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Identification of magnetic minerals in the fine-grain sediment on the Bengawan Solo River

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Abstract. The magnetic mineral content in the fine sediment of Bengawan Solo River is discussed. The fine sediment is obtained on the upper part of the tributary of Bengawan Solo River. Magnetic minerals are separated using permanent magnets. Furthermore the magnetic minerals are overnight dried using oven at 100°C. FTIR characterization indicate that the magnetic minerals in the fine sediment of Bengawan Solo River have the same characteristics as minerals in Cilacap and Purwokerto areas. Magnetic minerals are estimated to form at wave number k = 569.03 cm^{-1}. This hematite content increase to 70.67% after anealling treatment at 600°C for 4 hours in atmosphere condition. This result is interesting because the heating process increases the hematite content. Within results, the magnetic properties of the sample will change.

1. Introduction

Analysis of magnetic rocks from deposited sediments is a technique that has been established in the field of earth science. This is primarily with environmental magnetism. This method has the advantage of relatively fast, non-destruction, relatively cheap cost [1-4]. Characteristics of magnetic rocks in sediments are useful information for various field such as paleoceanography, paleoclimatology, sedimentology and soil science [4, 5].

In general, magnetic minerals include magnetite (Fe_3O_4), maghemite (γ-Fe_2O_3), hematite (α-Fe_2O_3), and goethite (α-FeOOH) formed well drained soils in response to external factors i.e. physical, chemical and biological factors [3]. Hematite and goethite are antiferromagnetic materials. Both of these minerals are stable and have a small magnetization saturation M_S (0.4 Am^2 kg^{-1} and 0.05~0.3 Am^2 kg^{-1} for pure hematite and goetite respectively). However the both minerals indicate as hard magnetic material owing a relatively large coercive field i.e. H_c > 300 mT [6].

In this paper, preliminary study of a magnetic mineral identification on the fine sediment of Bengawan Solo River is presented. The formed of magnetic minerals evaluate by FTIR spectroscopy. Finally, the magnetic property measure by vibrating sample magnetometer (VSM) at room temperature.

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2. Experimental

Preparation and evaluation of the natural mineral in a fine sediment of Bengawan Solo Rivers are conducted by the following steps. First, separation of the fine sediments by using permanent magnet. Thus the sample is then washed with water and alcohol. This procedure is repeated until clean. Subsequently the sample was heated overnight at a temperature of 100°C to remove the water content.

The second step is annealing process. Here the sample is annealed at a temperature of 600°C for 4 hours under atmospheric conditions. Then the sample is homogenized using mortar. The next step is characterization including the determination of metal mineral oxides using FTIR and x-ray fluorescence. Finally, the magnetic property of the fine sediment evaluate by using vibrating sample magnetometer at room temperature.

3. Results and Discussion

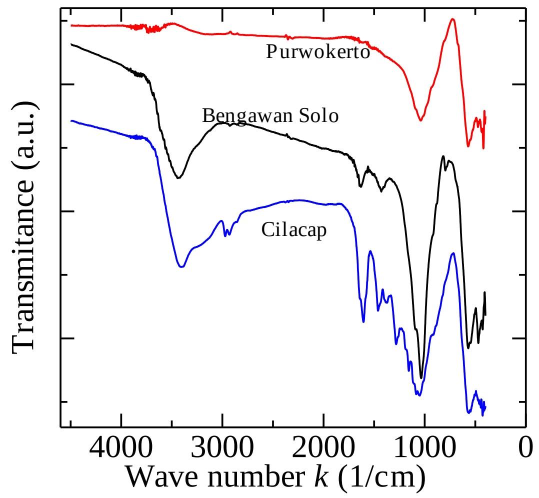

Figure 1. FTIR spectrum of a fine sediment sample of Bengawan Solo River compare with Cilacap and Purwokerto sediments.

Figure 1 shows a Fourier Transform Infra-Red (FTIR) spectrum characteristic for the fine sediments of Bengawan Solo Rivers compare to the fine-magnetic sediment of Cilacap and Purwokerto. The FTIR characterization indicates the formation of the oxide bond resonance of the fine sediment of Bengawan Solo including metal oxide bonds such kind Fe–O, Si–O and others. FTIR in a fine sediments of the Bengawan Solo River typically have the same spectrum as a magnetic fine sediment of Cilacap. Absorbance peak of FTIR spectrum at wave number 1447 cm^{-1} to 3000 cm^{-1} is associated to a vibration stretching and bending of H–O–H bond. Whereas a peak absorbance for wave number k = 1023 cm^{-1} is the anti symmetric stretch of the Si-O-Si bond attributed to the oxygen movement. It is known that the Fe-O bond observe at the wave number k of about 600–700 cm^{-1}.

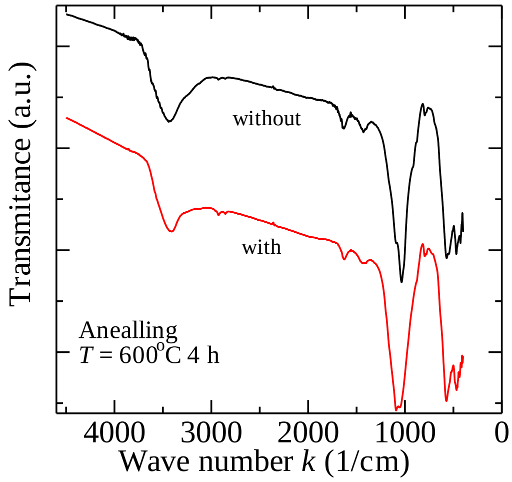

Figure 2. The FTIR spectrum evaluate for the fine sediment of Bengawan Solo River under with and without annealing at 600°C for 4 hours.

Table 1. The contents of the fine sediment sample Bengawan Solo River with and without annealing @600°C for 4 h

No	Compounds	Concentration (%)	
		Without annealing	With annealing @600°C for 4 h
1	Fe_2O_3	68.85	70.67
2	SiO_2	12.34	12.59
3	TiO_2	6.78	6.31
4	Al_2O_3	4.71	3.57
5	CaO	2.8	2.82
6	P_2O_5	1.12	0.84
7	Others (consist 12 compounds)	3.35	3.14

The annealing effect on the FTIR spectrum the fine sediment of Bengawan Solo River under with and without annealing temperature at 600°C for 4 h is depicted at Fig 2. It is clearly observed that there is no significantly change or shift in the absorption peak from the original condition. This indicates that the formed metal oxide is stable with high temperature treatment. The Fe–O bond realize at k = 569 cm^{-1} for case without annealing and a few change become k = 571.9 cm^{-1} for case with annealing.

In order to know more details about the oxide composition especially Fe–O in the sample, an XRF analysis is performed as shown at Table 1. From the result table XRF analysis confirmed that the Fe-O compound formed is hematite (Fe_2O_3). The hematite composition dominates up to 68.85% and increases to 70.67% by annealing treatment. The increase in concentrations of other compounds that increase in the sediment is only silicon dioxide i.e. from 12.34% to 12.59%. While concentration of the other compounds show decrease with annealing treatment. It can be said that only Fe_2O_3 and SiO_2 are stable with heat treatment.

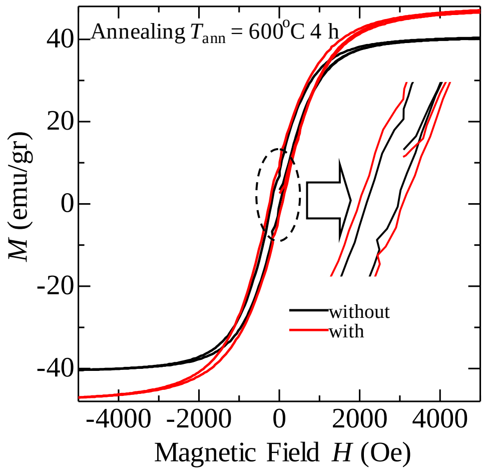

Figure 3. The hysteresis curve of the fine sediment on Bengawan Solo River without and with annealing temperature of 600°C for 4 h.

Finally, the magnetic property of the fine sediment evaluate by using vibrating sample magnetometer (VSM) at room temperature. Figure 3 show the VSM results of the fine sediment on Bengawan Solo River under without and with annealing temperature. It was clearly observed that the coercive field did not significantly change with the annealing treatment at temperature of 600°C for 4 h (see zoom figure). Coercive field changes slightly from 100.63 Oe to 157.46 Oe after annealing. This can be attributed the occurrence of the domain wall depining. While the magnetization of saturation increased from 32.97 emu/g to 39.98 emu/g due to the increase of hematite concentration in the samples sediments of Bengawan Solo River.

4. Conclusion

The magnetic mineral content in the fine sediment of Bengawan Solo River is discussed. FTIR characterization indicate that the magnetic minerals in the fine sediment of Bengawan Solo River have the same characteristics as minerals in Cilacap and Purwokerto areas. Magnetic minerals are estimated to form at wave number k = 569.03 cm^{-1}. This hematite content increase to 70.67% after annealing treatment at 600°C for 4 hours in atmosphere condition. Within results, the coercive field change from 100.63 Oe to 157.46 Oe. Finally the saturated magnetization increase from 100.63 emu/g to 157.46 emu/g.

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