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Muhammad Sayuti <sayuti_m@unimal.ac.id>

ciceq 4709

CICEQ Editor <ciceq@ache.org.rs> 15 March 2019 at 14:29
Reply-To: ciceq@ache.org.rs
To: Sayuti_m@unimal.ac.id

Manuscript number #4709: THE CHARACTERISATION OF MAGNETIC MATERIALS EXTRACTED FROM THE ACEH IRON SAND

Chemical Industry & Chemical Engineering Quarterly
(Chem Ind. Chem. Eng. Q.)
Belgrade, Serbia
(www.ache.org.rs/ciceq)

Dear Dr. Sayuti,

I have received your paper entitled “THE CHARACTERISATION OF MAGNETIC MATERIALS EXTRACTED FROM THE ACEH IRON SAND”, CICEQ 4709, and I am thankful to you for choosing the Chem. Ind. Chem. Eng. Q. for publishing your scientific results. However, I have noticed that your manuscript has not been prepared completely according to the Instructions for Authors (attached). Namely:

- The corresponding author should be identified with an asterisk. A footnote should contain an e-mail address, telephone number and fax number for the corresponding author.
- Headings should not be numbered
- Reduce the number of words in Abstract to max 200
- The list of references should be arranged according to their appearance in the text. Give names of all authors (do not use "et al."), with their initials before the respective surnames. Exclude article titles in journals. Journal titles should be abbreviated according to the Chemical Abstracts Service Source Index, 2005 edition, and supplements. The abbreviated titles should be followed by the volume number, year (in parentheses) and first and last page numbers.

Examples:
1. A. Wilchem, B. Wilchem, Chem. Ind. Chem. Eng. Q. 18 (2012) 123-125.
2. C. Wilchem, Textbook of Chemistry, Publisher, City (2012), p. 123.
3. D. Wilchem, in Chemistry Handbook, E. Editor Ed., Publisher, City (2012), p. 123.
4. E. Wilchem, Title of the Proceeding, in Proceeding of Name of the Conference or Symposium, Place of the Conference, Country (2012), p. 100.
5. F. Wilchem, (Holder), Country Code and patent number (registration year)

Online citations should be avoided, but if essential they should include the author, title, website and date of access (example: N.A. Wright, The Title of the Online citation, URL in full [accessed 7 June 2012]).

I have already made some technical corrections directly in the manuscript (attached).

Please correct the attached manuscript within no more than 10 days and return it to me so I can continue with the publication process.

Inadequately or incorrectly prepared manuscripts will be delayed or may be even rejected.

Thank you very much for your cooperation.

With best regards,
Avramovic Jelena
Technical associate

--
Prof. Vlada Veljkovic
Editor-in-Chief
Chemical Industry and Chemical Engineering Quarterly (CI&CEQ)
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Muhammad Sayuti <sayuti_m@unimal.ac.id>

ciceq 4709

CICEQ Editor <ciceq@ache.org.rs> 19 March 2019 at 13:06
Reply-To: ciceq@ache.org.rs
To: Sayuti_m@unimal.ac.id

Manuscript number #4709: THE CHARACTERISATION OF MAGNETIC MATERIALS EXTRACTED FROM THE ACEH IRON SAND

Chemical Industry & Chemical Engineering Quarterly
(Chem Ind. Chem. Eng. Q.)
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3. D. Wilchem, in Chemistry Handbook, E. Editor Ed., Publisher, City (2012), p. 123.
4. E. Wilchem, Title of the Proceeding, in Proceeding of Name of the Conference or Symposium, Place of the Conference, Country (2012), p. 100.
5. F. Wilchem, (Holder), Country Code and patent number (registration year)

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With best regards,
Avramovic Jelena
Technical associate

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Prof. Vlada Veljkovic
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Muhammad Sayuti <sayuti_m@unimal.ac.id>

ciceq 4709

CICEQ Editor <ciceq@ache.org.rs> 25 March 2019 at 15:30
Reply-To: ciceq@ache.org.rs
To: Sayuti_m@unimal.ac.id

Dear Dr. Sayuti,

Thank you for sending the article:

CICEQ 4709: THE CHARACTERISATION OF MAGNETIC MATERIALS EXTRACTED FROM THE ACEH IRON SAND

submitted for publishing in Chemical Industry & Chemical Engineering Quarterly (Chem Ind. Chem. Eng. Q.).

The paper has been received and will be sent to the addresses of at least two referees. As soon as I receive their comments you will be informed by e-mail about the status of above paper.

Please quote the above reference number CICEQ 4709 in all future correspondence.

I hope and believe that their comments and recommendation will be positive and that it will be very soon prepared for publishing in Chemical Industry and Chemical Engineering Quarterly.

As journal is in the open access regime, for every contribution submitted after July 15, 2012. and accepted for publication author(s) will participate in publishing expenses in amount of 100 € + VAT (for authors from Serbia the equivalent in RSD at the rate of NBS).

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Yours sincerely
Avramovic Jelena
Technical associate

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Muhammad Sayuti <sayuti_m@unimal.ac.id>

CICEQ 4709

CICEQ Editor <ciceq@ache.org.rs> 29 June 2019 at 18:59
Reply-To: ciceq@ache.org.rs
To: Sayuti_m@unimal.ac.id

Manuscript number #4709: THE CHARACTERISATION OF MAGNETIC MATERIALS EXTRACTED FROM THE ACEH IRON SAND

Chemical Industry & Chemical Engineering Quaterly
(Chem Ind. Chem. Eng. Q.)
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The Chemical Industry and Chemical Engineering Quarterly (Chem Ind. Chem. Eng. Q.) is on the SCIe list with an impact factor of 0.944 for 2017.

Dear Dr. Sayuti,

Please find attached the referee's comments concerning your paper. Based on the referee's report, my opinion is that the manuscript is not acceptable for publication in its present form.

However, if you feel that you can suitably address all referees' comments, I invite you to revise and resubmit your manuscript in 8 weeks.

If you are submitting the revised manuscript, please also:

a) answer to each referee’s comments in separate documents, indicating the referee’s number in the name of document,
b) outline each change made (point by point) as raised in the referee's comments
c) provide suitable rebuttal to each referee's comment not addressed and
d) color the new part of the text

PLEASE LET I KNOW IF YOU ARE GOING TO REVISE THE MANUSCRIPT AND SUBMIT IT AGAIN.

I am looking forward to receiving your revised manuscript.

Yours sincerely,

Vlada Veljkovic
Editor-in-Chief

--
Prof. Vlada Veljkovic
Editor-in-Chief
Chemical Industry and Chemical Engineering Quarterly (CI&CEQ)
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✓	

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If you suggest revision or rejection of the manuscript, please give your comments below. Alternatively, you can send your comments as an attachment.
Comments:

This paper reports a characterization of iron sand from Aceh, which has never been reported before. This is an interesting case study which can complement information related to iron sand, not only in Indonesia, but also throughout the world. My view, therefore, is that it deserves publication in CICEQ. Before publication, however, the authors should tackle some important issues:

1. **The authors gave very limited information related the sampling location. Readers will be very difficult to recognize local name such as Mon Klayu, Mantak Tari, Lam Panah and Syiah, also Burni Telong vulcano, Peut Sago volcano, and Seulawah volcano. Therefore the authors should add the coordinates of geographic positions and map which showing where this locality is located within Indonesia.**

2. **Figure 3 and Figure 5. Please add the scale bar.**

3. **Results and Discussion – Mineral Content, p1. was written:**
   "*The content of the iron sand magnetic material and the amount of impurities that cannot be separated from the external magnet were determined by SEM*".
   p.3 was written:
   "SEM results show that the levels of elements C, Mg, Si, Ti, Al, V, S, Na, Cr in the investigated magnetic materials are quite large."

These sentences are not correct and lead a misperception. One fundamental thing is that SEM tools are usually combined with spectrometer devices, such as energy dispersive spectroscopy (called SEM/EDS system). This spectroscopy, with help of software, used to calculate the mineral composition. The SEM itself was used to scan and analyze the surface images of the samples.
Authors should go through all the text and tables, and correct the explanation. Detail device information and measurement condition also need to be added.

4. **Fig. 4 XRD patterns and related compositions of the iron sands.**
There is no section discussing the XRD results, except for one sentence tucked into the mineral content section, p.3. "*The iron oxide from Aceh iron sand is dominantly composed of magnetite (Fe3O4) or ilmenite (Fe,Ti)3O4) (Figure 4)*".
XRD results was one of important results in the whole paper. Authors should provide a comprehensive discussion on this matter. Moreover, Fig 4 give very poor image quality. As I suspect, the image is a crop result from the image given by the system (I found *legend in Bahasa: pasir besi*). Authors definitely should re-plot used proper software, resulting in a professional and decent image for publication in CICEQ.

5. **Characteristic of irons sand from elsewhere in Indonesia and throughout the world, has been reported. I suggest to authors add references and discuss the comparison in discussion section related to iron sand from elsewhere, particularly from Sumatera, Java, and Papua. By adding these, I believe this paper will be better.**

EVALUATION FORM

Please select one or more highlight fields by checking or crossing and write your comments where required.

1. How you estimate the impact of this paper?

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		√	

2. Is this a new and original theoretical contribution?

Yes	Moderately	Not at all
	√	

3. Do authors present new experimental data not yet published in the literature?

Yes	Not
	√

4. Is this paper readable?

Yes	Moderately	Poorly	Not at all
		√	

5. Is this paper acceptable?

In the present form	With minor revision	With major revision	To be rejected
			√

6. Does this paper require addition of any kind?

Yes	No
√	

7. Which part of the paper might be omitted?

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8. Which part of the paper must be more precisely defined?

Introduction	Materials and methods	Results and discussion	Conclusion
√	√	√	

9. Are some figures and tables not well described in the context of the paper?

Yes	No
√	

10. Should some references be added or removed?

Yes	No	Yes	No
√			

If you suggest revision or rejection of the manuscript, please give your comments below. Alternatively, you can send your comments as an attachment.

Comments:

The script is well written, but the purpose of this study is not quite clear. The impacts generated from that study are also unclear. The method used is too simple. Actually, separate magnetic material using permanent magnets is simple and very common method. There is no break through process explained in that study. The results discussion is also unclear enough. I mean after got the phase, composition and shape of the magnetic materials then what advantages and steps could be taken for further application research. In my opinion, that experiment should be prepared with better method which include more complex extraction process, so that the material produced has more value than if it is just taken from nature without any extraction process.

Dear Editor,

We have carefully read the reviewers' comments and replied to them to the best of our knowledge. The manuscript is additionally improved in stylistic and technical details, as well as in discussion regarding the previous findings. We strongly believe that the quality of the revised manuscript will be enough to grant the publication in CICEQ. All changes made in the revised manuscript are yellow highlighted. If you feel that we need to address some more points, we will be happy to additionally improve the manuscript until the final acceptance.

Sincerely,
Assoc. Prof. Dr. M. Sayuti

Reviewer 5

This paper reports a characterization of iron sand from Aceh, which has never been reported before. This is an interesting case study which can complement information related to iron sand, not only in Indonesia, but also throughout the world. My view, therefore, is that it deserves publication in CICEQ. Before publication, however, the authors should tackle some important issues:

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   Thank you very much for your suggestion and encouragement. We absolutely agree with your comment and add the location and coordinates of the mentioned locations. This is also added in the revised paper. This figure now becomes Fig. 1 in revised manuscript.

   Mon Klayu: latitude 5°16'18,14"N, Longitude $96^0$51'48,90"E
   Mantak Tari: latitude 5°21'35.21"N, Longitude 95°59'57.48"E
   Lam Panah: latitude 5°34'42.22"N, Longitude 95°43'3.72"E
   Syiah kuala: latitude 5°35'37.94"N, Longitude 95°19'47.18"E

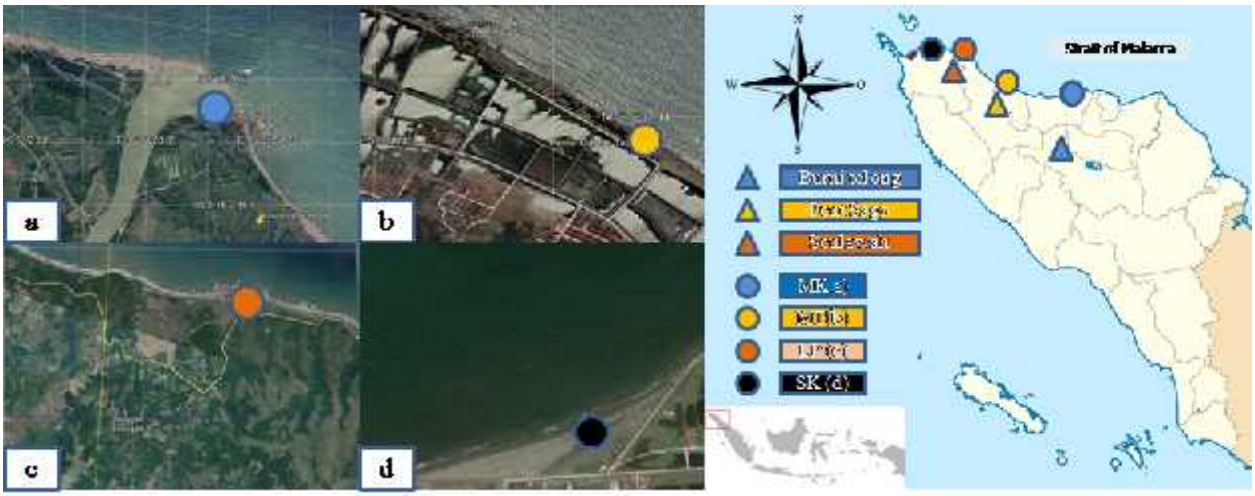

Fig.1. The location and coordinates of sampling: a) Mon Klayu (MK) beach, b) Mantak Tari (MT) beach, c) Lampanah (LP) beach, and d) Syiah Kuala beach (SK).

2. **Figure 3 and Figure 5. Please add the scale bar.**

   Thank you for your observation. In the revised manuscript we have decided to keep only the SEM micrographs of the samples, and we have added the scale bars, which is now Figure 6 in the revised manuscript. The comments of the samples' color before and after magnetic separation, shown in the previous Figure 3, are left in the manuscript just as a description.

3. **Results and Discussion – Mineral Content, p1. was written:**
   "*The content of the iron sand magnetic material and the amount of impurities that cannot be separated from the external magnet were determined by SEM*".
   p.3 was written:
   "SEM results show that the levels of elements C, Mg, Si, Ti, Al, V, S, Na, Cr in the investigated magnetic materials are quite large."

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   Authors should go through all the text and tables, and correct the explanation. Detail device information and measurement condition also need to be added.

   Thank you for your comment. We have added the information about the EDS device attached to SEM and corrected that throughout the revised manuscript. The EDS spectra are given in the revised manuscript as Figure 4.

4. **Fig. 4 XRD patterns and related compositions of the iron sands.**
   There is no section discussing the XRD results, except for one sentence tucked into the mineral content section, p.3. "*The iron oxide from Aceh iron sand is dominantly composed of magnetite (Fe3O4) or ilmenite (Fe,Ti)3O4) (Figure 4)*".
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   Thank you for your advice. We have re-plotted the XRD results and commented that in more details. The improved figure is added in the revised manuscript and is now Fig. 5.

5. **Characteristic of irons sand from elsewhere in Indonesia and throughout the world, has been reported. I suggest to authors add references and discuss the comparison in discussion section related to iron sand from elsewhere, particularly from Sumatera, Java, and Papua. By adding these, I believe this paper will be better.**

   Thank you for your comment. We have added some available literature data about iron sands in these regions and added that into the revised manuscript.

   The magnetic properties of iron sand extracted from Sarmi, Papua, Indonesia, region, showed that it consists mainly of magnesioferrite ($MgFe_2O_4$) mineral, having a high average magnetic susceptibility and proved to be useful for industrial applications [Togibasa et al., Geosciences, 2018, 8, 113; doi:10.3390/geosciences8040113]. The magnetic iron sand retrieved from Banten, Indonesia showed the presence of many different impurities, like Ti, Al, Ce, Co, Cr, Eu, La, Mg,

Mn, Na, Sc, Sm, Th, V, Yb and Zn [Sukriman, et al. IOP Conf. Series: Journal of Physics: Conf. Series **1091** (2018) 012007 doi :10.1088/1742-6596/1091/1/012007]. The iron sand collected from Lampung, Indonesia showed that it consists of majority Fe around 65 wt% and many additional elements as well [Gunanto et al., IOP Conf. Series: Journal of Physics: Conf. Series **1011** (2018) 012005 doi :10.1088/1742-6596/1011/1/012005].Rianna et al. separated magnetic phase by magnetic separation process using a permanent magnet, and showed that it mainly contains Fe_3O_4 phase [Rianna et al., Journal Natural, 2018, 18 (2) DOI 10.24815/jn.v18i2.11163].

Reviewer 7

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Thank you for your comment. We believe that the findings reported in this paper are important for developing of the industry of the region, but also for development of new magnetic materials for diverse application. The natural resources of iron sand in Indonesia region are very rich, and we have added a paragraph in the revised paper, which explains the previous findings. From industrial point of view, the applied processes should be simple but enough to extract the raw material of the reliable quality, which has been shown in this paper. This is a pioneer study and it is planned to be further developed with more complex extraction systems indeed, and we appreciate the reviewer's comment. In the revised manuscript, we have improved the specific parts and the discussion. All changes are yellow highlighted in the revised manuscript.

THE CHARACTERISATIONOF MAGNETIC MATERIALSEXTRACTED FROM THE ACEH IRON SAND

MUHAMMAD SAYUTI,*[1]REZA PUTRA[2] AND MUHAMMAD YUSUF[2]

[1]Department of Industrial Engineering, Faculty of Engineering Malikussaleh University , 24351 Aceh-Indonesia.

[2]Department of Mechanical Engineering, Faculty of Engineering Malikussaleh University, 24351 Aceh-Indonesia

Article Highlights

- Iron sand was taken from four coastal places: Mon Klayu, Mantak Tari, Lam Panah and Syiah Kuala.
- 100 g of the iron sand was separated by an external magnet and washed with distilled water.
- The iron oxide found in Aceh iron sand wasdominantly magnetite (Fe_3O_4) or ilmenite ($(Fe,Ti_3)O_4$.

[1]Corresponding author: **Muhammad Sayuti,** Sayuti_m@unimal.ac.id, Telp /HP : +62 645 21373 / +6285277293401, Fax : +62 645 44450;

Abstract – This study aims to identify the content and particle shape and to determine the type of iron oxide in the magnetic material from Aceh Iron Sand. The samples were taken from foursea coast locations, namely Mon Klayu, Mantak Tari, Lam Panah and Syiah Kuala beach. The magnetic materials are separated from the iron sand using an external magnet,washed outwithdistilled water and dried at 80 °C. The materials were characterized by XRD and SEM. The results show that the magnetic materials sampled from the Aceh iron sand contain 88.93%, 96.3%, 92% and 85% of Fe, respectively. The iron oxide found in Aceh iron sand was dominantly magnetite (Fe_3O_4) or ilmenite ($Fe,Ti_3)O_4$, however, there are also other oxide impurities, such as silica and chromium oxides. The identified minerals were classified as lithogeneous sedimentary volcanic minerals, which have blackcolour and spherical shape. Related to that, the sampling locations of these minerals were the type of volcanic minerals and lithogenous sediments since the position of the coast locations is adjacent to the Burni Telong, Peut Sago, and Seulawah volcanos,and the minerals are carried by the stream to beach through the river flow, which further supports the assumption of its volcanic origin.

Keywords: Iron sand, Magnetic materials, Iron oxide, Aceh

Introduction

Along with the development of technology, magnetic materials are currently used not only as raw materials for steel making, but also in various fields such as electrochemical,catalytic and medical science [1,2]. The development of the magnet industry criticallydepends on the use of magnetic materials components[3].The currently used magnetic materials include iron oxide materials, such as hematite (α-Fe_2O_3), maghemite (γ-Fe_2O_3), ilmenite (Fe,Ti_3)O_3), and magnetite (Fe_3O_4), sulfide iron materials such as pyrrhotite (Fe_7S_8) and greigite Fe_3S_4[4].The research on the use of iron oxide materials has been carried out in various fields [5].

Maghemite iron oxide is used as a supercapacitor material electrode [6] while magnetites are widely used as drug delivery agents to transport drugs to certain parts of the human body and as contrast agents in magnetic resonance imaging (MRI)[5]. The magnetic nanoparticle materials modified with polymerswere used to adsorb metal ions such as Cd (II), Zn (II), Pb (II) and Cu (II) [3]. These three magnetic materials are usually synthesized in the laboratory using the co-precipitation method [7]. The precursors in the synthesis of magnetic materials are usually $FeCl_{36}\cdot H_2O$, $FeCl_{24}\cdot H_2O$,$FeSO_{47}\cdot H_2O$ or $Fe(NO_3)_{39}\cdot H_2O$[8-10]. However, these precursors are relatively expensive and produce new waste. Therefore, a more effective, efficient, and environment-friendly source of magnetic materials is required to replace these precursors. The source of magnetic materials can be replaced with magnetic materials derived from the natural iron sand. Iron sandis generally composed of iron oxide, namely magnetite (Fe_3O_4), hematite (α-Fe_2O_3), and maghemite (γ-Fe_2O_3), and several other oxide compounds such as Al_2O_3, MgO, and SiO_2 [11]. Iron sand in Indonesia is found mostly on coastal locations, such as the coast of West Sumatra, the southern coast of Kebumen, and the north coast of Java Island. Aceh has several regions with excellent potential minerals, such as Monklayu, Mantak Tari, Lam Panahand the Syiah Kuala coast. Potential minerals found in the area include magnesite, chromite, iron, quartz, limestone, sandstone and clay stone[12]. Therefore, it is necessary to identify iron sand materialsfrom different areas, especially the province of Aceh, and to determine its iron content. An iron ore obtained from an iron sand is usually mixed with soil, so an appropriate method is required to purify the iron sand. On a laboratory scale,the iron sand magnetic material is prepared manually using an external magnet [13], but it still contains several impurities [10].Rianna et al. separated magnetic phase by magnetic separation process using a permanent magnet, and showed that it mainly contains Fe_3O_4 phase [14].

The sand can be classified by its physical properties or by the constituent mineral content. The classification based on the physical properties of the sand can be distinguished based on the shape, size,

colorand density of the sand. The three sub-quantities were used,where each quantitydescribes the shape at different scales [15]. These terms are morphology/form, roundness,and surface [16]. In Figure 1 is shown how the scale terms are defined, while the graphic scale to illustrate the quantitative measure is shown in Figure 2 [17]. It is important to highlight that any comparing chart that describes particle properties has a high degree of subjectivity. The classification can also be done according to differences of the chemical constituents of the sand. One method used to analyze mineral content in the sand is X-ray diffraction (XRD), which calculatesthe mineral percentagesin the specific sample [18].

Fig. 1.

Fig.2

Therefore, the magnetic material hasto be purified to remove impurities that cannot be pulled out by external magnets. In this study, the separation of the magnetic material from the iron sand was performed using external magnets; themagnetic material was preparedby washing out with distilled water before the further characterization, identification of magnetic material content, and determination of iron oxide types in the magnetic material of the Aceh iron sand. This research can provide an alternative use of iron sand as a support for the national steel industry.

Experimental

The samples of the iron sand originating from the coasts of Mon Klayu, Mantak Tari, Lampanah and Syiah Kuala Beach were used for the preparation of magnetic materials,and the sampling coordinates and locations are given below, with a geographical representation in Figure 3.

Mon Klayu: latitude 5°16’18,14”N, Longitude $96^0$51’48,90”E

MantakTari: latitude 5°21'35.21"N, Longitude 95°59'57.48"E

Lam Panah: latitude 5°34'42.22"N, Longitude 95°43'3.72"E

Syiahkuala: latitude 5°35'37.94"N, Longitude 95°19'47.18"E

100 g of the iron sand was separatedby an external magnet and afterwards washed with distilled water. The washing procedure was repeated three times. The magnetic solidswere dried in an oven with a

temperature of 70 ° C for 24 h. The obtained iron sand powder was characterized by X-ray diffractometry (Shimadzu XD610, and data processing software HighScore Plus) and scanning electron microscopy SEM equipped with EDS analysis (SEM JSM-6510LA, JEOL) in the laboratory of the National Nuclear Energy Agency of Indonesia (BATAN). The additional characteristic observation of the sand shape was conducted using an optical microscope. The shape of each sample was then compared with the image of the sand form in Figure 2.

Fig. 3

RESULTS AND DISCUSSION

The Mineral Content

The iron sand of Mon Klayu (MK) beach, Mantak Tari (MT), Lam Panah (LP) and Syiah Kuala (SK) before magnetic separation grayish showed black color. After the magnetic separation, the black magnetic concentrate was obtained. The black colorvisually implies that iron oxide in the magnetic material is dominantly composed of the magnetite type [19]. However, further characterization is needed to support the identification of iron oxide types and the content of the iron sand magnetic material. The content of the iron sand magnetic material and the amount of impurities that cannot be separated by the external magnet were determined by EDS analysis coupled withSEM characterization of the samples. The results of the characterization of iron sand magnetic materials are shown in Table 1.

Fig. 4

Table 1.

Based on Table 1, it is shown that the magnetic materials sampled out at Mon Klayu, Mantak Tari, Lam Panah, and Syiah Kuala locations contain Fe as a major element with the average levels above 90%, and also other minor elements. The high level of Fe is caused by the preparation procedure, which was carried out using external magnets and the geographical conditions of the area from where the samples were taken.This is very important since the iron sand collected from Lampung, Indonesia consists of majority Fe around 65 wt% and many additional elements as well [20].

SEM results show that the levels of elements C, Mg, Si, Ti, Al, V, S, Na, Cr in the investigated magnetic materials are quite large. This is in agreement with previous studies, where the magnetic iron sand retrieved from Banten, Indonesia showed the presence of many different impurities, like Ti, Al, Ce, Co, Cr, Eu, La, Mg,Mn, Na, Sc, Sm, Th, V, Yb and Zn [21].The iron oxide from Aceh iron sand is dominantly composedof magnetite (Fe_3O_4) or ilmenite $(Fe,Ti)_3O_4$) (Figure 5). The levels of these oxides are quite large since they also have magnetic properties. Therefore, if the magnetic material of iron sand is pulled out by an external magnet, the oxide is also attracted to an external magnet. In addition, the Aceh sampling area is also a region producing Cr mineral resources. The obtained magnetic material still contains these elements in sufficient quantities. The constituent elements of the magnetic material do not exist as chemicalelements but rather in the form of oxides. Therefore, the magnetic material needs to be further characterized to find out the oxide phases present in the magnetic material. The mineral content affects the color of the iron sand [19]. The iron sand appears as black because ofthe dominant presence of cromite with a heterogeneouscolor layer structure: the layer contains a mixture of red, brown, white, and solid black. This color identification can be seen in the Table 2. The iron sand content is very dependent on the source of the local stone and environmental conditions. The bright white sand found on the beach is limestone or silica and some sandsare rich in dark magmaticmaterial so that the black appearance comes from volcanoes and oxides. In the black sand, the dominant minerals are magnetite (Fe_3O_4), ilmenite $(Fe,Ti_3)O_3$), diamond (C), or chromite [(Mg,Fe) Cr_2O_4]. The darker is the color of the sand, the higher is the concentration of Fe phases or chromite.This is an interesting if compared to the iron sand extracted from Sarmi, Papua, Indonesia, region, which consists mainly of magnesio ferrite ($MgFe_2O_4$) mineral, having a high average magnetic susceptibility and proved to be useful for industrial applications [22].

Table 2.

Fig. 5

Based on the mineral content, the particle size of the iron sand can be classified asof fine grade. Arstrong suggested that high levels of SiO_2 and Ca-oxide can be found in medium-sized sand, while in afine sand, the mineral content is generally that of iron sand (Fe), Al_2O_3, and Ti [23]. Related to this, it is suggested that these minerals belong to the type of volcanic minerals and lithogenous sediments because the position of fourbeaches is adjacent to the Burni Telong, Peut Sago, and Seulawah volcanos, and the minerals are carried by the stream to the coast by the river flow [24].

Particle shape

It can be seen in Figure 6 that the grainsof the ironsand have an irregular form. The sphericity is a measure that describes the tendency of a grain shape toward a spherical shape [25]**.**The high roundness value or the round shape of the grains of sandindicates that the grain has undergone a further transport process, which resultsin the fine sand grains. The sand or the particle/grain is shaped by abrasion during transportation, where collisions between particles or with bedrock exist, so that the shape changes from angled/pointed to rounded. The longer the distance traveled, the more complex and the more rounded particles form [26].

Based on the analysis of the sediment fraction, the average particle size of sand is 0.14 mm, which means that Aceh beach sand can be categorized as fine. The visual inspection of the sample shows that the sand sample is in the coral form. The size of the sediment granules in the study location is inseparable from the surrounding environmental conditions, which favors the sediment formation. One of these conditions is the source of sedimentary components from the land, such as the process of abrasion or erosion, which are then carried by the river. The factor that influences the size of the sedimentation grain is the sediment material transport mechanism. This will determine the depositional variation that occurs, so the coarser particles are easier to be deposited than finer ones, since it is affected by hydro-oceanographic factors, such as water flow and tides [19].

Fig.6

Conclusion

Depending on the locations, the extracted magnetic materialshave different amounts of Fe-mineral: 88.93% (Mon Klayu), 96.3% (Mantak Tari), 92% (Lam Panah), and 85% of Fe (Syiah Kuala), as well as C, Mg, Si, Ti, Al, V, S, Na, Cr and other minor elements. Iron oxide in the Aceh iron sand is dominantly in magnetite (Fe_3O_4) or ilmenite ($(Fe,Ti_3)O_4$) form. The results of characterization show that the magnetic materials of the iron sand still contain oxide impurities, such as silica oxide and chromium oxide. The

types of minerals identified were classified into volcanic mineral types from lithogeneous sedimentary types, black in color and rounded in shape.This corroborates well with the position of the Mon Klayu, Mantak Tari, Lam Panah and Syiah Kuala beaches, which are adjacent to the Burni Telong, Peut Sago, and Seulawah volcanos, and the minerals are carried by stream to the beach by the river flow.

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Figure captions

Fig. 1. The shape-describing sub-quantities.

Fig. 2 A roundness qualitative scale [16].

Fig. 3 The location and coordinates of sampling: a) Mon Klayu (MK) beach, b) Mantak Tari (MT) beach, c) Lampanah (LP) beach, and d) Syiah Kuala beach (SK).

Fig. 4EDS spectra of iron sand samples from different regions : a) Mon Klayu, b) MantakTari, c) Lam Panah, d) Syiah Kuala beach.

Fig. 5 XRD patterns and related compositions of the ironsands a) Mon Klayu and b) Mantak Tari, and the corresponding concentrates c) Mon Klayu and d) Mantak Tari.

Fig. 6 The SEM micrographs of particle shape of different iron sands: a) Monklayu, b) Mintak Tari, c) Lampanah and d) Syiah Kuala.

Table 1.The elemental composition of the magneticmaterials determined by EDS coupled to SEM.

AREA	Composition (%)									
	F e	C	Mg	Si	Ti	Al	V	S	Na	Cr
MK	88.93		0.93	1.39	6.65	2.09				
MT	96.3			1.67	0.54	1.22	0.27			
LP	92	2.7	0.54	2.5	0.74	0.94	0.2	0.13		0.12
SK	85	0.67	1.09	1.64	7.93	1.49			1.65	

Table 2Theidentificationof the minerals according to the color.

Color	Type of Mineral/Compound/Element
Red	Hematite (Fe_2O_3), Cuprite (CuO_2), atauPyrope (Mg,Al_2SiO_{12})
Yellow	Marcasite (FeS), Sulfur (S), Chalcopyrite ($CuFeS_2$) or Vanadium (V)
Black	Magnetite (Fe_3O_4), Ilmenite ($Fe,Ti_3)O_3$), Diamond (C), orChromite [$(Mg,Fe)Cr_2O_4$]
Brown	TiO_2compound or Spinel ($MgAl_2O_4$)
White	SiO_2compound or Orthoclase ($KalSi_3O_8$)
Light green	Uvarovite ($Ca_3Cr_2Si_3O_{12}$) or olivine [$(Mg,Fe)_2SiO_4$],
Orange	Spessartine ($Mn_3Al_2Si_3O_{12}$)

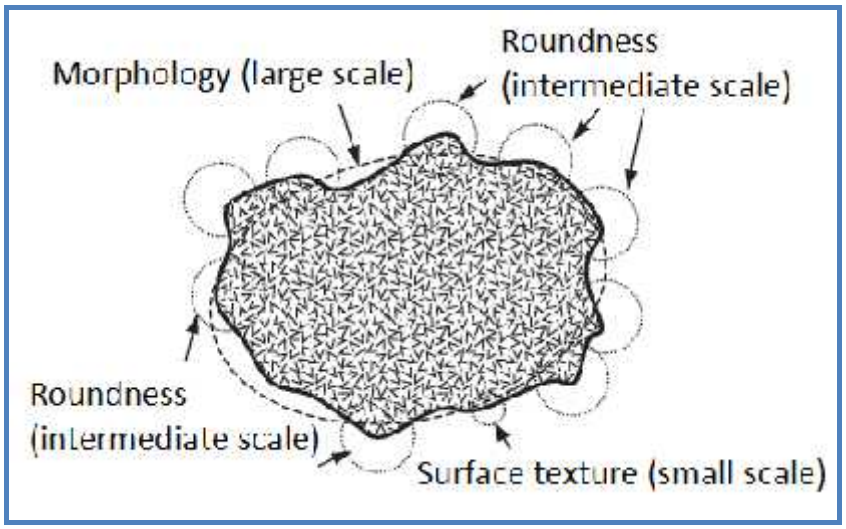
Morphology (large scale)
Roundness
(intermediate scale)
Roundness
(intermediate scale)
Surface texture (small scale)

Figure 1

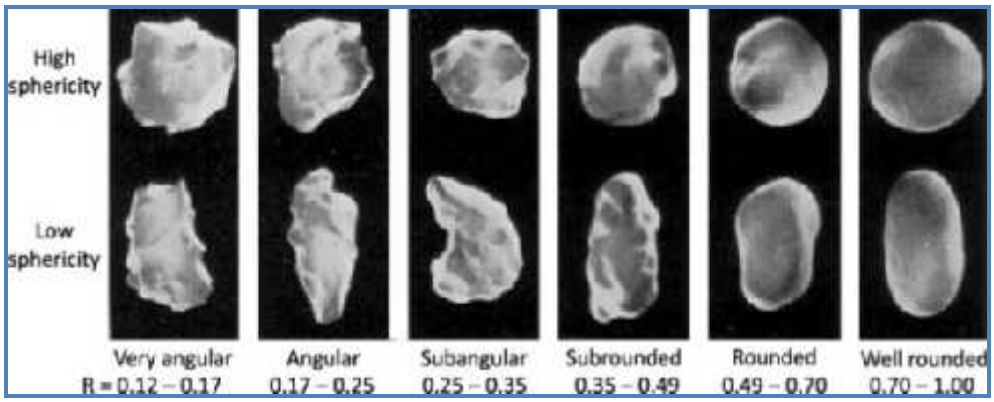
High sphericity
Low sphericity
Very angular
R = 0.12 – 0.17
Angular
0.17 – 0.25
Subangular
0.25 – 0.35
Subrounded
0.35 – 0.49
Rounded
0.49 – 0.70
Well rounded
0.70 – 1.00

Figure 2

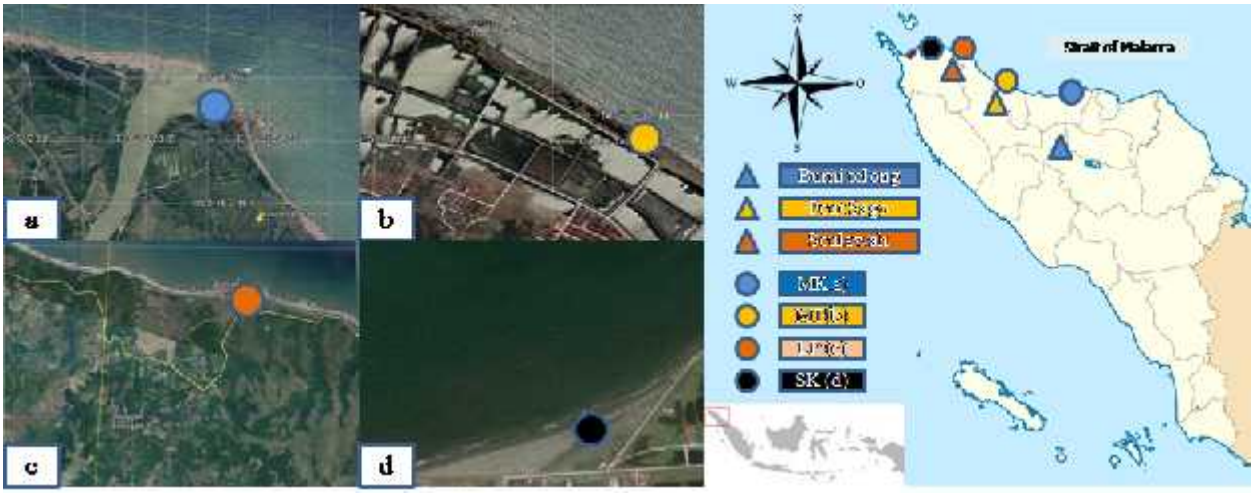

Figure 3

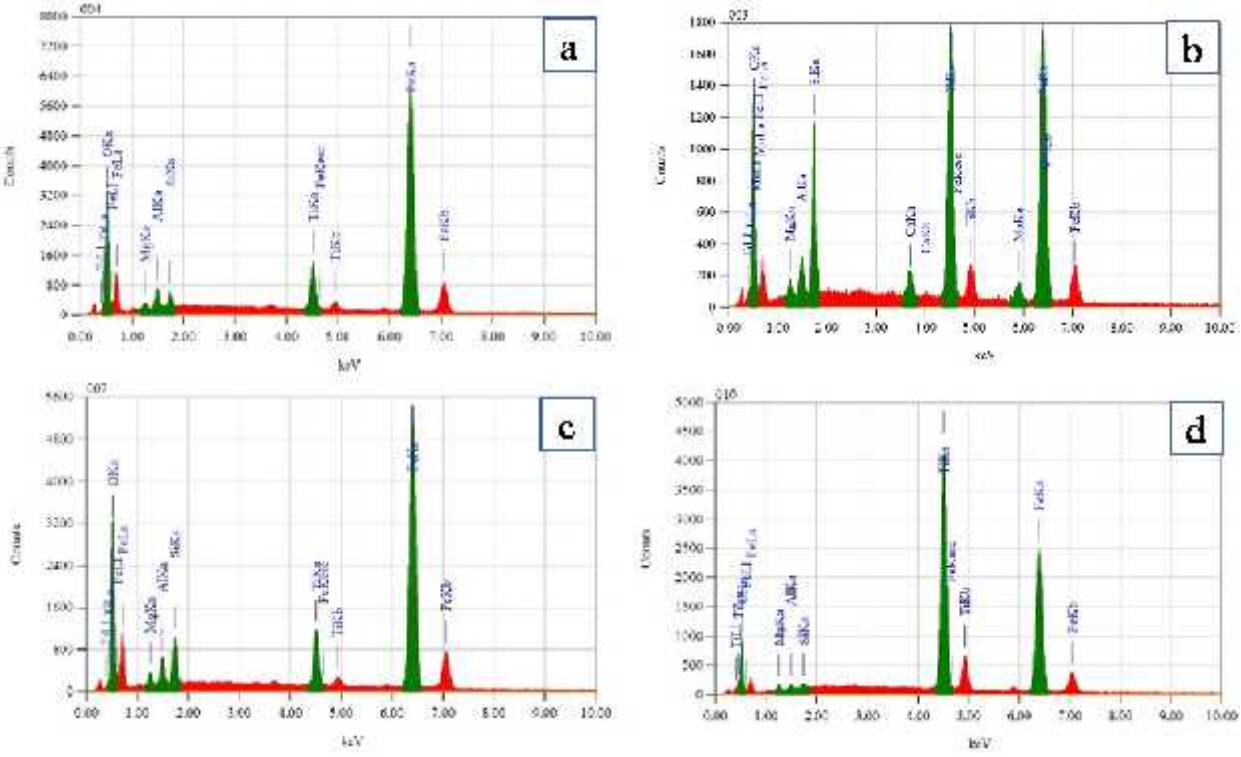

Figure 4

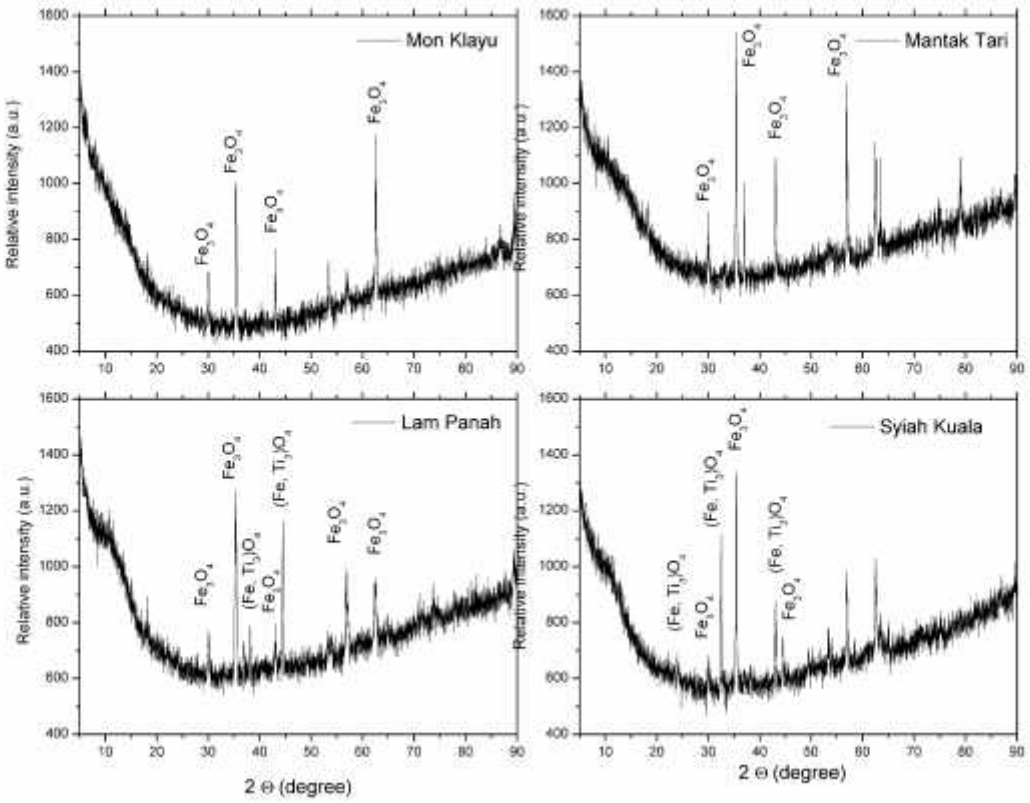
Mon Klayu
Mantak Tari
Lam Panah
Syiah Kuala
Relative intensity (a.u.)
2 Θ (degree)
Fe3O4
(Fe, Ti)3O4

Figure 5

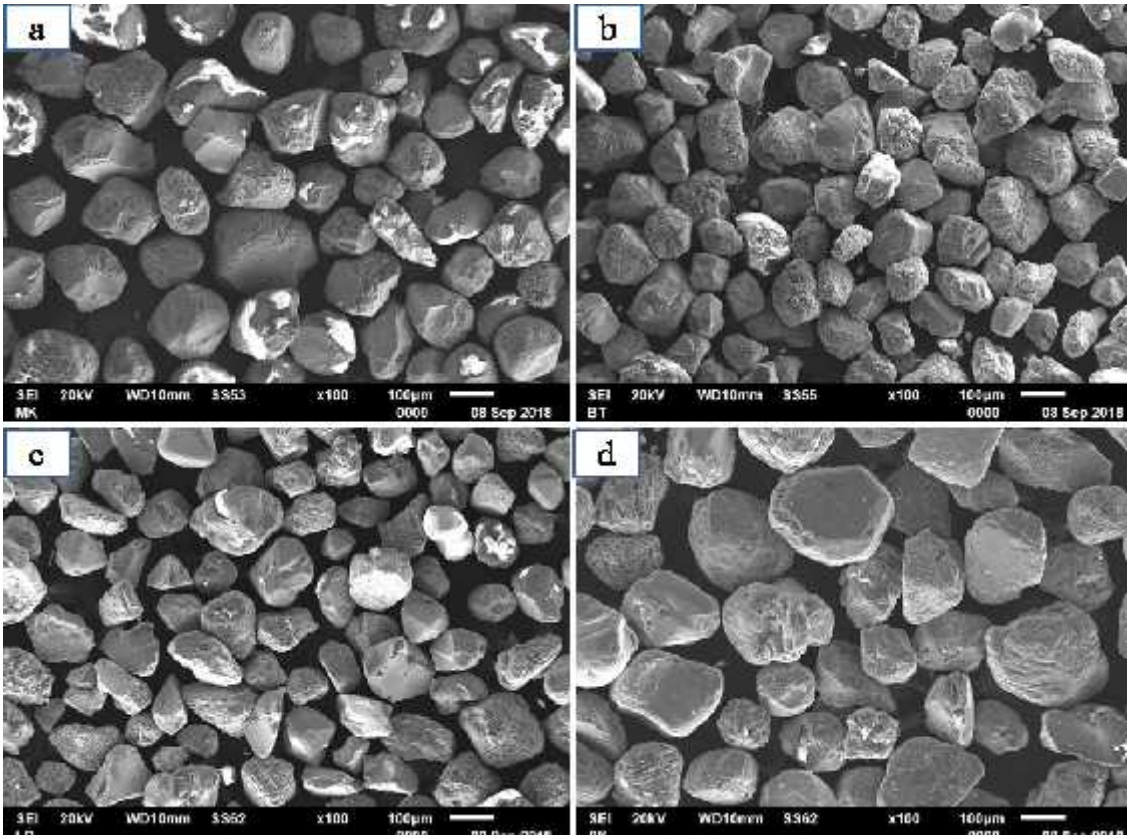

Figure 6

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