

Magnetic Separation and Enrichment of Ti-Fe Oxides from Iron Titaniferous Beach Sands: Process Design Applied to Coastal Ecuador

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A. Methodology

A.1 Water content (%) by moisture loss

The initial weight of the sands was recorded. Then, the samples were introduced into an oven at 90 °C to remove water from the sand. After one hour, the samples were taken out of the oven to register their current weight. The process was repeated each hour until obtaining a constant weight. Finally, the water loss percentage curve was plotted using the recorded data (Figure S1).

A.2 Granulometric size distribution by sieving and Dynamic Light Scattering (DLS)

The sands were passed through a vibrating sieve with different sieve sizes (size: 12.50 mm – 0.032 mm). Then the mass of sand retained in each sieve was weighed, and a logarithmic cumulative particle size distribution plot was produced.

DLS is a technique used to determine the size of a particle whose rank oscillates between 100 nm and 1000 µm. This technique involves passing particles through a light beam, where the scattering angle of light is related to the particle size. Large particles are dispersed at low angles and small particles at high angles. The particle size measurement was performed using a HORIBA LA-950V2 device. Particles with grain size larger than 1 mm were passed through a sieve N° 100 (Figures S2 - S3, Table S1).

A.3 Semi-quantitative chemical composition by Energy Dispersive Spectroscopy (EDS)

Compact tablets were prepared with ca. 3 g of sand samples (material sieved to 75 µm) and ca. 2.5 g of cellulose. These materials were mixed, homogenized, and compressed by a pressing machine. Once the sample was compacted, it was carefully placed on the electronic scanning microscope (Jeol, IT300) under reduced pressure of 55 Pa, and the data were analyzed using Aztec mode. The settled parameters were height from the detector of 12 mm-14 mm, area of analysis ca. 10000 µm², and a voltage of 20 kV–30 kV (Table S2).

A.4 Manual magnetic separation

The magnetic separation was carried out using a plastic-covered magnet (2 Tesla). Initially, 230 g of sieved sand was placed into a 500 mL beaker. Then, the sand sample was washed/soaked with 100 mL of distilled water. From the outside of the beaker, the particles were attracted by the magnet. Once the magnetic grains were attracted to the magnet, the water inside the beaker was drained, and the particles attracted to the magnet were placed into a petri dish. Then, the magnet was covered by a plastic film, and it was introduced inside the drained sand prior complete separation of the magnetic particles. This process was repeated until no magnetic particles were attracted to the magnet. Finally, the magnetically enriched sands were dried, and their weight was recorded to obtain the magnetic fraction (Figure S4).

B. Results

B.1 Water content

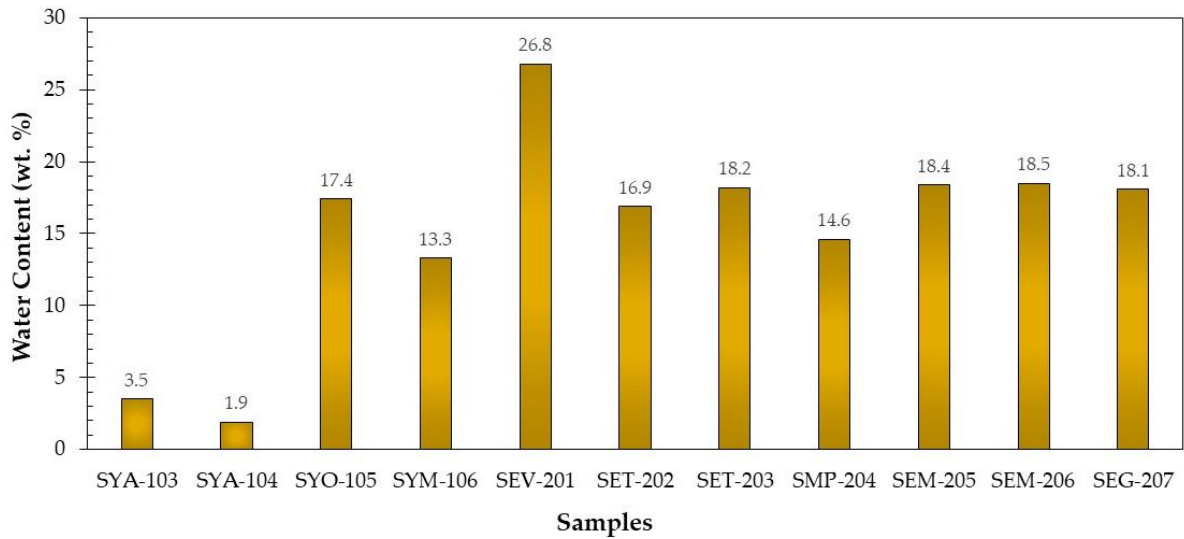


Figure S1. Water content percentage in black sands' samples from Ecuador.

B.2 Granulometric size distribution

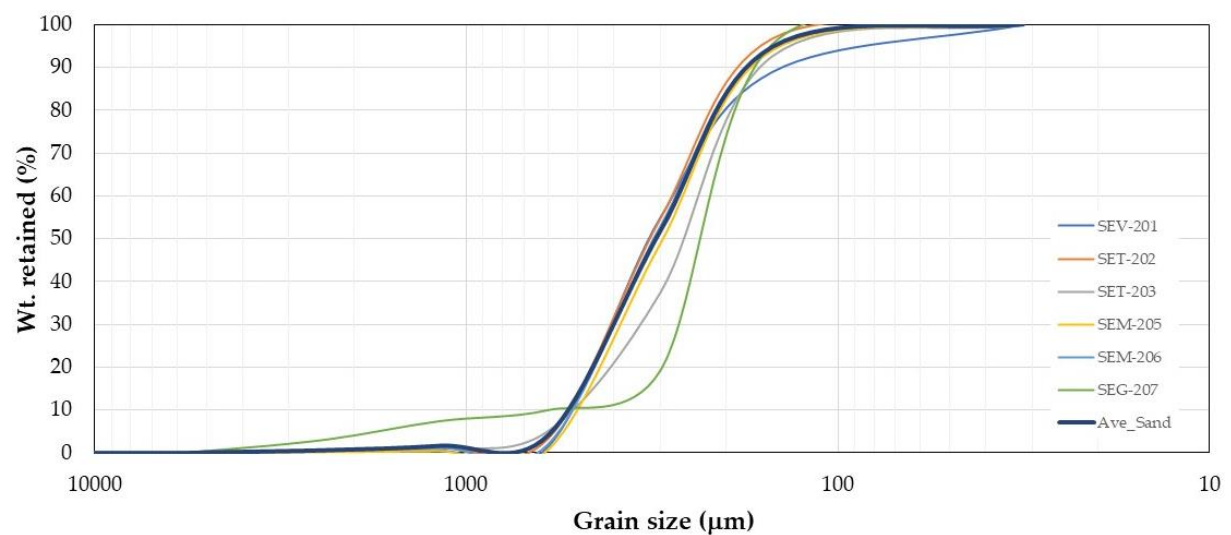


Figure S2. Granulometric curves of in black sands' samples from Ecuador.

Table S1. Particle size (median size and mean size) by DLS.

Sample	Median size (μm)	Mean size (μm)
SYA-103	383.07	548.90
SYA-104	349.74	558.64
SYO-105	176.57	756.65
SYM-106	257.12	747.29
SEV-201	298.46	1364.26
SET-202	277.40	582.91
SET-203	219.45	480.00
SMP-204 ¹	173.10	939.61
SEM-205	172.02	548.78
SEM-206	181.05	497.44
SEG-207	275.26	1202.55

¹ Sample passed through an N° 100 sieve (150 μm).

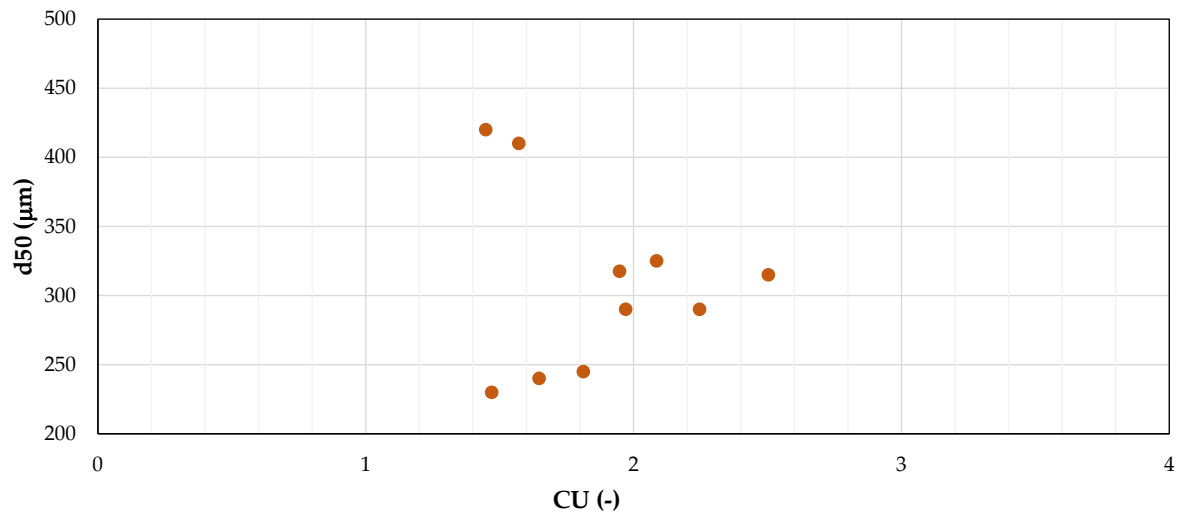


Figure S3. Granulometric-derived parameters of sandy sediments in sampled areas in Coastal Ecuador: Coefficient of uniformity vs. median value.

B.3 Semi-quantitative chemical composition

Table S2. Semi-quantitative chemical composition of sandy samples by SEM-EDS analysis expressed as oxides.

Samples	Oxides (%)		
	TiO ₂	FeO/Fe ₂ O ₃	Others *
SYA-103	0.15	1.87	97.98
SYA-104	1.25	6.91	91.84
SYO-105	0.33	1.92	97.75
SYM-106	0.30	2.04	97.66
SEV-201	0.58	6.17	93.25
SET-202	0.21	3.09	96.70
SET-203	0.36	3.60	96.04
SMP-204	0.63	5.90	93.47
SEM-205	1.56	4.52	93.92
SEM-206	0.44	2.54	97.02
SEG-207	0.38	3.54	96.08

* Na₂O, MgO, Al₂O₃, SiO₂, K₂O, and CaO oxides.

B.4 Manual Magnetic Separation

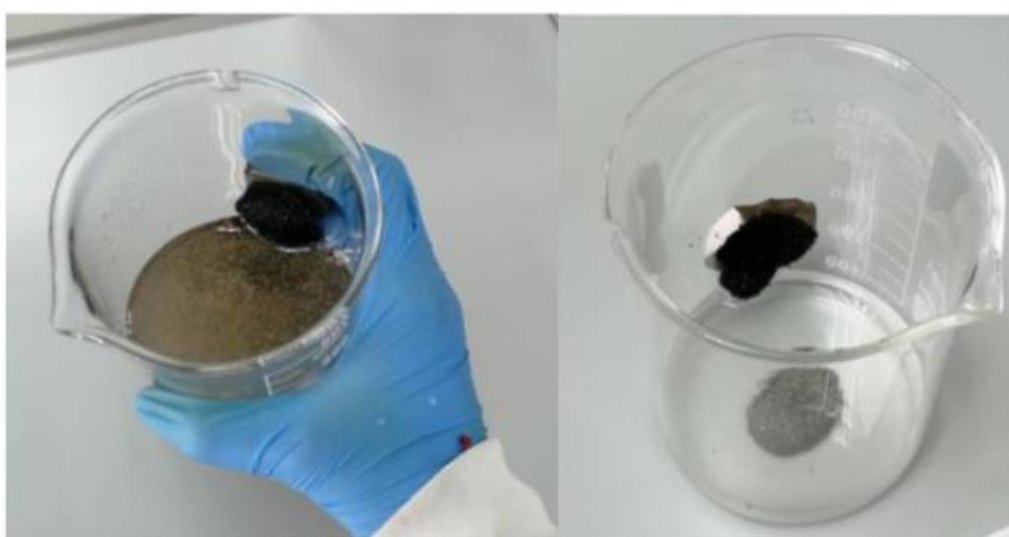


Figure S4. Manual magnetic separation procedure: initial and final conditions.