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Alfred E. Bergeat (1866–1924): a distinguished volcanologist and ore deposit researching scientist at the mining academies of Freiberg (Saxony) and Clausthal (Harz mountains) in Germany

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Abstract Alfred E. Bergeat, originated from a family, who produced gold-glance in a factory (porcelain painting), studied mineralogy and geology at the University of Munich from 1886 to 1892. Due to the results of his habilitation work on the volcanism of island arcs, especially of the Stromboli volcanic island in the Tyrrhenian Sea, he became a recognized volcanologist and specialist in volcanic petrography. He further became an explorer of syngenetic, epigenetic and deuterogenic ore deposits at the mining academies (Bergakademien) of Freiberg (Saxony) and Clausthal (Harz mountains). He described these ore deposits in a two-volume manual (1904–1906) which was summarized again in 1913. After his early death in 1924, the two manuals "Die Vulkane" (1925) and "Vulkankunde" (1927) were posthumously published by his colleague and friend Karl Sapper (1866–1945).

Introduction

Both, the University and the technological high school, had especially in the last third of the nineteenth century prominent and international well-known high school teachers. Descending scientists did not found independent work directions, but gained them after departure to other universities. Through his excellent habilitation work on the volcanism of the Liparic Islands, A. E. Bergeat achieved a high scientific reputation in the mining academies (Bergakademien) of Freiberg and Clausthal. His reputation further raised by the posthumous edition of both manuals (1925, 1927), called "Vulkane" and "Vulkankunde". His two other manuals "Die Erzlagerstätten" and "Abriß der Erzlagerstättenkunde"(1904–1906, 1913) were based on the extensive collections from the famous outcrops and mining districts in the mountains of the Erzgebirge and the Harz, which were available to him for his fundamental investigations in the best equipped laboratories and libraries of these days. A. E. Bergeat did never consider a comeback to the University of Munich, the locality of his glancing habilitation, because of the great support he received at Freiberg and at Clausthal.

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Biography of Alfred E. Bergeat

Alfred Edmund Bergeat (Fig. 1) was born on 17 July 1888 in Passau (lower Bavaria, southern Germany) as a son of Cristhoph and Elisabeth Bergeat having ten brothers and sisters. The Family Bergeat originated from Thonon (Chablais, France). She immigrated to Bavaria and settled at Schottermühle near Ebermannstadt in Franconia. There, Cristoph learned the Job of miller, but later studied technology in Munich and chemistry in Nuremberg and was appointed as teacher for the district at the junior high school in Passau. Through the invention of glance gold for porcelain painting (Bergeat 1860) he has acquired a great capital, which he could transfer to his son Eugen, but Eugen died already in 1901 and this event terminated the fabrication of glance gold.

After school years in Passau, Nuremberg and Wiesbaden, Alfred E. Bergeat studied sciences (geology, mineralogy and botany) in Munich from 1886 to 1892. His academic teachers were the professors v. Zittel, v. Groth,

Fig. 1 Alfred Edmund Bergeat (1866–1924), from R. Brauns 1924

Radhof, v. Baeyer, Lommel, Hertwig, Rothpletz, Dingler, Eik, Palety, Löw, Naumann, Fraas and Weinschenk. In 1892 he received his PhD with a work on the geological constitution of the Island of Cyprus (Bergeat 1892). His "doctor fathers" were Karl Alfred v. Zittel and Ernst Weinschenk.

None of the industrious and ambitious and talented young assistants and private docents had a real chance of acknowledgement and promotion from their dominating teachers and scientific popes at the University of Munich: Carl Wilhelm von Gümbel (1823–1898), Karl Alfred von Zittel (1939–1904) and Paul von Groth (1843–1927), the last one of them even celebrated himself as "the world highest authority in crystallography".

Therefore, Bergeat left Munich to join Alfred W. Stelzner as an assistant at the well-known mining academy in Freiberg (Saxony), where he met with his later wife Sophie Heisterbergk. After the early death of Stelzner he went back to the University of Munich as docent of mineralogy and geology in order to present his habilitation work on the geology and mineralogy of the volcano Stromboli (Liparic Islands). In 1899 he was appointed for a professorship in geology and deposits at the mining academy of Clausthal (Harz). After 10 years, in 1909 he was appointed as full professor of mineralogy at Königsberg (Eastern Prussia) and finally in 1921 he was appointed at the University of Kiel. There, he worked until his death due to an apoplectic stroke in 1924. In 1920 he became a corresponding member of the Prussian Academy of Science in Berlin.

The new foundation of the mineralogical institute and the new set up of the mineralogical collections of the mining academy in Clausthal resulted mainly from the effort of Bergeat. In honour of his work, he was delegated to the centennial celebration of the English Geological Society on London in recognition of these achievements. Bergeat took part in the international congresses of geology in America, in Austria, in Sweden, and in Canada. He received an honorary doctor degree of the faculty of law of the University of Montreal.

Alfred E. Bergeat was a vivid teacher and an indefatigable worker. The marine geologist Karl Andrée (1880–1959) started his scientific career under Bergeat as an assistant. He was an open minded character, he had a quick apprehension and a bright sense of humour. At the beginning of the First World War he voluntarily joined the Bavarian Army as patriot until he was asked to return to the University of Königsberg (Kaliningrad) to act as dean. The end of the war with all its consequences for Germany hit him very hard since he was a monarchist throughout (Brauns 1924). His list of publications records 36 books, brochures and single papers.

The habilitation work on the volcano Stromboli (Liparic Islands)

The mining consultant Dr. Stelzner in Freiberg procured him a study during teaching vacation on the Liparic Islands near Sicily in the Tyrrhenian Sea for doing the fieldwork for his habilitation at a German university. Already during a reconnaissance work (Fig. 2) prior to this extended field campaign, he made important corrections of previous observations (Bergeat 1896, 1899). It was his aim to combine previous communications of the condition and the set up of the volcano Stromboli with his own observations to an integrated study and description. His exact geological and petrographical mapping (Fig. 3) allowed a first concept of the evolution of this volcanic island. In autumn 1894 Bergeat returned from his 11 weeks fieldwork with about 800 samples of rocks from which 500 thin-sections were prepared in the institute of Freiberg.

One can read in his habilitation, already completed in 1896 the following: (the way how it is cited tries to follow the wording of that time):

"The first volcano (Stromboli), however, whose description is given on these pages, had been described so many times that I felt quite desperate at the beginning how I may be able to contribute new aspects to the knowledge. At that time I barely had decided to describe the volcano in such a comprehensive way as I did, if it had not turned out

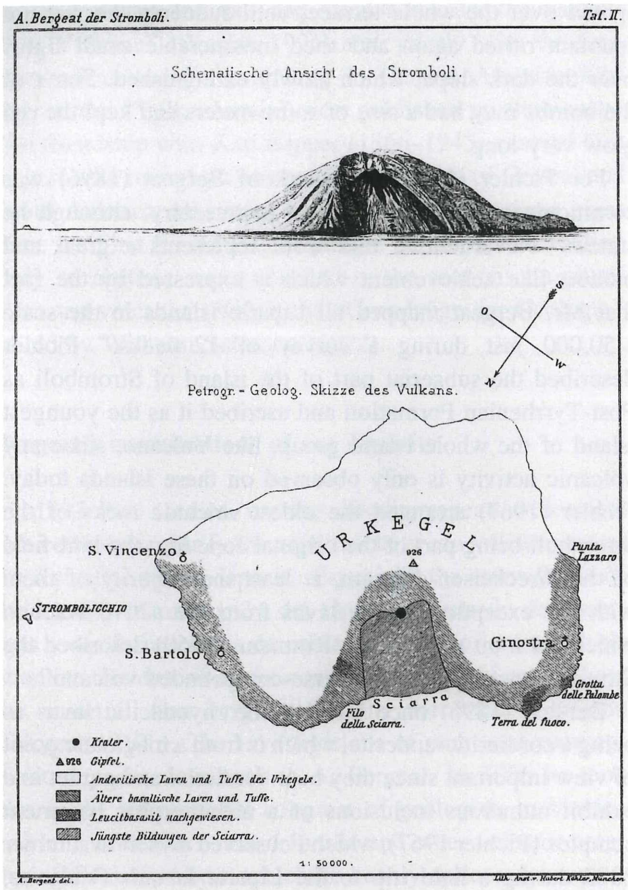

Fig. 2 Schematic view (*above*) and geologic-petrographic sketch of the volcano Stromboli (Italy), from A. Bergeat 1896

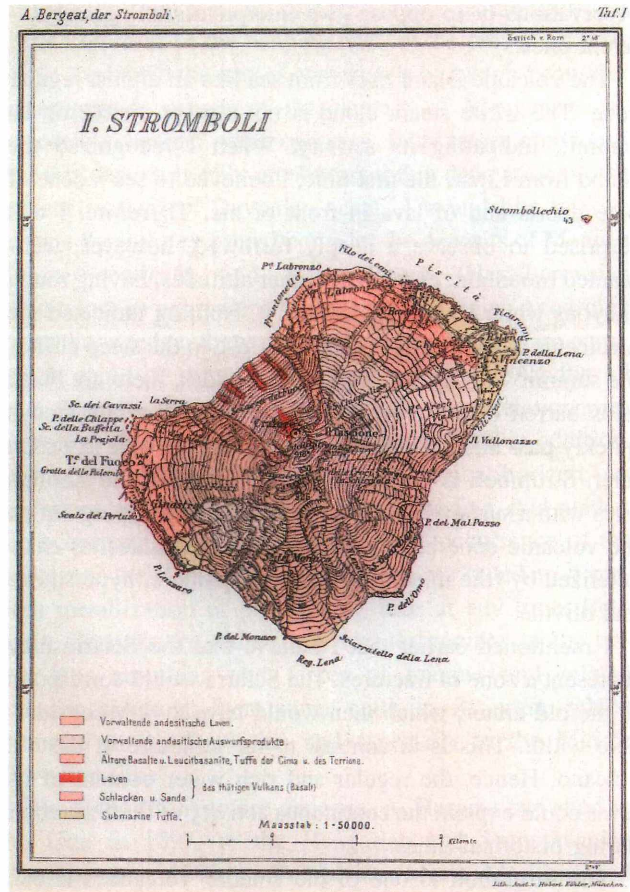

Fig. 3 Geological and petrographical map of the island of Stromboli (Liparic Islands) in the Tyrrhenian Sea, Italy, from A. Bergeat 1896

soon that the numerous papers provided many known aspects repeatedly while, on the other hand, they reported volcanic activities from different times: the combination of these different observations into one homogenous picture, however, was it worth to do this effort. I added all my own observations on the island during an 8-day stay, and, for the first time, I tried to outline the evolutionary history of the volcano. Within the small Aeolian Archipelago the island Stromboli is the most famous one. The still recent active volcano had inspired the imagination of the ancient people, and from this imagination also the name of the whole Island group derived, since on these islands the master of the winds, King Aeolus, had his residence according to a beautiful legend of the ancient people. The active volcano of Stromboli, located close to the sea passage between Napoli and Messina with its numerous ships passing by, was an attraction and a spot of admiration for sailors and travellers already in ancient time, long before the Vesuv restarted its explosive activity, which spread out fear and horror over southern Italy. And everybody, who travelled from Napoli to Messina during a bright night, will remember the beautiful spectacle, which offered the nightly and dark mountain to him: how a flash of fire shoots up into the air from the summit after longer or shorter periods, how it flashes only in a reddish blaze, or how the resting clouds over the mountain are bathed in red by the fire, or how thousands of glowing cinders pouring off the crater downhill inspire the impression of an out bursting lava flow.

The island has attracted scientists already from the beginning of its geological investigation, since it is easy to reach during the proper season and especially suitable, to observe the eruptive phenomena even in small scale from very close distances. Therefore, it was visited by numerous geologists of different nations and is still one of the most well-known localities of the Mediterranean Sea today. Hence it might almost look like that hardly any new aspect would be possible to be added to the published papers on the geological relations of the island. However, I do hope not to do needless work, if I am sketching here a complete image of what others reported before me and what I saw during an 8-day stay on Stromboli (10–17 October 1894). There exist repeated opportunities to combine old and new observations or to oppose own interpretations against different ones.

The volcanic island rises from sea like an almost regular cone. The white steam cloud is not always visible on its summit, indicating its activity. When I recognized the island from Lipari the first time, I believed to see a cone of bare debris and of lava in front of me. Therefore, I was surprised to observe a deeply furrowed, however, well-planted mountain, even up to higher altitudes, having rough canyons while I was approaching it. Nothing indicated me a volcanic activity. Only at the top close to the steep cliff of the summit with its drop offs to three sides, there are black talus barren of any vegetation above which white clouds quickly pass and become disintegrated in the blue sky soon after. Stromboli is the fourth largest island of the Aeolian Isles with a surface of 12.5 km^2. The rocks cropping out on the volcanic cone belong to the pyroxenic andesites characterized by (the minerals) biotite, amphibole, hypersthene and olivine.

I mentioned earlier that I believe that the Sciarra may represent a zone of fractures. The Sciarra would correspond to the old crater, which then would have a very considerable width. This is in contrast to the structure of the old volcano. Hence, the regular and rich water content of its lavas could explain the continuous activity of the Stromboli during historical times.

The Stromboli is one of the smaller volcanoes if one focuses on the smaller altitude of 926 m above sea level. However, in reality one is faced with a giant cone, which could be traced down to water depth of 2,300 m and therefore rising more than 3,200 m from the sea floor and is representing one of the largest known volcanoes. The sea covers most of its parts and ships drop their anchor close to the summit. During my observations of the volcano on 11, 14, 17 October, I recognized four craters at the end of the steeply inclined talus, originating from the inner circle on a line connecting Filo del Zolfo and Torrione.

The spectacle of 14 October in a full moon night was of a grave beautifulness. There was bright glow over the "Antico" from time to time. The roaring activity of the third crater was much more creepy in the silence of the night and produced burning bundles of glowing lapilli, like wet powder is being slowly blown up. However, the eruptions of the western pipe were most splendid. They started with a slight roaring, which was accompanied by increasing and decreasing illuminations while ductile masses of lava extruded sometimes on the edge of the crater. Suddenly it seemed that the glowing flood would rise over the abyss and a fire bundle unfolded itself with an explosion, which we attended with a tapping heart, like one of those bouquets, which ends classical fireworks. However, the explosions occurred even without warning and any sign of preparation. Sometimes a deep silence was spread over the whole terrace, until suddenly the red fire fountain raised again and shed innumerable small lights over the dark slope, which slowly extinguished. Some of the bombs may had a size of some meters and kept the red glow very long.

For Pichler (1967), the work of Bergeat (1896) was commonly out of date and also fragmentary, although he stated: "Nevertheless, this work represents a great and pioneer-like achievement which is expressed by the fact that Mr. Bergeat mapped all Liparic Islands in the scale 1:50,000 just during a survey of 12 weeks." Pichler described the subaerial part of the island of Stromboli as Post-Tyrrhenian Formation and ascribed it as the youngest island of the whole island group, like Vulcano, since any volcanic activity is only observed on these islands today. Pichler (1967) arranged the oldest volcanic rocks of the Stromboli being part of the original cone into the latit-field of the Streckeisen-diagram, at least the majority of them with the exception of the lavas from the active volcano which are a bit more basic. Rittmann (1960) described the Stromboli as a type of "inverse-compounded volcano".

Bergeat (1896) once labelled the rhyodacitic lavas as being a cordieritic-andesite, which is from a magmatic point of view important since they bear cordierite and garnet and exhibit numerous inclusions of a metamorphic basement complex (Pichler 1967), which I observed myself in summer 2005 during a field trip to the Liparic Islands (Vulcano, Lipari, and Stromboli). The xenolithic inclusions of cordierite–sillimanite–shists with andalusite, biotite, garnet, and spinel indicate a sialic–anatectic origin from the "pacific group" of magma sensu Bergeat (1910a) and Pichler (1967). This paper of Bergeat (1910a) concerning the cordierite and andesite from Lipari benefited a lot from his comprehensive studies for his thesis in 1890, published in 1892 in which he focused on the genetic relations of andalusite, sillimanite, biotite, cordierite, orthoclase, and spinel, based on rack samples he collected on Cyprus. A final paper was published in 1920 on the petrography of the Liparic Islands.

A. Bergeat was very much interested in volcanic processes, the examination of volcanic rocks and their genesis. His work on the Aeolian Islands will always remain as a fundamental scientific contribution, since it focused for the first time on the evolution of a volcanic island and its geological system with different eruptions and different magmas. According to Brauns (1924) he managed that in an excellent way. Bergeat wrote himself: "… the Italians quietly accepted my activity and my scientific work on one of their most beautiful geological areas, although I did not asked anybody in Rome before or afterwards." Instead, the academy of science Aci Reale appointed him a member in recognition of his geological work.

Bergeat did not describe only the volcanism of the island arc of the Aeolian Islands Stromboli, Panaria, Salina, Lipari, Vulcano, Filicudi, and Alicudi, but also the manuals "Die Vulkane" (Breslau 1925) and, jointly with the German volcanologist researching in Central America Karl Sapper, the "Vulkankunde" were published posthumously. The friendship with Karl Sapper (1866–1945) enabled him to start with investigations on the volcanism of Central and South America. However, he could not finish these plans since the First World War requested his service as soldier. Only an abstract was published in the sections on plutonism and volcanism within the "Grundzüge der Geologie" edited by Wilhelm Salomon (1922).

Bergeat's examinations of ore deposits

In 1897 his studies on the Mediterranean volcanism induced him to clarify the relations between volcanism and the formation of ore deposits. Especially the granodiorite of the locality "Concepción del Oro en el estrado de Zacatecas y sos formaciones de contacto, Mexico" attracted his attention. He described the contact metamorphism and how the material flux originated from the related magma (Bergeat 1910b). The investigations of peri- and apomagmatic deposits date back to A. Bergeat. In 1906 he took part in the international congress of geologists in Mexico and he studied the volcano Jorullo and other volcanic areas during field trips from which he keenly collected samples.

Bergeat (1914) described the pyrites and barites of the classical Meggen deposit in order to complete the complex history of that specific mineralogical structure. "On the basis of microscopic studies of numerous thin-sections, I could demonstrate that the primordial and simple structure of the originally deposited iron sulphide has entirely the same characteristics in the whole range of the ore bearing deposits, in the ore impregnated shists of the basement, in the intercalation of argillaceous schist, in the pyrites nodules from different deposits, as well as in the ore of the foot-wall and of the hanging-wall. The iron sulphide consists in any case of radial and fibrous marcasite, if it is not recrystallized to pyrite because of later penetrated solutions. I could prove that all crystallized pyrite is resulted either from a younger settlement or from a recrystallization from marcasite within the pyrite or within the barite bearing part of the Meggen deposit. The primordially formed iron bisulphide appears in a kind of structure, which could be called as "kidney ore" structure, if one may use this description for sulphidic ores and microscopic-scale formations as well. Since this structure is very characteristic for crystallized gels, the idea crossed my mind that the concretionary pyritic formations from Meggen were originally colloidal depositions. Such pyrites together with argillaceous schists, more or less sphalerite, and little galenite was the original stock of the Meggen's ore bearing from the argillaceous schist's of the foot-wall to the limestone of the hanging wall. In the preceding lines I have explained the causes and aspects by which I consider an epigenetic nature of the deposit of Meggen to be impossible, against other opinions. I am rather convinced that this deposit is only an abnormal flux deposition on the ancient seafloor of Devonian ocean. I would like to state repeatedly at the end that I consider the deposits of Meggen (Lenne/Sauerland) and Rammelsberg (Harz/hercynian mountains) as equivalent formations by origin. According to my knowledge, there are no other ore deposits on earth, which could be directly compared with both. Among all such deposits, these two exhibit a very close relation with respect to their composition and structure, and in addition, both occur within almost the same geological horizon. An important hint may already be seen in the fact, that neither the occurrence of the sulphides nor the occurrence of the barite nor their co-occurrence may be attributed to a random metallization of pre-existing beds at any time. Both pyrite deposits are rather only two testimonies of the tremendous eruptions and fluxes of magma and related metallic solutions from inner earth to its crust, which occurred in the Devonian and especially in the Middle Devonian time".

To study different ore deposits, A. Bergeat travelled to the Ural in 1897, to the Hungarian and Transylvanian Carpathians in 1898, to Temperino, Masse Maritima and Monte Catini in 1899, to the mount Monte Amiata, and the island of Elba in 1904. The scientific results and conclusions derived from these extended field trips were published on the base of his comprehensive lecture notes and those of A. W. Stelzner (Freiburg) in the two text books: "Die Erzlagerstätten 2 Bände. Die syngenetischen, epigenetischen und deuterogenen Lagerstätten" (Ore Deposits. 2 Volumes. The syngenetic, epigenetic and deuterogenic deposits) 1904 and 1905–06. In 1913 he edited the "Abriß der Erzlagerstätten" (Synopsis of Ore Deposits) published by Fischer in Jena.

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