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Hunting for Radium in Italy during the First World War: Marie Curie and Italian mineralogists and geologists

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ABSTRACT

Marie Curie's visit to Italy in August 1918 started with research for helium gas on sites chosen by chemists. She dedicated the two last days only to the Lurisia autunite occurrence as a possible source of radium. Here, mineralogists took over the leadership. They continued surveying after her departure, even after the war was over. Their study went on with continuous interaction with geologists and chemists. The outcome was abandoning the Lurisia mining claim as unprofitable, and transferring its right to a thermal water spa.

KEY WORDS: autunite, Lurisia, Maritime Alps, pitchblende, radioactivity, radium.

INTRODUCTION

July 31, 1918. A telegram from the Army headquarters in Rome – Office for Inventions and Research - summons Second Lieutenant Camillo Porlezza, a young assistant to Professor Raffaello Nasini's chair of Chemistry in the University of Pisa, for an immediate military duty: «*Stanotte ore 3.30 arriverà costì Signora Curie. Prego incontrarla stazione*. » (= Tonight [i.e., August 1] at 3.30 a.m., Madame Curie shall arrive there. Kindly meet her at the station [i.e., of Pisa]).

The visit to Italy of the twice Nobel Prize winner Marie Curie sharply begins in this way, to last until August 18, 1918. Then, she will leave Italy through Ventimiglia, leisurely heading for Paris and the *Institut du Radium* she was directing there. During the previous decade, the Italian Society for the Advance of Sciences (SIPS) led by Vito Volterra had often invited her to visit Italy, and she had always politely declined. This time, she had agreed to the official invitation, and had chosen a short moment of rest of the enduring war, when the "*battaglia del solstizio*" (= solstice battle: June 15-22, 1918) was over and the following, definitive battle against the Austrian-Hungarian enemy empire had not yet started.

The Italian Army had invited Madame Curie giving her the role of counsellor (Simili, 2013). Indeed, ever since late 1914 she had set up along the French front a system of mobile units ("*les petites curies*"), each consisting of a car equipped with some essential apparatus for radiology. These mobiles units would give immediate help and relief to wounded soldiers by locating metal fragments in their flesh. She felt she should share her experience on this sanitary matter with the Italians too, since she knew that their mobile radiological equipment on trucks was by then obsolete. Moreover, she planned to give additional help by measuring Italy's potentials in radioactive materials: radium first and "*émanation*", the radioactive gas (actually, radon-226) she and her late husband Pierre had studied deeply and extensively. Her long experience told her that both radioactive sources would greatly help over healing the numberless wounded soldiers that such an interminable war was continuously producing.

The expectations by the involved military circles, consisting mostly by physicists and chemists cast away from the front and set into the backline Office for Inventions and Research, were different. They too aimed at finding suitable sources of radium, indeed a very effective mean for curing, but also a very expensive one. However, their priority was for helium, a light gas that chemists would possibly draw out from vapours arising from radioactive thermal springs, where it is intermixed with *émanation*. Helium, in their expectations, was a more important commodity than radium was, as it could substitute for hydrogen as the uplifting medium of balloons and dirigibles, at that time a fundamental strategic implementation for the air survey of the battlefront (cf. Porlezza, 1920; Gallo, 1921).

MARIE CURIE'S TRAVELS THROUGH ITALY TESTING FOR RADIOACTIVITY

At first, Marie Curie obeyed to the military priority. She and her little group of scientists, most of whom were enrolled in the Army, visited three thermal spring in Tuscany, including Larderello, the geothermal field chosen by Nasini and his assistants as the best possible extraction site for helium and other noble gases, because the hot vapours were already in use to extract boron and to generate electric energy. Then the group moved to Ischia. There they measured the radioactivity of "Sorgente Romana" at Lacco Ameno, measured previously by Julius Engler and found by him to be among the most radioactive springs in the world (Engler and Sieveking, 1907). Curie's data were even higher than Engler's [2247 $\times 10^3$ Bq/L], and the water daily discharge showed that the spring could be a first-rate industrial source of *émanation*. By contrast, when they crossed Italy northwards to measure the spas in the Euganean thermal district, they found that their radioactivity was very low. All together, the results obtained during the first two weeks did not inspire too much confidence in the Italian potentials for helium, the inert gas that would best substitute hydrogen because it is not inflammable (Porlezza, 1921).

It was shortly before the end of the travel, on August 13 at Padua, the town hosting the front headquarters of the Italian Army, when Marie Curie decided to put an end to her position of military counsellor and to turn to her real priority: the sanitary project, which had actually been the main reason for her visit to Italy. Porlezza (1939 p. 12) records the change of her mind in this way:

«*In questa occasione la signora Curie passando in vicinanza di ospedali militari della zona di guerra espresse il desiderio di prendere visione degli impianti a raggi X e delle installazioni da campo per l'impiego di essi. Ricordo che essa manifestò il proprio compiacimento per la nostra organizzazione, rammentando quanto lavoro essa aveva dovuto compiere in Francia per analoghe installazioni*.» (= When traveling next to the military hospitals in the war zone, she asked to visit their X-ray apparatus and their mobile instalments. I recall that she congratulated for the Italian organization, as she could remember the great work she had been compelled to carry out in France to obtain similar instalments).

Porlezza does not mention it (possibly, he had not even realized it), but Madame Curie had also noticed that none Italian radiologic setup had a radioactive source depending on radium. The lack of such an important sanitary commodity urged her to visit the secluded village Lurisia, near Mondovì, in the Maritime Alps of Piemonte, at that time the only known Italian significant occurrence of uranium-bearing minerals (Fig. 1).

Fig. 1 - Madame Curie visiting the Nivolano quarry.

THE LURISIA AUTUNITE SITE

The occurrence of autunite (hydrated phosphate of uranyl and calcium: $Ca[UO_2|PO_4]_2 \cdot 10\text{-}12H_2O$) showing up as crusts on the cleavage planes of slabs of the "besimaudite" rock extracted at Lurisia for building purposes had been studied just before the war by Gabriele Lincio (1913), then a "libero docente" at Turin University.

Gabriele Lincio (Varzo, 1874 – Genova, 1938) is a praiseworthy example of scientist who earns best formation abroad and goes back to his native country only when he can contribute effectively to its development. Lincio had started studying Mineralogy in Turin under Giorgio Spezia (1894), but he soon left for Germany and graduated at Freiberg as "*Ingenieur-Geologe*" (1898). He then became the Curator of the Clausthal Mineral Collection (the first non-German person holding such a historically significant position) and earned his doctorate at Marburg (1905) after performing advanced studies at Munich under Paul von Groth and at Heidelberg under Viktor Goldschmidt. In 1904, then, he was back home, but after two year of unsuccessful attempts at getting permanent employ anywhere, he returned to Germany. Here, as "*Wissenschaftlicler Leiter der mechanisch-optische Werkstätten"* (= scientific director of the optical-mechanical section) of the Ernst Leitz company in Wetzlar, he developed a synchronous polarizing microscope (Lincio, 1906), which Max Berek, who succeeded him in 1912, further improved and made the standard research instrument for Petrology all over the world till several years after World War Two. Eventually, on his second attempt to return to Italy, Lincio could start a brilliant academic career: from "*libero docente*" in Turin (1909), he progressed to "*professore incaricato*" i.e., adjunct professor in the universities of Cagliari (1916-20) and Modena (1921-26). He ended up as full professor of Mineralogy and director of the Mineralogical Institute and Museum of Genoa University (1926-1938). The Italian Army did not draft him during the war, either because he was too old, or, possibly, because he was then teaching Mineralogy in Sardinia. This island was the most important district for the extraction of zinc and lead ores i.e., two metals essential for many military apparatus, and the presence of an expert directly on the spot was needed. Actually, Lincio was a very competent mineralogist, with a special inclination for practical applications, such as, e.g., developing a better apparatus for heavy mineral separation (Lincio, 1914). He had immediately recognized the greenish-yellow flakes encrusting "besimaudite" in the specimens received from Lurisia to be those of a "uranium-mica". To confirm his first view, he measured their tetragonal crystal morphology and uniaxial refraction indices, performed several chemical tests, which include a quantitative determination of UO_3 (60.57%), and even tried a first, approximate estimation of radioactivity. However, with the instrumental set up available at that time at Turin University, he could not determine radioactivity quantitatively. Thus, he just made a comparison between the Lurisia ore and the uraninite-rich pitchblende from the well-known locality Sankt Joachimsthal in Bohemia (now Jáchimov, Czech Republic). He clearly noticed that the Lurisia ore darkened the photographic film less than the reference mineral did (Fig. 2), as expected because of its lower uranium content. However, it was strongly radioactive.

Based on all these characters Lincio determined the specimen to be autunite, this being the first finding of this species in Italy. He did not go farther, nor was the new occurrence of the rare mineral exploited. By contrast, it was the water of the spring Nivolano, pouring out of "besimaudite" and encrusting the stone layers with autunite, which turned out to be so highly radioactive as to attract also the attention of the scientists. It was because of this potential lavish source of *émanation* that they had planned Madame Curie's travel to include the visit of Lurisia. The water of the Nivolano spring is indeed strongly radioactive, and Madame Curie measurements confirmed it, but her real interest turned back to autunite, being such a rare uranium mineral and a potential source of radium.

In August 1918 Lincio was not at Lurisia, thus he was not able to show the mine to Madame Curie. Another mineralogist, a close friend of him, was present, as documented by a picture taken on the spot (Porlezza, 1939 p. 13): Ten. Col. Pelloux. Moreover, the visiting party included Volterra i.e., the initiator of the travel of Madame Curie to Italy and the most interested person of its results in view of his plans to create an Institute for Radium in Rome similar to that existing in Paris from 1909.

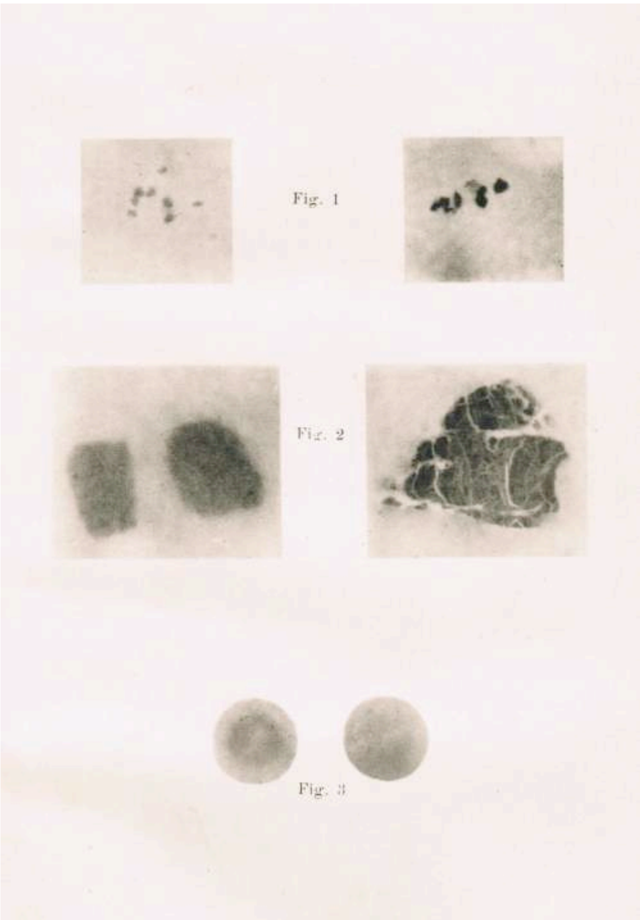

Fig. 2 - Darkening of the photographic film by the radioactivity of autunite from Lurisia (links) and pitchblende/uraninite from Sankt Joachimsthal (right).

Alberto Pelloux (Crema, 1868 – Bordighera, 1948), although not as highly qualified academically as Lincio was, is by far a more important actor on this stage. He was the son of a military officer from Savoy (Luigi Girolamo Pelloux) who had decided to follow his dynasty after the recess of his native region to France and rose all ranks of the Italian Army up to the top, becoming Lieutenant General and "*Capo di Stato Maggiore*" (= chief of staff). During the difficult years 1890-1900, he turned to politics and became President of the Council of Ministers (1898-1900). At first, Alberto Pelloux followed the family military tradition, and was on permanent duty from 1886 to his retirement as Captain in 1913. However, from 1898 on, in his free time he took up Mineralogy at the University of Rome, under the guidance of Professor Giovanni Struever. He became acquainted also with his assistant and successor, from 1915 on, Federico Millosevich. His outcomes were so good as to be appointed, in 1906, when still a military officer, director for Mineralogy of the City Museum "Giacomo Doria" in Genoa. When Italy entered World War One, he resumed his military career as Lieutenant Colonel and staff member of a division. In 1917, he moved the "*Ufficio Invenzioni e Ricerche*" (Office for Inventions and Researches) and here the officer in charge, Captain Vito Volterra, entrusted with evaluating the economic potentials of several orebodies throughout Italy. He continued with the same activity when he definitively left military duty in 1919 and, as a professional mineralogist, he surveyed orebodies in Alto Adige and Venezia Giulia. In particular, he studied the Idria cinnabar mine, which was the most profitable mine among all those confiscated from the Austrians for use of the Italian state. In 1920, Ansaldo Co. of Genoa appointed him as director of all mining research, thus putting him in charge of several mines in Italy and Albania including, from 1922 on, that at Lurisia. Concurrently, he started lecturing Applied Mineralogy at the University of Genoa, where in 1938-39 he had to take over the position of Professor of Mineralogy and Director of Institute because of the premature death of his long-time friend Lincio.

A third, important character enters now the cast of the Italian research on radium. He had not been present at Lurisia at the time of Madame Curie's visit, but he arrived shortly afterwards and surveyed the mining site for a few days together with his former pupil Pelloux.

Federico Millosevich (Venice, 1875 – Rome, 1942) was born from an outstanding astronomer, Elia, who in 1879 had moved to Rome as head of the local observatory. Therefore, he enrolled in the University of Rome and became a favorite student of Giovanni Struever. He learned from him not only the principles and the practice of morphological crystallography, but also the newly developed petrography and petrochemistry. To them, he added of his own a strong inclination for the economic aspects of Geology, mainly the study of orebodies. After five years passed as assistant to Struever, during which he had had Pelloux among his trainees, he lectured general Science in a Roman Lyceum for five more years before being nominated as extraordinary professor at Sassari University (1906). In 1908, he moved to Florence, where he advanced to full Professor of Mineralogy (1910), and finally he succeeded

Struever in Rome on October 16, 1915. When the war broke out, he refused (as he could have done, being a full professor) to withdraw from duty and joined the Territorial Army as Second Lieutenant. He was immediately involved in the activities of the Office for Inventions and Research, and did so well there as to gain promotion to Captain in June 1918.

After his first survey of the Lurisia site in September 1918 together with Pelloux, he published an evaluation of the geological asset of the area and of the related economical potential. This essay, hastily published in January 1919, contains the first quantitative data on the real amount of radium present in the orebody. For first quality ore: 1,3 × 10^{-7} g Ra over 1 g autunite (thus, confirming the results obtained independently by Marie Curie at Paris and Camillo Porlezza at Pisa on selected crystals: 1,3 × 10^{-7} g Ra), and 0,62 × 10^{-7} g Ra for autunite just scraped off the rock schistosity planes (Millosevich, 1919 p. 3). Millosevich's evaluation concludes that the Lurisia ore has excellent qualities and potentials, and the mine is worth as much as Guarda in Portugal, at that time the most productive sources available to the Entente states. The War had ended, but Sankt Joachimsthal was not yet open to interstate commerce, thus Millosevich's suggestion at pushing exploration at Lurisia by drilling galleries was open-minded, the more so as Secondo Franchi, who too had studied the geological structure of the area, supported it (Franchi, 1919). Indeed, he had revised the structural geology of the entire area in 1906 and, being well aware of the setting of most "besimaudite" outcrops all over the Maritime Alps, suggested the excavation of horizontal exploration galleries parallel to the main schistosity (Franchi, 1919, 1923). It is worth noting that the official geological maps surveyed in the years 1880-87 by Domenico Zaccagna (F° 91 Boves, F° 92 Albenga) did not appear until 1934 and the relevant explanatory notes until 1937 (!), when the State had already inclined to give up the claim.

WHY LURISIA DID NOT DEVELOP AS RADIUM MINE?

Towards the end of 1921 the *R. Commissione per lo studio delle sostanze radioattive* (= Royal Commission for the study of Radioactive Materials), chaired by Volterra and assisted by Millosevich, decided to survey the Lurisia uranium prospect. The reason was that Raffaele Bellini, a geologist, had found torbernite, another hydrated copper and uranyl phosphate, $Cu[(UO_2)|(PO_4)]_2 \cdot 8\text{-}12H_2O$, associated to autunite, limonite and wad i.e., Fe- and Mn-rich clays (Bellini, 1920), thus confirming the superficial formation of both minerals in a water-rich environment.

Pelloux was the right man to oversee the mining activities. As soon as he took over as responsible for the Ansaldo Co., he appointed for the chemical analysis of autunite Camillo Porlezza, whom the Army had released in 1919. He had gone back to the University of Pisa as research assistant.

The exploration began in late 1921 and ended in October 1923 after excavating only 120 m (Stacchini, 192): the ore found was too little.

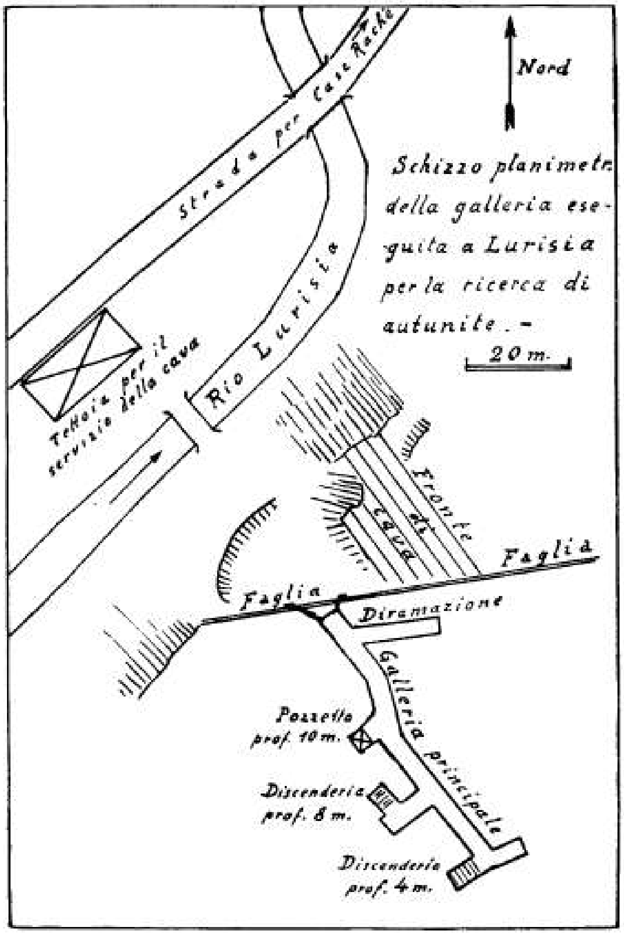

Fig. 3 - The Lurisia abandoned gallery and pit system.

A second exploration started in January 1933 (Corradi, 1934) within the frame of the autarchic policy. Further analyses of the radioactivity were carried out (Francesconi and Bruna, 1934) and a complete mineralogical and geological description was made (Pelloux, 1934, 1938). Indeed, from 1932 to 1937 a system of galleries and pits was excavated that was 350 m long and crossed the entire mountain slope from Nivolano to the nearby Asili gulley (Fig. 3). Once again, the results were unsatisfactory and the State renounced definitively to the Lurisia mine rights in 1939. At the same time, it conferred the entire area (561 hectares) to a private company, which intended to use the mineral water for a thermal resort (Ruata, 1943). The company built the resort rapidly, opened it during the first years of World War Two and operates it till now. However, the spa draws its water from another spring (Santa Barbara), since the Nivolano (also called Garbarino) spring is far exceeding the limits about water radioactivity, not only for bottling but also for direct use. Indeed, the radioactivity of the Nivolano spring is 13,219 ×10^6 Bq/L, the second highest in the world.

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REFERENCES

Bellini R. (1920) - Osservazioni sui minerali radiferi della besimaudite di Lurisia. Boll. Soc. Geol. It., 39, 208-212.

Corradi C. (1933) - Nota sulla ricerca di autunite in comune di Roccaforte, frazione Lurisia (Mondovì). Per. Miner., 4, 252-266.

Engler C., Sieveking H. (1907) - Zur Kenntnis der Radioaktivität der Mineralquellen und deren Sedimente. Z. Anorg. Allgem. Chemie, 53, 1-25.

Francesconi L., Bruna, R. (1933) - Radioattività e composizione delle acque della regione di Lurisia in quello di Mondovì, dei suoi minerali e delle rocce. Atti Soc. Ligustica Lett. Sc. Arti, 13, 124-136.

Francesconi L., Bruna R. (1934) - Relazione fra il colore e la composizione dell'autunite di Lurisia. Gazz. Chim. It., 64, 650-652.

Franchi S. (1906) - La zona delle pietre verdi fra l'Ellero e la Bormida e la sua continuità fra il gruppo di Voltri e le Alpi Cozie. Boll. R. Uff. Geol. d'Italia, 7, 88-117.

Franchi S. (1919) - Sulla giacitura dell'autunite di Lurisia in territorio di Mondovì. La miniera italiana, 3, 52-54.

Franchi S. (1923) - Nuove osservazioni sul giacimento di minerale radifero (autunite) di Lurisia. La miniera italiana, 7, 9-11.

Gallo G. (1921) - La produzione di gas leggeri per aeronautica. L'Aerotecnica, Giornale ed Atti dell'Associazione Italiana di Aerotecnica, 1, 28-48.

Lincio G. (1906) - Das neue Leitz'sche mineralogische Mikroskop-modell A. N. Jb. Min. Geol. Pal., 23, 163-186.

Lincio G. (1913) - Dell'autunite di Lurisia. Atti R. Acc. Sc. Torino, 48, 959-967.

Lincio, G. (1914) - Verbessertes Trennungsgefass für schwere Losungen. Beitr. Kryst. Min., 1, 103-104.

Millosevich F. (1919) - Il giacimento di autunite presso Lurisia. La Miniera Italiana, 3, 1-4.

Pelloux A. (1934) - I minerali uraniferi e le sorgenti di acque radioattive della miniera di Lurisia. Atti Soc. Ligustica Sc. Nat., 13, 137-170.

Pelloux A. (1938) - Le sorgenti radioattive di Lurisia ed i minerali di uranio e radio che le accompagnano. Indagine mineraria e studi a cui diedero luogo per la loro ricerca ed utilizzazione. Morino, Genova.

Pelloux A. (1942) - Notizie sulle nuove ricerche di minerali ed acque radioattive nella concessione di Lurisia (Roccaforte di Mondovì). Rend. Soc. Min. It., 2, 61-62.

Porlezza C. (1920) - L'ottenimento industriale dell'elio. Giorn. Chim. Industr. Appl., 1, 638-691.

Porlezza C. (1939) - La missione della Signora Curie in Italia nel 1918. Terme e Riviere (n. 22, 20/11/1938 - XVII), Lischi, Pisa.

Porlezza C., Donati A. (1922) - Analisi dei minerali di Lurisia. Ann. Chim. Appl., 15, 518-534.

Porlezza C., Donati A. (1926) - Ricerche sull'autunite di Lurisia. La Miniera Italiana, 10, 79-82.

Ruata G. (1943) - Un primato italiano: le acque radioattive di Lurisia. Le Vie d'Italia, 49, 413-417.

Simili R. (2013) - Vito Volterra and Marie Curie: The birth of the Italian Commission on Radium. Giorn. Fisica, 54, 59-76.

Stacchini P. (1924) - In Italia esiste una miniera di radio. Le Vie d'Italia, 30, 837-844.

Zaccagna D. (1887) - Sulla geologia delle Alpi occidentali. Boll. R. Uff. Geol. d'Italia, 8, 346-417.