ANNALI DI GEOFISICA, VOL. 42, N. 3, June 1999

The scientific life of Luigi Palmieri

100th Anniversary commemoration (21/04/1807-09/09/1896)

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Abstract
I present here a commemoration of the scientific life of Luigi Palmieri, II Director of the Osservatorio Vesuviano. His research on both volcanic and tectonic phenomena was supported by his development of the first electromagnetic seismograph, which he also built in a «portable» version. He had the intuition to relate seismic activity to eruptive episodes, and, in this sense, he was the first scientist to imagine the eruption forecast in a modern way.

Luigi Palmieri was born at Faicchio (Benevento) on 21st April 1807 and died in Naples 9th September 1896. He was noted to have a «prodigious versatility (*in his teaching*) as well as a vast literature and philosophical culture», to which should also be included scientific experience, demonstrated by his mathematics degree from the University of Naples. In Naples he opened a private school, an Academy of mathematics and philosophy in which he was a permanent member of staff. He also held academic positions within other institutions, the Royal Naval College of Naples and the University of Naples as professor philosopher, following Pasquale Galluppi in 1847. He became the Director of the Osservatorio Vesuviano in December 1854 and professor of Terrestrial Physics and Meteorology in 1860 when Garibaldi arrived in Naples.

From the commemoration ([1]) of the Pontaniana Academy where he was president from 1867-1868 and 1892-1896, it resulted that the students from his private school numbered more than 600 and came from all over Italy.

Regarding Luigi Palmieri's scientific activity, it must be said that as soon as Faraday discovered the electricity induced when a magnet is moved past a metal coil in 1831, Palmieri noted that the same effect must occur within the Earth, due to the fact that it is in itself a large magnet ([2]).

His experimental activity of this phenomenon included the 1845 construction of the Palmieri Circle with which he realised, thanks to the properties of earth magnetism, the electrolysis of water (Palmieri, 1845). This circle, which contributed to the realisation and construction of the Pacinotti dynamo, is still today noted in school books on electricity together with others of his inventions, such as the double wire electrometer (*elettrometro bifilare*).

Since 1847 he concentrated upon his work as a Professor of Philosophy with a continued interest in his research into Terrestrial Physics and in particular with regards to atmospheric electricity. His work on the double wire electrometer offered the first occasion on which Palmieri was introduced to the Osservatorio Vesuviano.

During this period, 1852, the Osservatorio was passing through a particularly difficult period with its founder and first Director, Macedonio Melloni, being removed from this position for political reasons, with the possible sale of the Osservatorio and its reconstruction as a hotel for visitors to Vesuvius.

It was at this time that Palmieri asked the authorities if he could use the Osservatorio to make measurements of the atmospheric electricity, so as to make comparisons between theoretical values of mountains and those of Naples. This request was not only welcomed but it was also proposed that Palmieri should become the new Director of the Osservatorio Vesuviano, a suggestion that Melloni did not accept, though during this period they had become good friends. The nomination was accepted by Palmieri in December 1854 when Melloni became ill with cholera which was infecting Naples at the time. After his nomination Palmieri continued his work on atmospheric electricity but found his circle was inadequate, which led him to build the double wired electrometer with mobile conductor «*elettrometro bifilare a conduttore mobile*» in 1878, with which he produced comprehensive field-work from Naples to Vesuvius.

This study concluded that, even on a fine day, the atmospheric electric current measured at Vesuvius was considerably higher than Naples. It was this conclusion which in the 1960's led to the realisation of a new system of geophysical surveillance of Vesuvius with reanalysis of various fixed cable apparatus, with the aim of substituting them with a mobile radio system.

We do not know whether in the later half of the 18th century the idea of site variations (*gradiente del campo*) was common scientific knowledge or whether Palmieri was the first to coin this term. Whatever the reply, the formulae produced by Palmieri were without external influence. This research had to formulate common formulae with regards to atmospheric electricity in which as expressed by Pinto (1896) «the rain must rain even when it is positively charged surrounded by small and large negative charges, which in turn are surrounded by an area of strong positive charge, as described as happening within large temporal storms and whirlwinds». The law was confirmed also for areas outside Italy, and was considered to be a type formulae, where it was contested as to who was its founder. The merit was given to Palmieri, who received congratulations from Faraday.

Palmieri claimed (1862a) that as the rain drops fall from the clouds, within the terrestrial gravity field, they would become positively charged due to electrostatic friction. Therefore it could be assumed that the same process would also affect volcanic ash, ash that fell as rain would be positively charged, and ash which fell as volcanic projectiles (not reaching the upper atmosphere) would become negatively charged. This would create a situation in which a volcanic cloud could produce and discharge large quantities of electrical energy, as was observed by the young Pliny during the 79 A.D. eruption. Pliny also noted for the first time that during the eruption the volcanic edifice tended to modify its position with respect to sea level, which more or less surrounds the volcano. He noted that the sea level dropped, due to isostatic uplift, with respect to its normal level. Two days after the eruption on the 8th December 1861, Palmieri (1862b), noted that the coastal area nearest to the vent had risen to a point at which sea algae and shellfish which normal lie below sea level were now exposed above the sea level.

The maximum relative lowering of the sea level, approximately 1.5 m, was seen at Torre del Greco with a gradual return to normal towards the north and south. Therefore from a reef in front of Torre del Greco, maximum uplift, to Granatello, approximately 4 km north, where there was no noted variation in sea level, it was presumed that the eruption had caused an uplift of the volcanic edifice which gradually returned to 'normal' within a year of the eruption. It was therefore concluded that in general isostasy was caused by a variation in the land with respect to the sea and not the sea as was previously assumed.

Palmieri (1891) had been conducting experiments since 1859 on this phenomenon, as well as its possible relation with local meteorological, electrical and magnetic anomalies. This work was further stimulated after the 1872 eruption, when, to reward the Director and his staff, the first telegraph line was built connecting the Osservatorio with the central Post Office of Resina. For anyone else this would have remained a simple telegraph line but for Palmieri it was a means of investigating the telluric current and its relation with the activity of Vesuvius. After establishing the relation between the telluric current and Vesuvius activity in 1894, two years before his death, he noted the variations in intensity and direction of the electromagnetic phenomena at Vesuvius.

The first eruption studied by Palmieri was the 1850 one (Palmieri, 1850) and the first earthquake, one year later, that of Vulture in collaboration with Arcangelo Scacchi (Palmieri and Scacchi, 1852).

Imbò (1949) commenting on the relation between seismic and volcanic phenomena wrote «*Palmieri with great insight anticipated the introduction of the close relationship between volcanic activity and the movement of the ground*» which gave him the initiative to study the possibility of recording this movement, which lead to the construction of what he called the «Electromagnetic Seismograph», even if the more correct term is «Sismoscope».

Thanks to Dr. Antonio Nazzaro and his assistant Bruno Tramma (Nazzaro and Tramma, 1985) the two versions, *stationary and field*, of this instrument were brought to light. Apart from the beginning and end of the earthquake, the Palmieri's equipment (1870) furnished other elements which were considered to be innovative:

1) The breakdown of ground movement ([3]).

2) The power of the earthquake, maximum frequency of ground movement.

3) The transformation of the oscillations of the ground into intensity or magnitude by the induction of an electrical current produced by a solid bobbin pendulum within a magnetic field.

It would appear almost superficial to note that since the beginning of the 20th century the intensity of earthquakes have been described in relation to the acceleration of the seismic wave (see: Cancani's law). In 1935 Richter introduced «magnitude» which, like Palmieri, referred to the maximum frequency of the ground oscillations. In the same way, to underline the great progress in seismological equipment, the transformation of intensity into induced electrical current as was first performed by Palmieri and his «Electromagnetic Seismograph»!

After having described (Palmieri, 1850) and observed the eruptions of 1850 and 1872 and made an in-depth analysis of the previous eruptive events Palmieri confirmed that «the history of the Vesuvius eruptions have been of little interest to the scientific community who have not connected, associated, the eruptions with one another; where the studies should be considered within the concept of periods of activity, of various duration, which start with weak eruptions and which may lead to a final eruption followed by a period of rest». Palmieri (1896) concludes that «catastrophic eruption do not represent 'principal' events but 'final' events, which represent an exhaustion of the eruptive energy, and eruptive activity».

This concept, reinforced by his successors (Mercalli, Malladra and Imbò) depicted the eruptive cycle evolution of the Neapolitan volcano like no other. It must also be concluded that Palmieri's observations of prints and pictures of Vesuvius during periods of eruption led to the curious fact that these events occur during periods of full or new moon and never during half or quarter moons. This conclusion of eruptive activity and the phases of the moon ([4]) has not only come from half a century of observations by Palmieri of Vesuvius but also from observations of other volcanoes around the world, such as: Los Capelinhos (Azores Islands), Stromboli (Aeolian Islands), Paricutin (Mexico), Ngauruhoe (New Zealand) and St. Augustine (Alaska) which have confirmed Palmieri's conclusion.

Palmieri also applied spectroscopy techniques to study the activity of volcanoes (Palmieri, 1873, 1881 and 1895). In particular, he was the first to use spectroscopy to distinguish within fumarole products the presence of selenium, lithium, helium, thallium, which up to this point had only been recognised in the stratosphere. It was later also found closer to the surface of the Earth by Ramsay and Cleve.

This discovery was noted by Ramsay as to be the work of Palmieri, though after his death Piutti (1910) tried to attribute the work to Ramsay.

To demonstrate the advanced techniques of his geophysical surveillance of volcanic activity, due to his excellent understanding of the mechanisms involved, he proposed during a session of the Pontaniana Academy the way in which Vesuvius should be studied:

1) Recording of temperature, volume and composition of chemical products released from

fumaroles on and around the volcanic edifice.

2) Recording of thermal gradients within the various stratigraphic layers on a daily basis.

3) Recording of the seismic, geomagnetic, atmospheric-electricity and telluric-electricity activity and variations.

4) A comparison of these readings with those made in Naples and Rome, with the aim of separating regional variations from possible volcanic variations.

To this program today we must add gravimetry which in 1862 was not yet known.

In conclusion, it would appear that Luigi Palmieri, like some other great names, Galileo and Newton, had great insight and the ability to understand by observation some of the most complicated aspects of terrestrial physics and their applications which led to important conclusions. Though unlike Galileo and Newton there is no single event of genius, it can be said that through an accumulation of individual conclusions and the development of precise experiments and apparatus Palmieri was a pioneer of modern volcanology and geophysics. His most appreciated developments within these disciplines were the «the Palmieri Circle, double wire electrometer, Electromagnetic Seismograph» as well as the development of an advanced project of research and monitoring of the volcanic edifice. Also pioneering were his interpretations of the relative movement of the volcano with respect to the level of the sea.

His biography (Pinto, 1896; Santillo, 1898) noted his «ability and clarity in expressing both work and ideas».

It was for these reasons that Palmieri's lectures on terrestrial physics where so popular, often followed by a large number of students but also by professors from local and European institutions and visitors.

The renowned politician and scientist Don Pedro of Alcantara was a frequent visitor to the University of Naples and the lectures of Luigi Palmieri by who fascinated him (Santillo, 1898).

Luigi Palmieri not only privately received admiration from his peers and from the public, which he was known not to appreciate ([5]), but was also honoured by many noble families of Europe, receiving many orders of Sirs and Knights within Europe and all Orders within Italy. From Italian Royalty he received the nomination of «Grande Ufficiale» (Honourable Official) of the orders of SS. Maurizio and Lazzaro and the Order of Knights of Savoia. He received this last nomination together with Giuseppe Verdi, the famous composer (Santillo, 1898). He enjoyed the same treatment within the academic world receiving positions of honour as well as being nominated for life Presidency of the Examinations Commission of Experimental Physics and Chemistry.

In a commemorative recognition of his work Malladra (1923) called him «The Father of Volcanology», and Alfano (1915) called him «The Founder of Volcanology».

Today, 100 years after his death, Palmieri still receives renowned recognition of his life's work and the way it has led to the modern techniques of geophysical and volcanological surveillance and monitoring.

NOTES

([1]) In which it was said that due to his extreme regularity, in both life and work, the residents of the area where he lived could *«adjust there watches as he passed»*.

([2]) This assumption was first verified by Weber, Neumann and Helmotz in 1840 by the publication of their classic work on electrology with the realisation of numerous experiments and new iterative apparatus.

([3]) This movement was broken down into two components; horizontal, defined as *ondulatorio*, and vertical, defined as *sussultorio*. Which were then used to divide earthquakes, depending upon the primary direction. This however is not correct as it is now known that the characteristics of the components are dependent upon the position of the receiver with respect to the epicentre. Another of Palmieri's incorrect conclusions came from his courageous experiments of the relative density of lava. Palmieri suggested that the relative density of lava was greater than that of iron, simply because pieces of iron put on lava flows did not sink. It was later shown that this was due to the viscous nature of lava and not to its density.

([4]) It was this argument which Palmieri presented at his last public conference (Santillo, 1898).

([5]) The same can be said for little interest in money. Santillo (1898), noted his refusal to conduct a series of conferences in America for a large fee, as well as his refusal to sell the rights of his *diagometro*, a type of electroscope, to the French.

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