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Scientific Report on the Sand Quarry, East Abu Zeneima, South Sinai, Egypt

Introduction

The area under consideration lies south of El-Tih Plateau, where it forms a part of the pediplain surface, which extends southwards, till Gebel Elghorab.

The area is located between latitudes 29 07 7N and longitudes 33 23 45E. The area is generally accessible through asphaltic semi paved route; however some places in the route are difficult and unpaved.

Field Study

Three field trips to the area have been performed, to shed the light on the sand exposures of the quarry.

The quarry represents an ovoid hill shaped anticline, averaging 100 m length by 200 m wide. Generally the sand is semi-consolidated, occasionally hard and sometimes semi-friable.

The sandstone hill appears yellow, brownish, greyish in colour; but the upper most surface of the exposure are tarnished with iron and / or manganese stain; this latter encrustation is notably thin and can be neglected lithologically.

The exposed sandstone is thick bedded, medium to fine grained, and in some places it may render pebbly, especially in the lower most beds in the southern part of the hill. Graded-bedding and cross-lamination are the most dominant sedimentary structures recorded. The pinkish and reddish patches are sporadically observed at the top of the hill.

Of the important observations is the well-marked stratification that characterizes the lower most horizons of the exposures. These stratifications are very thin and averaging in thickness between 3 to 5 cm; but the enveloped sand grains tend to be medium to fine-grained.

It is observed that the silicified parts of the hill is restricted to the whitish or greyish variety, where it becomes harder.

A detailed contour map is constructed by using the well-known surveying technique, with G.P.S, alidade, compass, stadia and tapes; the contour interval was quite adequate to illustrate the map and to facilitate the plotting of the results of chemical analyses of the collected samples.

Geomorphologically, the surface of the mapped area is generally slopping gently. The general dip of the beds is about 10 ˚ northward.

The floor of the hill is covered by a very thin film of desert gravels and sands.

The surface of the area is surrounded by Wadi Abu Thora tributaries, where drained from El-Tih plateau and debouched its load into the Gulf of Suez in the west. One of the tributaries of Wadi Abu Thora cuts through the southeastern part of the area under investigation, where forms a subdued scarp rising about 10 m above the wadi floor, and continues towards northeast, where it is twisted due north and then died out.

Few rills are dissecting the surface of the study area. In general, the highest point has an elevation is 520 m above sea level (asl). The elevation decreases northeast, where it attains 511 m (asl).

One of the interesting field observations is the occurrences of hard ferruginous sandstone dykes cut the surface of the mapped area, where stands one meter above the surrounding surface with one meter width and more or less 10 m length. These dykes fill the NNE - SSE and N-E fissures.

Stratigraphy

The considered area is nearly covered by 10 m thick sandstone section, where it is composed of dazzling white hard quartzitic, structurless (rarely) sands and in some places alternate with hard thin lamina of ferruginous, tabular planar and cross-bedded sandstones.

The exposed section belongs to the Carboniferous time (Paleozoic), this is based on the plant fossils as *Lepidodonderon Volcamanianum.*

Sampling

A: Surface Sampling

Twenty six surface samples representing all the possible varieties of the exposed sands were carefully collected. Samples 1–17 were collected from the northeastern scarp overlooking the wadi floor, while samples 18–26, were collected from the western ridge and the slopes bounding the area from the west.

B: Bore hole Sampling

Nine bore holes were excavated on the top of the surface of the area, by using a bore–hole driller. The boring was designed to reach 15 m. depth, one sample was collected each one meter interval. Six bore holes are located around the northern triangulation point (520 m asl), while the other three bore holes were dug around the southern triangulation point (518 m asl),

From each bore hole drilled, 15 samples were collected, washed thoroughly and packed for further investigations.

Grain Size Analysis

The results of grain size analysis for 15 samples representing all the possible varieties of the investigated sandstones from bore holes Nos. 8, 9, 15, 23 and 26. The selected samples chosen for mechanical analyses are at a well-designed pattern, i.e., at 1m depth, 7m and 14m depth (fore bore holes 8, 9 and 15). For bore hole no. 23, the samples were taken at depths 1, 7 and 15m., and for bore hole no. 26, the samples were collected from depths 1, 8 and 15 m.

Disaggregation of samples and removal of carbonates and iron oxides were done using stannous chloride and hydrochloric acid (Folk, 1968). A representative sample weighting 50 gm was taken from each sample by quartering and was subjected to grain size analysis. The size analysis was carried out using a selected set of six standard screens; according to the Wentworth Grade Scale having aperture diameters of 2.0, 1.0, 0.5, 0.25, 0.125 and 0.063 mm, respectively. The sieves were arranged in a descending order with a receiver under the lower screen. The set of screens shook for 30 minutes, using a vibrating automatic shaker. The retained weights on the different screens and in the receiver were weighted and their frequencies were calculated, and graphically represented by histograms. The obtained frequencies for each sample were cumulated and the cumulative curves were drawn.

The histograms display the modal class of the grain size distribution as well as the fine and coarse admixtures. The different percentiles were obtained in phi units from the cumulative curves using the phi scale. The four different sedimentological statistical parameters namely: the graphic mean (Mz), the inclusive graphic standard deviation (σ1), the inclusive graphic skewness (Ski), and the graphic kurtosis (Kg) were calculated for each sample, according to the equations quoted by Folk and Ward (1957) as follow:

Graphic Mean:

$$(M_z) = (\Phi_{16}+\Phi_{50}+\Phi_{84})/3$$

Inclusive Graphic Standard Deviation:

$$(\sigma_1) = [(\Phi_{84}-\Phi_{16})/4] + [(\Phi_{95}-\Phi_5)/6.6]$$

Inclusive Graphic Skewness:

$$(Sk_i) = [(\Phi_{16}+\Phi_{84}-2\Phi_{50})/2(\Phi_{84}-\Phi_{16})] + [\Phi_5+\Phi_{95}-2\Phi_{50})/2(\Phi_{95}-\Phi_5)]$$

Graphic Kurtosis:

$$(K_G) = (\Phi_{95}-\Phi_5)/2.44(\Phi_{75}-\Phi_{25})$$

The calculated grain size statistical parameters for the sand size fraction of the studied sediments are classified according to the limits given by Folk and Ward (1957), these limits are:

The graphical mean (M_z):

The very coarse sand is from –1.0 Φ to 0.0 Φ

The coarse sand is from 0.0 Φ to 1.0 Φ

The medium sand is from 1.0 Φ to 2.0 Φ

The fine sand is from 2.0 Φ to 3.0 Φ

The very fine sand is from 3.0 Φ to 4.0 Φ

The inclusive graphic standard deviation (σ_1):

The very well sorted sand <0.35 Φ

The well sorted sand 0.35 Φ to 0.50 Φ

The moderately well sorted sand 0.50 Φ to 0.71 Φ

The moderately sorted sand 0.71 Φ to 1.00 Φ

The poorly sorted sand 1.00 Φ to 2.00 Φ

The very poorly sorted sand 2.00 Φ to 4.00 Φ

The extremely poorly sorted sand >4.00 Φ

The inclusive graphic skewness (Ski):

The strongly fine skewed sand from 1.0 Φ to 0.3 Φ

The fine skewed sand from 0.3 Φ to 0.1 Φ

The nearly symmetrical sand from 0.1 Φ to –0.1 Φ

The coarse skewed sand from –0.1 Φ to –0.3 Φ

The strongly coarse skewed sand from -0.3 Φ to -1.0 Φ

The inclusive kurtosis (KG)

The very platykurtic sand <0.67 Φ

The platykurtic sand from 0.67 Φ to 0.90 Φ

The mesokurtic sand from 0.90 Φ to 1.11 Φ

The leptokurtic sand from 1.11 Φ to 1.50 Φ

The very leptokurtic sand from 1.50 Φ to 3.00 Φ

The extremely leptokurtic sand from >3.00 Φ

As seen from the data given and represented on histograms and size frequency distribution curves, these sands are generally fine to medium grained, moderately well-sorted to well sorted. Regarding skewness, they tend to be coarsely skewed (tending to fine-sized) and generally they are classified as mesokurtic.

These features of sedimentologic aspects and grain–size characteristics allow to design and classify these sands very suitable for glass industry of the high grade (this is also supported from the scanning electron microscopic study and chemical analyses, see later).

Scanning Electron Microscopy Studies

Selective samples from the drilled bores were collected at different depths and prepared by the conventional method to be examined under the scanning electron microscope.

The images revealed that these sands are highly siliceous (having a high silica content). The carbonate minerals are very rare and can be considered negligible. The clay minerals are generally authigenic and do not play any role in the sand grade.

The iron minerals are represented mainly by hematite (in industrial beneficiation it is easily removed).

These features are clearly seen in the SEM photographs.

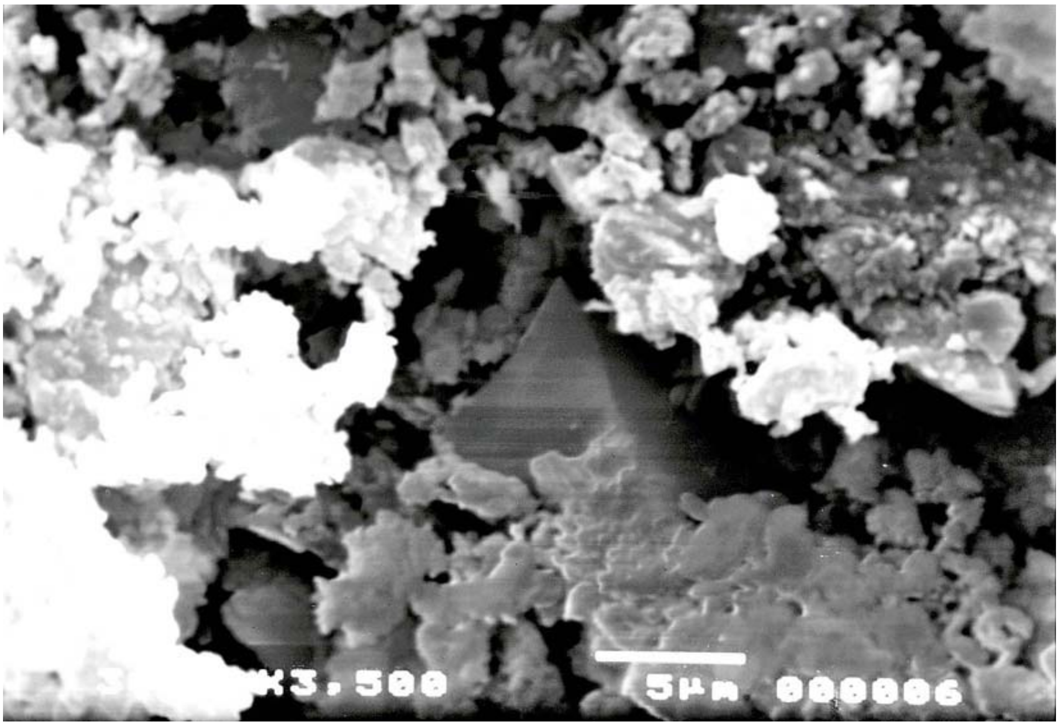


Fig. 6: SEM micrograph showing quartz overgrowth and infiltrated clays. BH-9, Depth (7 m).

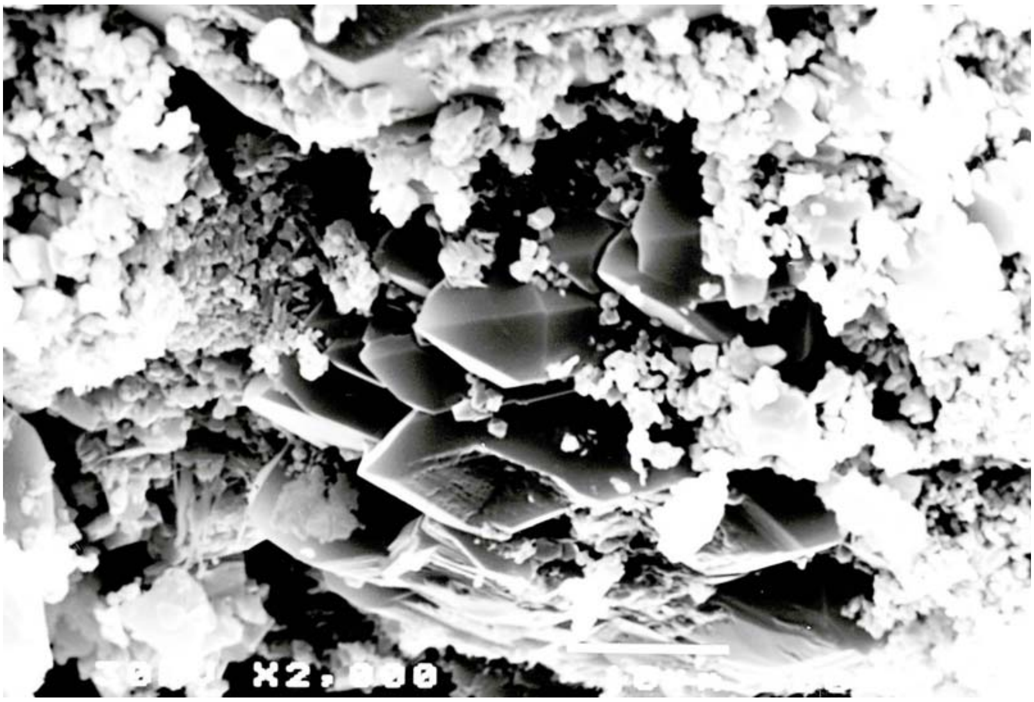


Fig. 7: SEM micrograph showing quartz overgrowths having perfect crystal faces. BH-9, Depth (7 m).

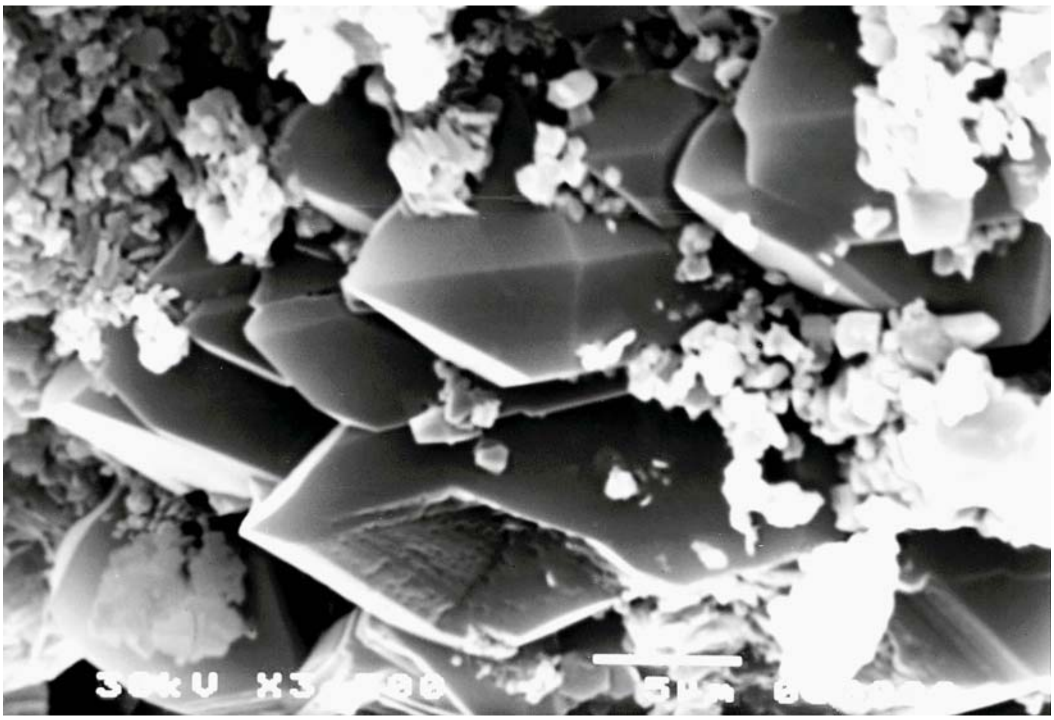


Fig. 8: SEM micrograph showing quartz overgrowths having perfect crystal faces. BH-9, Depth (7 m).

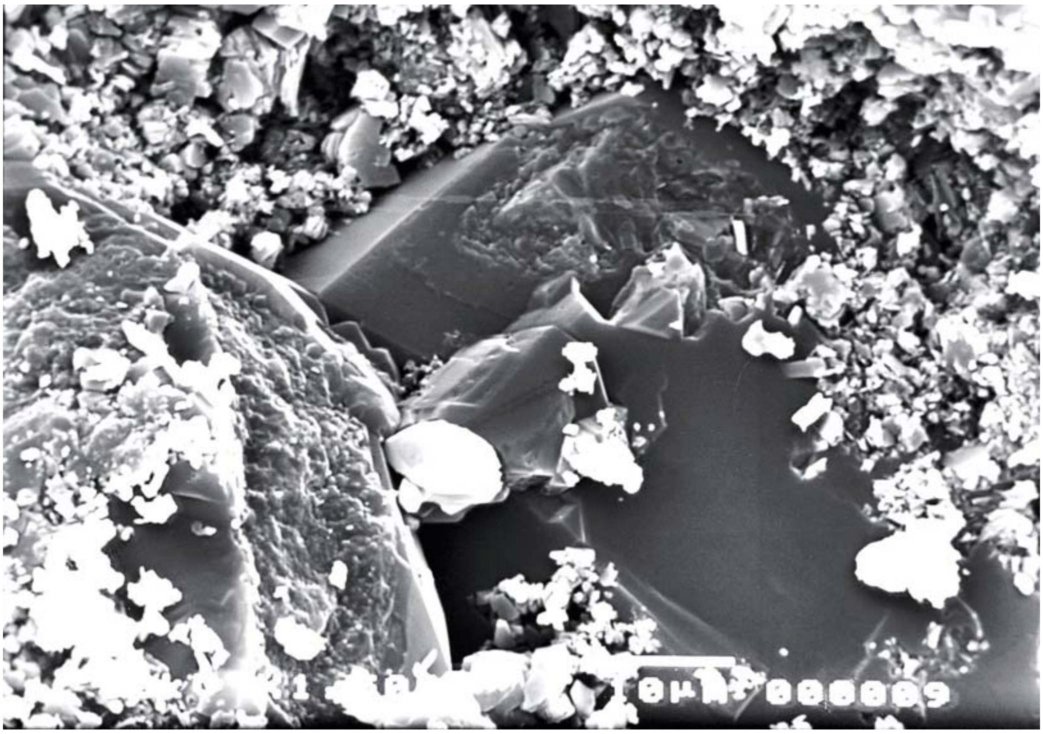


Fig. 9: SEM micrograph showing quartz overgrowth and detrital clays. BH-9, Depth (7 m).

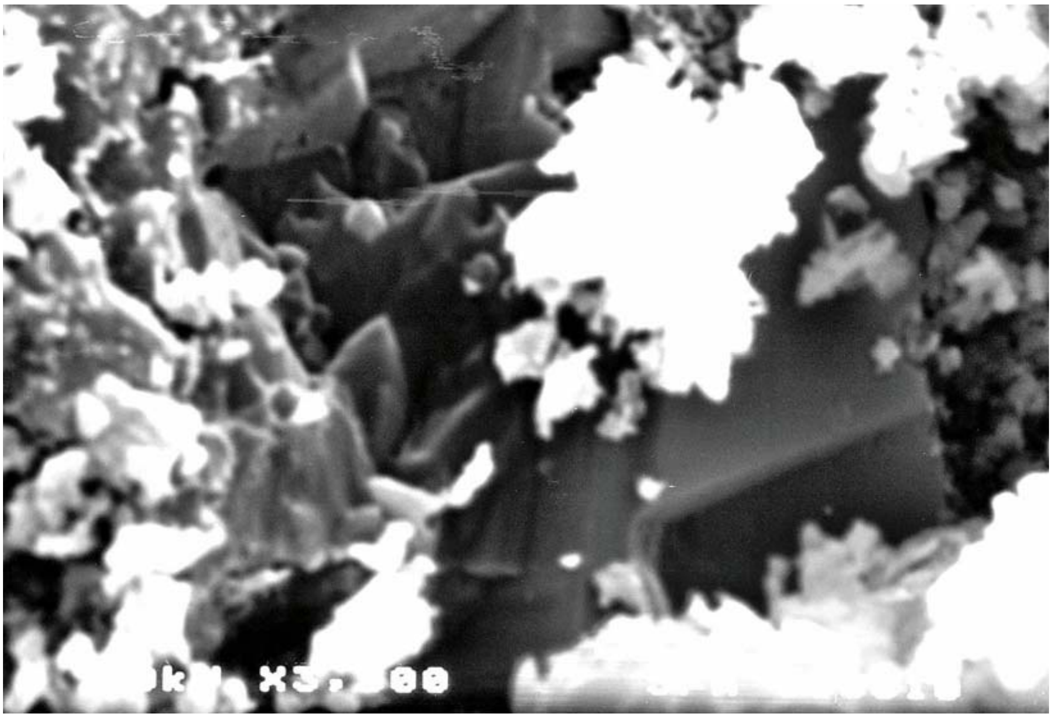


Fig. 10: SEM micrograph showing quartz overgrowth and detrital clays. BH-9, Depth (7 m).

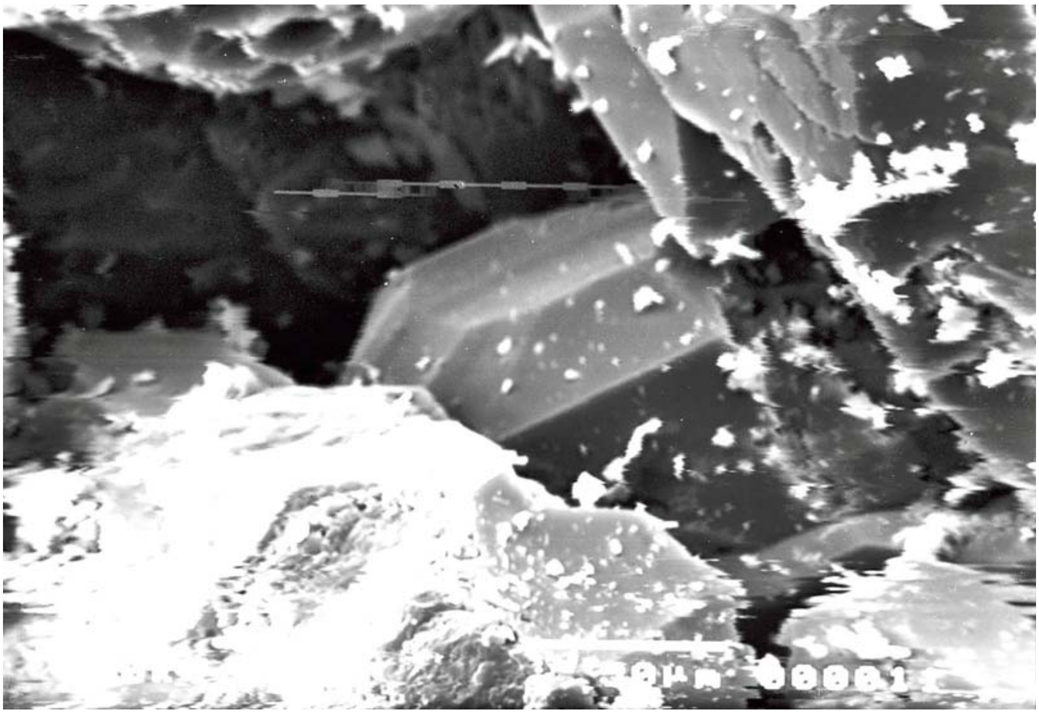


Fig. 11: SEM micrograph showing quartz overgrowth. BH-15, Depth (14 m).

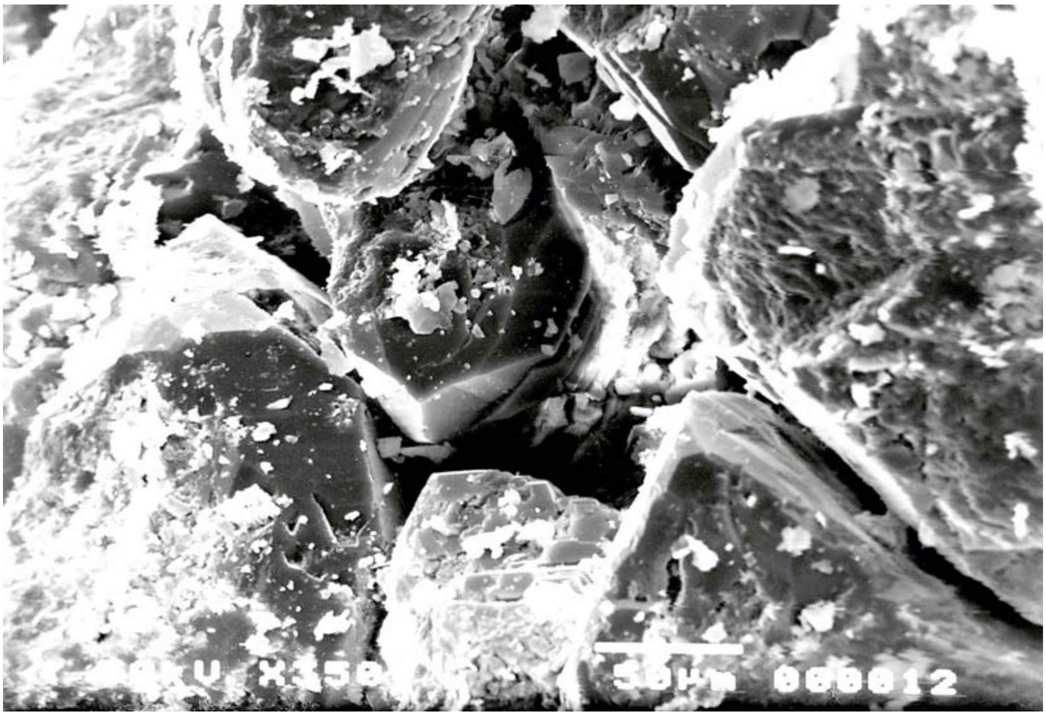


Fig. 12: SEM micrograph showing dissolution on quartz overgrowth. BH-15, Depth (14 m).

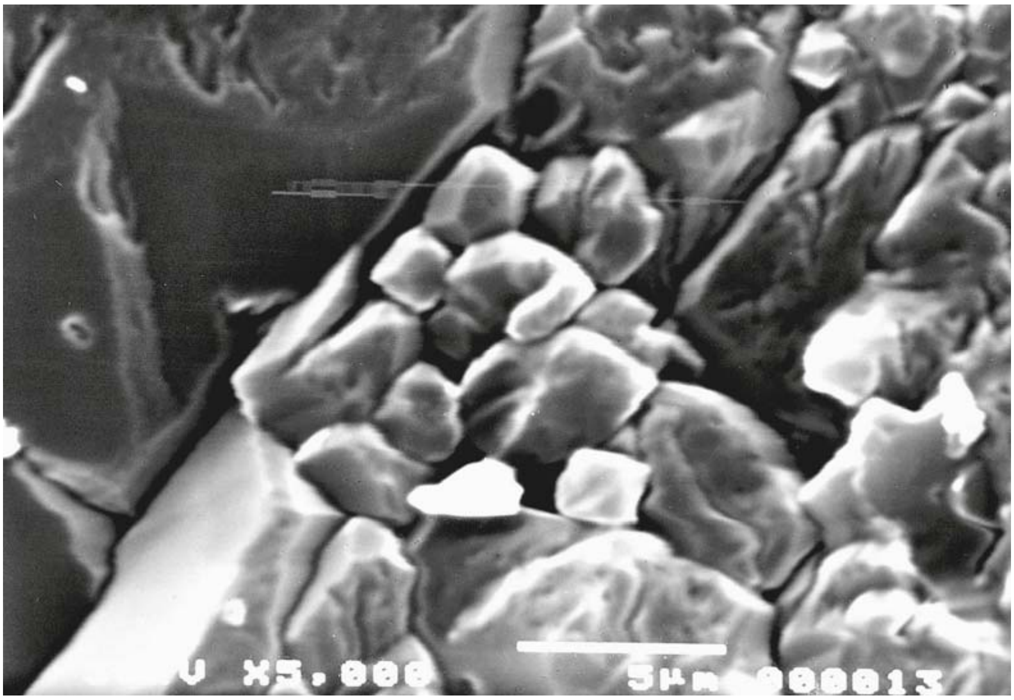


Fig. 13: SEM micrograph showing microcrystalline quartz. BH-15, Depth (14 m).

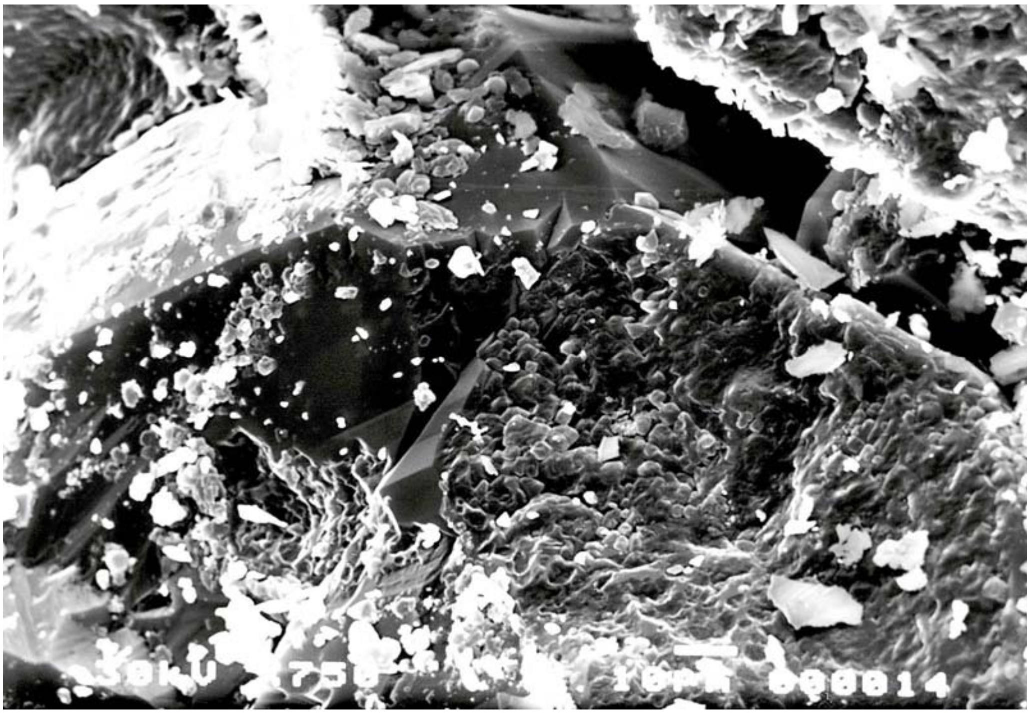


Fig. 14: SEM micrograph showing quartz overgrowth coated with microcrystalline quartz. BH-15, Depth (14 m).

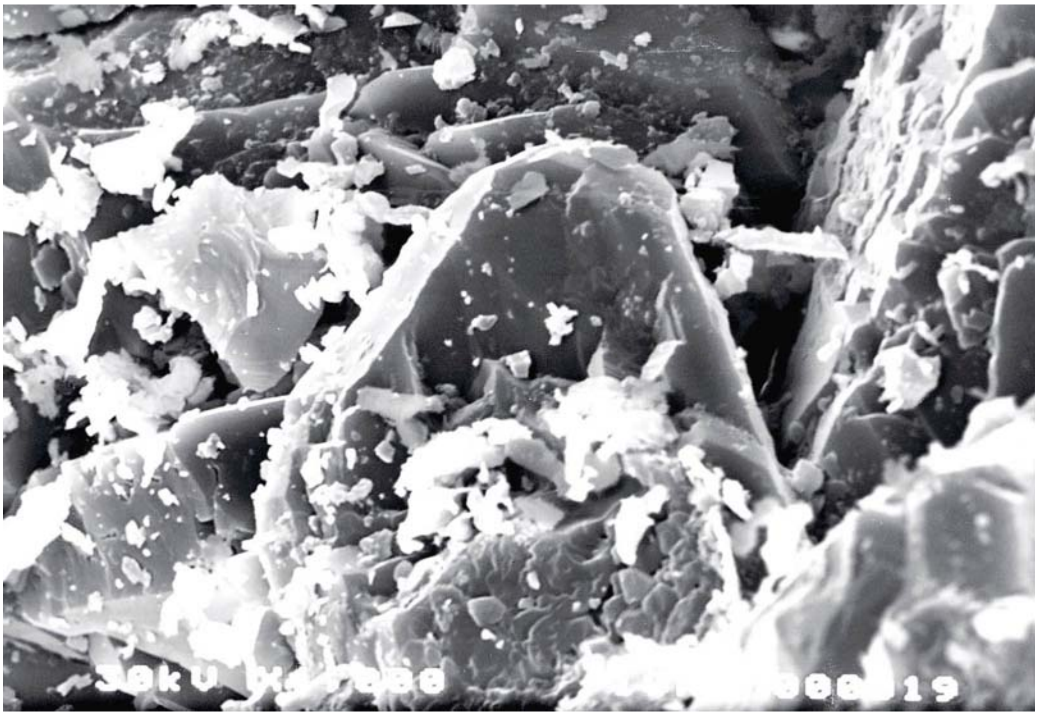


Fig. 19: SEM micrograph showing well developed quartz overgrowth. BH-15, Depth (14 m).

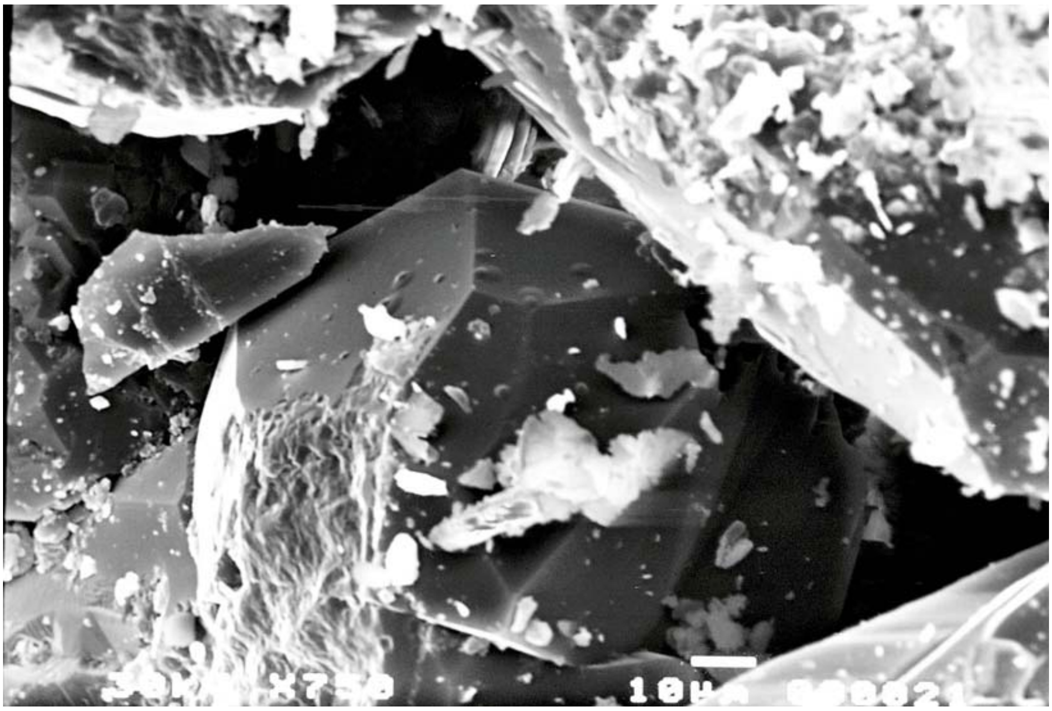
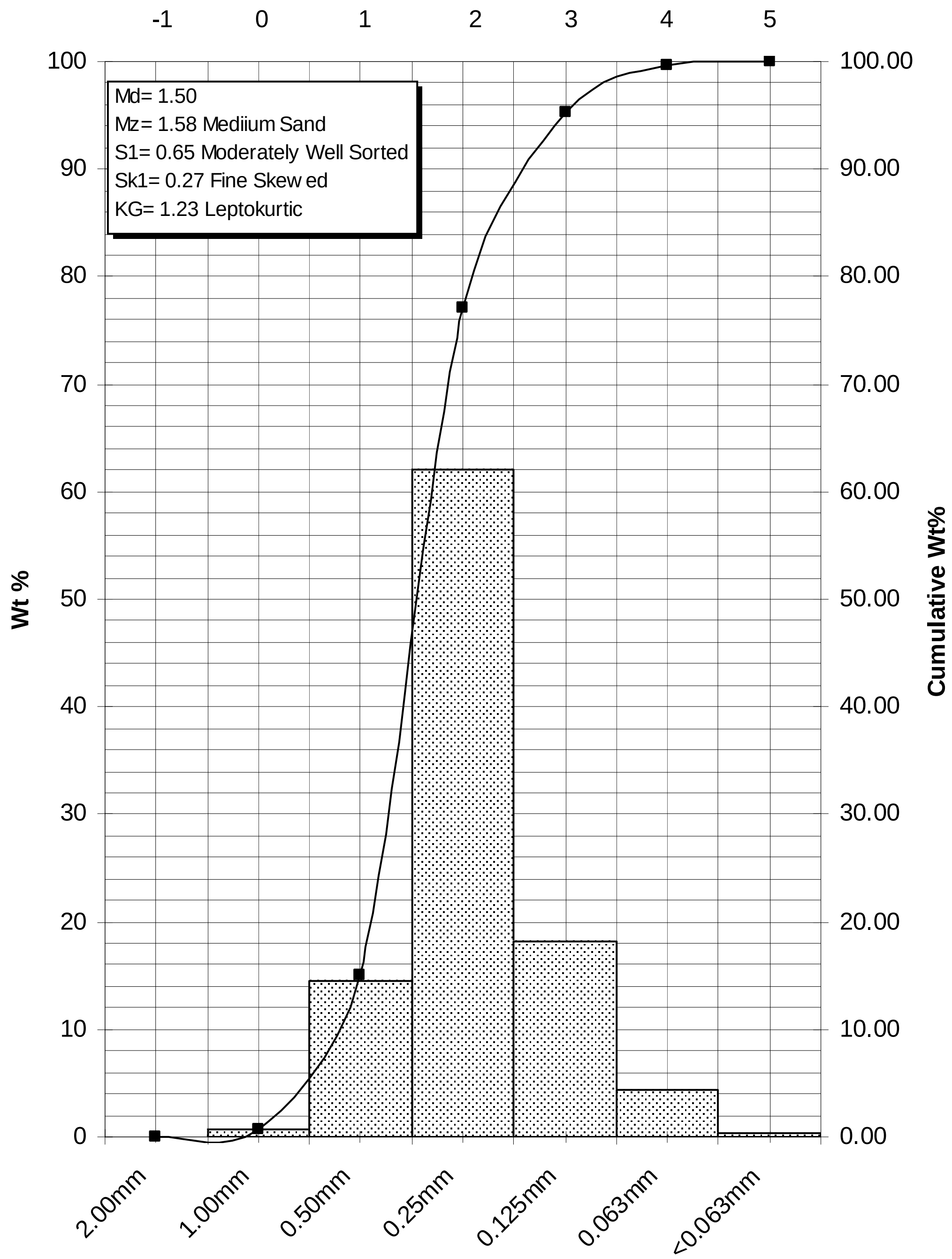
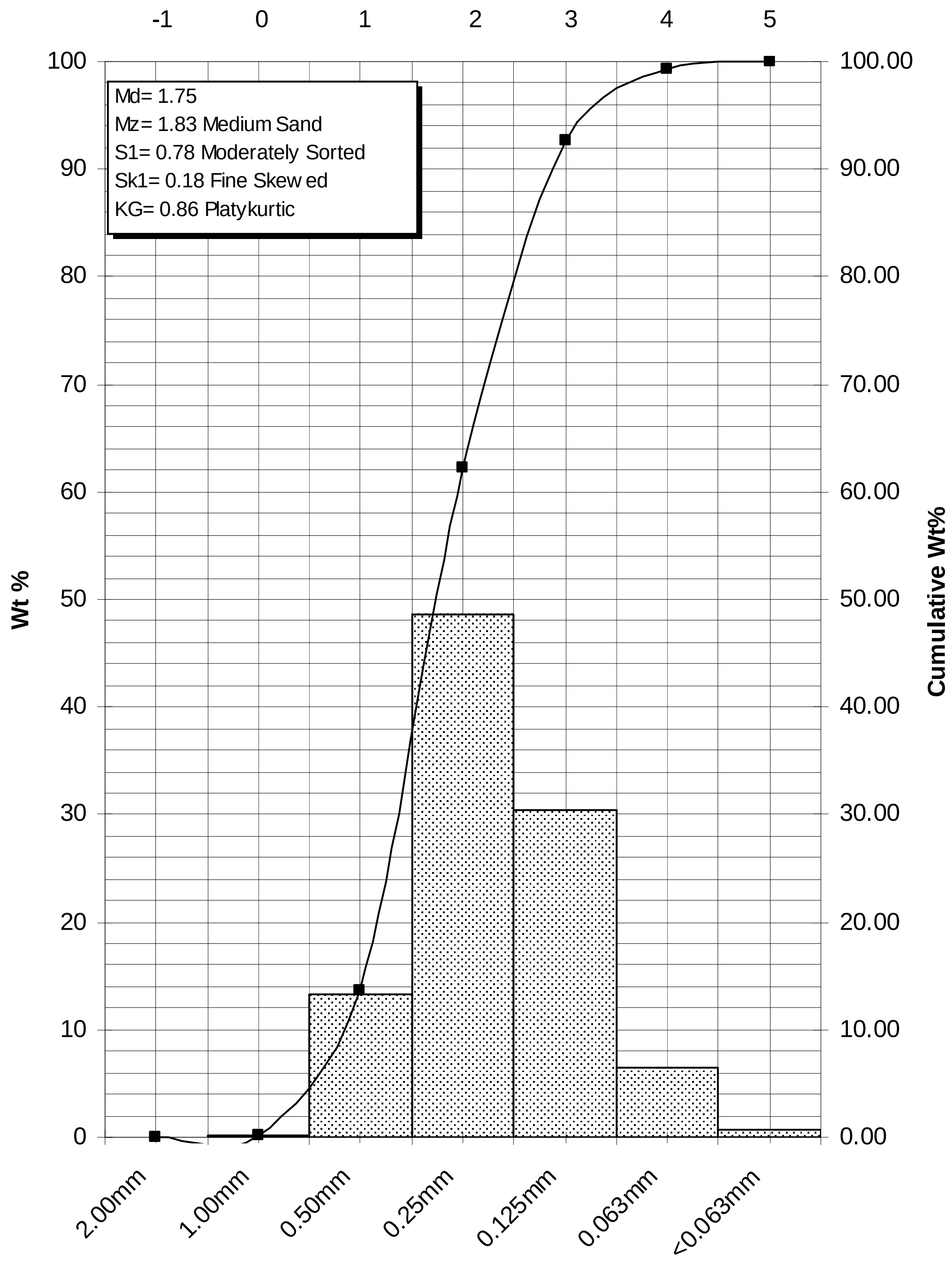


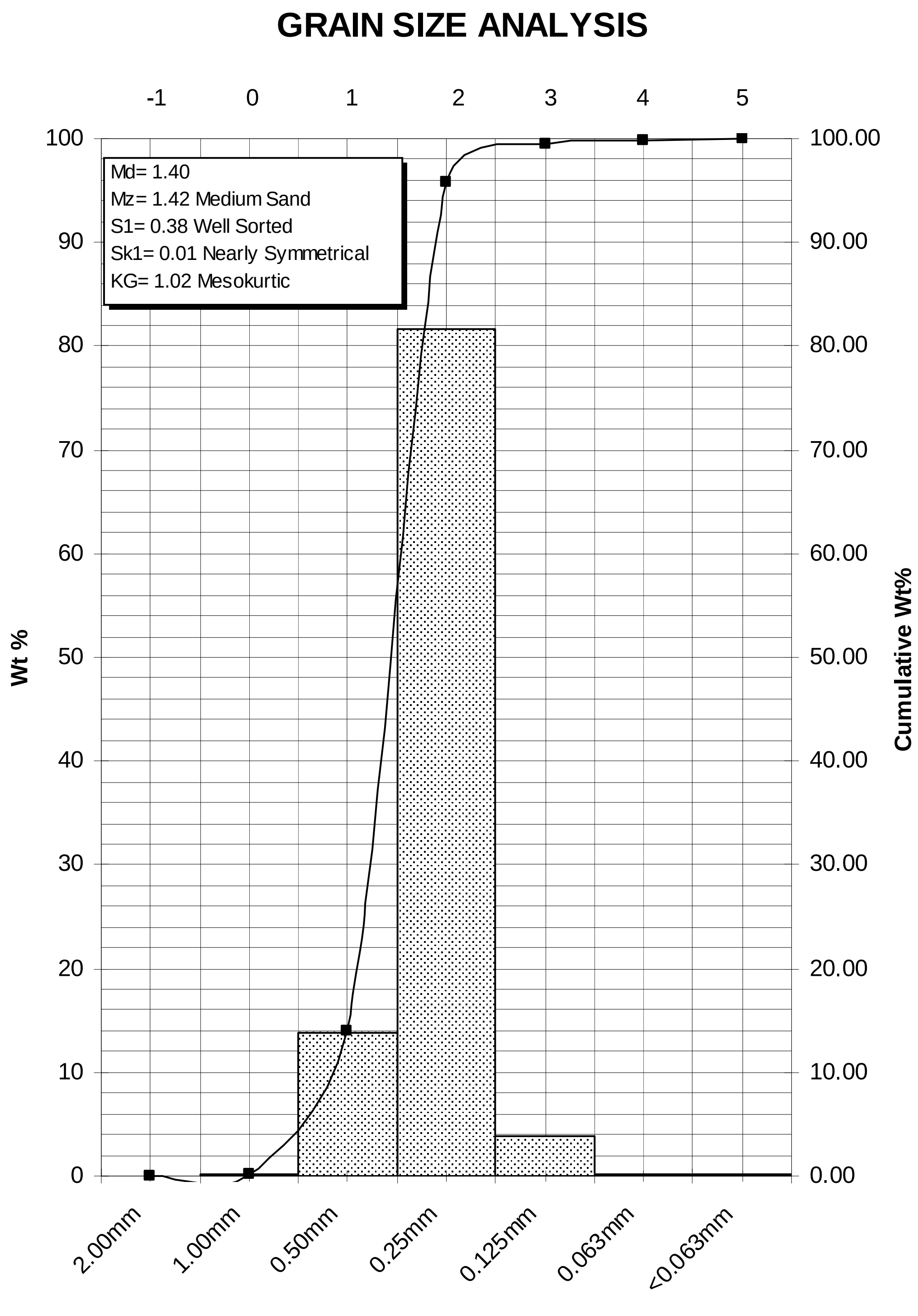
Fig. 21: SEM micrograph showing well developed quartz overgrowth. BH-23, Depth (7 m).

GRAIN SIZE ANALYSIS

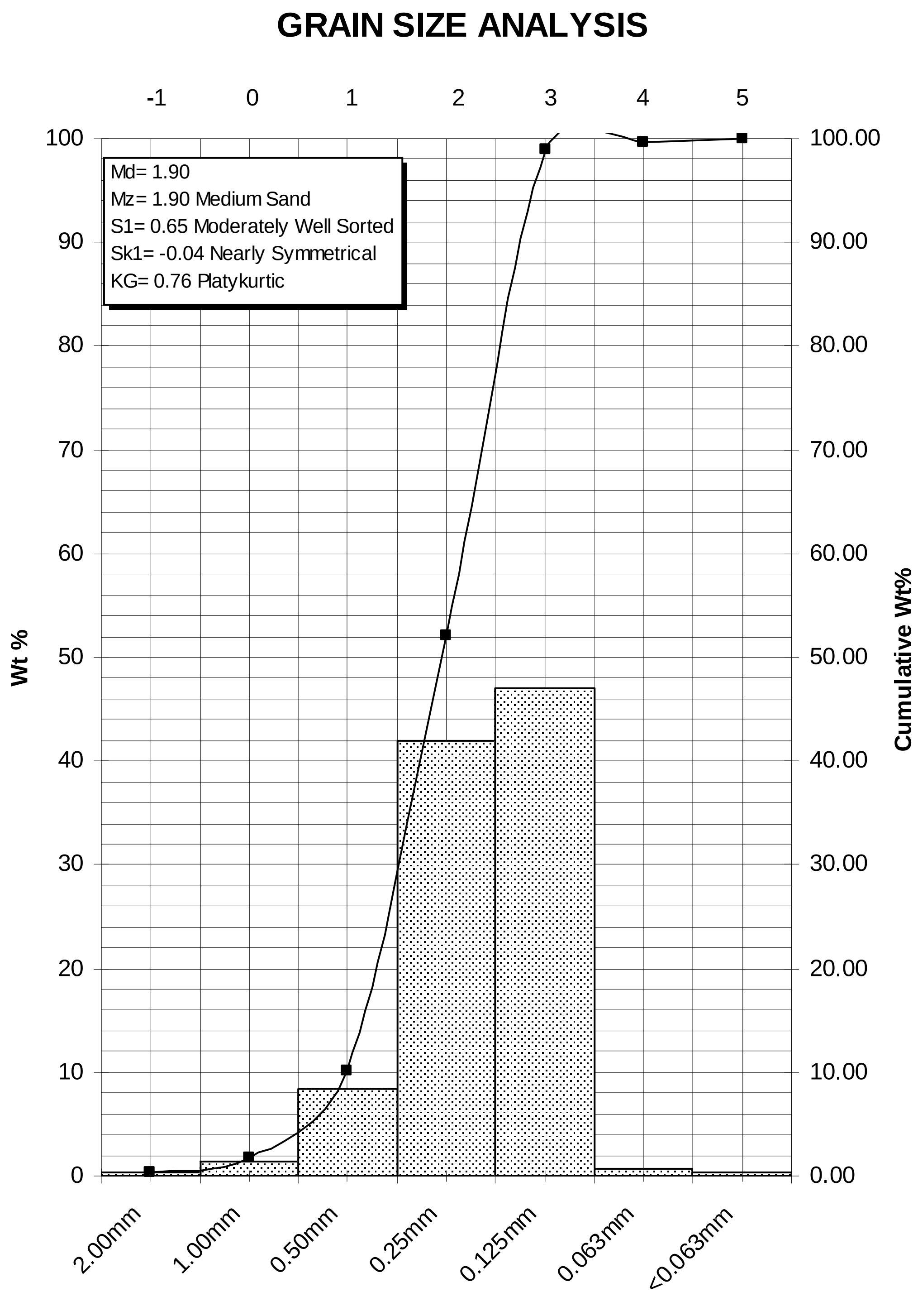


GRAIN SIZE ANALYSIS





GRAIN SIZE ANALYSIS
-1
0
1
2
3
4
5
Md= 1.40
Mz= 1.42 Medium Sand
S1= 0.38 Well Sorted
Sk1= 0.01 Nearly Symmetrical
KG= 1.02 Mesokurtic
Wt %
Cumulative Wt%
100
90
80
70
60
50
40
30
20
10
0
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
2.00mm
1.00mm
0.50mm
0.25mm
0.125mm
0.063mm
<0.063mm


GRAIN SIZE ANALYSIS
-1
0
1
2
3
4
5
Md= 1.90
Mz= 1.90 Medium Sand
S1= 0.65 Moderately Well Sorted
Sk1= -0.04 Nearly Symmetrical
KG= 0.76 Platykurtic
Wt %
Cumulative Wt%
100
90
80
70
60
50
40
30
20
10
0
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
2.00mm
1.00mm
0.50mm
0.25mm
0.125mm
0.063mm
<0.063mm

Chemical Composition and Evaluation

Representative samples of the investigated sands were collected from the drilled bore holes at 1 m interval, and reaching 15 m depth. The five drilled bore holes are sporadically distributed, mostly at the southern side of the hill, and represent the actual sand distribution.

The samples were chemically analyzed at the SPECTRO X-LAB of the National Research Centre (Dokki). The data of this laboratory are authorized on the national standards.

From the data provided, it is shown that the Na_2O, Mgo, Al2o3, CaO, TiO_2, SiO_2 Were determined in percentages. The following observation may be outlined.

1. Silica content in most samples is comparatively rich (more than 99%) on the averages, and the concentration is notably enrich to exceed 99.4% and reaching up to 99.7%. It is observed that the overburden is partially weathered and tarnished, but by going down in the bore holes, silica is markedly enriched. Therefore, the mixing of sand samples from the lower horizons of the collected samples will yield a highly concentrated silica content.
2. The content of MgO, CaO, and TiO_2 do not contribute any role for degrading the tenor of the studied sands.
3. The iron content which is represented by total Iron (as revealed from SEM) the iron mineral are hematite Fe_2O_3, goethite FeO (OH) and rarely siderite $FeCO_3$. The minerals are leach able during industries processing. As seen from the attached tables showing the results of the chemical analysis it is revealed that the iron content lies in the lower limit value which favors its suitable applications in mainly glass industry. According to the analysis the Fe_2O_3 ranges from 0.010% to 0.025% of the selected analysis.
4. The Alumina content (Al_2O_3)is of normal distribution, however some samples may show a high alumina content, but this is very limited and occurs on a minute local scale and does not contribute any scientific restriction.

Generally speaking as seen from the attached tables of the chemical analysis of the investigated samples, it is quite clear that these sandstones are high grade in their silica content. And all other detected elements are in the clan that permits designing these sandstones very suitable of a distinct category. See the contour map and the attached tables.