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The Yugoslav ‘Operation Paperclip’: German Geologists in the Yugoslav Nuclear Program in the Late 1940s and Early 1950s

Abstract: *This paper traces the early period of the Yugoslav nuclear program, in which the biggest problem was finding uranium. With only a handful of trained geologists and prospectors, the solution was found in the employment of German experts. This was a global trend at the time, and as this paper shows, was not reserved for great powers. Relying on the expertise of German scientists, Yugoslavia managed to raise the first post-war generation of geologists, who eventually found uranium and started its exploitation on several locations in the country, most notably in Kalna (Serbia) and Žirovski vrh (Slovenia).*

Keywords: Yugoslavia, Cold War, nuclear program, Trepča Mines, uranium, Friedrich Schumacher.

Introduction

“Before the Second World War nobody in Yugoslavia explored deposits of uranium, thorium and other materials interesting for nuclear energy, nor any data about their appearances existed in geological documentation.”[1] This was the starting point of the Yugoslav nuclear program in 1948, at least considering information on the availability of uranium and other radioactive materials in the country, although the

[1] Arhiv Jugoslavije (AJ), fond Savezne komisije za nuklearnu energiju 177, fascikla 23, jedinica 92. Problem istraživanja nuklearnih sirovina u našoj zemlji, January 20, 1959 (henceforth: AJ, 177-23-92. Problematika istraživanja nuklearnih sirovina).

situation was not better with the stage of development of nuclear physics and related scientific disciplines. Hidden behind the general interest for 'peaceful use of nuclear energy' was the strong desire to develop capabilities for construction of the atomic bomb. By the mid-1960s, Yugoslav nuclear institutes acquired all necessary technologies, at least on the laboratory level. However, by that time, a combination of the changed international position of Yugoslavia, the establishment of the global nuclear security system embodied in the Treaty for Non-Proliferation of Nuclear Weapons (1968/70), Yugoslav internal political and economic crises and reforms, led to the abandonment of these plans and formal cancellation of the nuclear program by 1970.[2]

This paper traces the early period of the Yugoslav nuclear program, in which the most pressing problem was finding uranium deposits in the country. With only a handful of trained geologists and prospectors and limited general knowledge about the country's geological structure, the solution was found in the employment of German specialists from the *Bergakademie* in Freiberg. The exploitation of the German scientific achievements was a global trend and a specific war booty for the Allies, which accelerated the development of advanced weapon systems, such as ballistic missiles or jet airplanes, thus contributing to the creation of Cold War divisions and acting as a signaling shot for the arms race.

Yugoslavia joined this frantic hunt for German scientists immediately after the war, transferring hundreds of them to eventually contribute significantly to the country's post-war reconstruction and industrialization. This paper reveals that, even though they were not directly involved in the Yugoslav nuclear program, they contributed significantly in educating the first post-war generation of Yugoslav geologists and developing the necessary scientific infrastructure. During the 1950s and 1960s, these Yugoslav pioneers in uranium prospection managed to find the elusive metal and start its exploitation on several locations in the country, most notably in Kalna (Serbia) and Žirovski vrh (Slovenia).

Paperclip, *Osoaviakhim* and their copies

On December 2, 1942, the famous physicist Enrico Fermi had created the first controlled nuclear chain reaction in the so-called uranium "pile" beneath the West Stands of the University of Chicago's Stagg Field athletic stadium. This was an important milestone for the U.S. Manhattan Project and the emerging Atomic Age, which confirmed that the construction of the atomic bomb was technically feasible.[3]

[2] More in: Marko Miljković, "Tito's Proliferation Puzzle: The Yugoslav Nuclear Program, 1948-1970", PhD Thesis, (Central European University, Budapest; Vienna: Department of History, November 2021).

[3] *The First Reactor: 40th Anniversary*, (Washington, D.C.: U.S. Dept. of Energy, Assistant Secretary for Nuclear Energy and Assistant Secretary, Management and Administration; Springfield, Va.: Available

However, soon after, the fear that the Germans were further ahead in this field of research had captured the imagination of both U.S. scientists and decision-makers. Their reasoning was based on the fact that it was the German scientists who had discovered nuclear fission back in 1938 (Otto Hahn, Lise Meitner, and Fritz Strassmann). Simultaneously, many scientists working on the Manhattan Project had been trained at German universities before the rise of the Nazis and were convinced of the superiority of German science.[4]

The U.S. Major General Leslie R. Groves, the director of the Manhattan Project, employed the same logic. In April 1944, he initiated the scientific intelligence mission, the so-called Alsos Mission, which consisted of a group of scientists led by physicist Samuel Abraham Goudsmit, with a task to determine how far the Germans had advanced with their atomic bomb project.[5] This "esoteric and dangerous endeavor," as Jacobsen calls it, eventually was expanded to a frantic investigation about the capacities of the Third Reich to wage a full range of "atomic, biological, and chemical warfare" against the Allies.[6] However, the main task of the Alsos Mission was to capture ten leading German atomic scientists and their research results, which may be considered as "the best-known and most obvious example of (…) intellectual plunder".[7]

The Alsos Mission revealed that the Germans were far behind the United States in their research and capacities to produce the atomic bomb, but it also exposed the Allies to other German scientific accomplishments and advanced weapons (V-2 guided missiles or jet airplanes) that were "ahead of Allied capabilities".[8] In the wake of the

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from the National Technical Information Service, 1982), 1-3. The word "pile" eventually gave way to the term "nuclear reactor." In Yugoslavia during the late 1940s and early 1950s, the most common term used for the nuclear reactor was "uranium oven" (*uranijumska peć*).

[4] Samuel A. Goudsmit, *Alsos*, (Woodbury, N.Y.: AIP Press, 1996), 3-7.

[5] Goudsmit, *Alsos*, xxxiv; Martijn van Calmthout, *Sam Goudsmit and the Hunt for Hitler's Atom Bomb*, (New York: Prometheus Books, 2018), 78-80.

[6] Annie Jacobsen, *Operation Paperclip: The Secret Intelligence Program that Brought Nazi Scientists to America*, (New York: Little, Brown and Company, 2014), 9-10.

[7] Burghard Ciesla, "German High Velocity Aerodynamics and Their Significance for the US Air Force 1945-52", *Technology Transfer Out of Germany after 1945*, edited by Matthias Judt and Burghard Ciesla, (Australia; United States: Harwood Academic Publishers, 1996), 96; Johannes Bähr, Paul Erker, Geoffrey Giles, "The Politics of Ambiguity: Reparations, Business Relations, Denazification and the Allied Transfer of Technology," *Technology Transfer Out of Germany after 1945*, edited by Matthias Judt and Burghard Ciesla, (Australia; United States: Harwood Academic Publishers, 1996), 132; Mark Walker, *Nazi Science: Myth, Truth, and the German Atomic Bomb*, (New York: Plenum Press, 1995), 207-208. The Alsos Mission was disbanded in October 1945, and by that time, consisted of more than 100 agents. Captured German scientists were Erich Bagge, Kurt Diebner, Walther Gerlach, Otto Hahn, Paul Harteck, Werner Heisenberg, Horst Korsching, Max von Laue, Carl Friedrich von Weizsacker, and Karl Wirtz. They were transported to England and detained at the Farm Hall, the country house near Cambridge.

[8] Goudsmit, *Alsos*, xiv; Jacobsen, *Operation Paperclip*, 10. For the comprehensive analysis of the Nazi atomic bomb project, see Mark Walker, *Nazi Science: Myth, Truth, and the German Atomic Bomb*, (New York: Plenum Press, 1995).

Cold War divisions and arms race competition, the general understanding became prominent among all parties involved that these weapons and technologies "would be decisive in future warfare", and that, "along with nuclear energy, they were prime symbols of a nation state's technological and scientific prowess."[9]

In May 1945, the United States initiated Operation Paperclip that initially focused on transferring more than 350 German rocket scientists to the United States, with Wernher von Braun, the scientific director of the V-2 rocket program, as the most prominent figure on this list.[10] Roughly 1,600 German scientists were eventually transferred to the United States "under secret military contracts," allowing them to continue their wartime weapons research projects for the U.S. Army, Navy, Air Force, Central Intelligence Agency (CIA), and other institutions.[11] This motley crew included dozens of dedicated Nazi scientists who stood trial at Nuremberg and regional war crimes courts, some of them even as members of Nazi paramilitary units (SA and SS). Their task was to continue "developing rockets, chemical and biological weapons, aviation, and space medicine (…) and many other armaments at a feverish and paranoid pace", including "ballistic missiles, sarin gas, cluster bombs, space capsules and weaponized bubonic plague."[12]

Already in May 1945, the Soviets organized their equivalent to the Alsos Mission, transferring roughly 100 German nuclear physicists and chemists to the Soviet Union. Some authors claim that this was just a fraction of the German pool of wartime nuclear scientists and that "[t]he German contribution to the [Soviet] atomic bomb project was small and limited", even though in the long term, the Soviet atomic program profited significantly from German-inspired innovations.[13] Regardless of

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[9] Michael J. Neufeld, "The Nazi aerospace exodus: towards a global, transnational history", *History and Technology* 28, 1 (March 2012), 49.

[10] Jacobsen*, Operation Paperclip*, 157-159, 454; Brian E. Crim, *Our Germans: Project Paperclip and the National Security State*, (Baltimore: Johns Hopkins University Press, 2018), 61; Neufeld, "The Nazi aerospace exodus: towards a global, transnational history", 51; George W. Mueller, "Wernher von Braun", published by the National Academy of Engineering, Washington D.C., URL: https://www.nae.edu/30668/Wernher-von-Braun (22.01.2022.). The original name of this mission was Operation Overcast, and it became known as Operation Paperclip in November 1945, when the program was expanded to include the permanent immigration of German scientists to the United States. Wernher von Braun eventually became the director of NASA's Marshall Space Flight Center and the leading designer of the Saturn V rocket, which propelled the U.S. astronauts to the moon.

[11] Jacobsen*, Operation Paperclip*, 5-6.

[12] Ibid., 5.

[13] David Holloway, *Stalin and the bomb: the Soviet Union and atomic energy, 1939-1956*, (New Haven: Yale University Press, 1994), 191, 221-222; Norman M. Naimark, *The Russians in Germany: A History of the Soviet Zone of Occupation, 1945-1949*, (Cambridge, Mass.: Belknap Press of Harvard University Press, 1995), 214. Neufeld, "The Nazi aerospace exodus: towards a global, transnational history", 51; Crim, *Our Germans*, 126. Nikolaus Riehl even won the Hero of Socialist Labor order for his work on purifying uranium. In the field of uranium enrichment, Gustav Hertz and Peter-Adolf Thiessen worked on gaseous diffusion and Konrad Zippe and Max Steenbeck on the ultracentrifuge. Regarding

these estimates, this mission also found "that the leading German nuclear scientists – Otto Hahn and Werner Heisenberg among them - had fallen into Western hands."[14]

This was an interlude to Operation *Osoaviakhim*, the Soviet response to Operation Paperclip. On October 22, 1946, in a "well-planned and neatly executed operation that took place simultaneously in the centers of armaments production" in the Soviets occupation zone in Germany, roughly 2,500 German experts in various fields were rounded up by the Red Army and the NKVD and sent in less than twelve hours to the Soviet Union.[15] This was actually the final step of the much more complex process, in which the Soviets ignored their obligations to liquidate German military industry in their zone of occupation, "resuscitated armaments factories, rehired skilled workers, and when the timing was right, uprooted the entire infrastructure" for the rocket, airplane, and other weapons production. Another characteristic of the Soviet strategy was to compensate quality with quantity, hoping that their initial failure "to obtain first-class scientists" would be offset by the sheer weight of numbers, "with the idea ten second-class scientists will be equivalent of one first-rate one."[16] Besides the obvious need for such expertise, Operation *Osoaviakhim* also denied the United States recruits for their own weapons projects, thus symbolically signaling the beginning of the Cold War scientific and arms competition.[17]

The United Kingdom and France, two remaining occupying forces of Germany and Austria, participated on a comparable level in this hunt for German scientific achievements and personnel. Neufeld reveals that hundreds of German specialists landed in other countries, regardless of the side they supported during the war, their political system, or even level of scientific development, such as Canada, Australia, Spain, Brazil, Argentina, Egypt or India, as the most successful in this process.[18] Considering that his analysis focuses only on aerospace experts, it may be expected that the eventual number of German scientists and experts in various fields was much higher, while even the simple logic also suggests that the list of countries that participated in this competition was much longer.

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the actual work on the design and construction of the atomic bomb, the intelligence information, and particularly from Klaus Fuchs, the Soviet spy in the Manhattan Project, was more important. More in: Holloway, *Stalin and the Bomb*, 106-107, 221-222.

[14] Holloway, *Stalin and the bomb*, 109-110.

[15] Naimark, *The Russians in Germany*, 220; Crim, *Our Germans*, 127-129.

[16] Memo, "German Scientists into Russian and French Territory," box 31, Records of the IIR, CIC, RG 319, National Archives and Records Administration (NARA), quoted in Crim, *Our Germans*, 128-129.

[17] Crim, *Our Germans*, 127-129; Naimark, *The Russians in Germany*, 220. Some estimates suggest that 2,522 German experts in the airplanes and airplane engine design, electronics, and electronic engineering with their families were sent to the Soviet Union, adding up to roughly 6,500 people.

[18] Neufeld, "The Nazi aerospace exodus: towards a global, transnational history", 51-54. France transferred between 800 and 1,000 German scientists, the UK roughly 500, Argentina 108, Brazil 27, Australia 150, Canada 41, Spain and Egypt less 100 each, and India less than 50.

Yugoslavia was in the group of developing nations that actively participated in this process. Saša Ilić recently published an important interdisciplinary analysis on the organized transfer of foreign, and particularly German labor and experts to Yugoslavia, meticulously tracing their participation and contribution in the process of the country's postwar reconstruction, modernization, and industrialization, also revealing details about their everyday life and sometimes even classified activities.[19] His results show that stretching from university professors to simple artisans, more than 10,000 Germans worked in Yugoslavia in the period between 1946 and 1950/51.[20]

The Soviet hunt for uranium ore

By 1945, "after the destruction of Hiroshima, it [uranium] became one of the most important, and most frightening, resources on the planet." General Groves managed "to virtually monopolize the world's known uranium" deposits, with an estimated 97 percent of the world's reserves under U.S. control, the richest ones located in Belgian Congo.[21] This competition for the new strategic raw material "led to an increase of Cold War tensions just as it was a reflection of that Cold War," although the policy of denying the Soviets access to uranium was rendered impotent by the mid-1950s, as new deposits were discovered across the globe.[22]

When it came to the uranium mining and prospection in friendly or countries under their control, the Soviets were quite open about their plans, although it would be difficult to hide their "uranium rush," which saw their experts exploring every known and potential source of uranium. The Soviets produced the first pure kilogram of uranium metal at the end of 1944, and the proper field prospection started only in September 1945, in a limited region in Central Asia. Their quest for uranium was further frustrated by the Lend-Lease Administration in Washington, which continuously denied transferring the desired amounts of uranium to the Soviet Union. General Groves wanted to stop the Soviets from acquiring any sensitive material or technology, and on March 15, 1945, he ordered the bombing of the Auer Company plant near Berlin, which produced thorium and uranium for the German atomic

[19] Saša Ilić, *Stranci „gastarbajteri": Strana stručna radna snaga u privredi Jugoslavije 1945-1950*, (Beograd: Arhiv Jugoslavije, 2020).

[20] Ilić, *Stranci „gastarbajteri"*, 8-9. Ilić focuses only on those experts and workers who voluntarily accepted job positions in Yugoslavia, and stresses that the number of prisoners of war, local German population, and other categories of (in)voluntary workers was much higher.

[21] Michael Gordin, *Red Cloud at Dawn: Truman, Stalin, and the End of the Atomic Monopoly*, (New York: Farrar, Straus and Giroux, 2009), 72; Susan Williams, *Spies in the Congo: America's Atomic Mission in World War II*, (New York: Public Affairs, 2016), 253-268. By 1951, the United States obtained 3,686 tons of uranium, with the largest amount coming from the Congo - 2,792 tons.

[22] Jonathan E. Helmreich, *Gathering Rare Ores: The Diplomacy of Uranium Acquisition, 1943-1954*, (Princeton, N.J.: Princeton University Press, 1986), xi-xiii.

project. Only a month later, Groves also managed to remove 1,200 tons of uranium hidden in the Soviet zone. Holloway reveals that "after much detective work," the Soviets eventually managed to find over 100 tons of uranium oxide, which eventually saved them roughly a year in developing their first nuclear reactor. The Soviet nuclear program also benefited from exploiting existing and newly found uranium deposits, mostly in Czechoslovakia and East Germany, as the only known uranium sources in the world outside of U.S. control.[23]

The victorious march of the Red Army through Eastern and Central Europe opened paths for uranium prospection in several countries. Following information left by the Germans about some uranium deposits in Bulgaria, the first group of Soviet experts arrived in the country already by the end of November 1944. The joint-stock "Soviet-Bulgarian mining company," later to be known as *Gorubso*, was established on October 17, 1945, and it took over prospection and mining of ores and minerals in the country. The company was exempted from paying export/import taxes and customs duties for commercial arrangements with the Soviet Union, employed "primarily Soviet specialists, and its core business became discovering and developing uranium deposits in Bulgaria." In the following years, the rumor was spread that the first Soviet atomic bomb was made with Bulgarian uranium, and although this was not completely true, by the middle of 1946, the Soviets managed to produce 272 tons of pitchblende (uranium mineral) from Bulgarian mines.[24]

Soon after the end of the war, the Soviets also took the control of Czechoslovakian uranium mine in Jáchymov (Joachimsthal), which was one of the very few known uranium mines in the world at the time, and the only one that had a history of continuous exploitation in Europe.[25] After some negotiations, on November 23, 1945, the Czechoslovak government signed the secret treaty with the Soviet Union, granting the Soviets to mine and transport home uranium ore, thus helping them

[23] Holloway, *Stalin and the Bomb*, 100-102, 111-112; Gordin, *Red Cloud at Dawn*, 73. Through the Lend-Lease program, in 1943, the Soviets acquired first amounts of 100 kg of uranium-oxide and nitrate each, but not the uranium metal. By 1945, the Soviet desire for uranium grew, but General Groves turned down their requests.

[24] Ivaylo Hristov, "The Communist Nuclear Era: Bulgarian Atomic Community during the Cold War, 1944-1986", PhD Thesis, (Technishche Universiteit Eindhoven, Eindhoven, 2014), 36-38; Zbynek Zeman, Rainer Karlsch, *Uranium Matters: Central European Uranium in International Politics, 1900-1960* (Budapest and New York: Central European University Press, 2008), 9, 27, 76. Pitchblende is a mineral with up to 80% of uranium.

[25] Holloway, *Stalin and the Bomb*, 105, 109; Zeman, Karlsch, *Uranium Matters*, 41-45. In the 1860s, Joachimsthal was famous for the production of uranium-based dyes that gave a particular luster to yellow, green, and orange colors. By the beginning of the 20th century, the region became famous for healing properties of radioactive water in the Radium Palace Hotel, built in 1910. With the emerging Atomic Age, radium became important and expensive material that was mined and produced in the region, with spin-off industries mushrooming during the interwar period (radium was used for medical purposes, in the luminous paints industry, and scientific research). In 1937, Czechoslovakia ranked third in world radium production (11%; Belgian Congo produced 15% and Canada 66%).

"solve the uranium problem without even being aware of its existence."[26] According to Zeman and Karlsch, this secret agreement transformed the small Czechoslovakian uranium industry into a huge enterprise and in the process "became the gate through which they entered Stalin's empire."[27]

This is a gentle way to describe the Soviet strategy for putting under control all of the uranium deposits in their field of influence, but also for expansion of their control of host countries. By that time, the Soviets already had a model agreement for prospection and exploitation of uranium deposits outside the Soviet Union, which required the establishment of a joint-stock company with the host country. The Czechoslovaks managed to avoid this particular model for their company, although it was "a Pyrrhic victory" since their uranium deposits were firmly under Soviet control. Among other provisions, the secret agreement guaranteed technical positions for Soviet experts, and it also left the prospection and entire geological service completely in the Soviet hands.[28]

The success in Czechoslovakia "led the Russians to neighboring Saxony," and already in September 1945, the Soviet team of geologists led by Semion P. Alexandrow "began with a review of the old mines," pretending before the Germans "that they were looking for bismuth and cobalt," although German geologists quickly understood the true purpose of the Soviet mission. The initial results were disappointing, but the prospection of Saxony continued in the following years, and by early 1948, the Soviets realized "that Saxony could provide more uranium than any other part of their empire."[29] In the first couple of years, the operation in Saxony was run and supervised by the NKVD and Beria himself, which was somewhat screened by the formal establishment of the *Wismut AG* mining company on May 26, 1947. The important difference in comparison to Bulgarian or Czechoslovakian case was that this company was completely in the Soviet ownership, thus becoming "a sort of uranium province" or "a state within a state," in the Soviet zone of occupation in East Germany, run by the NKVD general Maltsev.[30]

[26] Zeman, Karlsch, *Uranium Matters*, 75-76.

[27] Ibid., 76.

[28] Zeman, Karlsch, *Uranium Matters*, 76-77.

[29] Ibid., 27-29, 58. In the official communication, the Soviets used "raw material A9" as a code name for uranium, while the first mining facility was hidden behind a simple field-post number "no. 9372". Already in the 1950s, the Wismut AG, a uranium mining company in East Germany (Saxony), became the largest producer of uranium in Europe.

[30] Ibid., 159, 162-166.

Soviet uranium prospection in Yugoslavia

In Yugoslavia, the establishment of joint-stock companies was loosely discussed with the Soviet Union since 1944, but not much had been done. Andrija Hebrang, the head of the Yugoslav Economic Council and Planning Commission, restarted negotiations with the Soviets in 1946, and initial plans included establishing joint-stock companies "in excavation, energy, and infrastructure." Although there were signs that the Soviets were interested in providing support, Tito halted further negotiations and used the opportunity to demote powerful and pro-Soviet Hebrang. Officially, complaints were also raised that the mere concept of the joint-stock companies revealed the Soviet capitalistic behavior towards Yugoslavia, and as the relationship between Tito and Stalin gradually deteriorated in the following months, the topic was never seriously reopened.[31]

Consequently, this course of events in Yugoslavia made the Soviet standard approach and strategy for uranium prospection in host countries impotent. Without the joint-stock company agreement, it seems that there was little they could have done except use other means of pressure, especially at that time when they still have not found sufficient deposits of uranium, neither in the Soviet Union nor elsewhere.[32] This is what eventually happened in Yugoslavia. The Soviets did manage to organize a uranium prospection mission without formal agreements, and it effectively worked similarly as in other countries of Central and Eastern Europe.

Documents on this are scarce and scattered in various archival collections, but available information is rather instructive. In 1947, "a team of Russian specialists for exploration of nuclear ores performed measurements of all of our [Yugoslav] mines with Geiger-Müller counters" but "their findings were never delivered […], nor we know what they found" and even though "one of our [Yugoslav] geologists was accompanying them, they kept the results from him as well."[33] The mission of the Soviet geologists in Yugoslavia was a rather detailed survey of existing mines, which lasted between July 21 and October 4, 1947. Their arrival was suddenly announced only three days in advance by "comrade Vasiliev" of the Soviet trade mission in Belgrade, who set the date and hour of their arrival and requested they should be greeted at the Bulgarian border "without customs inspection, other formalities, and delays."[34]

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[31] Vladimir Unkovski-Korica, *The Economic Struggle for Power in Tito's Yugoslavia*: *From World War II to Non-Alignment*, (London, New York: I.B. Tauris, 2016), 30-32.

[32] Zeman, Karlsch, *Uranium Matters*, 29. The sources in Saxony proved to be very rich in uranium, but the first confirmation came only in 1948.

[33] AJ, 177-23-92. Problematika istraživanja nuklearnih sirovina.

[34] AJ, fond Centralni komitet Saveza komunista Jugoslavije 507, IX, 1119/V-32. Izveštaj o radu sovjetske ekipe geologa u vremenu od 21.VII-4.X 1947, October 29, 1947 (henceforth: AJ, 507-IX, 1119/V-32. Izveštaj o radu sovjetske ekipe geologa u vremenu od 21.VII-4.X 1947, October 29, 1947);

The fact that this report comes from the archives of the League of Communists of Yugoslavia (Communist Party of Yugoslavia), and an extremely short notice provided by Vasiliev, suggest that no negotiations about the mission of the Soviet geologists ever took place. It seems that the Soviets deliberately avoided the Yugoslav officials and used their Party connections instead, without revealing their true plans. The scenario is quite similar to what was happening in Germany a few years earlier. However, it is also true that in Yugoslavia, the Soviets obviously could not even begin proper negotiations on the establishment of a joint-stock company for the purpose, as they did in Bulgaria and to a certain extent in Czechoslovakia.

During their mission, the Soviet geologists visited all major mines in Serbia and Macedonia, one in Bosnia and Herzegovina, and finished their work with the tour of the biggest mining enterprises in Slovenia. They were accompanied by one unidentified Yugoslav geologist, who eventually wrote the report, but without sharing any information with him or answering any of his questions. Nevertheless, he did what he could to understand and document their activities. According to his report, upon their arrival at a mine, Soviet geologists would immediately ask for "all existing geological maps and plans […] as well as all the literature related to the geology of the wider area." After that, they would visit selected locations, carrying with them "special instruments and devices". In his report, the Yugoslav geologist admits that "these devices are of a particular construction […] and I was not acquainted with them, neither from my experience nor the literature." However, he did make an important assumption that they were used to "detect the presence of radioactive minerals and to register the intensity of their radiation." Soviet geologists had several types of these field instruments, alongside others that they kept in wooden boxes and used in privacy in a closed room or laboratory for the analysis of the collected samples.[35]

The Yugoslav geologist could not recognize these instruments, but he suspected that "they were constructed on the principle of spectroscopes or spectrographs." He understood that the Soviet field instruments were measuring the number of recorded impulses per minute, and he wasted no time counting those impulses, eyeballing what the Soviets had recorded. According to his limited observations, Soviet geologists would take samples from every rock which emitted more than 90 impulses per minute. The most interesting results were measured in the mines in *Vareš* (950.5 impulses per minute; Bosnia and Herzegovina), *Idrija* (630; Slovenia), *Trepča* (462.5; Serbia), *Aljin Do* (149.5; Serbia), *Dudica* (126; Serbia) and *Strumica* (unknown; Macedonia). Eventually, after the Soviet team of geologists finished their mission and performed all analyses they needed in the Institute of Geological Research (*Zavod za geološka*

Dragomir Bondžić, *Između ambicija i iluzija: Nuklearna politika Jugoslavije, 1945-1990*, (Beograd: Institut za savremenu istoriju Srbije, 2016), 89.

[35] AJ, 507-IX, 1119/V-32. Izveštaj o radu sovjetske ekipe geologa u vremenu od 21.VII-4.X 1947, October 29, 1947.

ispitivanja) in Pančevo (near Belgrade), they were escorted back to the Bulgarian border, where a car waited to take them back to Sofia.[36]

While it would be difficult to make any claims, it seems probable that the Soviet team of geologists took the radioactive samples with them to Bulgaria for further analysis or simply to hide them from the Yugoslavs, like they were doing in Germany in 1945. Later reports indirectly confirm that the Soviets found "small [levels of] radioactivity" in several existing mines in Yugoslavia, but that the samples of ores that were analyzed later by the Yugoslav scientists "did not show any radioactivity."[37] Another probable explanation could be that Yugoslav geologists at the time simply did not have enough knowledge or adequate instruments (or both) to perform a proper analysis that would confirm Soviet results. The Yugoslav geologist who accompanied the Soviet team in 1947 was obviously stunned with what he had seen, but like his colleagues from Saxony, he quickly connected the dots, and so did the Yugoslav authorities.

The limited information available from the Soviet uranium prospection in Yugoslavia confirmed to the local authorities that they were frantically searching for uranium, and it also revealed the most rudimentary methodology and equipment necessary for uranium prospection. This makes it difficult to accept the official historical account, which suggests that soon after Soviet geologists had left the country, in October 1947, Yugoslav scientists independently discovered the sample of uranium mineral autunite, proof that this strategic raw material could be found in Yugoslavia.[38] According to memories of Milan Ristić, a geologist who made this discovery, "[t]he first finding of uranium mineral in SFR Yugoslavia was not a coincidence, but was the result of anticipation of the possibility that in pegmatite bodies south of Prokuplje, in addition to the already discovered beryllium minerals, uranium minerals may be found."[39] Even though Ristić speaks from the geological, not political perspective, such a neat chronological overlap between the Soviet uranium prospection mission and the Yugoslav finding is impossible to accept as accidental. Within the general

[36] Ibid.

[37] AJ, fond Kancelarije Maršala Jugoslavije 836, II-6-a/4. Izveštaj o radu Uprave za naučno istraživački rad za 1948. i zadacima za 1949 (henceforth: AJ, 836-II-6-a/4. Izveštaj o radu Uprave za naučno istraživački rad za 1948. i zadacima za 1949).

[38] Radule Popović (ed.), *Od Uprave za koordinaciju rada naučnih instituta do Geološkog zavoda Srbije. 65 godina (1948-2013)*, (Beograd: Geološki zavod Srbije, 2014), 56; Bondžić, *Između ambicija i iluzija*, 84-85; Milan Ristić, „Prvi nalazak urana u SFR Jugoslaviji", *Radovi Instituta za geološko-rudarska istraživanja i ispitivanja nuklearnih i drugih mineralnih sirovina* 6 (1969), 10-12. Autunite was discovered in the vicinity of the village Dobrotić (near Prokuplje, Serbia). Different sources put this finding in September or October of 1947, but the earliest account suggests that after the original finding in September, more detailed prospection of the site was conducted in October, after which it took three different laboratories to confirm the actual presence of uranium, all of which evidently took some time. The first proper mining activities were organized only in February 1948.

[39] Ristić, „Prvi nalazak urana u SFR Jugoslaviji",10.

context of rapidly deteriorating relations between Tito and Stalin, the fact that Yugoslav authorities decided not to share this important information with the Soviets speaks volumes.

These events marked the beginning of the Yugoslav nuclear program. The institutional framework started to be created in early 1948, with the establishment of the Institute for Physics in Vinča (near Belgrade), designed to be the central scientific institution, and the Directorate for Coordination of Work of Scientific Institutes (*Uprava za koordinaciju rada naučnih instituta* – UKRNI), as the institution with a single task – to find uranium deposits in Yugoslavia.[40]

Enter Friedrich Schumacher

Several months before these events, on April 25, 1947, Professor Dr. Friedrich Schumacher, previously the director of the geological institute and the Mining Academy in Freiberg, moved after the denazification process to Yugoslavia, where he worked until 1949/50 as "chief geologist for lead and zinc mining enterprise", the Trepča Mines.[41] The importance of this information lies in the fact that Schumacher was one of the leading German experts who helped the Soviets in the discovery of rich uranium deposits in Saxony, an activity that was hidden behind an "office for colored metals."[42] Ivaylov also identifies that in Bulgaria uranium mining was camouflaged as the exploration of lead and zinc ores, which appears to have been yet another standard practice used by the Soviets to mask their uranium mining and prospection activities.[43]

Schumacher's biographer reveals that during 1946 he was at a real risk of being "relocated" to the Soviet Union as an expert geologist with vast experience who could help them find uranium in the country. However, this was just the beginning of his problems.[44] Back in the Soviet occupation zone in Germany, Schumacher was

[40] The Institute for Physics changed its name several times in this period: Institute for the Research on the Structure of Matter (*Institut za isptivanje strukture materije*, 1950) and eventually the Boris Kidrič Institute of Nuclear Sciences (*Institut za nuklearne nauke Boris Kidrič*, 1953). The interrepublican competitiveness, among other reasons, led to the establishment of the Jožef Stefan Institute (*Institut Jožef Stefan*, 1949) in Ljubljana, and the Ruđer Boković Institute (*Institut Ruđer Boković*, 1950) in Zagreb. The UKRNI, after many changes of its jurisdiction, eventually evolved by 1955 into the Federal Nuclear Energy Commission (*Savezna komisija za nuklearnu energiju* – SKNE) under the control of Aleksandar Ranković. Miljković, "Tito's Proliferation Puzzle," 127-143, 235.

[41] AJ, fond Ministarstva rudarstva FNRJ 24, fascikla 43, jedinica 110. Personal file of Friedrich Schumacher, 1947-1950 (henceforth: AJ, 24-43-110. Personal file of Friedrich Schumacher, 1947-1950); Zeman, Karlsch, *Uranium Matters*, 28; Andreas Udo Fitzel, "Friedrich Schumacher (1884-1975)", *Spaichinger Heimatbrief* 27 (2009), 65–66.

[42] Zeman, Karlsch, *Uranium Matters*, 28.

[43] Hristov, *The Communist Nuclear Era*, 38.

[44] Fitzel, "Friedrich Schumacher (1884-1975)", 66.

soon banned from teaching at the Mining Academy (*Bergakademie*) in Freiberg and was even threatened with the labor camp for his decision to decline membership in the newly formed SED (*Sozialistische Einheitspartei Deutschlands* – Socialist Unity Party of Germany). In a scenario worthy of a spy novel, his escape to Yugoslavia was organized by "two influential Yugoslavs," the director of the Trepča Mines, where Schumacher was eventually employed, and one of Schumacher's former students, "some Jovanović". They provided him with false identification and drove in a car through Czechoslovakia and Hungary to Yugoslavia, and even though Schumacher was held for questioning by the secret police in Czechoslovakia, the group eventually managed to arrive safely in Yugoslavia.[45]

In the late 1940s, dozens of German experts were employed in Yugoslavia, often using false papers provided by the Yugoslav Military Mission in Berlin.[46] According to the Mission's reports, only in August 1947 precisely 135 German experts and workers of various professions were sent to Yugoslavia, out of which 16 had a university degree, with additional 44 experts who were illegally transported to the country, probably in the same way as Schumacher.[47] In the following month, the number grew to 21 "doctors and engineers" and 165 technicians and artisans. It was also stressed that in a majority of cases this operation was organized "in secrecy and without knowledge of the occupying authorities" in Berlin.[48]

Ilić explains that the Yugoslav Military Mission in Berlin was tasked with conducting all business and legal arrangements with and within occupation zones in Germany, but that additional and critical task was "finding and soliciting German workers and specialists and sending them to work in Yugoslavia", which was initiated immediately after the Mission had been established, in January 1946.[49] However, by the end of the year, only 109 German workers and specialists in various fields and levels of expertise were transferred and employed in Yugoslavia. The process

[45] Fitzel, "Friedrich Schumacher (1884-1975)", 65–66. Schumacher escaped with his wife and another colleague who was not named in the report. After Schumacher escaped, his house was confiscated by the SED, his salary and pension entitlements were cut, his bank balance was confiscated, and his laboriously built mineral collection was taken away.

[46] AJ, fond Predsedništvo vlade FNRJ 50, fascikla 67, jedinica 149. Međunarodni odnosi. Vojne misije, 1944-1947 (henceforth: AJ, 50-67-149). Top secret report of the Yugoslav Military Mission in Berlin to the Yugoslav Army's Chief of Staff, April 29, 1947. For a detailed analysis of the activities of the Yugoslav Military Mission in Berlin in the process of recruiting German experts and workers, please refer to Ilić, *Stranci „gastarbajteri"*, 283-304.

[47] AJ, 50-67-149. Međunarodni odnosi. Vojne misije, 1944-1947. The report on employment of experts in August, September 12, 1947.

[48] AJ, 50-67-149. Međunarodni odnosi. Vojne misije, 1944-1947. Monthly Report, October 10, 1947. The Soviet Government did try to stop this flow of German experts to Yugoslavia and other illegal activities. In 1946 they stopped issuing passes to the Yugoslav representatives who traveled from Czechoslovakia to Berlin, and eventually completely stopped issuing passes to the Yugoslavs for the Soviet zone in Berlin on May 10, 1947, which the Schumacher's escape may have provoked.

[49] Ilić, *Stranci „gastarbajteri"*, 283-284.

was accelerated only in the spring of 1947, and by June, more than 200 experts with additional 100 family members arrived in Yugoslavia. Most of these demands for an expert workforce came directly from the leading figures in the Yugoslav state bureaucracy, but also through representatives of Yugoslav companies, who scanned Germany for potential war reparation and restitution possibilities, which put them in direct contact with German experts.[50]

These efforts were considered a crucial part of the Yugoslav First Five-Year Plan of industrialization, which was initiated in the spring of 1947, and most likely, these covert activities were managed by the Yugoslav secret police, UDB (*Uprava državne bezbednosti*). This must have been the case with Schumacher's escape since one of the "influential Yugoslavs," who, for all practical purposes, stole Schumacher in front of the Soviet eyes, was the director of the Trepča Mines, Miladin Radulović-Krcun. The other Yugoslav agent in this mission was "engineer Jovanović from Zvečan" (Trepča Mines), who was in the group of ten Yugoslav students of *Bergakademie* in Freiberg, and whom Schumacher managed to set free from the Sachsenhausen concentration camp, where they were imprisoned in 1941 after the German attack on Yugoslavia.[51]

Radulović had ample experience in similar activities. During the war, he operated for almost two years as an infiltrated communist agent in the ranks of the Yugoslav Army in the Fatherland (*Jugoslovenska vojska u otadžbini* – JVuO). He often used an invisible ink of his design for communication with other agents and was capable enough to become the commander of the JVuO Deževo Brigade, conducting several important missions that landed him in the headquarters of the JVuO and proximity of the Commander-in-Chief, General Dragoljub Mihailović. With an education in applied chemistry before the war and his wartime record, in 1945 Radulović became the director of the Trepča Mines where he stayed until March of 1947 when he moved to the position of the Chief Engineer in the General Directorate for Colored Metals. In following years, he advanced quickly through the ranks, taking high-level positions in various ministries, committees, and institutes related to the mining industry, eventually becoming the director of the Directorate for Nuclear Raw Materials in 1960. More importantly, his biographers conclude that he was "one of the few individuals acquainted with the pioneering works in the search for nuclear raw materials in Yugoslavia […] as well as in the beginnings of the secret Yugoslav nuclear program".[52]

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[50] Ibid., 287-288.

[51] AJ, 24-43-110. Personal file of Friedrich Schumacher, 1947-1950; Fitzel, "Friedrich Schumacher (1884-1975)", 65. Schumacher protested when his students were imprisoned and even visited the head of the Gestapo in Dresden, demanding their immediate release, but with no results. Finally, Schumacher approached a "reasonable party member in the Foreign Office in Berlin," after which the students were released.

[52] Dragomir Bondžić, Milutin Živković, „Miladin Radulović-Krcun. Prilozi za biografiju", *Tokovi istorije* 2/2018, 119-133. The JVuO was officially controlled by the exiled Yugoslav Royal Government

Radulović had the means and reasons to organize Schumacher's 'James Bondian' secret transfer to Yugoslavia. With some benefit of hindsight, and considering the growing Tito-Stalin conflict and its aftermath in 1948, it would be appealing to present this episode as an elaborate Yugoslav plan to steal from the Soviets, one of the very few experts in uranium prospection. However, Schumacher arrived in Yugoslavia a couple of months before the uranium prospection mission of the Soviet geologists and when the Yugoslav nuclear program was not even initiated. It seems more likely that the Yugoslavs were jumping to the opportunity to use Schumacher's services in their ambitious plans for the country's reconstruction and industrialization. His primary job position was of a chief geologist in the Trepča Mines, one of the biggest mining enterprises in the country with one of the richest lead and zinc deposits in Europe, suggesting rational economic calculation, not an elaborate tactical scheme against the Soviets. Ilić also confirms that in 1947, most of the German workers and former POWs were employed in mining enterprises.[53] Expert geologists from Freiberg were in fact, well known in Serbia, where they conducted the first geological survey already in 1835, while in subsequent years many students were educated in Freiberg, including the one who helped with Schumacher's escape to Yugoslavia.[54]

Zeman and Karlsch also do not mention any details about Schumacher's activities in Yugoslavia related to uranium prospection and official documents are equally silent, although some conclusions can be made. Much like some of the German scientists designated for the Soviet nuclear program, who were initially living "in comfortable conditions, in dachas outside Moscow, and were not immediately assigned specific tasks," his contract with the Trepča Mines provided Schumacher "a villa with four rooms and garden" in the neighboring town of Zvečan, "with free of charge firewood and electricity".[55] Schumacher's performance in Trepča Mines also suggests that his expertise was initially misunderstood and directed towards more practical and conventional activities. The official estimate of his accomplishments explains, with some disappointment, that Schumacher was "a better theoretician than practitioner", who had "more sense for scientific work in geological prospection" and whose expertise was better suited for "some scientific institute." It was also noted that he dedicated most of his time assembling the mineralogical collection for the Trepča

in London. Commonly known as the *Četnici* (Chetniks), they were royalists and Serbian nationalist troops who often bitterly fought against the Communists during the Second World War.

[53] Ilić, *Stranci „gastarbajteri"*, 266-267, 432, 526.

[54] Kosta Petković (ed.), *Geologija Srbije I. Istorijski razvoj* (Beograd: Zavod za regionalnu geologiju i paleontologiju Rudarsko-geološkog fakulteta, 1977), 8-9. Freiherr von Herder, the manager of the Royal Saxon Mining Excavations in Freiberg, conducted in 1835 the first mining survey of Serbian lands on the invitation of Prince Miloš Obrenović. For this footnote and related information, I wish to express my gratitude to my colleague and friend, Dr. Dejan Lukić.

[55] Holloway, *Stalin and the Bomb*, 111; AJ, 24-43-110. Personal file of Friedrich Schumacher, 1947-1950.

Mines geological museum, showing no interest in the management of the mine or work in mine shafts.[56] However, Schumacher was not sitting idle and the final result of his work was a detailed analysis of "geological, tectonic, mineralogical and genetic relations of the main deposits" of the Trepča Mines and its vicinity, published in Croato-Serbian and German.[57]

This does not exhaust the scope of Schumacher's activities in Yugoslavia. In late October 1948, he was urgently transferred from the Trepča Mines to the Institute for Geological Research (*Zavod za geološka ispitivanja*) in Pančevo, on the direct order of Miladin Radulović, who at the time worked as an Assistant of the Minister of Mining of Yugoslavia, Svetozar Vukmanović-Tempo. Schumacher was needed for some very urgent, albeit temporary task since he did return to the Trepča Mines by the mid-1949, the latest.[58] The Institute for Geological Research probably had one of the best-equipped laboratories for analysis of different ores, at least judging by the fact that it was used by Soviet uranium prospectors a year before for preliminary analysis of samples they collected in Yugoslavia.[59] Schumacher's transfer to the Institute for Geological Research also overlaps chronologically with the beginning of the organized uranium prospection in the country. In July 1948, the newly established UKRNI took over all uranium prospecting activities, and already in September started intensive mining exploration works of the site where the first uranium mineral was found, revealing "somewhat stronger concentrations of uranium and beryllium".[60]

It would be appealing to present a story in which the geologist who discovered very rich uranium deposits in Saxony for the Soviets was eventually employed to do the same for the Yugoslavs, right before their eyes and in the heat of the conflict between Stalin and Tito. However, the UKRNI's official report for 1948 states that the "final analysis" of collected radioactive samples were performed by the Institute for Physics in Vinča.[61] This does not deny the possibility that some initial analyses were performed in the Institute for Geological Research in Pančevo at the time when Schumacher worked there, but the documents are silent.

Additional problem is that all activities related to the Yugoslav nuclear program were under the policy of secrecy (*konspiracija*), which eventually turned out to be counterproductive as it was employed "infinitely harsher […] than in any other coun-

[56] AJ, 24-43-110. Personal file of Friedrich Schumacher, 1947-1950.

[57] Friedrich Schumacher, *Ležišta Trepča i njegova okolina*, (Beograd: Izdavačko preduzeće Saveta za energetiku i ekstraktivnu industriju Vlade FNRJ, 1950).

[58] AJ, 24-43-110. Personal file of Friedrich Schumacher, 1947-1950.

[59] AJ, 507-IX, 1119/V-32. Izveštaj o radu sovjetske ekipe geologa u vremenu od 21.VII-4.X 1947, October 29, 1947.

[60] AJ, 836-II-6-a/4. Izveštaj o radu Uprave za naučno istraživački rad za 1948. i zadacima za 1949.

[61] Ibid.

try, except within the Soviet bloc."[62] This meant that often many people or institutions worked on the same problem, isolated from each other and without the ability to compare their results and reach adequate conclusions, all of which made a research on any topic and in any field more expensive and less effective.[63] Holloway identifies a similar policy in the early years of the Soviet atomic bomb project, where all the sensitive information was "strictly compartmentalized", code words were used in reports to mask scientific terms, while scientists could not even talk to unauthorized people about their work.[64] According to memories of Stevan Đurić, at the time a young radio-amateur who worked on the maintenance of Geiger-Müller (GM) counters during uranium prospection missions since 1949, none of the prospectors knew what they were searching for and instead systematically and obediently collected samples in a given location. These were later screened for radioactivity with GM counters by trusted team members, usually those with the Party membership card.[65]

In the environment of secret transfers of German scientists on a global scale, emerging Cold War divisions, frantic work on the Yugoslav Five-Year Plan projects, Tito-Stalin split, direct orders, *konspiracija*, and one hastily organized nuclear program, it would be unrealistic to expect finding "a smoking gun" in the archives that will untangle this complicated history. Schumacher was hired initially to help with the development of the Trepča Mines, which was based on a straightforward economic calculation. However, as the relations between the Soviet Union and Yugoslavia rapidly deteriorated and the ambitious Five-Year Plan lost its momentum, Schumacher's expertise was used in other fields. The attempt to establish his involvement in the uranium exploration in Yugoslavia is exceptionally precarious, but even though it is impossible to make any claims, there are too many coincidences to accept that the Yugoslavs did not employ his expertise in the uranium prospection activities in the country.

Schumacher was under the contract to analyze geologic formations of a region particularly rich in various metallic ores. His track record in working for the Soviets in Saxony also suggests that he would have been happy to share information about potentially interesting topics locations for uranium prospection in 1947. More importantly, after his return to West Germany (1951), Schumacher continued working on secret projects related to uranium prospection. In 1954, he was hired by the Brazilian

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[62] AJ, fond Kabineta Predsednika Republike 837, II-6-a. O dva bitna uslova za razvitak atomske energije kod nas, May 25, 1953 (henceforth: AJ, 837-II-6-a. O dva bitna uslova). Quoted in Bondžić, *Između ambicija i iluzija*, 109. The term *konspiracija* is best defined as secrecy employed in underground organizations and their activities to protect them from enemies and their potential infiltration. Bratoljub Klaić, *Rječnik stranih riječi, A-Ž* (Zagreb: Nakladni zavod MH, 1989), s.v. "konspiracija".

[63] AJ, 837-II-6-a. O dva bitna uslova. Quoted in Bondžić, *Između ambicija i iluzija*, 109-110.

[64] Holloway, *Stalin and the Bomb*, 202.

[65] Popović (ed.), *Od Uprave za koordinaciju rada naučnih instituta do Geološkog zavoda Srbije*, 54, 65, 71.

National Research Council (*Conselho Nacional de Pesquisa* - CNPq) to explore local uranium and thorium deposits. This was just one of the components of the secret agreement of cooperation between Brazil and West Germany, which included "geological prospecting and the possible export of Brazilian uranium to West Germany" in exchange for uranium enrichment and other sensitive technologies.[66] It would be next to impossible to consider that back in Yugoslavia Schumacher's work consisted of making simple geological maps and writing scientific monographs.

Schumacher was the most renowned expert among a larger group of German geologists that were employed in various Yugoslav ministries and scientific institutions. The biography of Croatian academician Dr. Ivan Jurković provides insights into how Schumacher's and German geologists' expertise was used in the Yugoslav nuclear program. In 1947, Jurković closely collaborated with Dr. Ljudevit Barić from the University of Zagreb, who helped him specialize in the optical analysis of the presence of minerals in rocks and ores. This information is vital since Barić was working closely with Schumacher in the Trepča Mines and was the person who translated his book into Croato-Serbian. It is possible that Jurković was also educated by Schumacher, who did organize practical courses and training in the Trepča Mines for the Yugoslav geologists, engineers, and their professors from universities in Belgrade and Zagreb. By the end of 1950, Schumacher became a professor at the Faculty of Mining and Geology in Belgrade, where he taught courses Mineral Deposits and Methodology of Mineral Deposit Research, before he moved back to West Germany in July 1951, taking a position as a professor at the University of Bonn.[67]

Jurković moved quickly through the ranks, and between 1949 and 1951, he held the position of chief geologist in the Ministry of Black and Colored Metallurgy, where he worked with many German geologists and experts in related disciplines, predominantly from the *Bergakademie* in Freiberg. Most of them stayed in Yugoslavia until the early 1950s, except Dr. Arnold Cissarz, who returned to Germany only in 1956. Until 1955, Cissarz worked in various advisory positions as the leading expert for metal ore deposits in Yugoslavia. He was also an external professor of the Faculty of Mining and Geology in Belgrade, in the period between 1951 and 1956, the same place where Schumacher also taught in 1950/51.[68]

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[66] Ilić, *Stranci „gastarbajteri"*, 432; Fitzel, "Friedrich Schumacher (1884-1975)", 66-67; Carlo Patti, *Brazil in the Global Nuclear Order, 1945-2018*, (Baltimore: Johns Hopkins University Press, 2021), 31.

[67] AJ, 24-43-110. Personal file of Friedrich Schumacher, 1947-1950; Schumacher, *Ležišta Trepča i njegova okolina*. In a personal letter to Miladin Radulović, Schumacher expressed his wish to teach in Zagreb instead of Belgrade, since scientific institutions in Zagreb were better equipped, the "scientific level" of their students was higher, and they understood German better.

[68] Ladislav Palinkaš, Vesnica Garašić, Goran Durn, "Akademik Ivan Jurković (1917. – 2014.) – život i djelo", Vijesti Hrvatskoga geološkog društva 54, 2 (2017), 9-15. URL: https://urn.nsk.hr URN: urn:nbn:hr:169:507832 (24.01.2022.); "Akademik Ivan Jurković", Hrvatska akademija

This small community of German geologists and scientists in related disciplines functioned in the late 1940s as a Yugoslav branch of the *Bergakademie* in Freiberg. This was indirectly recognized by the officials in the Ministry of Mining who commented that "in comparison to others, all these professors have unrealistically high salaries," because "these experts are truly experts of highest scientific qualities."[69] At least on one occasion, scientific inquires and exchanges between colleagues led to open debates in scientific journals. This was the case with Schumacher and Cissarz, who exchanged somewhat strong critiques regarding each other's research results published in Yugoslav scientific journals.[70] This debate remained in the realm of professional disagreements, and it seems that state officials supported the creation of such a competitive environment. In 1950, the same year Schumacher published his monograph, Cissarz prepared a university textbook about the deposit theory and formation of ore deposits, which was also published in Serbo-Croatian and German.[71]

According to Jurković's biographers, the collaboration with these German geologists gave him an "extensive and broad experience in the field of ore deposits research." Working primarily with Cissarz, he explored almost all known deposits of metal ores in Yugoslavia. In 1951, under Cissarz's supervision, he specialized in ore microscopy and metallogeny at the Faculty of Mining and Geology in Belgrade, thus becoming one of the leading experts for analyzing ore deposits in Yugoslavia. More importantly, working simultaneously and independently from Cissarz, Jurković used this experience and specialized in methods for laboratory analysis and research of uranium ores. In the following years, he became deeply involved in the Yugoslav nuclear program, where he participated in the exploration of uranium ores as one of

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znanosti i umjetnosti, https://www.info.hazu.hr/en/clanovi/jurkovic-ivan/ (12.01.2022.); "Rektoren der Bergakademie", Technische Universität, Bergakademie Freiberg, https://tu-freiberg.de/universitaet/rektoren-der-tu-bergakademie (27.01.2022); AJ, 24, f. 43-110. Personal file of Otto Meisser, 1947-1950. Besides Dr. Schumacher, the Ministry for Black and Colored Metallurgy employed Dr. Otto Meisser, Dr. Arnold Cissarz, Dr. Martin Donath, Dr. Nöth, Dr. Ledebur and Ing. Franz Brenthel, although the list is probably not complete. Before 1945, Cissarz was the director of the Geological Bundesanstalt in Hannover, Germany

[69] AJ, 24-43-110. Personal file of Otto Meisser, 1947-1950; AJ, 24, f. 43-110. Personal file of Friedrich Schumacher, 1947-1950; Ilić, *Stranci „gastarbajteri"*, 444-445; An average workers' monthly salary in 1947, ranged between 2.232 and 3.165 dinars, while the highest salary experts in administration was 6.000 dinars. However, the monthly salary of German professors from Freiberg was 8.000 dinars with an additional 3.000 as a monthly supplement. By 1949/50, their monthly income rose to 18.000 dinars, with additional supplements and rewards. Schumacher also negotiated 4.500 dinars per copy of his book, which was printed in 18.000 copies.

[70] Arnold Cissarz, "Die Stellung der Lagerstätten Jugoslaviens im gelogischen Raum", *Geološki Vesnik* 9 (1951), 23-60; Fridrich Schumacher, Karl Stier, "Krittischer Beitrag zur Kenntnis der Lagerstätten Jugoslaviens", *Geološki vjesnik* V-VII (1951-1953), 25-34.

[71] Arnold Cissarz, *Nauka o rudnim ležištima: opšti deo: postanak ležišta i njihova sistematika*, (Beograd: Izdavačko štamparsko preduzeće Saveta za energetiku i ekstraktivnu industriju Vlade FNRJ, 1950).

the leading experts in the field and an invaluable educator of many generations of Yugoslav geologists.[72]

Besides expert training, the budding first generation of post-war Yugoslav geologists desperately needed many special instruments unavailable and impossible to produce in the country. Back in 1947, when the first uranium mineral had been discovered in Yugoslavia, the final measurement of radioactivity was taken with an improvised GM counter, made at the Institute for Physics by professor Dragoljub Jovanović, who used a piece of a tin can as an electrode and similarly devised other components.[73] This was one of the reasons why it took such a long time and three laboratories to confirm the finding of a first uranium mineral, or perhaps why Yugoslav geologists could not replicate at least some of discovered radioactive anomalies found by the Soviet uranium prospection team.

Professor Dr. Otto Meisser arrived from the *Bergakademie* in Freiberg to Yugoslavia on November 22, 1947, as a recognized expert in the "special construction of geophysical instruments." Together with Dr. Martin Donnath, he continuously performed fieldwork missions with a task to "find and explore deposits of useful mineral ores and determine the geological composition of the Earth crust." Until 1950, when he returned to Germany, Meisser made electric and magnetic measurements in most of the Yugoslav metallic mines, predominantly in Trepča, investigated availability and composition of deposits, and eventually produced several dozens of detailed maps. More importantly, upon his return to Germany, Meisser sold all the instruments he brought with him from Freiberg and constructed in Yugoslavia to the Ministry of Mining for the astonishing amount of 900.000 dinars. Like with other emergency investments at the time, this purchase was made "outside of the Plan" and "without a particular contract," and on informal approval of the Minister of Mining, Svetozar Vukmanović-Tempo.[74]

Epilogue

In 1952, some uranium ore samples from Yugoslavia were sent to the United States for analysis. The radiometric and chemical analyses were received later in the year, and they were used for comparisons with results of the Yugoslav laboratories,

[72] Ladislav Palinkaš, Vesnica Garašić, Goran Durn, "Akademik Ivan Jurković (1917. – 2014.) – život i djelo", Vijesti Hrvatskoga geološkog društva 54, 2 (2017), 9-15. URL: https://urn.nsk.hr URN: urn:nbn:hr:169:507832 (24.01.2022.); "Obituary: Professor Emeritus Ivan Jurković", *Geologia Croatica* 68, 2 (2015), 162; "Akademik Ivan Jurković", Hrvatska akademija znanosti i umjetnosti, https://www.info.hazu.hr/en/clanovi/jurkovic-ivan/ (12.01.2022.). In the 1950s and 1960s Jurković was a member the Council of the Institute for Nuclear Raw Materials (*Zavod za nuklearne sirovine*) and Federal Geological Institute (*Savezni geološki zavod*), and a member of the Federal Nuclear Energy Commission (*Savezna komisija za nuklearnu energiju*).

[73] Popović (ed.), *Od Uprave za koordinaciju rada naučnih instituta do Geološkog zavoda Srbije*, 57.

[74] AJ, 24-43-110. Personal file of Otto Meisser, 1947-1950.

which was crucial in confirming the quality of their independently developed methods. Soon after, the Yugoslav Embassy in Washington officially requested to expand this cooperation, and eventually, "a prospection expert" geologist Donald G. Wyant came to Yugoslavia and "visited all interesting radioactive phenomena."[75]

Learning their lessons from experience with the Soviet geologists in 1947, the Yugoslavs sent an entire team of their experts to accompany Wyant, yet to no avail. During his mission, Wyant "did not give any data or advice, transfer any experience, nor did he want to get into any kind of conversation." The Yugoslavs were appalled to discover that he even "hid his field-type Geiger-Müller counter […] so it would not fall into the hands of our experts," and when the first unit broke down, he exchanged it for a new one in the U.S. Embassy in Belgrade. His report was received only in 1954, but it turned out to be "useless" since it contained only data received from the Yugoslav side, combined with some laboratory analyses of the raw materials acquired during this mission.[76]

More importantly, by 1953, Yugoslav geologists had enough knowledge and experience in uranium prospection and about known uranium deposits in the country to be at least confident enough to understand that Wyant did not want to provide any interesting information and to dismiss his report as "useless." This was probably also the last signal that they could not expect support from abroad in their quest to find promising uranium deposits in the country. In 1956, Yugoslavia eventually opened its first uranium mines, *Mezdreja* and *Gabrovnica*, in the region of Kalna (Serbia), which produced roughly 16 tons of uranium metal until 1965, when they were closed. Between 1961 and 1965, several other locations revealed additional uranium deposits. This included *Bukulja* and *Iverak* in Serbia, *Zletovska reka* in North Macedonia, and *Žirovski vrh* in Slovenia. Uranium exploitation was eventually initiated only in *Žirovski vrh*, which started its operations in 1982 and managed to produce 457 tons of uranium-oxide by 1989 when the production ended.[77]

German geologists from *Bergakademie* in Freiberg did not find illusive uranium in Yugoslavia, and it seems that most of them were not directly engaged

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[75] AJ, 177-23-92. Problematika istraživanja nuklearnih sirovina; AJ, 177-23-90. Saradnja sa SAD, September 5, 1957; J.O. Harder, D.G. Wyant, "Preliminary report on a trace elements reconnaissance in western states", *Geological Survey* (October 1944), Washington D.C.: United States Department of the Interior. Donald G. Wyant was one of the pioneers in uranium prospection in America. Since 1944, he was conducting field analyses for the U.S. Geological Survey and later for the U.S. AEC for potential sources of uranium and thorium in the states of Utah, North Dakota, Montana, New Mexico, Wyoming, California and others, performed primarily between 1950 and 1954.

[76] AJ, 177-23-92. Problematika istraživanja nuklearnih sirovina; AJ, 177-23-90. Saradnja sa SAD, September 5, 1957.

[77] Miljković, "Tito's Proliferation Puzzle", 369-375, 447-460; Bondžić, *Između ambicija i iluzija*, 173-187; Alojzil Pavel Florjančič, "Koliko elektrike je proizvedeno iz urana Žirovskega vrha", *Loški razgledi* 41, 1 (1994), 86. This amount was enough for 64.2 tons of uranium fuel, or four charges for the nuclear power plant Krško (Slovenia), producing 12.3 billions KWh of electric energy by 1993.

on this project, but their contribution in these efforts was invaluable. They made analysis of known ore deposits in the country, prepared geological maps of the most exciting regions, equipped laboratories and universities with necessary instruments, offered specialized education to the first post-war generation of Yugoslav geologists, and eventually planted the seed for the establishment of the Yugoslav geological scientific community. Strictly implementing the policy of *konspiracija*, the UKRNI directed their capacities towards "general geological exploration" of areas for which reliable data did not exist, which was the case with Trepča and the broader region of the mountain Kopaonik.[78] Most of the German expert geologists were employed by the Trepča Mines, which was both the training ground and talent pool from which the UKRNI recruited young geologists. This was the case with Radosav Pantić, a graduate of the first generation of students at the Faculty of Mining and Geology. After he graduated in January 1950, he was first employed in the Directorate for Colored Metals, and almost immediately sent to Trepča Mines, only to be transferred to the UKRNI six months later, where he continued to work on uranium exploration and mining.[79]

The work of Friedrich Schumacher and his colleagues in Yugoslavia and their role in the country's nuclear program also reflect a range of global post-war phenomena, such as denazification, industrialization, exploitation of German scientific achievements in civilian and military projects, the evolution of the nuclear age, the scientific revolution, technology transfer, uranium rush, Cold War divisions, nuclear and conventional arms race, decolonization and emergence of the Third World, and much more. They were involved in all of these processes, whether through their voluntary or involuntary participation and to understand their actions and deeds, they have to be perceived from all of these perspectives. More importantly, the analysis presented in this paper shows that these global processes were not reserved exclusively for great powers, as it is often (mis)represented in scholarship, but that Yugoslavia, Bulgaria, Czechoslovakia, East, and West Germany, or Brazil were active players with varying degree of success along the way. This conclusion enriches the current debates and emphasizes the need for further research of the Cold War phenomena outside the traditional bipolar perspective.

[78] AJ, 836-II-6-a/4. Izveštaj o radu Uprave za naučno istraživački rad za 1948. i zadacima za 1949.

[79] Popović (ed.), *Od Uprave za koordinaciju rada naučnih instituta do Geološkog zavoda Srbije*, 52, 68, 364-365. Bondžić, *Između ambicija i iluzija*, 176. During the early 1950s, Popović worked on the development of uranium mines in Kalna, eventually becoming the director of the Geoinstitut in 1966, an institution, which evolved from the UKRNI.

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Резиме

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Југословенска „Операција *Paperclip*“: Немачки геолози у југословенском нуклеарном програму крајем четрдесетих и почетком педесетих година 20. века

Преузимање научних достигнућа нацистичке Немачке у периоду непосредно после Другог светског рата, представљало је глобални процес и специфичну врсту ратног плена савезничких окупационих сила, током којег су на хиљаде немачких стручњака разних дисциплина пребачене у научне институте, пре свега у Сједињеним Америчким Државама и Совјетском савезу. Супротно традиционалним представама о биполарном хладноратовском свету, у којима су земље у развоју и мање силе имају првенствено улогу посматрача, Југославија је била активни учесник ових глобалних процеса. У раду се анализира рани период југословенског нуклеарног програма, када је највећи проблем било проналажење резерви руде урана у земљи. Прва истраживања су указала на хронични недостатак искусних геолога и проспектора, као и на опште слабо познавање геолошке структуре Југославије. Решење је пронађено у запошљавању немачких стручњака из *Bergakademie* у Фрајбергу, који су још од средине 19. века вршили организована истраживања рудног богатства Србије. Најистакнутији међу њима био је Фридрих Шумахер, који је још 1947. године Совјетима открио богате резерве урана у Саксонији. Немачки стручњаци из Фрајберга, од којих је већина била запослена у руднику олова и цинка Трепча, али и као професори на Рударско-геолошком факултету у Београду, дали су значајан допринос образовању прве послератне генерације југословенских геолога и стручњака из блиских дисциплина. Многи од њих су радом на развоју југословенског нуклеарног програма успели да пронађу резерве урана у земљи и започну његову експлоатацију, пре свега у Кални (Србија) и Жировском врху (Словенија).

Кључне речи: Југославија, Хладни рат, нуклеарни програм, Трепча, уран, Фридрих Шумахер