INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

METALLURGICAL ENGINEERING AND MATERIALS SCIENCE

MM206 Project Report

Analysis of Beach Sand

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1 Introduction

India has one of the longest coastlines in the world, having a total coast length of more than 7600km. The heavy minerals, the small crystals or sand grains liberated from the weathering of crystalline rocks, are carried to the sea by the flowing streams. This results in deposits of silica as well as other beach sand minerals — ilmenite, rutile, zircon, garnet, sillimanite, monazite and leucoxene [1]. These minerals are of great strategic and industrial importance. This report conducts an analysis of the sand found on Versova Beach, Mumbai, to gain insight on the potential mineral deposits. The sample collected is analysed using X-Ray Diffraction to detect the presence of various crystallographic phases present. The data extracted gives an idea about the profitable deposits in a beach. Additionally, the size distribution of the sand particles is calculated via image analysis of SEM secondary electron imaging.

2 X-Ray Diffraction

We performed X-ray Diffraction using Cu $K_{\alpha 1}$ with λ = 1.540598 nm and Cu $K_{\alpha 2}$ with λ = 1.544426 Åin the ratio 2:1. We scanned for 2θ values from 5° to 100° with a step size of 0.0262606°. This resulted in 3618 data points which have been plotted and analysed by us. We identified 19 major peaks using a Python program (Tab. 4). Some peaks corresponding to $K_{\alpha 1}$ and $K_{\alpha 2}$ overlap due to which they are not distinctly visible in the Fig 1, but can be identified in the data that was obtained. d_{hkl} values from Pananalytical database and the predominant phases were found to be quartz and calcite. Quartz is a hexagonal system with lattice parameters $a = 4.91$Åand $c = 17.07$Å. Calcite is also a hexagonal system with peaks $a = 4.99$ Åand $c = 5.41$Å. These values were put into Eqn. 1

$$\frac{1}{d^2} = \frac{4}{3}\left(\frac{h^2 + hk + k^2}{a^2}\right) + \frac{l^2}{c^2} \tag{1}$$

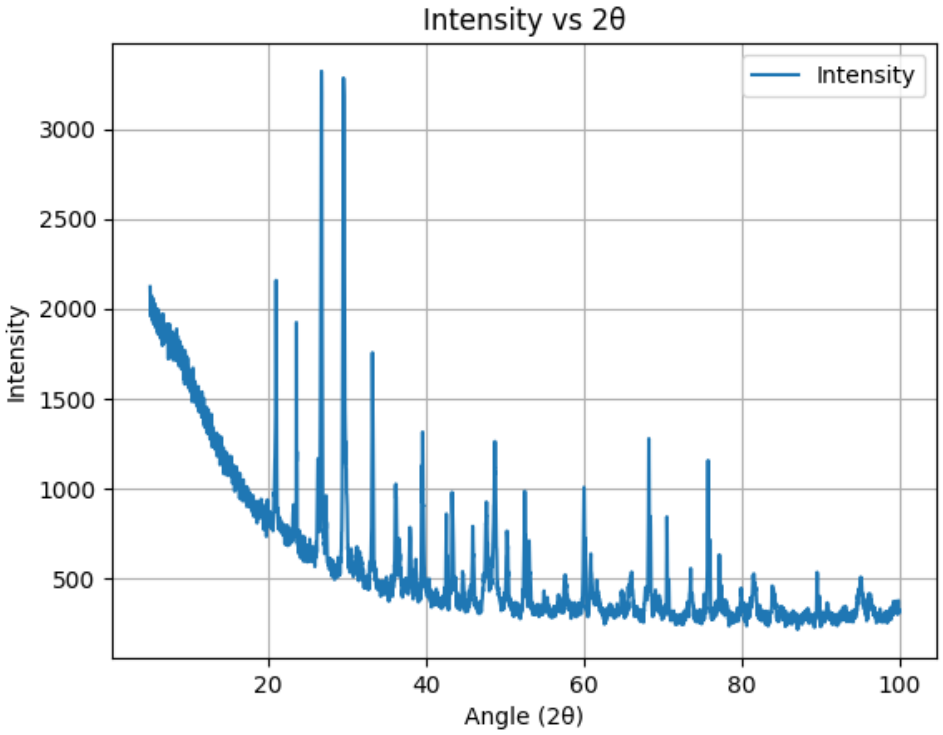

Figure 1: *Powder X Ray Diffractogram of sample of beach sand*

The data was also cleaned and matched in Pananalytical as shown in Fig. 3 the most intense peaks are tabulated in Tab. 1. The predominant phases of this analysis match the one we have conducted.

Sr. No.	2θ	Relative intensity	Corresponding (hkl)
1	29.52	1.0000	Calcite (104)
2	26.73	0.9955	Quartz $(10\bar{1})$
3	33.19	0.4696	Unknown
4	20.99	0.3783	Quartz (100)
5	68.22	0.3578	Quartz $(30\bar{1})$
6	48.72	0.2924	Calcite (116)
7	39.48	0.2934	Calcite (113)
8	59.99	0.2333	Quartz $(21\bar{1})$, Calcite (214)

Table 1: *Highest intensity XRD Peaks obtained from beach sand sample*

The ideal peaks and peaks obtained from sample data are compared in Tab.

Peak from data (2θ)	Ideal Peak (2θ)
20.9796	20.5276
26.7306	26.3643
39.5458	39.7362
48.7107	49.6504

Table 2: *Comparison of theoretical values and measured data*

3 Scanning Electron Microscopy

SEM images were generated for the sample using the secondary electron signals. An accelerating voltage of 10kV was used to generate images with magnifications of X27, X1000, X4000 and X5000 as shown in Fig. 2.

3.1 Image Analysis

We used the image with magnification X27 was used to find the particle size distribution. This image was analysed using ImageJ software. We measured the maximum diameter of 200 particles as a sample space for data analysis as shown in Fig. 5. 5 particles having size greater than $0.5mm$ were considered as outliers in subsequent data analysis, which is summarized in 3. The P-P and Q-Q plots generated in R are displayed in Fig. 6.

Statistical Result	Value (in mm)
Mean	0.254
Median	0.250
Stadard Deviation	0.0798

Table 3: *Results of image analysis*

4 Conclusion

Using typical characterization in materials science, we have characterized beach sand in Versova beach and found that the two predominant phases are quartz and calcite. This data can be used along with EDX data to gain a thorough compositional analysis. The size distribution of te sand particles was also found.

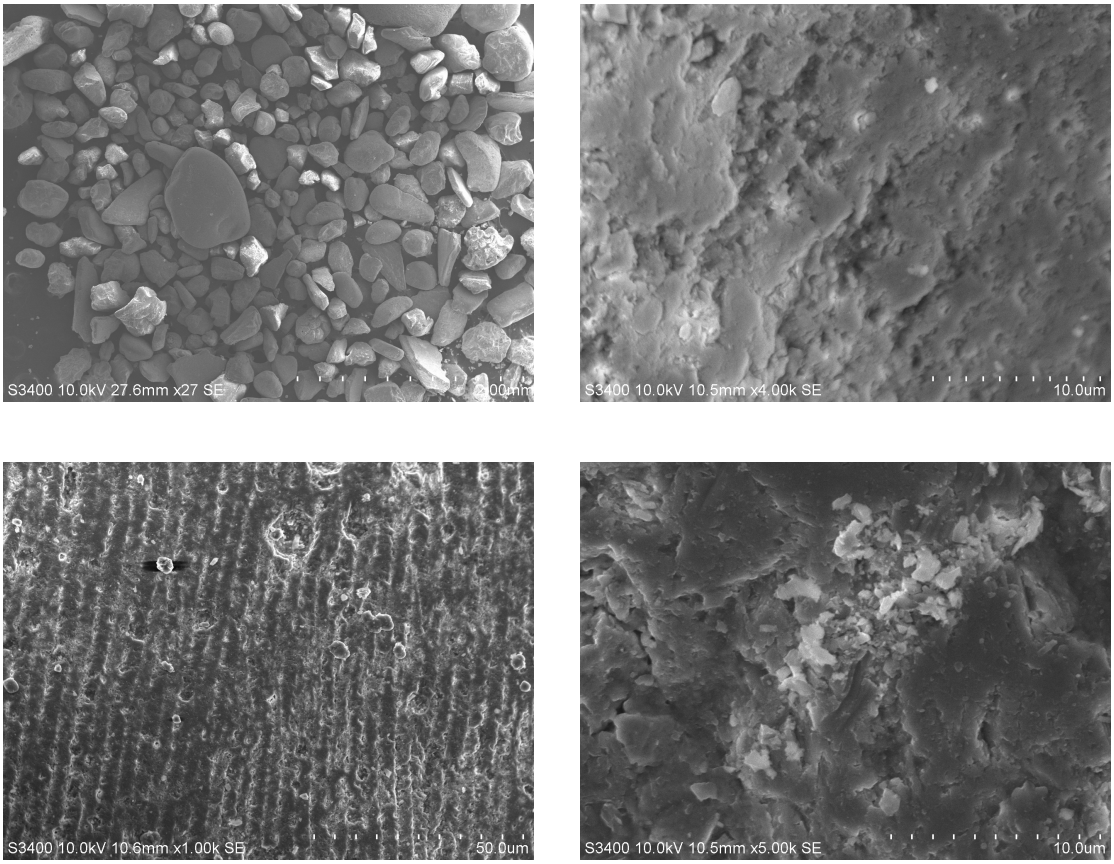

Figure 2: *SEM micrographs with magnification- X27 (top-left), X4000 (top-right), X1000 (bottom-left), X5000 (bottom-right)*

References

[1] Goutam Banerjee. Beach and minerals: a new material resource for glass and ceramics. *Bulletin of Materials Science*, 21:349–354, 1998.

[2] García Rosales Genoveva, Ordóñez Regil Enrique, Romero Guzmán Elizabeth Teresita, and Ordóñez Regil Eduardo. The influence of agitation speed on the morphology and size particle synthesis of zr (hpo4) 2. h2o from mexican sand. *J. Minerals and Materials Characterization Engg*, 6:39–51, 2007.

[3] GM Mudd and SM Jowitt. Rare earth elements from heavy mineral sands: assessing the potential of a forgotten resource. *Applied Earth Science*, 125(3):107–113, 2016.

[4] N Saratchandran, RK Garg, CV Sundaram, and HC Katiyar. The present status and the projected programme of zirconium development in india. 1969.

5 Appendix

5.1 Peaks Identified and mentioned in Python

Link to Code

Sr. No.	2θ	Intensity
1	20.97955381	2157
2	23.55308918	1923
3	26.28418794	1165
4	26.73061754	3320
5	27.30834997	960
6	29.51423743	3283
7	33.19071654	1755
8	36.15816038	1024
9	39.54577327	1314
10	42.56573824	858
11	43.2747735	978
12	47.63402729	925
13	48.71071046	1261
14	52.49223182	984
15	60.00275341	1006
16	68.22231026	1277
17	70.50697941	842
18	75.73283185	1156
19	77.15090236	631

Table 4: *Peaks detected using python*

5.2 Noise Removal and Peak Matching

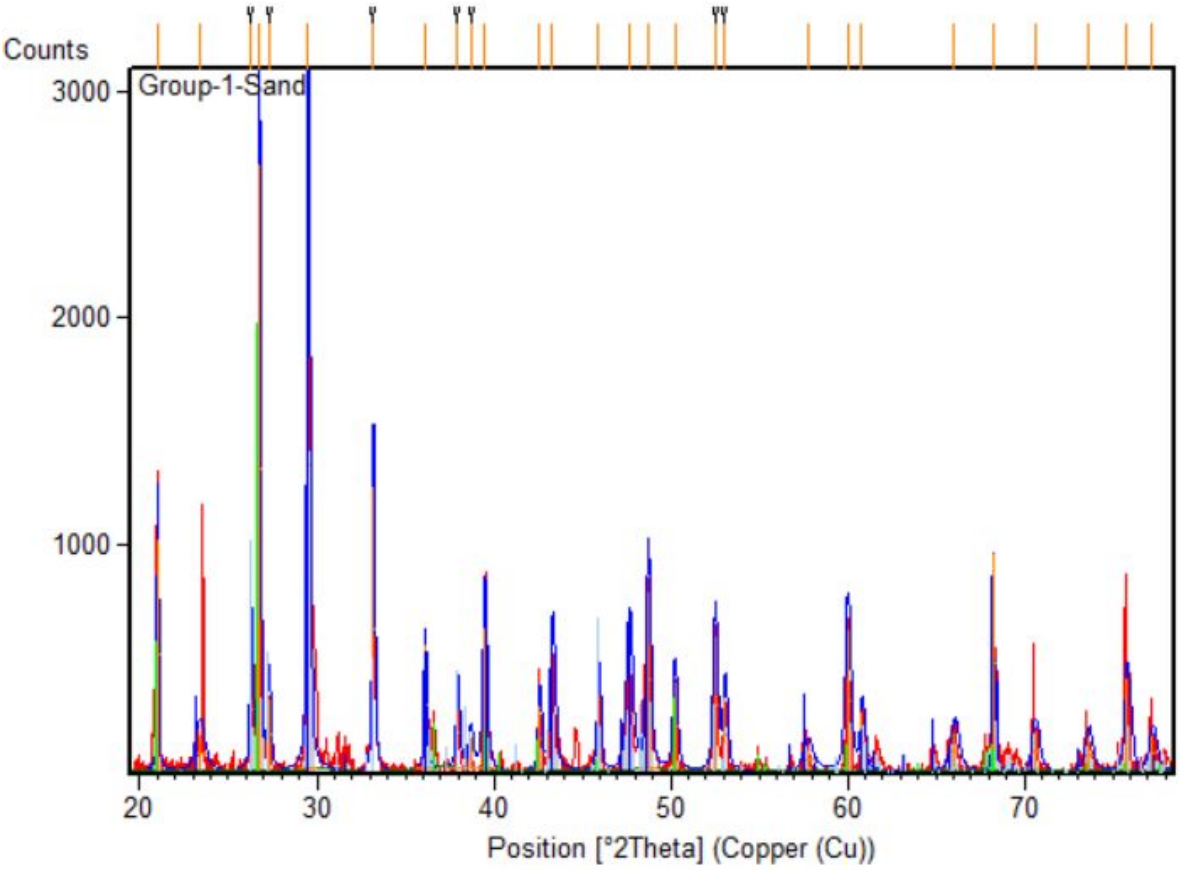

Figure 3: *Processed data in Pananalytical*

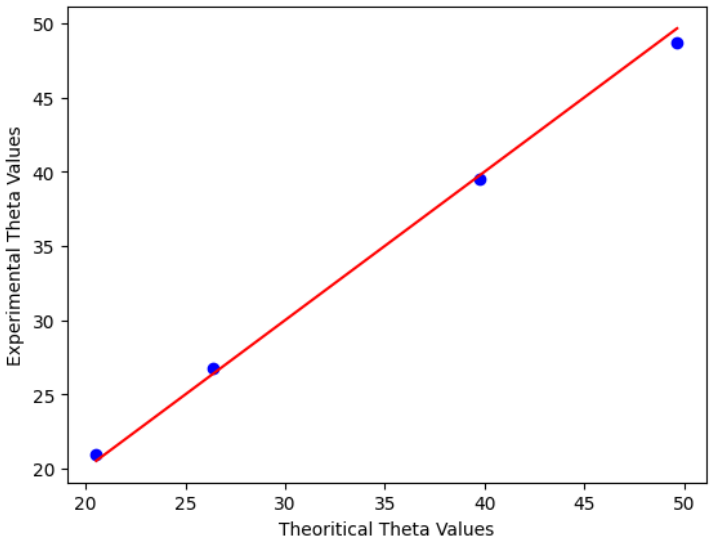

Figure 4: *Peak matching of theoretical and measured values*

5.3 Data Analysis of Size Distribution

Link to Code

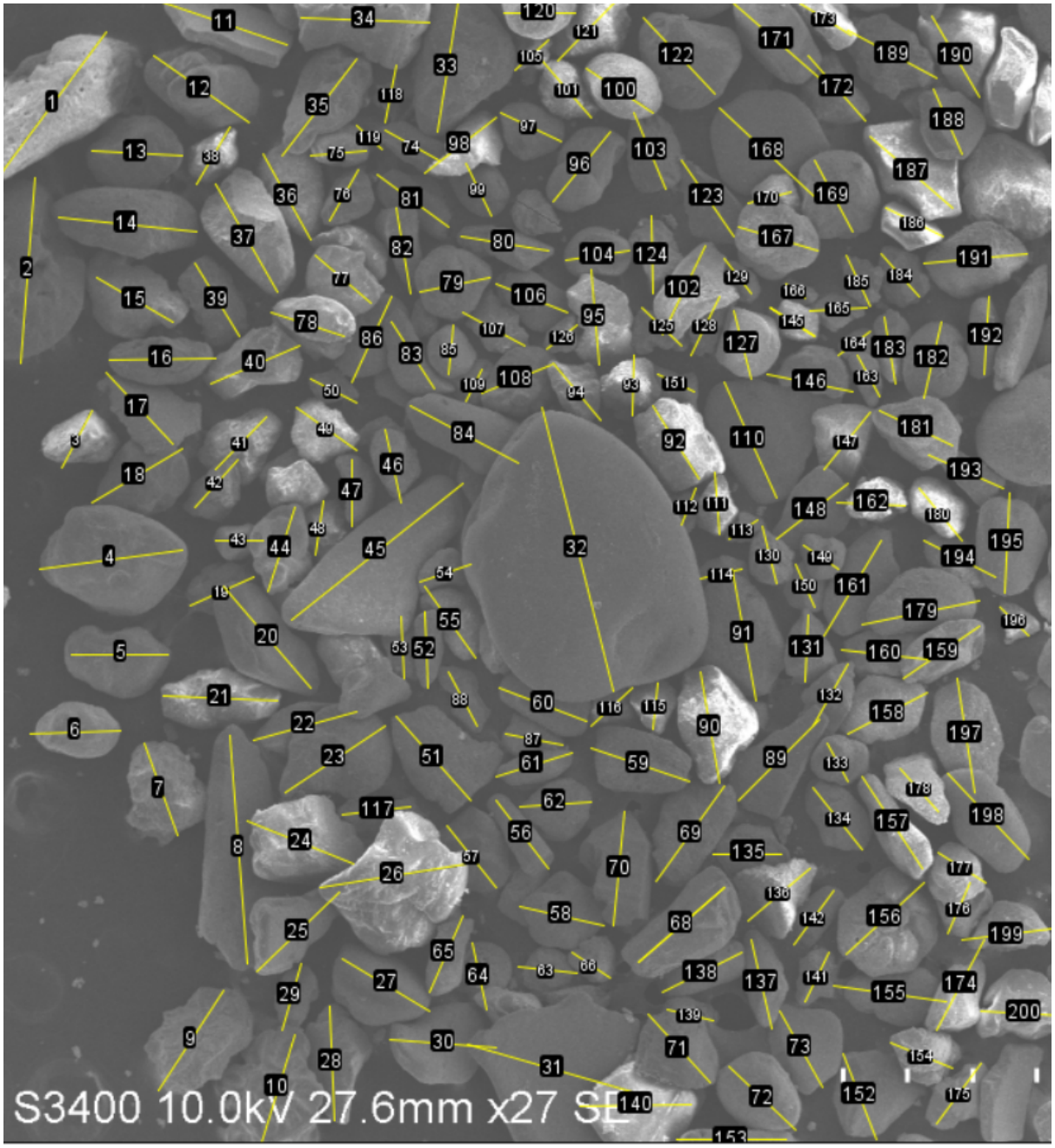

Figure 5: *Size distribution analysis using ImageJ*

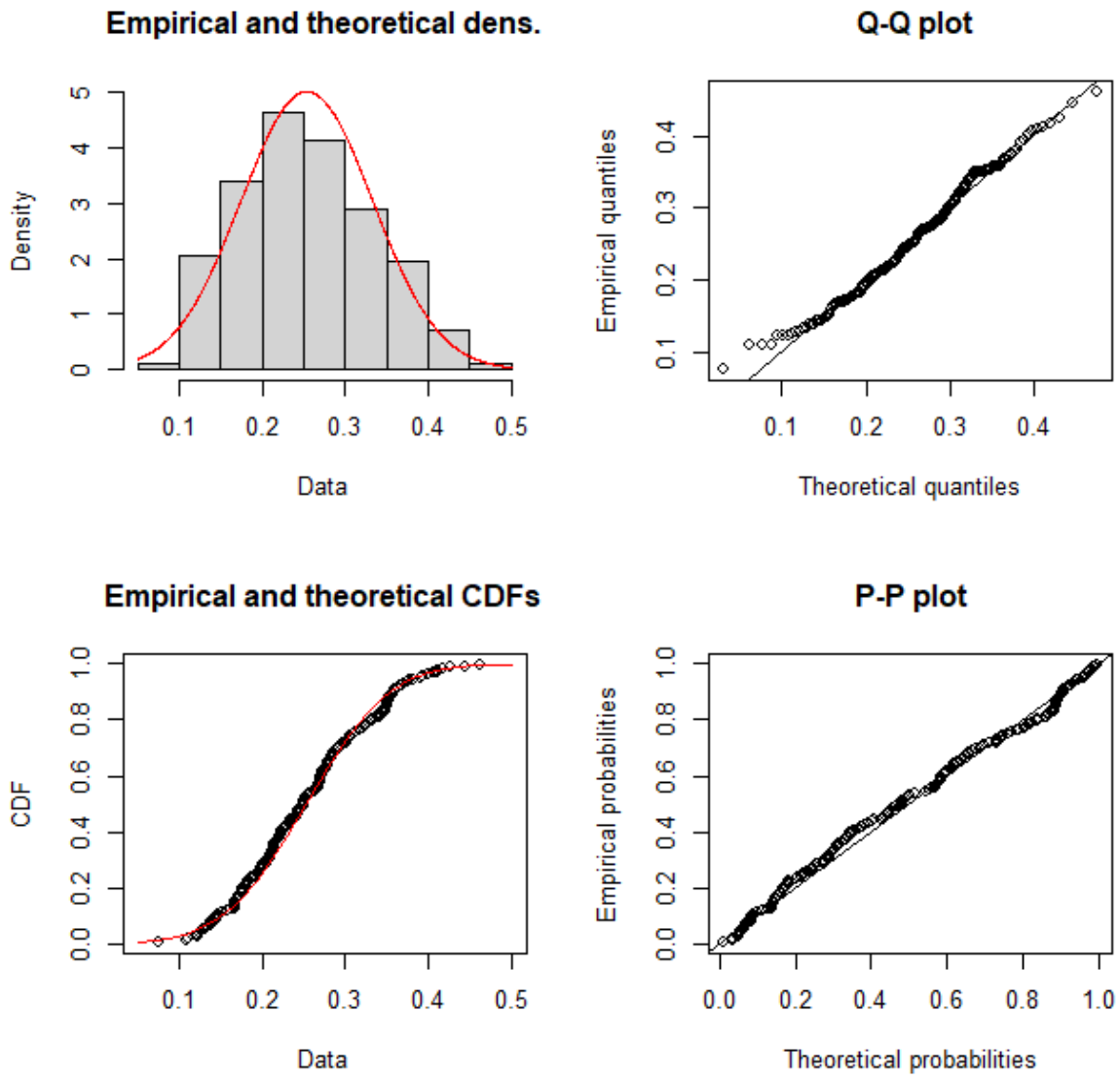

Figure 6: *Results of size distribution analysis*