"Interrelationship between Electric and magnetic field components of EM radiation Induced due to applied stress of tangential or radial nature on the purview of observant OLR, MMC and TEC data in monitoring seismicity "

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Abstract

The variant nature of Electric and Magnetic component of Induced EM radiation due to progressing Stress in the mantle (Up- Lr Interface) [1][17, 25] shows interesting pattern under some rule (?) With the progress of applied stress in a particular amount and direction typifying radial or tangential in nature induces the amount and direction of EM radiation from mesosphere to ionospheric height[2][8].With the investigation of observations on TEC(total Electron Count) MMC(Multiple Magnetic Components) and OLR(Outgoing Long Wave Radiation) data over world map for continuously two months directly connected with the, IPS(Australian) and, IRS (Indian satellite) have established compensating and mutual relationships in proportionate manner with the progressing stress. Facts enshaped are: (1) either of Electric or Magnetic components increases with the increasing stress in a particular direction and are inversely proportion in general[3] [14, 18, and 24]. (2)In some cases it(either of them) is directly varying with the varying stress amount and thus OLR value.(3) Decrease in the amount of any component is compensated in the associated component 's value lying in the plane at 90^0 .Specific condition of simultaneous rise in the components value of TEC , MMC.and OLR indicates of approaching critical moment for the seismicity over an area viz; Indonesia(8.2Mw) on 11-04-12, Chile (6.8Mw) on 24-04-12 and Tonga6.4Mw on 4th of May"12 as per our expectations. Findings of investigation flash the idea for estimation and expectation of seismicity with deterrent focal depth, and magnitude of energy and thus add in prediction of an event.

Key words: OLR, MMC, TEC data, Electric and magnetic field, seismicity.

INTRODUCTION: Since past earthquake forecasting and prediction had been an enigmatic issue as the hazard looks like[4] [8]in the decade 60-70 works in this sphere of research and investigation by Z Suzuki et al(1960)[5] [24,25]opens systematic panorama of research .In the decade 70-80 researchers' toil in the geodetic- geodesic approach viz ground uplifting. Fluctuation in level of Underground, water resistivity variation[6] [22]Vp-Vs ratio fluctuation, radon emanation: Eliby(1980), CO_2diffusion in the surface atmosphere7 [8]annexes chain of advanced pre-seismicsignals. In recent induced EM propagation theory in the perspective of SES(seismo-electric signals), ELS(earthquake lightning Signal)[8] [10,14,17] ULF /ELF emission as pre-seismic phenomena[9] [8,14,17,22]IF infrared anomalies prior to major event provides much estimation as precursory aid. Still despite demonstration of piezoelectric and piezomagnetic effect by surface rocks of substratum[10] [6,7,14,24] in addition to electrets effect on the surface rocks prior to seismicity much more study on investigative platform of EM radiation due to stress propagation leading failure is essential.

TEC (Total electron count),MMC (Multiple magnetic component) and OLR (Outgoing Long wave radiation) all are associated features of induced EM radiation due to stress propagation in tangential and radial components mutually perpendicular[11] [[13,19]].The initiation of stress (Shearing often) at the interface of Lr-Up mantle forwarded to the globe surface through the

stratum rocks of heterogeneous (Geochemical and Geophysical) character in response to the interaction with the overlying rock sub-volume induces EM radiation not only to the crustal surface but to the Mesospheric and ionospheres' height[12] [6,7,8,14].Its signature is displayed as PHP(positive hole pair or simply positive charge) culmination[13] [7,8,12]F.T Freidman et al (2010) with ionosphere electronic charge and produces ELS,IF anomaly with rising temp by 4-5^0C[14][5,6,7,] Ozunov and Demeter(2007,2010),Plasma bubble accumulation[15] [12,14,17]Lee Fang(2012) Cheng Ling Kuo et al .all characterize the EM radiation induced due to stress propagation at depth within the stratum rocks under constraints parameters of density, rigidity, elasticity, resistivity, viscosity, and internal friction μetc[16] [17,25]The nature of EM radiation with the impending stress within the stratum rock is associated with the electric and magnetic component of EM waves. What makes variant nature of TEC with respect to OLR and MMC (in magnitude and direction) requires investigative study. The mission in the paper lies to establish the consequent relationship between the rise in TEC or electric field from surface to ionospheres height[17] [8, 12] (F.T Friedman2010) and corresponding attitude (?)of magnetic component (MMC) value at specific region plus OLR description over the area. Following facts were observed from March 24 to Jun 4 by availing the TEC, MMC and OLR data felicitated by IPS satellite for space and weather forecast system of Australia over global map.

1TEC rises at perpendicular direction and in inverse proportion to the MMC values and OLR in the plane at right angle to the plane containing former two elements.

2The signature of progressing TEC, MMC and OLR values are observed at three mutually perpendicular planes.

3 Increase in one components' magnitude is compensated with the decrease in other's magnitude

4Rise in merely one elementary component magnitude does not signify the pre -seismic signal for any big event.

5Rather, simultaneous rise in the components '(viz; MMC, OLR, or TEC) magnitude compels to consider about any big event like that of Indonesia (11th April) with 8.6Mw: Chile (7.6Mw) on 28thMarch'12 drop out the stress.

Eden(1980)'equation $\Delta\mathbf{J} == \Delta\boldsymbol{\chi}+\Delta\mathbf{NRM}+\mathbf{PRM}$ ---- ---------- (1)

(here,$\Delta j$is the applied field,$\Delta\chi$ is change in susceptibility,NRM is remnant moment of magnetism, and PRM is acquired pressure by the rock sub volume)plays the compensatory role for the enhancement in any one of charge generation , susceptibility rise is due to the proportionate decrease in the remnant magnetism or susceptibility by stress applied. This is obvious even by the Maxwell general equation for Electric and corresponding magnetic component of EM radiation.

$$\oint \boldsymbol{Bdl} = \boldsymbol{\mu 0 icc}+\boldsymbol{\mu 0 \varepsilon 0}\frac{\boldsymbol{d\varphi E}}{\boldsymbol{dt}} \text{----------} \quad (2)$$

That gives the exact explanation of differentiating electric and magnetic components. Nature and development of these components under parameterized constraints (i.e. taking the magnitude of one or two components minimum or up to zero) are displayed in the principle and mechanism(stated in the paper) involved behind the observed facts incorporating the seismicityon28th March at Chil;e7.2Mw and 11th April 8..4Mw at Indonesia and30thMayatTonga(6.3Mw).

2. Principle and Mechanism: Fourier transform of the wave **function (**electromagnetic) gives rise to their components as E= Eon sin (ωt+θ) and, Hn=HoCos (ωt+θ):

This after expansion becomes:

$Ezs(y)=E_1e^{\alpha y}e^{j\beta y}+E_2e^{-\alpha y}e^{-j\beta y}$ ---------- (3a)][18] [2, 5, 12, 18] and equation,

$Hzs(y)=H_1e^{\alpha y}e^{j\beta y}+H_2e^{-\alpha y}e^{-j\beta y}$---------- (3b)]

$Ez(yt) = E_1 e^{\alpha y}\cos(\omega t+\beta)+E_2 e^{-\alpha y}\cos(\omega t-\beta)$------(4)19 [6,7,12,18] are the general solutions to the polarized TEM(Transverse electromagnetic) ,reduced wave equations consisting of only two field components (electric and Magnetic)where Ezs(y) are the electric component Hzs(y) are the magnetic component of TEM wave . E1,E2, H1 and H2 are the constants of amplitudes of electric and magnetic fields respectively Equation 4 is the general field solutions consisting of instantaneous fields (electric and Magnetic) in time domain. Here, (ωt+β) and (ωt-β) are the phase angle with $E_1 e^{\alpha y}$ $\alpha E_2 e^{-\alpha}$, amplitudes of fields(electric) α (Np/m)β(rad/m) and ? (m $^{-1}$)are constants of attenuation loss, phase and propagation constant respectively, for the particular electromagnetic wave of certain frequency ω. Which are defined by the values of σ, ε, and μ of the medium of propagation considered.

Values of electric and magnetic components are ascertained as the three possible tensor considered along x,y,and z axes of reference and can be associated by the wave equations in the direction perpendicular plane to the components assigned as in the equation (A)and (B).

$$\frac{\partial^2 Exs}{\partial x^2}+\frac{\partial^2 Exs}{\partial y^2}+\frac{\partial^2 Exs}{\partial^2 z}=\gamma^2 xs$$

$$\left|\frac{\partial^2 Eys}{\partial x^2}+\frac{\partial^2 Eys}{\partial y^2}+\frac{\partial^2 Eys}{\partial^2 z} = \gamma^2 ys\right| \text{---------- (A)}^{20} \textbf{[from Maxwell Boltzmann equation]}$$

$$\frac{\partial^2 Ezs}{\partial x^2}+\frac{\partial^2 Ezs}{\partial y^2}+\frac{\partial^2 Ezs}{\partial^2 z} = \gamma^2 zs$$

$$\frac{\partial^2 Hxs}{\partial x^2}+\frac{\partial^2 Hxs}{\partial y^2}+\frac{\partial^2 Hxs}{\partial^2 z}=\gamma^2 xs$$

$$\left|\frac{\partial^2 Hys}{\partial x^2}+\frac{\partial^2 Hys}{\partial y^2}+\frac{\partial^2 Hys}{\partial^2 z} = \gamma^2 ys\right| \text{---------- (B)}^{21}\textbf{[4,5,18]}$$

$$\frac{\partial^2 Hzs}{\partial x^2}+\frac{\partial^2 Hzs}{\partial y^2}+\frac{\partial^2 Hzs}{\partial^2 z} = \gamma^2 zs$$

All the three tensors defined by the partial derivatives are never carrying complete values. At least one in the direction of wave propagation shall have zero in amount. Equations (A) and (B) are Laplacian scalar conversion for the wave equation $\gamma^2 (x,y,z)_s$. Solution to these equations will carry the vector form and whose Cross product of solution(in vector form) to these (A)'sand (B) 's equation gives the resultant wave equation's strength in the direction perpendicular to the electric and magnetic components (existing and nonzero) which is naturally plane wave or uniform wave equation. For maximum strength of electromagnetic wave formed has Amplitude and $\frac{A}{\sqrt{2}}$for individual components..Diagrammatically mechanism can be understood in figure 1.

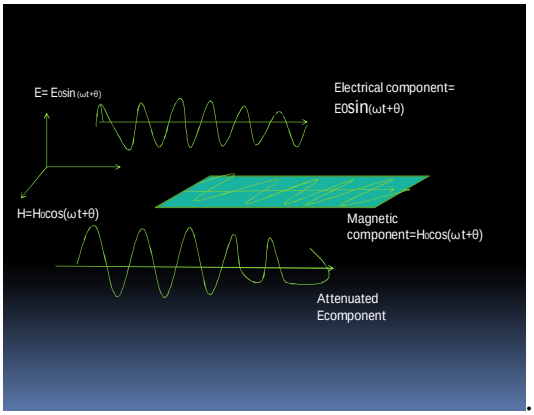


Fig1 attempts to show the electric component of EM radiation by wave (curves) in vertical plane and Magnetic component by wave(curves in horizontal plane

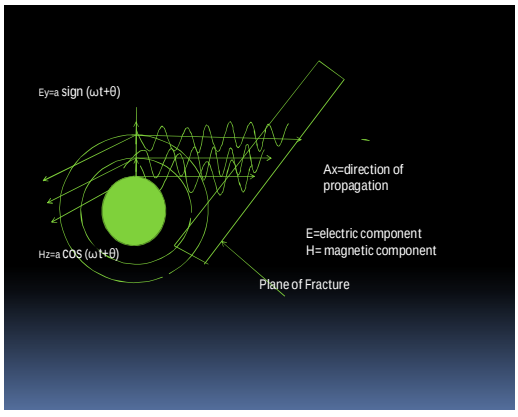


Fig2 attempts to explain the formation of stress circle and associated induced electromagnetic waves components. Along x axis waves propagation, y-axis electric components and along z axis element of component (magnetic) has been shown.

Possible values of $\theta_1$andθ_2 that components make with the fracture plane are 0^0,45^0 ,90^0,and180^0 Except o and 45^0 cases are for attenuated waves that gets compensated by enhancement in other element Which is qualified by the phasor(Helmholtz) wave equation $\nabla^2 Es$ -γ^2Es.=0 and ∇^2Hs=γ^2Hs where $\nabla^2$is the Laplachian operator on electric and magnetic components.,γ wave propagation constant, which is **α+jβ .**=$\sqrt{J\omega\mu(\sigma + j\omega\varepsilon)} \approx \sqrt{J\omega\sigma\mu} = \sqrt{J\omega\mu}\mathbf{90^0} \equiv \sqrt{\mu\omega\varepsilon}45^0$. for a lossy like anisotropic and heterogeneous mantle and crustal stratum. Attenuation value is maximum in case of conducting medium and is dependant in the inequality equation on frequency of wave **as** $\mathbf{J=J_{conduction}+J_{displacement}=\sigma E+J\omega\varepsilon E}$**and**$\mathbf{|Jconduction| \gg |J}\boldsymbol{displacement}|$---------- **(5) .**

if($\sigma \gg \omega\varepsilon$) . This is the fact that **at greater depth of homogeneous conducting medium electromagnetic waves are attenuated with high frequency of infrared at hot temperature about 3000-6000^0**c$^{\$}$.This attenuation is extreme in magnetic wave component case in plasma bubble formation (at more than 6000^0c temperature*)followed by successive rise in electric components and current displacement in the mesospheric height culminating with streaming potential of PHP discharge from the ground air interface to the ionosphere height.** Energy accumulates in form of induced EM waves with loss and compensation in proportionate manner and conserves the energy identical to Poyanting vector equation for EM waves as.

$\int_s^\infty (E \times H)ds = -\frac{\partial}{\partial t}\int_v^V [\frac{1}{2}\varepsilon E^2 + \frac{1}{2}\mu H^2]dv - \int_v^V \sigma E^2 dv$----------(6)[22] **Poyanting equation for Electromagnetic Radiation]** which has values of

$\nabla^2 E = \mu\sigma\frac{\partial E}{\partial t} + \mu\varepsilon\frac{\partial 2E}{\partial_{t^2}}$----- ---------- (7)[23] [3, 5, 6, 12] and

∇^2H=$\mu\sigma\frac{\partial H}{\partial t} + \mu\varepsilon\frac{\partial^2 H}{\partial t^2}$------- -- --- (8)[24] [5, 12, 17] as

Instantaneous vector form of Helmholtz wave equation.

3. Acquisition of data: Based on reporting of TEC, OLR and MMC data on global map focus were made **over Australian, Asian and Western Asian regions.** Since 24thMarch 2012 to May05of 2012 continuous notice (leaving few exceptions) were taken on the pattern of variation in these elementary components viz Electric and Magnetic. For first one week rise in TEC started from 50 % over Australian then next week in Central Asian region up to 79% and more. Variation in MMC at Gin gin Lear more and Springdale were interesting. OLR rise in infrared % found surrounding over central Asian region till the availability by 5thMarch'2012.

Profound rise in MMC at Australian region were recorded in these two weeks from 24th March to 5th of April. Further rise in TEC started at central region mainly over Indonesian (Sumatra) areas. OLR % continued to rise in Indian and eastern Asian region by 250 to 300w/m^2.On the basis of OLR rise event could be expected at Indian sub region. On the MMC variation and due to foreshocks at Australian region we expected at western and central Australian region. But it was the TEC with 80% till 10th of April over a good area of Indonesia were located. It were frightening for the event at most probably at Indonesian region and it happened soon 11th April12.Tabulised information and fig associated recorded by satellite information are produced for felicitation as below.

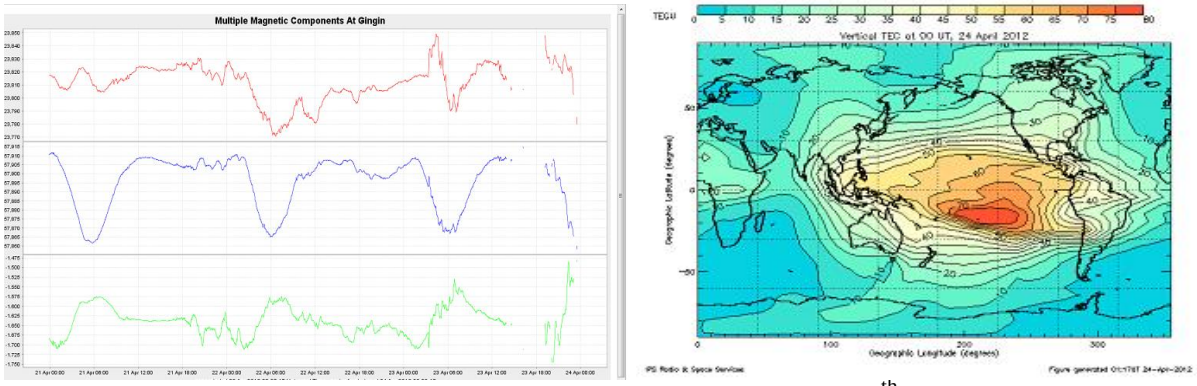
Table1

Date and time	TEC%			MMC			OLR%		Lat. and,long.		Station	Remarks
	Vert	Hor.	Diag.	X	Y	Z	Contract.	Expand	N/S	E/W		
2503. 2pm	50-60	-50-60 China	60-65 Haiti	→	↑	↑	100 India	300 Indonesia	5S-25N	120-180E	GinginS Wells	Increase
25034 pm	50-60	50 China	65 Haiti	↓	↑	↑	100 India	300 Indonesia	5S-25N	120-180E	LearmoSpringdale	do
26034 pm	60-65	50 China	65 Haiti	↓	→	→	100 India	280 Indonesia	5S-25N	120-180E	do	still
270310am	65-70	60 China	60 Haiti	→	↓	↓	100 India	280 Indonesia	do	do	do	decrease
27.03 4pm	65-70	60 China	55haity	↑	→	↑	100 India	250 Indonesia	do	do	do	Slight increase
28.03 1.37p	50-60	50China	40Haiti	↑	→	↑	Na	NA	5S-25N	120-180E	GinginS Wells	Increase
28034 pm	60-65	60 China	50 Haiti	↑	→	↑	50 Indonesia	250 india	do	do	do	Still
050410am	60-65	60 China	45haity	→	→	↓	50 Indonesia	200 india	do	do	Learmore, Springdale	Decrease
05043 .13p	70-75	60China	40Haiti	→	→	↓	50 central Idonesia	300 Aus.India	5S-20N	80-140E	GinginAliceland	Decrease
100410am	70-75	55 China	45 Haity	→	↑	↑	55 indonesia	do	do	do	do	Increase
110404am	75Sumatra	60China	50Haiti	↓	↑	↑	60 Indonesia	300 India,Aus.	03-10 S	100-110E	Learmore	Increase
11048 am	80Sumatra	75CInonesia	50 Haiti	↑↓	↑	↑	70 Indonesia	300 Aus	03-10S	100-110	Learmore	Increase!

By having careful notice over the pattern of TEC we observe first variable rise from 24th March to 28th March with associated variation in MMC, First four days the steep rise in MMC at Gingin and Lear more (Australia)were recorded.. Next week iefrom1st April to 7thApril rise In TEC were 70-75 MMC about fluctuation in critical way ,OLR expanded at right angle towards Africa and western Asia. After 7th to10th April by 2400 UT Interesting fluctuations in MMC and TEC rise were recorded. TEC was continuous over Indonesian region in Vert. and horizontal both. MMC were fluctuating except at Baltimore and S Wells rise in z component of MMC was recorded. On 11thApril 6.00to 8.00 UT steep rise in MMC's in X ,Z were recorded and TEC was about 80 % in Vert, and Horizontal both direction. OLR were gushing out Western Asian region Just at right Angle to these elements.

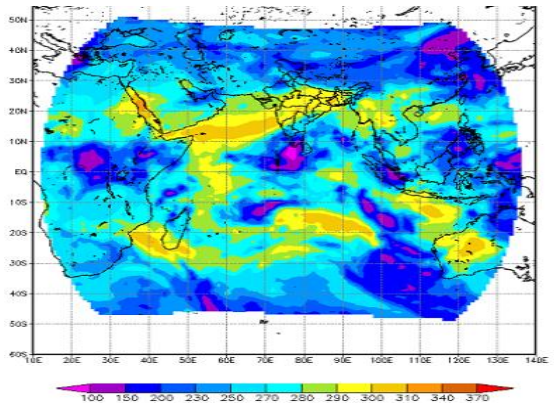
Table2

date and time	TEC%			MMC			OLR%		Lat,longfor TEC		Station MMC	Remarks
	Vert	Hor.	Diag.	X	Y	Z	Contract. w/m^2	Expand w/m^2	N/S	E/W		
2204.8am	60	50	-	↑	→	↓	Australia 150-200	India250-300	0-10s	200-230 E	Xgingin Zswelsi	Fluctuate
22049am	70	60	-	↑	↓	↓	Fizi-tonga 150	SAfrica250	0-10s	200-215E	Alice Spring	Do
22044pm	75 Tonga	65	?	→	↑	↓	Fizi-Tonga 150	350Egypt	0-12s	200-215e	S wels	Decrease
230410 am	50 Tonga	40	40	→	↓	↑	Indonesia 100	India 200	10-20s	100-110e	Perth	Remains still
24047.50p	60-65 Tonga,	60Fizi Haiti	50 Haiti	→	↑	↓	>250 Indonesia	290 W Africa	5-15s	180-230E	Gingin	decrease
24049.45p	75-80 Tonga	65-70 Chile	50 Haiti	↑	→	↓	NA	NA	5-20S	190-240E	S Wells	decrease
240411 am	75-80 Tonga	60..65Chile.	65 CAmer.	↓	→	↓	<100 C. Indonesia	>300India&Aus.	5-20S	180-230E	Gingin	decrease
24043.39p	>80 Tonga	70C Indonesia	40 CAme	↓	→	↓	100-Cpacific	250India	5-15S	180-220E	Gingin S Wells	do
25049.45a	65-tonga	40 C.Ame Rica	35 Chile	→	↗	↓	150 India. Indonesia	250Aus	do	do	Gingin S Wells	Decrease
250412 pm	65-70 Tonga	60Indonesia (.	50 C.Ame	↓	↑	→	50C.Indian&Pacific	250Indonesiaia&Aus!	5-15S	do	do	Still !!
280410 am	65-70 Tonga	60,do	60 CAme	↑	→	→	50indonesia	>300,IndiaC. Australia	do	190-225e	Gingin S.Wells	Slight Increase!
280401.7p	70-75 Tonga	65 ,SE China	60 Haiti	→	↑	↗	60,LrIndonesia	290, C India	5-15S	190-225E	Gingin Swells	Slight! increase!
28042.13p	40 Tonga	70S China, Indonesia	40India	↑	→	↑	50C.Indonesia	310India&Africa	5s-20N		Lear More S.Wells	Increase
30.042.10p	70 Sumatra	60 China	40Haiti	→	↑	→	40indonesia	300India ,Aus.	0-10s	95-110E	do	decrease



TEC Rise at Tonga Fiji area **and**MMC variation at Gin gin on 24th April, at8.0.11am courtesy IPS Australian (Gov)

OLR shifts towardslower end of SE Indonesia SE Africa as Y axis of EM component.



OLR shifting towards SE Indonesia and Africa: on 24th April8.20AMCoutsey: IRS Kalpana.(India)

4Discussion and conclusion: (a) With the **recording o**f observations on TEC and OLR ,MMC data prior to the events of Indonesia (8.4Mw) 11April and 2nd of Tonga (6.2Mw) on 28th April best provides investigative report on rise of electric field and magnetic field and thus electron density quite agreeing the

$$\{\frac{\partial}{\partial t}+\bar{v}\cdot\nabla_{\bar{x}}+\frac{q}{m}[\bar{E}(\bar{x},t)+\bar{v}\times\bar{B}(\bar{x},t)]\cdot\nabla_{\bar{v}}\}f(\bar{x},\bar{v},t)=(\frac{\partial f}{\partial t})_{collision} \quad \text{----------8.}^{25}$$

Which is Maxwell Boltzmann equation){Babvaeva and Nadirs 1997}[9.10,20]

Where f(xv,t)are the velocity distribution function such that f($\tilde{x}\vec{v}t$) is the number density of finding the particles in a unit volume and $\tilde{x}$position at t time and prevailing velocity of the medium particle.

(b)Slow rise in TEC value and greater rise in MMC over an area signals about accumulation at peak value and agrees with observation of(Contoyiannis et al., 2005).[26 [5,17,19a]]for low frequency (≤1 Hz) electric signals as precursor of foreshock [Cicerone et al.,2009].

©Greater rise in the TEC value and simultaneous decrease in the MMC indicates of stress level approaching the failure by the rock at up stratum agrees the view by Kapiris et al., 2004; Contoyiannis et al., 2005, during MHz EM radiation by the fracture of the highly heterogeneous system that surrounds the family of large high-strength entities distributed along the fault sustaining the system.(d)OLR % increase at the site may be attributed to the IR anomaly and thus

phase transition of EM waves[27] [2,3,5,12,19]indicating seismicity preceding main shocks [Contoyiannis et al., 2005].

(e)Simultaneous rise (at lower pace) in LOR, TEC and MMC at the site is critical nature of stress to get failure and outbreak into an expected event as in case of Indonesia (8.6Mw) on 11April ;(in Table1)and at Tonga(6.2Mw) on 28 April (after 2.13 pm –in table2)(f) Explanation to (e) can be made by Boltzmann Maxwell's mathematical formula $\bar{n} = \frac{2\varepsilon^{1/2}}{\pi^{1/2}\varepsilon_0{}^{3/2}} e^{-\frac{\varepsilon}{\varepsilon_0}}$. mentioned in the paper of Cheng Ling Kuo[28] [3,12,21,23].where n^- =no of electron density due to ε=electric field andε_0=electric field in the vacuum and ε electric field in the medium.

(h)For **the acknowledgment** of an observed signal as EQ precursor [Cicerone et al., 2009]. The first one was "the reported existence of credible scientific evidence for anomalies in the observables prior to at least some earthquakes" and the other was the existence of "acceptable physical models to explain the existence of the precursor".

(I)The transient luminous events were accidentally observed in the ground observation (Franz et al., 1990) and Earth orbit observation (Boeck et al., 1992), and were soon recognized as the manifestations of total electric current of 1.5 kA flowing into the ionosphere, and sustain the electric potential ~200 MV of the ionosphere (Volland, 1987). With the thunderstorms, the electric energy gradually accumulates.

Acknowledgement; Acknowledgement to CEO NASA Mr F.T Freidman CEO, NASAfor providing frequent guidelines.

2Gratitude and thanks are paid to NASA authority and IPS Australia Space weather forecast system for providing valuable data on TEC and MMC over Indonesia, Chile, and Fiji-Tonga areas.

3. Gratitude is paid to Dr and Professor DVR Chief Editor IJEE Hyderabad, India. For felicitating the communication with the Australian authority.

4 Thanks and gratitude are paid to Mr P, Hollis, Watts, research scholar WA Australia for being with me in the research activities of such kind.

5. Gratitude and acknowledgements are bid to my nearer and well-wishers and special thanks to my reviewer for enriching the worth of the paper without whose examination the paper could not get the worth.

6 Acknowledgements and thanks are paid to the director BIT Sindri, Dhanbad Jharkhand, and Bihar University Muzaffarpur, Bihar India for supporting me on various levels,

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