INTERNATIONAL STUDY ITALY-MALAYSIA PRE-SEISMIC SIGNALS RECORDED BY RDF – RADIO DIRECTION FINDING MONITORING NETWORK, BEFORE EARTHQUAKES: MW 6.3, OCCURRED AT 111 KM SW OF PUERTO MADERO IN MEXICO AND MW 6.3, OCCURRED AT 267 KM NW OF OZERNOVSKIY IN RUSSIA, NOVEMBER 20, 2019.

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ABSTRACT

Through this study, the authors want to establish the existence of a possible correlation between the electromagnetic signals recorded and the occurrence of some strong earthquakes of magnitude:

1. M 6.3 - 111km SW of Puerto Madero, Mexico - 2019-11-20 04:27:05 (UTC) GPS: 13.982°N 93.130°W - 11.0 km depth.
2. M 6.3 - 267km NW of Ozernovskiy, Russia - 2019-11-20 08:26:07 (UTC) GPS: 53.163°N 153.685°E - 486.8 km depth.

In this context, the study was carried out by a close international cooperation between Italy and Malaysia, from the monitoring network developed by the Radio Emissions Project, based on the RDF technology - Radio Direction Finding, which is also part of Malaysia. The data have identified the presence of electromagnetic signals having a precise azimuth of arrival and is registered by the Italian resort of RDF – Ripa-Fagnano (AQ) (GPS: Lat. +42.265663N, Long. +13.583765E), both from the station Pontedera, (PI) (GPS: Lat. +43.672479N, Long: +10.640079E), and the equation for the RDF station Malaysia, University of Malaya (GPS: Lat: +3.120956N, Long: +101.655326E).

Keywords: RDF systems, earthquake prevision, electromagnetic signals, candidate precursors.

INTRODUCTION

It was 1890 when the British geologist John Milne, inventor of the eponymous horizontal seismograph, a professor at the Imperial College of Engineering in Tokyo and founder of the Seismological Society of Japan (SSJ), in his work entitled "*Earthquakes in connection with electric and magnetic phenomena*" (J. Milne, 1890), described some electrical phenomena magnetic and related to seismic activity. It was the first scientific publication ever in which they were described a series of electromagnetic phenomena, about one hundred years later, the international scientific community renamed as "*Electromagnetic Seismic Precursors*" or ESPs. In 2007, Gabriele Cataldi and Daniel Cataldi founded a scientific research project (Radio Emissions Project) dedicated to monitoring and study of Electromagnetic Seismic Precursors (ESPs) and, in the course of a few years, they have developed an innovative electromagnetic tracking method (G. Cataldi, 2019), who was able to provide valuable data on the pre-seismic electromagnetic anomalies, meaning by this term also electromagnetic phenomena of solar origin and those of geomagnetic nature (G. Cataldi et al., 2013-2019; D. Cataldi et al., 2014-2019; V. Straser, 2011-2012; Straser V. et al., 2014-2019). The use of the RDF system, as part of the seismic prediction, has been realized starting from March 2017, from Radio Emissions Project, through which it was possible to obtain the first important results on the registration of electromagnetic signals appeared before the occurrence of strong earthquakes (Straser et al., 2017). In this suit, the international cooperation with

Malaysia and with Radio Cosmology Research Lab, Department of Physics, Faculty of Science University of Malaya, has allowed us to further develop the monitoring capabilities of the RDF system for the identification, registration and the analysis of pre-seismic electromagnetic emissions on a global scale.

1.0 – Methods and Data

1.1 – Monitoring Stations.

To carry out this study, the authors analyzed the electromagnetic signals from the three main stations:

- **First station**: Italian RDF Station Ripa-Fagnano (AQ) (Lat. + 42.265663N, Long. +13.583765E), equipped with a station monitoring continuous electromagnetic monitoring, broadband, technology implemented with RDF (Radio Direction Finding). The technology developed by the Radio Emissions Project, for the monitoring of the pre-seismic radio emissions, it is able to identify the target arrival direction (azimuth) of the electromagnetic signals picked up between the band SELF (Super-Extremely-Low-Frequency: 0 <f <3Hz) and the first portion of the band LF (Low-Frequency; 30 <f≤300kHz) reaching 96kHz (total bandwidth ≈ 96kHz; 0 <f≤96 kHz) with a resolution <1Hz, an analog-to-digital conversion 24-bit and a digital sampling to 192kHz.
- **Second Station**: Malaysian RDF station of Kuala Lumpur, (Lat. +3.123088N, Long. +101.653117E), this one equipped with a station monitoring continuous electromagnetic monitoring, broadband, technology implemented with RDF (Radio Direction Finding). The technology developed by the Radio Emissions Project, for the monitoring of the pre-seismic radio emissions, it is able to identify the target arrival direction (azimuth) of the electromagnetic signals picked up between the band SELF (Super-Extremely-Low-Frequency: 0 <f <3Hz) and the first portion of the band LF (Low-Frequency; 30 <f≤300kHz) reaching 96kHz (total bandwidth ≈ 96kHz; 0 <f≤96 kHz) with a resolution <1Hz, an analog-to-digital conversion 24-bit and a digital sampling to 192kHz.
- **Third Station:** Italian RDF station of Pontedera (PI), (Lat. +43.672479N, Long: +10.640079E), this one equipped with a station monitoring continuous electromagnetic monitoring, broadband, technology implemented with RDF (Radio Direction Finding) . The technology developed by the Radio Emissions Project, for the monitoring of the pre-seismic radio emissions, it is able to identify the target arrival direction (azimuth) of the electromagnetic signals picked up between the band SELF (Super-Extremely-Low-Frequency: 0 <f <3Hz) and the first portion of the band LF (Low-Frequency; 30 <f≤300kHz) reaching 96kHz (total bandwidth ≈ 96kHz; 0 <f≤96 kHz) with a resolution <1Hz, an analog-to-digital conversion 24-bit and a digital sampling to 192kHz.

All three stations are equipped by an antenna system, oriented on the cardinal axes, and characterized by square loops with a copper wire winding 25 and 50 coils. The signals converted by the amplification system developed by the Radio Emissions Project, it is then processed by a computer system that generates a set of dynamic spectrograms and graphs on which then has been possible to carry out the analysis.

1.2 – Case number one:

On November 16, 2019, around at 22:10 UTC, the RDF station Ripa-Fagnano (AQ), showed the appearance of electromagnetic signals of azimuth "bluish-violet" (Fig. 3), with characteristics of impulsivity in frequent appearance, located mainly between 0-2 kHz, 5-20 kHz and 40-45 kHz (Fig. 1). This first increment is then passed around at 23:20 UTC of 15 November 2019, only to reappear in a peremptory manner around 10:30 hours UTC of 16 November 2019, presenting a similar frequency distribution with respect to the first appearance, namely: between 0- 2 kHz, between 5-20 kHz (Fig. 2).

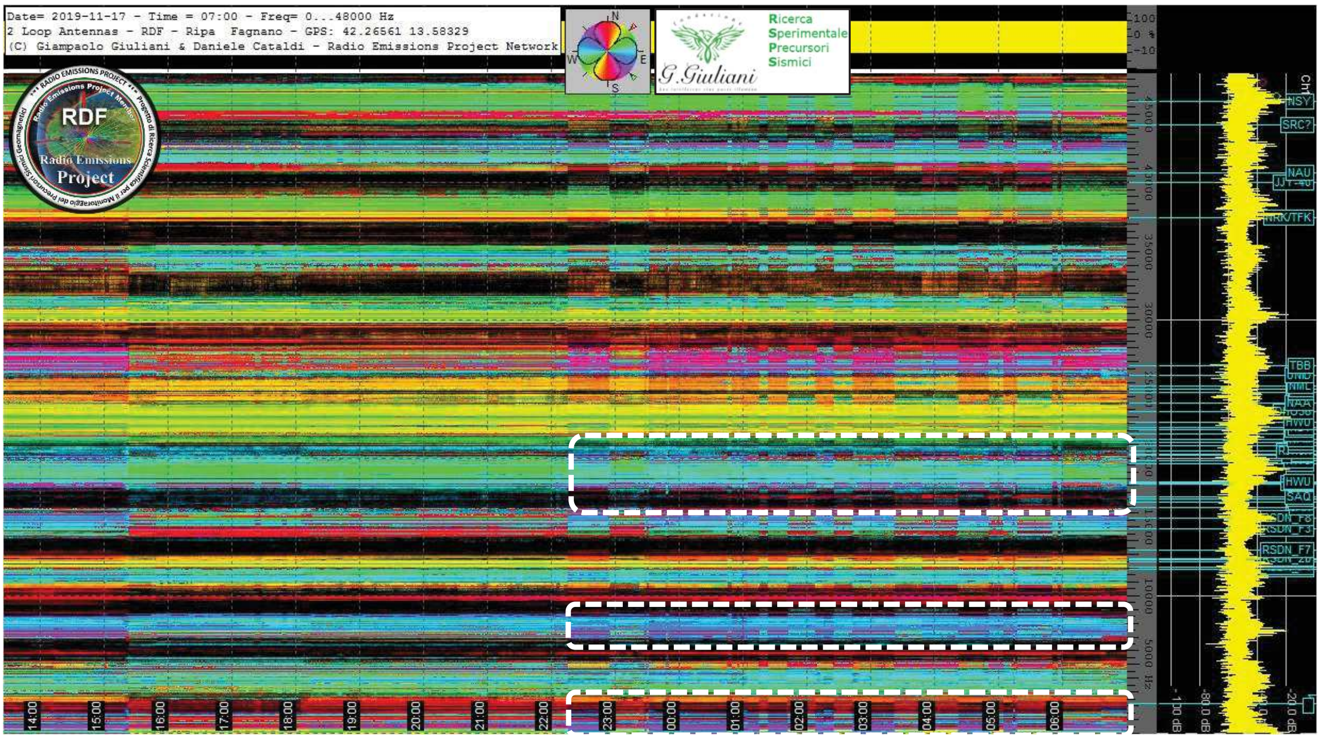

Figure 1 – Spectrogram of Radio Emissions Project, Ripa-Fagnano station (AQ), which highlights the presence of electromagnetic color signals "bluish-violet" (Fig. 3), displaced in frequency, broadband. Source: Radio Emissions Project and Permanent Foundation G. Giuliani.

All signals, clearly evident, they are presented without any notice, so detached from the normal background natural geomagnetic. The detection system of Ripa-Fagnano (AQ) has indicated the precise azimuth, bluish-violet color (Fig. 3).

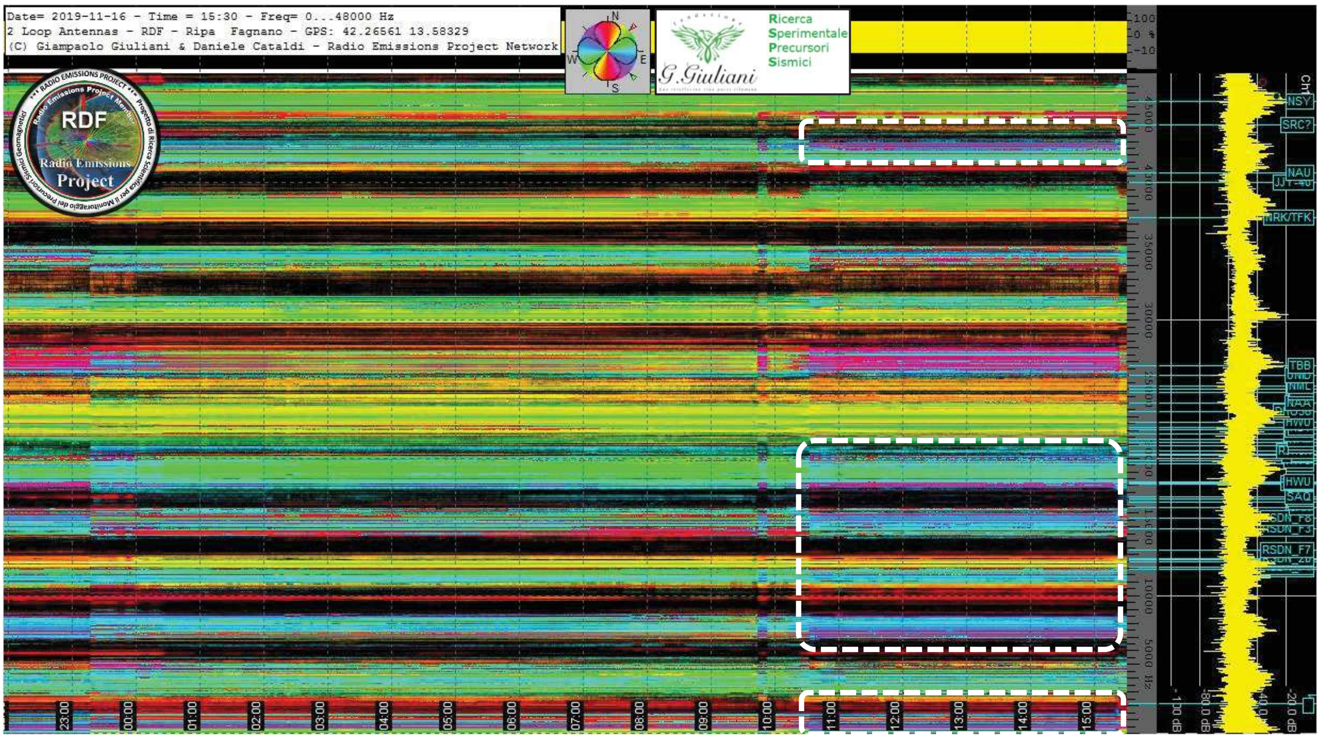

Figure 2 – Spectrogram of Radio Emissions Project, station-Ripa Fagnano (AQ), which highlights the presence of electromagnetic color signals "bluish-violet" (Fig. 3), displaced in frequency, broadband. Source: Radio Emissions Project and Permanent Foundation G. Giuliani.

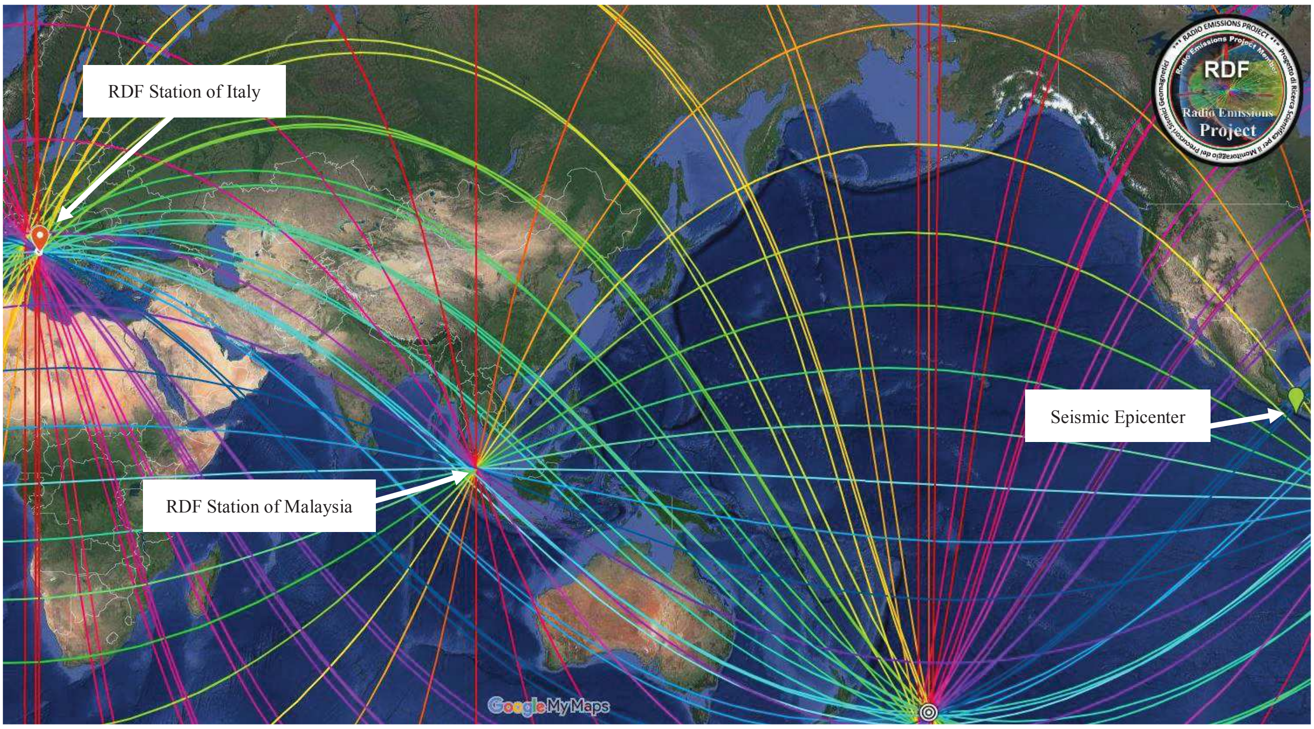

Figure 3 – World Mapping the RDF system, developed by the Radio Emissions Project, it highlights the azimuths of the various monitoring stations located on the globe and the earthquake epicenter considered in this study. Source: Radio Emissions Project, Google Maps.

In the same period the Malaysian RDF station, recorded the increases not be underestimated, including azimuth between the yellow and the green (Fig. 3). In this context, the highlighted increments and recorded by the Malaysian RDF station emphasized as such signals of the electromagnetic type had appeared without notice, and equipped with precise azimuthal characteristics

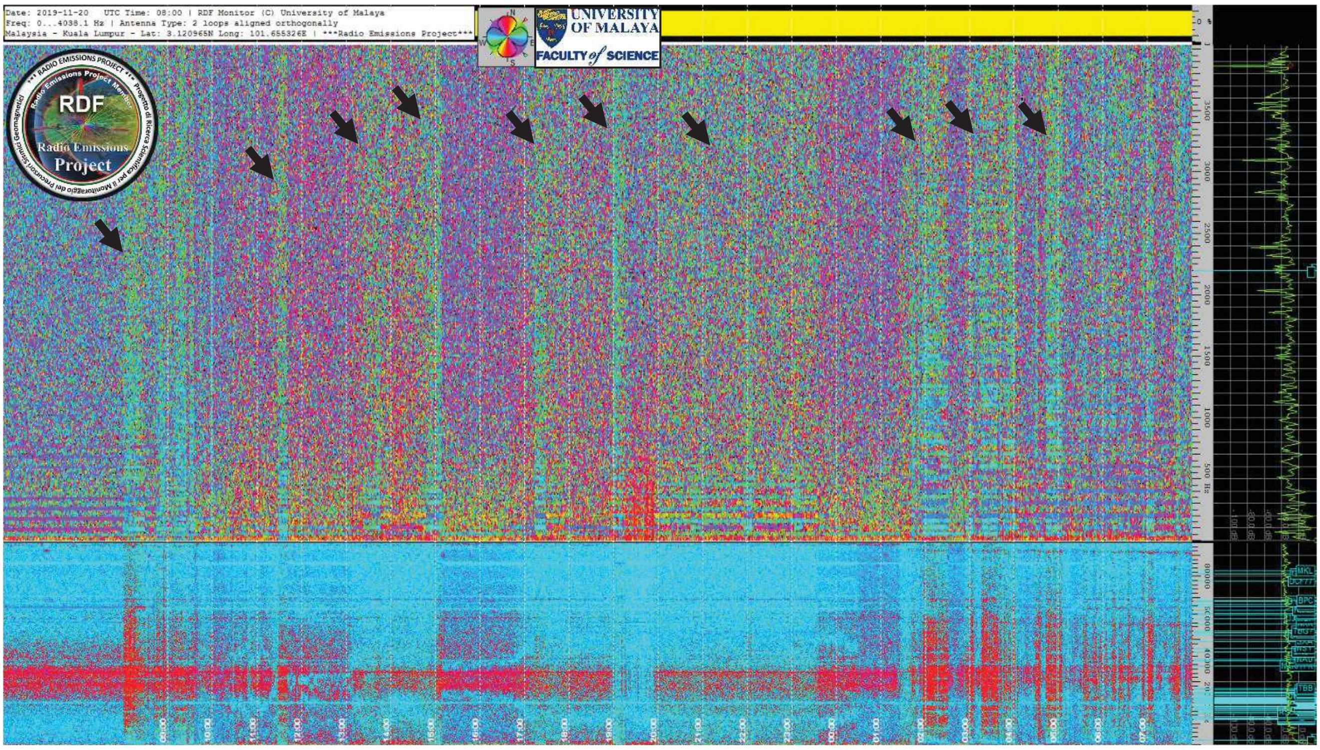

Figure 4 – Spectrogram of Radio Emissions Project, Malay house, run by the University of Malaya. It shows the presence of signals on a yellow-green azimuth (azimuth visible on the map in Fig. 3), and appeared previously to the earthquake which occurred in Massico, object of this study. Source: Radio Emissions Project Network, University of Malaya.

The increases recorded by that station (Malaysia), have appeared with impulsivity characteristics, confirming the recordings of the Italian station Ripa-Fagnano (AQ), as shown in Fig. 1 and 2. In addition to this it has been possible to ascertain the presence of emissions located in a restricted time period, just behind the earthquake, the subject of this study. The characteristics of the signals recorded by the Malaysian RDF station are the following: the increase occurred between the hours of 11:00 UTC of 19 November 2019 02:00 UTC of 20 November 2019. The electromagnetic frequency of the recorded signals, as evidenced by the RDF system was between 0-5 kHz and 0-48 kHz increments to the entire band (Fig. 4).

1.3 – Triangulation of the received signals.

Following the appearance of such increments, highlighted by the RDF stations, it has been possible to realize a triangulation suggested by the azimuth highlighted by the detection system, in this case:

1. The first type of signal has been the one with azimuth bluish-purple, evidenced by Italian RDF station.
2. The second type of signal has been the one with yellow-green azimuth, recorded by the Malaysian RDF detection station.

Both signals, if we look at the global mapping of the RDF system (Fig. 3) intersect along the area of the center-America (Mexico), and should be to identify, with some degree of phase shift of the signal, due to the high distance of detection, well-defined area (Fig. 5). The study shows that the electromagnetic emissions have had a certain percentage of the signal phase shift in degrees, such as not having made it possible to accurately identify the real seismic epicenter. On this issue we are working to try to understand what the cause is. The main hypothesis, see the presence of electromagnetic emission is not isotropic, that is due to the particular structure of the fault and the crustal structure that is not capable of emitting an isotropic signal that is irradiated in a regular manner along each direction, but due to the characteristics the earth's crust, such emissions are partly directional.

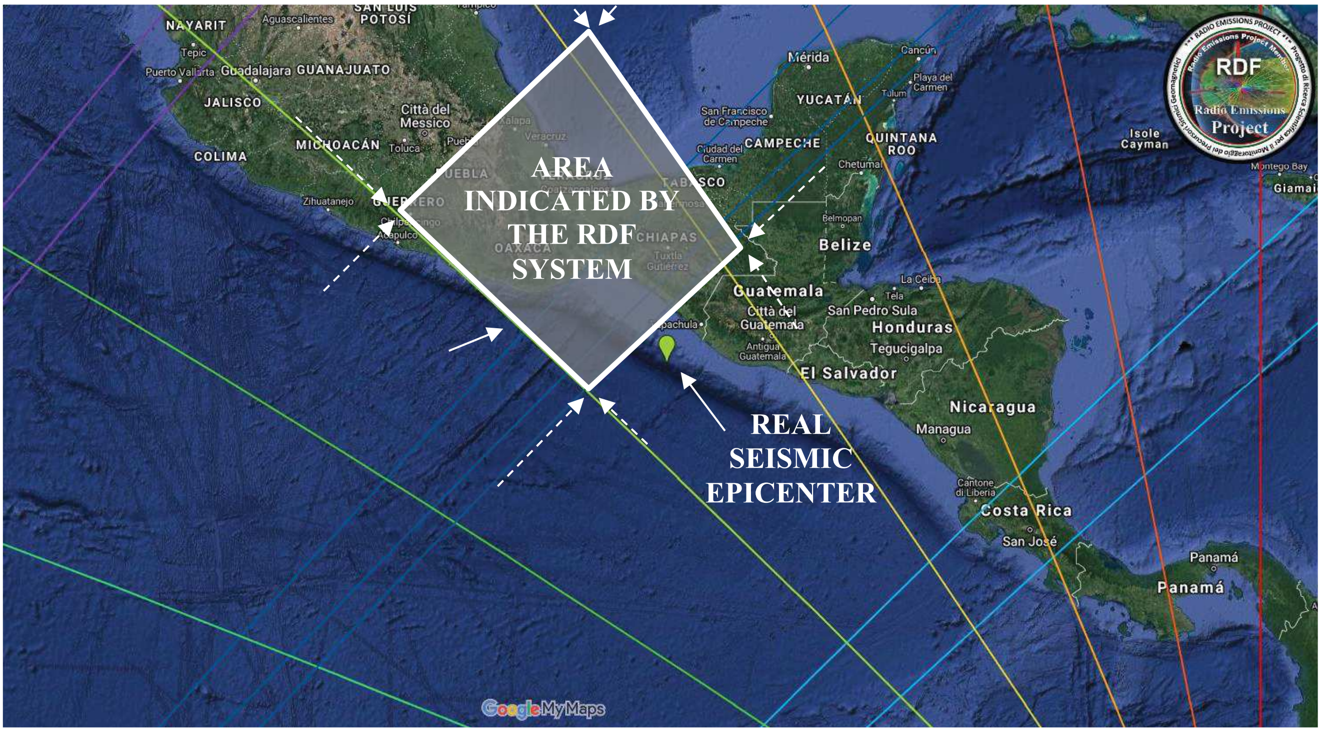

Figure 5 – World Mapping the RDF system, developed by the Radio Emissions Project, it highlights the azimuths of the various monitoring stations located on the globe and the earthquake epicenter considered in this study. In this case, the area indicated by the RDF system was highlighted in advance an area close to the epicenter earthquake. Source: Radio Emissions Project, Google Maps.

The non-homogeneity of the issuer, may in this case generate signals that are spread unevenly from the electromagnetic emission source and, therefore, can get to the monitoring station in a slightly phase-shifted in azimuth. Considering then the ionospheric variations where such signals are guided (propagation of the Earth-ionosphere cavity), also due to solar activity and weather, it is understood as such phase shift can be frequent. In this regard it would require additional RDF stations, spread on the globe to increase the accuracy of the detection system.

1.4 - Case number two:

On the same day, it occurred a second earthquake of high intensity: 6.3 mW at 267km NW of Ozernovskiy, Russia - 11/20/2019 08:26:07 (UTC) (GPS: 53 163 153 685 ° N ° E) 486.8 km depth. Around at 00:45 UTC of 19 November 2019, one of the Italian RDF stations, this time localized in Pontedera (PI), recorded some very interesting impulsive increments (Fig. 6):

- Peak hours of 00:45 UTC - 40 kHz (mid-frequency signal).
- Peak hours of 02:50 UTC - 40 kHz (mid-frequency signal).
- Peak hours of 04:05 UTC - 40 kHz (mid-frequency signal).
- Peak hours of 06:05 UTC - 40 kHz (mid-frequency signal).
- Peak hours of 07:15 UTC - 40 kHz (mid-frequency signal).
- Peak hours of 08:20 UTC - 40 kHz (mid-frequency signal).

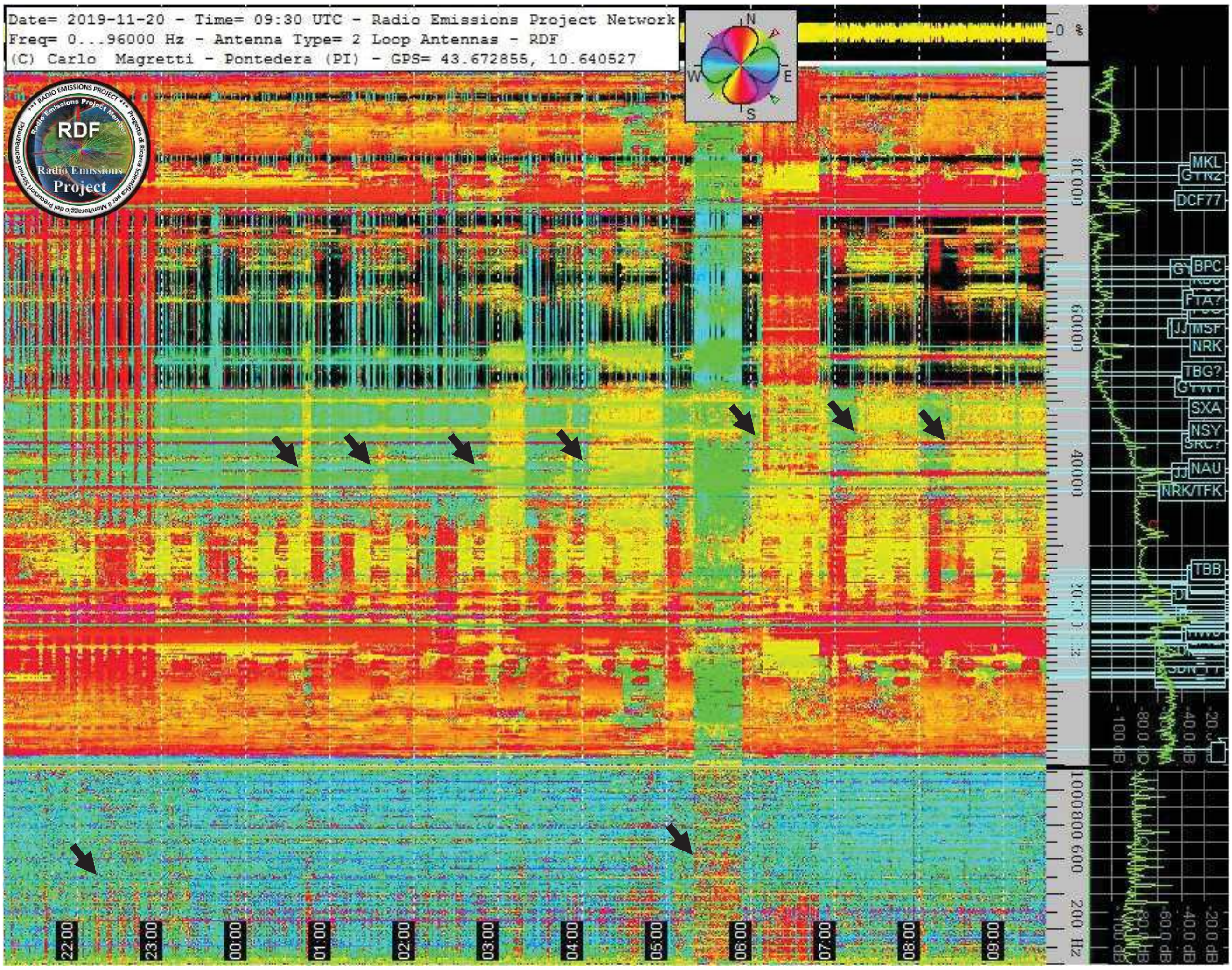

Figure 6 – Spectrogram of Pontedera RDF station (PI), in Italy, managed by Mr Carlo Magretti (collaborator of Radio emissions Project), in which one sees some net and intense electromagnetic emissions yellow (yellow azimuth), which appeared to start from hours: 00:45 UTC on 18 November 2019. Source: Radio Emissions Project Network.

Such electromagnetic increments have had an azimuth of yellow color, well detached from the natural geomagnetic bottom, while some yellowish increments have appeared in band SELF-ULF, between

22:00 UTC of 19 November 2019 the 05:20 UTC on November 20, 2019 . The researchers' hypothesis is that there was therefore important electromagnetic emissions along that azimuth. The confirmation is then arrived from the RDF station of Malaysia, when an increase of all well detached from the local geomagnetic bottom and also this impulsive type, showed the presence of electromagnetic emissions with yellowish type azimuth and orange.

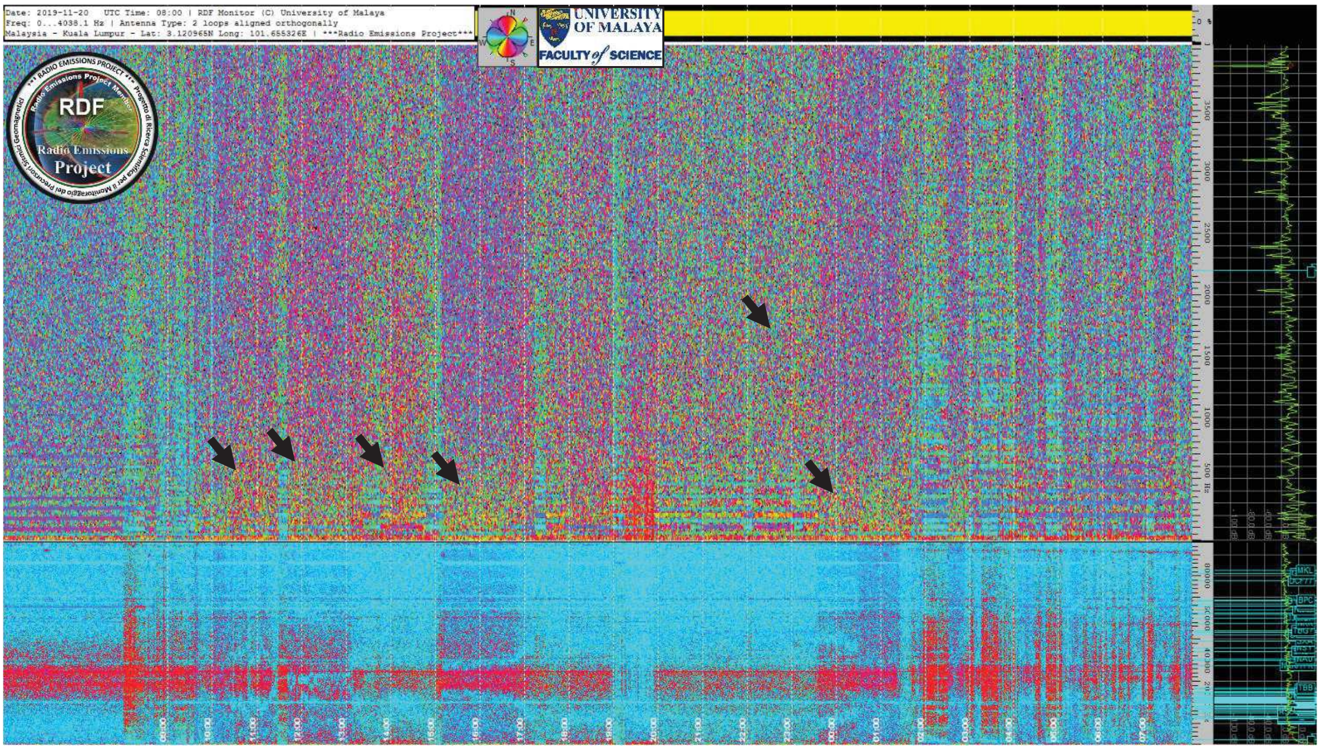

Figure 7 – Spectrogram of Kuala Lumpur RDF station, Malaysia, managed by the University of Malaya. It shows the presence of signals on azimuth yellowish-orange (as visible in Fig map 8 and 9), especially appeared within the 5 kHz and at full bandwidth (40 kHz). Source: Radio Emissions Project Network, University of Malaya.

The data confirmed that there was an act an intense electromagnetic emission of crustal origin which could identify. These increases had appeared at the following times and frequencies to the same medium:

November 19, 2019

- 10:00 UTC - by 1 kHz
- 11:50 UTC - by 1 kHz
- 13:50 UTC - by 1 kHz
- 15:10 UTC - by 1 kHz
- 17:30 UTC - by 1 kHz
- 23:15 UTC - by 1 kHz

November 20, 2019

- 02:30 UTC - by 1 kHz

Such electromagnetic surges lasting up to a few hours, they occurred sporadically to the entire band 0-40 kHz), between 10:00 UTC of 19 November 2019, and 03:00 UTC on 20 November 2019. The increase has had a sudden appearance, and it was clearly visible. The RDF system has now determined the azimuth of origin, providing useful data to the triangulation of the signals to intercept the emission area (as shown in Fig. 7).

1.5 – Triangulation of the received signals.

Triangulation was made by weaving the data of the stations of Pontedera, Pisa, Italy, and one in Kuala Lumpur, Malaysia. The data in fact could provide precise details in a azimuth reported by the RDF system, which showed an area positioned at Russia.

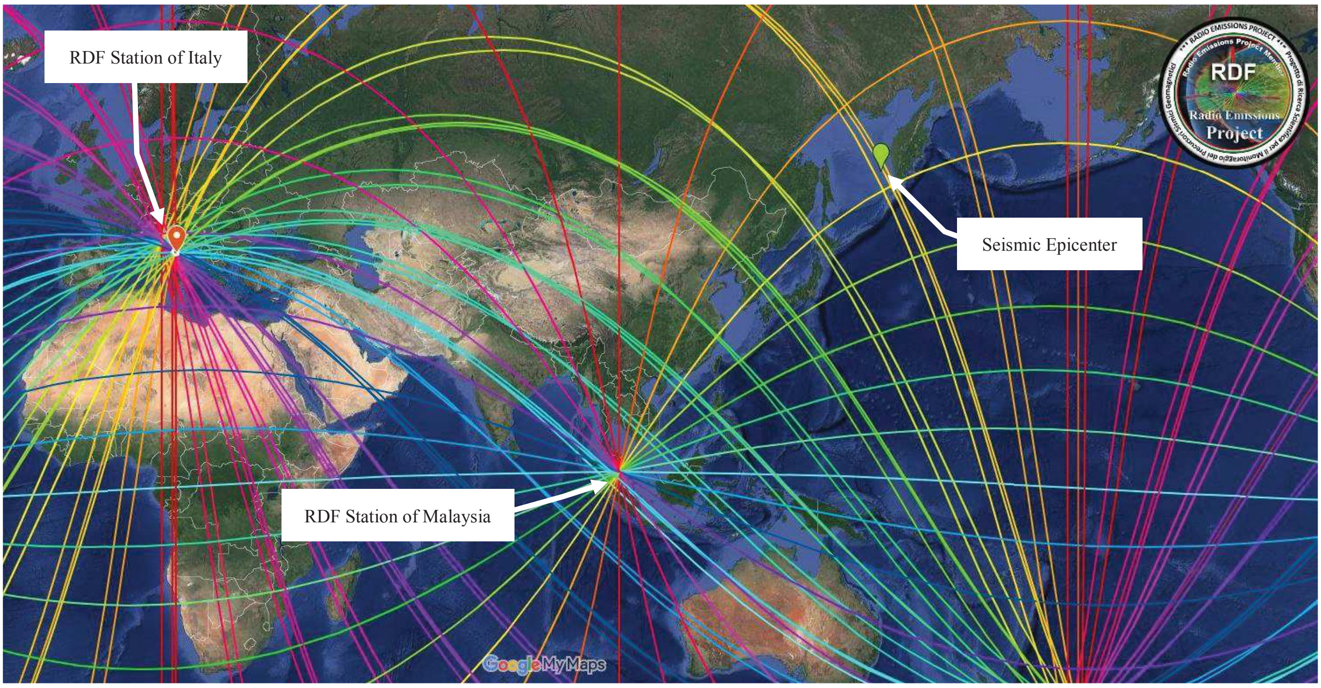

Figure 8 – World Mapping the RDF system, developed by the Radio Emissions Project. It shows the azimuths of the two stations considered in this study and the location of the epicenter earthquake. Source: Radio Emissions Project.

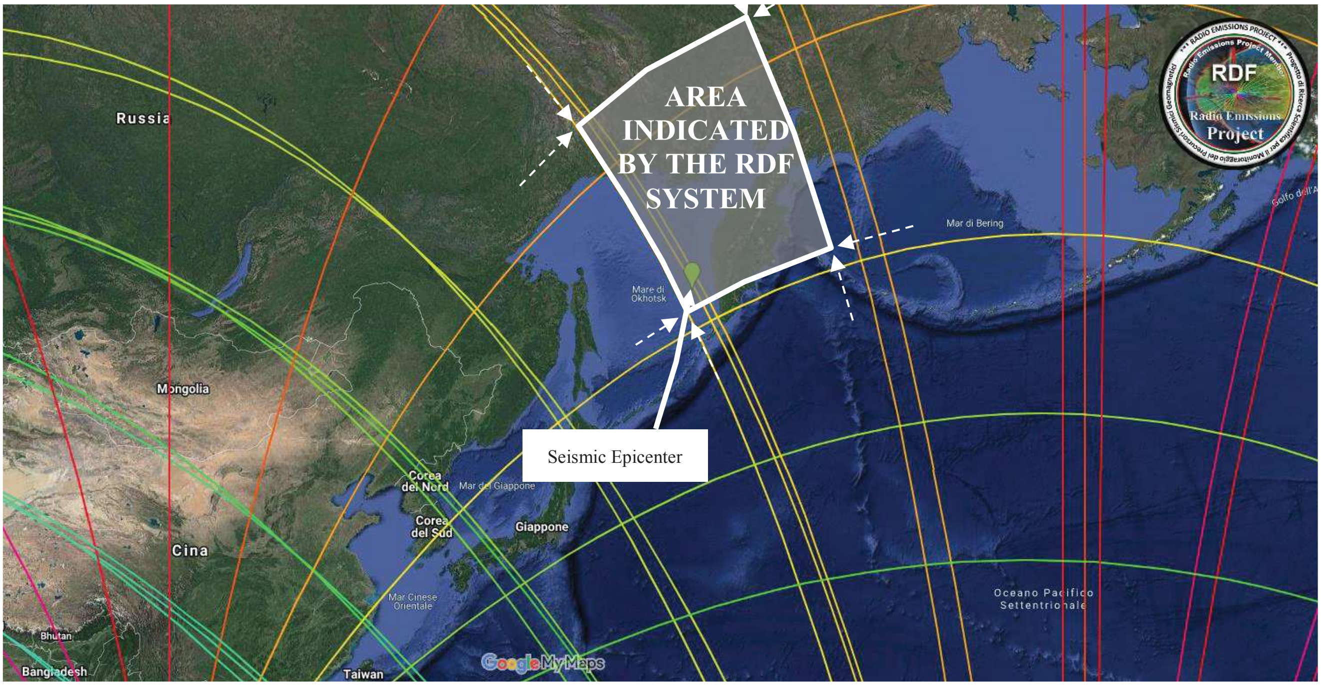

Figure 9 – World Mapping the RDF system, developed by the Radio Emissions Project. It shows the azimuths of the two stations considered in this study and the location of the epicenter earthquake. In this case the magnification sports highlights the geographic portion identified by the RDF system in triangulation. Source: Radio Emissions Project.

In this case the data supplied by RDF system as confirmed in that area could be the strong earthquake. Within a few hours, in fact, the quake occurred. Exactly at: 08:26:07 (UTC) of 20 November 2019, ie at the end of the increase reported by RDF station in Kuala Lumpur, Malaysia, and in the course of the increase reported from Pontedera RDF station (PI).

2.0 DISCUSSION

2.1 – The detection method.

The electromagnetic detection system, used in this study has the ability to detect signals coming also from a considerable distance, as compared to other survey and monitoring systems with which it is not possible to obtain such a capacity and sensitivity.

Mexican Earthquake:

- In addition 10.2 thousand kilometers away from the point of origin of the electromagnetic emissions from the Italian RDF station.
- More than 17,500 kilometers away from the point of origin of the electromagnetic emissions from the Malaysian RDF station.

Russian Earthquake:

- More than 8,600 km away from the point of origin of electromagnetic emissions, from the Italian RDF station.
- More than 7300 km away from the point of origin of the electromagnetic emissions from the Malaysian RDF station.

The use of electromagnetic amplification systems, such as those developed by the Radio Emissions Project, also allows greater highlight weaker signals compared to those present in the natural electromagnetic background which tends to cover them (electromagnetic noise). In this case the method used ensures the amplification of such signals and the recognition of their arrival azimuth.

2.2 – Prevision Hypothesis.

While it is therefore possible to obtain, as in this case, signals having a precise azimuth, it is possible to consider them in a forecasting context that has a certain precision? Of course it is, even if in order to obtain greater accuracy, which is sufficient to suggest the area within which to expect a strong earthquake, it must necessarily increase the number of RDF stations, and dislocarle on the Earth's surface.

The spatial distribution of the RDF system is just one of the essential elements in order to ensure a certain predictive accuracy, a great importance lies in the elaboration of the same signals on their ability to be triangulated and thus obtain continuous data. In this regard there is the need of having to use a computer system that carries out such work in an automated manner, indicating the azimuth of the signals and the possible area in which it can verify the earthquake.

The analysis of this study, has allowed us to emphasize the importance of the methodology based on triangulation of electromagnetic signals and on the construction of an automatic detection system, active 24h7.

2.3 - Error in azimuth

In the course of the RDF system experimentation, developed by the Radio Emissions Project, it was several times denoted a small signal localization error, especially over long distances, or in those signals coming from a distance of several hundred kilometers. In this context, the detection system has denoted the origin of the signals with an error of about 5 degrees (maximum approximation). After the initial trial was concluded by researchers that this error is generated by the phenomenon known as "Fading". The fading can be flat or constant at different frequencies, or selective or depend on the frequency, thus generating a distortion in the signal amplitude. In this case, the types of Fading identified by researchers who were able to interact with the monitoring system are the following:

1. STATIC FADING due to the absorption by oxygen and atmospheric water vapor (mostly at certain absorption peaks corresponding to the respective molecular resonances). In these bands it

is obviously not advisable to transmit any electromagnetic power. The complementary bands useful for transmission are commonly known as transmissive windows.

2. SPARKLING FADING, due to the scattering particle and characterized by low levels of attenuation and zero average over time.
3. DEEP FADING characterized by high levels of attenuation. It may be due to the presence of multiple paths (*multipath fading*) followed electromagnetic wave in its path and whose recombination in phase is random in time generating power variations in the receiver as a result of constructive or destructive interference.
4. FADING BY PRECIPITATION (eg. rain): strongly increases with the frequency of the electromagnetic wave and is depending on the intensity of precipitation.
5. EFFECT FROM FADING DUCT: anomalies in the vertical distribution of the refractive index, caused by changing weather conditions (eg. Temperature inversions), leading to the formation of 'atmospheric ducts' remains confined in which the electromagnetic signal which undergoes strong attenuations in the reflection on the walls of the duct itself.
6. FADING OF REFLECTION FROM SOIL that produces reflected waves that come in addition, with different phases, creating direct wave interference and fading random similar to multipath fading.
7. FADING FOR DIFFRACTION due to the presence of physical obstacles.

In the physical system considered, namely that the propagation of electromagnetic emissions, compared to the location of the monitoring station, must also be considered the type of electromagnetic emission generated at the level crustal (both in the fault surface that in the immediate vicinity, for piezoelectric effect and for effect of the formation of flowing charges that generate electric dipole and thus natural load-bearing).

In this context the electromagnetic emission generated at the level of the fault is susceptible to the following characteristics of the rocks capable of varying the type of issue:

1. Form and extent of the fault and the area in which it accumulates the tectonic stress and, therefore, where they accumulate the electrical particles flowing (current) capable of generating an electromagnetic field.
2. Presence of obstacles in the vicinity of the fault point of origin, as the presence of mountains.
3. Rock type and their crystal lattice.
4. Presence of water.
5. Depth emission of electromagnetic signals, with respect to the ground level.
6. Pressure and temperature of the rocks.
7. Electromagnetic permeability of the rock layers.
8. Type intrusion inside the rocks, such as ferrous or siliceous elements.

All these characteristics can affect the type of signal generated, beyond its power in kW. It is therefore a physical system that has many variables and which may determine a different electromagnetic field according to the characteristics mentioned above. These variables have been widely debated by researchers and already identified starting from 2017. In this case, the signals may propagate in different directions and thus assume the delays and variations in azimuth with respect to their initial point of origin (Straser et al., 2018).

Hence the importance, confirmed by all researchers, who resides in the installation of more RDF stations located on the globe, which would be able to better identify the origin of these crustal emissions and thus reduce the level of error of the system.

3.0 – CONCLUSIONS

In conclusion, the researchers involved in this study, important to consider the use of such a detection system, associated with the prediction-seismic and to the study of seismogenesis, as well as to the study of solar activity (closely related).

The data highlighted by the survey stations, equipped by the RDF technology - Radio Direction Finding, have provided important information and sufficient to consider such a detection technique, useful for earthquake prediction to a certain degree. The data are still scarce in order to use this method accurately, so the researchers all agree on the need for dissemination of this technology on a global scale. It is also important to proceed in improvement of the receiving system using the best sound systems, they can provide information even more precise and sharp, starting with the system designed and developed by the Radio Emissions Project.

The data have confirmed that the recorded electromagnetic signals, can be considered of electromagnetic seismic precursors (PSE), having direct relation both temporal and azimuth with the earthquake occurred in Mexico and Russia. It was also all agree how the dislocation of other RDF stations on Earth's soil, having to be made quickly.

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Daniele Cataldi and Gabriele Cataldi - Radio Emissions Project founders

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