

ELECTROMAGNETIC PHENOMENON
RELATED TO
**EARTHQUAKES
AND VOLCANOES**



Narosa

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Diurnal and Semi-diurnal Patterns of EM emissions Related to Earthquakes and Volcanoes.

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Abstract

Various research workers reported EM emissions prior to earthquakes/volcanoes and/or during such sequences. In few cases, these EM emissions were consistently found during certain hours of the day. EM emission in semi-diurnal pattern spaced in time domain from the local noontime was observed in many examples prior to earthquakes/volcanic eruption. Also such emissions were observed in a very wide frequency band from VLF to Microwave range. It was also found in these examples that the occurrences of earthquakes/eruption of volcanoes were simultaneous with the timings of these EM emissions. From this study, it can be concluded that the semidiurnal stresses on the earth are primarily caused by the position of the Sun and those on the Moon by Sun-Earth system.

Besides this semi diurnal type of pattern, some other type of EM emissions had diurnal pattern. This type was witnessed in Valsad (1991) and Chilean earthquake sequence (1960), in which it preceded semidiurnal pattern found in these earthquake sequences. The cause of this type of EM emission seems to be completely different than that for semidiurnal type. Efforts are made here to check whether the gravitational forces of the planetary alignments caused these types of RF emission. This paper discusses all these examples in details and discusses an application for the development of reliable monitoring of Earthquake/ Volcanic eruption precursors in the high seismicity area.

Keywords: Telemetered network, semidiurnal, diurnal RF emission, earthquake sequence

1. INTRODUCTION:

During the operation of a radio telemetered seismic network (RTSN) at Bhatsa, Maharashtra state, India, in 1989-1995, RF interference to the radio links operated in UHF (ultra high frequency) band, presumably associated with Valsad earthquake sequence of 1991¹, was observed only during certain timings of the day. Many research workers witnessed EM emission related to earthquakes and volcanoes in different frequency band starting from ultra low frequency (ULF) to microwave range, again during certain hours of the day. These were found twice during the day at timings equally spaced from local noontime.

Takeo Yoshino and Ichro Tomizawa (1989) observed low frequency (82 KHz) EM emission at precursors to the volcanic eruption at Mt. Mihara during Nov.1986. Several clear bursts like emission were gathered during Nov. 3 to 22. The EM emissions were confined to 09 to 11 and 14 to 16 hours (JST) only². Besides the timings of the first eruption in creator A (at 17:25 hours on Nov 15,1986) and simultaneous eruption in creator C (at 16:21 hours on 21st Nov 1986) match with the timings of the EM emission observed.

The recording of diurnal signal intensity envelope at frequency of 10 MHz on the Washington-Huankayo path prior to the disastrous quake in Chile (22nd May 1960), has a pronounced 24-hour variation in the shape of a wave minimum at 14-21 hours (GMT) (day interval) UT and maximum 23-11 hours (night interval), mainly caused by ionosphere changes and signal gradually rising over 20-00 hours and decreasing over 11-14 hours³. Anomalies in terms of sharp variations were noticed between 08-12 hours and 19-00 hours almost all these days (17-23 May 1960), which had linearly modulated this intensity envelope. The onset time of the foreshock, main shock and aftershocks also corresponds to the timing of these anomalies.

Yamamoto Isao, Kuga Kiyoshi, Okabayashi Tohru and Takashi Azakami, generated a system for earthquake prediction research in the region of VHF frequency band. EM noise of the atmospheric at the ORSOC (Okayama Ridai Seismic Observatory Center, E 144-55'48.3, N34-41'48.1) and its neighborhood was carried out using multiple antennas in VHF band. EM noise was experienced at 09-11 hours and 12:30-14:30 local time before an earthquake; the same noise affected the whole FM band⁴. Four events (Source: NEIC-USGS), which fell within ± 500 km range, occurred within three days of this type of RF emission (on 17.07.2001) close to ORSOC. It is seen from the timings of the first and fourth events (of table 4), that they seem to have occurred during first and second of the semi-diurnal RF emissions (considering the +9 Hours of time difference between UT and JST). This is consistence with other examples in which seismic and volcanic activities were observed during the timings of RF emissions.

Hayakawa M, Molchanov O A, Ondoh T and Kawai E studied precursory signature effect of the Kobe earthquake of VLF sub-ionospheric signals transmitted from Tsushima (34°37'N, 129°27'E), Japan, is continuously received in Inubu (35°42'N, 140°-52'E). The signal propagation characteristics [phase in particular] exhibited abnormal behavior (especially around the sunrise and sunset local times) a few days before the main shock of the 17th Jan 1995. The timings of these VLF signals phase reaching minimum, again spaced equally from the noon local time. The Kobe earthquake (0546 Hrs) occurred couple of hours prior to the first VLF phase minimum timing⁵.

Apollo Lunar Seismic Experiment (APSE) consisted of four seismometers placed on lunar surface between 1969 and 1972. Each station included three long period instruments and a vertical short period. The data was telemetered to earth and recorded until 1977. Deep moon quakes at the depth 700-1000 km dominate the entire collection of data and show good correlation with the tidal stresses⁶.

DIURNAL AND SEMIDIURNAL PATTERN OF ELECTROMAGNETIC EMISSIONS 17

Table 1: Details of all the six examples of semi-diurnal EM emission spaced equally from the local noon timings.

EQ /VOLCANO SEQUENCE PLACE -PERIOD FREQ-BAND OF EM EMISSION	TIMINGS OF THE EM EMISSIONS	LOCAL NOON TIME & TIME OFFSET OF EM EMISSIONS	OCCURRENCE OF EARTHQUAKE-VOLCANIC ERUPTION	REMARKS
Valsad, India. 10–30 April 1991 UHF RANGE 460-461 MHz.	0400 GMT (0900 LT) & 1200 GMT (1700 LT) Duration 10-100 min.	0800 GMT (1300 IST) Time offset = ± 4 hours	04:17(GMT) on 14.04.1991 foreshock 05:13 hrs (GMT) on 30-04-1991 Main shock	The timings of the main shock and one of the two foreshocks closely match the timing of the first RF emission. Semidiurnal type EM emission seized after the main shock
Mt Mihara Volcano, 03-21 Nov 1986 LF - 82 KHz	09-11 Hrs JST 14-16 Hrs JST	1230 Hrs JST – Time offset = ± 2.5 hours	1st eruption at 1725 Hrs JST, Nov 15, 1986. 2 nd eruption 1615 Hrs JST, Nov 21, 1986	Both eruptions occurred within the timings of the EM emissions
Chilean Earthquake 16-23 May 1960 HF 10 MHz and HF 18 MHz	08-12 Hrs GMT & 19-24 Hrs GMT	1700 GMT approx. Time offset = ± 5 hours	All six earthquakes, with magnitude range of 6.7 – 9.5 occurred within the timings of RF emission.	These six events consist of two foreshocks, main shock and three aftershocks listed in the book “Earthquake prediction Seismo-electromagnetic phenomena”
ORSOC,Japan 17.07.2001 VHF 76-108 MHz	09-11 Hrs JST 1230 – 1430 JST	1200 hrs JST approx. Time offset = ± 1.5 hours	Four events occurred within the time period of 3 days of the RF emission occurrence. The timings of two of them match with the timings of the RF emission.	RF Emission received on an array of VHF receivers on 17.07.2001. Four events [NEIC-USGS] occurred within three days of this emission, which lie within ± 4 deg Long and ± 5 deg of Lat from ORSOC.
VLF sub-ionospheric signals [Kobe quake] VLF range Jan 03-23,1995 10.2 KHz and 11.3 KHz	0830 hours JST & 1630 Hours JST	Around 12-30 Hrs JST (Timings of the VLF phase reaching minimum) Time offset = ± 4.0 hours	The timings of these VLF signal phase reaching minimum are spaced equally from the noon local time. Kobe earthquake timings (0546 Hrs) differ by couple of hours to the first VLF phase min. timing.	The sub-ionospheric VLF Omega signal transmitted from Tsushima to Inubu .The signal propagation characteristics (phase in particular) exhibited abnormal behavior (especially around the sunrise and sunset local times) a few days before the main shock of 1995.
Apollo Lunar Seismic data for stations 12 and 16 (1969-1977) Microwave range 1-2 GHz	Around 10 & 23 days from new Moon (station 12) Around 07 & 20 days from new Moon (station 16)	Around 16.5 days from new Moon (station 12) Around 13.5 days from new Moon (station 16)	The power spectra of the moonquakes provide major peaks corresponding to sidereal phase and smaller peak corresponding to synodic month, which suggest occurrences of moonquakes during the noisy periods.	The three days (Solar) offset in time of sunrise/sunset for station 12 and 16 reflects 39 degrees difference in longitude between the stations. The local noisy period, around 10 & 23 days for station 12 around 7 & 20 days (from new moon) for station 16, is not simultaneous and vary with longitude.

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It is seen from the record that the noisiest part of the record occur near the times of lunar sunrise and sunset, even accompanied with spikes. The three days (solar day) offset in time of sunrise/sunset for station 12 and 16 (commissioned during Apollo 12 and Apollo 16 missions respectively) reflects difference of 39 degrees in longitudes of two stations. This indicates that the local noisy period is not simultaneous and varies with longitude. The pattern is similar to semi-diurnal pattern seen on the earth at different longitudes.

Table 1 provides the details of semidiurnal EM emissions in all above cases including the RF disturbance presumably related with Valsad earthquake sequence.

EM emission related to Valsad earthquake sequence: Similar types of semidiurnal and diurnal type of emissions were observed in RTSN in Bhatsa presumably associated with the Valsad earthquake sequence of 1991. RTSN at Bhatsa had 10 field stations spread in an area of around 500 sq. km. Each station had a single vertical seismometer and frequency modulated analog signals were telemetered to the base station via individual links operated at the spot frequency in UHF band (461- 462 MHz), on a 24 hours basis¹. In the second quarter of 1991, this network recorded an earthquake sequence (swarm) from Valsad region of the Gujarat State, India. Between 25th March 1991 to 28th June 1991, nearly 400 events in the magnitude range of 1.4 to 5.1 were recorded from this region, which is situated about 115 km north of this network.

This network experienced a unique RF (radio frequency) disturbance in the UHF telemetry links between field stations and the base station, before, during and after this earthquake sequence. Between 5th March and 11th March 1991, the telemetry links were severely disturbed during certain timings of the day. A specimen of the RF disturbance is provided in the Fig.1. In this figure only the starting portion of the RF disturbance (at 23:57:00 on 8th March 1991) as well as the end portion (at 00:18:00 on 9th March 1991) are illustrated in separate parts. As illustrated in this figure, the end portion of the RF disturbance provides an exact mirror replica of the starting portion.

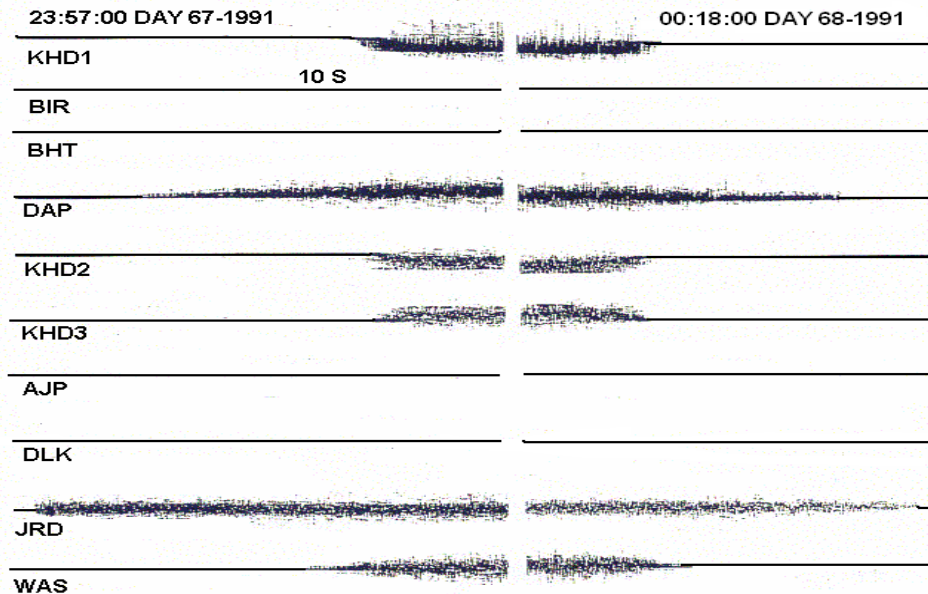


Fig 1: The starting portion (23:57:00 on day 67, 8th march 1991) and end portion of the RF disturbance 00:18:00 on day 68, 9th March 1991 are illustrated on a multi-channel seismic noise sample at low sensitivity, which normally should provide straight lines. The latter portion provides exact mirror replica of the starting portion of this RF disturbance. At the base station, the events are triggered online and edited multi channel data in digital format is recorded on a single track of an audio-tape. KHD station had tri-axial sensor and three component analog data was telemetered using FDM (frequency division multiplexing) technique.

Table 2: Details of the RF disturbance experienced by Bhatsa network prior to the onset of the earthquake sequence on 25th March 1991. AJP, PAT, JRD, DAP are the short forms of few field stations. The signals from AJP and PAT stations were monitored on helical drum recorder on 24-hour basis.

SER. NO.	DATE[DAY]	TIME	DURATION	REMARKS
1	05.03.91[64]	01:25:20	300 Sec.	Seen in AJP and PAT helical records
2	05.03.91[64]	12:45:30	40 Sec.	<u>All working channels affected</u>
3	05.03.91[64]	22:17:06	270 Sec.	Seen in AJP and PAT helical records
4	08.03.91[67]	01.28.10	180 Sec.	<u>All working channels affected</u>
5	08.03.91[67]	23:57:00	7.5 – 23 Min.	<u>All working channels affected</u>
6	09.03.91[68]	23:56:30	22 Min.	<u>All working channels affected</u>
7	10.03.91[69]	00:37:00	120 Sec.	Multi-channel play-out available
8	10.03.91[69]	23:53:20	100 Sec.	Seen in AJP helical records
9	11.03.91[70]	23:56:00	13 Min.	<u>All working channels affected</u>

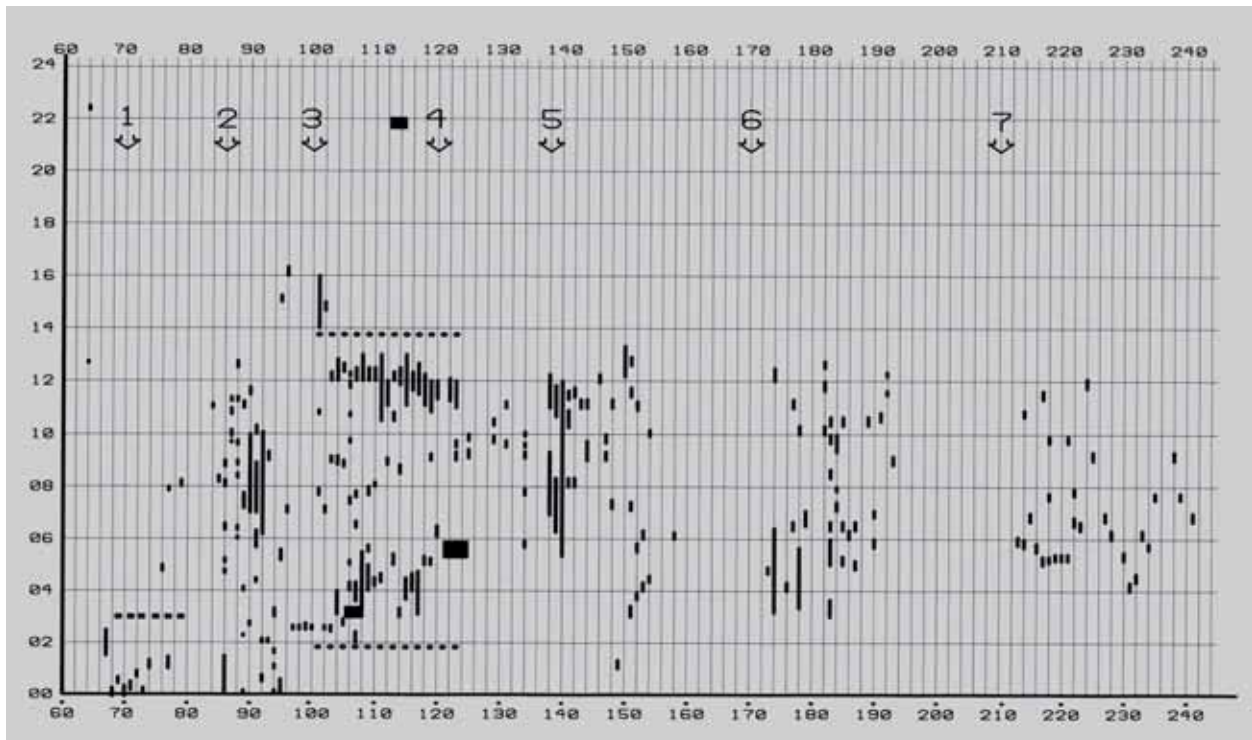


Fig 2: Picture of the RF disturbance for period of 1st March (day 60) till the end of August 1991. In this figure each vertical line represents a day and is segmented every 2 hours. For convenience lines are shown for alternate days. Thick lines indicate the RF activities and their lengths indicate the duration. For the sake of noticeable display, longer lines are drawn for short duration disturbances (in the order of few seconds). Positions of two foreshocks are shown with small square dots and that of the main event with bigger square dot. The timings of the main event and one of the foreshock match with timings of the EM emission at around 0400 hours. (**Semi-diurnal portion of the RF disturbance is indicated within a pair of round dotted lines, where as the diurnal portion is indicated under a square dotted line**)

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The indications of arrows in Fig 2. are as follows:

Arrow 1: Start of the RF disturbance in the radio links at around 00 hours GMT.

Arrow 2: Start of the earthquake sequence.

Arrow3: Occurrence of major foreshock, RF disturbance shifted to around 04 and 12 hours GMT

Arrow 4: Occurrence of major Shock of Mag. 5.0. RF disturbance pattern changed.

Arrow 5 and 6: RF disturbances associated with few aftershocks of Mag. 2.5-3.5.

Arrow 7: End of earthquake sequence. However RF disturbance continued in patches for 2 months.

Generation of the RF emission envelope due to stress front (SF): Fig 1 provides starting portion and end portion of the RF disturbances of equal length. If all these starting and end portions of different links in the Bhatsa net are rearranged in terms of their length of RF emission period [which is inversely proportional to the received signal strength] then they would provide an envelop of rising and falling RF emission signal as illustrated in Fig. 6.

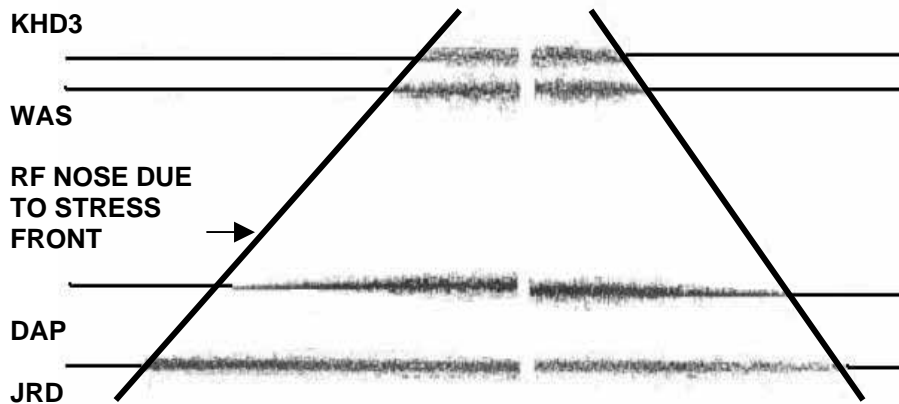


Fig.3. Starting and end portions of different links in the Bhatsa net are rearranged in terms of the received signal strength (from remote field stations) then they would provide an envelop of rising and falling RF emission signals. The other channel links (BIR, BHT, AJP, DLK) have also provided noise of much shorter duration and hence those corresponding noise portions do not figure in this diagram. The KHD stations had three axial seismic sensors and hence the duration of noise portions were identical for all three signals from this station.

In order to study the causes of these phenomena, the following experimental facts, observed in relation to UHF telemetry of the seismic analog signals, may be noted. The received signal strength of the telemetry links depend on various factors such as transmitted power, receiver sensitivity, antennas gains, distance between the field station and the central place, type of terrain etc. With all these factors, the received signal strength for different links at any time could lie within 10 – 30 dB above the noise level. In Fig. 3, it is demonstrated that if the strength of the stress front gradually increases and the RF noise generated by this stress front (which is experienced as broadband noise by different workers) also goes up proportionally, then the signals of the telemetry links cuts off when the RF noise exceeds the received signal strength. Since the received signal strength for different radio links within the RTSN are different as discussed earlier, the different links cut off at different time. Again, when the stress front recedes, the RF noise generated by it goes down proportionately and goes below the different received signal strengths at different time intervals. Fig 3, illustrates how this results in equal start and stop RF noise for each RF link, thereby generating mirror images of start and stop RF disturbances as illustrated in Fig. 1.

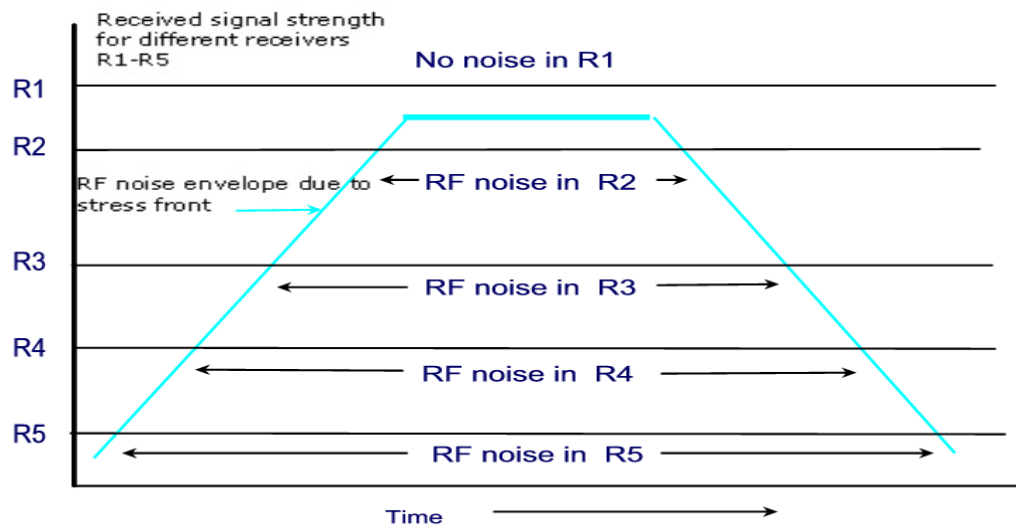


Fig 4. General noise envelope and length of RF noise, which could be seen in different receivers outputs with different receiver signal strength indicated by R1- R5. The received signal strength in R1 is above the level of RF noise generated by the stress pulse and hence shall not provide any noise. The rise and fall time of this stress pulse was about a minute interval in Bhatsanet.

RF emission, an earthquake precursor: probably caused by the planetary alignments

Case 1: Valsad earthquake sequence

Two examples of RF emission do not match this pattern of semidiurnal occurrences as explained earlier [details provided in table 5]. One such example is in regards to Valsad earthquake sequence. The details of the first portion of the RF emission from presumably associated with this earthquake sequence is provided in table 1. As seen in this table RF emissions from 5th –11th March 1991 were seen in diurnal fashion (only once a day) at around 00 hours GMT. The semi-diurnal pattern is seen in the period from 10th–30th April 1991 (portion between arrow 3 and 4 of Fig 2 marked under two round dotted lines). The timings of Diurnal type RF emission (at 00 hours GMT approx.) and those of semi-diurnal type (at 0400,1200 hours GMT) are different.

Fig.5–7 provide graphs of relevant timings of the starting or end portion of the RF disturbances for all network stations on horizontal scale with respect to the JRD station (in which the RF disturbance was first initiated) Vs the approximate strength of the received signals from all these stations in vertical scale. The sensitivity of all these receivers were $0.3 \mu\text{V}$ @ 12 dB SINAD equivalent to -146 dB . JRD station signal strength was assumed to be about 16 dB above this level. The relative signal strength is computed for all other stations considering linear increase in RF noise in time scale and also max signal in the order of -110dB level which was found in few receivers during the operation of this network.

From all these records following points were noted.

1. Starting and end of the RF disturbances were not simultaneous in all the RF links from remote field stations. Hence these types of disturbances due to power line fluctuations etc. were ruled out.
2. The starting sequence of RF disturbance in stations was found to be in the following order.
A - JRD, B - DAP, C - WAS, D - KHD, E - BHT, F - DLK, G - AJP, H - PAT.
3. The end sequence of RF disturbance in stations was found to be in exactly reversing order. A - PAT, B - AJP, C - DLK, D - BHT, E - KHD, F - WAS, G - DAP, H - JRD.

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4. Four of these eight stations were found to be at lower level of received field strength (-130dB to -126dB) where four other were at much higher received field strength (-115dB to -110dB).

The steady increase and then decrease of this RF noise was due to steady increase and decrease in the regional stresses, which could have been attributed by planetary position. Following two paragraphs provide explanation for this phenomenon.

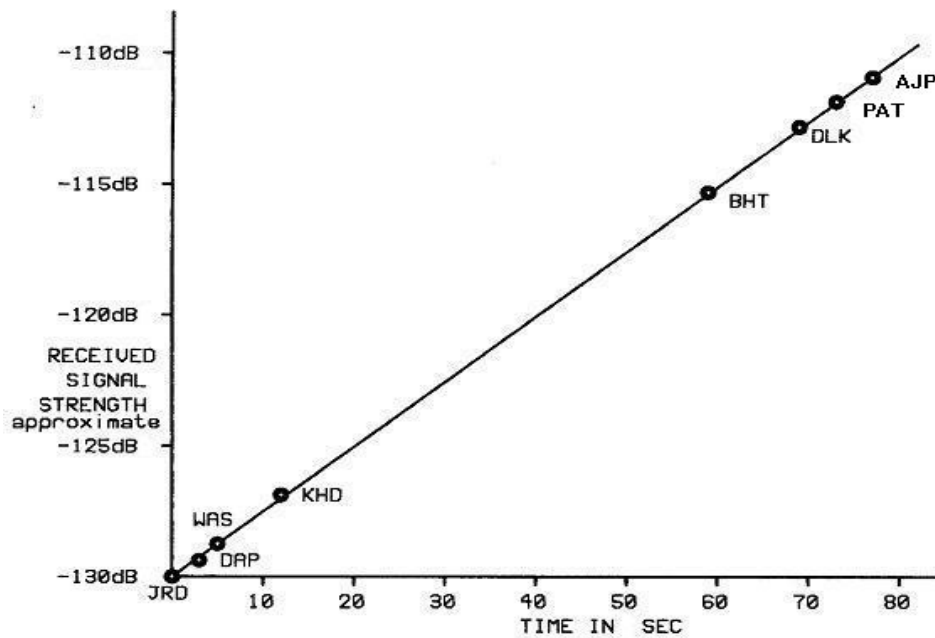


Fig 5. The graph for the RF disturbance record (ser. No 4 of table 1) starting at 01:28:10 hours on 8th March 1991 (day 670). The relative timings for all network stations on horizontal scale are with respect to the JRD station in which the RF disturbance was first initiated. The vertical scale indicates approximately the strength of the received signal from all these stations.

According to a paper⁸ on "Planetary configuration: Implication for Earthquake Prediction and Occurrence in South Peninsular India", if two or more than two planets, Sun, Moon are aligned more or less in line (0° or 180°) then the earth would be caught in the middle of a huge gravity struggle between the Sun and the planets. The gravitational stresses would change the speed of the earth in its orbit. When the speed of rotation of earth changes the tectonic plate motion is also affected, just as people collide with each other when the bus driver applies break suddenly. Thus the planetary forces act as a triggering mechanism for the accumulated stress to be released abruptly. The total force of the planets in alignment acts at the epicenter in the direction opposite to the rotation of the earth.

For any earthquake to be triggered at a particular place two condition should satisfy. 1. Triggering distances (TD) and 2. Direction of force acting at the possible epicenter. Considering the total circumference of the earth $\sim 40,072$ km, the wavelength $\lambda = 20,036$ km. = $\frac{1}{2}$ circumference of the earth. The planetary position with regards to earth is measured as Right Ascension (RA) representing Longitude in celestial sphere and Declination (Dec.), representing Latitude in Celestial sphere. The possible epicenter would be at distance of $0.125 * \lambda/4$, $0.25 * \lambda/4$, $1 * \lambda/4$ and so on, from the projected planet position on the earth. This distance works out to be 626.125 km or whole multiple of this number⁸.

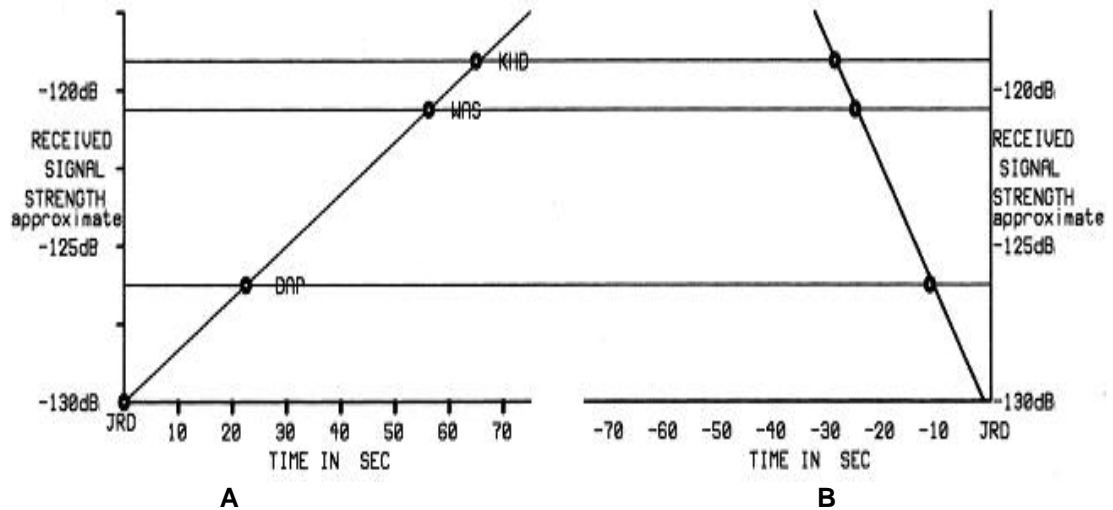


Fig 6: The graph for the starting (part A) and end (part B) portion of RF disturbance record: (displayed in Fig 1, ser no. 5 of table 1) starting at 23:56:00 8th March (Day 67). The relative timings for all network stations on horizontal scale are with respect to the JRD station in which the RF disturbance was first initiated. These graphs resemble two slopes of Fig.4. However the slopes of these portions in time scale are different.

(The data of RTSN at Bhatsa was not acquired in continuous mode but the seismic event data was edited online¹. The technique used, was not suitable for triggering and recording data of this type of RF disturbance. The part of this data obtained is presented in Fig. 5-7).

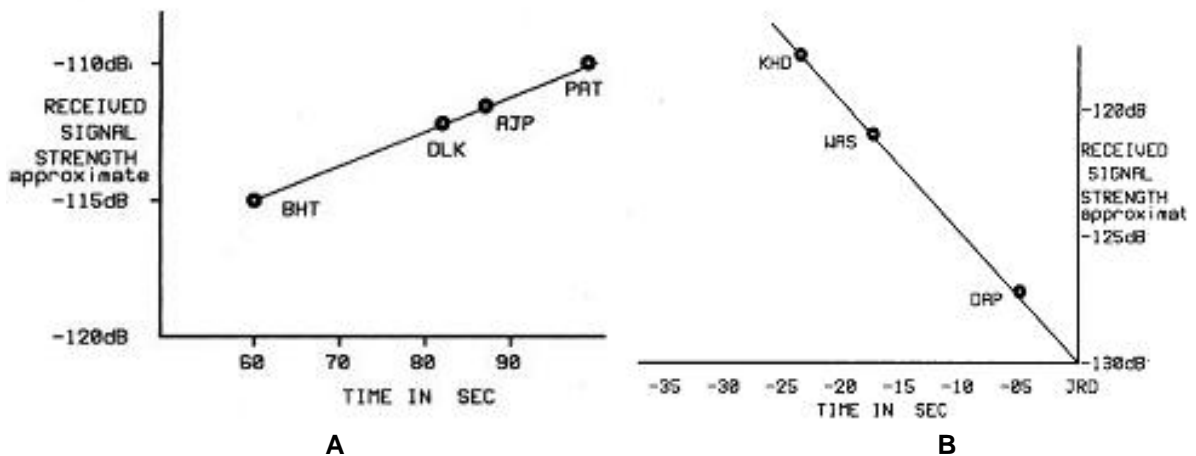


Fig 7: The graph for the RF disturbance record (SER. NO 8), Part A (starting at 23:56:30 on 11th March 1991) and Part B (end portion 12th March at 00:09:00 hours). The relative timings for all network stations on horizontal scale are with respect to the JRD station in which the RF disturbance was first initiated. Part A provides starting RF disturbance in four channels (BHT, DLK, AJP & PAT). The other four stations providing much lower receiver output were noisy from the start of the record. The horizontal scale is selected considering the timings for these four channels in Fig.8. In all above examples of the starting and end sequence, the channel (links) strength and their position remained unaltered.

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Thus the external force from the planetary alignment, would be acting on many points on the earth simultaneously. If any of these points fall in the seismic zone, which has matured for earthquake and the force is acting in right direction, then this could directly trigger earthquake OR it can make this region vulnerable and earthquake can occur within few days. Due to the rotational motion of the earth, the surface of the earth where the planetary alignment would be acting is a changing phenomenon. For any specific seismically potential place which would be at a triggering distance from a particular position of planetary alignment (on earth), the huge gravitational effect would be seen once in a 24 hours when earth position itself at the same spot once in every 24 hours. The speed of the rotation at earth at equator is around 1670km/h, which works out to be around 27.82 km/min. As the earth revolves at this speed uniformly, the planetary alignment approached to that key position (on earth), from where the Valsad earthquake area was at a triggering distance. Due to the steady speed of rotation, it resulted in linear transformation from no stress to high stress at the earthquake area. This was represented by the steady rise of the RF noise envelope. Again when the planetary position displaced from that key position again due to earth rotation, linear transformation takes place in the reverse order and RF noise level falls steadily. The phenomena repeats for seven consecutive days due to the planetary alignment of Mercury & Sun, which remained almost unaltered.

Considering the planetary position on 4th and 5th March at 00.00 hours, it is seen that RA and Declination of Sun and Mercury were equal which means both these planets were in conjunction (in line with earth on same side of earth) so also Jupiter (Ra = 8H28M, Dec = +19'53. 3") and Saturn (Ra = 20H20M, Dec = -19'44. 6") were in opposition (in line with earth but on opposite sides). One of these planet positions (mostly by Mercury-Sun-earth alignment) probably produced some kind of gravitational waves, which developed considerable pressure at the earthquake site (Valsad), which was probably at the triggering distance (TD) and also the direction of force was acting at the earthquake site in the right direction to trigger earthquake.

Case 2: Chilean earthquake of 22nd May 1960 Mg = 9.5.

This is the biggest event recorded in the history so far. Dr. Warwick of Radio-physics Inc. Boulder, Colorado, in his paper⁹ (Warwick et. al.) has provided the details of network of worldwide radio receivers for cosmic radio noise at 18 MHz. These stations include lake Angelus, Michigan (42.7° N, 83.4° W), Boulder, Colorado (40.1°N, 105.3° W), Sacramento Peak Sunspot, New Mexico (32.7° N, 105.8° W) and Makapuu point, Oahu, Hawaii (21.3°N, 17.6° W). Apart from these, the Boulder radio observatory operated a radio interferometer at the same frequency, (18 MHz). Six days prior to this Chilean earthquake, on May 16, 1960 between 0350 – 0410 GMT, these stations, which were part of sudden cosmic noise absorption (SCNA) network, received unique RF signal, simultaneously. Dr Warwick and others termed this as signal, which did not come from any outer space and came within earth possibly from the region of this great earthquake. This signal traveled through multiple reflections between ionosphere and earth surface and reached different destination sprawled thousands of km. As per this paper, this is a single incident and the phenomena were not repeated at any other time.

Considering the planetary position at the time of this impact, the Sun and Mercury were in conjunction (with earth). However huge gravitational impact was possibly created by the Moon, which came in opposition with Uranus (with respect to earth) at this time (RA diff. of 1 hour (15 degrees), Dec difference of 1 degree approx.). Just about 24 hours prior to this, Moon was in conjunction (with respect to earth) with Saturn (RA diff of 1 hour (15 degrees), Dec. difference of 4 degree approx.) and most probably both these alignment must have caused huge gravitational forces and would have resulted in emission of broadband RF signal from this earthquake prone area. Since the Moon is the closest celestial body, within the next rotation of the earth, it had moved considerably away from alignment position and the phenomena of RF emission did not repeat on subsequent days as was observed in case of Valsad RF emission from 5th to 11th March 1991.

Case 3: Volcanic eruption at Mt Mihara in Japan.

RA of Venus and Moon matched on 2nd Nov, 1986 at 1200 hours, where as the declination for both these planets matched exactly at 0000 hours on 3rd Nov. At this time the semi diurnal RF emission had commenced. Just after 12 hours later Moon- Mercury came in conjunction with the earth and the combined effect of all these alignment must have initiated a huge gravitational force. Mt. Mihara is located close to Ohshima Island 34.75 N, 139.25 E approx.

Table 3 provides planetary configuration for two earthquake sequences and one volcano eruption.

Table 3: Planetary Configuration for two earthquake sequences and one volcano eruption. Timings of the first EM emission precursors are provided. Two sets of planetary alignments were considered for Chile earthquake and Mt Mihara volcano eruption and triggering distance shown in bold letters provide near whole multiple of 626.125 km = 0.125 of $\lambda/4$ (wavelength $\lambda = 20,036$ km = 0.5 circumference of the earth)

Earthquake/Volcano Precursor-Date -Time	Lat -Long Quake/volcano place	Planet aligned	Right Ascension	Declination	Effective Longitude (Earth)	Triggering Distance [TD]
Valsad : 05.03.1991 Time = 00.00 GMT	20.37 ⁰ N-73.18 ⁰ E	Sun- Mercury	22H56M	-6 ⁰ , 43.1'	4H 26 M [66.5 ⁰ E]	3105.52 km
Chile 16.05.1960 Time = 0400 GMT	39.50 ⁰ S- 74.50 ⁰ W	Sun- Mercury	3H27M	+18 ⁰ 48.2'	-8.25 ⁰ W	9850.75km
Chile 16.05.1960 Time = 0400 GMT	39.50 ⁰ S- 74.50 ⁰ W	Moon- Uranus	20H 20M	-15 ⁰ 36.8'	-119.66 ⁰ W	5685 km
Mt. Mihara Volcano 03.11.86 0000 GMT	34.75 ⁰ N- 139..225E	Venus - Moon	14H 40M	-20 ⁰ 23.4'	5h 12 M [75.2 E]	9405 km
Mt. Mihara Volcano 04.11.86 0000 GMT	34.75 ⁰ N- 139..225E	Mercury - Moon	15H44M	-22 ⁰ 23.2'	6H 16M [90.266E]	8375.3

Discussion:

1. EM emission related to earthquake and Volcano: It is believed that the RF emissions come directly from the crystalline rocks of the crust. These rocks provide some sort of a piezoelectric effect when subjected to stress. In a semidiurnal type of RF emission, the timings of the stresses developed were seen consistently twice during the day which were centered on the mid day (local time). The application of semi-diurnal stresses, which results in RF emission, does not seem to be localizing phenomena. The entire rock in the vertical column (few km wide) could contribute to emission under stress. However the region close to seismic fault when matured can provide higher emission prior to an impending earthquake.

The type of emission observed at Bhatsa and also observed at other places (with regards to Chilean earthquakes and eruption of Mt Mihara Volcano) does provide correlation with the rotation of the earth. However, this semi-diurnal RF emission observed on daily basis does not provide any correlation with the lunar tidal forces, which is considered as another triggering source for earthquakes.

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The main important feature of this RF emission observed at UHF is that it is presumed to be associated with relatively smaller earthquakes in the magnitude range of 2.5-5.0. This is possible due to the proximity of the earthquake region in Valsad to Bhatsa net. EM noise of the atmospheric was monitored at the ORSOC and its neighborhood using multiple antennas in VHF band and high noise was witnessed for occurrence of earthquakes with magnitude range of 4-5. However in most cases different workers have tried to find precursors for earthquakes with magnitude above 6.

2: Monitoring EM Emission related to earthquake and volcanoes: A method of utilizing grid of RF network in the high seismicity area and monitoring RF emission in HF-VHF-UHF band should provide good clues of any impending event. Unlike other methods here one can monitor the emission on daily basis, which is predominantly seen twice around local noon timing and any increase in this emission can be monitored precisely. The utilization of VHF and HF band could broaden the technique for use in the detection of precursors for normal and deep focus earthquakes. The technique effectively can be used for monitoring large size area.

3. Study of temporal and spatial variation of the time-offsets: In the six examples shown in table 5, the timings of semidiurnal emission provide different time-offset (displacement) from the local noontime from +/- 1.5 hours to +/- 5 hours. At Bhatsa seismic telenet it was experienced that this time-offset is not fixed. Although it does not vary day-to-day basis but indicate different time for different periods. During the Valsad earthquake sequence of April 1991, it was found to be +/- 4 hours. While in the helical record of July 1993, this time -offset was found to be +/- 6 hours.

Continuous data synodic phase versus occurrence time of RF emission for station 12 and 16, in which the maximum amplitude associated with RF spikes, exhibit a sinusoidal behavior consistent with the varying length of the lunar synodic month. Similar behavior is also witnessed in the timings of temporal variation of monthly average values of t_m and t_e for phase and amplitude of VLF signal which shows good correlation with the varying day period from Oct to April at Inubu, Japan⁶.

The other four cases are different than the above two examples and in general the temporal and spatial variation in these time-offsets with respect to the local noontime need to be studied systematically, which shall provide some clues about the cause of such timely stresses being built within the body of the earth.

In general the EM emission of semidiurnal type is associated on the earth surface and primarily caused by the Sun. Similarly similar type of EM emission on the moon surface is primarily caused by Sun-earth system. As seen in all these examples the timings of these emissions are at time intervals equally spaced from the local noontime. This is a daily phenomena and the rise in the intensity of the EM emission, is attributed by the region, which is matured for earthquakes. Earthquakes/Volcanic eruptions were consistently found during the timings of these EM emissions, which are the result of stresses developed during these timings. The six examples provided, proves such emission was observed in a broad frequency band from VLF to Microwave range.

4. RF emission: probably caused by the planetary alignment: In case of Chilean earthquake sequence, the timings of the RF emission (0350 – 0410 GMT on 16th May 1960) @ 18 MHz (reported by JW Warwick and others) are distinctly different than those of semidiurnal RF emission @ 10 MHz, associated with occurrences of earthquakes (08-12 hours and 19-24 hours GMT) provided in the table 2, which includes foreshock, main shock and aftershocks during 17th to 23rd May 1960. In this case the first RF emission on 16th May 1960 presumably associated with planetary alignment lead the other RF emission of semidiurnal nature by few hours.

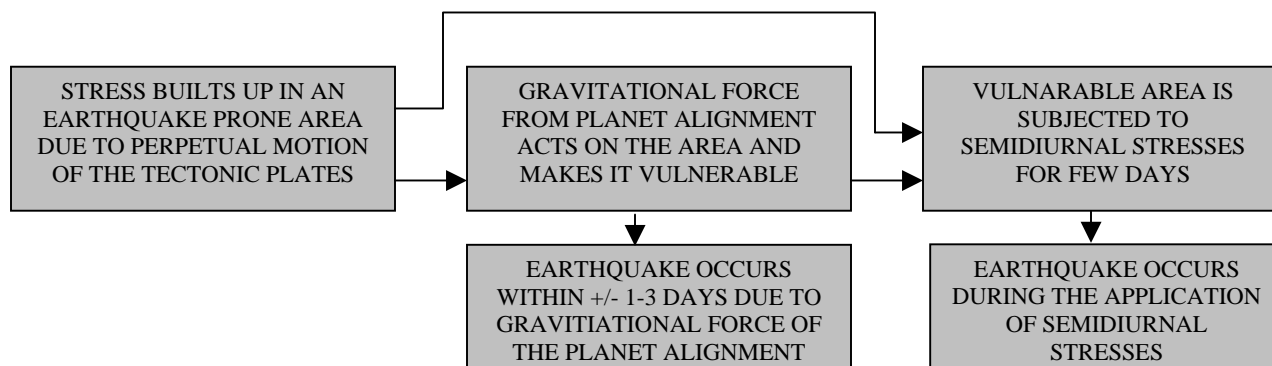


Fig. 8: Block diagram illustrates the possible event sequence, which results in an earthquake.

Similar timing sequence is also seen in case of Valsad earthquake sequence of 1991. The first set of RF emissions was experienced between 5th and 11th March at around 00 hours GMT. Compared to the semi diurnal RF emission experienced during 10th and 30th April 1991, this was very intense, disrupting the entire RTSN on five occasions. Again as in the earlier case (of Chilean earthquake sequence of 1960) the timing of the first set (around 00:00 hours GMT) is different from the timings of semidiurnal RF emission experienced during 10th and 30th April 1991 (around 0400 and 1200 GMT).

Both these cases are very rare since they have recorded RF emissions presumably due to the gravitational force of the planetary alignments. Similarly, in case of Mt. Mihara volcanic eruption sequence, the semidiurnal RF emission pattern seems to have initiated by the planetary alignment although there is no recorded RF emission observed.

As per Dr Venkatnathan⁸, most earthquakes occur within +/- 1-3 days of formation of planetary alignment the planetary forces act as a triggering mechanism for the accumulated stress to be released abruptly. The total force of the planets in alignment acts at the epicenter (if it falls within the triggering distance) in the direction opposite to the rotation of the earth. In few such instances, the occurrence of the earthquake is not instantaneous and these planetary forces would make this earthquake-prone area more vulnerable. As seen in above examples, during the application of semi diurnal stresses acting on daily basis, the region under stress provides higher emission of the RF noise. The phenomenon continues for few days and subsequently results in the occurrence of earthquake during the application of one such semidiurnal stress.

The sequence of events seen in all these cases can be as follows:

1. Initially each one of these areas would be under stresses due to perpetual motion of the tectonic plates below them.
2. Earthquake sequence OR volcano eruption sequence initiated with the gravitational force from the planet alignment acting on the specific point on the earth which would be at the triggering distances from these areas in respective cases. Earthquake occurs within +/- 1-3 days in majority of the other cases, however in these cases the places become very vulnerable. In some other cases, the area could become vulnerable even naturally without the planetary forces acting on it. The vulnerable area is then subjected to the semidiurnal stresses during the daytime at the timings equally spaced [in time domain] from the local noontime. This stage lasts for few days.
3. Finally the vulnerable area gives up during one of the timings of semidiurnal stresses, resulting in an earthquake/ volcanic eruption.

Fig. 8 illustrates the block diagram of possible event sequence, which results in an earthquake.

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ELECTROMAGNETIC PHENOMENON RELATED TO EARTHQUAKES AND VOLCANOES

Editor
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Earthquake prediction studies based on "Electromagnetic technique" have drawn considerable global attention in recent years. This technique is based on ground and satellite based monitoring of electromagnetic signals in a broad frequency range between DC and VHF employing variety of sensors. Definite earthquake precursors have been reported from these experiments. Besides the above, ionospheric perturbations and geochemical anomalies have also been reported prior to the occurrence of the earthquakes. This book contains some important research output in the above fields obtained by well-known researchers. More precisely, there are descriptions on recent progress in VAN method, anomalies in ULF/VLF signals, ionospheric parameters and Schumann resonance etc. The book also includes one topic not related to seismicity which deals with space weather, Trimp phenomena, and neural network approach to TSP solutions etc.

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