



ANALYSIS OF MINERAL CONTENT AND MAGNETIC PROPERTIES OF IRON SAND OF BAH BOLON SIMALUNGUN RIVER, NORTH SUMETERA

¹Novita, ²Marzuki Naibaho, ³Endah Puspita, ⁴Ramlan, ⁵Masno Ginting, ⁶Syahrul Humaidi

^{1,6}Department of Physics, Universitas Sumatera Utara, Indonesia

^{2,5}Research Center for Advanced Materials, National Research and Innovation Agency (BRIN), Indonesia

^{3,4}Department of Physics, Universitas Sriwijaya, Indonesia

Email: novita.ichsanbasuki@gmail.com, marzuki@gmail.com, endah@gmail.com, ramlan@unsri.ac.id, masno.ginting@gmail.com, syahrul1@usu.ac

ABSTRACT

Analysis and characterization of the natural iron sand of the Bah Bolon River in Simalungun Regency has been carried out. Separation of iron sand is carried out using a 500 Gauss permanent magnet 10 times. After that, the iron sand is washed using Aquades 5 times so that the iron sand is clean of impurities and dried using an oven at a temperature of 85o C for 24 hours. Iron sand samples with a size of 250 mesh (74 μ m) were then characterized using SEM-EDS and VSM. Measurements using SEM-EDS show that the Sungai Bah Bolon iron sand contains 66.9% Fe, 24.3% O, and 8.8% other elements. Meanwhile, the hysteresis curve from the results of measurements with a Vibrating Sample Magnetometer (VSM) shows that the Bah Bolon River iron sand has magnetic saturation (Ms), magnetic remanance (Mr), and coercivity (Hc) properties of 57.70 emu/g respectively 7.09 emu/g, and 129.93 Oe.

Keywords: Natural iron sand, Bah Bolon, SEM-EDS, VSM

INTRODUCTION

Iron sand is iron ore in the form of sand which is often found in nature mixed with sand (Susilawati et al., 2015)(Toto et al., 2012). Iron sand is formed due to the erosion of natural rocks containing iron minerals, which occurs as a result of the destruction process by weather and rain which then accumulates and is washed by sea waves or river water flows (Palkrisman & Budiman, 2014). Therefore, iron sand is

often found on beaches and along river flows.

Iron sand contains magnetic minerals such as magnetite (Fe₃O₄), hematite (α -Fe₂O₃), and maghemite (γ -Fe₂O₃) (Effendy et al., 2014)(Susilawati et al., 2017)(Arsyad et al., 2018). Apart from that, iron sand also contains non-magnetic materials such as silicon oxide which also affect its magnetic properties (Susilawati et al., 2022). The magnetic content contained in iron sand makes iron sand have wide applications in

various fields such as electronics, energy, chemistry, ferrofluids, catalysts, medical diagnosis and others. The wide application of iron sand can be done by further processing the iron sand into magnetic iron oxide nanoparticles (Fadhil et al., 2021).

In the industrial sector, iron oxide Fe₃O₄ can be used in electronic engineering (Indrayana, 2019), as a material for making permanent magnets and a material for making thin films (Ansari et al., 2020)(Wangoh et al., 2020).

Whereas Iron oxide α -Fe₂O₃ can be used as a raw material for cathodes in lithium batteries (Ma et al., 2020), hydrogen gas sensor (Sharma et al., 2020), as well as supercapacitors (Li et al., 2021). Iron oxide γ -Fe₂O₃ can also be used as a supercapacitor material in electrodes and as a base for dry ink in photocopiers and laser printers (Fahlepy et al., 2018).



Figure 1. Sand in the Bah Bolon River

The Bah Bolon River has abundant iron sand potential, one of which is in Dagang II Village, one of the villages in the Simalungun Regency area, where the samples for this research were taken. The sand in the Bah Bolon River has a blackish color and is often found along the Bah Bolon River (Susilawati et al., 2019)(Karbeka et al., 2020). With this abundance of iron sand, research has been carried out specifically on the analysis of the crystal structure and magnetic properties of iron sand from the Bah Bolon River so that it can be further developed as a potential iron sand as raw material for making permanent magnets. In this research, the extraction or separation process of iron sand from sand is carried out using a magnet which attracts the metallic materials contained in the iron sand. Next, the iron sand samples were characterized using SEM-EDS to determine the surface morphology of the samples and the percentage of mineral content as well as measurements using VSM to determine the magnetic saturation and coercivity values of the Bah Bolon River iron sand.

RESEARCH METHODS

Iron sand was taken from the Bah Bolon River in Dagang II Village, Bandar District, Simalungun Regency, North Sumatra as can be seen on the geological map of the research area in Figure 2.

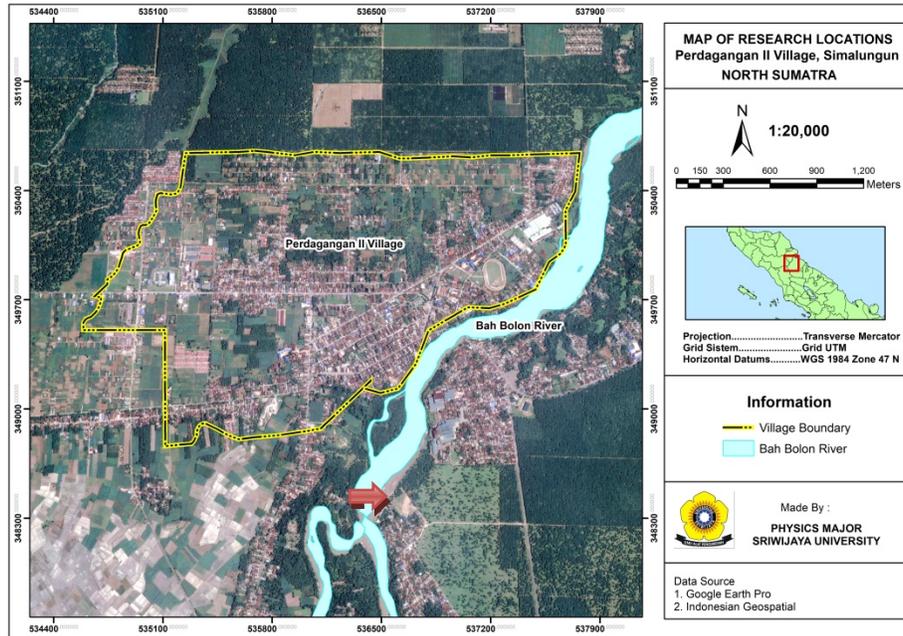


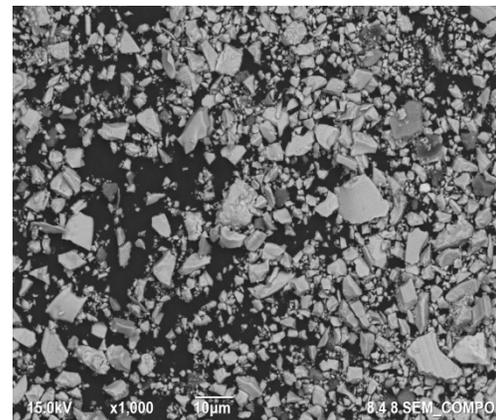
Figure 2. Geological map of the research area.

In the sample preparation process, the iron sand was first separated using a 500 Gauss permanent magnet 10 times. After that, the iron sand is washed using Aquades 5 times so that the iron sand is clean from impurities such as dust that stick to the iron sand, and then dried in the oven at a temperature of 85o C for 24 hours. To increase the level of homogeneity of the iron sand, it is refined using a mortar cup and then filtered using a 250 mesh (74 μm) sieve. The iron sand samples were then characterized using SEM-EDS to see the morphology and mineral content contained in the iron sand and VSM to determine the magnetic properties of the iron sand.

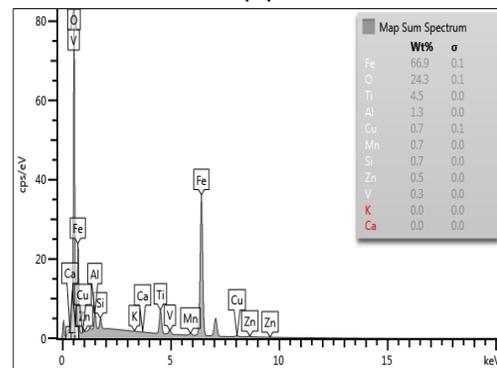
RESULTS AND DISCUSSION

SEM & EDS

The results of SEM-EDS characterization of the finely ground Bah Bolon natural iron sand are shown in Figure 3.



(a)



(b)

Figure 3a. SEM characterization results; 3b. EDS results

Based on the SEM photo results (Figure 3a), the morphology and distribution of the Bah Bolon River iron sand at 1,000 times magnification shows that the particles in the iron sand sample have a non-round (aggregate) and rough shape. It can be seen that the surface morphology structure is quite homogeneous.

From the Bah Bolon natural iron sand sample, the results of EDS analysis detected the elements contained in the sample which can be seen in the table in Figure 3b.

From the table that can be seen in the EDS measurement results (Figure 3b), it shows that iron (Fe) is the dominant element at 66.9%, Oxygen (O) at 24.3%, and other elements at 8, 8%. The elements Fe and O are elements that originate from the magnetite (Fe_3O_4), hematite ($\alpha\text{-Fe}_2\text{O}_3$), and maghemite ($\gamma\text{-Fe}_2\text{O}_3$) phases. Where magnetite, hematite, and maghemite are oxides that are generally found in iron sand (Pratap et al., 2021)(Husain et al., 2016). Meanwhile, other components such as Ti, Al, Cu, Mn, Si, and V have a percentage of < 10% in iron sand. The characteristics of magnetite iron ore are that it is blackish in color, difficult to reduce, and has very strong magnetic properties (Albar J et al., 2022).

The Fe content in Bah Bolon natural iron sand is 69.9%, which is the largest Fe content, much higher than the iron sand that was studied at Puntaru Beach, Alor Regency, NTT (34.63%)(Karbeka et al., 2020), Ambal coast (21 %)(- et al., 2014), Musi River (9.49%)(Luh Ayu Melinia, Endah Puspita, Marzuki Naibaho, Ramlan, 2022), and also still higher than the iron sand of Kata Beach, West Sumatra (55.15%)(Rianna et al., 2018). This is thought to have originated from the eruption of the Toba volcano which occurred around 74,000 years ago. Toba erupted megacologically,

reaching a volcanic explosion index (VEI-volcanic explosivity index) above a maximum value of 8.0, throwing a minimum of 2,800 km³ of explosive material/ejecta to a minimum height of 40 km, then covering an area of 100 x 30 km. The Toba super eruption is calculated to have produced 3 billion tonnes of fine ash and 540 billion tonnes of water ejected high into the stratosphere. The eruption material is mostly a mixture of gas and magma which has been reduced to volcanic ash due to strong pressure, ignited, mixed with older rock fragments originating from the walls of mountain crevices. These fiery volcanic clouds were thrown everywhere and the sediment fell down the lowlands around Toba, especially to the wide lowlands in the northeast, namely the Pematangsiantar area(Satyana et al., 2013).

VSM (Vibrating Sample Magnetometer)

The hysteresis curve of natural iron sand for the Bah Bolon River can be seen in Figure 4.

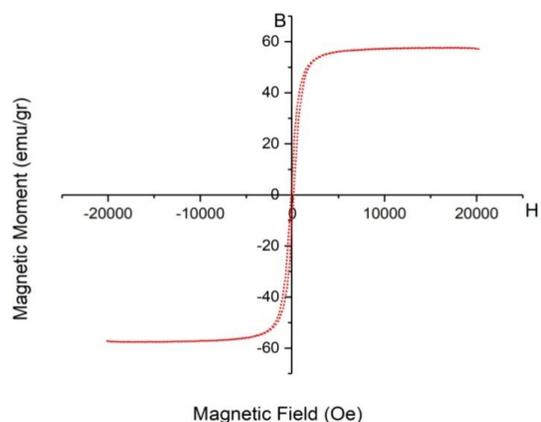


Figure 4. Hysteresis curve of natural iron sand in Bah Bolon

Based on the hysteresis curve which can be seen in Figure 4, the magnetic saturation value (M_s) is 57.70 emu/g, the magnetic remanence value (M_r) is 7.09

emu/g, while the coercivity field value (Hc) is 129.93 Oh. We can see some of the iron

sand research that has been carried out on its magnetic properties in Table 1.

Table 1. Magnetic properties based on the results of several previous studies

No	Place name	Saturation	Remanance	Coercivity	Ref
1	Alor Beach	25.42 emus/g	5 emus/g	200 Oe	(Karbeka et al., 2020)
2	Musi River	46.61 emus/g	8.72 emus/g	322.09 Oe	(Luh Ayu Melinia, Endah Puspita, Marzuki Naibaho, Ramlan, 2022)
3	Ambal Beach	31.88 emus/g	5.55 emus/g	123 Oe	(Effendy et al., 2014)
4	Beach said	30 emus/g	4 emus/g	93 Oe	(Rianna et al., 2018)

Based on the results in the table above, iron sand from the Bah Bolon River has a higher saturation value than previous research. This is thought to be because the iron sand content of the Bah Bolon river is much higher. Based on the data obtained, the coercivity value (< 132 Oe), the sample can be categorized as a soft magnet(Rianna et al., 2018).

CONCLUSION

Based on the SEM-EDS test results, the Sungai Bah Bolon iron sand contains 66.9% Fe elements, 24.3% O elements, and 8.8% other elements. Where the Fe and O elements in iron sand come from the phases of magnetite (Fe₃O₄), maghemite (γ-Fe₂O₃), and hematite (α-Fe₂O₃). Furthermore, the VSM results show that the parameters of magnetic saturation (Ms), magnetic remanance (Mr), and Coercivity (Hc) are 57.70 emu/g, 7.09 emu/g, and 129.93 Oe, respectively. Based on the results of this research, the natural iron sand of the Bah Bolon River has the potential to be used to make soft magnets for applications as microwave absorption.

BIBLIOGRAPHY

- Albar J, M. A., Putra, A. P., & Putra, E. A. P. (2022). Analysis of the Mineral Content of Iron Sand on the South Coast of Lumajang Regency, Magnetic Separation Results. *Journal of Mineral Chemical Technology*, 1, 24–29.
- Ansari, M. S., Othman, M. H. D., Ansari, M. O., Ansari, S., & Abdullah, H. (2020). Reactively sputtered half-metallic Fe₃O₄ thin films at room temperature on polymethyl methacrylate: A perspective for flexible spintronics. *Ceramics International*, 46(11), 19302–19310. <https://doi.org/10.1016/j.ceramint.2020.04.270>
- Arsyad, M., Tiwow, V. A., & Rampe, M. J. (2018). Analysis of magnetic minerals of iron sand deposit in Sampulungan Beach, Takalar Regency, South Sulawesi using the x-ray diffraction method. *Journal of Physics: Conference Series*, 1120(1). <https://doi.org/10.1088/1742-6596/1120/1/012060>
- Effendy, M. (2014). Analysis of Chemical Compound Content and Test of Magnetic Properties of Ambal Beach Iron Sand (Pages 29 to 31). *Indonesian Journal of Physics*, 17(50), 29–31. <https://doi.org/10.22146/jfi.24420>
- Fadhil, F., Yusuf, M., & Ningsih, Y. B. (2021). The Process Of Increasing Magnetite Mineral Levels (Fe₃O₄) Uses A Magnetic Separator With Variable Width Of Feed Hole And Length Of Feeding Time To Meet The Raw

- Material For Manufacturing Dry Ink (Toner). 27–28.
- Fahlepy, M. R., Tiwow, V. A., & Subaer. (2018). Characterization of magnetite (Fe_3O_4) minerals from natural iron sand of Bonto Kanang Village Takalar for ink powder (toner) application. *Journal of Physics: Conference Series*, 997(1). <https://doi.org/10.1088/1742-6596/997/1/012036>
- Husain, S., Suarso, E., Maddu, A., & Sugianto. (2016). Characterization of Natural Iron Ore Content as Raw Material for Magnetite Nanoparticles. *National Physics Symposium*, November, 146–150.
- Indrayana, I. P. T. (2019). Review Of Fe_3O_4 From Iron Sand: Synthesis, Characterization, And Functionalization To Its Application In The Field Of Advanced Nanotechnology. *UNIARA Journal*, 8(2), 65–75.
- Karbeka, M., Koly, F. V. L., & Tellu, N. M. (2020). Characterization of the Magnetic Properties of Iron Sand at Aru Beach, Alor Regency, NTT. *Lanthanide Journal*, 8(2), 96–188.
- Li, J., Luo, S., Zhang, B., Lu, J., Liu, W., Zeng, Q., Wan, J., Han, X., & Hu, C. (2021). High-performance asymmetric $\text{Mn}(\text{OH})_2/\text{Fe}_2\text{O}_3$ supercapacitor achieved by enhancing and matching the respective properties of cathode and anode materials. *Nano Energy*, 79(September 2020), 105410. <https://doi.org/10.1016/j.nanoen.2020.105410>
- Luh Ayu Melinia, Endah Puspita, Marzuki Naibaho, Ramlan, M. G. (2022). Analysis of natural iron sand from the Musi River, South Sumatra. *Journal of Science Research*, 24(3), 122–126.
- Ma, J., Kong, Y., Liu, S., Li, Y., Jiang, J., Zhou, Q., Huang, Y., & Han, S. (2020). Flexible Phosphorus-Doped Graphene/Metal-Organic Framework-Derived Porous Fe_2O_3 Anode for Lithium-Ion Battery. *ACS Applied Energy Materials*, 3(12), 11900–11906. <https://doi.org/10.1021/acs.aem.0c02030>
- Palkrisman, P., & Budiman, A. (2014). Mapping the Percentage Content and Susceptibility Value of Magnetic Mineral Iron Sand at Sunur Beach, Padang Pariaman Regency, Bara Sumatra. *Unand Journal of Physics*, 3(4), 242–248.
- Pratap, V., Soni, A. K., Abbas, S. M., Siddiqui, A. M., & Prasad, N. E. (2021). Effect of zinc substitution on U-type barium hexaferrite-epoxy composites as designed for microwave absorbing applications. *Journal of Alloys and Compounds*, 865. <https://doi.org/10.1016/j.jallcom.2020.158280>
- Rianna, M., Sembiring, T., Situmorang, M., Kurniawan, C., Setiadi, E. A., Tetuko, A. P., Simbolon, S., Ginting, M., & Sebayar, P. (2018). Characterization of Natural Iron Sand From Kata Beach, West Sumatra With High Energy Milling (Hem). *Natural Journal*, 18(2), 97–100. <https://doi.org/10.24815/jn.v18i2.11163>
- Satyana, A. H., Hutagalung, R., & Latifah, U. (2013). Toba supereruption 74,000 years ago: Geological catastrophe and mass extinction. *Proceedings HAGI-IAGI Joint Convention Medan 2013*, 1–12.
- Sharma, B., Sung, J. S., Kadam, A. A., & Myung, J. H. (2020). Adjustable n-p-n gas sensor response of Fe_3O_4 -HNTs doped Pd nanocomposites for hydrogen sensors. *Applied Surface Science*, 530(June), 147272. <https://doi.org/10.1016/j.apsusc.2020.147272>
- Susilawati, Doyan, A., & Khalilurrahman. (2017). Synthesis and characterization of barium hexaferrite with manganese (Mn) doping material as anti-radar. *AIP Conference Proceedings*, 1801(January), 1–8. <https://doi.org/10.1063/1.4973096>
- Susilawati, Doyan, A., Taufik, M., Wahyudi, Gunawan, E. R., Fitriani, A., & Nazarudin. (2019). Characterization of barium m-hexaferrite with doping zn and mn for microwaves absorbent. *Materials Science Forum*, 966 MSF, 282–289.

<https://doi.org/10.4028/www.scientific.net/MSF.966.282>

Susilawati, Khairunnisa, & Doyan, A. (2015). Synthesis Of M-Hexaferrites With Metal Dope Co. *Journal of Physics and Technology Education*, 1(3), 180–184.

Susilawati, S., Doyan, A., & Hadisaputra, S. (2022). Analysis of Magnetic Mineral Content of Natural Iron Sand in Beach Island Lombok as Basic Materials of Micro Wave Absorbers. *Journal of Science Education Research*, 8(4), 2048–2052. <https://doi.org/10.29303/jppipa.v8i4.2274>

Toto, R., Wildan, M. W., Abraha, K., & Kusmono, K. (2012). The Potential of Iron Sand from the Coast South of Bantul Yogyakarta as Raw Ceramic Magnet Materials. In *Journal of Technology* (Vol. 5, Issue 1, pp. 62–69).

Wangoh, L. W., Yang, Z., Wang, L., Bowden, M. E., Yin, X., Wee, A. T. S., Mueller, K. T., Murugesan, V., & Du, Y. (2020). Mg²⁺ diffusion-induced structural and property evolution in epitaxial Fe₃O₄ thin films. *ACS Nano*, 14(11), 14887–14894. <https://doi.org/10.1021/acsnano.0c04025>

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