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ASSESSMENT ISSUES OF ENVIRONMENTAL RISKS AND ECONOMIC LOSSES OF UKRAINE'S SUBSOIL AS A RESULT OF RF ARMED AGGRESSION AGAINST UKRAINE

ПИТАННЯ ОЦІНКИ ЕКОЛОГІЧНИХ РИЗИКІВ ТА ЕКОНОМІЧНИХ ВТРАТ НАДР УКРАЇНИ ВНАСЛІДОК ЗБРОЙНОЇ АГРЕСІЇ РОСІЇ ПРОТИ УКРАЇНИ

Stella B. Shekhunova, Svitlana M. Stadnichenko, Nataliia P. Siumar
С. Б. Шехунова, С. М. Стадніченко, Н. П. Сюмар

Institute of Geological Sciences, NAS of Ukraine, 55-b O. Honchara Str., Kyiv, Ukraine, 01601
(shekhun@gmail.com; stadnik_sm@ukr.net)

After armed conflicts, at the current stage of world society's development, international courts are now hearing cases for compensation, including ones for environmental damage. In particular, the hostilities lead to pollution of soil, surface and groundwater, air, disturbance of landscapes, damage to flora and fauna etc. Ukraine has been heavily affected by russian federation (rf) armed aggression since 2014. As a result of hostilities and missile attacks, the entire network of major metallurgical and chemical industry facilities concentrated in the east of Ukraine was completely destroyed. In total, at least 60 oil depots and other storage facilities for fuel and lubricants were affected in 23 regions, that has led to the unprecedented environmental damage. In this regard, the purpose of the article is to raise the question of the role of monitoring in assessing the damage caused directly to the subsoil: damage and destruction of geological objects (deposits, unique stratotype sections, and other geological elements of ecosystem services). Based on the analysis of the created map of comparison of active deposits and hostilities (missile attacks points), the deposits that were damaged have been identified and it is extremely important in the absence of access to such objects. It was found that as of 23.09.2022, 453 deposits (21%) out of 2,164 total mineral deposits in Ukraine (without taking into account water resources) are located in the temporarily occupied territories (358) and damaged or occupied ones (95). Consequently, the use of geological monitoring and remote sensing with GIS tools play a key role in obtaining reliable and internationally acceptable data as evidence for the award of financial compensation. In this regard, there is a crucial need for urgent action to restore and reform the geological monitoring system in Ukraine.
Keywords: geological environment, monitoring, environmental risks, economic losses, hostilities, Ukraine.

На сучасному етапі розвитку суспільства після збройних конфліктів у судах на міжнародному рівні відкриваються слухання за отриманням компенсацій, у тому числі за збитки, завдані навколишньому середовищу. Зокрема, ведення бойових дій призводить до забруднення ґрунтів, поверхневих і підземних вод, повітря, порушення ландшафтів, завдає шкоди флорі і фауні тощо. Україна дуже сильно постраждала від збройної агресії росії з 2014 р. Внаслідок бойових дій та ракетних обстрілів повністю знищена вся мережа великих об'єктів металургії та хімічної промисловості, що зосереджувались на сході України. Крім того, постраждало не менше 60 нафтобаз та інших сховищ паливно-мастильних матеріалів у 23 областях, що в сукупності призвело до шкоди навколишньому середовищу безпрецедентних масштабів. Метою даної роботи є постановка питання щодо ролі моніторингу при оцінці збитків, завданих безпосередньо надрам: пошкодження та руйнування геологічних об'єктів. На основі аналізу створеної карти потрапляння снарядів та активних родовищ було встановлено родовища, які зазнали ураження, що надзвичайно важливо за відсутності доступу до таких об'єктів. Встановлено, що станом на 23.09.2022 р. усього 453 родовища (21%) із 2164 від загальної кількості родовищ корисних копалин України (без урахування вод) розташовані на тимчасово окупованій території (358) та пошкоджено чи окуповано (95). Таким чином, застосування моніторингу геологічного середовища та його дистанційного зондування із використанням засобів ГІС відіграє ключову роль в отриманні достовірних і прийнятних на міжнародному рівні даних як доказів для присудження фінансових компенсацій. У зв'язку з цим постає критична потреба в термінових діях для відновлення та реформування системи геологічного моніторингу в Україні.
Ключові слова: геологічне середовище, моніторинг, екологічні ризики, економічні втрати, воєнні дії, Україна.

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INTRODUCTION

Hostilities inflict heavy losses not only to infrastructure and industrial objects but also to the environment, which includes pollution of soil, surface and underground water, air, landscape disturbance, decommissioning of agricultural land and cause damage to flora and fauna, etc. Despite the existence of several important legal instruments for environmental protection, it still remains a silent victim and casualty of armed conflicts all over the world (Protecting..., 2009).

The environment suffers tremendously during armed conflict: resources may be targeted for destruction or damaged by bombs, missiles and artillery shelling; war can displace populations into fragile environments where the struggle to survive degrades the resource base and the institutions designed to manage the environment may be disrupted or shut down during a war.

A thousand-year history of mankind demonstrates a strong relationship between natural resources and armed conflicts. The "natural resources" that cause these problems are largely oil and hard-rock minerals — including gold, coltan, diamonds, and other gemstones.

Since 1990 there have been at least 18 violent conflicts fuelled by the exploitation of natural resources: Afghanistan (1978–2001, Gems); Angola (1975–2002, Oil, Diamonds); Angola (Cabinda) 1975–, Oil); Burma (1949–, Tin, Gems); Cambodia (1978–1997, Gems) Colombia (1984–, Oil, Gold) Congo, Rep. (1996–1998, Oil, Copper, Coltan, Diamonds, Gold, Cobalt); Indonesia (Aceh) 1975–, Natural gas); Indonesia (W Papua) 1969–, Copper, Gold); Liberia (1989–1996, Timber, Diamonds, Iron, Gold); Morocco (1975–, Phosphates, Oil); Papua New Guinea (1988–, Copper, Gold); Sierra Leone (1991–2000, Diamonds); Sudan (1983–, Oil) (Shnyukov, 2008; Natural..., 2002; Enaruvbe et al., 2019).

The burning of oil wells during the Iraq–Kuwait war (1990–1991), the chemical contamination following the bombing of industrial sites in Kosovo (1999), and the oil leak in the Mediterranean Sea during the Israel–Lebanon war (2006) are just a few examples of environmental harm being caused during an armed conflict. From more than 20 post-conflict observations over the last two decades, the United Nations Environmental Programme (UNEP) has concluded that significant environmental harm is caused during armed conflicts. Only recently, however, the assessment, management, and restoration of the natural resource base have become essential components of post-conflict peacebuilding (Protecting..., 2009; Jensen, Lonergan, 2012; Directive..., 2004; Assessment..., 1999).

Ukraine has sustained considerable damage (and that to geological environment as well) from the rf military aggression since 2014. As a result of hostilities and missile attacks, the entire network of major metallurgical and chemical industry facilities concentrated in the east of Ukraine, in particular, the most environmentally dangerous plants — "Azovstal", Avdiivka Coke Plant, Lysychansk Oil Refinery Plant, "Sumykhimprom" and others were completely destroyed. In total, at least 60 oil depots and other storage facilities for fuel and lubricants were affected in 23 regions, in particular, in the village of Kalynivka, Fastivsky district. The unprecedented environmental damage from the fire at the oil depot in the village of Kryachki, Vasylkiv community, Kyiv region, amounts to UAH 810 billion. As a result, soil, surface and underground water, vegetation etc. have been polluted. The destroyed military equipment (more than 14,000 pieces) and ammunition as well as exploded aerobombs and missiles pollute the soil and groundwater with chemicals, especially with heavy metals. As a result of damage to hydraulic engineering facilities, there was a large-scale flooding of territories. Bombings damaged pipelines, pumping stations, and sewage treatment plants. Untreated sewage from Severodonetsk, Lysychansk, Rubizhne, Popasna, and parts of Zaporizhzhia contaminates surface water and deprives people of drinking water supply.

Unfortunately, this list of impacts on the environment as a result of aggression is almost endless. To overcome these terrible consequences systemically, in April 2022, in accordance with the Decree of the President of Ukraine dated April 21, 2022 # 266/2022 "Issues of the National Council for Ukraine Reconstruction", the National Council for Ukraine Reconstruction from the Consequences of the War was established, which also includes the working group of "Ecological Safety", and the State Environmental Inspectorate has set up Operational Headquarters for recording, organizing information and compiling a single register of damage caused to the environment as a result of the rf invasion of the territory of Ukraine. To provide scientific and methodological support to this work, experts have been involved, in particular, those in the field of *Subsoil, including underground water.*

With mankind moving to civilization, after armed conflicts, litigations are opened in international courts for obtaining compensation, including those for damages caused to the environment. But for that it is necessary to evaluate and justify the claimed amounts of losses, for the evaluation of which special procedures have been developed. These procedures are to take into account a number of factors and parameters, with one of the key ones being the "zero point/point of reference". The pivotal role in obtaining reliable data for evidence is played by the data of monitoring various environment elements and remote sensing.

Therefore, the ***aim of this study*** is to outline various aspects of the impact of armed aggression on the geological environment, the subsoil, and issues regarding the role of GIS-assisted monitoring in the assessment of the damage caused directly to the subsoil: the damage or destruction of mining facilities, deposits (disturbance of the geological environment), the damage and destruction of geological objects (unique stratotype sections, geological landmarks, landscape parks, which are the elements of ecosystem services).

THEORY AND MATERIALS

The analysis of the materials of existing court cases on compensation for the environmental damage caused by armed conflicts, has revealed no precedent for assessing damage to the subsoil, except for the damage caused by oil spills and, as a result, pollution of surface and underground waters (Kuwait, Lebanon, etc.) and that due to illegal mineral appropriations during a war conflict (Rwanda) (Republic..., 2007; Summary...2020; Payne, 2016).

The United Nations Compensation Commission (UNCC) was established by the United Nations Security Council (UNSC) as a special quasi-judicial body to award financial compensation for damage caused by Iraq's invasion of Kuwait and it is a unique model of liability and environmental redress in the international context (Omar et al., 2000). UNCC provided a legal process that cataloged, appraised and allocated money to pay for the cleaning and repair of damaged soil, water, coastal ecosystems and other damage caused by the 1990–1991 Gulf War. Its contributions include integrating environmental law principles into the reparations process; employing advanced methods for environmental damage assessment; using a multilateral process in a way that balances confidentiality and transparency. Seen as an innovative approach to post-war justice, the UNCC's environmental program highlights the contribution that can make norms of environmental integrity (Payne, 2017; Enaruvbe et al., 2019).

Establishing a legal regime to address the environmental consequences of war and elaborating scientific techniques to characterize the specific nature of the damages create a need for economic methods to value these damages and to suggest appropriate compensation measures. Approaches to assessing environmental damages vary depending on the particular type of damage: ecological, natural resource or public health impacts; use or non-use values; permanent or temporary losses; and compensation for lost values or restoration of the values — to name just a few of the variables. While damages to natural resources are usually assessed using market-based approaches, many economists believe that ecological and public health damages require other approaches in order to assess noncommercial values fully and yield sums that market-based approaches would otherwise underestimate.

The "Methodology for determining damages caused by pollution and/or clogging of water, arbitrary use of water resources" has been developed by specialists of the State Environmental Inspection. It was approved by order of the Ministry of Environmental Protection and Natural Resources of Ukraine dated July 21, 2022 No. 252, registered in the Ministry of Justice of Ukraine 09.08.2022 No. 900/38236 and entered into force from September 2, 2022. The Methodology is the first document adapted to assess the damage caused to the environment as a result of rf aggression against Ukraine. This Methodology establishes the procedure for determining the damage that has resulted in pollution and/or clogging of water, unauthorized use of water resources due to the armed aggression of the rf. Consequently, estimation of losses (UAH) is based on the consideration of the relevant parameters/coefficients:

- coefficient that takes into account the increase in damage to the water ecosystem during martial law;
- coefficient that takes into account the category of the water body;
- regional groundwater scarcity coefficient;
- coefficient that takes into account the natural protection of groundwater;

— mass of the i-th pollutant that entered the groundwater, t;
— specific economic loss from water pollution; it is important to note that the specified coefficients require a detailed justification and critical analysis of the initial calculated values, such as, for example, the indexed specific economic loss from water pollution in the previous year (UAH/t), which is a component of the calculation of the specific economic loss from water pollution.

The research is based on the analysis of international experience and practice concerning the assessment of geological and environmental damage caused by military operations, databases of licensed mineral areas, and databases of hostilities (with the marked points of shelling hits and front line movements), as well as using the author's updated database of evaporites formations of Ukraine (Interactive Dashboard; Map of the licensed areas; Shekhunova et al., 2019, 2021a, b; Shekhunova et al., 2022).

RESULTS AND DISCUSSION

The UNEP has conducted over twenty post-conflict assessments since 1999, using state-of-the-art science to determine the environmental impacts of war. From Kosovo to Afghanistan, Sudan and the Gaza Strip, UNEP has found that an armed conflict causes significant harm to the environment and the communities that depend on natural resources (Protecting..., 2009). Direct and indirect environmental damage, coupled with the collapse of institutions, leads to environmental risks that can threaten people's health, livelihoods and security, and, ultimately, undermine post-conflict peacebuilding.

The mineral and raw material complex of Ukraine provides a significant share of its gross national product. Up to 48% of the country's industrial potential and up to 20% of its labour resources are associated with the extraction and use of minerals. From 20–40% of total investments are concentrated in the mining industry. There is no country in Europe, except for rf, with a similar mineral and raw material base, which critically affects Ukraine's economic, socio-political and geopolitical stability, as well as the livelihood of its population. Therefore, the entire economy is very sensitive to losses and destruction of the mineral and raw material bases.

As a result of the occupation of a part of its territory in 2014, Ukraine lost a number of objects in the Southern oil and gas region, 100% of dolomites for metallurgy, 100% of carbonate raw materials for the production of sodium carbonate, a raw material base and a complex for the production of bromine and magnesium oxide, the production of hafnium, 90% of sawn stone, more than 80% of flux raw material deposits, which yielded 98% of the product, as well as over 95% of refractory clay deposits that were developed, etc. The Artemivske rock salt deposit — the only one that is being developed — is now in the front-line zone (Table 1).

It has been established that 358 mineral deposits are located in the temporarily occupied territories as of 09/23/2022 and 95 deposits were damaged/occupied. Overall, that amounts to 453 deposits (21%) of the total of 2,164 in Ukraine (without taking into account water resources). Thus, the application of monitoring based on GIS tools in the assessment of subsoil damage due to the hostilities allows not only qualitative, but also quantitative assessment of the general situation regarding deposits that were/are located in the occupied territories and/or in the war zone (Fig. 1). Large-scale maps of comparison of active metallic and non-metallic mineral deposits (licensed areas) and hostilities for Kyiv, Kharkiv and Zaporizhzhia oblasts as of 09 September 2022 are shown in the Figs. 2–4. Fig. 5 illustrates the impact of hostilities on evaporites mineral deposits, as well as related exogenous geological processes, karst in particular.

SecDev's* analysis shows that Ukrainian energy deposits, metals and minerals worth at least $12.4 trillion are now under rf control. This figure represents almost half of the dollar value of the 2,209 deposits verified by the company. In addition to 63% of the country's coal deposits, rf has confiscated 11% of oil deposits, 20% of natural gas deposits, 42% of metals and 33% of deposits of rare earth and other critical minerals, including lithium as for August 10, 2022 (Faiola, Bennett, 2022). *SecDev's* research mapping and quantifying Ukraine's mineral resources seized by rf was featured in the *Washington Post, BBC, Financial Times, Foreign Policy and Globe and Mail*. SecDev is also undertaking a global assessment of critical minerals and rare earth elements.

The aspects of impact on the subsoil, including groundwater, are differentiated into direct and indirect. The direct ones include those related to the decommissioning of mining facilities and deposits, not only due to the destruction of infrastructure elements but also through direct disturbance

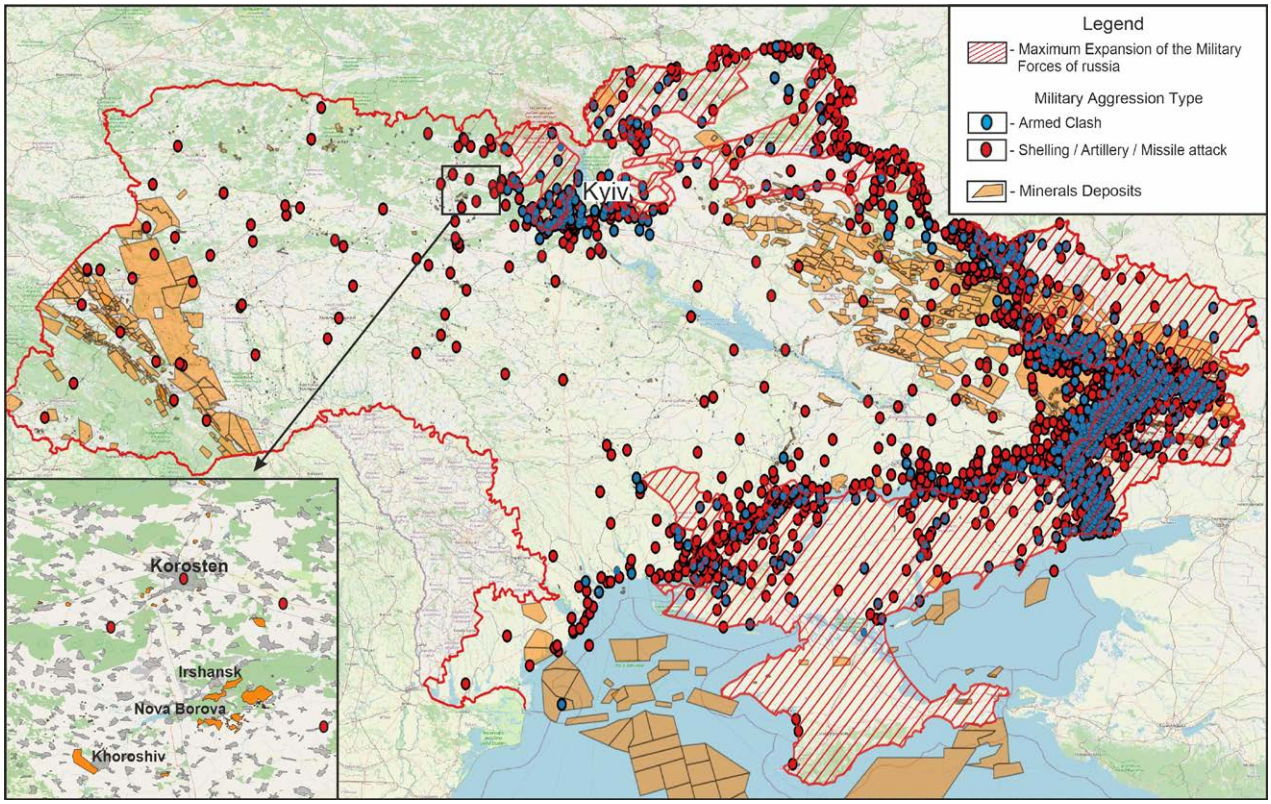

Fig. 1. Overview map comparing active deposits (licensed areas) and hostilities as of 09 Sep. 2022, generated using QGIS software.

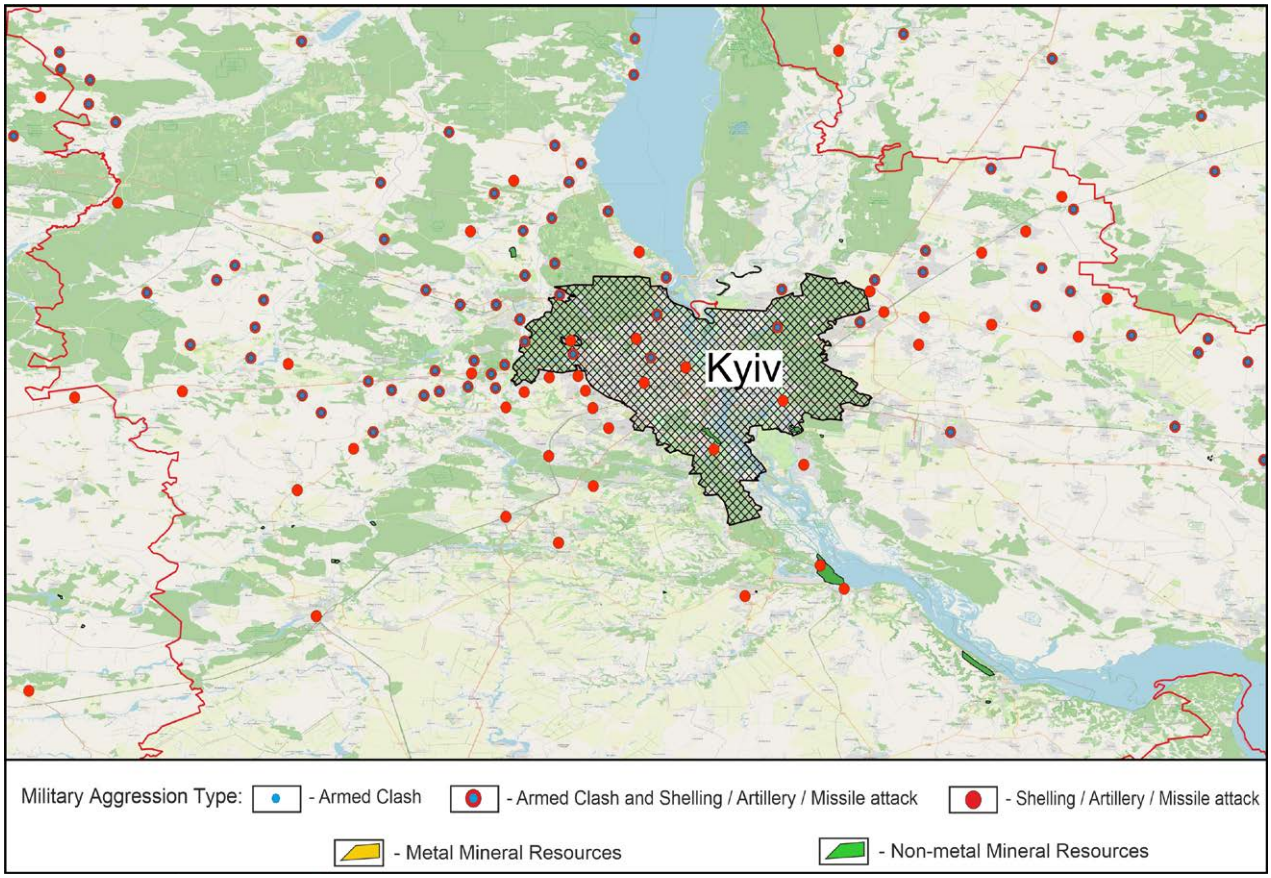

Fig. 2. Large-scale map of comparison of active metallic and non-metallic mineral deposits (licensed areas) and hostilities in Kyiv oblast as of 09 Sep. 2022.

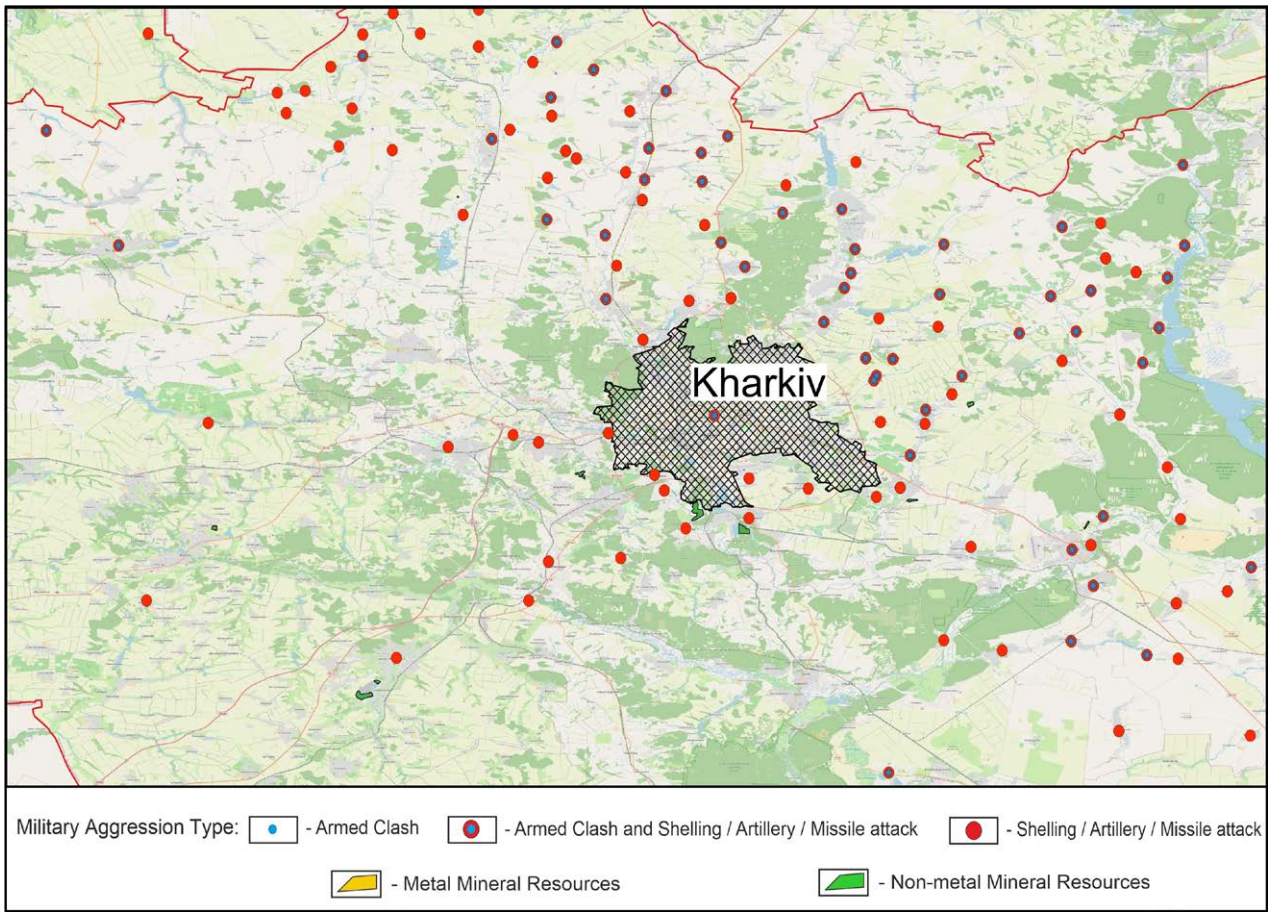

Fig. 3. Large-scale map of comparison of active metallic and non-metallic mineral deposits (licensed areas) and hostilities in Kharkiv oblast as of 09 Sep. 2022.

of the geological environment (integrity of the rock mass) associated with negative alterations in hydrogeological conditions, which can lead to irreversible changes and would make the restoration of this mining facility impossible. They can also activate hazardous geological processes leading to the loss of reserves and/or mineral resources suitable for extraction. Indirect damages include the loss of benefits (appropriation of minerals, impossibility of mining in the hostilities zone and occupied territories), the loss of ecosystem services resources (the impossibility of access to recreational resources — geological landmarks and landscape parks) and the loss of scientific geological heritage (damage to stratotype sections, geological landmarks: mined territories will be inaccessible for a long time for performing scientific fieldwork).

In the occupied territories and in the zone of hostilities, there are more than 35 stratotype and reference sections of the Phanerozoic of Ukraine of regional and local significance, among them being unique ones (according to prof. O. P. Olshtynska estimation, IGS NASU). It is not yet possible to assess their condition and the degree of their damage/destruction. Even after the liberation of the territory because of the mines, if the aforementioned objects are not damaged, there will be still no opportunity to conduct scientific field research for a long time. Besides, the part of the protected lands and natural monuments is located in the occupied territories and it is impossible to assess its condition. A number of natural monuments were destroyed due to missile attacks (Poltava and Dnipropetrovsk oblasts).

Current strategies for assessing losses and damages from the military aggression of the rf in Ukraine recommend extensive use of preliminary monitoring data and remote methods. It would be a certain challenge to assess the impact on the subsoil (including groundwater). The system of geological monitoring in Ukraine, which was well organized in the past and included, in particular, the system of monitoring underground water, hazardous geological processes, etc., has undergone a destructive “optimization” due to the

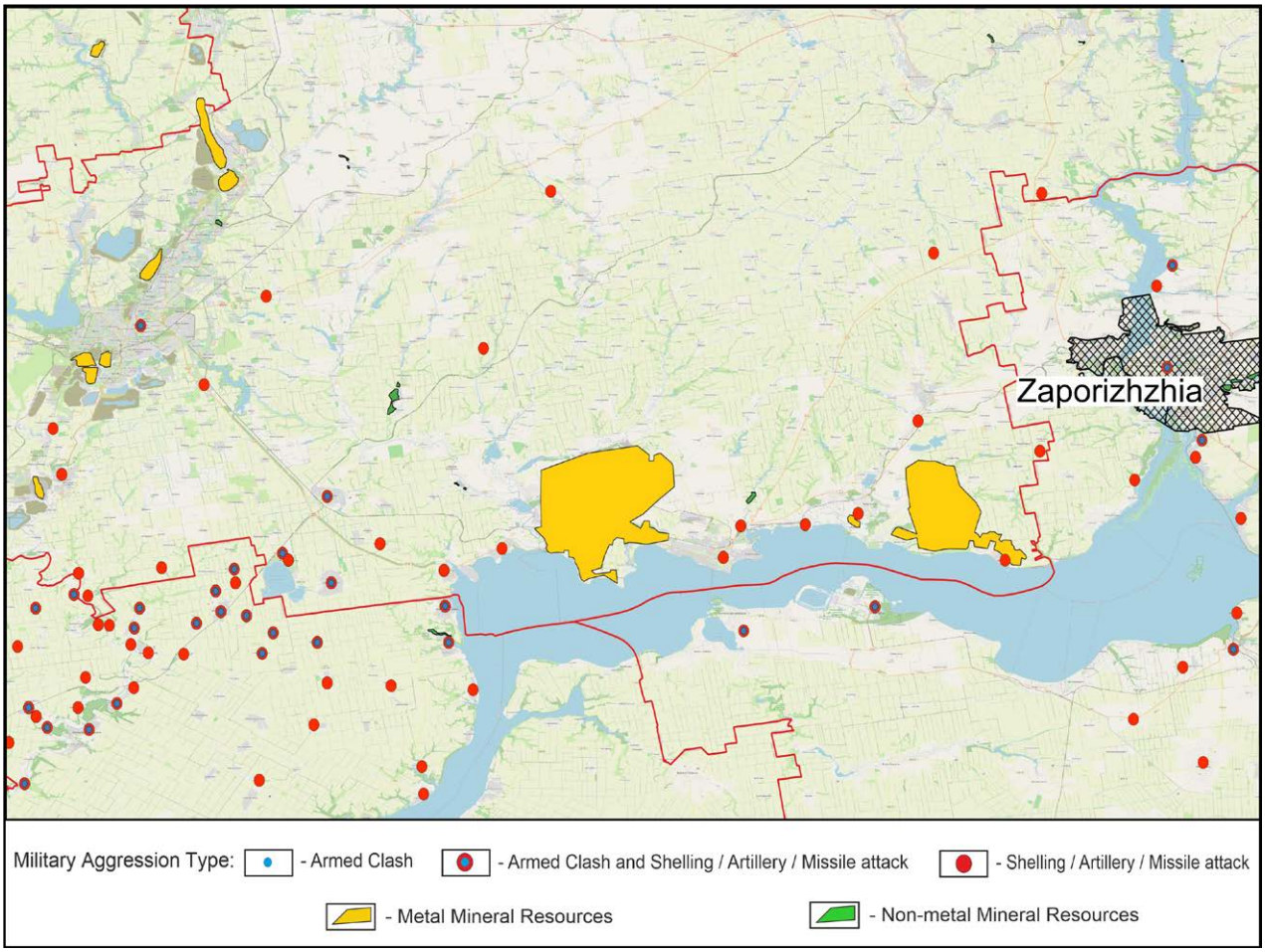

Fig. 4. Large-scale map of comparison of active metallic and non-metallic mineral deposits (licensed areas) and hostilities in Zaporizhzhia oblast as of 09 Sep. 2022.

lack of funding, e.g., of 7,100 observation wells for underground aquifers, less than 350 ones remained until recently (Shestopalov, Lyuta, 2016). A vivid example of the loss of system observations at the object level — monitoring at the Sloviansk site is represented in Table 2.

The data of geological environment monitoring and its remote sensing play the major role in obtaining reliable and internationally eligible data as evidence for financial compensation. Assessment of environmental risks and economic losses for Ukraine's subsoil due to the rf military aggression against Ukraine requires taking into account a number of parameters, with one of the key ones being the "point of reference". Therefore, urgent actions should be taken to restore monitoring and reform its system.

Regarding the financial compensation amounts some preliminary evaluations of economic losses for Ukraine's environment caused by the rf military aggression have been provided. At the meeting of the European Parliament's Committee on Environment, Public Health and Food Safety in Strasbourg (October 3, 2022) the Minister of Environmental Protection and Natural Resources of Ukraine Ruslan Strilets emphasized that Ukraine would initiate the creation of Global Platform for the development of international methods for assessing environmental damage from military actions. According to these preliminary assessments of the damage caused to Ukraine's environment by hostilities economic losses have already exceeded 36 billion EUR. The ministry estimated damages due to air pollution in the amount of about 25 billion EUR, and another 11,4 billion EUR are needed to eliminate the damage caused to the soil. Millions of hectares of natural reserves are under threat — one-fifth of the protected areas in Ukraine — are under threat of destruction; in total, about 2,000 cases of environmental damage have been recorded (Government..., 2022).

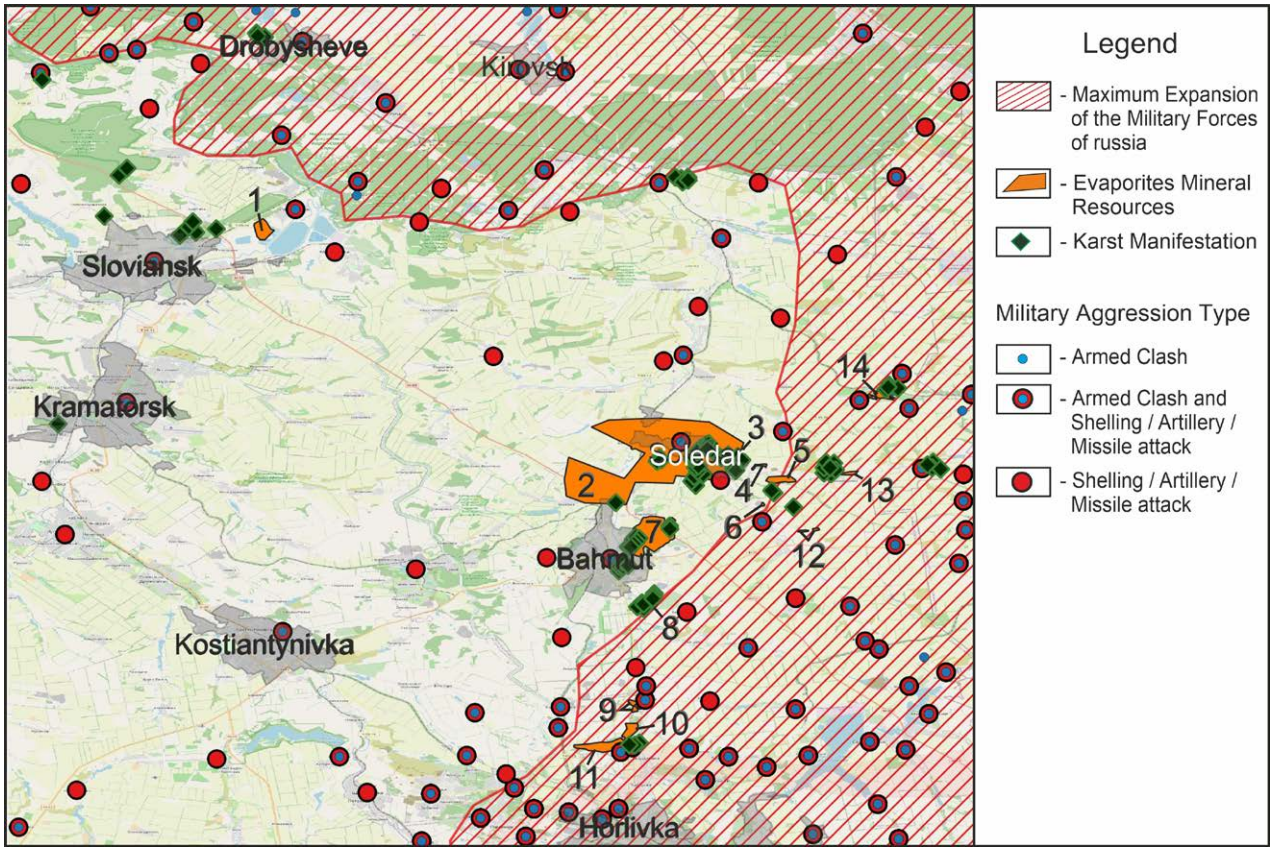

Fig. 5. Large-scale map comparing active deposits (licensed areas) of evaporites mineral resources and hostilities within Donetsk oblast as of 09 Sep. 2022, generated using QGIS software. Rock salt deposits: 1 — Slovianske; 2 — Artemivske; gypsum and anhydrite deposits: 3 — Zakhidno-Mykhailivske; 4 — Skhidno-Mykhailivske; 5 — Pshenychanske; 6 — Pokrovske; 7 — Artemivske; 8 — Ivanhradske; 9 — Mykolaivske; 11 — Popasni Liskyvske (Zaitsivske); 12 — Skhidno-Pokrovske; 13 — Pshenychansko-Dekonske (Preobrazhenka-Sokolivka); 14 — Nyrkivske; dolomite deposit: 10 — Mykytivske.

Further on, as of October 27, 2022, Olena Kryvoruchkina, People's Deputy and chief coordinator of rf eco-crimes operational headquarters, reported that since the beginning of the invasion of Ukraine, the occupying forces of rf caused damage to the environment in the amount of more than UAH 1.35 trillion (Information..., 2022). About 574 processed cases out of more than 800 ones were registered. The People's Deputy clarified that the damages were considered in the following directions, "damage to land resources", — "damage to atmospheric air", — "damage to water resources". The amount of damages is approximate, it may increase significantly after processing all registered cases that have signs of environmental violations, as well as after conducting the necessary examinations in the territories that are currently under the temporary occupation of rf. All evidence collected by specialists of the operational headquarters will be used in international legal proceedings against the russian aggressor.

CONCLUSIONS

Various aspects of the impact of hostilities on the geological environment and issues regarding the role of monitoring in the assessment of the damage caused directly to the subsoil: the damage or destruction of mining facilities, deposits (disturbance of the geological environment), the damage and destruction of geological objects (unique stratotype sections, geological landmarks, landscape parks, which are the elements of ecosystem services) have been outlined.

The preliminary assessment of environmental damage to Ukraine's subsoil caused by the rf armed aggression with the use remote sensing monitoring data has been provided. As a result, based on the analysis of the created map of comparison of active deposits and hostilities (missile attacks points), the deposits that were damaged were identified. It has been established that 358 mineral deposits are located in the temporarily occupied territories as of 09/23/2022 and 95 deposits were damaged/

Table 1. Table of active deposits (licensed areas) of evaporite minerals, Donetsk oblast

Name of the deposit	Area	Administrative division	Type of Mining	Deposits	State of the deposit	Beneficiaries
Mykolaivske	23.10 hectare	Donetsk oblast Bakhmut district	Underground, surface mining	Gypsum and anhydrite	Active	A private individual
Artemivske	6.10 km^2	Donetsk oblast Bakhmut district	Underground	Gypsum and anhydrite	Active	-
Skhidno-Mykhailivske	16.70 hectare	Donetsk oblast Bakhmut district	Underground, surface mining	Gypsum and anhydrite	Active	A private individual
Popasni Liskyvske (Zaitsivske)	242.0 hectare	Donetsk oblast Bakhmut district	Underground, open	Gypsum and anhydrite	Active	-
Nyrkivske	74.27 hectare	Donetsk oblast Bakhmut district	Underground, surface mining	Gypsum and anhydrite	Active	A private individual
Pshenychanske	97.53 hectare	Donetsk oblast Bakhmut district	Surface mining	Gypsum	Active	A private individual
Ivanhradske	29.0 hectare	Donetsk oblast Bakhmut district	Underground, surface mining	Gypsum	Active	A private individual
Zakhidno-Mykhailivske	43.60 hectare	Donetsk oblast Bakhmut district	Surface mining	Gypsum	Active	A private individual
Skhidno-Pokrovske	19.09 hectare	Donetsk oblast Bakhmut district	Surface mining	Gypsum	Active	A private individual
Pokrovske	4.75 hectare	Donetsk oblast Bakhmut district	Surface mining	Gypsum	Active	A private individual
Pshenychansko-Dekonske (Preobrazhenka-Sokolivka)	29.23 hectare	Donetsk oblast Bakhmut district	–	Gypsum	Not active	A private individual
Slovianske	157.17 hectare	Donetsk oblast Bakhmut district	Underground	Rock salt	Active	A private individual
Artemivske	5347.90 hectare	Donetsk oblast Bakhmut district	Underground	Rock salt	Active	The state

*Provided by using *Map of the licensed areas.*

occupied. Overall, that amounts to 453 deposits (21%) of the total of 2,164 in Ukraine (without taking into account water resources). Thus, the application of monitoring based on GIS tools in the assessment of subsoil damage due to the hostilities allows not only qualitative, but also quantitative assessment of the general situation regarding deposits that were/are located in the occupied territories and/or in the war zone, that is extremely important in the absence of access to such objects.

Nevertheless, assessing environmental risks and economic losses for Ukraine's subsoil due to the rf military aggression against Ukraine requires taking into account a number of parameters, with one of the key ones being the "point of reference". The pivotal role in obtaining reliable and internationally eligible data as evidence for financial compensation award is played by the data of geological environment monitoring and its remote sensing. Consequently, there is a crucial need for urgent actions to restore and reform the geological monitoring system in Ukraine.

Table 2. Monitoring of exogenous processes within the Sloviansk karst field (Aleksieienkova et al., 2018)

	1950–1960	1960–1970	1970–1980	1980–1990	1990–1995	1996–2000	2000–2010	After 2010
Monitoring network of the State Regional Geological Enterprise "Donetsk Geology"								
Periodicity		1960, 1962, 1965	Quarterly since 1975	Quarterly	Annually			
Alluvial aquifer		40	45	95	70			
Fissure-karst aquifer		7	7	18	6			
Water observation points		6	6	6				
Monitoring network of the experimental water-reducing facility								
Alluvial aquifer			Projecting	11	End of funding from 1992. Destroyed.			
Fissure-karst aquifer				4				
Monitoring network of the SHCOS (Sloviansk hydrogeological control and operation station, functioning since 1983)								
Alluvial aquifer				19	18	18	16	15
Fissure-karst aquifer				8	10	9	8	7
Estimation of removal of easily soluble salts, t/year				36 000–70 000	21 000–40 000			
Mine Surveying Observations	Quarterly since 1952				Destruction of the benchmark network since 1990			
Route survey	Since 1958 annually						2001–2004	2012

– observations were not carried out

SHCOS — Sloviansk hydrogeological control and operation station

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Інститут геологічних наук НАН України,
Київ, Україна