# ENVIRONMENTAL ISSUES OF SURFICIAL URANIUM DEPOSITS: OUM DHEROUA CASE STUDY (ISLAMIC REPUBLIC MAURITANIA)

**Assoc. Prof. PhD Mariia Kurylo[1]**
**Assoc. Prof. PhD Ivan Virshylo[2]**
[1, 2] National Taras Shevchenko University of Kyiv, Ukraine

## ABSTRACT

Uranium deposits and resources are considered as an important raw material base for the implementation of scenarios for the green and clean energy transition. Traditionally discussed risks of potential environmental impacts of Uranium projects development could be subdivided by deposit type. Surficial type mineralization connected to the calcretes in shallow paleovalleys or playas has many specific features which might be analysed separately. Case study of Oum Dheroua Uranium project in the Islamic Republic of Mauritania shows an unexpected lower estimation of environmental risks comparatively to conventional Uranium projects despite to open-pit mining technology. The reasons for such estimation, connected to geographic location, the inclusion of Uranium minerals in natural ecosystems and low scale of deposits (both in grade and size sense). Potential by-products (Vanadium and Strontium) are not part of environmental factors assessment.

***Keywords:*** *Uranium, calcretes, environment, Mauritania*

## INTRODUCTION

Nuclear power is often excluded from the clean energy conversation, despite being the second largest source of low-carbon electricity in the world after hydropower. U.S Office of Nuclear Energy answers the question why we can consider nuclear energy sustainable and clean [1], [2]. It is a source with no harmful by-products like fossil fuel energy production. This is especially true about air and land pollution. The need for land resources is much less than any other source of clean air. The next reason why - nuclear energy produces minimal waste [2]. Today 34% of the total clean electricity in the world is produced from nuclear energy [1].

In the report of the World Bank Minerals for Climate Action, uranium is not included in the list of minerals for the green energy transition, but nuclear energy is included in the list of technologies that this transition is associated with. One of the models in this report – the International Energy Agency (IEA) model assume increased contribution from hydropower and nuclear power as sources that do not pollute the environment [3].

Given the above, uranium deposits and resources are considered as an important raw material base for the implementation of scenarios for the green and clean energy transition.

Energy transition to the low-carbon economy demands a deeper focus not only on “green” technologies (solar, wind, geothermal, etc.) but alternative like nuclear. There are some negative reasons commonly disputed with nuclear:

1. This energy source is not renewable (similar to fossils);
2. High risk related to the safety of nuclear reactor with catastrophic damages while accidents (Chornobyl, Fukushima, etc.)
3. Risk of groundwater contamination due to mining, including underground leaching method;
4. Risk of air and groundwater contamination during the ore processing;
5. Risk of radioactivity impact during the transportation and finally
6. Risk of soil and groundwater contamination during the storage of buried nuclear fuel.

Another reason impacted to spreading of nuclear power is a significant inhomogeneity of World commodity distribution [4]. The major producers like Kazakhstan, Australia and Canada have concentrated a significant part of World production [5]. The common feature of these countries is a low density of population and large country area. On other hand, Uranium has various genetic types of deposits with very different peculiarities of deposits position, ore mining and processing technology, including grades, Uranium minerals variety, and mining methods (underground mining of leaching, open pits). The only one surficial type connected with calcretes allowing the open pit method due to shallow position (1-20 meters). There are some very specific characteristics of such deposits [6]:

1. Near-surface origin of mineralization connected with mixing of Uranium-rich and Vanadium-rich groundwater in arid conditions;
2. Structural position connected to the parts of comparatively young paleovalleys or lakes playas;
3. Usually they still occur in deserts due to arid origin;
4. Very poor grades (0.01-0.1% of $U_3O_8$) and small tonnage but economically significant due to low CAPEX and OPEX.

The most known deposit of this type is Yeelirrie (Western Australia) with the worldwide highest grades of about 1600 ppm. The story of this deposit is quite bright due to environmental issues, which were approved and then appealed long time during the rehabilitation of the project [7].

Oum Dheroua project was discovered in 2013 by Karfagane Ltd. with the collaboration of Taras Shevchenko National University of Kyiv, Ukraine. The project site is located in the north-western part of Reguibat Precambrian shield (Figure 1).

Prospecting and exploration work in the licensed area began in 2013. The first stage of research was completed in 2015 and made it possible to draw a conclusion about the general prospects of the site for uranium mineralization. Based on the results of geological, geophysical and geochemical studies, promising structures were identified, the genetic types of a possible deposit were determined, and the area of the license area was reduced from 500 km$^2$ to 300 km$^2$. Two types of mineralization are identified, which are found on the site. The main one is the surface type, associated with calcretes in the rivers paleochannels and/or the lake's shores. The second type is associated with pegmatite veins in granitoids. It is very likely that the origin of the first type is closely related to the redeposition of uranium from bedrock.

Primary Uranium sources are connected to granite-hosted pegmatite veins situated to the northeast from the deposit (Figure 2). Vanadium source is identified in banded-iron formation of Lebthenia iron ore project westward. Vanadium could be considered as a by-product due to the mineralization of tyuamunite or carnotite. Vanadium grade was estimated by ICP method in 2015 for trench data (60 samples). The highest grade is up to 0.2% that is much lower than economically valuable Vanadium deposits (1.0-1.5%).

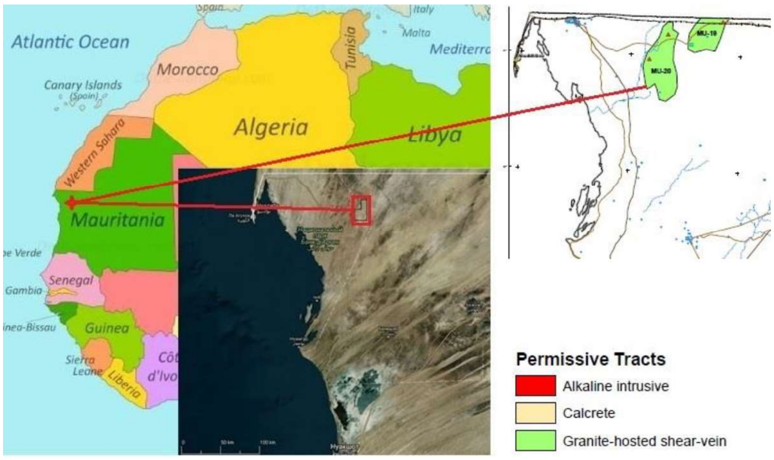


***Fig. 1.*** *Location of the study area and Uranium permissive tracts (modified after [8])*

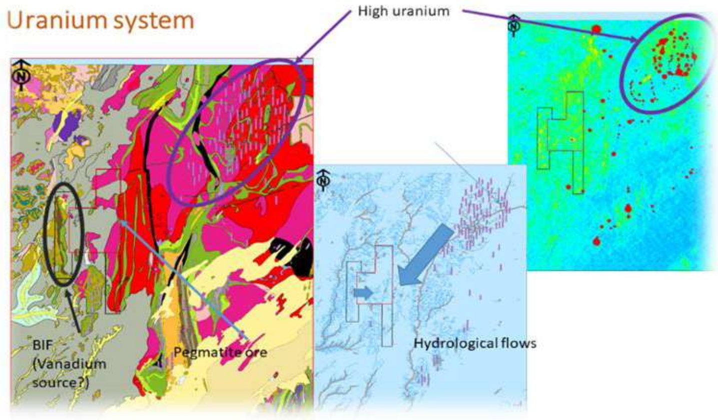


***Fig. 2**. Conceptual model of Uranium system in Oum Dheroua site (modified after [8], [9])*

More specific is high-grade Strontium mineralization reported previously [10]. A large number of Sr anomalous values (over 8000 ppm, 0.8%) are noted with modes of 1% and 1.5%. The highest grade reaches almost 8%. The relationship between Uranium and Strontium are not clear yet, but there is the second potential by-product of deposit.

These results allowed the second stage (2016-2019) to conduct a targeted study of promising structures. Three priority areas have been identified, with an area of 3 km2, 0.9 $km^2$ and 1.7 $km^2$, where calcrete type mineralization has been identified, exploration work is being carried out to delineate them and then calculate the reserves. In addition, other promising zones have been discovered with potential mineralization.

Available resource estimation with pessimistic grade of 105 $U_3O_8$ representing a very small development area of measured and indicated resources (Figure 3). Due to proposed mining plan different targets could be developed separately as individual pits. The decision for each target is applied independently. Detailed resources list by targets (Table 1) shows sizes of targets, which relatively defines a potential industrial impact for the environment.

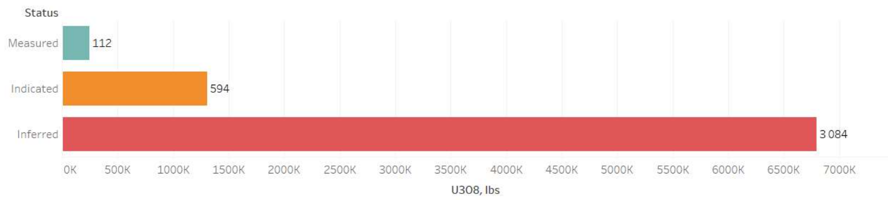


***Fig. 3.** Resource summary of Oum Dheroua project (labels near bars is $U_3O_8$ content in tons)*

***Table 1.*** *Resource list for targets of Oum Dheroua project*

| Target Name | Resources status | Confidence | Area, km2 | $U_3O_8$ Content, klbs |
|---|---|---|---|---|
| ABH | Measured | High | 0.026 | 93.8 |
| ABH_West | Measured | High | 0.013 | 44.6 |
| B_TR2 | Measured | High | 0.030 | 108.2 |
| | | | | |
| A_SouthTR3 | Indicated | Average | 0.203 | 723.5 |
| A_NorthTR1 | Indicated | Average | 0.073 | 260.3 |
| A_NorthStream | Indicated | Low2High | 0.090 | 320.7 |
| | | | | |
| A_EastFlank | Inferred | Low | 0.321 | 1 144.4 |
| A_EAnom | Inferred | VeryLow | 0.074 | 263.5 |
| A_NEastTR1 | Inferred | Low2Average | 0.072 | 255.1 |
| B_NWAnom | Inferred | Low | 0.014 | 52.1 |
| C | Inferred | Low2Average | 1.424 | 5 076.0 |
| **Total** | | | **2.340** | **8 342.3** |

Special research for all aspects of potential environmental impact will be provided before any activity related to the mining or processing operations. No permanent settlements or nomadic groups in radius of 30 km from planned mining sites are located. Impact on other industrial facilities (Tasiast gold mine, Lebthenia iron ore deposit) will be evaluated. Archaeology, cultural heritage, terrestrial fauna, flora and biodiversity, aquatic ecology, hydrogeology and air condition issues will be estimated. Effects of artisan gold miners will be included withthe correction to the current situation periodically. The development of Oum Dheroua project allowing to create some workplaces for local people living in the Chami region as well as some artisan gold miners could find here a permanent job.

The most important environmental factors of potential mining are the following (Table 2). We ranked different types as a relative environmental factors of potential impact. This analysis is not connected to the potential by-products (Vanadium and Strontium).

***Table 2.*** *Environmental factors impact summary.*

| Environmental factors group | Impact | Impact type | Impact rate | Rank (0-10) | Impact suppression procedures |
|---|---|---|---|---|---|
| Flora and vegetation | Clearing of flora | Direct | very low due to desert conditions | 1 | Possible rehabitlitation of rare-happened trees or seeding new ones |
| | Clearing of vegetation | Direct | absent | 0 | |
| Terrestrial fauna | Clearing of fauna | Direct | very low due to desert conditions | 1 | There are huge areas nearby with the similar condition for living for most of species |
| Subterrestreal fauna | Clearing of fauna | Direct | medium while mining especially during startup stage | 4 | Management of preparatory works with activity which cause the fauna migration (noise, vibration) |
| Fauna | Conservation of threatening species | Direct | need to be estimated locally on site | n/a | Demand special longterm research |
| Hydrogeology | Abstraction of groundwater level | Indirect | absent due to absence of permanent groundwater | 0 | |
| | Reinjection of groundwater | Indirect | very low due to absence of leaching plant | 1 | Control of water management for camp and ore primary processing procedures |
| | Alteration of groundwater | Direct | absent due absence of permanent groundwater | 0 | |
| | Uptake of radionuklides | Direct | low due to the low grades and resistance of vegetation living with | 2 | |

| | | | | | |
|---|---|---|---|---|---|
| | | | near-surface deposit | | |
| Hydrology | Alteration of surface water flows | Direct | low-to-medium due to shallow pits and quick backfilling | 3 | Full and rapid recultivation of mined areas by waste backfilling and natural sand dust filling |
| Air conditions | Dust impact | Direct | medium due to significant wind and treatment of radionuclides in the dust. | 5 | Constriction of closed buildings, waste dumps, management of spatial location of facilities |
| Land management | Construction of facilities and roads | Direct | Low-to-medium due to small capacity of project productivity | 3 | Spatial analysis of facilities location while planning |

## CONCLUSION

The environmental issues of any Uranium project demand careful investigations of potential impacts. The surficial type deposits have a specific position in this question due to shallow near-surface ore bodies and thus, demands just only open-pit mining technology. But many peculiarities of such deposits show lower risks compared to more rich, conventional Uranium deposits (sandstone-hosted, unconformity or metasomatic types). As shown in our analysis on the example of the Oum Dheroua project, most of the factors are low level due to specific geographic position, low-grade ores and comparatively simple processing.

The most risked environmental factors are the dust impact on air condition dangerous for people, flora and fauna in the local area and mechanical destroying of near-surface potential habitable layer (0-10 meters). The first factor must be controlled by specific engineering decisions such as wind-protective dumps, covers of trucks, etc. The second factor should be estimated by continuous observation of fauna and biodiversity.

## ACKNOWLEDGEMENTS

Authors thanks Karfagane Ltd. (Tunisia) for the joint research and grateful permission to publish the data. We also thank to our colleagues Igor Bondarenko, Vasyl Zagnitko, Dmytro Kravchenko, Viktor Tarasov, Serhii Chulkov, and Andrii Mazko for the data acquiring, processing and interpretation.

## REFERENCES

[1] NICE Future initiative of Clean Energy Ministerial//https://www.nice-future.org

[2] Three reasons why nuclear clean and sustainable. U.S. Office of Nuclear Energy //https://www.energy.gov/ne/articles

[3] Hund, K.; La Porta, D.; Fabregas, T. P.; Laing, T.; Drexhage, J. Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. International Bank for Reconstruction and Development, The World Bank, 2020 //http://www.eqmagpro.com/wp-content/uploads/2020/05/MineralsforClimateActionTheMineralIntensityoftheCleanEnergyTransition_compressed-1-18.pdf.

[4] NEA, 2016, Uranium 2016: Resources, Production and Demand, A Joint Report by the Nuclear Energy Agency and the International Atomic Energy Agency: Organisation for Economic Co-operation and Development Publishing, Paris, France, http://dx.doi.org/10.1787/uranium-2016-en.

[5] World uranium geology, exploration, resources and production / International Atomic Energy Agency, 2020

[6] Jaireth, S., Roach, I. C., Bastrakov, E., & Liu, S. (2014). Basin-related uranium mineral systems in Australia: A review of critical features. Ore Geology Reviews, August. https://doi.org/10.1016/j.oregeorev.2015.08.006

[7]https://www.cameco.com/businesses/uranium-projects/yeelirrie/reserves-resources#measured_and_indicated (Accessed 29.07.2021)

[8] Fernette, G.L., 2015, Uranium in the Islamic Republic of Mauritania (phase V, deliverable 81), chap. N of Taylor, C.D., ed., Second projet de renforcement institutionnel du secteur minier de la Republique Islamique de Mauritanie (PRISM-II): U.S. Geological Survey Open-File Report 2013?1280-N, 56 p., http://dx.doi.org/10.3133/ofr20131280. [In English and French.]

[9] Bradley, D.C., Motts, H.A., Horton, J.D., et al. [2015] Geologic map of Mauritania (phase V, deliverables 51a, 51b, and 51c), chap. A1 of Taylor, C.D., ed., Second projet de renforcement institutionnel du secteur minier de la République Islamique de Mauritanie (PRISM-II): U.S. Geological Survey Open-File Report 2013– 1280-A1, 3 pl., scale 1:1,000,000, http://dx.doi.org/10.3133/ofr20131280/. [In English and French.]

[10] Virshylo I., Zagnitko V., Kravchenko D., Andreev O., Kurylo M. [2020] Geostatistical assessment and resource classification of the Oum Dheroua (Islamic Republic of Mauritania) strontium-uranium surficial type occurrence In: Proceedings of XXth International Multidisciplinary Scientific geoconference Surveying, Geology and Mining, Ecology and Management – SGEM 2020, Albena, Bulgaria DOI: 10.5593/sgem2020/1.2/s03.016