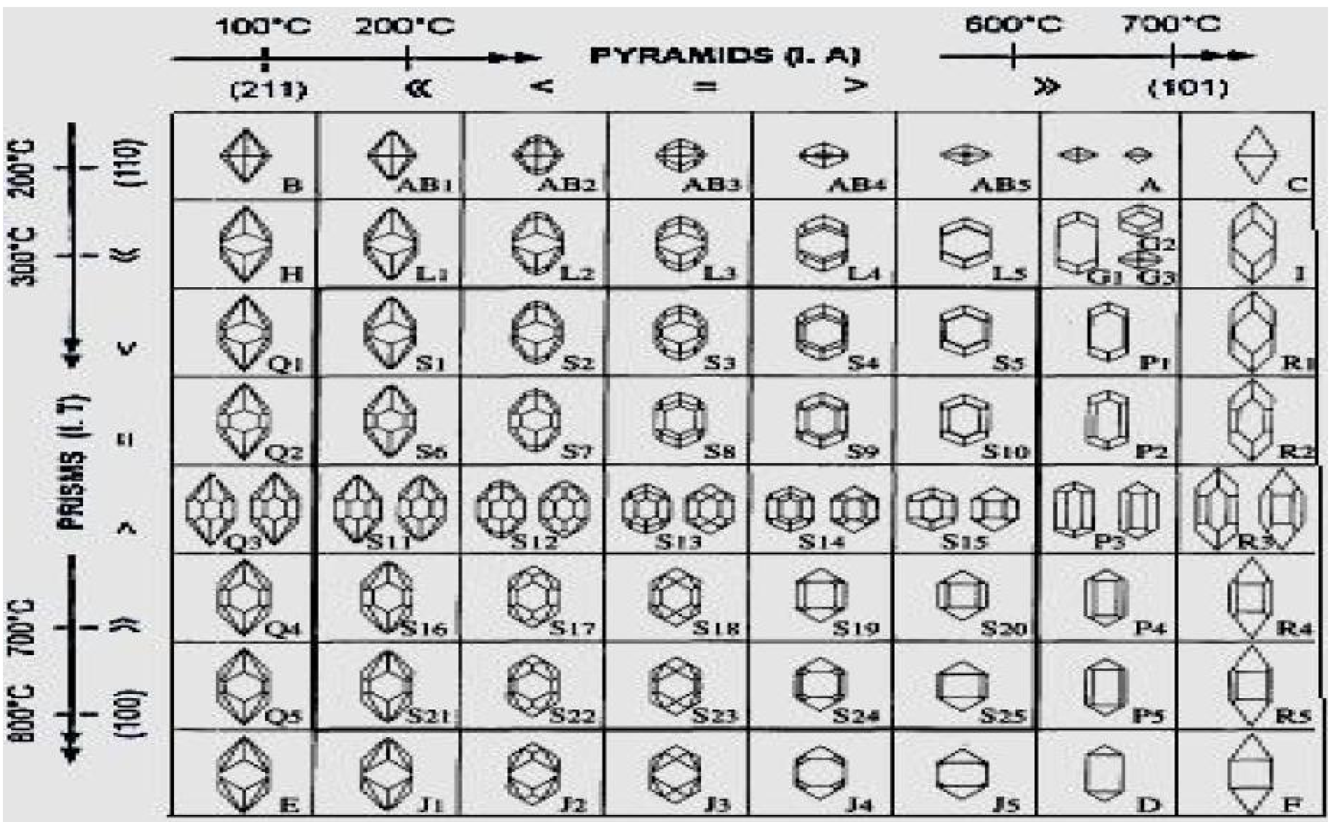

Figure 7 : Zircon typological classification and corresponding geothermometric scale proposed by pupin (1980)

age of the elongation ratio (L/B) in the different grain size classes of Rosetta and Al Arish zircon are given in TABLE (2).

Zircons from Rosetta have moderate elongation (TABLE 2 and Figure 6), weakly zoned, homogeneous or patchy, this indicates that they were derived from a metamorphic source[22, 20]. El Hinnawi (1964) studied the zircon characters from Rosetta beach and mentioned that the zircon grains are generally moderately elongated (84%) while the slightly elongated and the highly elongated zircon are 9.4% and 6.2% respectively branch to El Farama area. On the other hand, the zircons from Al Arish area show pencil like crystals with some crystals showing slight roundness i.e., Idiomorphic or slightly rounded and typically displaying oscillatory concentric (Figures 6 f) zoning. These zircons were probably derived from an igneous source[22, 20].

Frequency calculations of the (L/B) ratio (TABLE 2 and Figure 6) revealed that the Al Arish zircons are mainly higher elongation than Rosetta indicating their derivation from igneous rocks.

Zircon typology

Pupin and Turco (1972a and b) established a method for the statistical evaluation of distinct zircon crystal shape (Figure 8). This method is based mainly upon the relative sizes of two prism faces ({110} and {100}) and two pyramidal faces ({211] and {101}) respectively. The distinct crystal shape of zircon types are plotted in a typological grid commonly known as the "Pupin-diagram"[12, 14], (Figure 10). Subsequently, this approach has been applied to sedimentary and low-grade metamorphic rocks[17, 10]. The fundamental basis for the study of morphological populations in zircon was established by Pupin (1980), who argued on the basis of empirical observations that the chemical characteristics of the crystallization medium play a leading role in the relative growth of different pyramid forms. Zircon crystallized from peraluminous liquids shows well-developed {211} pyramids whereas zircon grown under peralkaline conditions has well-developed {101} pyramids; thus the Al/ (Na + K) ratio is designated 'index A' (Figure 7).

Typological analyses of studied zircon

Zircons from Al Arish are very widely spread over the diagram, the data used in plotting the fields of sub-types S12, S13, S14, S15, S18, S19, S24, S20, S25, P3 and P4 (Figure 8). They could have a plutonic or volcanic origin. However, the continuous trend toward sub-types S19 and S20 and also suggests crystallization in igneous rocks of calc-alkaline affinity.

The most satisfactory explanation for this pattern is the possible mixing between two source materials, one being volcanic and the other is of plutonic origin with calc-alkalic affinity. To summarize, the typological analysis of detrital zircons shows that a large proportion of this mineral is derived from source-rocks that could have volcanic or plutonic origin.

On the other hand, the second sub-population of Rosetta zircon, with high A and T indices, is the most abundant and is represented by sub-types P4 and P5 with some of sub-types S25 and S24 and type D (Figure 9). They probably originated from volcanic material derived from a magma of calc-alkaline affinity with a strong mantle-like component.

The development of this sub-population towards subtypes P4, P3, P2 suggests a mixing with zircons from a magma having an alkaline affinity. The contribution of metamorphic source-rocks is supported by the presence of abundant rutile crystals whose characteristics (yellow colour, rod shape, and cleavages) indicate a metamorphic origin. To summarize, the typological analysis of detrital zircons shows that a large proportion of this mineral is derived from source-rocks of volcanic and metamorphic rocks.

This distribution pattern makes it possible to distinguish two sub-populations which relate to different source types. The zircon of Al Arish contains mainly "S"-type crystals (especially the S18–S12 fields); the "P"-type crystals are missing or they have a very subordinate role. In contrast, the Rosetta zircon contains fields of various compositions, and both (the "S" and the "P"-type zircons).

SUMMARY AND CONCLUSION

Our study of zircon from Al Arish and Rosetta reveal the following:

1- Zircons from Al Arish are markedly coarser than zircons from the Rosetta, zircons of Rosetta are moderate elongated while zircons of Al Arish are high elongated.
2- Al Arish Zircon display color ranges from purple to pinkish (Only some samples contain the colorless grains) while Rosetta zircons mostly range from colorless to pale pink. According to El Hannawi (1964), Al Arish zircons have higher Hf/Zr ratio and Th and U contents than those of Rosetta zircon.
3- On the typological diagram of Pupin, two different populations can be recognized with an overlap. Al Arish zircons are concentrated in the middle of the diagram, while the Rosetta zircon tend to plot on the right side with the dominance

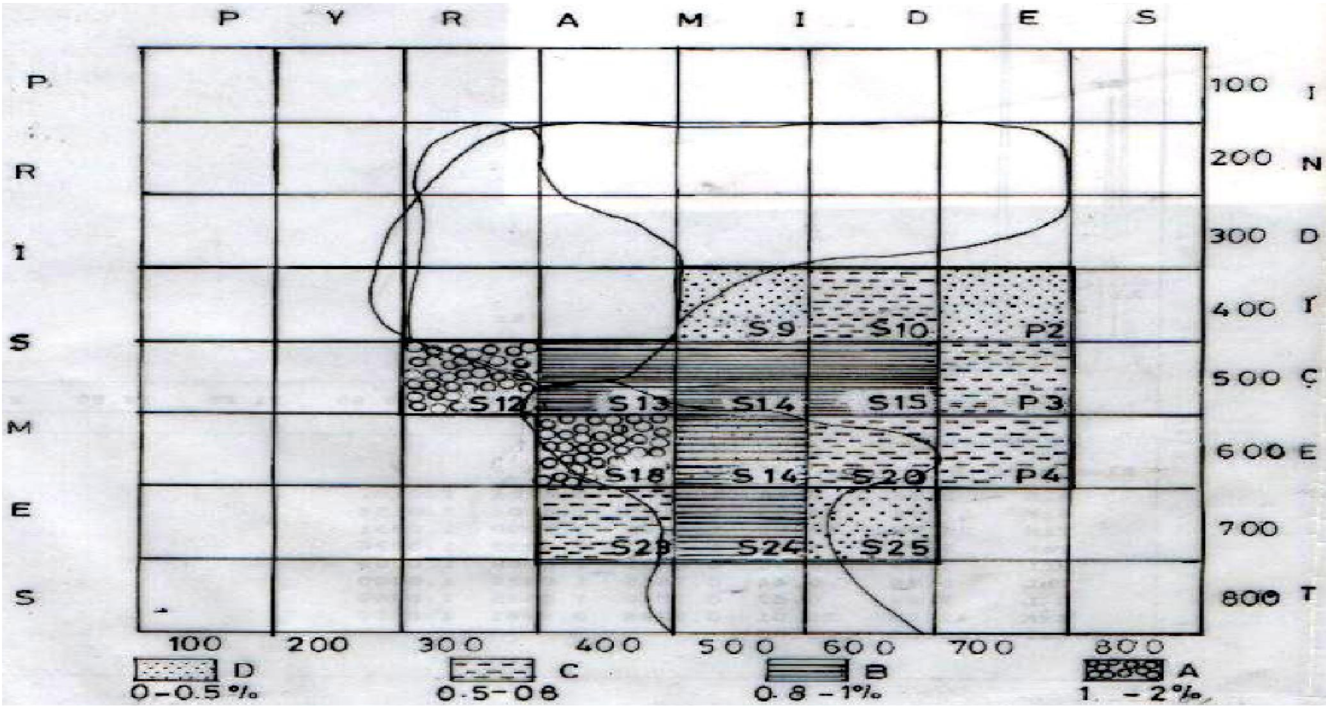

Figure 8 : The typological classification of al arish zircon (main types and subtypes) modified by pupin (1980) after pupin and turco 1972 a and b)

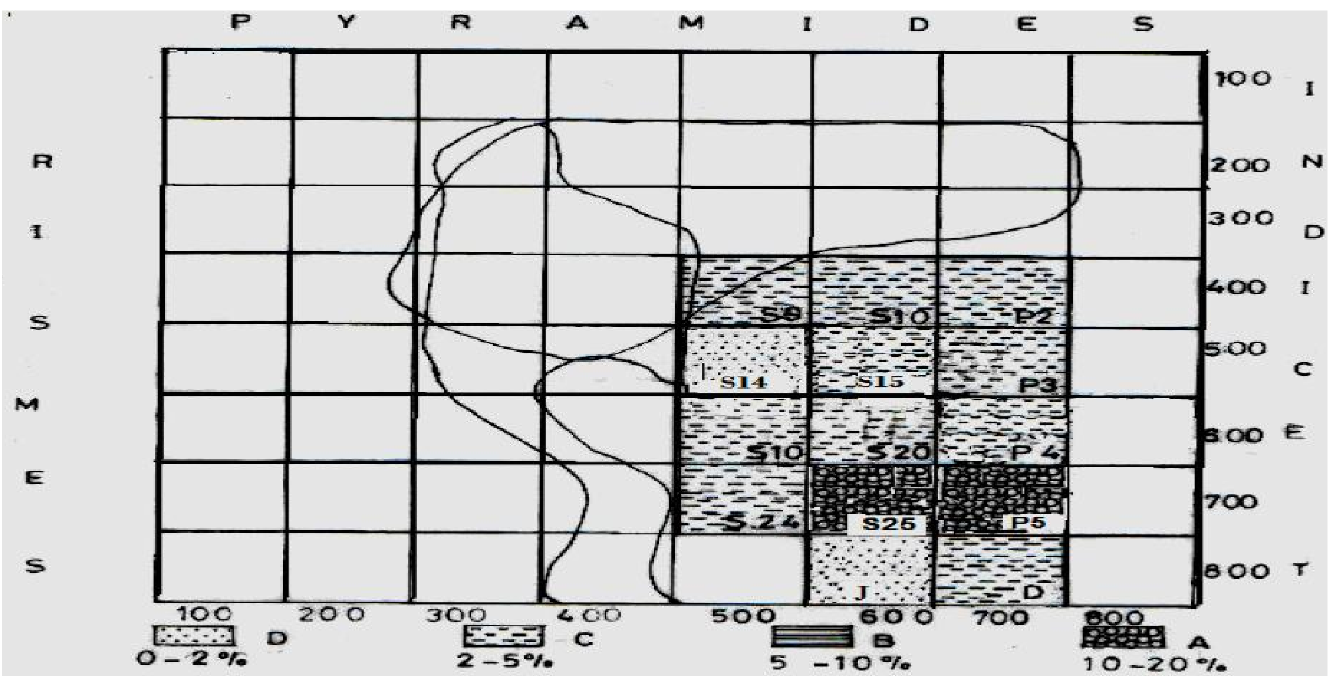

Figure 9 : The typological classification of rosetta zircon (main types and subtypes) modified by pupin (1980) after pupin and turco (1972 a and b).

of the {100} prism. This indicating that, zircons of Al Arish is derived from source-rocks that could have volcanic or plutonic origin. On the other hand, zircons of Rosetta is derived from source-rocks of volcanic and metamorphic rocks. The contribution of metamorphic source-rocks for Rosetta zircon is supported by the presence of rutile inclusions.

4- Apatite and silica are common inclusions within Al Arish zircons, while rutile, iron and titanium oxides are the dominant inclusions within the Rosetta zircons. Baddeleyite and zirconium-rich limonite are commonly associated with zircon from the Nile.

5- Granitic rocks in southern Sinai are the main source for zircon of Al Arish, while the metamorphic zircon represent considerable amount in the Rosetta especially the Blue Nile
6- These phenomena lead to the conclusion that Wadi Al Arish is the main source for the placer deposits in Al Arish coastal area while Rosetta beach zircon may be attributed to central Africa.

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