Early applications of seismic reflection in Italy: Tiziano Rocco, Po Valley and Agip

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ABSTRACT

Tiziano Rocco (1908-1984) was a mining engineer involved since his early career in a new key activity for oil companies: applied geophysics. Hired by Agip in 1931, after a short period of training he led gravimetric, magnetic and electrical survey crews in Italy. Rocco soon learned that a new geophysical method for oil exploration had been successfully tested in the USA since the early 1930s: reflection seismology. Thanks to his vision and suggestions, Agip purchased two reflection seismic groups from an American contractor (not an easy decision at the time), which started to operate in the Po Valley in early 1940. Rocco left Agip in 1943, due to the turbulent events of the armistice and the German occupation of Italy. In 1945 he moved to Società Petrolifera Italiana and then to Western Geophysical. Back to Agip in 1951 as Director of Exploration, in the 1950s and '60s he contributed to the many company's discoveries in Italy and foreign countries, as well as for the definition of the geological structures of the Po Valley. He retired in 1968, and in the same year he was elected President of the Italian Geological Society for the years 1968-69.

KEYWORDS: AGIP, exploration geology, History of Geosciences, seismic surveys, Tiziano Rocco.

SEISMIC REFLECTION SURVEYS, A REVOLUTION IN PETROLEUM EXPLORATION

Seismic methods are crucial in the field of geological exploration to investigate, discover and assess oil and gas reservoirs, which rarely can be identified and located by surface geological surveys alone. Until the 1930s, surface geology was integrated with the geophysical methods of the time, then limited to early gravimetry, magnetometry and electrical surveys, which however were not able to provide detailed information on the geometry of the underground. It was therefore impossible to map the layers that were supposed to contain hydrocarbons, and thus the discovery rate of exploratory wells was very low.

Demonstrating an investigative resolution capacity of the underground far superior to any other geophysical method then known, refraction and then reflection seismic surveys marked a revolution in oil and gas exploration. Based on the study of the propagation of elastic waves in the geological formations, seismic surveys applied to petroleum engineering were developed in the decades 1920 and 1930. The origins of seismic exploration can be traced back to studies and research conducted by numerous European and North American scholars, probably also boosted by First World War-triggered technology, when the involvement of (geo) physicists in the study of calculating the position of enemy artillery and of underground constructions in tunnel warfare would lead to focus the practice of seismic surveys to hydrocarbons exploration (Macini & Sammuri, 2022). In those years, several geophysical service companies were founded, mainly in the USA.

In 1924, Gulf Oil hired a crew of Seismos GmbH, a German company headed by Professor Ludger Mintrop (1880-1956), who successfully located a salt dome along the Texas coast using the seismic refraction method at the Orchard dome in Fort Bend County. In 1921, the pioneering research led by the American geophysicist Professor John C. Karcher (1894-1978) performed a historical experiment near the Vines Branch area in south-central Oklahoma, recording a seismic reflection profile that matched with

a known geologic structure (Dragoset, 2005; Sheriff & Geldart, 1995). A comprehensive review of the "founders of seismology" can be found in Davison (1927) and Weatherby (1940). Moreover, the Society of Exploration Geophysicists (SEG, 2025) hosts, among the others, the detailed history and accurate biography of the most prominent scientists that lead to the development of modern seismic surveys applied to petroleum engineering.

In Italy, before 1925 "prospectors focused their activity on areas rich in oil and gas seepages. The Piacenza and Parma Apennines attracted the early researchers. At that time, those who had to drill a well and choose a suitable site, waited for a windy day and threw a hat high into the air; where it fell, drilling began" (SPI, 1965, p. 67).

With a royal decree of April 1926, the government of the Kingdom of Italy, headed by Mussolini, founded Agip (*Azienda Generale Italiana Petroli*), the Italian state-owned company aimed to carry out all activities related to the industry and trade of petroleum products (R.D.L. 556/1926). In the early years, Agip was in fact a holding company responsible for the distribution of fuels and lubricants imported from Russia, also created with the goal to break the oligopolistic market for petroleum products, which, in Italy, was almost entirely controlled by local branches of Shell and Standard Oil of New Jersey (Pozzi, 2003b). A year later, in 1927, the modern rationalization of the Italian mining legislation was enacted, introducing the concept of state (public) ownership of mineral and petroleum resources throughout all the territories of the State, and imposing that any mining activity was subject to government authorization, in the form of Concession and Royalty system, under the control of the national Mining Authority (the Royal Corps of Mines).

However, in the early years, Agip had limited financial resources for carrying out new exploration in Italy, and did not even have the specific technical skills, which were borrowed, at least until the early 1930s, from external consultants recruited from Italian universities and research institutions, such as Guido Bonarelli (1871-1951), Enrico Camerana (1860-1941), Camillo Crema (1869-1950), Bartolomeo Galdi (1873-1962), Bernardino Lotti (1847-1933), Cesare Porro (1865-1940), to name but a few (Magini, 1976). Encouraging results were soon obtained, although from time to time this approach was prone to possible misalignment and congruence between the final industrial needs and never-ending academic studies (Belluigi, 1929; Belluigi, 1932; Zuber, 1933).

Only later, in 1933, a dedicated royal decree entrusted Agip to carry on a five-years program of petroleum exploration in the Kingdom (R.D.L. 1017/1933). In the words of the then Agip President Alfredo Giarratana (1890-1982) "What is absolutely necessary for us, in any case, is to emerge from the state of uncertainty and ignorance in which we have been for years and years, faced with this nagging problem of the existence or not of real and important oil reservoirs in our subsoil; which paralyzes all our other decisions and compromises our most vital interests in the matter" (Giarratana, 1933).

Thus, sufficient resources were allocated for the company to empower the exploration department and begin a modern and adequate program of geological and geophysical studies in Italy (Rocco, 1942; Pizzigallo, 1984; Pozzi, 2009).

Despite the scarcity of investments in exploration activities, as early as 1927 the Agip Management began to carry out several gravimetric surveys in the Po Valley (Fig. 1). In the words of Professor Soler Balsano "Agip, then at the beginning of its development, and lacking in Italy both specialized companies and scientific groups capable of performing gravimetric surveys and field studies for petroleum geological exploration purposes, and on the other hand having to immediately begin the exploration activities of the

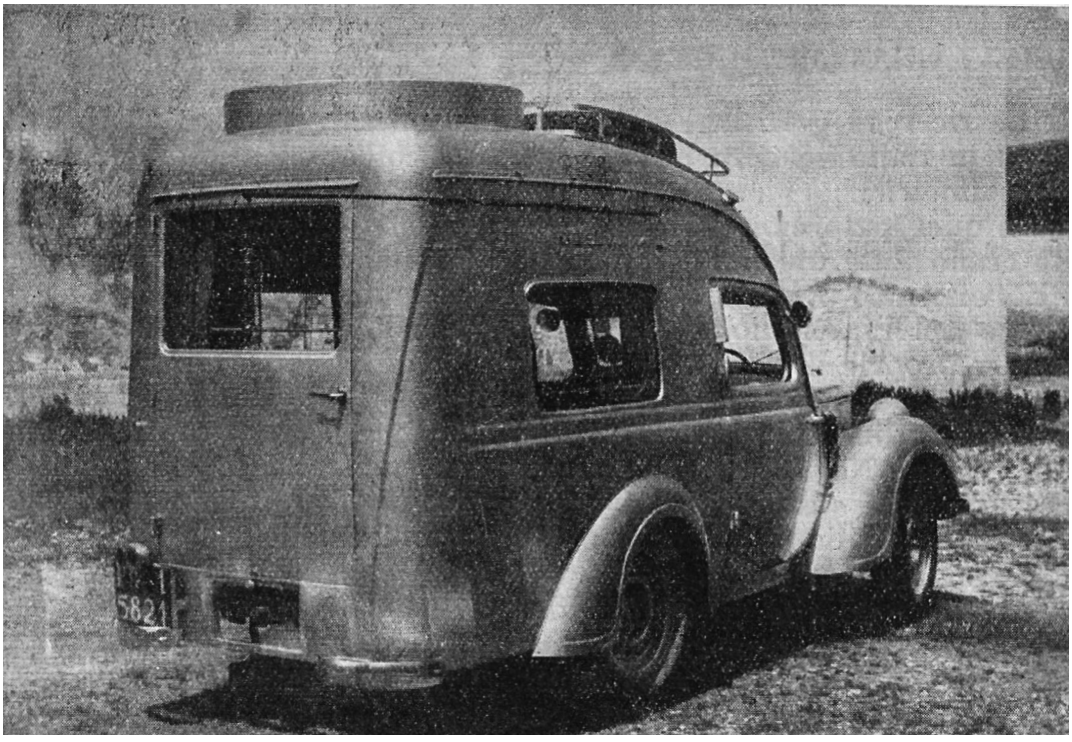

Fig. 1 - Gravimetric equipment mounted inside a small truck ready for the field survey (Contini, 1949).

general development plan entrusted to Agip by the government, it was decided to use reputable foreign companies. A team from *Exploration* of Berlin was therefore invited to carry out Eötvös (gravimetric) surveys in the Po plain (January 1927), starting from S. Colombano al Lambro, assisted for control purposes by a state geophysicist" (Soler, 1936).

1936: TIZIANO ROCCO HEADS THE GEOPHYSICAL SECTION OF AGIP

Agip soon realized the need to create its own geophysical office. The senior geologist Guido Bonarelli (1871-1951), with the advice of Professor Francesco Vercelli (1883-1952), then head of the Royal Geophysical Institute of Trieste (*Regio Istituto Geofisico*), proposed Arnaldo Belluigi (1891-1978), then considered the only Italian expert of applied geophysics, as Director of the future Agip's Geophysical Section (Crea, 1988). Belluigi was a brilliant physicist employed at the Ministry of Agriculture, which already had a geophysical branch that dealt with meteorology, oceanography and seismology. Moreover, Belluigi had already published reports on the possible applications of geophysics to mineral and hydrocarbon exploration (Belluigi, 1929; Belluigi, 1932).

The Geophysical Section of Agip was established at the end of 1928, headquartered in Parma under the direction of Belluigi. Initially, he encouraged and performed gravimetric and magnetic surveys, and then from 1934 he began to carry out seismic (refraction) surveys, capable of recording refracted signals originated from small depths. At that time, Agip owned two seismographic groups, both self-built in the laboratories of the geophysical section of Parma. Here, in 1935 a third device was completed and equipped to perform seismic reflection surveys as well. In this context, one of the future managers who would revolutionize oil exploration in Italy and who would allow Agip to compete with the international industry as early as the 1950s, Tiziano Rocco (Motta di Livenza, 12/2/1908 – Milan, 2/7/1984), slowly made his way in the Company's organization (Fig. 2).

We know little about Tiziano Rocco's private life (Macini & Argentieri, 2024). He had a difficult childhood due to the First World War, and the family had to abandon Motta di Livenza (Treviso) and move to Carpi (Modena) following the Austrian occupation of Veneto after the defeat of Caporetto in 1917.

Living in Emilia created a strong bond with the land both for him and for his parents, who remained there until they died. His father Guerino managed to send Tiziano to study at the Polytechnic of Turin, where he graduated in Industrial Engineering - mining section, on 24th November 1930, with a final mark of 92/100 (Annuario, 1931). Rocco was hired by Agip in August 1931 and assigned to the Geophysical Section under the guidance of Bonarelli and Belluigi. After a short period of training, he led gravimetric, magnetic, and electrical survey crews in Italy, during the 1934 campaign in eastern Sicily. He was fluent in English, an uncommon skill for the time, and he eagerly studied the scientific literature and soon learned that seismic reflection, a novel geophysical method for oil exploration, had been successfully tested in the USA since the early 1930s (Guidi, 1998).

Fig. 2 - Tiziano Rocco in 1955, then Director of Exploration of Agip Mineraria S.p.A., a branch of the recently established ENI (Ente Nazionale Idrocarburi). Photo Courtesy of Archivio Storico ENI, (https://archiviostorico.eni.com) from the Agip monthly magazine *Il gatto selvatico*, May 1955.

In 1936, Belluigi left Agip, and Rocco was promoted to head the Geophysical Section. Belluigi first returned to the ministry, then moved to Argentina, where he worked with the national oil company *Yacimientos Petroliferos Fiscales* (YPF), but soon sailed back to Italy for family reasons. In 1942, always well supported by the Government, he moved to the academic activity, his ambition since he was a young physicist. He was as professor of applied geophysics first in Cagliari, where after the Second World War he was elected as dean of the School of Mining Engineering, and then in Perugia until his retirement (Crea, 1988).

It is also necessary to recall the historical context of the time. In May 1936, after the invasion of Ethiopia, Mussolini proclaimed the Italian Colonial Empire. The invasion violated the article XVI of the Covenant of the League of Nations, of which both Italy and Ethiopia were members. Therefore, the League approved the "unfair" economic sanctions against Italy, which inaugurated the period of Italian autarchy, and the Italian government exerted considerable pressure for a rapid exploitation of national mineral resources, including the colonies, Eritrea, Ethiopia, Somalia, and Libya. In consideration of the above situation, Professor Umberto Puppini (1884-1946), president of Agip after the death of Alessandro Martelli (1876-1934), from 1935 to the beginning of the Second World War, stimulated a strong relaunch of exploration activities in Italy. From the spring of 1935, contracts were signed between Agip and the National Research Council of Italy (CNR- *Consiglio Nazionale delle Ricerche*,) to gather a group of experts who would form an advisory committee. The committee was formed by the Professors Giorgio Dal Piaz and Michele Gortani for geology, Emanuele Soler Balsano, Alfredo Pochettino, Francesco Vercelli and Paolo Dore for geophysics and geodesy, and Carlo Mazzetti for chemistry (Magini, 1976). Moreover, it was during this period that Guglielmo Marconi, the newly appointed president of the CNR, considering the importance of modern geophysics' practical developments, founded in 1936 the National Institute of Geophysics (ING - *Istituto Nazionale di Geofisica*). Although the newly formed ING was not involved in oil exploration, its foundation at that time accounts for the growing attention to geophysics by research institutes and technology industries. It is no coincidence that some of the scientists mentioned above, such as Vercelli and Pochettino, were also part of the ING staff or collaborated with this Institute (Foresta Martin & Calcara, 2010).

Back to Rocco's contribution to the new exploration policy of Agip, we recall that his professional life was always aimed at technological improvement, a difficult task at the beginning of his career due to the economic difficulties of the country and the autarchic policies of the regime. However, he foresaw the potential of geophysics and of reflection seismic, at least a decade in advance in Europe, in times of poor collaboration between Companies, Universities and Research Institutes, when scientific and technological advances were shared with difficulty. In this venture, the contribution of Rocco was initially intertwined with the contribution and experience of a senior Agip consultant, Professor Francesco Vercelli, quite active in launching petroleum exploration in Italy and in the Italian colonial empire (Dore, 1939; Vercelli, 1939).

Regarding Agip's exploration activities, gravimetry had already shown its limits by the mid-1930s, since the most productive structures in the Po Valley did not have sufficient density contrast with respect to the surrounding formations. Even less significant had been the geoelectric and magnetic surveys based on terrestrial resistivity and magnetism. Some attempts had also been made with seismic refraction, using German equipment or devices built by Agip itself. Already after a decade of exploration activity (1926-1936), it was clear to Agip that "the geological hypothesis guiding exploration is inevitably inaccurate but correct for an exact location of the explorative wells. On the other hand, the available geophysical methods are qualitatively inadequate, and the stratigraphic reconstructions are inaccurate or incorrect. The industrial results are inadequate, and … the exploration techniques seem to have exhausted its possibilities" (Rocco & Jaboli, 1959).

The 2nd World Petroleum Congress, held in Paris from 14th to 19th June 1937, put a large emphasis on the dissemination of the successful results obtained in geological exploration by seismic methods and on the related theoretical studies. As early as 1936, there were approximately 500 seismic groups operating in the USA, and exploratory wells were located exclusively according to seismic reflection results. About 10 papers were presented on this topic, and the participation of the Italian industry was quite large, with the papers of Soler (1937) for geophysics, Contini (1937) for drilling engineering, Gortani (1937) and Migliorini (1937) for geological exploration; other paper concerning the Albanian oil industry, where the Italian technical know-how was very strong, were presented by Ineichen (1937) and Maddalena & Zuber (1937).

In 1937, after some trials with German equipment and the in-house construction of rudimentary seismic units, Agip asked Vercelli to visit Berlin to verify the state of the art of the German allies (Vercelli & Rocco, 1937; ASENI, 1937-1938) and look for a more convenient alternative than the proposal of the American Western Geophysical, already contacted by Rocco. Vercelli and Rocco visited Berlin, verifying the lack of satisfactory technical standards: "Germany is still involved in theoretical studies and has not yet faced and solved the problems of applying the seismic reflection method to field surveys from a practical standpoint. And this is demonstrated by the fact that the German oil industry has not yet achieved tangible successes from its application" (Guidi, 1998). Instead, they found both an adequate field experience in seismic reflection surveys and more than satisfactory technical standards in the USA, in another joint visit carried out at the end of 1938.

ROCCO, VERCELLI AND SALVATORI: THREE ITALIANS IN THE OIL EXPLORATION BUSINESS

As mentioned above, seismic methods were already known in Europe and the USA since the 1920s. In Europe, and especially in Germany, seismic methods were predominantly an academic field of study, mostly confined to refraction seismic, which however had a limited use in mining and petroleum exploration, and where it had already revealed its technical limits. Refraction seismic was helpful to define the extension and depth of sedimentary basins, and to identify the large-scale tectonic trends by comparing the high seismic velocity bedrock with the overlying sediments, with lower velocity. Unfortunately, it is a technique not suitable for studying the details of geological structures with low seismic velocity contrasts, as occurs in most of petroleum basins, including the Po Valley.

On the contrary, in the 1920s reflection seismic had a great development in the USA, and soon became a key method for hydrocarbons exploration. It was the studies and improvements carried out by the Geophysical Research Corporation (GRC), under the direction of John Clarence Karcher, who recognized that reflection seismic required different equipment from that used for refraction methods. The first oil discovery in a structure located by GRC reflection seismic surveys was drilled in 1928 in a field around Seminole, Oklahoma. Compared to refraction seismic, different frequency bands were used (30 to 90 Hz) and controlled by the natural frequencies of the geophones and galvanometers. Single-channel equipment was replaced by 4 or 5-channels, and the importance of the near-surface aerated layer was understood, and the slope of the reflecting horizons was calculated. In 1930's the number of channels increased to 12, multiple geophones per track were introduced, electromagnetic geophones with electrical damping, automatic gain control devices, and more stable amplifiers were constructed, *etc.* (Rocco, 1942; Guidi, 1998) (Fig. 3).

But a "reflection man" was to appear on stage. Henry Salvatori (1901-1997) was born in Tocco da Casauria (Chieti) and was registered in the municipality registry records as Ercole. His father emigrated from Abruzzi to the USA, first to New Jersey, and then to Philadelphia. Henry joined his father, together with his mother and two sisters, only later in 1908. This family of traders was motivated and fortunate, and managed to enroll Henry to the University: in 1923 he earned his BS in electrical engineering from the University of Pennsylvania and then his MS in Physics from Columbia University in 1926. In 1930, he joined Geophysical Service Incorporated (GSI), the new company founded by Karcher in the same year. Henry left GSI in 1933 to establish his own seismic company, the Western Geophysical, who will become a major contractor in this field. It seems that already in 1936 Salvatori visited Agip in Rome, where he probably met also the head of the Geophysical Section, Tiziano Rocco (Guidi, 1998).

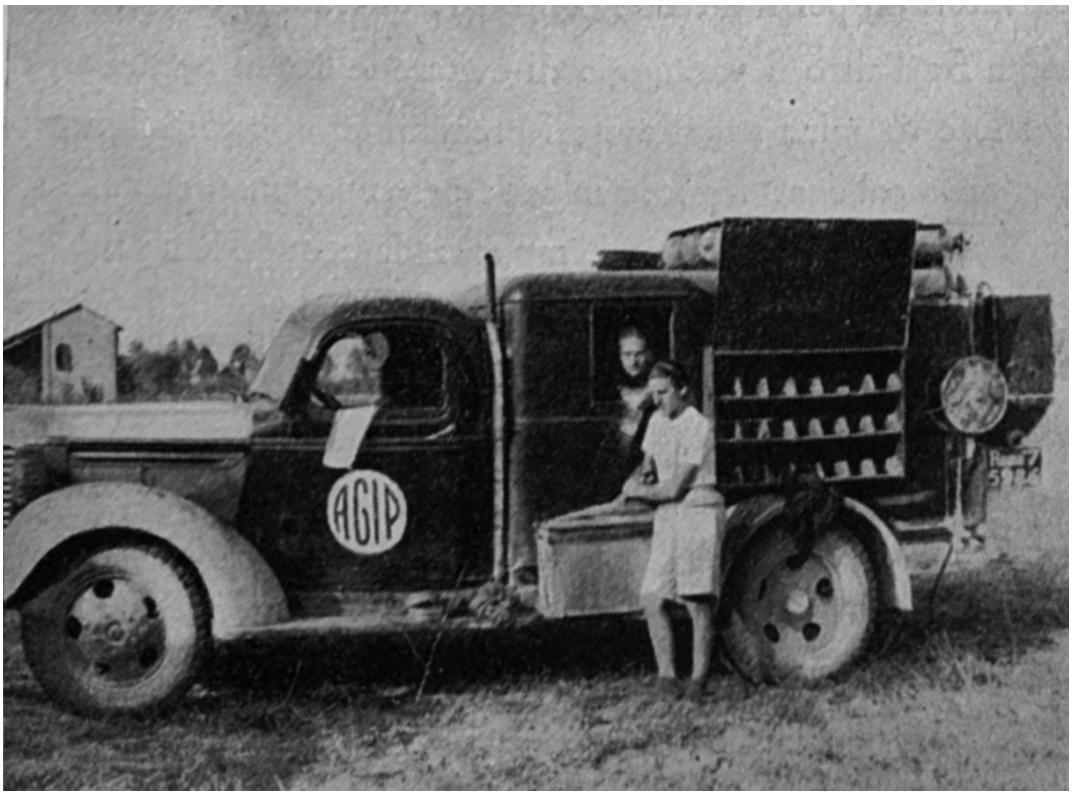

Fig. 3 - Truck for the transportation of the field equipment for seismic surveys (Rocco, 1942).

As mentioned above, after the visit of Vercelli and Rocco to Germany, in the light of increasing the expertise of Agip in reflection seismic and keeping up the pace with the international industry, Rocco and Vercelli planned a travel to the USA. Thanks to the top management approval, they took a two-months trip from December 1938 to January 1939. "Thanks to the enlightened mind of His Excellence the President of Agip, Prof. Puppini, I had the fortunate opportunity of being sent to the USA to examine on site the progress made in geophysical research methods" (Vercelli, 1939).

They arrived in New York on 11th December 1938, then moved to the Italian Embassy in Washington, D.C., and from here by train to St. Louis, Tulsa (19 Dec), Dallas (23 Dec.), Houston (28 Dec.), Los Angeles (7 Jan. 1939) and finally San Francisco (16 Jan.), the last leg of their long journey through the Continent. With a focus on exploration activities, they visited several oil companies and geophysical service companies (Rocco & Vercelli, 1939), and once again had confirmation of how seismic reflection surveys were revolutionizing petroleum exploration in the USA. On this occasion, they were mainly interested in the offers of Western Geophysical (Salvatori's company) and Seismograph Service Corporation, both visited during the field trip.

Upon their return, the Board of Agip approved Western's offer (although with great political worries, scarcity of American dollars and a probable hostility and humiliation to deploy a novel foreign technology), and in late 1939 two seismic groups arrived in Italy, together with two American operators in charge of field operations, Al Barlow and Michael Boccalery, whose family was native from Genoa. The first survey was carried out on 10th June 1940, by a strange coincidence the very day Italy entered the Second World War (Rocco & Jaboli, 1959; Pozzi, 2009).

It is not yet clear, and no documentation has yet been found, why the USA authorized Western Geophysical to send to Italy, at the time still a partner of Germany, both technical personnel and strategic equipment that was still not fully tested in Europe, in a time when the expansion of the Second World War was quite certain. Nor are the Agip payment methods known, nor what guarantees the company was able to provide. We only know that the Western Geophysical seismic groups did not immediately become Agip property, probably because the payments had been delayed over time. In December 1941, when the USA entered the war, the two seismic groups were nationalized and returned to Western ownership only at the end of the war, in 1945 (Guidi 1998).

Rocco, on the contrary, reports that the surveys "started in the spring of 1940 and continued without interruption until the end of 1943; afterwards, and until a few months ago, due to the political and war situation, they were almost halted" (Rocco, 1946a; Rocco 1946b; Rocco, 1946). Italy's entry into the war changed the scheduled activities (the seismic surveys were initially planned for a duration of two years and included the training of Italian personnel), also because the American embassy in Rome had repatriated their technicians early in October 1940. Fortunately, Rocco and the Italian seismic crew were already sufficiently trained to carry out the surveys by themselves (Fig. 4, Fig. 5).

The exploration program of the seismic groups was very rational, *i.e.*, to survey three large strips, starting from the edge of the Apennines, and extending north towards the Po plain for 50-60 km, by means of seismic lines spaced 5-6 km apart; the strips were oriented transversally to the presumed structural axes of the Po Valley, already deduced from the gravimetric survey. A first strip was to include Piacenza, the second Modena, and the third the eastern edge of the Po Valley, towards the Adriatic Sea. Good results

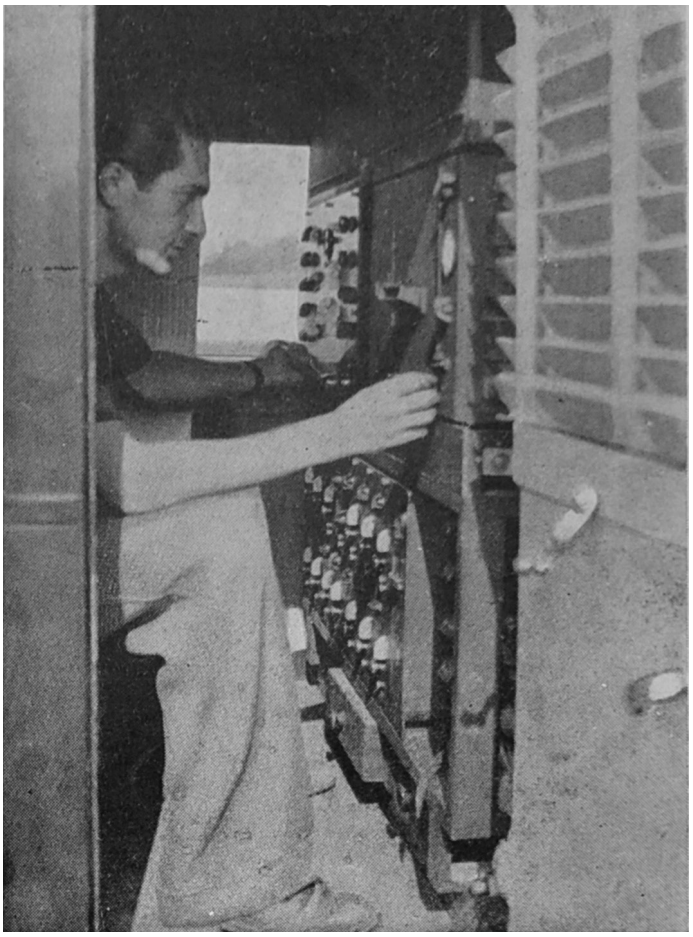

Fig. 4 - Inside the recording control cabin (Rocco, 1942).

arrived quickly: in late 1940, the structures of Ripalta, Caviaga, Cortemaggiore, Cornegliano Laudense and Piadena had already been outlined. Rocco located the first exploratory wells (S. Giorgio Piacentino, Caviaga and Ripalta), but Agip management decided to drill only the largest structure, the Caviaga one, which however led to the first success in October 1944: the discovery of Caviaga gas field (Rocco, 1946a; Rocco 1946b; Rocco & Jaboli, 1959).

THE TURMOIL OF THE ITALIAN OIL INDUSTRY DURING THE SECOND WORLD WAR

The war prompted a strong acceleration in the energy sector, where increased domestic production of natural gas, not to mention crude oil and coal/lignite, could prove invaluable in a situation of continuing fuel shortages. Notwithstanding the period of constant instability and emergency, drilling at Caviaga started in May 1943, under the direct supervision and data interpretation by Rocco himself. It was a period of troubled political events. On 25th July the fascist regime fell and on 8th September Italy signed the "Armistice", formally leaving the war. In practice, Italy surrendered unconditionally to the Anglo-American Alliance, triggering the German occupation of Central and Northern Italy and starting and fuelling the civil war.

Nonetheless, drilling at Caviaga continued, and Rocco would have left Agip in late 1943 or early 1944. In October 1944, as mentioned above, an important gas layer was identified at a depth of 1500 m in Caviaga; the newly discovered gas field was immediately put on stream to supply natural gas and condensates as fuel for cars. Caviaga's abundant condensates were used "as is" as gasoline, and natural gas was compressed on site and used for the many natural gas vehicles of the time. In the following months great care was taken to hide the gas/gasoline production activities during the slow retreat of the German army; fortunately, the well, the drilling and the production equipment always remained in Italian hands. Later, Caviaga field turned out to be a giant gas reservoir, with reserves in the order of 12 billion m^3; as a comparison, Podenzano gas field, at the time the largest discovery in Italy, had reserves in the range of 100 million m^3, two orders of magnitude smaller.

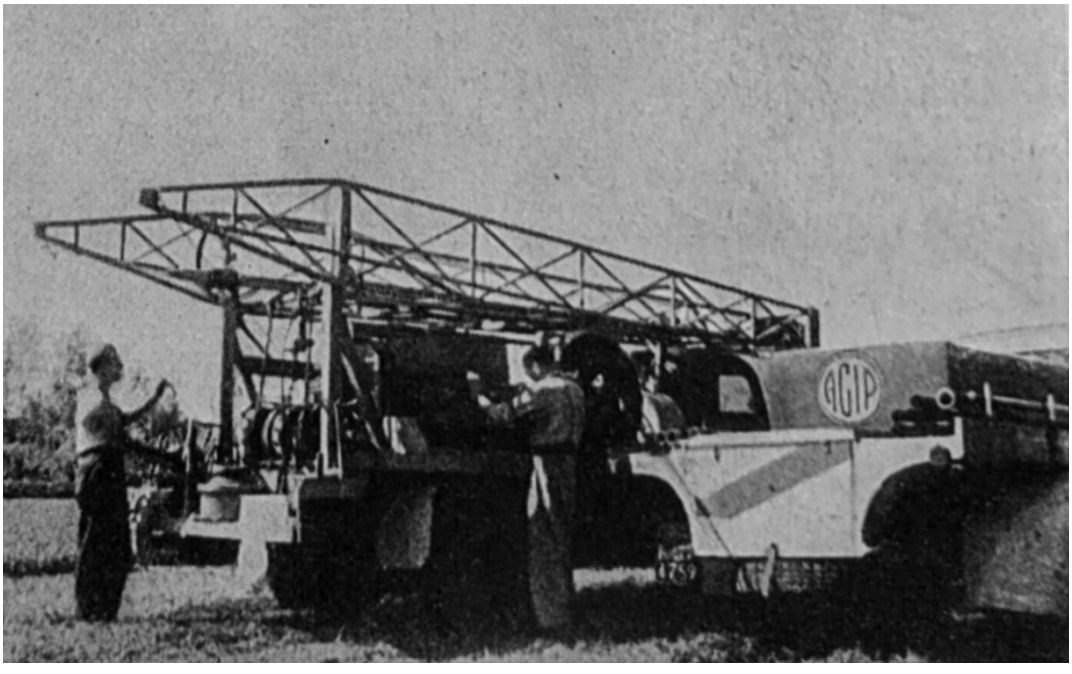

Fig. 5 - Truck-mounted rig for land seismic drilling; on the right, water tanker (Rocco, 1942).

Rocco left Agip in 1943, due to the turbulent events of the armistice and the German occupation of Italy. That chaotic period was interspersed by destruction of all kinds, interruptions of roads and railways, discontinuity in all public services, forced evacuations of homeless from cities hit by bombings, blocked ports, electrical blackouts, food shortage, famine and black market, reprisals and internments. In fact, he refused to join the Italian Social Republic (Republic of Salò), who decided to move the Agip management to Northern Italy (from Rome, where Rocco had been living since at least 1939, to Milan). For this reason, he was fired in (early?) 1944, remaining unemployed in Rome, with his wife and three children to support. A dramatic personal event of which it will never be possible to know the details. He was left with a deep bitterness for that unreasonable dismissal, which he preferred not to talk about even after so many years.

Meanwhile, his colleagues, relocated "in a small number of sites in the north of Italy and the need to work as a team in a complex and dangerous situation helped to forge a strong unity among the technicians and to develop a formidable loyalty to the company, which was the only guarantee of job security and an alternative to being forced to work for the occupiers or being deported to Germany" (Pozzi, 2003-b).

Carlo Zanmatti (1896-1978), a key manager in Agip before and after the war, and until 1943 head of Agip petroleum production section, rehired Rocco in November 1944; Zanmatti, fully aligned with regime of the Italian Social Republic, had been elected Agip's President and CEO in October 1944. Ironically, Rocco was fired again in April 1945 (Pozzi, 2003-a; Agip, 1955), this time by the former-partisan Enrico Mattei (1906-1962), following the post-war Italian Government's decision, enforced by means of the Partisan Forces' Economic Commission (*Commissione economica CLNAI*), to dismantle, at least, the petroleum production section of Agip.

During the uncertain years of the war, Rocco was employed until October 1946 by the Italian Petroleum Committee (*Comitato Italiano Petroli*, CIP), an organization created by the Allied Control Commission after the liberation of Naples (1st October 1943), with the exclusive task of organizing, during the progress of the liberation of the country from the German occupation, the storage and distribution of imported petroleum products, made available for military, civil, industrial and agricultural needs. After the liberation of Rome (4th June 1944) the central management of the CIP was moved to the Capital and its organization, which followed the Allied troops step by step in their backbreaking advance towards the North, was extended to Lazio, Abruzzo, Umbria and Marche.

In 1945, Rocco was appointed director of the Geophysical Section of the *Società Petrolifera Italiana* (SPI), based in Fornovo di Taro, near Parma. At the time the company was a subsidiary/affiliate of Standard Oil of New Jersey (later Exxon), which had planned a large oil exploration campaign in Italy. In 1947, SPI entrusted Western Geophysical with its first seismic survey; the seismic crew was led by Boccalery. As mentioned above, after the war Western Geophysical started again to work in Italy and regained the ownership of its technological equipment, which had already been nationalized during the conflict by the fascist government.

In 1947-48 Rocco carried out important seismic surveys in the eastern Po Valley (Rocco, 1949; SPI, 1965), but in 1949 he left SPI, accepting an offer from the same Western Geophysical, which was planning to move to Italy several new reflection seismic groups, at least 6 equipment, of which Rocco became the Supervisor. So, in April 1950, Rocco moved to Western Geophysical, which in that period had also resumed its collaboration with Agip, fully relaunched by the tireless work and vision of Mattei. Zanmatti, who in the meantime had become one of Mattei's closest collaborators, never stopped to highlight the need to have Rocco back again to Agip. Zanmatti was tried at least twice for his past links with the regime but was eventually acquitted and reinstated in his managerial roles (Pozzi, 2009).

MATTEI AND THE BURIED WEALTH OF THE PO VALLEY

Rocco probably did not have an easy personality, and perhaps he did not hesitate in expressing his dissent towards the management, when he believed he was right, if only from a technical point of view. This propensity emerges in a technical debate that appeared in the journal *La Rivista Italiana del Petrolio* between March and July 1946. At that time Rocco was already working with SPI, and he did not hesitate to criticize some decisions taken by the Agip top management in the early 1940's regarding the programming of exploratory drilling, in his opinion badly managed (Rocco, 1946a; Rocco, 1946b).

Does this episode reveal a trait of his strong personality that will make it difficult for Rocco to return to Agip in the late 1940s? He was in fact pro-American before and after the war, and he left Agip for a precise political choice, contrary to the mainstream of the top management who joined the regime and moved to Northern Italy. Already in 1941, the government accused Rocco of "possible intelligence with the enemy", and it was only thanks to the President of Agip Giuseppe Cobolli Gigli that he was acquitted (Guidi, personal communication).

Zanmatti, politically a man of all trades, who knew his ability and high technical profile, insisted for several years to rehire Rocco at Agip, at least from 1948 to 1951. The operation was not simple, and indeed much debated. Was Rocco considered an awkward personality, who hardly aligned himself with the management decisions? His rehiring occurred in 1951, with Mattei's prudent opinion, probably influenced by a part of the old Agip management. It was known that Rocco wanted and would have obtained the position of Director of exploration, an office to which other people more aligned with the company also aspired. Did Mattei and Rocco get along? (Fig. 6).

Finally, Rocco returned to Agip in 1951, as Director of Exploration (*Capo del Servizio Studi e Prospezioni*), a position previously held *ad interim* by Zanmatti, already head of Agip's Mining Department (*Direzione Mineraria*). At the beginning of the 1950s, in practice the Mining Department operated as an independent company, with its own staff and administration. Thus, in 1953 it seemed logical to establish the autonomy of the upstream activity by transforming the *Direzione Mineraria* into *Agip Mineraria* under the new holding company ENI (*Ente*

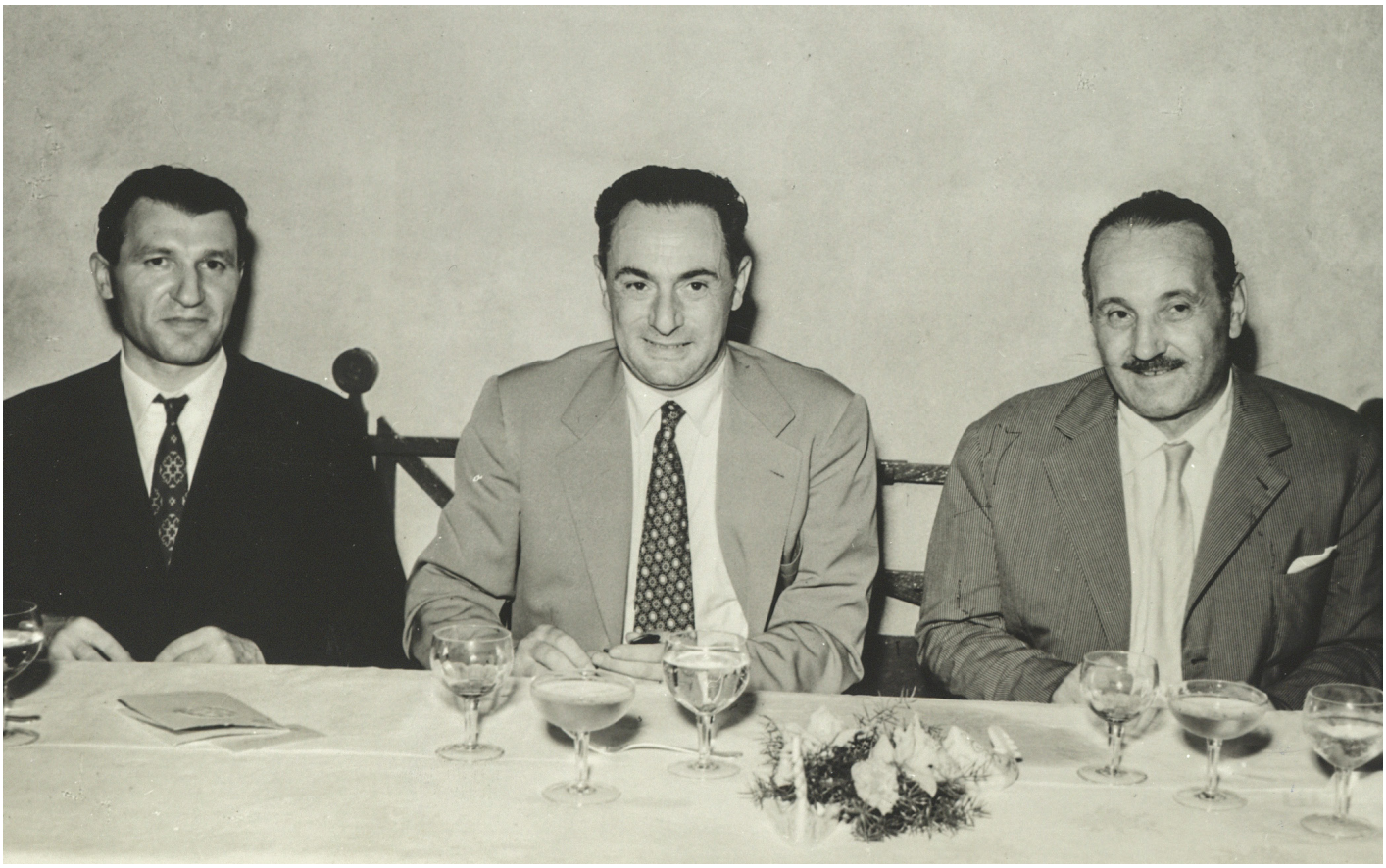

Fig. 6 - Left: Tiziano Rocco in 1952, immediately after his return to Agip. Center, Enrico Mattei (1906-1962), President of ENI. Right, Carlo Zanmatti (1896-1978), at the time General Director and CEO of Agip Mineraria. Photo Courtesy of Archivio Storico ENI (https://archiviostorico.eni.com), Album "Work Memories" by Carlo Zanmatti.

Nazionale Idrocarburi), of which Mattei was president. In Mattei's mind, the creation of ENI was a rational consequence of the evolution of the Italian State's upstream sector, which had already begun in the second half of the 1930s. Furthermore, the new *ENI - Agip Mineraria* was granted with the exclusive right to carry out hydrocarbon exploration and production in the whole territory of the Po Valley (Italian Law n. 136, 10th February 1953, Art. 2), named by Mattei as the "Italian treasure chest" (Legge 10 febbraio 1953; Mattei, 1955).

Between 1951 and 1968, Agip tackled the exploration of the geological trends of the Po Valley with the maximum of its strength. It employed an average of eight seismic groups (five of which were its own) and about 25 drilling rigs, which supported an ever-increasing gas production which, at the end of the 1960s, exceeded the target of 10 billion m^3 per year. So, the early 1950s were the decisive years for the future programmes of the Company, because the conspicuous gas discoveries shaped the financial strength that would allow Agip to expand its activities in other Italian regions and abroad, to compete with the Big Oil of the "Seven Sisters" (Frankel, 1966; Colitti, 1979).

In the 1950s and '60s Rocco significantly contributed on the company's successes first in Italy (Fig. 7, Fig. 8, Fig. 9, Fig. 10), for the detailed definition of the geological structures of the Po Valley basin, already started in the 1940s (Rocco & Jaboli, 1955; Rocco, 1955; Rocco, 1959a; Rocco, 1959b) and then abroad.

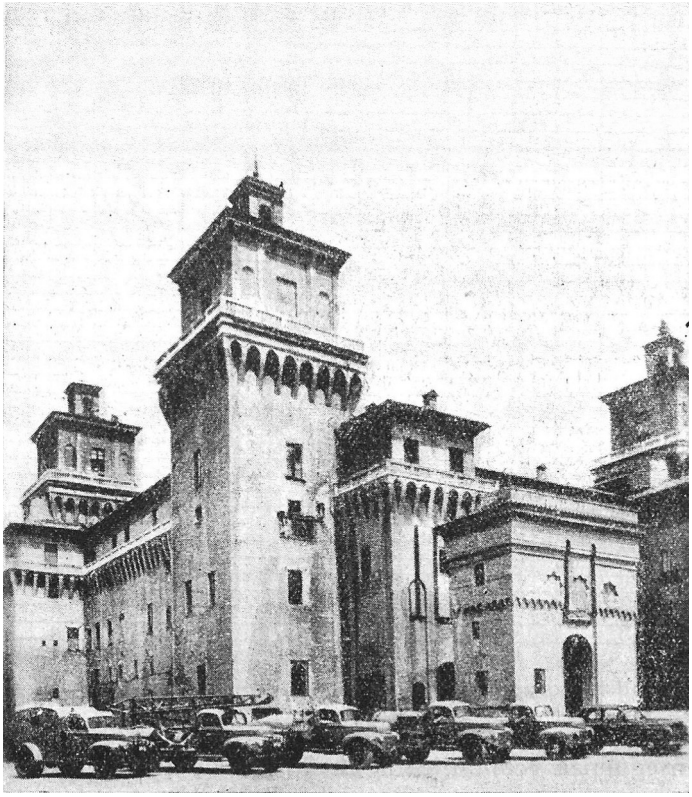

Fig. 7 - A Western Geophysical reflection seismic group in front of the Estense Castle (Ferrara), on its way to the field (Boccalery, 1949).

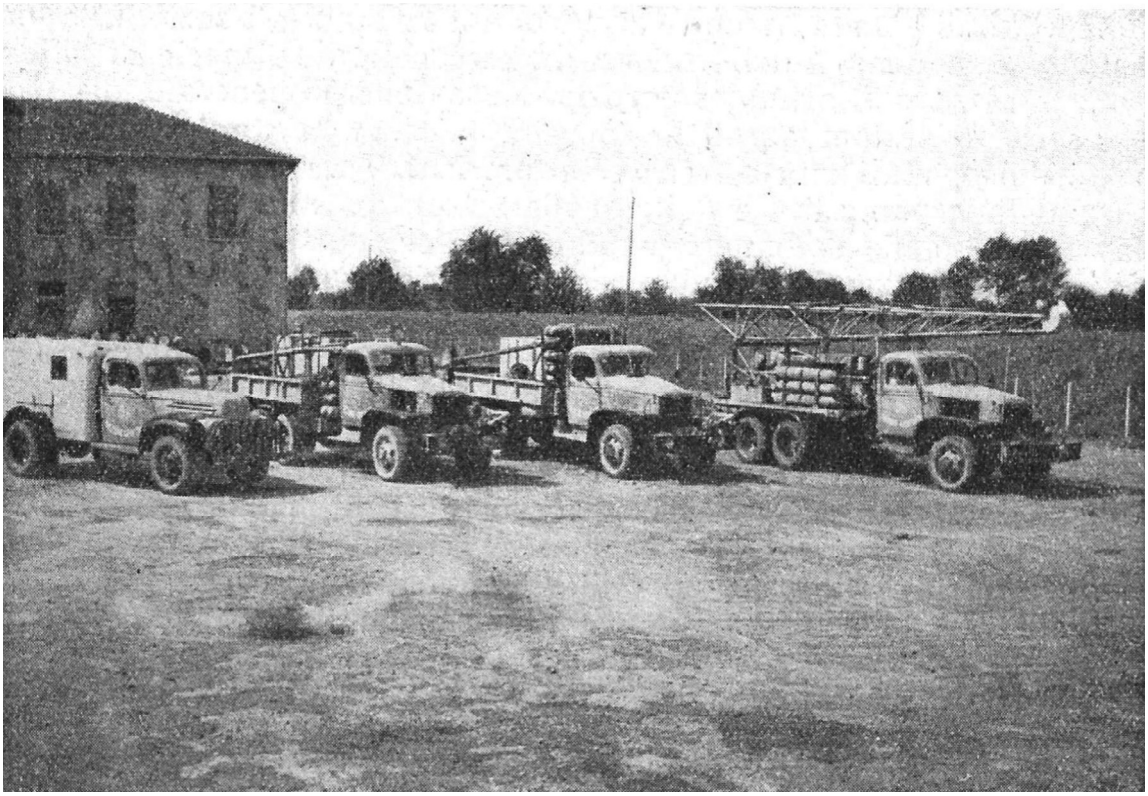

Fig. 8 - Seismic group and equipment for land seismic drilling (Contini, 1949).

We recall the principal Agip's discoveries of Bargan Sar and Now Ruz (Iranian offshore), Zagros (Iran), Belaym and Abu Madi (Egypt), El Borma (Tunisia), Bu Attifel (Libia), Ebocha (Nigeria) and the penetration of Agip in the new petroleum plays of the North Sea in the late 1960s.

Rocco always kept pace with technological progress. If in the 1930s he was the first to promote the use of reflection seismic in oil exploration in Western Europe, at the end of the 1950s, when magnetic recording and therefore the use of computers were introduced in the field of seismic surveys, he quickly adapted, always supporting the use of the most up-to-date techniques.

TIZIANO ROCCO PRESIDENT OF THE ITALIAN GEOLOGICAL SOCIETY

Rocco retired on 28 February 1968, due to age limit, although he continued to work with Agip for further 5 years as an external consultant. In the same year, he was elected President of the Italian Geological Society (SGI, *Società Geologica Italiana*) for the two-year period 1968-69. Rocco had been an SGI member since 1940 and held the position of Vice President under the chairmanship of Roberto Malaroda (1966-67). With his appointment, SGI intended to facilitate the applicative aspects of geosciences and intensify the relationships with the industrial sector, and particularly with the State-owned Agip (Macini & Argentieri, 2024).

Rocco, after starting the review of SGI Statute and Regulation, early resigned after a few months. This is his concise letter to Vice President Fiorenzo Mancini, sent on 20th July 1968: "Dear Professor Mancini, for reasons depending on my current professional status, I am unable to attend the organization of the S.G.I. Congress to

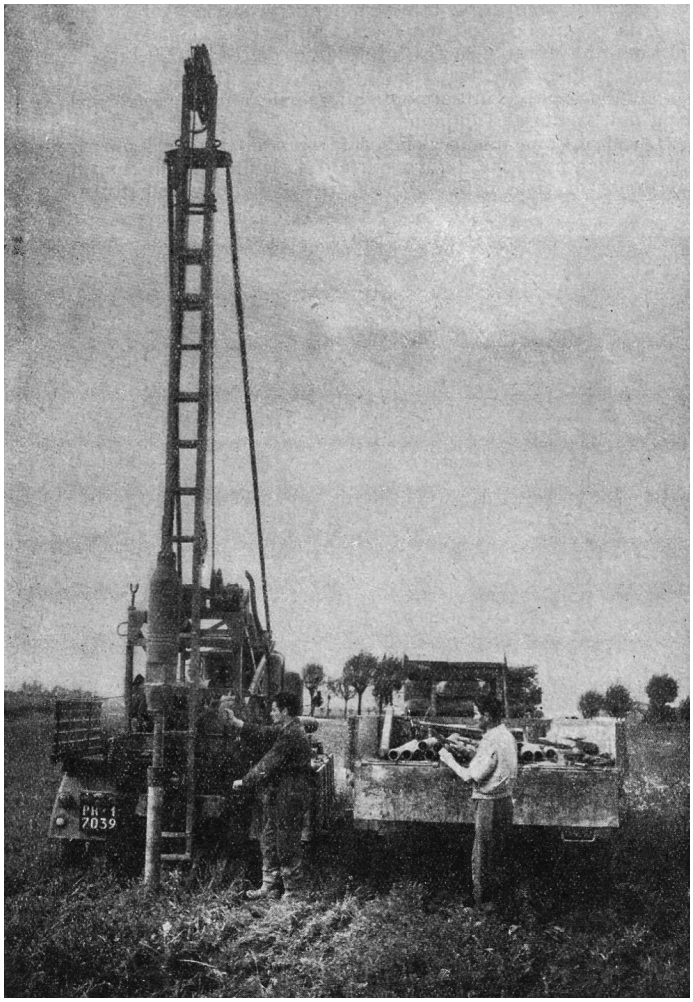

Fig. 9 - Land seismic drilling operations (Contini, 1949).

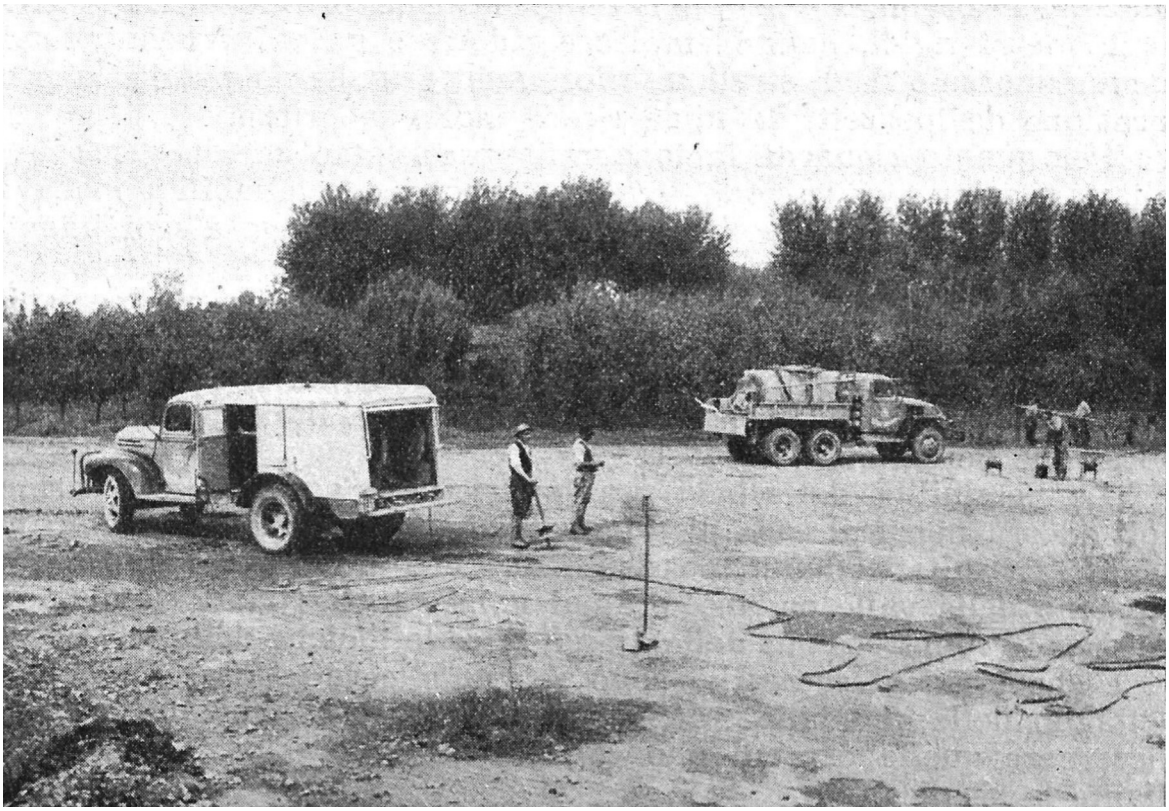

Fig. 10 - Seismic crew at work in the field (Contini, 1949).

be held in summer 1969. Thus, not being able to comply with the prescriptions of subparagraph 1, article 11 of our Society's Statute, I am forced to formally resign from the S.G.I. presidency. I am sorry for the trouble I cause to you and, while praising to accept my sincere apologies, I extend to you my warmest greetings".

The missed Congress of 1969, entitled "Contribution of oil exploration to geological knowledge of Adriatic region", was going to be held in Ravenna. Despite the endeavour of several colleagues to convince Rocco to change his mind, he was inflexible without alleging further explanation. During the SGI sessions held on 28th September 1968 in Rome, at Sapienza University Institute of Geology, the Executive Committee accepted his resignation, and the Assembly subsequently took note of it. The agronomist and pedologist Fiorenzo Mancini became President a year early, and the following congress, to be held in Florence, shifted to 1970 (Macini & Argentieri, 2024).

CONCLUSIONS

After his retirement in 1968, Tiziano Rocco worked as consultant of Eni for about five more years. He passed away on 2nd July 1984 in Milan, where he lived close to Porta Ticinese.

This note wants to pay homage to the contribution of Tiziano Rocco, active from the early 1930s to the first half of the 1970s, to the progress of geological knowledge, by means of the introduction of reflection seismic methods in Italy. His intuition, in collaboration with Francesco Vercelli, opened new perspectives not only for oil exploration, but also for unraveling the secrets of the underground resources of the Italian peninsula. Geophysical data provided by the flourishing petroleum industry, led by Agip and then by ENI, opened new perspectives to scientific research in Italy and abroad. On these bases, the following generation of scientists and investigators would be able to play a role in the incoming revolution of the Plate Tectonics. In these terms, the change of geological paradigm in the Central Mediterranean may be attributable also to the work of the forerunners, the technicians and scientists operating during the hard times of the Second World War.

Among them is Tiziano Rocco, an anti-conformist and reserved character, who leaves no room for compromise and whose personal dimension remains shrouded in uncertainty.

REFERENCES

Annuario (1931) - Annuario della Regia Scuola di Ingegneria (R. Politecnico) di Torino 1930-31. Torino, 172 pp. https://digit.biblio.polito.it/secure/3284/1/annuario_1930-1931.pdf#page=117&pagemode=bookmarks.

Agip (1955) - Artefici e precedenti del successo di Casalbordino. Il Gatto Selvatico, 5, p. 10. https://archiviostorico.eni.com/aseni/it/magazines/gattoselvatico/IT-ENI-BIB0001-000839.

ASENI Archivio Storico ENI (1937-1938) - fascicolo, Segnatura: busta 78 fascicolo 15F, Collocazione AA.II.4, n. 4775: viaggio del Prof. Vercelli in Germania; n.4776: viaggio in Germania Prof. Vercelli (Agip, Vercelli - R. Istituto Geofisico Trieste, Jacobini).

Belluigi A. (1929) - Caratteristiche fisiche fondamentali della pianura padana. Rend. R. Acc. Naz. Lincei, cl. Sci. Fis., Mat. e Nat., serie 6, 10, pp. 58.

Belluigi A. (1932) - Anticlinale gravimetrico-petrolifera di Fontevivo. Bollettino del Comitato per la geodesia e la geofisica del CNR, serie 2, II, n. 2, 25-27.

Boccalery M. (1949) - Suggerimenti per una condotta razionale ed economica nella ricerca degli idrocarburi in Italia. In: Atti del VI Convegno nazionale per il metano, Padova, 14-16 giugno, 157-166.

Colitti M. (1979) - Energia e sviluppo in Italia: la vicenda di Enrico Mattei. Bari, De Donato, 240 pp.

Contini R. (1937) - Systems et moyens de forage employes par l'A.G.I.P. pour les recherches petroliferes dans les differentes regions d'Italie. 2nd World Petroleum Congress, Paris, 14-19 June, paper n. WPC-2006.

Contini C. (1949) - Le ricerche geofisiche dell'Agip. In: Atti del VI Convegno nazionale per il metano, Padova, 14-16 giugno, 167-182.

Crea A. (1988) – Belluigi, Arnaldo. Dizionario Biografico degli Italiani, 34, Istituto dell'Enciclopedia Italiana fondata da Giovanni Treccani.

Davison C. (1927) - The Founders of Seismology. Cambridge University Press, Cambridge, 256 pp.

Dore P. (1939) - Il metodo di indagine gravimetrico nelle ricerche petrolifere. In: I combustibili nazionali ed il loro impiego. R. Accademia delle Scienze, Torino, 43-53.

Dragoset B. (2005) - A historical reflection on reflections. The Leading Edge, 24, s46-s70, https://doi.org/10.1190/1.2112392.

Foresta Martin F. & Calcara G. (2010) - Per una storia della geofisica italiana. La nascita dell'Istituto Nazionale di Geofisica (1936) e la figura di Antonino Lo Surdo. Springer-Verlag Italia, Milano, pp. 278, https://doi.org/10.1007/978-88-470-1578-4.

Frankel P.H. (1966) - Mattei: Oil and Power Politics. London, Faber, 190 pp.

Giarratana A. (1933) - Le ricerche petrolifere in Italia compiute dall'Agip e programma per l'avvenire. La Rivista Italiana del Petrolio, anno I, 8, dicembre, 1-5.

Gortani M. (1937) - Problemes poses par la recherche du petrole en Italie. 2nd World Petroleum Congress, Paris, 14-19 June, paper n. WPC-2005.

Guidi F. (1998) - Un pioniere dalle intuizioni vincenti. Notiziario Interno Agip, 129, 30-34.

Ineichen G. (1937) - Le service geologique organise par l'A.I.P.A (Azienda Italiana Petroli Albania) pour le controle des forages d'exploitation dans le bassin petrolifere du Devoli en Albanie. 2nd World Petroleum Congress, Paris, 14-19 June, paper n. WPC-2061.

Legge 10 febbraio 1953, n. 136 - Istituzione dell'Ente Nazionale Idrocarburi (E.N.I.). Gazzetta Ufficiale della Repubblica Italiana. Anno 97, n. 72, venerdì 27 marzo 1953, Roma, p. 1134.

Macini P. & Sammuri P. (2022) - The Italian Corps of Engineers in World War I: Innovations in Mining and Tunnel Warfare. In: Bondesan A., Ehlen J. (Eds), Military Geoscience: A Multifaceted Approach to the Study of Warfare, Advances in Military Geosciences, Springer Nature Switzerland AG 2022, 107-123, https://doi.org/10.1007/978-3-030-79260-2_7.

Macini P. & Argentieri A. (2024) - Tiziano Rocco. In: Mente et Malleo. La Società Geologica Italiana e i suoi presidenti. Società Geologica Italiana, pp. 337-339.

Maddalena L. & Zuber S. (1937) - Sur la geologie des petroles Albanais. 2nd World Petroleum Congress, Paris, 14-19 June, paper n. WPC-2060.

Magini M. (1976) - L'Italia e il petrolio tra storia e cronologia. Mondadori, Milano, pp. 279.

Mattei E. (1955) - L'utilization du gas naturel en Italie. 4th World Petroleum Congress, Rome, 6-15 June.

Migliorini C. (1937) - Short account of the geological conditions and of the oil prospection of a zone in Southern Italy. 2nd World Petroleum Congress, Paris, 14-19 June, paper n. WPC-2062.

Pizzigallo M. (1984) - L'Agip degli anni ruggenti (1926-1932). Giuffrè, Roma, 326 pp.

Pozzi D. (2003a) - L'introduzione della sismica a riflessione in Italia. In: Giuntini A., Pozzi D. (Eds), Energia per il territorio. Enrico Mattei e il metano in Italia, Lodi, Giona edizioni, 159 pp.

Pozzi D. (2003b) - Techno-Managerial Competences in Enrico Mattei's Agip: A Prolonged Accumulation Process in an International Network, 1935-1965. Joint Meeting of the Business History Conference and the European Business History Association, 26-29 June, Lowell Massachusetts. https://thebhc.org/sites/default/files/Pozzi_0.pdf

Pozzi D. (2009) - Dai gatti selvaggi al cane a sei zampe: tecnologia, conoscenza e organizzazione nell'AGIP e nell'ENI di Enrico Mattei. Marsilio, Venezia, 547 pp.

Regio Decreto-legge 3 aprile 1926, n. 556 - Costituzione di una Azienda Generale Italiana Petroli (A.G.I.P.) per lo svolgimento di ogni attività relativa alla industria e al commercio dei prodotti petroliferi. Gazzetta Ufficiale del Regno d'Italia. Anno 67, n. 173, mercoledì 28 luglio 1926, Roma, p. 3338.

Regio Decreto-legge 21 luglio 1933, n. 1017 - Conferma all'Azienda Generale Italiana Petroli dell'incarico di eseguire ricerche petrolifere nel Regno. Gazzetta Ufficiale del Regno d'Italia. Anno 74, n. 191, venerdì 18 agosto 1933 - Anno XI, Roma, p. 3708.

Rocco T. & Vercelli F. (1939) - Relazione della missione Vercelli-Rocco sulle esplorazioni petrolifere con metodi geofisici negli S. U. In: Archivio Storico ENI (marzo 1939), fascicolo; Segnatura: busta 20 fascicolo 3, Collocazione: AF.I.3, n. 47781.

Rocco T. (1942) - Progressi della sismica a riflessione nell'esplorazione petrolifera dell'A.G.I.P. nella pianura padana. La Rivista Italiana del Petrolio, marzo, 13-19.

Rocco T. (1946a) - In tema di ricerche petrolifere. La rivista italiana del petrolio, marzo, 6-7.

Rocco T. (1946b) - In tema di ricerche petrolifere. La rivista italiana del petrolio, luglio, 8-8.

Rocco T. (1949) - Possibilità del metodo sismico nella ricerca degli idrocarburi. In: Atti del VI Congresso sul metano, Padova, 245-263.

Rocco T. (1955) - Comparative Geological and Geophysical Study of the Po Basin. 4th World Petroleum Congress, Rome, 6-15 June.

Rocco T. (1959-a) - Giacimenti gassiferi padani. Accademia Nazionale dei Lincei, Convegno sui giacimenti gassiferi dell'Europa Occidentale, vol. II, 29-44.

Rocco T. & Jaboli D. (1955) - Geology and Hydrocarbons in the Po Valley Basin. 4th Annual Meeting of the AAPG, New York, March 28-31.

Rocco T. (1959-b) - Gela in Sicily, an unusual oil field. 5th World Petroleum Congress, New York, 30 May - 5 June.

Rocco T. & Jaboli D. (1959) - Notizie sulle ricerche svolte dall'Agip e dall'Agip mineraria nella Pianura Padana. Accademia Nazionale dei Lincei, Convegno sui giacimenti gassiferi dell'Europa Occidentale, vol. II, 49-59.

SEG (2025) - Society of Exploration Geophysicists https://wiki.seg.org/wiki/Ludger_Mintrop, https://wiki.seg.org/wiki/John_Karcher, https://wiki.seg.org/wiki/Reginald_Fessenden, retrieved jan. 15, 2025.

Sheriff R.E. & Geldart L.P. (1995) - Exploration seismology, Volume 1, History, theory, and data acquisition. Cambridge University Press, Cambridge, 628 pp.

Soler E. (1936) - Cenni riassuntivi sull'attività geofisica svolta dall'Agip (ricerche Italia) dall'inizio a tutt'oggi. In: Archivio Storico ENI (1936-1939), fascicolo; Segnatura: busta 6 fascicolo C4, Collocazione: AA.I.1, n. 506.

Soler E. (1937) - Rapport sur les recherches geophysiques executees en Italie par l'A.G.I.P. 2nd World Petroleum Congress, Paris, 14-19 June, paper n. WPC-2007.

Società Petrolifera Italiana - SPI (1965) - I pionieri alla ricerca del petrolio in Italia. Parma, Tipografie Riunite Donati, 95 pp.

Vercelli F & Rocco T. (1937) - Relazione sulla visita a Berlino del Prof. Francesco Vercelli e dell'Ing. Tiziano Rocco. In: Archivio Storico ENI (1932-1941), fascicolo; Segnatura: busta 123 fascicolo 239, Collocazione: AA.III.4, n. 8596.

Vercelli F. (1939) - L'esplorazione geofisica dei campi petroliferi. In: I combustibili nazionali e il loro impiego, contributi ai problemi autarchici, Reale Accademia delle Scienze di Torino, 382 pp.

Weatherby B.B. (1940) - The history and development of seismic prospecting. Geophysics, 5(3), 215-230, https://doi.org/10.1190/1.1441805.

Zuber S. (1933) - Osservazioni sulle prospettive petrolifere dell'Italia centrale (Marche-Abruzzo-Toscana. In: Archivio Storico ENI (1932-1943), fascicolo; Segnatura: busta 527 fascicolo 5D4, Collocazione AC.I.6, n. 46403.