Atmospheric Plasmas that Precede Earthquakes in Seismically Active Areas

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ABSTRACT

The question that arises in this study is whether there is a potential relationship between the formation of ball lightning (BL) or plasmoids that occur in the atmosphere before earthquakes. Luminous phenomena occur in various parts of the world and a few years ago they are attracting the interest of a growing number of scientists. The physical mechanism that regulates the luminous phenomenon has not yet been fully understood and various hypotheses are being formulated in this regard. The anomalous luminous phenomena in the atmosphere show to have a relationship with the orientation of faults in tectonically active areas and with magnetic anomalies, but also in correspondence of hydrocarbon deposits. The light balls consist of "spheres" of different sizes, stationary or in motion with variable speeds. The ball lightning, by constitution, can be associated with plasmas that violate their neutrality condition, and manifest themselves in particular areas of the earth globe such as in Texas, Norway and the Po Valley and the Northern Apennines in Italy, which represent the area of research investigation. The spectrography of the light balls indicates the presence of gases such as hydrogen, oxygen and methane, associated with local seismic activity.

Keywords*: Earthquakes, Seismic Precursors, Ball Lightning, Plasmas, Hydrocarbon Deposits*

1. INTRODUCTION

In Italy, in the North-Eastern Apennines, research has been underway for over 35 years to identify candidates for seismic precursors. First observations collected date back to 1983 along the Taro River Seismic Line, considered by the author to be an "open-air laboratory". The survey focused on the appearance of plasmas in the atmosphere that precede earthquakes in the range between 48 and 56 days, within 30 km of the neighborhood of the epicenter. The anomalous luminous phenomena in the atmosphere, analyzed in this study, are not equal events. The balls of light related to the preseismic events are red and appear from 2° to 5° with respect to the horizon, while those of white color, clearly visible in the sky at higher altitudes, are not related to seismicity but, according to the author, with emissions of hydrocarbons: generally methane. The duration of the EQl in the sky is variable, but usually less than a minute, and more rarely more than 1'30 '' from the sudden appearance. In several cases, for the red balls of light also of metric size, it was possible to perform the spectrography which showed the presence of molecular hydrogen and, sometimes, oxygen. In seismically active areas, hydrogen was indicated by other authors as a seismic precursor candidate, especially in studies conducted in Japan. In this case, as hypothesized by Bunnell (2009) [1] for the Lights of Marfa (USA), the "ball of light", which in practice consists of a plasma, is formed in the atmosphere by combining molecular hydrogen with oxygen, associated with the presence of charges that are released from the subsoil in areas subjected to tectonic stress. Both in Italy and in the Lights of Marfa, the presence of luminous globes manifests itself in correspondence of important tectonic fractures, as is the Seismic Line of the Taro River (Italy), in the area of investigation considered in the present study. However, in this research over thirty years, the position of the light balls almost never corresponds with the epicentral area of the earthquake that follows, but out of phase by a few kilometers, according to characteristic recurrences. The earthquakes analyzed in the survey area are generally of modest magnitude, less than 3. The study was also extended to other Italian areas that provided interesting coincidences between the appearance of plasmas and potentially destructive earthquakes, such as those of the Center Italy. The time interval, in the latter case, is 15 days.

2. CHARACTERISCS OF LUMINOUS GLOBES

1.1 The sightings are known in various parts of the world, but they are not always frequent.
1.2 The colors observed in the Parma area and in the study area (Fig. 1) are generally red or yellow-orange, but other colors are not uncommon, such as white in the center of the luminous globe, the warmest, which descends towards the exterior in yellow, orange and finally red.
1.3 The luminous globes observed in the survey area leave no traces of light during the movement in the sky, both at low altitude and above the horizon, they are nocturnal and move in the sky without causing noise.
1.4 The trajectories are recurrent and generally horizontal. In the area studied: N-S (Taro Seismic Line), E-W, and NW-SE.
1.5 Sometimes from a single globe other small lights can be generated that sometimes orbit around the main one, or more than one can be observed (Fig. 2).
1.6 Trajectories are not influenced by the wind and are believed to be sensitive to magnetic fields [2][3][4][5][6].
1.7 Sightings can occur during the first four hours after sunset [1].
1.8 Apparent dimensions are like a grapefruit and, at least in one case, an energy of the order of 10,000 watts of visible wavelength was calculated [1].
1.9 The durations of sightings in the survey area vary from a few seconds to 3 minutes.
1.10 Some types of apparitions have been related to tectonic and seismic activity [7], as a response to incipient stress.

The recurrent appearance of luminous phenomena in the investigation area (Fig. 3), known for over two centuries, suggests that it may be gaseous emissions that are released into the atmosphere a chemical reaction they trigger the luminescence.

Fig. 1. Index map. The two circles indicate the areas of investigation: The Seismic Line of the Taro River (North-western Apennines) and the area of the Po Valley, near the city of Rovigo and Venice (Italy).

Fig. 2. Types of ball light are in the atmosphere within the seismic area under study. The photograph was taken on August 15, 2007, on the province of Parma, in the North-Western Apennines (Italy).

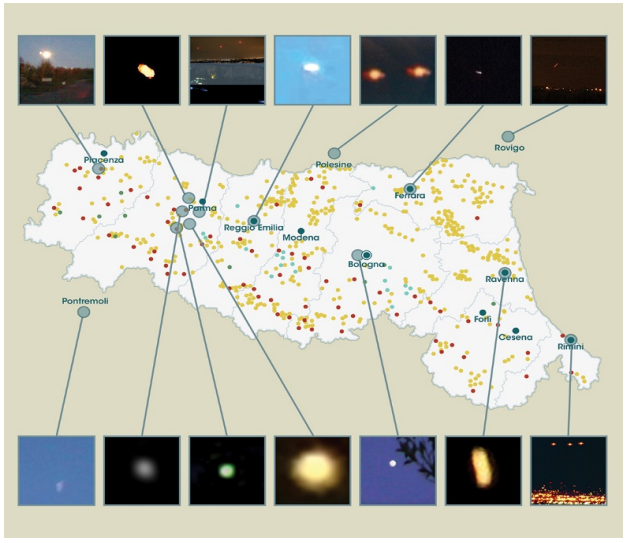

Fig.3. Sighting sites of seismic lights and associated with the presence of hydrocarbons.

Gas Rising Mode

Some gases trapped in the subsoil, such as methane (CH_4), tend to reach the surface in the form of bubbles and, having reached the atmosphere, remain there for relatively short times, from 10 to 12 years. Methane generated in depth can migrate into clay or sandstone or flysch formations, or find preferential channels, such as underground fractures. The detection of methane, but also of hydrogen (H_2), can provide valuable information on the evaluation of seismic risk and take a practical interest in the field of exploratory geology. The migration of gases vertically, through faults, fractures, or horizontally, along lithological sequences, constituted, for example, by permeable levels in clay sequences, are in direct relation with the existence of hydrocarbon deposits or geothermal fluids. The movement of the gases in the subsoil can be caused by: pressure gradients or concentration gradients. The pressure gradients concern the movement of the gas from areas of high pressure towards areas of low pressure along faults and fractures, even for long distances. Conversely, concentration gradients are related to slower and disordered movements such as, for example, the diffusion of gases between granules and inter-granular spaces. If the gas tank is placed at relatively small depths, it can migrate and reach the surface through fractures or porous rocks with a practically continuous flow, as if it were confined inside a pipe. The speed of migration of moving gas naturally depends on the degree of water saturation, the tortuosity, the roughness and the width of the fractures.

The existence of gases that migrate to the surface by advection, through fractures or areas of high permeability, is well documented in the literature [8][9][10]. The detection of anomalies in the concentration of gases in the soil [11] are used, both for preliminary analyzes for the identification of hydrocarbon deposits, and for mapping faults or tectonic accidents.

At active tectonic structures, such as in the San Andreas Fault, significant levels of hydrogen have been detected [12][13] recently used as a seismic precursor [14]. The presence of H_2 and CO_2, however, can exclude that of CH_4. The presence of both gases can occur in the presence of phosphine, especially in geologically recent soils or in areas of subsidence, as happens in the Po Valley, in the survey area.

Hypothesis on Genesis of Luminous Phenomena: In Relation to Tectonic Stress and Hydrocarbon Deposits

2.1 The anomalous luminous phenomena in the atmosphere recur in particular areas of the Earth, in relation to the geographical position and geological characteristics [14]. The areas are subject to tectonic efforts or, in the case of Hessdalen (Norway) to isostatic readjustment [16], coincide with magnetic anomalies and are associated with hydrocarbon deposits and gaseous emissions and with primary and secondary magmatic phenomena.

2.2 Laboratory experiments have shown that tectonic stress can produce magnetic anomalies and gaseous elements in rocks can produce plasmoids or low-pressure terrestrial plasmas [17]. Plasmoids are ionized gases, within which electrons and ions move independently without being bound together. Plasma, on the other hand, is a great conductor of electricity due to free charges, and sensitive to the action of electromagnetic fields, in which a part, or all, of the particles are ionized. Sufficiently hot gas molecules formed by atoms with more or less electrons (ie, charged particles, positive and negative ions). Like gas, plasma has no definite shape or volume but, unlike gas, plasma is very

sensitive to magnetic fields and this may explain the ability of anomalous lights in the atmosphere to withstand wind currents, and move horizontally at low altitude. The plasmas, after reaching the atmosphere, the heat transfer in the cold night air disrupts the components of the plasma state that burn by capturing atmospheric oxygen to form water molecules to give rise to visible light [1].

2.3 The luminous globes in the atmosphere, after appearing in the sky, rarely remain in the same apparent position. In most cases, in fact, they move in a straight line and then suddenly go out. Recent studies [7] show that the displacement of the "balls of light" generally follows the fault lines.

3. INSTRUMENTS

- Professional digital SLR cameras
- Analog cameras with infrared film
- Infrared / ultraviolet filters
- Professional HD camcorders
- Spectroscopes applied to cameras
- Binoculars
- Infrared viewers
- ELF / VLF radio receivers
- HF / VHF / UHF / SHF radio receivers
- Geiger counters
- Field EM detectors
- Portable radiometer for measuring the temperature in the antenna

4. MONITORING STATION

The atmospheric plasmas detection stations are located along the Taro River seismic line and near the Vallezza hydrocarbon mine in the North Western Apennines and near Rovigo, in the Po Valley, not far from Venice.
In the first case the observations do not have a daily frequency and the instrumentation consists of cameras, a portable magnetometer and the detection of frequencies in the SELF / VLF bands. The second station, set up by "45 GRU" has two stations for monitoring the luminous phenomena:

1). Focus on radio monitoring on all frequencies and particularly in ELF / VLF bandwidth with directional antennas.

2). Monitoring Station use 4 astronomical cameras with wide angle optics for sky monitoring on the Rovigo area (with a 360° coverage and a 30° on the horizon), all stations are connected to computers for recording and data analysis; In parallel with this instruments there are ELF / VLF radio receivers, a radio receiver for meteor scatter (radio meteor interception), a radiometer with directional antennas, a geophone 4 -15Hz.

In its database, are considerate all artificial light (aircraft, light, lighting, sky lantern) and natural phenomena that can give rise to misinterpretations can be considered, with a comparative system to be able to search for a restricted channel.

5. METHODOLOGY

The working methodology is that of comparing the plasmas of the investigation area, where the presence of hydrocarbons is certain, compared to those observed in areas where seismic and tectonic activity is taking place. The anomalous phenomena in the atmosphere, in fact, are not all of the same type, in shape, duration and color. Examples include the sightings of Hessdalen (Norway), Marfa (Texas) and Min Min (Australia), while those observed and photographed in the study area are generally spherical in shape with a white core (Fig. 4), which move or appear at altitudes in the order of hundreds of meters above the ground, and red in color, close to the ground. A comparison of the types of light balls was made between sightings in the Po Valley, where certain methane gas emissions [18] are present (Fig. 5), with the Vallezza mine and the Taro River Seismic Line [19]. The white lights (Fig. 4 & 5), single or in groups, are associated with the emission of hydrocarbons and are sub-circular in shape with movement in the air at altitudes of the order of one hundred meters, lasting between 5" and 2'45". A further feature concerns the time of appearance, with hourly recurrences that vary from area to area. For example, the light balls associated with the Vallezza hydrocarbon mine (Western Apennines) occur between 18:48 and 19:12 local time, as shown in the graph where the interpolation curve indicates the range of greatest probability of sighting (Fig. 4).

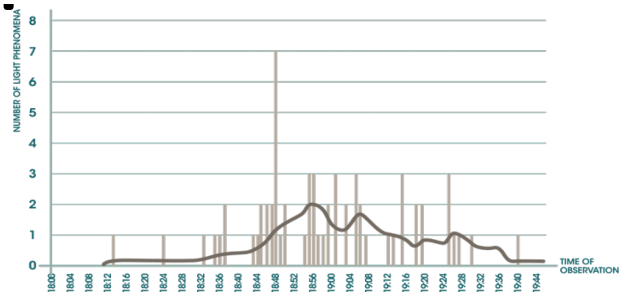

Fig.4. Hourly distribution of the appearance of light balls in the Vallezza field in the North Western Apennines, located in the seismic zone of the Taro Line.

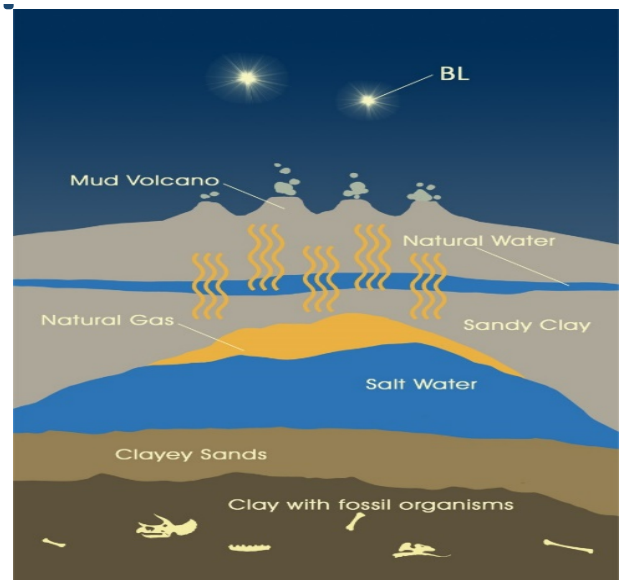

Fig.5. Mechanism hypothesized for the "periodic" release of gas into the atmosphere, at the base of the formation of light balls. The hypothesized mechanism is similar to that of a geyser, with more or less regular charging times between the accumulation in the tank and the release of the gas into the atmosphere through fractures and tectonic faults.

Unlike oil fields, light balls detected in tectonically active areas generally occur close to the ground with vertical or horizontal movements, a few times a year, and precede earthquakes with the epicenter near the apparition area of the ball of light. Also in this case the movements of the light balls take place without making a noise and last about one minute before dissolving. The mechanism of ignition of the light balls is hypothesized to derive from particular atmospheric conditions and from the concomitant presence in the atmosphere of gases and ions, without neglecting additional elements such as, for example, natural radioactivity or electromagnetic anomalies generated, for example, by stress crustal.

Balls of Light Associated with Preseismic Phenomena

The observed luminous phenomena, which appear during the pre-seismic stage are of two types:

1.) Spheroidal shape, yellow-orange, constant brightness, sudden appearances, elevation from the ground between 10 ° - 20 °, no noise, no wake emitted, estimated size about 2m, and duration of few seconds (Fig. 6).

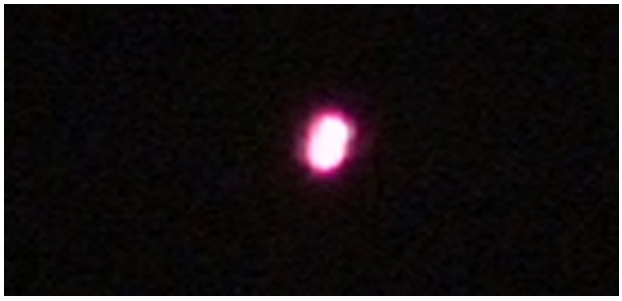

Fig.6. Red light associated with preseismic phenomena (Courtesy Jerry Ercolini).

2.) Spheroidal shape, intense red fuzzy coloration (Fig.7), constant brightness, sudden appearances and fast movements in a linear fashion or slow movements, elevation from the ground between 2° to 7°, no noise, no waves emitted, estimated dimensions over 2m, with a duration from a few seconds to a few minutes such as to allow (in several cases) spectroscopic shooting.

In all documented cases, no lightning strikes have been observed in order to be able to think of a particular trigger phenomenon; The Po Plain area does not have wetlands to consider any formations of natural gas bubbles that for some reason climb to the altitude and encounter an electrostatic trigger so as to create a form of ionized plasma.

Fig. 7. Light ball photographed near Rovigo, in the Po Valley, on 6 July 2013 (Courtesy Jerry Ercolini).

6. A NEW ENERGY SOURCE?

The balls of light, characterized by a spherical shape, of long duration and occasionally also of large dimensions, of the metric order, have a high radiant power, of the order of 20 kW. Optical spectra are highly variable and the anomalous light distribution is not typical of standard plasma. From the physical point of view, for a correct comparison between the luminous phenomena in the atmosphere, one can calculate the radiant energy level (**P**) of the light sphere obtained from the image, using the equation proposed by Maccabee (1999) and taken from Teodorani (2008). In equation (1), **d** is the distance in m, **E = I x A** (lm / sec) is the total energy received by the film (100 ASA), **I** is the energy per unit area of the image (lm / sec m-2), **A** is the image area (m2), **V** is the optical visibility distance (m), **τ** the duration of the luminous phenomenon expressed in seconds, **F** and **f** indicate the focal length, **D = F / f** the lens aperture diameter and **T** lens transmission factor.

$$P_E = 4\pi \cdot d^2 \cdot \frac{E}{\tau \cdot \frac{\pi}{4} \cdot \left(\frac{F}{f}\right)^2 \cdot T} \cdot e^{\frac{3.9 \cdot d}{V}} \approx 20kW \qquad (1)$$

7. CASE STUDIES

Earthquakes in the North Western Apennines that occur along the Taro River seismic line are usually less than M3 in magnitude and occur in a time interval between 60 and 48 days [7]. The situation is different in the case of the Po Valley which has three time intervals: the first of about 60 days for earthquakes with epicenters close to the area of apparition of the balls of light and low magnitude; the second between 50 and 40 days with magnitude and an increasing distance of the epicenter; the third interval is less than 20 days and the magnitude higher than the first two cases.
By way of example, we illustrate the type of the second case with the Pradespin globe by Lendinara, filmed on 6/07/2013 at 10.45pm (Fig.7). It is a bright red fuchsia sphere, shot with video camera and spectroscope. The analyzes, carried out by dr. Massimo Teodorani, showed strong oxygen peaks. In the frame proposed here the luminous spectrum of the sphere is denoted in comparison with the spectrum of artificial lights in the area. The sighting preceded by 46 days the seismic event in the area of Monte Conero (Ancona) of magnitude (Ml) 4.9 occurred at 03:32:24 Italian time of 08/21/2013. A similar interval of time, of 45-48 days, is recurrent also in the Western Apennines, especially in the area of the Tuscany Region, in Italy. Spectrometry indicates obvious peaks of oxygen as a chemical element present in the light ball (Fig.8).

The third case concerns the globe, filmed 08/15/2016 (Fig.9). The figure shows one of the 14 photos taken at Pradespin di Lendinara. It is a sphere of fuchsia red color appeared on 08/15/2016 at about 3 ° from the ground. The sphere remained suspended for 32sec. In the picture we can see the light spectrum of the sphere in comparison with the luminous spectra of the illuminations in the area. On 24/08/2016 the strong 6M magnitude earthquake occurred in Amatrice, in Central Italy, which started the seismic sequence, still in progress. In this case, spectroscopy highlights the presence of hydrogen peaks (Fig.10).

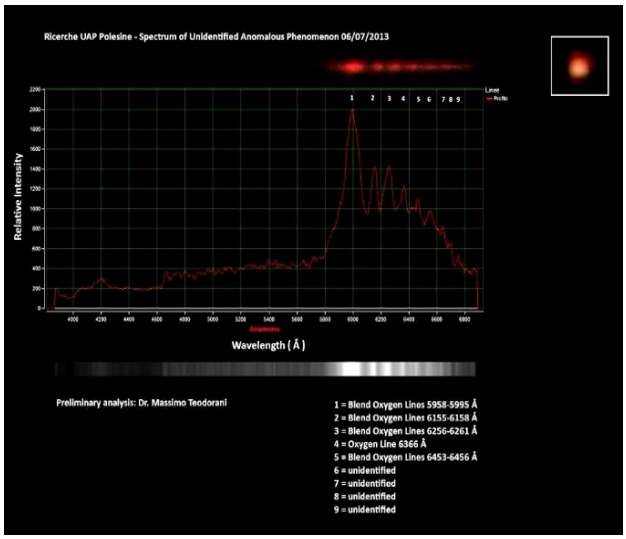

Fig.8. Spectrography of light of 6 July 2013 which highlights in its composition peaks of oxygen (Courtesy Jerry Ercolini).

Fig.9. Photograph of the light ball of August 15, 2016 taken in the survey area of the Po Valley (Courtesy Jerry Ercolini).

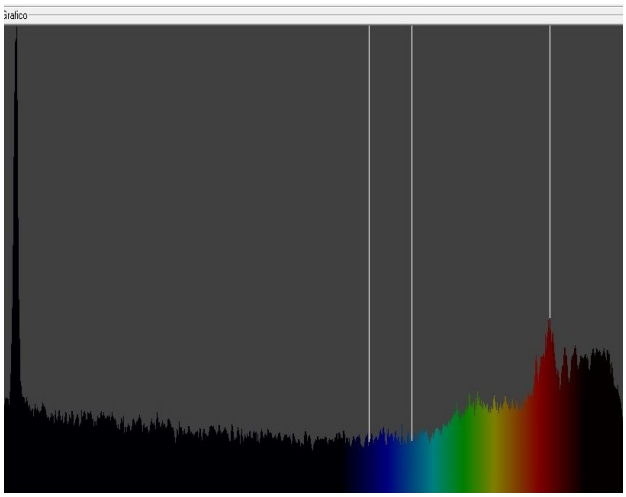

Fig.10. Spectrography of light of August 15, 2016 which highlights in its composition peaks of hydrogen (Courtesy Jerry Ercolini).

8. CONCLUSIONS

The conclusions of this study are partial, as the experimentation is still ongoing. When the amount of data will allow a more detailed modeling, despite the research has been ongoing for over 30 years, the Method can be used both for the geognostic investigation for the identification of potential hydrocarbon deposits and for directing scientific research towards a better understanding of reliable seismic precursor candidates. At this stage of the research the following observations can be made:

1. The Anomalous Luminous phenomena in the investigation area, in the Northern Apennines and in the Po Valley, can be related to the tectonic activity.

2. The study area can become a "laboratory" for the research of Physics and Geology.

3. Light phenomena can be measured, even if with different difficulties.

4. In the area of investigation there are at least two types of prevalent luminous phenomena, the first relating to the pre seismic stage and the second to the presence of hydrocarbons.

5. In the investigation area the luminous phenomena in the atmosphere, in particular those of red color, precede the earthquakes within a time window of 60 days.

6. The magnitude of earthquakes associated with the appearance of luminous phenomena in the atmosphere increases as the time interval between the sighting and the main shock decreases.

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