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Valentino Straser

ATMOSPHERIC PLASMAS RESEARCH LINKED TO ELECTROMAGNETIC SIGNALS AND EARTHQUAKES

This paper presents the outcome of monitoring aimed at studying seismic precursor candidates with a multi-parameter system, carried out at a Science Camp in July 2022 in the northwestern Italian Apennines, in the province of Parma. Pre seismic signals, closely related to the preparatory stages of an earthquake, were detected with a crustal diagnosis, based on physical signals, generated by tectonic stress. The instrumental results show a potential temporal concatenation, which describe, at the level of hypothesis, the phases of the ongoing tectonic stress. The model followed Zou's theories who which associate the formation of plasmas in the atmosphere with the piezoelectricity of rocks under stress. According to his model, rocks placed under tectonic stress and in the presence of moisture can produce both charged particles and radio electromagnetic waves, at high and low frequencies. A spherical plasmoid would originate from this combination as a wave-particle interaction effect. According to Teodorani's description High-Frequency radio waves-particularly microwaves-would heat and ionize the surrounding air, while low-frequency waves, particularly Very Low Frequencies and Extremely Low Frequency, would help condense the plasma, which in turn would immediately go into swirling motions within it, until it formed the «self-contained» structure seen in the sky as a light phenomenon. Monitoring, therefore, involved the detection of low-frequency waves preceding plasmas in the atmosphere, directional electromagnetic signals from the Radio Direction Finding (RDF) network, and the occurrence of an earthquake within the 5/6 days' time window along the same fracture line. A study model that, if confirmed, could be applied to other seismic zones for crustal monitoring.

Keywords: *piezoelectricity, extremely low frequency, earthquakes, radio direction finding network, energy plasmas.*

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1. Introduction

The delicate problem of seismic precursor research has always aroused heated scientific debate. The progress made in recent decades indicates that the current limit is essentially technological, and at present, instrumental data can be used for crustal diagnosis, pending the realization «within certain limits» of a reliable method for earthquake prediction. This is a goal that has not yet been achieved, but for it to be applied in the future, especially when dealing with potentially destructive earthquake events, it will have to confront political, civil defense and scientific decisions. The multi-parameter method presented in this paper can also be applicable in other tectonic contexts and enhanced with additional multi-parameter detections, such as, for example, luminous phenomena in the atmosphere [1, 2], the detection of subsurface gases (radon, carbon dioxide), satellite data (changes in temperature, ground motions, charge concentration), solar activity and atmospheric phenomena, hydrological type (changes in groundwater levels), acoustic emissions, and observations of unusual phenomena manifested by animals [3]. The scientific literature regarding seismic precursors has expanded in recent decades [4, 5], after a pioneering phase that had to contend with prejudices and obstacles, not always of a scientific nature, as evidenced by the L'Aquila earthquake of April 6, 2009, which generated judicial investigations and attributed scientific responsibility, later dispelled. The publications offer a wide range of knowledge and reports of experiences conducted in the field, dealing with the different facets of the problem inherent in testing candidate seismic precursors. Thus, the need arises to associate the multitude of methods known to date and compare them in a comprehensive and synergistic concept. The occurrence or detection of a certain number of data in a given area, potentially at seismic risk, if superimposed in a time window one will be able to make estimates based on a multi-parameter system, in which a team of experts from the various fields of physics, solar physics, seismology and geology are compared. This study, therefore, aims to indicate the choice of certain precursors, but also to inspire an interdisciplinary working method, including civil protection decisions, implemented in the present experiment.

2. Materials and Methods

The following instruments, provided by 45 GRU Group in Rovigo, Italy, supplied by Jerry Ercolini, were used to carry out the field research for data collection, to be analyzed later in the laboratory:

– Fujifinepix S5 Pro digital SLR camera, Nikkor 70–300 mm zoom lens;

– Fujifinepix S3 Pro digital SLR camera, Nikkor 70–300 mm zoom lens;
– Fujifinepix S2 Pro digital SLR camera, Nikkor 28–80 mm zoom lens;
– Nikon F65 analog Slr camera, Nikon 28–80 mm zoom lens;
– Rollei 400 infrared film;
– Panasonic 3Mos full HD digital video camera;
– 200 line/mm ROS (Rainbow Optics Spectroscope) applied to a 70–300 mm;
– 850 nm–2 micron infrared filters for daylight infrared photography;
– Night Owl 5X model infrared viewer;
– Flir infrared camera with Lepton 3.2 sensors;
– 10×50 binoculars;
– Elf 0 Hz–3 KHz radio receiver, VLF BBB4 0 Hz–30 KHz receiver;
– Ral10 radiometer 950 MHz–12 GHz;
– Icom ICR2500 radio receiver 10 KHz–3.3 GHz, PROEXEL X1 multiband antenna;
– Geiger counter;
– EM field detector;
– 10 Hz Geophone;
– Infrasonic probe with VLF receiver 0 Hz–30 KHz;
– 4 portable notebooks for radio signal acquisition;
– 1 notebook for analysis.

The detection of electromagnetic signals was carried out by Gabriele and Daniele Cataldi, using the Italian Radio Direction Finding (RDF) System network, formed by the monitoring stations of:

1) Lariano, Rome, Italy (GPS: Lat. 41.728799 N, Long. 12.843205 E).

2) Pontedera, Pisa, Italy (GPS: Lat. 43.672445 N, Long. 10.640100 E).

3) Ripa-Fagnano, L'Aquila, Italy (GPS. Lat. 42.265709 N, Long. 13.583850 E).

The method used was the comparison of physical, geological and seismological data to verify potential relationships, at a time scale and in the same areal, of candidate pre-seismic signals, such as electromagnetic anomalies and light globes in the atmosphere. In fact, the zone being monitored involves an area of tectonic fracturing, known in the literature as the «Taro River Line», which connects two sectors of the northwestern Apennines that have been uplifted differently over the last million years and are still seismically active [6]. The area has been known since the 16th century for recurrent anomalous light phenomena in the atmosphere, which have been associated with geophysical events, such as earthquakes, since ancient times [7]. The investigation is based on the property of certain minerals to generate electrical charges and electromagnetic fields [8], in response to the pressure exerted by rock masses in the subsurface during the building phases of the Apennine Range still in progress. The survey stations for the field study were placed in two different areas of the «Taro River Line», at Berceto and Casola, in the province of Parma, Italy.

3. Results and Discussion

3.1. Anomalous light phenomenon, Berceto (Italy) July 15, 2022 – 22.59 (Local Time). At 22:59 Local Time, a faint glow suddenly appeared near the mountain ridge in a westerly direction. The light phenomenon was recorded using Fujifinepix S3Pro digital camera with a shutter speed of 0.5 sec at Iso 1600, zoom to 70 mm, f 4.0. Observing the photograph, it was possible to determine that the light phenomenon moved from right to left with an almost horizontal trajectory and disappeared with an upward tilt of about 40°. Astrometric analysis with Iris and Astroart astrometry software provided some values: the phenomenon presented its own brightness, although faint to natural vision, but definitely marked providing a point light curve but with a well-defined profile; the phenomenon analyzed in false colors presented areas with luminous variability, confirmed by PSF (Point Spread Function) analysis of the distribution of light photons in 3D and photometry.

3.2. Anomalous light phenomenon, Berceto (Italy) July 15, 2022 – 11:49 p.m. Local Time. Still at the same monitoring location, at 11:22 p.m. (Local Time) the ELF receiver recorded a very faint peak between 1 Hz and 4 Hz. A few minutes later, at 11:49 p.m. (Local Time) also in the same area, along the side of the mountain ridge, a very intense light phenomenon suddenly appeared, moving from left to right and changing shape (Fig. 1). Two photographs were taken in succession with a Fujifinepix S3Pro digital camera with a shutter speed of 0.5 sec at ISO 1600, zoom to 70 mm, f 4.0, recording the change in shape and brightness of the phenomenon itself. Observing the luminous phenomenon at magnification, it can be seen that initially it appeared as if it consisted of two luminous cores, while in the second photo the two cores appear to have merged together, changing completely in shape with change in brightness as well. Astrometric analysis, in false colors, confirmed the change in brightness and shape of the light phenomenon, showing the presence of two initial bright «cores» that later merged together, changing their profile. The Point Spread Function (PSF) of the distribution of photons of light in 3D and photometry show that the phenomenon emitted light of its own and as if it was within contained in a kind of energy «bubble», such that it confined the light itself.

Fig. 1. Plasma in the atmosphere appeared at 11:49 p.m.

Their light emission was not constant and linear in the short period of time that they occurred and they have their own light emission characteristics and a surface that most likely has temperature variations. Similar phenomena are observed in various parts of the world, such as, for example, Hessdalen in Norway [9, 10] and at Marfa in Texas [11]. Their motion cannot be equated with any aircraft, drones, Chinese lanterns, fireworks or known natural events of the lower atmosphere (lightning,

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fatuous fires, St. Elmo's fires, sprites, blue jets). The Elf radio signal was recorded 17 minutes before the light phenomenon, its marking is weak, and it does not show a subsequent Doppler effect. We rule out anthropogenic ELF-band radio interference in that frequency range because no other similar signals were recorded throughout the subsequent 4 hours of radio monitoring. No signal in radiometry; no spectroscopic detection was possible because of the sudden onset of such phenomena and the high speed and low duration to obtain an accurate spectroscopic field shot.

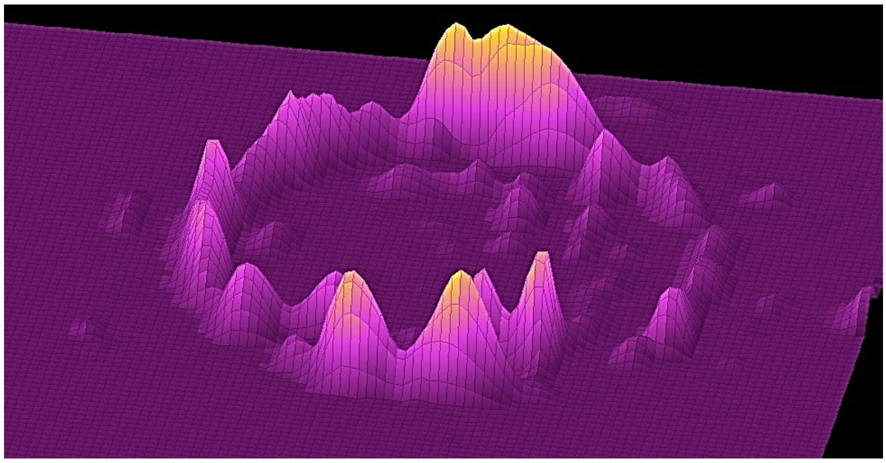

Fig. 2. Light photons in 3D of «bubble» (Courtesy; Jerry Ercolini)

3.3. Anomalous light phenomenon, Casola (Italy) July 16, 2022 – 11:27 p.m. (Local Time). At 11:27 p.m. with the thermal imaging camera, an anomalous phenomenon with a spherical shape was photographed that was not visible, but appeared in the thermal imaging camera display itself, with an average temperature of 25.7 °C. The phenomenon was floating a few meters away from the research team's location, and three photographs were taken before it disappeared. The duration of the phenomenon was 1 minute. Subsequent false-color analysis and isophotometry (distribution of light photons) showed an emission of brightness at several points; an infrared brightness that had precisely a strong thermal component but with good probability also a scattering in the mid- to near-infrared. The same PSF of the distribution of light photons in 3D shows that the phenomenon emitted its own light but contrary to what appears to be a kind of «bubble» of heat, the phenomenon instead presented itself as a kind of multiple thermal points arranged in a spiral shape, also presenting several cold areas. Analyses on the infrared film, in false colors, of the Point Spread Function distribution of photons of light in 3D and photometry, confirm the emission of infrared light peculiar to the phenomenon. Specifically: the «bubble» exhibits a non-constant and linear light emission and its own light emission characteristics (Fig. 2).

In addition, it presents a surface that most likely has temperature variations. The motion cannot be equated with any aircraft, drones, Chinese lanterns, fireworks or known natural events of the lower atmosphere. However, since the phenomenon was not visible, it was not possible to perform spectroscopy that could possibly provide data on the chemical composition of this phenomenon, thus trying to figure out whether it was a gas or a superheated body. Radiometry performed with the RAL10 radiometer at 12 GHz at the same time juncture did not detect any changes such that more in-depth analysis could possibly be performed. The phenomenon was not anticipated by ELF-VLF frequency signals.

3.4. Earthquakes. Earthquake data were retrieved from the website [12] and followed the occurrence of the light phenomena, respectively, 5 and 9 days later along the same fault lineation and at an approximate distance of 25 and 4 km from the two monitoring locations (Table 1).

Table 1

Earthquakes associated with electromagnetic anomalies and light phenomena detected in the Science Camp

No.	Day/hh:mm:sec	M	Deep	Lat.	Long.
1	July 20, 2022 (23:29:35 UTC+2:00)	2.0	24 Km	44.6110	10.2310
2	July 27, 2022 (21:41:09 UTC+2:00)	2.3	25 Km	44.6200	10.0310

3.5. Radio Direction Finding (RDF). The electromagnetic signals with azimuth oriented toward the future epicenter areas were detected starting July 17, 2022 from the Pisa monitoring station, that is, one and two days after the light phenomena appeared in the atmosphere, respectively. The signals continued to occur, with the same azimuth (Fig. 3), in the following days from the stations of the Italian RDF network, conceived by Daniele and Gabriele Cataldi and active since 2017.

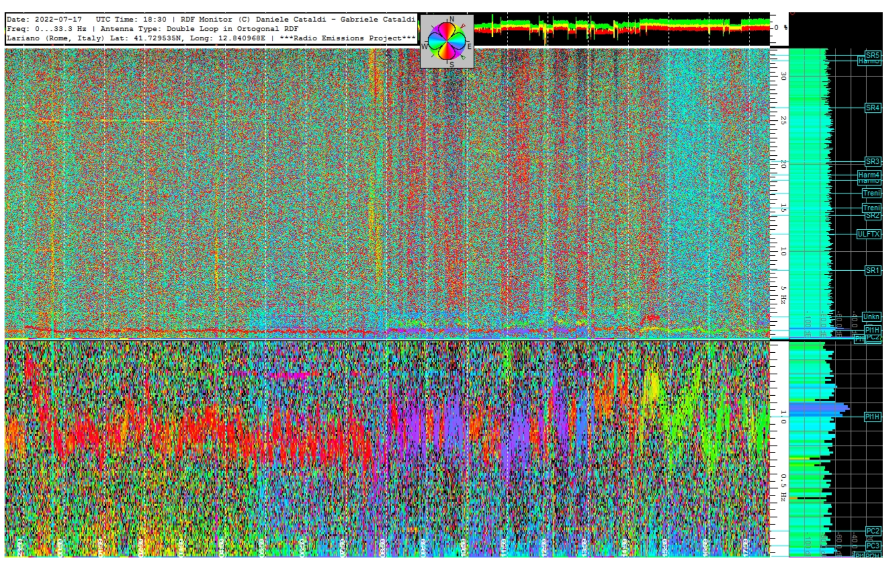

Fig. 3. Low-frequency interference whose colors indicate the azimuth of the future areal epicenter (Courtesy: Daniele Gabriele Cataldi)

The data allowed triangulation of the signals, which allowed estimating the future epicentral zone, in the time window of five and nine days [13].

3.6. Data Interpretation. The sequence of data, which began with the detection of ELF signals, followed by the appearance in the same area of «glowing globes», characterized by a major zone of tectonic fracturing, and then by triangulated electromagnetic signals in the epicentral future and the occurrence of seismic events, indicates a potential concatenation of the events measured in the field. The experimentation described is among the first, if not the first, to be field tested with a multi-parameter procedure and is unprecedented in the scientific literature. Experiments along these lines have been tested based on the RDF system, compared with radon gas emission and microgravity variations that preceded seismic events, including potentially destructive ones. The current limitation for successful prediction is essentially technological, but replicable to other seismic contexts. Experimentation could be strengthened in the future with the addition of other parameters, previously listed, to be detected in tectonic, seismically active contexts.

4. Conclusions

The results of this research, partial and inconclusive, and essentially qualitative, show a potential link between low-frequency wave signals, plasmas in the atmosphere, and electromagnetic signals with the occurrence of earthquakes in the same areal a few days after their detection. These results indicate facets of the same problem, namely the effects exerted by tectonic stress on minerals under pressure, which can produce both electric fields, magnetic fields [14] and, in particular situations, such as humidity, plasmas in the atmosphere [15]. The outcome of the research, still in the pioneering stages, could eventually lead to the monitoring of crustal diagnosis of a given area subject to seismic risk, and to a greater understanding of the mechanisms on earthquakes and the study of the energy produced by plasmas in the atmosphere [16]. Interdisciplinary studies may confirm, or not, the validity of the proposed method.

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Conflict of interest

Author declares that he has no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

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Valentino Straser, *Doctor of Geological Science, Department of Science, Environment and Energy, U.P.K.L. aisbl, Brussels, Belgium, e-mail: valentino.straser@gmail.com, ORCID: https://orcid.org/0000-0002-1736-1887*