

SEM compositional analysis determines the suitability of different sands for construction

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Introduction

Sand plays a crucial role in construction as a fundamental component in various building materials and projects. Despite deserts covering 20% of the Earth's land area, there's an ongoing scarcity of sand suitable for construction, as not all types of sand are suitable for these applications. For example, construction in Dubai uses imported sand from Australia, despite the city being located in a desert environment. This application note aims to illuminate the differences between river, sea, and desert sand with scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). This combination of imaging and elemental analysis reveals the unique properties of these sand types and illuminates why river sand is the preferred choice for construction applications.

Method

Small portions of desert, sea, and river sand were placed onto SEM stubs using carbon adhesive tape. These stubs were then inserted directly into the chamber of a Thermo Scientific™ Phenom™ XL G2 Desktop SEM for imaging. The instrument was operated in low-vacuum mode to address the non-conductive nature of sand. This minimizes charging effects and enables direct imaging of the sand samples. The resulting SEM images were analyzed using Thermo Scientific Phenom ParticleMetric Software, which can measure sample particle size, shape, and distribution, generating size histograms and reports for each sand type. EDS analysis was used in conjunction with the SEM imaging to determine the elemental composition of the sands.

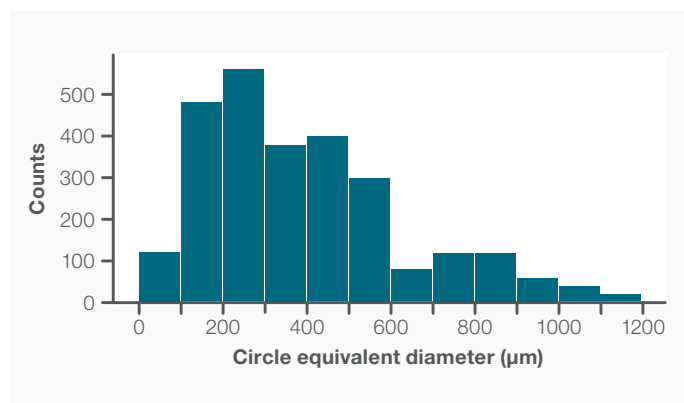
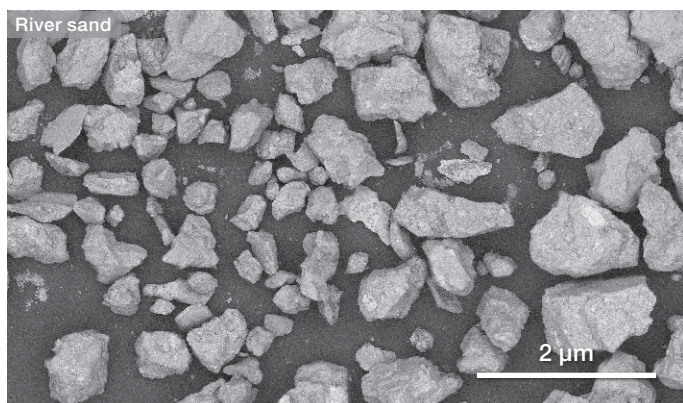
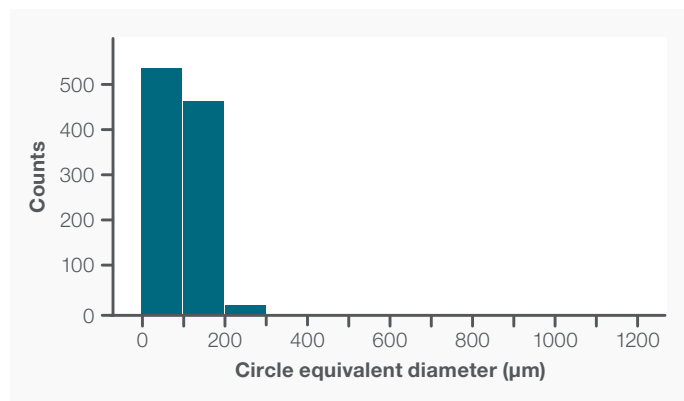
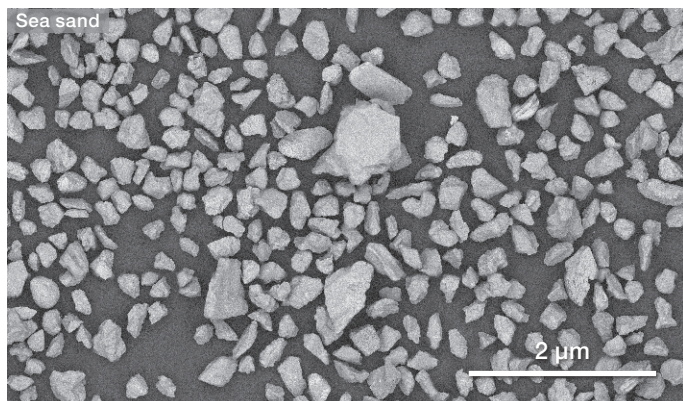
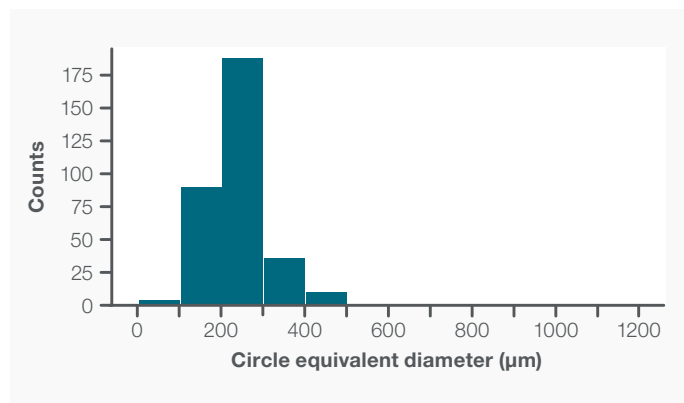
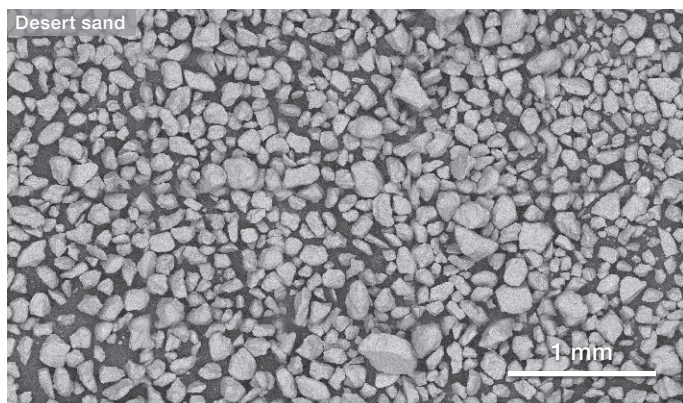


Figure 1. SEM images and particle analysis results for the desert, sea, and river sand samples.

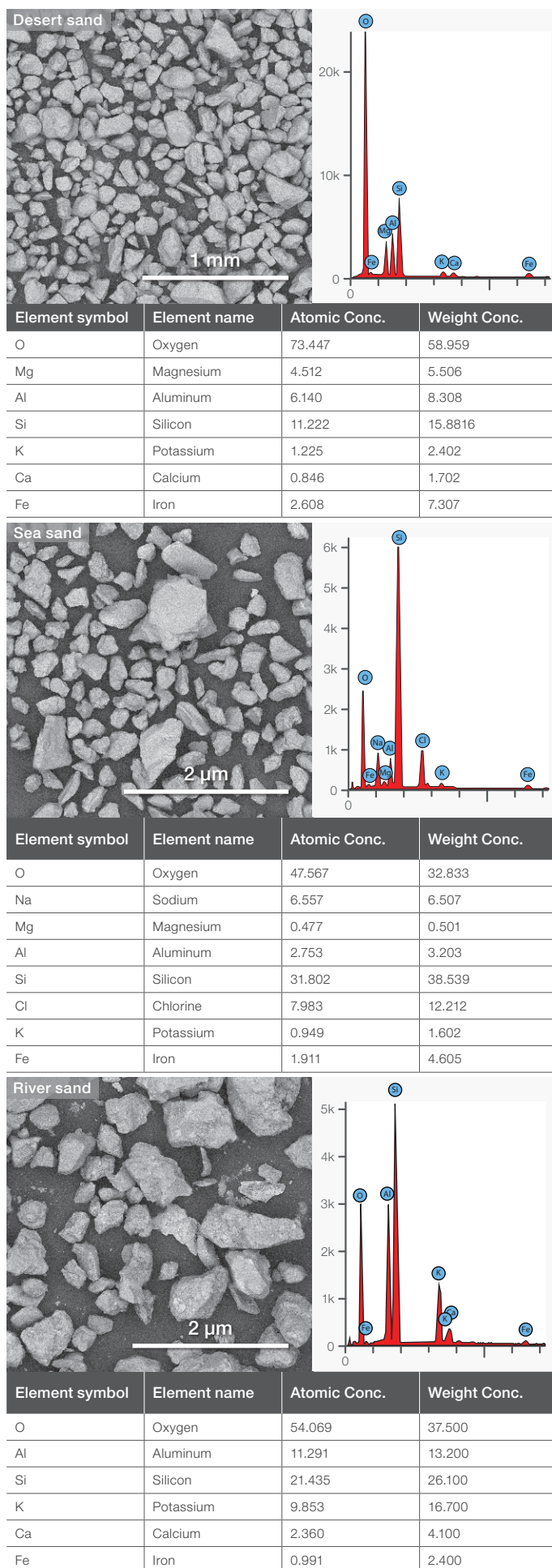


Figure 2. EDS analysis of desert, sea, and river sand.

Results and discussion

SEM imagery reveals that desert sand exhibits a smoother surface compared to other sands, likely due to extended wind-driven erosion. River sand, meanwhile, displays irregular, angular shapes. ParticleMetric analysis of the SEM images indicates a relatively uniform particle size for the desert sand, mostly around 100 μm. The size distribution of sea sand centers around 250 μm, encompassing a range of larger granules. River sand's variability spans around 400 μm, containing both fine and coarse grains.

EDS analysis shows that desert, river, and sea sand share similar elemental compositions, with silicon and oxygen as the primary components, likely due to quartz making up the bulk of the sand. Additionally, aluminum, iron, calcium, potassium, and sodium are commonly present; their distributions are likely the result of variations in local geology. Minor elements like magnesium and manganese were also detected. Notably, EDS results for sea sand reveal a higher concentration of chlorine, attributed to the sand's prolonged exposure to seawater and marine environments.

Standards for construction sand used in concrete and mortar production vary by region and country. These standards generally encompass particle size, shape, cleanliness, and chemical properties. For instance, ASTM C33/C33M-18 specifies grading requirements for fine particles in concrete aggregates (Table 1). A cumulative passing percentage of 10% (as seen for the 150-μm sieve size) implies that the aggregate can have up to 10% of particles smaller than or equal to 150 μm in diameter. The particle analysis results (Figure 1) reveal that desert sand significantly exceeds this 10% limit.

Sieve size (ASTM< E1.1 standard)	Percent passing (%)
9.9 mm (3/8 inch)	100
4.75 mm (No. 4)	95–100
2.36 mm (No. 8)	80–100
1.18 mm (No. 16)	50–85
600 μm (No. 30)	25–60
300 μm (No. 50)	5–30
150 μm (No. 100)	0–10
75 μm (No. 200)	0–3.0 ^{A,B}

Table 1. Grading requirements for fine particles in concrete aggregates.

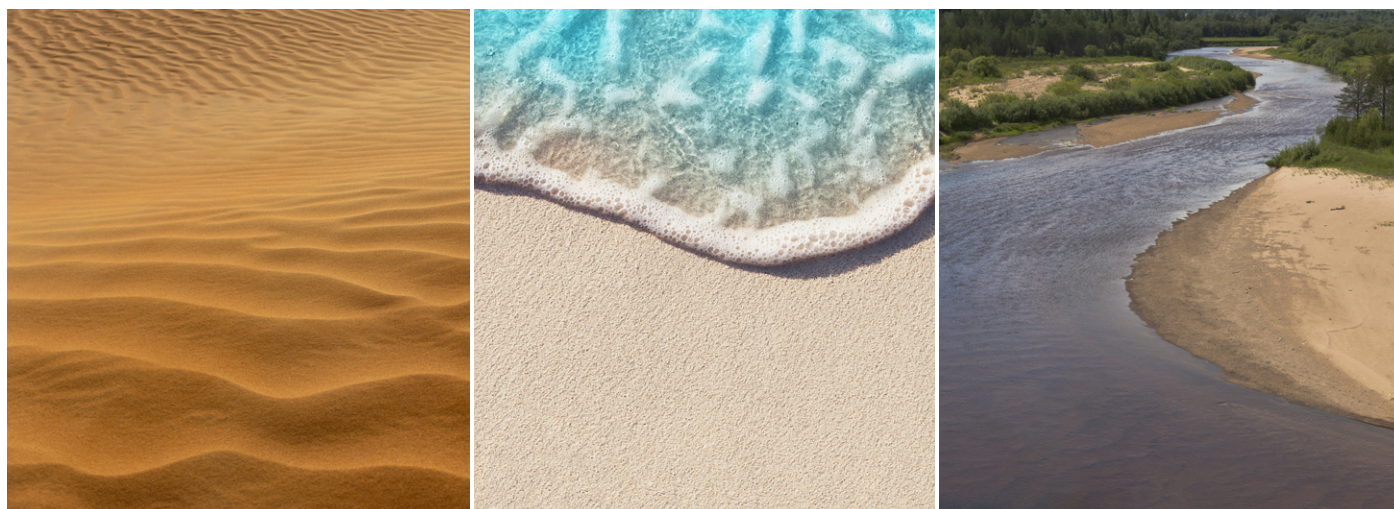
The ASTM C1152/C1152M standard specifies the standard test method for acid-soluble chloride content in mortar and concrete. This test aids in assessing the potential presence of detrimental chlorides, which could lead to corrosion of steel reinforcement in the concrete. As the EDS analysis results show, sea sand exhibits an excessive chlorine concentration, indicating a corrosion risk.

Conclusions

In construction, the physical and chemical properties of sand have a significant impact on the durability and safety of the resulting structures. SEM analysis is a potent tool for unravelling these properties, capable of distinguishing between sand types and determining their suitability for construction.

The fine-grained composition of desert sand makes it unsuitable for these applications, as its small particle size would produce materials lacking in structural integrity. Meanwhile, the high salt and chlorine content of sea sand poses a corrosive risk to metal, jeopardizing the longevity of structures made with this sand. As a result, river sand emerges as the ideal option for construction projects for both its physical and chemical properties.

We hope this application note has highlighted the value that SEM-EDS analysis provides for the evaluation of sand samples. Construction standards vary globally, so understanding the microscopic characteristics of sand sources can help you make informed choices that meet these standards, ultimately enhancing the durability and safety of your construction projects.



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