G105

Determinations Onset time of Earthquake Precursor by Analizing ULF-EM Emission Signal in Sumatra region,

Case Studi Padang 2009 and Mentawai 2010.

S.Ahadi
Faculty of Earth Sciences and Technology
Bandung Institute of Technology
Bandung, Indonesia
su4idi@yahoo.com

S. Saroso
National Institute of Aeronautic and Space
Bandung, Indonesia

N.T. Puspito and G. Ibrahim
Faculty of Mining and Petroleum Engineering
Bandung Institute of Technology
Bandung, Indonesia

S. Ahadi
Meteorological Climatological and Geophysical Agency
Jakarta, Indonesia

Absract-**Determination of onset time precursors of strong earthquakes for Padang 2009 and Mentawai 2010. We are using geomagnetic data from Geomagnetic station KTB, Sumatra and two station references DAV, Philippine and DAW, Australia. Separate techniques are required in its determination. Not the same as that recorded in the kinetic wave seismograms can be determined by direct time domain. Difficulties associated with electromagnetic waves seismogenic activities require analysis of the transformed signal in the frequency domain. Determination of the frequency spectrum will determine the frequency of emissions emitted from the earthquake source. We analize signal ULF emission with associated strong earthquake in sumatera period 2009 – 2010 for Padang earthquake 2009 and Mentawai earthquake 2010. The aim is to analyze the power amplitude of the ULF emissions in the horizontal component (H) and vertical component (Z). Polarization power ratio S_Z/S_H is used for determining the sign of earthquake precursors controlled by the standard deviation. The pattern recognition polarization ratio should be obtained which can differentiate emissions from seismogenic effects and geomagnetic activity. ULF emission patterns generated that seismogenic effect has duration > 1 days before event. The dominance of emission intensity recorded at the Z component and for the dominance of the emission intensity of geomagnetic activity recorded in the component H. The result shows that the onset time is determined when the polarization power ratio S_Z / S_H standard deviation over the limit ($p \pm 2\sigma$) which has a duration of > 1 days .**

Keywords—component; *Earthquake precursor, polarization ratio, Onset time, ULF emission and Sumatra Earthquake,*

I. INTRODUCTION

Earthquake precursor studies using data geomagnetic has been widely reported by several researchers Hattori et al [1-4].The result is still the problem of how to determine the signature and how the onset time precursor as anomaly earthquake associated with ULF emissions determined?. This study tried to answer the earlier problems by analyzing the pattern of earthquake precursor emissions associated with ULF f = 0.023 Hz, it is based on reports from Ismaguilov et al. [5 and 6] report is the seismogenic frequency spectrum f = 0.02 - 0.05 Hz. it has also been strengthened by Hattori et al. [2] using frequencies in the range f = 0.01 Hz. Yumoto et al. [7] also uses frequencies in the range f = 0.01 - 0.022 Hz . This spectrum used to investigate a strong earthquake Padang 2009 and Mentawai 2010. Result of the earthquake investigation eventually led to a question of how relations earthquake magnitude and distance to the length of ULF emissions recorded in the magnetogram.

II. DATA AND METHOD

These research is to analyze the data geomagnetic with associated strong earthquake Padang 2009 and Mentawai 2010 using BMKG catalog previously been conducted by Ibrahim et al. [8]. This research uses data during nigthtime (23.00 – 04.00 local time) and an increase in the signal processing analysis. Data selection when a quiet day that the monitoring by geomagnetic index Dst (Distrubence Storm time). We are using geomagnetic reference station DAV (Davao in

Philippines) at the North and DAW (Darwin in Australia) at the south.

Our goal to observe the earthquake did not occur when storm or sub storm. in the same way we determine the precursor to a strong earthquake in Sumatra within ≤ 500 km from KTB. We also choose a quiet day at the station and for comparison the DAV (Davao, Philippines) in the north and DAW (Darwin, Australia) in our South also collected data on strong earthquake within ≤ 500 km from the station. And we selected earthquakes recorded at stations DAV does not occur simultaneously or ± 10 days when the earthquake occurred in Sumatra. From here we get an earthquake in Sumatra will be chosen completely clean of another earthquake disturbances in comparison with reference station.

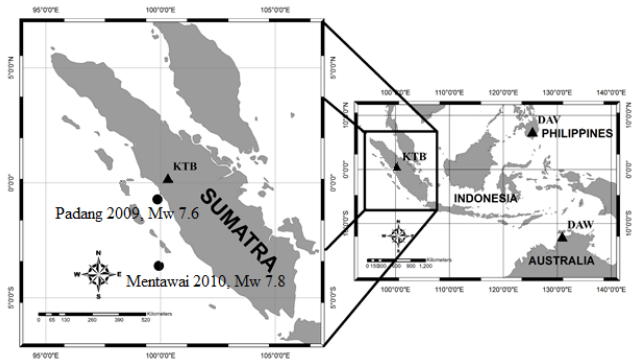

Fig. 1. Distribution epicenter two earthquake investigation [13] and Geomagnetic station Kototabang (KTB, Sumatra) and two station reference Davao (DAV, Philippine) and Darwin (DAW, Australia)

The polarization ratio using power spectral analysis of the ULF emission is a collection contains variety of frequencies are presented in the frequency domain. It is clearly observed that polarization showed a remarkable pre-seismic enhancement [1], Previous research is a possible to determine the pattern of anomalies caused by magnetic disturbances from lithosphere [9-11], and polarization ratio (Z/H) gradual decrease about one month before the Earthquake and recover within 2 week after earthquake [12].

We have been done analyze the Power Spectral Density Spectral (PSD) used with the Welch method of dividing the length of the signal (N data) into several segments, overlapping 50% on each segment [8]. FFT performed on each segment called nFFT the use of type window and type Hamming window of length L = N + 1. Standard deviation need to control and determination onset time. We determination onset time if polarization power ratio Z/H cross moving average from standard deviation.

III. RESULT AND DISCUSSION

From the results of research that has been done by developing a technique polarization power ratio S_Z/ S_H to the timing of onset is still hard to do. But here we got a conviction in which each earthquake occurrence by using spectrum analysis on each component found an intensity anomaly where if there is interference with geomagnetic disturbances external to the component response intensity H has a higher frequency than the component Z. we using Dst Index for control geomagnetic activity in low latitude [8 and 12] in Fig. 2

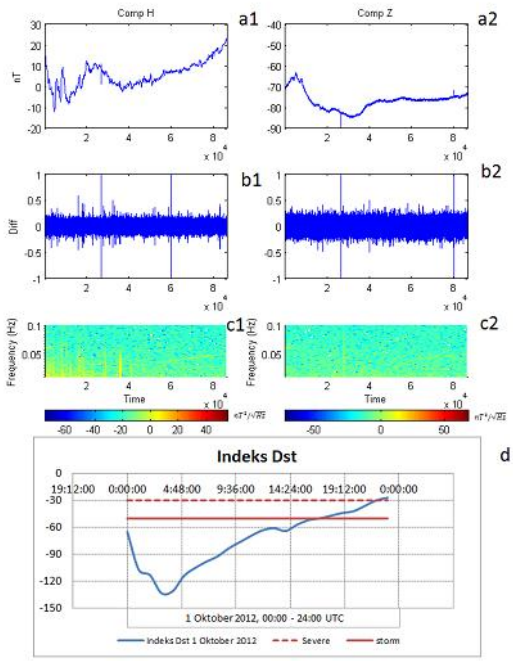

Fig.2 Showing geomagnetic storm (October 1, 2012) with spectrogram in panel c1 and c2 form H Comp. and Z Comp. Dst Index, in Panel d

We showing response frequency if with associated seismogenic, Z comp. have intensity response more than H comp. This is The Padang earthquake September 30, 2009 with a quiet day (no geomagnetic activity) in Fig.2.
Analysis spectrum with polarization rasio S_Z/S_H for determination onset time and lead time to Padang earthquake showing in fig.3.

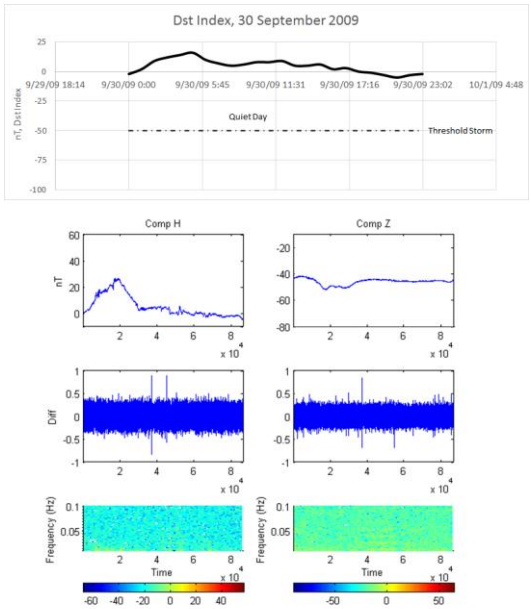

Fig. 3 The associated seismogenic effect for Padang Eq. 30 September 2009 Mw= 7.6 and distance 139 km from KTB, The Comp. Z have response intensity more than H Component.

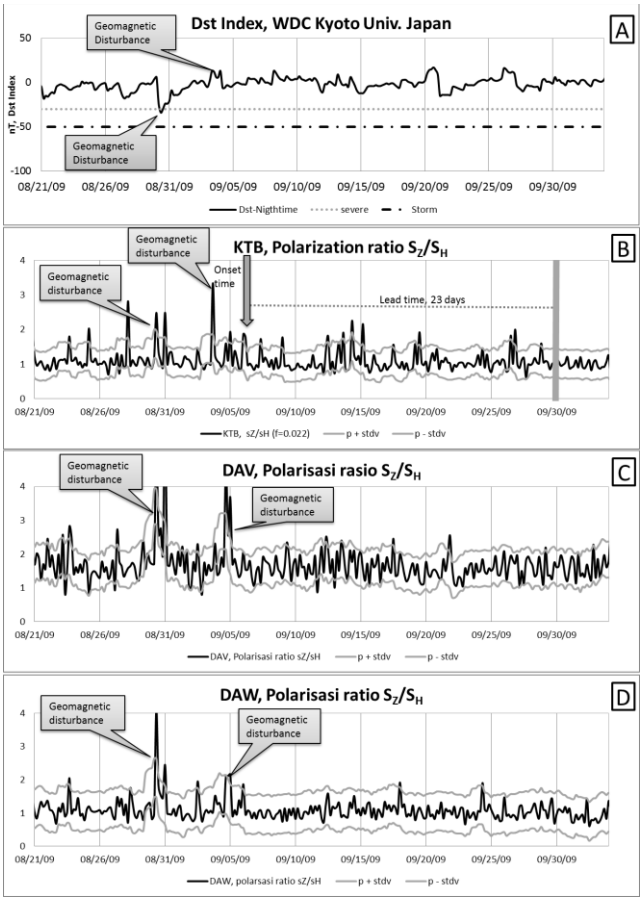

Figure 4 . Top panel (A) is Dst index (black line) (WDC-Kyoto Univ.[14]) in period August 21 – October 10, 2009 was quiet and the middle panel KTB (black line) shown information anomaly ULF emission with onset time September 06 – event (lead time) with shown crossed the line standard deviation (p+σ, p-σ). For below panel is station geomagnetic reference DAV and DAW shown not Information ULF emission all period.

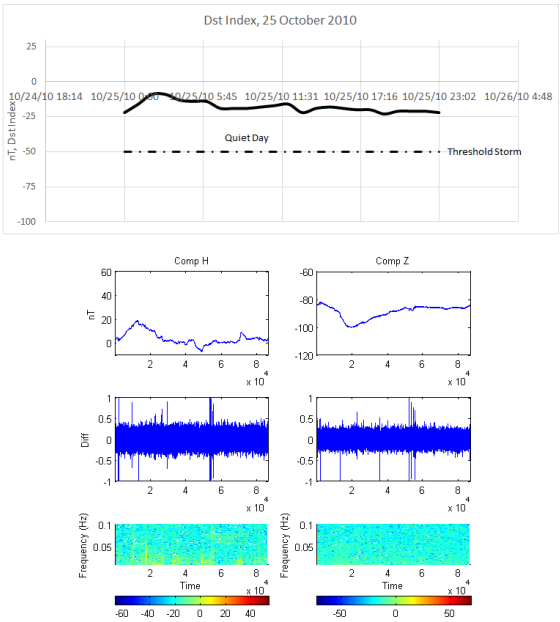

Figure 5. Mentawai earthquake 25 October 2010 showing when event. Top Panel is Dst Index from WDC Kyoto University Japan dan Low panel are comp. H and Z for raw data, diff data and spectrogram.

In Fig.5 low panel in spectrogram showing frequency response in component H and Z. we selected spectrum frequency is f = 0.022 Hz and showing Polarization power ratio for mentawai Earthquake 2010.

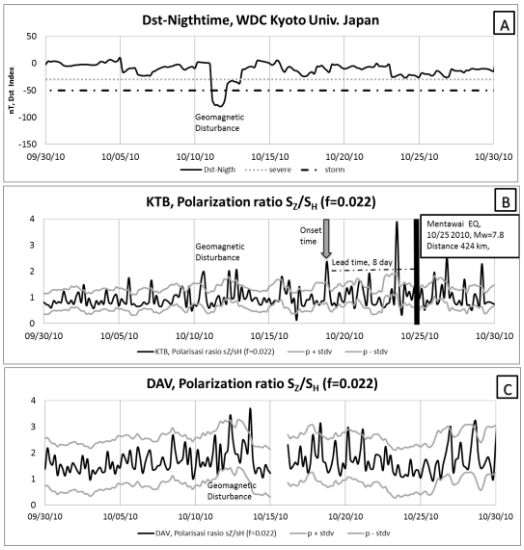

Figure 6. Top panel is Dst index (green line) (WDC-Kyoto Univ.[14]) in period October 16 – 30, 2010 was quite day and the middle panel KTB (blue line) shown information anomaly ULF emission with onset time October 17 – event with shown crossed the line standard deviation (p+σ, p-σ). For below panel is station geomagnetic reference DAV and DAW shown not Information ULF emission all period.

IV. CONCLUSIONS

We have found that electromagnetic frequencies generated from the earthquake source is in the range f = 0.02 to 0.06 Hz for frequencies below or above it is caused by disturbance from outside. Molchanov and hayakawa [11] have modeled the effects of microfracturing which shows the angular frequency < 0.1 Hz. frequency intensity response type effects occur seismogenic the Z component is more dominant than the components of H. we determination onset time using technic polarization rasio Z/H with using standard deviation (p±2 σ) if the signal cross moving average standard deviation we determine as onset time.

Thus the confidence to build an earthquake early warning to the precursor of the ULF emission is in sight, although still far from the earthquake prediction. With the method carried out by previous researchers and the development of methods that we do so we add a new contribution which we can know the objective connection between ULF emission with the magnitude, epicenter distance so that with this method, at least we can know how big an earthquake will the earthquake occurred and the distance of the monitoring stations, even though we have not been able to find out where the fault position is going to happen. Further

ACKNOWLEDGMENT

We thanks to Dr. A. Yoshikawa as a PI: ICSWSE and The part of research has been done in ICSWSE/SERC (International Center Space Weather Science and Education Formerly SERC) Kyushu University Japan to conduct a student visit and to use the data of MAGDAS (JSPS Core to Core Program, B.Asia Africa Science Platforms). Also thanks to LAPAN (National Institute Aeronautic and Space, Indonesia) and STEL (Solar Terrestrial Environment Laboratory) Nagoya University, Japan for Geomagnetic data KTB (Kototabang). The first author grateful acknowledge BMKG for providing the scholarship for his PhD research at Bandung Institute of Technology.

REFERENCES

[1] Hattori, K., Akinaga, Y., Hayakawa, M., Yumoto, K., Nagao, T., and Uyeda, S. (2002): ULF magnetic anomaly preceding the 1997 Kagoshima earthquake, “Seismo- Electromagnetics: Lithosphere-Atmosphere-Ionosphere coupling”, edited by M. Hayakawa and O. Molchanov, TERRAPUB, Tokyo. 19-28

[2] Hattori, K., Takahashi, I., Yoshino, C., Isezaki, N., Iwasaki, H., Harada, M., Kawabata, K., Kopytenko, E., Kopytenko, Y., Maltsev, P., Korepanov., V., Molchanov, O., Hayakawa, M., Noda, Y., Nagao, T., and Uyeda, S. (2004): ULF geomagnetic field measurement in Japan and some recent results associated with Iwateken Nairiku Hokubu earthquake in 1998. Phys. Chem. Earth, 29, 481-494, doi: 10.1016/j.pce.2003.09.019

[3] Hattori,K., A.Serita, C. Yoshino, M. Hayakawa, and N. Isezaki., (2006) : Singular Spectral analysis and principal component analysis for signal discrimination of ULF geomagnetic data associated with 2000 Izu Island earthquake swarm, Phys. Chem. Earth, 31,4-9, 281-291, doi:10.1016/j.pce.2006.02.034

[4] Hattori, K., Han, P.,Yoshino, C., Febriani, F., Yamaguchi, H., Chen, C.H.,Investigation of ULF Seismo-Magnetic Phenomena in Kanto, Japan During 2000-2010., (2013) : Case Studies and Statistical studies, *Survey in Geophysic*, 34,293-316,DOI 10.1007/s10712-012-9215-x,

[5] Ismaguilov, V.S. Kopoytenko Yu. A. Hattori K. Voronov P.M. Molchanov O.A. dan Hayakawa M. (2001) : ULF magnetic emissions connected with under sea bottom earthquakes. *Natural Hazards and Earth System Sciences*. 1: 23-31. doi:10.5194/nhess-1-23-2001

[6] Ismaguilov, V.S. Kopoytenko Yu. A. Hattori K. dan Hayakawa M. (2003) : Variation of Phase velocity and gradient values of ULF geomagnetic disturbance connected with the Izu strong earthquake. *Natural Hazards and Earth System Sciences*. 3: 211-215. doi: 10.5194/nhesss-3-211-2003.

[7] Yumoto, K., Ikemoto S., Cardinal, M.G, Hayakawa, H., Hattori, K., Liu J.Y., Saroso, S., Ruhimat, M., Husni, M., Widarto, D.S., Ramos E., McNamara, D, Otadoy R.E, Yumul G., Ebora R., and Servando N.:A new ULF wave analysis for Seismo-Electromagnetics using CPMN/MAGDAS data. Phys. Chem. Earth, Parts A/B/C, 360-366, doi:10.1016/j.pce.2008.04.05, 2008

[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*. Vol 13. No.2.81-89

[9] Ida, Y. Yang D. Li Q. Sun H dan Hayakawa M., (2008) : detection of ULF electromagnetic emissions as a precursor to an earthquake in China with an improved polarization analysis. *Natural Hazards and Earth System Sciences.* doi: *10.5194/nhess-8-775-2008*

[10] Karakelian, D. Klemperer, S.L. Fraser-smith A.C. dan Beroza G.C. (2000) : A Transportable system for Monitoring Ultra Low Frequency electromagnetic signal associated with earthquakes. *Seismologica Research Letter*. Vol 71, No.4, 432-436. doi:10.1785/gssrl.71.4.423

[11] Molchanov, O.A., and Hayakawa, M., (1995) : Generation of ULF electromagnetic emissions by microfracturing. Geophys. Res. Lett. 22. 3091-3094, doi:10.29/95GL00781, 1995

[12] Saroso S., Hattori K., Ishikawa H., Ida Y., Shirogane R., Hayakawa M., Yumoto K., Shiokawa K., Nishihashi M., (2008): ULF geomagnetic anomalous changes possibly associated with 2004-2005 Sumatra earthquake. Phys. Chem. Earth. 34. 343-349, doi:10.1016/j.pce.2008.10.065, 2008

[13] BMKG Eq. Catalog, http://www.bmkg.go.id/BMKG_Pusat/Geofisika/Gempa_Dirasakan.bmkg, 2012

[14] WDC, World Data Center for Geomagnetic: http://wdc.kugi.kyoto-u.ac.jp/aeasy/index.html , 2013