Identification of magnetic mineral forming elements in peatland
Alahan Panjang West Sumatra Indonesia, section DD REP B 693 using X-Ray Fluorescence

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Abstract. The elemental composition in peatland samples has been measured using the XRF (X-Ray Fluorescence) instrument. Peat soil samples were taken using a peat core near the Lake Diatas Alahan Panjang. After the magnetic susceptibility of the samples were measured using Bartington Magnetic Susceptibility with MS2C sensor the samples that had the highest value were subsequently selected for analysis of elemental composition. The given results of percentage of major composition, including Si (50,552%), Al (13,545%), Fe (12,23%) S (4,896%) and Mg (4,204%). The most magnetic element forming magnetic element was Fe that formed mineral such on hematite, magnetite, maghemite, ilmenite, greidite or goethite.

1. Introduction
Tephra is a term used for all materials released into the air during volcanic eruptions [1][2][3]. Materials released by volcanoes in the form of coarse-sized grains (gravels) usually fall within a radius of 5-7 km from the crater, and fine-sized grains can fall at distances reaching hundreds of kilometers or even thousands of kilometers from the crater because they can be affected by the presence of wind, rain and water flow [4]. Tephra or volcanic ash that falls on rivers and lakes will be deposited at the bottom, while tephra which falls into peatland will be deposited and become an element of peatland.

Peat is formed from heaps of dead plant residues, whether or not already rotten [5]. The accumulation continues to increase because the decomposition process is hampered by anaerobic conditions and other environmental conditions. Peatlands mixed with tephra contain various elements that can form a magnetic mineral. Peat soils have high pore numbers and very high water content so that their carrying capacity is very low and their absorption capacity is very high [6]. Peatlands mixed with tephra, dust and decomposers contain various elements that can form a magnetic mineral [7][8][9].

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Magnetic minerals are minerals that have high magnetic properties. Magnetic minerals are categorized into 3 groups based on their magnetic properties including diamagnetic, paramagnetic, and ferromagnetic. Examples of ferromagnetic minerals are magnetite (Fe₃O₄) containing Fe²⁺Fe³⁺O₄²⁻, hematite minerals (α-Fe₂O₃) and maghemite (γ-Fe₂O₃) containing Fe²⁺O₃⁻. It can be seen that these magnetic minerals consist of elements related to oxidation.

The achievement in this study is identify the elements that form magnetic minerals on peat land located in Alahan Panjang District, Solok, West Sumatra. To see the content of these elements can use (XRF). X-ray fluorescence (XRF) is a non-destructive analysis technique used to identify and determine the concentration of elements present in solids, powders or liquid samples.

2. Methods

2.1 Time and Location
Sampling was carried out in March 2018 in the Lake Diatas District peatland area, Solok West Sumatra, Indonesia. Located at coordinates 1° 4'19.95" LS and 100° 46'13.53" BT (Figure 1).
In Figure 1 above, it can be seen that the sampling location is very close to the Danau Diatas, Kabupaten Solok. Peatland samples were taken using peat core equipment (Figure 2a), after which they were put into PVC which was halved first. Then the cores were wrapped using plastic and stored in a fishing box prepared as a temporary storage container before being stored in the freezer at the FMIPA UNP Geophysics Laboratory.

**Figure 1.** Map of research location and position of peat soil sampling

**Figure 2.** The process of sampling peatlands. a) The process for sampling peatland using peat core. b) Observation of samples of peat land that have been obtained
Peatland samples were measured for the abundance of magnetic minerals and the types of elements. The abundance in magnetic minerals was determined using MS2C, while the concentrations of the type of the element was determined using X-Ray Fluorescence (XRF) (Figure 3).

2.2 Sample Measurement

After obtaining the value of the peat magnetic susceptibility, samples are then selected which have a high susceptibility value to be inserted into the holder using a plastic spoon. Then the sample was measured using XRF brand PANanalytical type Epsilon 3 (Figure 3) in the Chemistry Laboratory of FMIPA UNP. X-Ray Fluorescence (XRF) is one a tool can be used to determine the chemical elements of a sample in the form of powder, soil, liquid or other forms. The XRF method is a fast method because it only requires a little sample preparation. In addition, the XRF method is accurate and not destructive. X-ray fluorescence (XRF) works by firing X-rays against a sample so that electrons from an inner orbit will be released and the outer shell electrons will replace it. This change of orbit will emit X-rays of different wavelengths. Different wavelengths are characteristic to the element found in the sample.

![Figure 3. XRF (X-Ray Fluorescence)](image)

3. Results and Discussion

| Element | Conc % | Oxide | Conc% |
|---------|--------|-------|-------|
| Na      | 0      | Na₂O  | 0     |
| Mg      | 4.204  | MgO   | 4.659 |
| Al      | 13.545 | Al₂O₃ | 15.643|
| Si      | 50.552 | SiO₂  | 57.887|
| P       | 3.287  | P₂O₅  | 3.456 |
| S       | 4.896  | SO₃   | 5.497 |
| Cl      | 0.014  | Cl    | 0.007 |
| K       | 2.811  | K₂O   | 1.464 |
| Ca      | 4.984  | CaO   | 2.908 |
| Ti      | 1.123  | TiO₂  | 0.751 |
| V       | 0.032  | V₂O₅  | 0.022 |
| Cr      | 0.018  | Cr₂O₃ | 0.011 |
| Mn      | 0.18   | MnO   | 0.089 |
| Fe      | 12.23  | Fe₂O₃ | 6.639 |
The results of measuring peatland using XRF (X-Ray Fluorescence) in the Alahan Panjang can be seen in table 1. Based on the results of these measurements, the most abundant elements were found Si (50.552%), Al (13.545%), Fe (12.23%), S (4.896%) and Mg (4.204%). Fe and S are elements that belong to the Ferromagnetic group, Si is an element that belongs to the diamagnetic group while the elements Al and Mg are elements that belong to the paramagnetic group. Other elements with measurable concentrations in peat include P, Cl, K, Ca, Ti, V, Cr, Mn, Ni, Cu, Zn, As, Rb, Sr., Zr, Ag, Ba, Nd, Eu, Yb, Re and Pb [19][20]. Generally, the Fe content is very little and is hardly found in peatlands. The most abundant element in peat samples obtained from Sumatra and Kalimantan, consist of Ca, Mg, K and Na. Trace element include Cu, Zn and Fe [21]. Major element of the peatland in the Bogor area consist of P, K, Ca and Mg, while for trace elements consists of Cu, and Zn [22]. Na content is an element that is found in many peatlands, but in DD Rep B 693 samples also do not contain Na. The results of DD Rep B 693 measurements also contain minerals formed from several elements.

Minerals that have the highest magnetic susceptibility are pure iron (Fe) which has the magnetic properties of ferromagnetic material [23][24]. Iron is an abundant element in the earth's crust which is around 5% and is usually rarely found in a free state. Fe is one of the constituent elements of magnetic minerals found in DD Rep B 693 samples. Fe₂O₃ has a content of 6.681%. On rare peatlands magnetic minerals are found, but in this measurement magnetic minerals are obtained. Peatlands in areas close to volcanoes contain abundant magnetic minerals. The results of the measurements also found that the highest mineral content was SiO₂ of 58.127%.

Oxide is a chemical compound that contains at least one oxygen atom and one other element [14]. The above measurements indicate that SiO₂ is the most abundant oxide in the peat with a concentration of 57.887%, whereas Na₂O, Nd₂O₃ and Yb₂O₃. The characteristics of peat soils are very different from mineral soils, related to chemical, physical and biological properties [25]. Peat characteristics can change due to human actions in the form of land clearing, land combustion, the construction of drainage channels, and mining.
Figure 4. Element graph on peatland

Figure 4 there shows the elemental concentrations of peat land in Alahan Panjang Kab. Solok, West Sumatra [26]. From the picture, Si has the highest content. In figure 6 also obtained Si element as forming SiO$_2$ minerals which have high content. We infer that the high concentration of Fe$_2$O$_3$ in this peatland sample is from the high abundance of magnetic minerals, which was determined from the magnetic susceptibility measurements [27]. Fe content in peat lands can come from human activities, volcanoes and also decomposition of plants. Figure 6 also shows that there is a high amount of SiO$_2$, which likely come from SiO$_2$ compounds.

4. Conclusion
Based on the results of research that has been done can be concluded that the elemental abundances of magnetic minerals forming in peatland is very varied. Many of these elements are classified as ferromagnetic and paramagnetic. One example of ferromagnetic is Fe which is an element of magnetic mineral such on
hematite, magnetite, maghemite, ilmenite, greidite or geothite. Si is one of the diamagnetic elements and is found in peatlands, while Al is one of paramagnetic elements.

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Reference
[1] G. Rapp, “Natural Science in Archaeology,” Springer, 2009.
[2] A. J. Dugmore, G. Larsen, and A. J. Newton, “Seven tephra isochrones in Scotland,” Holocene, 1995.
[3] H.-U. S. PAUL v.d. BOGAARD, “Laacher See Tephra: A widespread isochronous late Quaternary tephra layer in central and northern Europe,” Geol. Soc. Am. Bull., 1985.
[4] Sudaryo and Sutjipto, “Vulkanik Di Daerah Cangkringan Kabupaten Sleman,” no. November, pp. 715–722, 2009.
[5] A. Nazeb, D. H. Darwanto, and A. Suryantini, “Efisiensi Alokatif Usahatani Padi pada Lahan Gambut di Kecamatan Pelalawan, Kabupaten Pelalawan, Riau,” J. Ekon. Pertan. dan Agribisnis, 2019.
[6] D. Noor, “Program studi teknik geologi,” Pengantar Geol., no. 2009, p. 279, 2009.
[7] B. Safaa Al-Alia and R. P., Frances Walla, Richard Sheridan, Joe Picklesa, “Magnetic properties of REE fluorcarbonate minerals and their implications for minerals processing,” Elsevier, 2018.
[8] Pourya Biparvab Setare Gorjia, Morteza Bahrama, “Optimized Stir Bar Sorptive Extraction Based on Self-Magnetic Nanocomposite Monolithic Kit for Determining Bisphenol A in Bottled Mineral Water and Bottled,” Iran. Chem. Soc., 2019.
[9] R. Putra, H. Rifai, and C. M. Wurster, “Relationship between magnetic susceptibility and elemental composition of Guano from Soke Cave, West Sumatera,” J. Phys. Conf. Ser., 2019.
[10] U. Malik and S. U. Putra, “Sifat Magnetik Dan Ukuran Partikel Magnetik Serta Komposisi Material Pasir Besi Pantai Kata Pariaman Sumatera Barat Di Sintesa Dengan Iron Sand Separator Dan Ball Milling,” Jop, 2018.
[11] E. Handoko, “Studi Sifat Magnetik Material Magnet Sinter Nd-Fe-B,” Sains Mater. Indones., 2005.
[12] A. Yulianto, “Fasa Oksida Besi Untuk Sintesis Serbuk,” J. Sains Mater. Indones., 2007.
[13] SistinA.Ani, E. G. RachmanPutra, S., Abarrul Ikram, S. Purwaningsih, and T. danDarminto 1Jurusan, “Analisis Ukuran Dan Korelasi Nano Partikel Fe 3 O 4 Dalam Fluida Magnetik Dengan Teknik Hamburan Neutron Sudut Kecil,” (PTBIN)-BATAN, 2007.
[14] H. Rifai, Erni, and M. Irvan, “Ekstraksi Magnetik pada Methanol-Soap Bathed Muds,” J. Penelit. sains, 2010.
[15] Peter Brouwer, X-Ray Fluorescence Spectrometry. 2010.
[16] M. E. Finnegan et al., “Synchrotron XRF imaging of Alzheimer’s disease basal ganglia reveals linear dependence of high-field magnetic resonance microscopy on tissue iron concentration,” Elsevier, 2019.
[17] I. W. Croudace, L. Löwemark, R. Tjallingii, and B. Zolitschka, “Current Perspectives on the Capabilities of High Resolution XRF Core Scanners,” Elsevier, 2019.
[18] J. J. S. Huang et al., “Rapid assessment of heavy metal pollution using ion-exchange resin sachets and micro-XRF core-scaning,” Sci. Rep., 2019.
[19] D. Zulfita, P. Agroteknologi, and U. T. Pontianak, “Efektivitas Pupuk Hayati Dan Jenis Pupuk Kandang Pada Serapan Hara N , P , K Dan Proses Fisiologis,” Agroteknologi, 2018.
[20] M. Z. H. U. 2 Rinny Agri Surya , Widodo Haryoko , “Respon Varietas Kacang Tanah (Arachis
Hypogaea L.) Terhadap Perlakuan Pupuk Kandang Sapi,” *Sains Agro*, 2019.
[21] Wahyunto, S. Ritung, Suparto, and Subagjo, *Sebaran Gambut dan Kandungan Karbon di Sumatera dan Kalimantan*. 2005.
[22] E. Maftuah, M. Norr, W. Hartatik, and D. Nursyamsi, “Pengelolaan dan Produktivitas Lahan Gambut Untuk Berbagai Komoditas Tanaman,” *J. Litbang Tanam. Pertan.*, 2015.
[23] F. Firmansyah and A. Budiman, “Pendugaan Mineralisasi Emas Menggunakan Metode Magnetik di Nagari Lubuk Gadang Kecamatan Sangir, Solok Selatan, Sumatera Barat,” *Fis. Unand.*, 2019.
[24] M. Shinta J. Hapsari1, Risalatul Latifah, “Journal of Vocational Health Studies THE ROLE OF BLACK TEA AND PINEAPPLE JUICE AS,” *Vocat. Heal. Stud.*, 2019.
[25] F. F. Adji, Z. Damanik, R. Teguh, and K. G. Suastika, “Pengaruh Jarak Dari Saluran Drainase Terhadap Karakteristik Lahan Gambut Pedalaman Kalimantan Tengah (Studi Kasus: Kanal Penghambat Dan Dampak Pembasahan),” *Pros. Semin. Nas. Lingkung. Lahan Basah*, 2019.
[26] C. B. De Maisonneuve *et al.*, “Bathymetric survey of lakes Maninjau and Diatas (West Sumatra), and lake Kerinci (Jambi),” *J. Phys. Conf. Ser.*, 2019.
[27] R. N. Fajri, R. Putra, C. B. de Maisonneuve, A. Fauzi, Yohandri, and H. Rifai, “Analysis of magnetic properties rocks and soils around the Danau Diatas, West Sumatra,” *J. Phys. Conf. Ser.*, 2019.