The 6th Annual Scientific Meeting on Disaster Research 2019
International Conference on Disaster Management

PROCEEDING BOOK VOL. 1

Social and Technological Innovation on Disaster for Industry 4.0

INDONESIA DEFENSE UNIVERSITY, BOGOR

18 - 19 JUNE 2019

The 6th Annual Scientific Meeting on
Disaster Research 2019
International Conference on
Disaster Management

PROCEEDING BOOK VOL. 1

Social and Technological Innovation on Disaster

for Industry 4.0

Indonesia Defense University, Bogor
18 – 19 June 2019

PROCEEDING BOOK VOL. 1

Penanggung Jawab	:	Dr. Tri Legionosuko, S.IP., M.AP
Ketua	:	Dr. M. Adnan Madjid, SH., M.Hum
Wakil Ketua I	:	Drs. Wibisono Poespitohadi, M.Sc., M.Si (Han)
Wakil Ketua II	:	Agus Winarna, S.I.P., M.Si., M.Tr (Han)
Sekretaris	:	Dony Rizal Lubis, S.IP
Bendahara	:	Rahman, S.Pd., M.Sc
Ketua *Organizing Committee*	:	Dr. Bambang Wahyudi, M.Si
Ketua *Steering Committee*	:	Dr. Edi Suhardono, S.E., M.A.P
Editor	:	Dr. IDK Kertawidana, S.KM., M.KKK
Reviewer	:	Prof. Syamsul Maarif, M.Si
		Prof. Dr. Sobar Sutisna, M.Surv.Sc
		Dr. Siswo Hadi Sumantri, ST., M.MT
		Dr. Arief Budiarto, DESS
		Dr. Dr. Anwar Kurniadi, S,KP., M.Kep
		Dr. Fauzi Bahar, M.Si
		Lasmono, M.Si
		Dr. Sri Sundari, SE., MM
Ilustrator	:	Dindin, SE
		Wilopo. SE., MM., M.Han

Cetakan Pertama Volume 1, Agustus 2019
Prodi Manajemen Bencana, Fakultas Keamanan Nasional
Universitas Pertahanan

ISBN : 978-602-5808-43-2
Ilus : 395 hlm + x hlm; 21 x 29 cm
www.icdm.or.id
icdm@idu.ac.id

Kawasan IPSC, Sentul, Sukahati, Citeureup, Bogor,
Jawa Barat, Indonesia, 16810.
Telp/Fax: +62 21 296187

TABLE OF CONTENTS

Preface ..... **viii**
Keynote Speech ..... **ix**
Determining Geographic Resilience Index through the Analysis of Remote Sensing Image and Digital Elevation Model **1**
Sukendra Martha, Asep Edi Rosyidin
Analysis of Lightning Strike Density Based on Landform for Reducing The Risk of Death in Wonosobo District, Indonesia **14**
Gagad Nur Ridho, Yan Abdi Rahmanu, Astry Zulky Permatasari, and Emilya Nurjani
Landslide Disaster Investigation Based on Correlation of Geologic and Meteorologic Characteristics in Naringgul, Cianjur Regency, West Java, Indonesia **31**
Mi'raj Maulana, Muhammad Dhika Pratama, Silvya Oktaviana Setia, Irwan Novianto Rusadi, Arrazi Diki Elnanda, and Dicky Muslim
The Effectiveness of Clutter Map towards the Quantitative Precipitation Estimation (QPE) on the Heavy Rain Condition in the Region of Padang (a Case Study on March 26, 2018, and September 18, 2018) **40**
Nur Riska Lukita, Agung Hari Saputra, Imma Redha Nugraheni, Abdullah Ali, and Lalu Mantigi Wana Paksi
Identification of Earthquake Hazard Zones Through Deterministic Seismic Hazard Analysis (DSHA) Method at Bandar Lampung City Based **51**
Syamsurijal Rasimeng, Putri Amalia, Desta Amanda Nuraini, Masdar Helmi, and Suharno
Collaborative Leadership in Search and Rescue Operations On Earthquake And Tsunami in Palu, Donggala, Central Sulawesi **68**
Abdul Haris Achadi and Edi Purwanto
The Role of Local Wisdom in Disaster Risk Reduction **81**
Deny Hidayati
Designing Flood Early Warning System Based on IoT as Flood Mitigation Awareness **89**
Agus Tri Sutanto, Naufal Ananda, and Wandes Gumamven
Relationship of Meteorological Drought with El Nino and Its Correlation with Physical Condition of the Land in Kebumen District **101**
Nurul Chamidah Masruroh, Tito Latif Indra, and Kuswantoro
InAWARE: an early warning and decision support tool for Indonesia **108**
Victoria C. Leat, Cassie Stelow, and Dian Oktiari
Study of Generalized Pareto Distribution to Flood Disaster Mitigation in Bandar Lampung **114**
Achmad Raflie Pahlevi, Warsono, and Khorin Nisa
Community Groups Role in DRR through Community Education: The Strength, Challenges, and Recommendation **120**
Wahyu Setiawan Minarto
Pemetaan Cepat Untuk Identifikasi Wilayah Terdampak Bencana (Studi Kasus: Sulawesi Tengah, Banten, Dan Sentani) **129**
Nurul Sri Rahatiningtyas
Elaboration of Structural and Non-Structural Mitigation as A New Paradigm To Reduce Flood Disaster Risk in Manado City **140**
Rizki Kirana Yuniartanti, Hani Fatimah Azzahra, and Budi Santosa
Community Resilience in Dealing with Flood and Haze in Jambi Province, Indonesia **147**
Ali Yansyah Abdurrahim, Deny Hidayati, Intan Adhi Perdana Putri, Ari Purwanto Sarwo Prasodjo, and Herry Yogaswara
Earthquake Readiness and Preparedness at Early Age **160**
Cornelia Dede Yoshima Nekada, Thomas Aquino Erjinyuare Amigo

Peran Gereja dan Sistem Kekerabatan, Budaya dan Kearifan Lokal Dalam Penanganan Pengungsi Korban Erupsi Gunung Sinabung **169**
S. Otniel Ketaren and Ivan Elisabeth Purba
Membangun Ketahanan (Resiliensi) Bencana Pada Kawasan Pariwisata (Studi Kasus: Kabupaten Pandeglang Pasca Tsunami Selat Sunda 2018) **174**
Osmar Shalih, Mangapul P Tambunan, and Rudy P Tambunan
Management of Industrial Disaster Emergency Response in the Chemical Industry in Cilegon City **180**
Arief Bagus Arjuna, Mirajiani, and Sawarni Hasibuan
Common Emergency Situation Picture Development for Disaster Relief Operations **187**
Sri Sundari, Stefanus G. Wardhana, Jazmi Adlan Bohari, and Emanuel A. Bimo
Kearifan Lokal Masyarakat Terdampak Bencana Erupsi Gunungapi Kelud di Kecamatan Nglegok Kabupaten Blitar **195**
Kuswaji Dwi Priyono and Yusuf Mohamad Ibrahim
An Augmented Building Urban Community Resilience to Floods Through Social Learning: Case Studies of Surabaya and Medan Cities **206**
Gusti Ayu Ketut Surtiari, Luh Kitty Katherina, Lengga Pradipta, Fadjri Alihar, Dwiyanti Kusumaninggrum, Ari Purwanto Sarwo Prasojo, and Puji Hastuti
Effectiveness of First-aid Training in School among High School Students in Indonesia **222**
Sutono, and Achmad BF
Application of Geographic Information System (GIS) for Landslide - prone Areas Determination: Case Study of Menoreh Mountains **230**
Rachmad Padli, Maulani Rukya, and Titan Nicola Hoda
Surabaya: Flood Management in The Past and City Management in Today **238**
Erlita Tantri and Choerunisa Noor Syahid
The Community Capacity of Kampung Warna-Warni, Malang City in Dealing with Floods and Landslides **244**
Turniningtyas Ayu Rachmawati, Dwi Rahmawati, and I Wayan Suyadnya
Strengthening Government, Community and Industry Collaboration for Industrial Disaster Risk Reduction in Cilegon City **254**
Mirajiani and Arief Bagus Arjuna
Sistem Monitoring Adaptasi dan Mitigasi Bencana dalam Standard Pengelolaan Destinasi Pariwisata dan Pengelolaan Lingkungan dalam Prkatek Pembangunan Pariwisata Berkelanjutan **261**
Muhammad
The perception of community related with risk element, as a baseline for evaluating the disaster management training program in the prone areas of Mt. Merapi **274**
Subandriyo, Dewi Sri Sayudi, and Raditya Putra
Prevent Health Problems In The Refugee Camp With Huntara Tents As Family Shelter Post Natural Disasters **283**
Ikhsan Yoga Utama and Nirmala Bayuningtyas
The Study Of Coastal Dynamics Of Jabon Coast from Impact Lumpur Lapindo Disaster, Sidoarjo, Indonesia **289**
Supriyadi, N Hidayati, and A Isdianto, Ari Widodo and Elvis
Forest and Land Fire Mitigation Efforts for Air Quality Changes **297**
Nurul Safitry and IDK Kerta Widana
Hydram Ram as a Supply Water Needs and Drought Solution in Mountain Areas **306**
Ahmad Sazrhi, Faisol Abdul Kharis, Khadijah, Sovian Aritonang and I Nengah PA

The Preparedness in Disaster Management: A Case Study of State Private School 1 Badung Facing The Potential Earthquake and Tsunami Threats **316**
Zahrotul Khumairoh, Dewi Apriliani and Taufiq Prasetyo
Preparedness of tourist managers in Bali for facing disaster risk **324**
Deddie Wijayanto, Novita A Nainupu, Oktavia P Rahmawati and Santi Oktariyandari
Civil and Military Sinergity in Preparedness for Natural Disaster Threats (Case Study in Bali Province) **330**
Fani Aprilia Perdani, Nurul Safitry, and Yohannes Ari
Effectivity Analysis of The Use of Telemetry 433 Mhz to Deliver of Sensors Data As Early Warning System Das Jeneberang **336**
Iris Sumariyanto, Ramanta Pinem, and Andry Anzhari
Mitigation of landslides through erosion rate reduction in pine stands in BKPH Kebasen, KPH East Banyumas, Central Java **344**
Oktavia P Rahmawati and Sugeng Triutomo
The Importance of Disaster Mitigation Education for Early Childhood to Reducing Impacts of Disasters **351**
Muhammad Eric F R, Vania K F Navalina, and Wildan Akbar H R
Forecasting of CO2 Emissions from Energy – Environment in Blending Biodiesel Regulacy using Modified Fuzzy Density Approach **357**
Wisnu Ramadhan, Danur Lambang Pristiandaru, and Yanif Dwi Kuntjoro
Strengthening Women in Facing the Threat of Post-Disaster Conflict **365**
Nailuttaris Indriane, Ira Guslina Sufa and I Gede Sumertha KY
Readiness of Tsunami Early Warning System in Bali, Indonesia **373**
Adib Hermawan, Saifuli Sofi'ah and Sugeng Widodo
Coordination in Disaster Communication in Bali Province **380**
Deny Widi Anggoro, Dian Efrianti and Novita Berhitu
Implementation of Sister Village as an Alternative for Handling Refugees in the Mount Agung Eruption: Case Study in Semarapurakangin Village, Bali **388**
F A Kharis, B D Priambodo, M P Rizayati, IDK Kerta Widana

PREFACE

Praise be upon the Almighty God for allowing the completion of the Proceeding of ICDM 2019 which held in the 6th Annual Scientific Meeting on Disaster Research 2019. ICDM 2019 was held at Indonesia Defense University and Indonesia Disaster Relief Training Ground (INA-DRTG) on 18 – 19 June 2019. This proceeding is a documentation of scientific work by academics, bureaucrats, practitioners, and community members who are participate in ICDM 2019.

The committee has received more than 220 manuscripts from national and international participants. After going through review process by our esteemed team of reviewers, there are 118 manuscripts to be included in a four-volume proceeding. The proceedings will be available for download on our website. The manuscripts will discuss following themes: Strengthening Local Partners to Reduce Disaster Risk; Innovation and Disruption in Disaster Management Technology; Social Engineering in Technology Application of Disaster; Early Warning System Technology, Preparedness and Society Communication; The Role of Local Wisdom as a Creative Consideration in Managing Local Disaster; The Role of National Resilience as a Consideration in Disaster Management; Innovation and Application of Disaster Management; Disaster Management in Industrial Areas; Strength of Science and Technology in Disaster Management to Reach the SDGs; and Smart and Resilience Cities.

Lastly, we are truly grateful to all parties who supports this event: keynote speakers, invited speakers, committees, moderators and reviewers, and all of the authors and participants. We hope that all participants can make the best use of this event as the best practice for managing and reducing disaster risks in the future.

Conference Chairman,

FADM Dr. M. Adnan Madjid, SH., M.Hum
Vice Dean of Faculty of National Security
Indonesia Defense University

KEYNOTE SPEECH

First of all, let us raise our most gratitude to God the Almighty, for giving us his blessing, and allowing us to finish the series of proceedings of the sixth Annual Scientific Meeting Disaster Research, the International Conference on Disaster Management (ICDM 2019).

As has been declared, that one of the purposes of the Sixth Annual Scientific Meeting Disaster Research is to implement planners to improve research culture, to provide comprehensive, holistic and systematic thinking contributions. Then, the theme of this year's meeting is: **"Social and Technological Innovation on Disaster for Industry 4.0"**

The theme is important to be raised, considering the dynamics of geopolitics and geostrategic development, and development of dynamic technology, that impact on challenges and threats which are complex, including challenges on state defense. The various threats are military threats, nonmilitary threats, and hybrid threats, which can be grouped into real threats or unreal threats. One of the real threats faced by the Indonesian is a natural disaster.

Last year, many disasters happened in Indonesia so the efforts to prepare ourselves for disasters become a very important focus. The loss of a big disaster was beyond our expectation. Our highly risk and vulnerability rate that detain us in disaster management efforts to save human life or minimize loss.

In handling disaster, it doesn't require speed only, but also accuracy. Industrial revolution 4.0 is marked by the emergence of artificial intelligent, internet of things, robotic, and 3-d. Everything will assist the implementation of disaster management in every prevention phase, emergency response, or rehabilitation and reconstruction phase.

Complete information about hazards in a region will be well analyzed by the internet of things, artificial intelligent, including drones. These may help prevention phase. At the time of emergency response, it will also accelerate victims registration in insolated areas using drones or robotic faster that they may immediately get evacuated.

On the other hand, in rehabilitation and reconstruction stages, they can accelerate housing and other building development using very quick 3-d copy to easyly return and normalized community life. By so, the 4.0 industry must be used for the efforts of disaster management, especially in transforming towards reliable next generation in disaster management.

In the social aspect, social innovation is required for creation of disaster responsible communities. The innovation on social, educational, education and training aspects to improve special awareness and community behavior in disaster and remote areas, in order to be ready to save or reduce risk from disaster or actual disaster threats. IDU as state defense campus, focus to give attention from national and defense security aspects. In Law Number 3 of 2002 on State Defense, it is stated that disasters are non-military or non-traditional threats. It is important to protect the community and the environment of extreme disasters.

In this context, this disaster is considered as a full threat of inaccuracy that will come around the distribution of vulnerable communities, communities that are low

capacity against natural, non-natural or social threats. That is why, the community should be enhanced to be able to face disaster to avoid on the impact of victims and damages that are done. The sinergry in facing such disaster threats is required, so the stakeholders must be involved actively, planned, direct, and holistic as well as universal. Involving pentahelix elements which government, community, business sector, higher education and mass media. Moreover, the role of wisdom for development, for example togetherness, culture, religion, vocationality, trust, tradition, religion, experience in disaster. Such things have been appreciated by the un as a global champion for disaster risk reduction.

Therefore, in the future, in facing such threats, we are not just partially depending on the power of conventional defense, but also the power of integrated and synergic defense, in order to create a harmony relationship, communication, coordination to face and overcome the threat together. Various abilities and advantages of each stakeholder to support the power of state defense. For those interests, IDU opens the study of disaster management that include the scope of national security faculty. Expected IDU graduates can construct their planning in disaster management. They also have a Disaster Study Center and Climate Change Adaptation (PSB-API), research activities, devotion to communities and other cooperation with national disaster management agency of indonesia.

In this good opportunity, we would like to express the best gratitude to the national disaster management agency of indonesia for a very intensive cooperation to support a learning in IDU, in particular on the disaster management product, and the trust that has been given to idu as the partner of the Sixth Annual Scientific Meeting on Disaster Research International Conference on Disaster Management (ICDM) 2019. Hopefully, this proceeding may contribute to the comprehensive and holistic thoughts for disaster management in Indonesia.

Rector of Indonesia Defense University,

LG Dr. Tri Legionosuko, S.IP., M.AP

Lead Time Prediction Between Magnetic Anomaly and Earthquake Occurrence Using Lombok Earthquake's Magnetic Anomalies and Seismograph Data, West Nusa Tenggara

Rindi Antika Sari[1], Suaidi Ahadi,[2] M.Syirojudin,[3] Syamsurijal Rasimeng,[4]
[1,4] Geophysical Engineering, Faculty of Engineering, University of Lampung
[2,3] Meteorological Climatological and Geophysical Agency Jakarta, Indonesia
e-mail : antikasaririndi@gmail.com[1)], suaidi.ahadi@gmail.com[2)], syirojudin.bmkg@gmail.com[3)], syamsurijal.rasimeng@gmail.com[4)]

Abstract. Lombok earthquake event that indicated as the major earthquake on August 5, 2018 at 21:56 WIB, with strength of 7 Mw and 10 Km depth, has a epicenter distance 30 km away to NorthEast of East Lombok. BMKG (2018) states that this earthquake occurred due to Flores Back Arc Thrusting activities, this statement concluded as a result of earthquake source mechanism movement analysis to the shifting rocks (plates) that moving up. In an effort to mitigate earthquake disaster, BMKG try to figure out the changes in the magnetic field due to plates shifting activities that cause earthquakes by installing LEMI 018 on August 28, 2018 at Bayan field. This tool is used for measuring earth's magnetic variance data to find out the cause of the earthquake in further analysis. By using magnetic anomaly data from August to October recorded by the LEMI 018 at Bayan Station, a frequency spectrum analysis and *Z/H* ratio polarization was carried out to determine Onset time anomalies. As a result of data processing and analyzing, show that the lead time between magnetic anomalies and earthquake events using data from the earthquake seismograph of Lombok ,West Nusa Tenggara, has a minimum leadtime occurring for 173 hours and maximum leadtime occurring for 658 hours.

Keywords : Lead Time, Magnetic Anomaly, Precursor, Seismograph.

1. INTRODUCTION

Earthquake events that appear suddenly cause a lot of material losses and fatalities. Earthquakes occur because of tectonic events that always cause the earth's surface to move, such as the collision between plates and others that will cause earthquakes. The process of *stress* accumulation that occurs in rocks causes the emission of electromagnetic waves, and these emissions will result in changes in the value of measuring the magnetic data of the earth. At this time a theory has been found about earthquake precursors, earthquake precursors can be done

by knowing changes in rock magnetism values in an area, with parameters from earthquake precursors including onset time, earthquake forecast zone, magnitude, and lead time.

Hattori, et al (2006), illustrate the three approach models of the mechanism of the occurrence of *ULF* wave changes in **Figure 1** by (Kamogawa, 2004). Two models explain *ULF* emissions caused by electrokinetic effects and the effects of micro-fracturing and one model explains the changes in the amplitude of electromagnetic waves seen from Power Ratio (*Z/H*) where the *H* and *Z* components greatly influence changes in the earth's magnetic field. If a significant change in conductivity occurs in the *H* component while the *Z* component is small then it is believed to originate from the atmosphere or ionosphere, but if there is a large conductivity in the *Z* component but small in the *H* component it is believed to be a result of lithosphere activity.

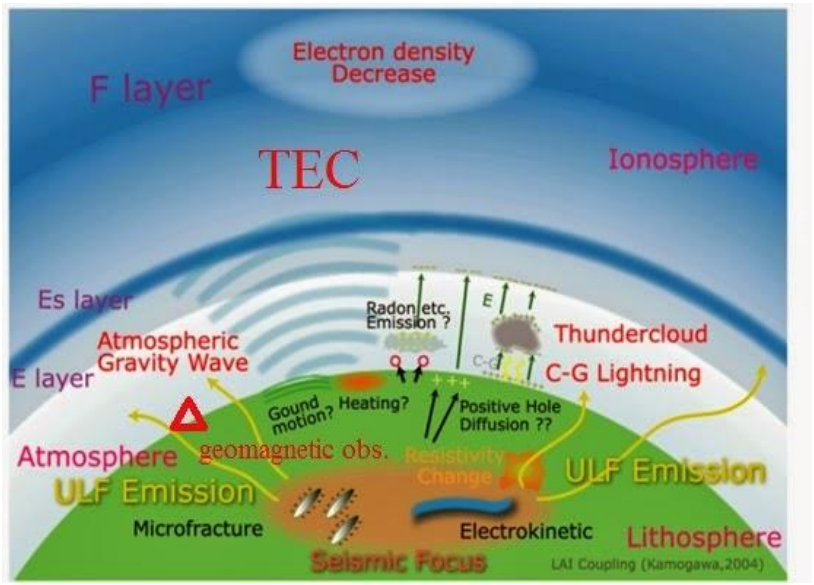


Figure 1. Three models of ULF emission anomalies related to earthquakes (Kamogawa, 2004).

The electrokinetic effect in theory, Fenoglio, et al. (1995) explains that this effect arises because rocks experience changes in pressure caused by deposits of silica in these rocks resulting in a disruption of the earth's magnetic flow.

Induction effect according to (Kovtun, 1980; Mogi, 1985) the effect of induction is the effect that arises due to the activity at the source of the earthquake (*focal zone*) which causes changes in the geo-electrical conductivity and amplitude of electromagnetic waves, non-lithospheric.

The effect of Micro-Fracturing Molchanov and Hayakawa (1995) explains that the emission of electromagnetic waves with the recorded *Ultra Low Frequency* (ULF) spectrum is assumed to experience a significant increase in the event of a fault in the rock. Therefore only the pressure induction process can meet to explain micro-fracturing observations.

This research was conducted to find out the leadtime of the earthquake, where the lead time of the earthquake is the time for estimating the occurrence of the earthquake from the time the initial anomaly appeared until the occurrence of the earthquake event. Ahadi.dkk., (2013) has conducted a 2009 earthquake earthquake precursor study related to ULF emission anomalies, namely with polarization ratios for determining the onset time and Single Station Transfer Function to determine the direction of anomalies magnetic. Lombok is one of the regions that has a high seismic history and Lombok is also an area that has high geomagnetic value because it is located between two earthquake plants namely the subduction zone and the *Flores Back Arc Thrust*. So, in this study the authors used Lombok's magnetic anomaly data which was used as

an earthquake precursor. With the aim of this research is to find out the relationship between magnetic anomalies and earthquake events and determine the onset time and lead time for earthquakes

2. LITERATURE REVIEW

2.1 Research Areas

The area in this study is located in the Lombok area, West Nusa Tenggara.

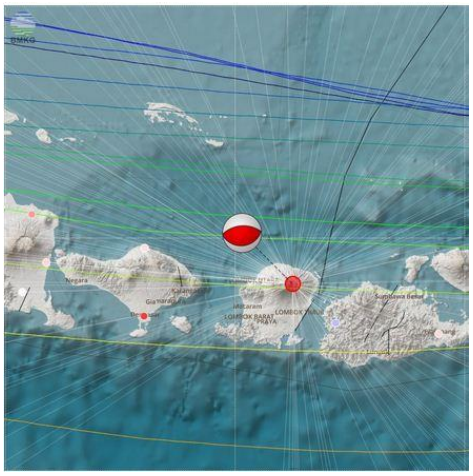


Figure 2. Map of Research Area (Bmkg, 2018)

2.2 Lombok Tectonic

Figure 3 explains that Lombok is between two earthquake generators originating from the south and north. In the south there is a subduction zone of the Indo-Australian plate that dips below the island of Lombok. Whereas from the north there is a geological structure named fault rose Flores or *Flores Back Arc Thrusting*. This fault rises Flores, the route extends from the Bali Sea to the east to the Flores Sea and is very close to Lombok Island (Daryono, 2011). With this, Lombok is said to be an earthquake-prone area, although with a hypocenter depth and varying magnitude.

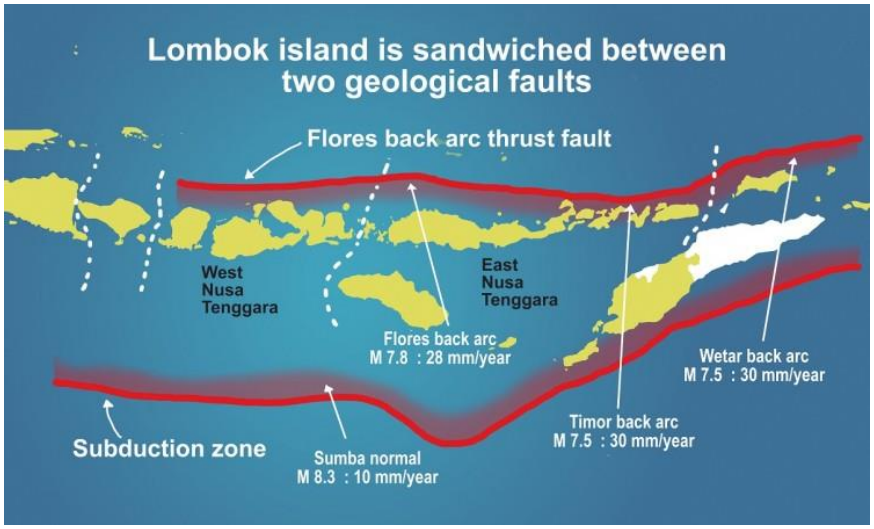


Figure 3. Subduction and Flores Zone *Back Arc Thrust* (Bmkg, 2018)

3. RESEARCH METHODS

The data used in this study is geomagnetic data from September 2018 to October 2018 which was recorded by the magnet LEMI-08 at bayan station, Lombok. And also used earthquake data that has occurred with an epicenter distance of up to 500 Km from the station.

The geomagnetic data to be analyzed are daily *H* and *Z* component data with an hourly time interval. Also used is the daily Dst Index data according to the time the anomaly appears as a validation to find out the cause of the anomaly arising from the earth's external or internal activities. Where the *H* component is believed to be more influenced by the activity of the external earth and the *Z* component is believed to be more influenced by the earth's internal activity (lithosphere).

Geomagnetic data processing as an earthquake precursor is carried out several stages, namely, conversion, correction, *Z/H* Polarization Ratio, Single Station Transfer Function (*SSTF*), determination of anomalies as earthquake precursors and validation with earthquake events that occur

3.1 Data Conversion

This conversion phase is done to change the data format to ASCII format data, this is done to facilitate reading the data

3.2 Data Correction

This correction phase is carried out daily trend correction which is useful to fill in the blank data with trend data so that complete data is obtained on each component. And the diff ploting process is performed to show the difference in data with data criteria that do not exceed ± 1. Furthermore, a bandpass filter process is carried out on each component, namely the *H* component and *Z* component frequency range 0.02-0.006 Hz, because the frequency range is believed to be more influenced by seismogenic activity.

3.3 Single Station Transfer Function (SSTF)

This method is used to convince geomagnetic interference signals originating from the earth's internal activities (lithosphere), where according to Hattori (2004) this transfer function can solve an equation from components X,Y,and Z geomagnet. This relationship is considered a linear system that has input and output. This transfer function also has information about underground electrical conductivity or commonly called CA (Counductivity Anomaly). With the equation as follows:

Linear relationship of geomagnetic variation of components X, Y, Z

$$\Delta Z(\omega) = A.\Delta X(\omega) + B.\Delta Y(\omega) \quad (1)$$

To determine the magnitude of constants A and B, linear inversion is used, as follows:

$$d = G\,m \quad (2)$$

Information :
d: Data matrix (value ΔZ (*ω*))
G: Kernel matrix (values ΔX (*ω*) and ΔY (*ω*))
m: Model matrix ((values A (*ω*) and B (*ω*))

$$\begin{bmatrix} \Delta Z1 \\ \Delta Z2 \\ \Delta Zn \end{bmatrix} = \begin{bmatrix} \Delta X1 & \Delta Y1 \\ \Delta X2 & \Delta Y2 \\ \Delta Xn & \Delta Yn \end{bmatrix} \begin{bmatrix} A \\ B \end{bmatrix} \quad (3)$$

Values A and B can be searched by formula

$$m = [G^T \quad G]^{-1} G^T d \quad (4)$$

$$\begin{bmatrix} A \\ B \end{bmatrix} = \left[\begin{bmatrix} \Delta X1 & \Delta X2 & \Delta Xn \\ \Delta X1 & \Delta Y2 & \Delta Yn \end{bmatrix} \begin{bmatrix} \Delta X1 & \Delta Y1 \\ \Delta X2 & \Delta Y2 \\ \Delta Xn & \Delta Yn \end{bmatrix}\right]^{-1} \begin{bmatrix} \Delta X1 & \Delta X2 & \Delta Xn \\ \Delta X1 & \Delta Y2 & \Delta Yn \end{bmatrix} \begin{bmatrix} \Delta Z1 \\ \Delta Z2 \\ \Delta Zn \end{bmatrix} \quad (5)$$

The magnitude of magnetic anomalies is formulated as follows

Amp (ω) = $\sqrt{A(\omega)^2 + B(\omega)^2}$

And then, the magnitude of the direction of the magnet anomaly is formulated as follows

θ = $tan^{-1}(\frac{B}{A})$

Where : ΔZ = Vertical Geomagnetic Component (nT)
ΔX = Geomagnetic (nT) Horizontal Component (North - South)
ΔY = Geomagnetic (nT) Horizontal Component (East - West)
A and B = constants sought
Amp = Conductivity scale (Distance between conductivity fields)
θ = Direction of magnetic anomaly source (°)

The results of *SSTF* processing are in the form of a quadrant graph that shows the direction of the earthquake forecast zone which will then be plotted on the map with a zero position graph according to the location of the sensor at the station. Where according to Ahadi. Et al. (2014) the direction of this azimuth can be categorized as an earthquake precursor if it has a direction in the direction of the earthquake epicenter, with a tolerance limit of 25 ° with the up and down direction of the actual azimuth.

3.4 Polarization Ratio of Z/H

This method is used to determine the onset time anomaly, by analyzing standardization and daily normalization so that the daily value of component *H* and component *Z* will be obtained. Which refers to the research conducted by Prattes, et al., (2011). geomagnetic daily variation, so that it can be seen that the emission or anomalous value that arises comes from internal activities of the earth or global geomagnet. The equation used is as follows:

Prattes et al. (2011) analyzed the standardization and daily normalization with the following formula:

$$S_{HDAY}(\omega) = \frac{|SH(\omega)|^2}{2\pi.\Delta f} \quad (6)$$

$$S_{ZDAY}(\omega) = \frac{|SZ(\omega)|^2}{2\pi.\Delta f} \quad (7)$$

To get statistical analysis that is better used in daily averages:

$$S_{\Sigma HDAY}(\omega) = \sqrt{\frac{1}{n}\Sigma[SH(\omega)]^2} \quad (8)$$

$$S_{\Sigma ZDAY}(\omega) = \sqrt{\frac{1}{n}\Sigma[SZ(\omega)]^2} \quad (9)$$

And the daily values of H and Z components are obtained as follow:

$$H_{Day} = \frac{s\Sigma HDay - \mu\Sigma HMonth}{\sigma\Sigma HMonth} \quad (10)$$

$$Z_{Day} = \frac{s\Sigma ZDay - \mu\Sigma ZMonth}{\sigma\Sigma ZMonth} \quad (11)$$

For the polarization of the power ratio the following equation is used:

$$P\ Day = \frac{Z\ Day}{H\ Day} \quad (12)$$

3.5 Fast Fourier Transform

This stage is used as a process to change data from the time domain to the frequency domain. The equation used is as follows:

$$f(k) = \int_{-\infty}^{\infty} x(t) e^{-i2\pi ft}\, dx \quad (13)$$

Where *f (k)* as a function in the frequency domain, *x (t)* is a function in the time domain, *i* is an imaginary number, and *t* is time.

3.6 Determination of anomalies as earthquake precursor

The identification of the most accurate anomaly of the earthquake is known by calculating the standard deviation value using moving average geomagnetic data, and the determination of the anomaly is seen through the daily *Z* and *H* values that have passed the standard deviation.

4. RESULTS AND DISCUSSION

4.1 Identify anomalies as earthquake precursors

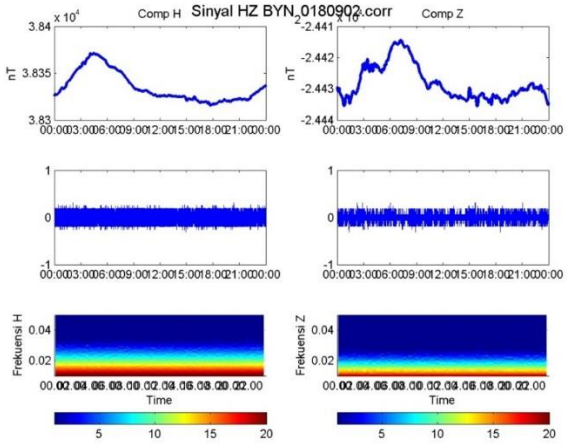
In determining anomalies as earthquake precursors it is necessary to identify with several parameters, including onset time, azimuth as earthquake forecast zone, amplitude as magnitude prediction, and leadtime. In this study 15 magnetic anomaly data were used as shown in **Table 1** which was indicated as a precursor of recorded earthquakes from Bayan station, Lombok, West Nusa Tenggara.

Tabel 1. Earth Magnet Anomaly as a Precursor Indicator

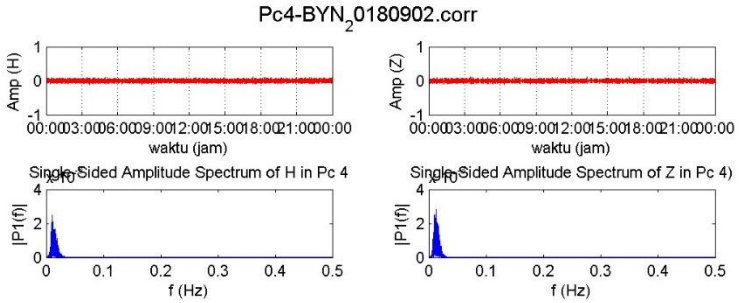
No.	Earth Magnet Anomaly as a Precursor Indicator				
	Date	**Time (WIB)**	**Station**	**Amplitudo**	***Azimuth***
1.	29-Agustus-108	13.00	Bayan, Lombok	2.247	314
2.	30-Agustus-2018	14.00	Bayan, Lombok	6.726	212
3.	02-September-2018	20.00	Bayan, Lombok	2.771	22
4.	03-September-2018	22.00	Bayan, Lombok	10.744	99
5.	04-September-2018	16.00	Bayan, Lombok	17.832	71
6.	05-September-2018	17.00	Bayan, Lombok	5.192	99
7.	14-September-2018	22.00	Bayan,Lombok	2.267	138
8.	19-September-2018	10.00	Bayan,Lombok	2.202	134
9.	22-September-2018	22.00	Bayan,Lombok	2.451	345
10.	23-September-2018	07.00	Bayan,Lombok	29.895	281
11.	01-Oktober-2018	02.00	Bayan,Lombok	3.668	105
12.	03-Oktober-2018	13.00	Bayan,Lombok	2.591	286
13.	04-Oktober-2018	17.00	Bayan,Lombok	2.532	314
14.	06-Oktober-2018	05.00	Bayan,Lombok	2.461	142
15.	08-Oktober-2018	20.00	Bayan,Lombok	3.355	333

The anomalious data was then analyzed for earthquake precursor parameters. The first analysis carried out was spectrum analysis, signal response, *diff* and intensity of power spectrum to ensure that the cause of the anomaly appeared as a result of global seismogenic or geomagnetic activity. According to Ahadi, et al. (2012) the *H* component is believed to be more

influenced by the global or external geomagnetic activity of the earth, while the *Z* component is believed to be more influenced by the earth's internal activities**. Figure 2a** shows the signal response on *H* and *Z* components, and shows the diff ploting results and spectrograms. Seeing the data indicates that each component has a good response, does not indicate the cause of the anomaly. However, seen in **Figure 2b** shows that the intensity of power on component *Z* is greater than component *H*. By stating that the anomaly that appears on September 2, 2018 is a result of internal activities of the earth. Because component *Z* is believed to be more influenced by internal activities of the earth, while component *H* is more influenced by external activities of the earth.



(a)



(b)

Figure 2. (a) Signal Response Components *H* and *Z*. (b) Data before and after FFT and Band Pass Filter

And then azimuth analysis is used as an earthquake forecast zone using the Single Station Transfer Function (*SSTF*) method. From the results of processing using the *SSTF* method, it was found that on September 2, 2018 there were identified anomalies as earthquake precursors that occurred on September 10, 2018. With azimuth value of 22,150 ° and in the direction of the earthquake epicenter on September 10 2018 as in **Figure 3** (a) and (b).

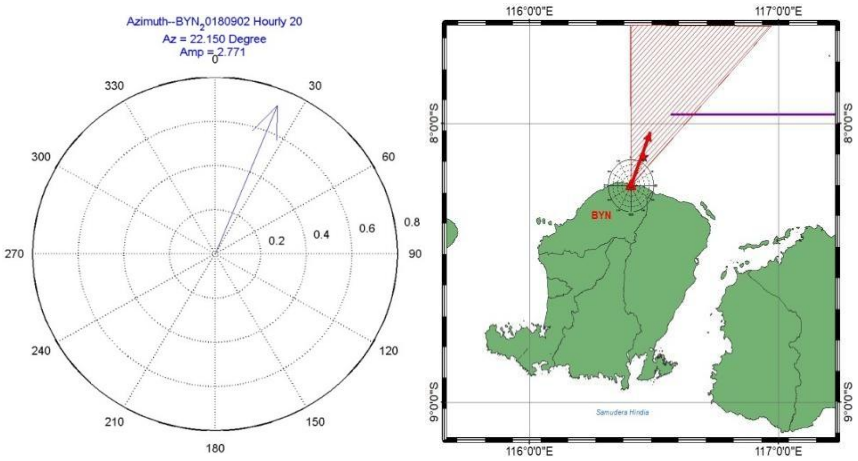


Figure 3. (a) Azimuth September 02 2018. (b) Epicenter of Earthquake September 10, 2018.

Figure 4 is the polarization of *Z/H* anomaly 02 September 2018 ratio which has been limited by standard deviation to determine the onset time anomaly and validated by the Dst index, because it refers to the research that has been done (Ibrahim, et al. 2012; Ahadi et al., 2013: 2014) Dst index is used to determine global geomagnetic activity when anomalies occur whether there are magnetic storms or not, so that it can be used to ensure that the anomalies that arise are a result of the earth's internal activities rather than global geomagnets. Data that exceeds the standard deviation is believed to be the onset time of anomalies, thus it can be seen that the onset time anomaly on 02 September 2018 is at 20.00 with an anomaly amplitude of 2,771. Looking at the daily Dst data curve on September 2, 2018, it shows a calm global geomagnetic activity, which does not indicate a geomagnetic storm. With this, it can be ascertained that the anomalies that arise are a result of the earth's internal activities.

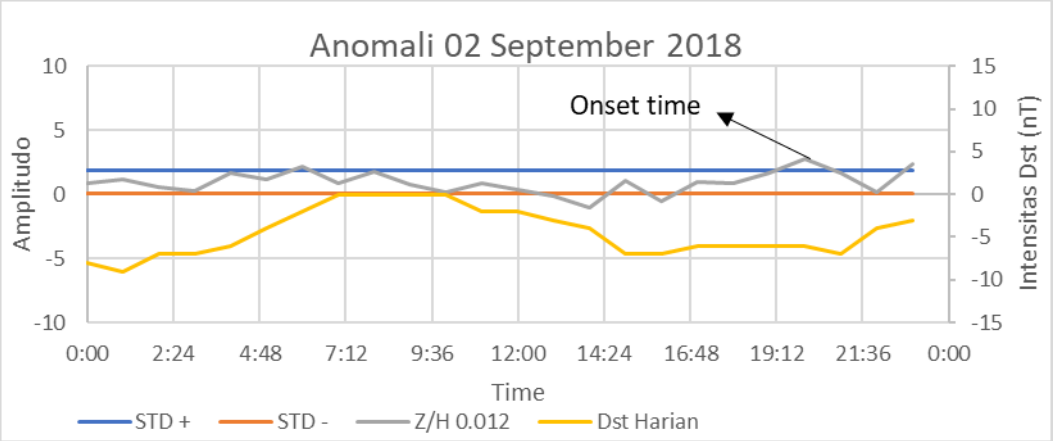


Figure 4. Polarization ratio of the Z/H September 02 2018

4.2 Determination of earthquake lead time

The lead time is the waiting time for an earthquake event, calculated from the onset time anomaly to the occurrence of an earthquake event. In determining earthquake leadtime, seismograph data from earthquake events that occur is needed. The seismograph data is then plotted with *Z/H* ratio polarization data, and daily Dst data. The maximum estimation of the earthquake lead time is 30 days from the anomaly appearing or before the earthquake event occurs. Seeing the results of ploting in **Figure 5**, it is known that the onset time anomaly is at 20:00 with an amplitude of 2,771 and the anomaly appears when the day is quiet (quiet day) does not indicate a geomagnetic storm that occurs. Validation results with earthquake seismograph data from 10 September 2018 revealed that the lead time of the anomaly appeared

until the earthquake occurred for 175 Hours or for 8 days, with a blue dashed line marked as the September 10 2018 earthquake leadtime.

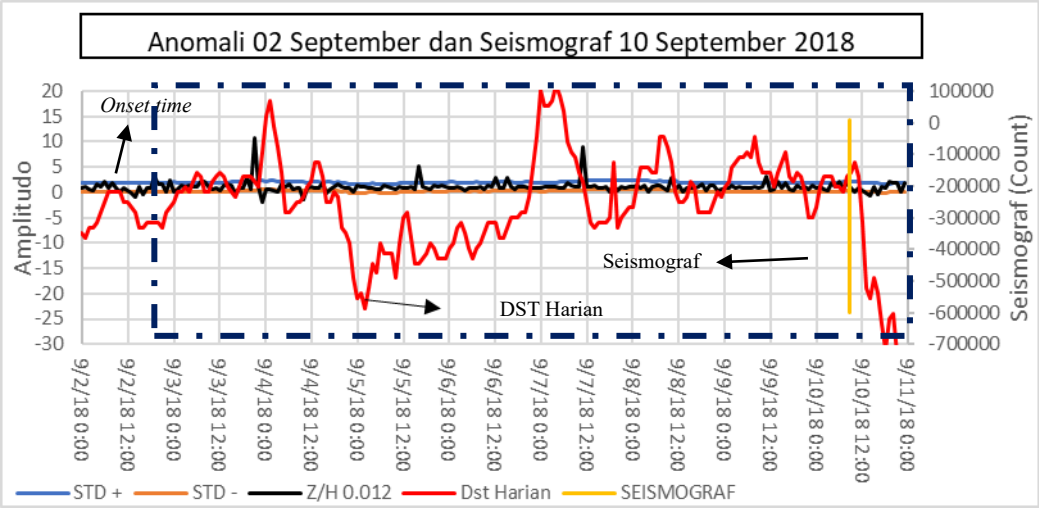
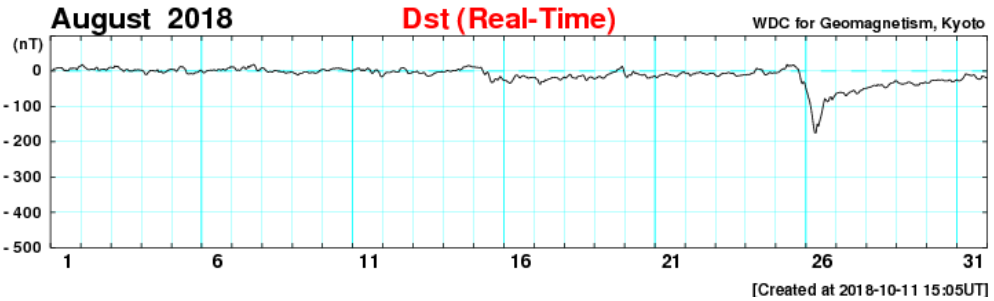


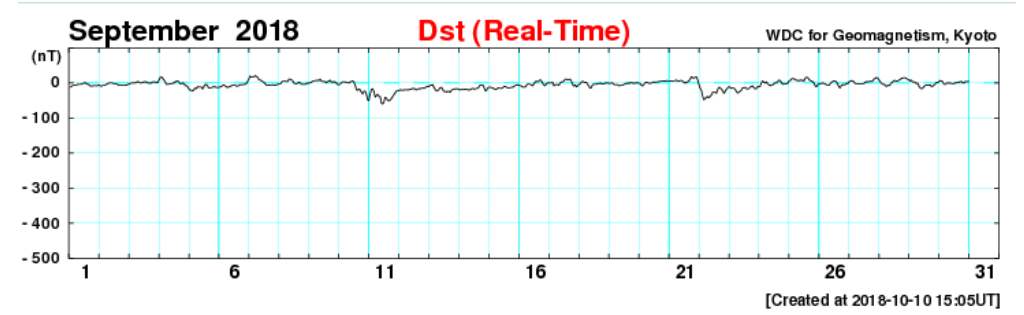
Figure 5. Earthquake lead time September 10, 2018

In this study, 8 release earthquake event data were in accordance with earthquake precursors from magnetic anomaly data in **Table I**, which had been analyzed for earthquake precursor parameters, with an earthquake epicenter distance from the station maximum 500 Km. Earthquake events that occur have magnitudes> 4 Mw. **Table 2** is 8 magnetic anomaly data and earthquake information that have been analyzed such as anomalious data September 02 2018 and earthquake information September 10 2018. With this it can be stated that the 8 anomalies that have been identified as precursors of earthquakes are a result of internal activities of the earth (lithosphere), because it is seen from the graph of the Dst index data in **Figure 6** when an anomaly appears there is no geomagnetic storm event.

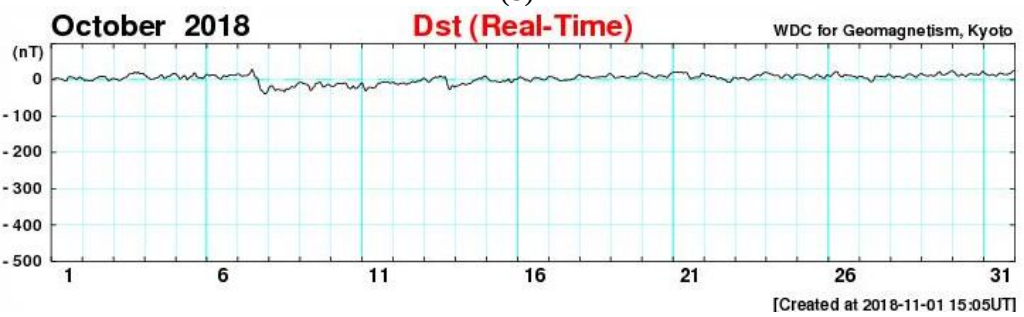
Determination of the lead time of 8 earthquake events in accordance with earthquake precursors and validation of the *Z/H* ratio polarization data with sesmograph data from each earthquake event that occurred, obtained the minimum lead time and maximum results from anomalies appearing until the earthquake event occurred for 8 days and 28 days. With this, it can be stated that the 8 earthquake precursor data is right because it is seen from the lead time there is also no lead time that exceeds the limit that is for 30 days.



(a)



(b)



(c)

Figure 6. (a) Index Dst. in August. (b) Index Dst in September. (c) Index Dst in October

Table 2. Data on Anomalies as Precursors and Earthquake Data

No.	Date Anomalies	Amplitudo Anomalies	Earthquake Event	Lead time (Δt)	Indeks Dst	Magnitude (Mw)	Distance (Km)
1.	29 Agustus 2018	2.247	18 September 2018	474 Hour (20 day)	-20 nT	4.7	20
2.	02 September 2018	2.771	10 September 2018	175 Hour (8 day)	-6 nT	4.6	15
3.	03 September 2018	10.744	11 September 2018	173 Hour (8 day)	2 nT	5.4	17
4.	05 September 2018	5.192	23 September 2018	448 Hour (18 day)	-13 nT	4.4	41
5.	14 September 2018	2.267	12 Oktober 2018	658 Hour (28 day)	-22 nT	4.9	485
6.	23 September 2018	29.895	11 Oktober 2018	443 Hour (18 day)	-27 nT	6.4	232
7.	26 September 2018	6.757	07 Oktober 2018	261 Hour (11 day)	-4 nT	5.1	46
8.	06 Oktober 2018	2.461	16 Oktober 2018	251 Hour (10 day)	3 nT	4.9	324

5. CONCLUSION

Based on the research that has been done the following conclusions are obtained:

1. Changes in the Z / H magnetic anomaly at the time of the earthquake will be caused by lithospheric activity or movement of the earth's plates.
2. Each earthquake will be preceded by the appearance of magnetic anomalies, this can be used as an earthquake precursor. With leadtime between magnetic anomalies and earthquake terjaidnya is 173-658 hours.

Referenches

[1] Ahadi, S., Puspito, N.T., Ibrahim, G. dan Saroso, S. 2012. Determination *Onset time* of Earthquake Precursor by Analizing ULF-EM Emission Signal in Sumatra region, *Proceeding Conference on Applied Electromagnetic Technology (AEMT),* Lombok. hal. 22-26.

[2] Ahadi, S., Puspito, N.T., Saroso, S., Ibrahim, G., Siswoyo. dan Suhariyadi., 2013. Prekursor Gempa Bumi Padang 2009 Berbasis Analisis Power Rasio dan Fungsi Transfer Tunggal, *Jurnal Ilmia Geomatika*, Badan Informasi Geospasial. Bogor. hal. 49-56.

[3] Ahadi, S., Puspito, N.T., Ibrahim, G. dan Saroso, S. 2014. Determination of The *Onset time* in Polarization Power Ratio *Z/H* for Prekursor of Sumatra Earthquake, *AIP Conference Proceeding*. American Institute of Physics. Maryland. hal. 75-78.

[4] Daryono. 2011. Identifikasi Sesar Naik Belakang Busur (Back Arc Thrust) Daerah Lombok Berdasarkan Seismisitas dan Solusi Bidang Sesar, *Jurnal Meteorologi* dan *Geofisika*. Badan Metereologi Klimatologi dan Geofisika. Jakarta.

[5] Fenoglio, M.A., Johnston, M.J.S. dan Byerlee, J.D., 1995, Magnetic and electric fields associated with changes in high pore pressure in fault zones, Application to the Loma Prieta ULF emissions, *Journal Geophys.Res, 100 (B7), 12951-12958.*

[6] Hattori, K., 2004, ULF Geomagnetic Changes Associated with Large Earthquake, *Journal Terrestrial, Atmospheric and Oceanic Sciences (TAO)*, Vol.15, No. 3, 329-360.

[7] Hattori, K., Serita, A., Yoshino, C., Hayakawa, M., dan Isezaki, N. 2006. Singular Spectral analysis and principal component analysis for signal discrimination of ULF geomagnetik data associated with 2000 Izu Island Earthquake Swarm, *Proceedings Physics and Chemistry of the Earth*. 31, 2006,281-291.

[8] Ibrahim, G., Ahadi, S., dan Saroso., S. 2012. Karakteristik Sinyal Emisi ULF yang Berhubungan dengan Prekursor Gempa Bumi di Sumatera, Studi Kasus: Gempa Bumi Padang 2009 dan Gempa Bumi Mentawai 2010, *Jurnal Meteorologi* dan *Geofisika*. Puslitbang Badan Meteorologi Klimatologi dan Geofisika. Jakarta, hal. 81-89.

[9] Kamogawa M., 2004. Preseismic Lithosphere-Atmosphere-Ionosfer Coupling, *EOS Trans. American Geophysic Union*.Vol.87.Issue 40.417-424. DOI: 10.10 29/20 06EO40 0002.

[10] Kovtun, A.A., 1980, *Using of Natural Electromagnetic Field of the Earth under Studying of Earth's Electroconductivity,* Lenigrad University.

[11] Mogi, K., 1985, Earthquake Prediction, *Academic Press*, Hal. 355.

[12] Molchanov, O.A. dan Hayakawa, M., 1995, Generation of ULF electromagnetic emissions by microfracturing, *Proceeding Geophys. Res. Lett. 22, 3091-3094*.

[13]Prattes.G.,Schwingenschuh,K.,Eichelberger,U,H.,Magnes,W.,Boudjana,M.,Stachel,M.,Vell ante,M.,Villante,U.,Wesztergom,V., dan Nenovski,P., 2011. Ultra Low Frequency (ULF) European Multi Station Magnetic Field Anlaysis before and during the 2009 Earthquake at L'Aquila regarding Geotechnicalk Information.
Nat. Hazards Earth Syst.Sci.,11,1959-1968.