BULGARIA

Geography

The topography of Bulgaria is characterised by both lowlands and mountainous or hilly terrain. In the north, the Danubian plain extends along the Danube River and gradually rises in the south to the Stara Planina or Balkan Mountains (the highest point is Botev (2376 m)). The capital, Sofia, is located in the western part of the mountain ranges. The Balkan Mountains are divided into the west, high and east Balkan, forming watersheds flowing northwards to the Danube ending in the Black Sea, and southwards to the Marica River, which in its southern course forms the border with Turkey and Greece before discharging into the Aegean Sea. The mountains of Sredna Gora and Sarnena Gora are part of the Balkan range. South of the Balkan Mountains, the area extends via the sub-Balkan valleys to the Thracian Plain and to the Marica River. Many parts are hilly. The western extension of this area is formed by the Sofia Basin. The southern part of Bulgaria is dominated by the mountainous regions of Rila (highest peak Musala at 2 925 m), Pirin (highest peak Vihren at 29 15 m) and Rhodope (~2 200 m).

Owing to the ongoing mountain building processes and to the drift of the African Plate towards Eurasia, the country is prone to seismicity. Higher elevations are prone to landslides, especially in areas of deforestation.

The Bulgarian climate varies from continental to Mediterranean. The continental climate, mostly in the northern area and in the mountains, results in cold winters and abundant snow in the mountains, whereas the Mediterranean influence is marked by hot dry weather. In Sofia, the average summer temperature is around 28°C, which drops to below 0°C during winter. The average annual precipitation is ~630 mm in the areas close to the Black Sea and ~500 mm inland.

Industry plays a key role in the Bulgarian economy. Ferrous metallurgy is of major importance. Much of the production of steel and pig iron takes place in Kremikovtsi and Pernik, with a third metallurgical base in Debelt. The country leads its Balkan neighbours in the per capita production of steel and steel products. As well as steel, Bulgaria has major refineries for lead and zinc at Plovdiv, Kardzhali and Novi Iskar, for copper at Pirdop and Eliseina, and for aluminium at Shumen. Bulgaria ranks first in south-eastern Europe in production per capita for several metals [1].

Geology

Bulgaria's geology [2, 3] is complex (Fig. 1) and heavily influenced by the collision of the African Plate with the Eurasian Plate. Four principal regions resulted and are defined as the:

(a) Rhodope Massif, mostly comprising Precambrian rocks intruded by Palaeozoic granites;
(b) Marica valley and Tertiary basins;
(c) Balkan Mountains, part of the Hellenide belt of miogeosynclinal sediments, containing volcanics and acid intrusions and related to Alpine orogenic events;
(d) Danubian Platform, covered mostly by Cretaceous limestone and underlain by folded rocks of Hercynian age.

Geological research [4] indicates that portions of the Balkan Peninsula have their geological origin as part of Gondwanaland. Two types of terrain are distinguished: the Balkan and the Moesian. The Balkan terrain is characterised by a Precambrian–Cambrian ophiolitic island arc unconformably overlain by a Palaeozoic sequence. The ophiolites have Pan-African features. In the Moesian, the pre-Palaeozoic (Proterozoic–Vendian) consists of metamorphics of continental origin. The proto-Moesian appears to be peri-Gondwanaland.

According to Ref. [5], the dating of basement rocks at Sredna Gora indicates Neoproterozoic ages (617 and 595 Ma), corresponding to Gondwana ages elsewhere and the authors suggest that Sredna Gora is

Gondwana derived terrain. The ages of the sediments indicate their deposition between the Ordovician and the Early Carboniferous. During the Carboniferous, metamorphism affected most of the older rocks. Studies of plate tectonics [6] have shown that the Balkanides is a mobile belt in the microcontinent formed by the Moesian Platform and the Rhodope Massif. In a complex development, rotation of the microcontinent and sea-floor spreading occurred together with ophiolitic magmatism in the Vardar Trough. During the Middle and Late Cretaceous, island arcs with adjacent marginal basins were formed. In the Vardar Trough, sedimentation took place between the Triassic and the Eocene. The Rhodope Massif in both Bulgaria and Greece is believed to be a Mesozoic nappe stacked within an active Alpine margin environment [2, 7].

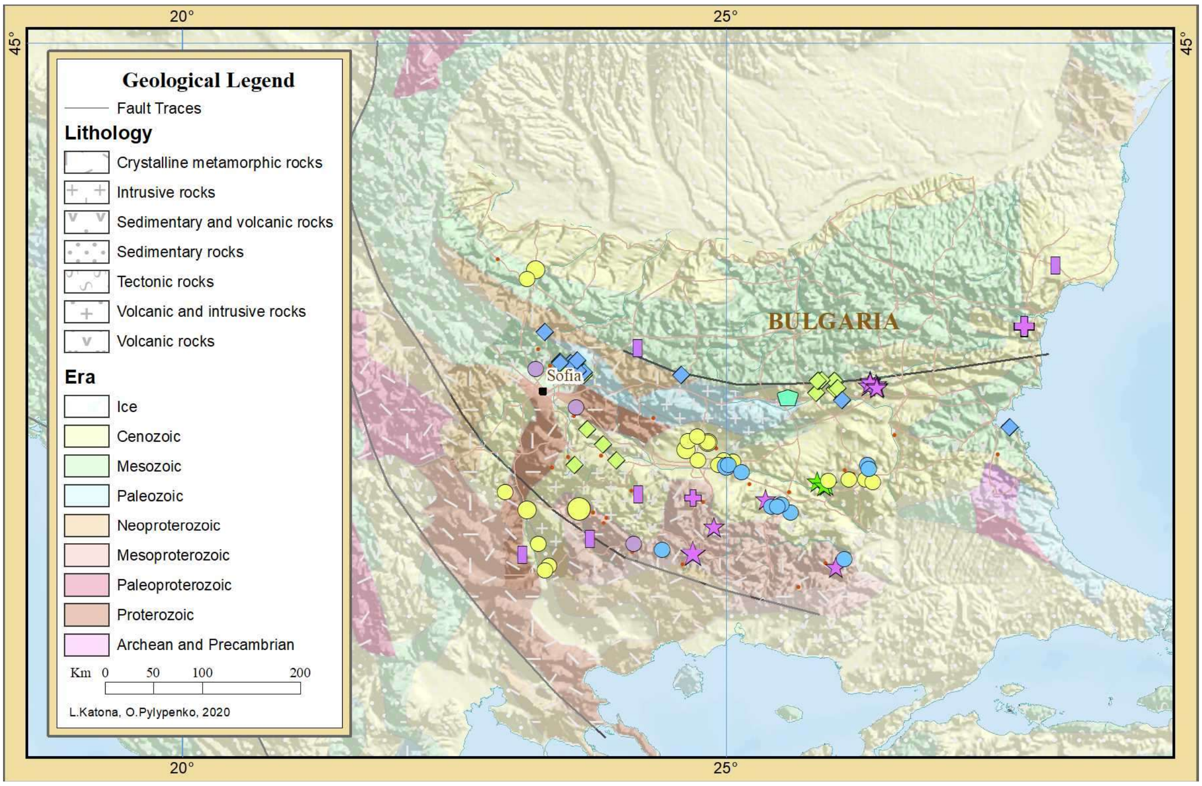

FIG. 1. Regional geological setting of Bulgaria showing the distribution of selected uranium deposits and occurrences. For the general uranium deposit and occurrence legend see World Uranium Geology, Exploration, Resources and Production, IAEA, 2020. A general global geological legend is shown although not all geological units necessarily occur on this particular map.

Uranium exploration and description of deposits

Uranium mineralisation at Buhovo (also Bukhovo) has been known since 1920. Detailed mining studies were undertaken during 1938–1939. Buhovo hosts high grade uranium in Ordovician black schists, intruded by quartz syenite stocks and dykes. In 1939, ~300 t of ore was mined.

Systematic exploration was started after 1945 by Bulgarian and Soviet geologists. In 1946–1956, a joint Bulgarian–Soviet company was responsible for uranium exploration and mining. After 1956, the Bulgarian uranium company 'Rare Metals' replaced the latter organisation and was assisted by Soviet consultants until 1990. In the early 1950s, the deposits of Eleshnitsa, Smolian and Planinetz were discovered. Reconnaissance and general exploration, using all available methods, were carried out over ~80% of the country. Buhovo, Momino and Eleshnitsa contain several individual deposits. Mineable deposits of uranium are small to medium in size (up to 20 000 tU).

Exploration resulted in the discovery of 39 deposits of four principal types:

(i) Several are vein type deposits, similar to Buhovo, with tonnages of 500–5000 tU, and of similar grade. These include Proboinitsa, Kurrilo, Gabra, Biala Voda, Kostenetz, Partisanska Poliana (grade >1% U), Beli Iskar, Dospat, Narretshen and Sborishte;
(ii) Fifteen are sandstone-type deposits of Permian, Oligocene and Pliocene age. Grades generally vary in the range 0.03–0.07% U (with one exception of 0.1% U). The most important deposits are hosted in Tertiary sandstone and include Eleshnitsa, with several horizons of Oligocene age and total resources of 5000–20 000 tU and Momino, a roll front type hosted in a Pliocene sandstone of the Thrace Basin, between 100 and 260 m deep, with total resources of 5000–20 000 tU. Other deposits include Smolianovtzi, Simitli, Gradovo, Pripetshen–Deltshevo, Melnik, Belosem, Pravoslaven, Haskovo, Marritsa, Navasen–Troian, Orlov Dol, Isgrev and Okop–Tenebo;
(iii) Deposits of the volcanic type occur mainly in Cretaceous (Sliven and Rosen deposits) and Miocene volcanics (Smolian, Sarnitsa, Planinetz deposits) in the form of veins and stockworks. Resources are in the range 500–5000 tU, with grades of 0.01–1.0% U;
(iv) Surficial type deposits occur in river valleys draining granitic terrains. These include Igralishte, Senokos, Beslet and Selishte deposits, which have low to medium tonnages (500–5 000 tU) and grades of 0.1–1.0% U [8–11].

Details of exploration efforts, for example, drilling and expenditures, are not available. Exploration activities ceased in 1990. Fig. 5.5 indicates the deposits locations.

Uranium resources

Details of uranium resources are shown in Figures 2 and 3 respectively. In recent years, Bulgaria did not reported identified resources to the Red Book, as the tonnages previously reported were categorised as uneconomic. The following description of resources was submitted to the 2007 Red Book [11].

Identified resources

Identified resources as of 1991 amounted to 20 565 tU and were categorised as uneconomic. A recalculation (as of 1 January 2007) undertaken by the National Geo Fund identified in situ resources of 19 809 tU. Of this total, 11 908 tU could be extracted from underground mining and 7901 tU by in situ leaching (ISL) at 16 sites, assuming a mean recovery factor of 65%. These resources are hosted within 67 small deposits which are currently not considered viable, either economically or technologically.

Undiscovered resources

Prognosticated and speculative resources amount to 18 200 tU at a recovery cost of <US $130/kgU (Table 1). No unconventional resources have been reported.

TABLE 1. URANIUM RESOURCES (tU) [12]
(As of 2005)

	<US $40/kgU	<US $80/kgU	<US $130/kgU	Cost unassigned	Total
Reasonably assured resources	1 665	5 870	5 870	n.a.[a]	5 870
Inferred resources	1 650	6 300	6 300	n.a.	6 300
Prognosticated resources	n.a.	2 200	2 200	n.a.	2 200
Speculative resources	n.a.	n.a.	16 000	0	16 000

[a] n.a.: not available.

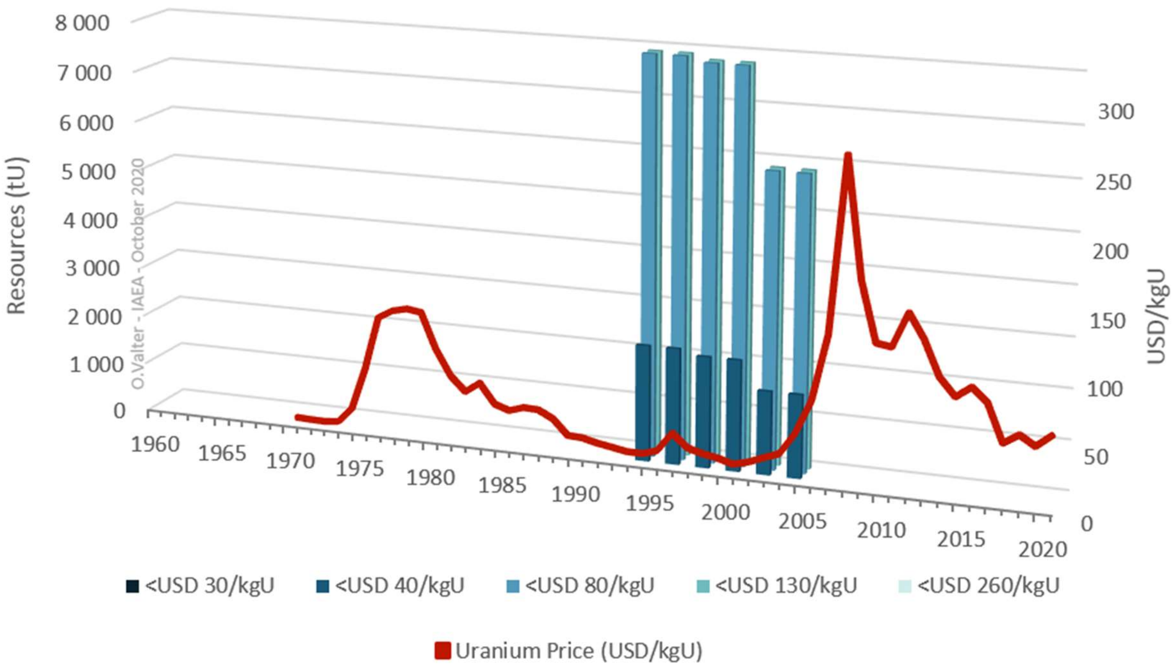

FIG. 2. Historical variation of recoverable reasonably assured resources within various cost categories in Bulgaria. Periods where no resources are shown in any cost categories are periods where resources are not reported, either by the Member State or as a secretariat estimate.

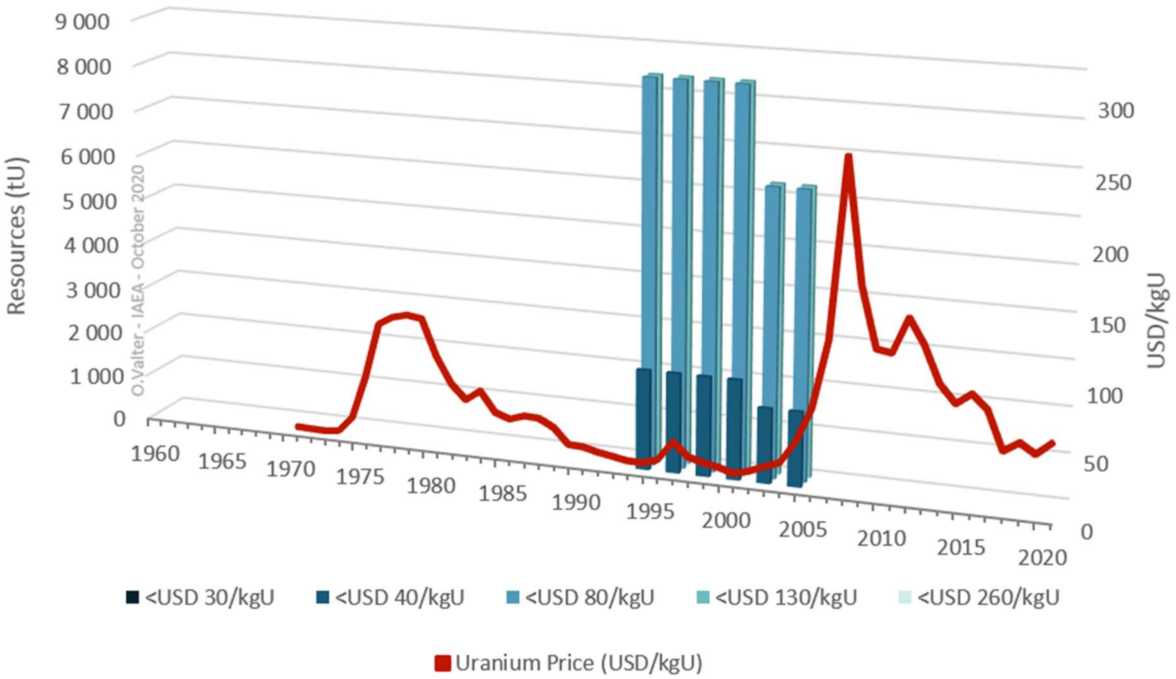

FIG. 3. Historical variation of recoverable reasonably assured resources within various cost categories in Bulgaria. Periods where no resources are shown in any cost categories are periods where resources are not reported, either by the Member State or as a secretariat estimate.

Potential for new discoveries

According to Ref. [5], moderate potential exists in the country. It is believed that the Rhodope Massif and the Balkan Mountains have potential for vein, disseminated and possibly sedimentary deposits. At the time of compilation of the report, limited knowledge was available owing to the political situation prevailing at that time. Official reports for various Red Books since 1990 indicate a great variety of deposits have been found in the areas formerly assigned as having potential. However, it should also be noted that there are areas that were assessed as having the potential to contain deposits owing to their previous exploitation. Currently, no deposits are being mined and no exploration is being carried out. It is likely that only limited potential exists for finding new economic deposits.

Uranium production

Uranium mining began in 1946 with the opening of an underground mine in the Buhovo district, ~20 km NE of Sofia. Individual deposits at grades varying in the range 0.1–1.0% U were delineated and mined. The ore was shipped to the former Soviet Union for further treatment.

Additional underground mines operated in the mid-1950s. Underground mining was the predominant production method until 1979. The first ISL operation was tested in 1967 on the sandstone hosted deposit at Orlov Dol, in south-eastern Bulgaria. After 1979, ISL was applied. In 1981, stope leaching was introduced in underground mines to extract lower grade ores. Since 1981, 23 deposits have been exploited by underground mining, 17 by ISL and 11 using leaching in association with conventional mining.

During the late 1980s, four conventional mines closed and by 1989 ~70% of production came from the ISL mining of sandstone-hosted deposits, mainly using sulphuric acid leaching. The ISL method was mainly applied in those deposits with grades too low for conventional underground mining. In the early 1990s, three ISL operations (Orlov Dol, Madrets and Vladimirovo) were exhausted.

During 1991–1992, 15 well fields, comprising 14 000 wells, were in operation with four satellite ion exchange recovery units and one resin enrichment unit. The resins were hauled by road to the Eleshnitsa plant (~120 km south of Sofia) for concentrate production.

In 1993, several underground deposits were mined out, including: Buhovo, Partisanska Polina, Beli Iskar, Melnik, Beslet, Dospat, Narretshen, Sarnitsa, Planinetz, Sliven and Rosen. The mines using underground mining and stope leaching at Igralishte and Selishte and the ISL production facility at Orlov Dol were also closed. Underground mining continued at Proboinitsa, Kurillo, Eleshnitsa, Simitli, Smolian and Sborishte. Underground mining and ISL production were conducted at Biala Voda. ISL production continued at Momino, Belosem, Provoslaven, Haskovo, Navasen–Troian, Isgrev and Okop–Tenebo and in one open pit was in operation at Senokos.

Ore extracted from vein deposits in underground mines and resins from ISL were treated at the Buhovo plant. Ores and ISL resins from sandstone deposits were treated at Zvezda near Eleshnitsa. Up to 1990, 60 000 tU had been discovered and ~16 500 tU produced. Production had increased steadily from 150–200 tU/year in the 1950s to 430 tU/year by 1975. With the advent of ISL mining, production increased further to 660 tU in 1989, when 70% of uranium production was by ISL. After 1994, no production was reported [5.8–5.11]. Details of uranium production are summarised in Table 2 and in Fig. 4.

TABLE 2. URANIUM PRODUCTION FOR 1946–1990 BY PRODUCTION TYPE (tU) [11]

Open pit[a]	Underground mining	ISL[b]	Heap leaching	In place leaching	Co-/by-product	Uranium from phosphate	Other	Total
0	11 526	4 272	0	549	0	0	14	16 361

[a] No open pit production is reported, although seven open pit mines are mentioned in the country report.
[b] ISL: in situ leaching.

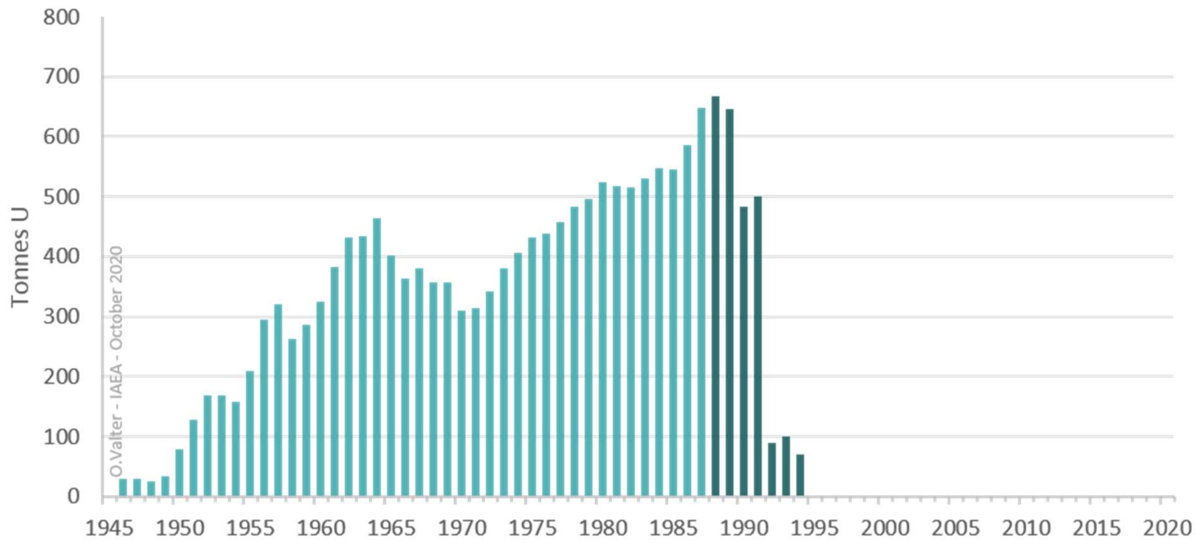

FIG. 4. Historical uranium production in Bulgaria (Data in light green are from the Red Book Retrospective, in dark green from Red Books) [11, 13].

After 1990, uranium was also extracted by mine water treatment during site rehabilitation. At Zvezda, on the site of the past processing plant, an installation for ion exchange resins is used to recover uranium from contaminated mine water. In the period 1991–2009, 5.5 tU was recovered.

Status of production capability

No uranium production centres exist. According to Government policy, were uranium production to restart, then all facilities and processes would have to be operated by private companies. Currently, at the erstwhile Zvezda ore processing plant, the ion exchange resin plant is operational and is being used to purify mine waters. It has a capacity to process ~742 m^3 of resin annually. From 1992, activities have concentrated on disassembling facilities, closing mining works, re-cultivating contaminated areas, purifying contaminated mine waters and conducting environmental monitoring.

Environmental activities and sociocultural issues

Environmental activities are summarised in a short contribution in Ref. [13], reflecting the status as of the end of 1998.

Uranium production officially ceased in 1992. Remediation activities include liquidation, biological and technical re-cultivation, decontamination of mine waters and environmental monitoring of former mine sites, provision of technical documentation on hydro-ecological and radiological assessments and prognoses, and conduct of pre-project investigations. Remediation of subsurface and open pit production centres of uranium has been accomplished. Mine adits have been closed and vertical shafts backfilled and covered by concrete slabs. Remediation was completed in seven open pit mines.

Facilities for production by ISL have been disassembled and associated soils re-cultivated, except for 26.5 ha of concrete and foundations. Currently, technical remediation at all sites listed in the Governmental decree has been accomplished, except the Gabra shaft close to Novi Han. Remediation was completed in 54 sites. Of the existing 21 vertical shafts owned by Rare Metals, 19 have been filled and capped and over 600 horizontal mine adits sealed (including galleries totalling over 600 km in the Buhovo deposit). A total of 37 re-cultivation projects were accomplished and 1172.7 ha of agricultural land were re-cultivated biologically and reverted to their owners after remediation was approved by the concerned commissions for land property.

Assessment and categorisation of risk was accomplished for 37 facilities. The Metalurg/Buhovo plant, owned by Rare Metals, was sold. The tailings facility at this plant is being investigated for re-cultivation. The plant at Zvezda/Eleshnitsa is nearly wholly disassembled and all buildings have been razed. The tailings facilities have been closed and re-cultivated. The capacity of the decontamination facility has been lessened to meet the requirements for water decontamination. Biological and technical re-cultivation on the waste banks close to the mining sites are continuing. Concurrently, monitoring, chiefly of waters, is continuing at some sites and where polluted mine waters are penetrating to the surface, water decontamination is continuing.

According to Government decrees issued between 1992 and 1998 on the termination of uranium production, a total expenditure of ~26.6 million Bulgarian Lev had been incurred.

By 2007, the majority of environmental remediation of the mining impacts of uranium were considered to be thorough. A project on closing and re-cultivation of the tailings facilities and contiguous areas in Buhovo was completed by 2009. Projects for remediation at former exploration sites and at locations of small- scale mining activities are likewise essentially complete. The overall cost was BGN 35.653 million (USD $15.673 million) (Fig. 5) [8–11, 14].

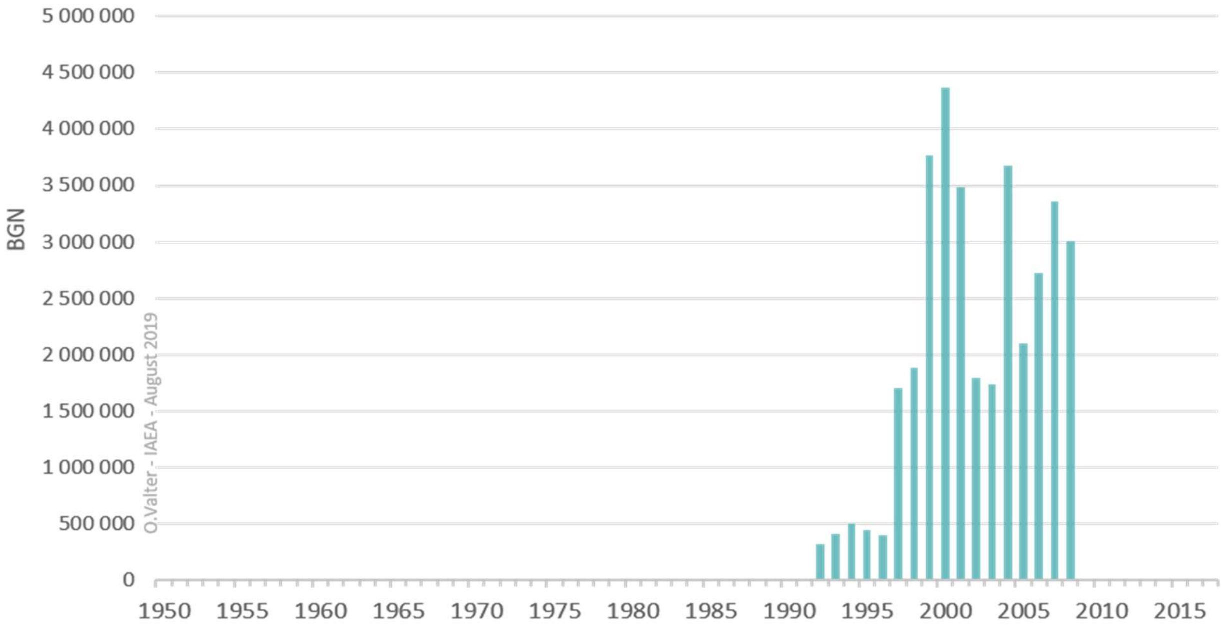

FIG 5. Annual environmental expenditures (in Bulgarian Lev).

National policies relating to uranium

Currently, Bulgaria has no intention to renew mining activities for uranium. In view of the building of the Belene nuclear power plant project, this policy may be reviewed.

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