URANIUM MINING

WHAT ARE WE TALKING ABOUT?

uranium-network.org

Index

INTRODUCTION

Introduction to the Booklet

In 2007/2008, the price of uranium skyrocketed from around US$ 20 per pound to nearly US$ 140 per pound within less than a year.

Big uranium companies as well as 'junior' miners started to explore for uranium all over the world, hoping for major profits to be made; the new rush for uranium had much in common with the gold rush of former times – with exaggerated prospects to attract investors' monies.

Africa quickly became one of the targets for uranium exploitation. But why?

"Australia and Canada have become overly sophisticated. They measure progress in other aspects than economic development, and rightly so, but I think there has been a sort of overcompensa- tion in terms of thinking about environmental issues, social issues, way beyond what is necessary to achieve good practice."

Source:

- John Borshoff's statement at the Joint Standing Committee on Foreign Affairs, Defence and Trade Reference: Australia's relationship with the countries of Africa, Thursday, 6 May 2010, Melbourne)
  https://parlinfo.aph.gov.au/parlInfo/download/committees/commjnt/12858/toc_pdf/7599-2.pdf;fileType=application %2Fpdf#search= %22committees/commjnt/12858/0004 %22)

Borshoff only expressed along which lines many companies were thinking and acting: There would be fewer concerns about environmental regulations and in regard to social issues in Africa than in most other parts of the world. Consequently, his company PALADIN went to Africa – Malawi and Namibia – to exploit uranium – and many others did so, too. Within a short time, in nearly each and every country in Africa, companies were searching for uranium.

They met a population for the most part completely unaware of what uranium is, let alone its uses or the impacts of mining it. Only a few countries had experience of the mining of uranium:

CONGO *(in Shinkolobwe, uranium had been mined since the 1940s)*, GABON *(France's state-owned nuclear companies had mined U since 1960)*, NIGER *(France's state-owned nuclear companies had mined U since 1971)*, NAMIBIA *(Rio Tinto had mined uranium there since 1976)* and SOUTH AFRICA *(Uranium had been mined, initially unintentionally as a by-product of gold mining. From 1952 U was mined for its ownsake)*.

The general public in the vast majority of African countries had no experience or knowledge about uranium, its exploitation and impacts, making it easy for interested companies to veil their intentions when searching for uranium. Governments emphasized the jobs which would be created, the taxes and royalties for the state rather than the risks and dangers associated with uranium exploitation.

uranium-network.org together with IPPNW – International Physicians for the Prevention of Nuclear War, Switzerland and Germany, with financial and logistical support from the Rosa-Luxemburg-Foundation, Germany, and in cooperation with national and local grassroots NGOs, organized three major conferences on the issue of uranium mining and its impacts on health and the environment *(Bamako/Mali 2012, Dodoma and Dar es Salaam/Tanzania 2014, Johannesburg/South Africa 2015)* in order to inform and educate a wider public in the said countries about the realities around uranium exploitation. Ongoing activities with national and local NGOs concerned with environment, health, human rights and social issues complemented the conferences.

Some of the information from these conferences was passed on to a wider public by engaged film makers:

Shri PRAKASH from India produced m "Gere dan" on the plans to mine uranium and the resistance against those plans in Falea/Mali.

Marta CONDE from Spain produced the film "Namibia's Uranium Rush" on the ongoings in Namibia after the 2007/2008 rise of the price of uranium.

In Niger, young film maker Amina WEIRA made a film from the perspective of a person from Niger, "La Colere dans le vent" ("Anger in the Wind").

- "Gere dan", by Shri Prakash, India, 2014 literally translated into english 'For The Supreme Fight', in french 'Pour le combat suprême' French with english sub-titles (50 min)
  http://shriprakash.com/filmography-2 (scroll down)
- "Namibia's Uranium Rush", by Marta Conde, 2014, 30 min, English
  www.youtube.com/watch?v=5zZre4r-VrM_
- The film comes with a documentation by EJOLT.
  www.ejolt.org/2014/05/watch-a-lamca-ejolt-movie-on-uranium-mining-in-namibia

GREENPEACE produced a short video "Left in the Dust" highlighting the hazards to people and the environment in Niger's mining town of Arlit.

Ujuzi media produced "Legacy Warnings!" on the aftermath of uranium mining in south Africa, and short summaries of the conferences in Tanzania and Johannesburg.

The films cover important issues and aspects in regard to uranium mining. Nevertheless, we felt some basic information on what uranium is all about, what its uses are, how it is exploited and processed, its place in the worldwide nuclear fuel chain, how uranium mining impacts health, the environment at large, and communities, what is the aftermath of mining, and how uranium mining impacts the economy should be compiled. Thus, we decided to put information on all these aspects into the film "Uranium Mining – what are we talking about?" and the accompanying booklet.

- "La Colere dans le Vent", by Amina WEIRA, 2016, French
  https://vimeo.com/ondemand/lacoleredanslevent
- "Left in the Dust" by Greenpeace, 2010, English
  www.youtube.com/watch?v=ioRtzOWm07A
- "Legacy Warnings!"
  www.ujuzi.media/en/2016/01/01/legacy-warnings

The film has been produced to inform people with little previous knowledge about uranium and nuclear issues. We had to walk a fine line between over-simplification and being "un-scientific" on the one hand and overstraining our audience with details and scientific terminology. Wherever possible, we abstained from using nuclear terminology, and we did not include any radiation measuring units in the film.

Such details can be found separately in the chapters of the accompanying brochure available on the internet. This pool of information will be updated as need arises and new relevant information surfaces.

Personally, my inspiration to try and explain complex and complicated facts and issues as simply as possible in words and pictures derives from 40 years' experience in the struggle against nuclear power, and from the writings of Arjun Makhijani, Director of IEER (Institute for Energy and Environment) on the democratization of science.

Today, on both sides – that of the proponents of nuclear developments and those critical of, or opposed to, such developments – experts and scientists express contradictory statements, opinions and recommendations. People are basically asked to 'believe' one side or the other since the matter would be too complex, too complicated for a layperson to understand.

Makhijani says: "IEER's aim is to provide people with literature which has a quality equal to that in scientific journals, but which doesn't require you to go back to college to get a degree in science to understand it."

- IEER's Goals and the Democratization of Science, by Arjun Makhijani , in: Science for Democratic Action, by IEER, Vol 1, No. 1, Winter 1992
  www.ieer.org/sdafiles/1-1.pdf

With this film and accompanying booklet, we try to give as much information as possible in ways that are hopefully understandable to the layperson so that people can get a picture of what uranium mining and its consequences are all about so that they are less dependent on 'experts', company information and politicians. The film was produced on a small budget which did not allow much travel; much of the material used had been gathered by the team of ujuzi Media and by John Zedekiah Magafu of Dar es salaam Christian Communication Centre at the conferences mentioned above, as well as footage by a few other film makers. In addition, some of the photos came from individuals.

The WISE Uranium Project website was (and is) an indispensable source of information on many issues around uranium mining; much of the factual information as well as some graphics are taken from it.

THANK YOU.

A big thank you also to Dr. Angelika CLAUSSEN, Dr. Günter BAITSCH, both IPPNW Germany, and to Prof. Doug BRUGGE who contributed greatly to Chapter 11 Health Impacts. Sheila GORDON-SCHRÖDER edited the final text, and Sara LOPES created the layout.

THANKS for good cooperation – and your patience.

> Aktion Selbstbesteuerung
https://www.aktion-selbstbesteuerung.de

> Music Video
http://www.cesopetz.org/hatutaki-new-music-video-in-support-of-cesope-by-wakazi-feat-sophie-the-harmonies

Further information:

> "Frontline issues alert on detention of HR defender in the DR Congo"
https://humanrightshouse.org/articles/frontline-issues-alert-on-detention-of-hr-defender-in-the-dr-congo
https://de.wikipedia.org/wiki/Golden_Misabiko
https://www.nuclear-free.com *(currently under re-construction)*

THE FILM

Music by ...

The music at the beginning and at the end of the film is the result of an intercultural cooperation between Hamburg-based Musicians Sophie Filip and Robert Cordes with massive Support from Tim Lucas, Joka Johannsen, Manuuh from Swahili Records and Goldie Crisps and Tanzania-based musicians Wakazi (rapper) and the vocal trio 'The Harmonies' .
We are grateful for the financial support of Aktion Selbstbesteuerung for making this possible.

Hatutaki – Wakazi feat. Sophie & the Harmonies
"SAY NO TO URANIUM MINING in TANZANIA"

Golden Misabiko

"They ask you to be quiet,
they ask you to be ignorant,
but the time of fearing, of being silenced – is over."

Golden Misabiko, from the DR Congo, is a human rights activist with ASADHO – Association Africaine pour les Droits de l'Homme, Katanga section. After exposing extrajudicial executions in DR Congo, he denounced a deal in 2009 between France represented by the then president Nicolas Sarkozy and the then-CEO of AREVA, France's state nuclear company, Anne Lauvergeon, and the Kabila Government. The purpose was to grant France/AREVA the exclusive rights to mine uranium in the DRC. The deal was meant to be kept secret and was never raised in Parliament.

Golden Misabiko had to pay dearly for his activities: he was arrested, incarcerated and tortured; one of his colleagues died in a car accident under mysterious circumstances. Golden was released later in 2009. He left the country and lives as a refugee in South Africa and other African countries.

In 2014, Golden Misabiko was awarded the Nuclearfree Future Award, in the category "Resistance" in Munich/Germany at the annual award ceremony.

1

C H A P T E R **O N E**

Narration

Our solar system began between 4 and 5 billion years ago, as a cloud of swirling hot gas. And as it formed, the heat was so intense that centers of atoms were crushed together, and smaller atoms formed into larger ones.
The largest, heaviest atom known to us has 92 protons with the same number of electrons, and anywhere from 141 to 146 neutrons.

The atom disintegrates slowly and as it does so, it gives off radiation. It takes about 4 ½ billion years for half of it to decay, just about the age of the solar system. This element is Uranium. What are we talking about exactly?

PROF. FRANK WINDE

It is the very core of our planet. In fact, it is because uranium contains the only fissionable isotopes Uranium-235, which, if it amasses to a critical mass, starts building a nuclear reactor, and this is what actually runs the Earth. The magma and the fact that we have continued building up in the Earth, getting to the surface, shifting the continents, feeding volcanoes, causing tsunamis, is due to uranium. It is therefore no surprise that uranium is also found in the Earth crust.

Speaking of the periodic table, Uranium is the last of all elements, it is the most heavy one, we find naturally on earth. Everything above uranium is artificial. So we don´t have any other element find on Earth which is heavier than that. And that makes it unique and under many respects.
(Presentation at the 2017 Johannesburg Conference)

Uranium was identified as a chemical element by German chemist Martin Heinrich KLAPROTH in 1789. At that time there was little commercial use for it.

Animation

A *Hey, why are they demonstrating against mining of uranium and against nuclear power, … it is such a unique element … ?*
B *well, it is a much disputed matter … especially in the industrialized countries, they use a lot of nuclear power, now they want it also in Africa …*
A *ya ya, I know, I hear about it all the time concerning South Africa … but what is it all about really, with this uranium? What problem do those people demonstrating have with it?*
B *hmmm, that's a long story …*
A *… I have lots of time …*

1. Uranium –what is it?

An atom is the smallest unit of an element which still has all the properties of that substance. Atoms consist of protons, neutrons, and electrons.
Protons and neutrons form the core or nucleus of an atom, the electrons form its 'shell'.
Protons have a positive electric charge, electrons have a negative electric charge (neutrons have no electric charge). The positive and negative charges of protons and electrons keep the atom together. Although there is no final clear explanation how the positive and negative charges originally came about, they are measurable properties of the elemental particles formed in the early stages of the formation of the universe and our solar system. Without the force of the positive and negative charges, atoms would, most prob- ably, not exist – nor our world as we know it.
The heaviest (densest) element known to us is Uranium.
Like all other elements, it is made up of protons, electrons and neutrons:
Uranium has 92 protons and the same number of electrons, the number of neutrons varies between 141 and 146 neutrons. Thus, there are three kinds of uranium: Uranium-234, Uranium-235 and Uranium-238. The different kinds of an element are called 'isotopes' (only some elements have isotopes).

Source:
> "Ökosystem Erde – der Aufbau des Atoms"
www.oekosystem-erde.de/html/exkurs-02.html

Unlike most other elements, uranium is not stable – it changes its form by shooting off some of its parts; this is called decay. Uranium then changes into another element. In the process, energy and/or small parts of the atom are set free; this is radiation (→ Ch. 2.).

NOTE

Uranium is NOT like any other element. The decay process and the radiation emitted make uranium (and its decay products) rather unique – and at the same time dangerous for health and environment through the radiation emitted.

The core of the Earth contains uranium, and as this uranium decays – as mentioned above – it gives off energy and heat. This heat keeps the core of the Earth molten and somewhat fluid.
The continents (more correctly: the tectonic plates) – such as the African plate - are adrift on this molten core of the Earth.
As those plates move, they sometimes crash into one another – resulting in Earthquakes and, if the crash happens under an ocean, in tsunamis. In areas where tectonic plates meet, the magma from the inner part of the Earth may find its way to the surface thus creating volcanoes such as Mount Kilimanjaro or Mount Meru.

Further readings:
> "What is plate tectonics?"
www.livescience.com/37706-what-is-plate-tectonics.html
> "Volcanoes of Africa and Arabia"
www.volcanodiscovery.com/africa.html

In the 1700's, humans began to explore and systemize nature and naturally occurring elements. What we know today as the periodic table, naming all known elements on Earth in a systematic order, was about to be created. Identifying an element for the first time was a major achievement. Martin KLAPROTH, a German pharmacist and chemist, identified a new element, naming it after the newly discovered star Uranus: Uranium.
In 1841, French chemist Eugène-Melchior PELIGOT was able to isolate pure uranium metal. Some sources say that uranium was used in former times for coloring glass and ceramics. Though this may be correct, people at that time had no name for the element and did not know about its properties – and dangers; they simply used the mineral for its coloring capacity.

However, Klaproth (and Peligot) did not recognize the special quality of uranium as being unstable, decaying and giving off radiation.

CHAPTER TWO

Narration

Uranium exists in three different forms. More than 99 % of uranium is Uranium-238, only 0.71 % is Uranium -235 and there is a very small component of Uranium-234 ...
but that's minimal so we won't be dealing with it here.

Animation

A ... *and what is so special about it?*
B *The Uranium atoms fall apart, very slowly, but they fall apart. They change form, and turn into another kind of atoms – and those are instable and fall apart, too.*
A *So there is no uranium left?*
B *No, no, the process is very slow. For Uranium-238 it takes approximately 4 ½ billion years for HALF of a certain amount to fall apart – the scientists call this period "half-life".*
A ... *and the rest?*
B *Well, the rest of the Uranium is still here ... and decays slowly.*
Let's take a look at how that works: the decay chain.

Uranium has been identified as a chemical element by German chemist Martin Heinrich KLAPROTH in 1789. At that time there was little commercial use for it.

2. Uranium – its properties

2.1. Historic Research on Radioactivity and Radioactive Elements

Radioactivity was first discovered in 1896 by French scientist Henri BECQUEREL. Marie and Pierre CURIE later coined the expression "radioactivity" and explored it further in the early 1900s. Marie CURIE found out that radioactivity did not come from the interaction of two elements, but from an atom itself – this was a groundbreaking finding.

She identified Radium as well as Polonium (named after her country of origin, Poland), and was awarded the Nobel Peace Prize for her work. The material from which Marie CURIE extracted radium, was pitchblende, mined in the Erzgebirge (literally translated as the "ore mountains") on the border between what is today Germany and the Czech Republic.

The "Ore Mountains' had earned their name from the rich ore deposits found in these mountains: silver, copper, cobalt, nickel, iron etc. Silver had been mined since 1176 first in the Freiberg area, later on in other areas such as Schneeberg and Joachimsthal (Jáchymov, today Czech Republic).

Unfortunately, silver is often associated with uranium and thus the miners – unwittingly – also mined uranium (in the form of pitchblende) which was mainly cast aside. However, uranium decays into Radium, and Radon-222-gas, and dust as well as Radon gas became a serious health risk in the – unventilated – mine shafts.

Many miners died prematurely from an – at the time – inexplicable lung disease referred to as "Schneeberger Lungenkrankheit" (Schneeberg lung disease). Today, we know that those miners died from the radioactivity of uranium, radium and Radon-gas.

"The town [Jáchymov] was also of great importance in the development of coining. The silver thalers minted in the Jáchymov Royal Mint influenced the development of the early modern currency system in Europe. The "thaler" gave its name to the most important global currency of the modern age, the dollar."

Thus, from the very beginning, uranium, its potentially fatal radioactivity, silver, money, the dollar and negative health impacts up to death were closely connected.

When the CURIEs worked with pitchblende from the mines of Jáchymov, they did not know or think about the detrimental health impacts the materials from the mine might have; whereas Pierre Curie was killed in an accident, Marie CURIE died – after years of deteriorating health – in 1934 at the age of 67 of aplastic anemia (leukemia), almost certainly a result of radiation exposure.

After the CURIEs, Ernest RUTHERFORD, Frederick SODDY and others explored and identified what is today known as the decay chains of uranium.

Source:

> Ore Mountains (on sachsen.de)
www.sachsen.de/en/265.htm

Further readings:

> "Schneeberger Krankheit"
www.chemie-schule.de/KnowHow/Schneeberger_Krankheit

> "Schneeberg lung disease and uranium mining in the saxon ore mountains (Erzgebirge)" by Dr. Werner Schüttmann MD, first published: February 1993, in American Journal of Industrial Medicine, Historical Perspectives in Occupational Medicine
https://onlinelibrary.wiley.com/doi/abs/10.1002/ajim.4700230212

Source:

> "Jáchymov Mining Cultural Landscape"
www.montanregion-erzgebirge.de/en/welterbe/tschechien/montanlandschaft-jachymov.html

Further readings:

> "Discovery of Radioactivity"
on Chemistry LibreTexts, updated 5. June 2019
https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Nuclear_Chemistry/Radioactivity/Discovery_of_Radioactivity

> "Guide to the Nuclear Wallchart"
The Discovery of Radioactivity
www2.lbl.gov/abc/wallchart/chapters/03/4.html

> "Radium revealed: 120 years since Curies found the most radioactive substance on the planet", December 19, 2018, on The Conversation
https://theconversation.com/radium-revealed-120-years-since-curies-found-the-most-radioactive-substance-on-the-planet-108945

> "Marie Curie's Belongings Will Be Radioactive For Another 1,500 Years", by Barbara Tasch, BUSINESS INSIDER, 31. August 2015
www.sciencealert.com/these-personal-effects-of-marie-curie-will-be-radioactive-for-another-1-500-years

> "Discovery of Radioactivity" by the Royal Society of Chemistry, Radiochemical Methods Group
www.rsc.org/images/essay1_tcm18-17763.pdf

Narration

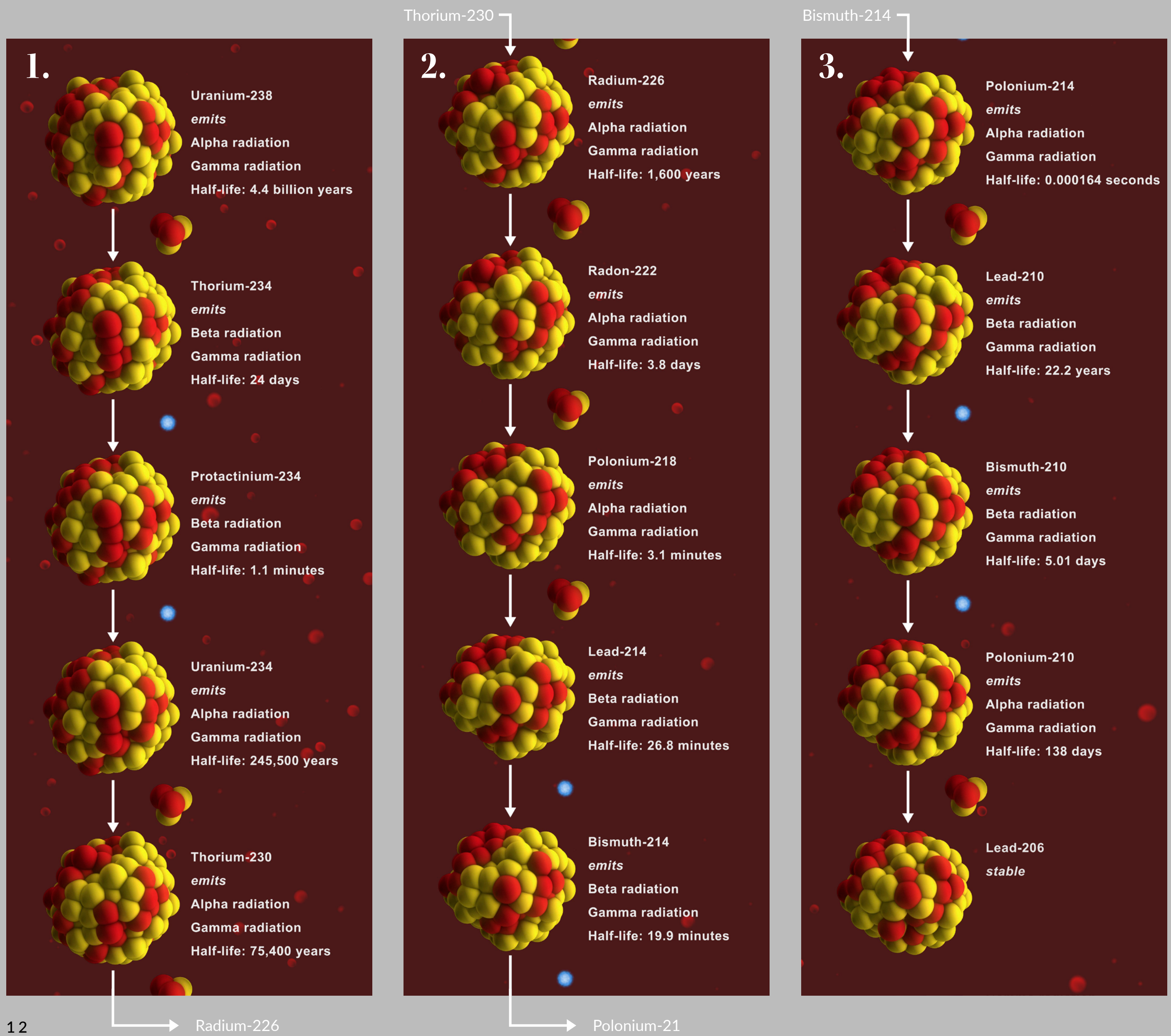
As you can see, Uranium changes its form and turns into Thorium. The half-life indicates how long it takes for half of the uranium to decay. As it decays, uranium gives off radiation. In this first step, it is alpha radiation.

This process continues – and Thorium changes into Protactinium; in the process, it gives off beta-radiation.

The decay process continues; you see that at each step either alpha or beta radiation is given off. Gamma-radiation is also emitted at each step. One of the elements is Radon-222, the only gas in the decay chain; it emits alpha-radiation.

After some 20 steps, the process ends with a stable element – lead. As you can see, Uranium never comes alone – it is always accompanied by a cocktail of 20 – 25 decay products – all of them radioactive, and some are also poisonous.

Uranium-235 decays in a similar chain, with another approximately 20 decay products.



2.2. Decay Chains of Uranium

Scientists (Rutherford, Soddy and others) established that the decay of radioactive elements happens in a systematic process: one element changes into a specific next one, shooting off parts of the atom (alpha- or beta-radiation → Ch. 2.3.).

The systematic decay change from one element into the next is called decay chain.

The change from one element into the next on (the decay) takes time: Within a certain period of time, half of the atoms of the of the original element will have decayed, i.e. changed into another element, the next one in the decay chain: this time is called **half-life**.

Meanwhile the other half of the original element is still there, and it will decay within the next half-life; at the same time, the first half of the mass of the original element continues its way along the decay chain, until, after some 14 steps (for U-238), it changes into a stable element (lead).

The graph shows the elements in the decay chain of Uranium-238, the type of radiation they emit, and their half-lives; please note that some elements have very short half-lives, whereas others have half-lives of thousands of years.

All elements in the decay chain will be produced in continuity as long as a part of the mass of the original element is still there – and they will continue to give off radiation.

Uranium is by nature not stable – no matter if it's U-234, U-235 or U-238 – all kinds (isotopes) of uranium are unstable; they all decay; they all emit radiation.

The film and the graph in the book show the decay of Uranium-238 – which makes up the biggest part of uranium in a naturally occurring setting.

The other kinds – the isotopes Uranium-234 and Uranium-235 also decay, and U-235 generates another, similar decay chain.

Further readings – all decay chains:

> "Nuclear Forensic Search Project"
http://metadata.berkeley.edu/nuclear-forensics/Decay%20Chains.html

NOTE

Uranium never comes alone – it is ALWAYS accompanied by its decay products (sometimes referred to as "daughters").
Thus, when discussing the dangers of uranium in the context of mining, the dangers of all decay products of uranium must be considered: They all emit radiation; some (for example Radium) emit many times more radiation than uranium itself.

Proponents of uranium developments sometimes argue that uranium would not be dangerous, since it is only mildly radioactive.

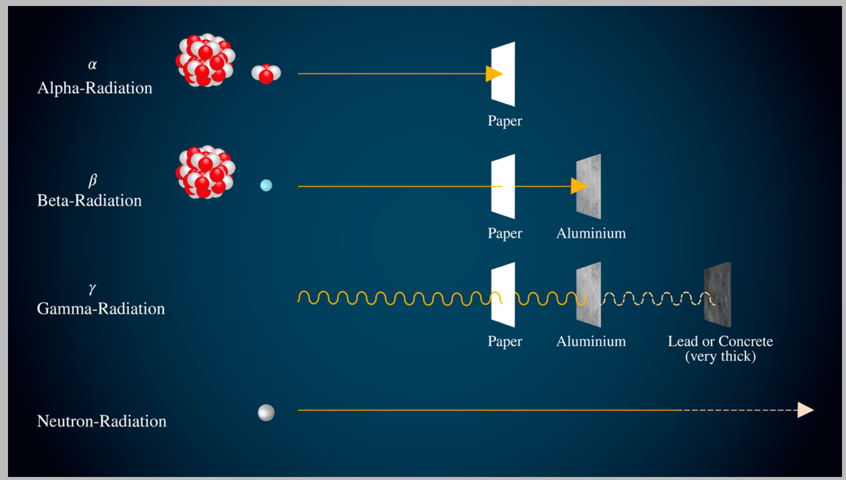
However, all elements in the decay chain are present when uranium ore is explored or mined; Radium, for example, emits one million times more radiation than uranium, and thus is more dangerous to human health.
Discussing the dangers of uranium alone misses the point – ALL decay products and their impacts must be taken into account.

Narration

Alpha-radiation means that the element shoots off a small part of itself.

The particle travels only a short distance – but it is big. It can be stopped by a sheet of thick paper.

The particles of alpha-radiation travel only a short distance, but, due to their size, they can do serious damage toliving tissue, especially when the element is taken up into the body with food or by breathing.



ANGELIKA CLAUSSEN (INTERVIEW)

Alpha Strahlen haben in der Regel nur eine Strahlungsweite von 10cm aber wenn sie über den Wind einmal in den Körper gekommen sind, und dort ja bleiben und auch nicht weiter transportiert werden können, nicht ausgeschieden werden können, dann verbleiben sie ja auch ganz lange im Körper und richten da die Schäden an. Und das hängt davon ab, wie sie aufgenommen worden sind, und wo sie stecken bleiben. Zum Beispiel in der Lunge, dann gibt es Lungenschäden, wenn es im Knochenmark ist, dann gibt es eben Schädigung des blutbildenden Systems, also Krebs zum Beispiel, oder andere Immunschäden.

ENGLISH TRANSLATION

Uranium itself and alpha rays usually have a radiation range of only 10 cm, but once they have entered the body through the wind (and breathings) and remain there and cannot be transported further, they cannot be excreted, then they stay in the body for a very long time and cause damages, and that depends on how they were taken in and where they got stuck: for example, in the lung, then they will damage the lung, if it is in the bone marrow, then there will be damage to the blood forming system, cancer, for example, or other damages to the immune system.

2.3. Radioactivity

2.3.1. Alpha-radiation and its impacts

An atom shoots off a part of itself, 2 neutrons and 2 protons. The alpha-particle does not travel very fast, and it cannot penetrate material very well; the alpha-particle is comparatively big – and can do serious harm to living tissue of humans or animals.

HEALTH IMPACTS OF ALPHA-RADIATION

Alpha-particles cannot penetrate the outer layers of the skin, and are considered not very dangerous when the source of radiation is outside the body ('external exposure'). However, alpha-emitting radioactive elements can be absorbed by the body through breathing (inhalation) or with food or beverages/drinks (ingestion). They may also enter the body through open wounds contracted at work in mines, mills or around them. Taking up radioactive elements into the body leads to internal exposure.

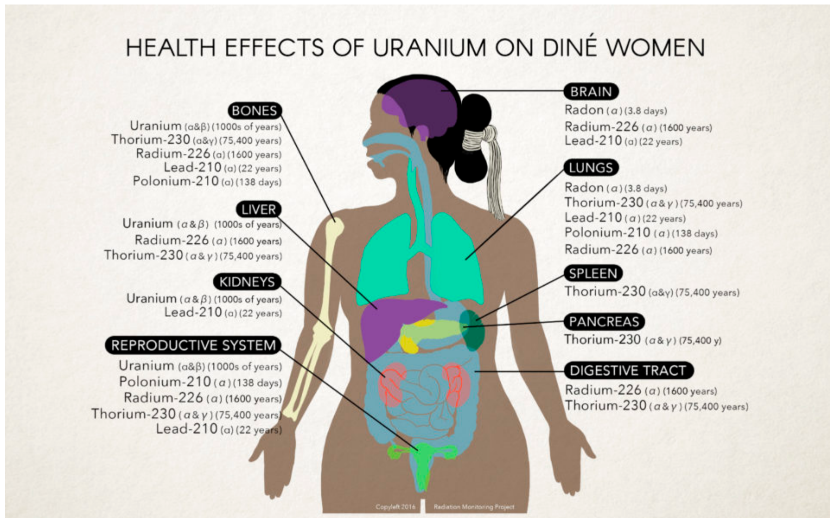
Internal exposure to alpha-radiation is considered to be dangerous since the comparatively big particles can do considerable damage to living tissue (the cells) in the body of humans as well as animals. The health impact depends on the kind of alpha-emitter which has been absorbed by the body and where it is disposed in the body.

For example, Radon-222, a radioactive gas in the decay chain of U-238, can be inhaled by breathing. It passes through the respiratory tract (throat) to the lungs. During its journey inside the body, it emits alpha-radiation and thus causes damage to the respiratory tract and/or to the lungs. Some of the Radon-222-gas will decay during its time in the body into short-lived Radon decay products ("Radon daughters"), among them Polonium-214 and Polonium-210, strong alpha emitters. This internal exposure can cause lung cancer.

Radium (Ra-226, with a half-life of 1602 years) is deposited in the bones and bone marrow, irradiating the bones from inside and damaging the process of blood-building; it can cause bone cancer, cancer of the nasal sinuses as well as leukemia (through interfering with the blood-building process).

For more details → Ch. 11. Health Impacts.

The graph show where radioactive elements may be deposited in the body, leading to internal exposure.



Source:

> Radiation Monitoring Project
https://discardstudies.com/2016/05/09/illustrating-the-invisible-an-interview-with-yuko-on-the-radiation-monitoring-project-illustrations/#jp-carousel-7607

Further readings:

> PowerPointPresentation on Health Effects of Uranium Mining by the Public Health Association Australia (NT), 2009
http://slideplayer.com/slide/6910

> Health effects of ionising radiation: Summary of expert meeting in Ulm, Germany, October 19th, 2013
www.ippnw.de/commonFiles/pdfs/Atomenergie/Health_effects_of_ionising_radiation.pdf

Narration

In some cases, elements shoot off very small particles; this is referred to as beta-radiation. The particles are much smaller than alpha-particles, but they travel longer distances.

Beta-radiation penetrates lighter materials. It takes a thick sheet of metal or a wall of concrete to stop it. Beta-radiation may cause damage to the body even from outside.

Narration

All the elements in the decay chain give off powerful 'energy waves', called gamma-radiation which is the most penetrating kind of electromagnetic radiation. It takes several inches of lead or a thick wall of concrete to stop it!

Thus, Gamma radiation is a risk even if a person is further away.

Some of the elements in the decay chain of uranium are more radioactive than uranium itself – and thus pose a bigger danger. Polonium-210, for example, a decay product of uranium which emits alpha-radiation, is many times more radioactive than uranium – and thus, many times more dangerous.

2.3.2. Beta-radiation and its impacts

An atom shoots off an electron at high speed; the electron is much smaller (about 5000 to 8000 times smaller) than an alpha particle (alpha radiation). The beta-particle travels much further and has greater power to penetrate material like clothing or skin. It takes a (thin) sheet of metal or a wall to stop it.

HEALTH IMPACTS OF BETA-RADIATION

"Beta-particles can travel through many centimeters, or even meters, of air and through millimeters of skin or tissue. Sufficient intensity of beta-radiation can cause burns, rather like severe sunburn. If beta-emitting radionuclides are inhaled or ingested, they can also do damage to internal cells and organs."

"Ionizing radiation [e.g. beta-radiation] damages the genetic material in reproductive cells and results in mutations that are transmitted from generation to generation …"

As with alpha-radiation, internal exposure to beta-radiation is more harmful to health than external exposure.

Source:

> "Understanding Radiation – beta particles"
by Australian Radiation Protection and Nuclear Safety Agency (arpansa)
https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/ionising-radiation/beta-particles

> "Genetic Effects of Radiation"
in Health Effects of Exposure to Low Levels of Ionizing Radiation, BEIR V
www.ncbi.nlm.nih.gov/books/NBK218706

Summary

When considering the health impacts of radioactivity, the external exposure and internal exposure to the radiation-emitting particles or to gamma-radiation must be differentiated.

External exposure means the source of radiation that is and remains outside the body.
Internal exposure meant that the source of radiation is taken up into the body via breathing (inhalation), eating or drinking (ingestion).
Radioactive elements may also enter the body via wounds which miners or workers contracted in mines or mills.

Whereas alpha-emitting radioactive elements do little harm as long as exposure remains external, the situation is very different when they are inhaled or ingested: radiating the body from inside may cause serious health impacts.

Gamma radiation, to which miners and workers are often exposed, will penetrate the body (clothes are no protection), and may cause serious damage even when irradiated from the outside.

2.3.3. Gamma-radiation and its impacts

Gamma radiation is basically different from alpha- and beta radiation; no particles are shot off: gamma radiation is an electromagnetic 'wave' with a very short wavelength. **It is extremely powerful and can penetrate living tissue, a sheet of metal and even walls.**

It takes a thick layer of lead or a thick wall of concrete to stop gamma radiation or shield humans from the gamma radiation.

Gamma radiation is emitted by all elements in the decay chains. , the intensity of the radiation emitted differs from element to element.

HEALTH IMPACTS OF GAMMA-RADIATION

Gamma radiation is considered to be the most dangerous type of radiation for human health. Due to their high penetration power, the impact of gamma radiation can occur throughout a body. External exposure to gamma radiation is a hazard to health (unless the person is protected).

Gamma radiation can cause cancer as well a genetic damages.

NOTE

Gamma radiation is sometimes compared to X-rays, used in medical diagnosis and treatment.

Gamma radiation is continuously emitted by radioactive elements.

X-rays (also called Roentgen rays) are produced by electric devices, X-ray machines, in hospitals or by specialized doctors etc. Once the X-ray machine is switched off, there is no more radiation. Gamma radiation from uranium and other elements, however, cannot be switched off.
X-ray machines do not use uranium or other radioactive elements, the X-rays are artificially generated. X-rays are not a "benefit" of uranium (as sometimes suggested).

Uranium is also not used for food or seed irradiation; X-rays or gamma rays from artificially produced elements such Cobalt 60 are used. Again, food irradiation is not a benefit of uranium.

Further readings:

> Detailled and scientifc descriptions of radioactive decay and types of radiation
Atomic Archive
www.atomicarchive.com/Physics/Physics5.shtml

REPAIR MECHANISMS

When a body cell is hit by radiation, there are basically three possibilities:

- The cell is destroyed and 'dies'. The remnants of the cell are transported away by the organism and no major problems follow. However, if a larger number of cells is affected and 'dies', this will cause problems: organs can become dysfunctional and – in the worst case – high radiation doses may lead to serious radiation sickness or death.
- The cell is damaged but repair mechanisms are able to repair the damage.
  No problems ensue. However, repair mechanisms cannot repair all damages at all times.
- The cell is damaged (DNA) but continues to function. However, its DNA is changed and the cell behaves differently from how it should. When cells multiply, the damaged DNA is also multiplied, and finally some kind of cancer develops.

Narration

Besides, Uranium is a heavy metal – and thus toxic to humans and other living beings due to its chemical properties. Heavy metals can cause a wide variety of damage, negative influences on the kidneys being the best known.

The toxicity of the elements in the decay chain should not be neglected.

2.4. Toxicity of uranium

Besides being radioactive, uranium is a (heavy) metal – and thus toxic (chemically poisonous) to the health of humans and animals.

The 'Encyclopedia of Toxicology' suggests that the toxicity of uranium is more responsible for most health effects than the radioactivity (more details → Ch. 11. Health Impacts).

Uranium is deposited in the bones (like calcium), where it can remain for one to 1,5 years. It is mainly excreted via the kidneys (and urine), however, a part of it that is deposited in the bones may stay there for years.

Note that miners and uranium mill workers may be exposed again and again to uranium dust etc. during their whole working lives.

Research on mice has shown that uranium is a developmental toxicant (bad for the development of the fetus). It can cause decreased fertility (for males as well as females), increased numbers of deaths at birth, teratogenicity, and reduced growth.

In addition, a number of studies on humans and animals has shown that uranium is genotoxic: it can damage the genetic information within cells and thus can cause mutations and cancer. In some regards, limits are in place, for example for uranium in drinking water, However, the limits differ from agency to agency.

Source:

> **Encyclopedia of Toxicology,** 3rd edition vol 4. Elsevier Inc., Academic Press, 2014:883–884, EBrugge, D, Uranium. In: Wexler, P. (Ed.), not accessible via internet.

Limits for Uranium in (Drinking) Water:

> World Health Organization: provisional drinking water quality guideline of 0.015 mg per liter. (2011)

> US EPA – Environmental Protection Agency: limit Primary Drinking Water Standard of 0.03 mg per liter.

> US FDA – Food and Drug Administration: limit of 0.03 mg l per liter for bottled water.

Further readings:

> WISE Uranium Project > Uranium Toxicity www.wise-uranium.org/utox.html

2.5. Dose-effect relationship

Radiation is basically harmful to health of humans (and animals). There is a long-standing dispute on the question of how much negative health impacts are caused by a certain 'dose' of radiation.

It is not possible to discuss these matters in detail in this context. It may suffice to clarify:

Data collected after World War II from the atomic bomb victims of Hiroshima and Nagasaki lead to a model suggesting that there would be a 'threshold' of radiation dose – and it was assumed that below this dose, there would be no harm.

Over the years, it showed that this model was not tenable. Some scientists suggested that even small doses of radiation would lead to harm to human health (linear, no threshold dose-effect relationship). Lately, some studies suggest that small doses received over a longer period of time may even have a bigger negative impact on health than previously supposed.

In any case, the assumption that low doses of radiation would cause no negative health impacts, cannot be supported. ANY dose of radiation is harmful to the health of humans (and animals) and may cause diseases or genetic effects.

2.6. Radiation dose limits

Radiation protection became a concern after scientists working with radioactive materials had died in the early 1900's, and the use of Radium in cosmetics, in medicines etc. had induced negative health impacts.

A precursor of the current International Commission on Radiological Protection (ICRP) was founded in 1928, and restructured in 1950. There are many problems with the ICRP, from the 'closed circle' of members to scientific disagreements with scientists outside the ICRP; the ICRP has been criticized seriously by some of its former members.

Although the members of the ICRP are not elected and the ICRP does not have any democratic validation, the ICRP recommendations for dose limits are regarded by Governments as an international standard setting which is rarely questioned by governments.

In fact, the ICRP had to lower its recommendations for radiation dose limits repeatedly in the past as new evidence came forth and could not be ignored anymore.

ALARA is the acronym for "As Low As Reasonable Achievable" used to define the principle underlying optimization of radiation protection: "... radiation exposure must be kept as low as reasonably achievable, taking economic and social factors ... into account".

This means that measures of radiation protection are only adopted when it is "economic", or, that radiation dose limits are set in a way that they allow a development of the nuclear industry and do not necessarily guarantee protection of people from negative impacts of radiation.

The European Committee on Radiation Risk (ECCR), an independent group of scientists with no ties to the nuclear industry, voiced serious concerns about the ICRP and its systematic under-estimation of the risks of radiation exposure.

In the film (55:51min), Dr. Peter WEISH, Austria, points out that "... they [the ICRP] believe to have granted sufficient room for manoeuvre to the nuclear industry for the foreseeable future. So it is primarily about making a nuclear economy feasible."

Current dose limits
(for orientation only, detailed regulations apply)

> ICRP Recommendations for radiation dose limits

> for general population: 1 millisievert/year

> for occupationally exposed persons (e.g. uranium miners): 20 millisievert/year (with exceptions)

Source:

> Critique of ICRP structure and membership, by Dr. Rosalie Bertell. 1993
https://ratical.org/radiation/inetSeries/wwc2_10.txt

> Strahlenschutz: Schutz der Strahlen oder Schutz vor Strahlen?, by W. Köhnlein
www.online.uni-marburg.de/isem/themen/docs/icrp.pdf

Source:

> "Frequently Asked Questions on ALARA", IAEA consultancy meeting, 4th & 5th of March 2010
https://nucleus.iaea.org/sites/orpnet/resources/frquentlyaskedquestions/Shared%20Documents/faq-list-en.pdf

Source:

> The Lesvos Declaration, European Committee on Radiation Risk (ECCR), 6th May 2009
https://euradcom.eu/lesvos-declaration

Further readings:

> WISE Uranium Project > Uranium Radiation and Health Effects
www.wise-uranium.org/indexr.html#EXPOS

> WISE Uranium Project > Uranium and Health – Currrent Issues
www.wise-uranium.org/riss.html

CHAPTER THREE

Animation

A … what does all this have to do with nuclear power?
B oh, right, we talked about uranium and nuclear … Well, towards the end of the 1800's/beginning of the 1900's, scientists were exploring radiation and properties of elements like uranium, radiation and so on: Marie and Pierre CURIE, Henri BECQUEREL and others found out the connections between uranium and radioactivity. Actually, some of them died from the negative health effects of radioactivity on human health. Then, in 1939, German physicists Lise MEITNER and Otto HAHN managed for the first time to split an atom artificially; until then, it was believed that an atom cannot be split up. The atoms they had split were Uranium – more exactly: Uranium-235. Only Uranium-235 can be split artificially. The energy which normally keeps the pieces of an atom together, was released. Since that invention, life on our planet has not been the same.
B YES … this energy which kept the atoms together since Earth was created, was released … It is called "nuclear fission", since the nucleus, the core of the atom, is split.
A … and then … what would you do with this nuclear fission?
B Physicists realized quickly that huge amounts of energy would be released if this nuclear fission was performed in great numbers – in a chain reaction. If it is used in an uncontrolled way – it creates an explosion, a nuclear bomb.
A Oh, so I see where nuclear bombs come from … Did they also succeed to control that process?
B Yes … if the chain reaction and the energy release are controlled, it can be used for power generation – a nuclear power plant. The first one who managed to do so was Enrico FERMI, an Italian scientist, and his team, they worked in the USA.
A So this is why companies are interested in Uranium?
B Right … they want to dig up uranium to use it for nuclear weapons or for nuclear power plants.

Narration

When in 1938 German scientists Lise MEITNER and Otto HAHN had performed the first artificial nuclear fission – it marked the beginning of the "nuclear age".

At that time, tensions between the states in Europe ran high – the eve of World War II; scientists and military quickly realized that a country which could develop a weapon from the discovery of nuclear fission, would have immense advantages over their enemies, and would win the war. To build such a weapon, Uranium was needed. It was important to find it, at any cost.

DAVID FIG (INTERVIEW)

The very beginning of nuclear weapons had a connection to Africa. The uranium for the bombs came from Africa. They came from the province of Katanga, the DRC.

During World War 2 the Americans built the weapons in the United States. That was the start of the nuclear weapon industry. What was supposed to happen that at the end of the war the countries who had weapons would have [to] hand them into the United Nations. But instead, we had the cold war where countries started their own program, they began an arms race based on nuclear weapons. But the world didn't know there is plenty of uranium. In the 1940ies it wasn't very much around because no one until then had realized the commercial value of uranium.

In 1953, US President Eisenhower announced the program "Atoms for Peace" to make nuclear technology more acceptable. The first commercial nuclear power plant went into operation in 1956 in the United Kingdom and 1958 in the United States.

As of July 2018, 413 reactors are in operation worldwide, they provide approximately 10 % of the electricity used in the world. 50 nuclear power plants are currently under construction, but only 4 were started up in 2017 and 5 in the first half of 2018; every year, a number of nuclear power plants is phased out due to age or other reasons.

Serious accidents have occurred in nuclear power plants: the Chernobyl disaster in the Soviet Union in 1986 and the Fukushima Daiichi nuclear disaster in Japan in 2011.

From 1945 to 1965 uranium was almost exclusively mined for nuclear weapons, thereafter increasingly for commercial nuclear power plants.

3. Uranium and Artificial Nuclear Fission: The Uses of Uranium

The discovery of artificial nuclear fission was a process involving German scientists Otto HAHN und Fritz STRASSMANN performing the initial experiment splitting, unwittingly at first, an atom. Lise MEITNER, already in exile in Sweden due to her Jewish ancestry and the Nazis governing Germany at the time, gave the critical explanation – that a uranium-235 atom had been split. This was then confirmed to be the correct explanation of the phenomena by other scientists.

Uranium-235 atoms can be split artificially by 'bombarding' them with neutrons; when a uranium-235 atom is split, it sets free 2 (or 3) neutrons which then, split 2 more uranium-235 atoms setting free 2 neutrons each, 4 neutrons in total; they, again split 4 uranium atoms, setting free 2 neutrons each, i.e. 8 neutrons, which then split 8 uranium-235 atoms … a chain reaction is set in motion.

With each splitting of a uranium-235 atom, energy (heat) and radiation are set free.

Energy which had been enclosed in the uranium atoms from the time of the beginning of the universe and our solar system, is released (→ Ch. 1.).

Thus, nuclear energy is fundamentally different from other forms of energy.

We will not go into all the technical and scientific details since the film is focusing on uranium and uranium mining, we just take a look at the outcome of the discovery of 'splitting the atom':

IF the chain reaction is set in motion without control, and if there are enough uranium-235 atoms close to each other, the chain reaction will continue very very rapidly, and will lead to a massive explosion, setting free lots of heat as well as radioactivity – a nuclear bomb.

IF this chain reaction happens slowly and in a controlled way, it can be used to generate heat; the heat can then be used to boil water, generate steam which drives turbines which then generate electricity. This is the principle of a nuclear power plant.

HAHN's and STRASSMANN's experiment took place in December 1938, MEITNER's and her nephew Otto FRISCH's explanation were published early in 1939 and confirmation from other scientists followed quickly.

Tension between Germany and other states ran high. the beginning of World War II was less than 9 months away, and foreseeable.

Albert EINSTEIN quickly comprehended the possibility and addressed then-US-president Franklin D. ROOSEVELT that recent research on chain reactions utilizing uranium made it probable that large amounts of power could be produced by a chain reaction and that the construction of "extremely powerful bombs …" would become possible.

Uranium – U-235 – thus became a material of strategic importance; whoever would be able to construct a bomb based on uranium (U-235) and an uncontrolled chain reaction would own a weapon with more destructive power than any single weapon before – and might win the war.

However, one prerequisite was uranium (U-235), the other one was lots of work, scientific research and engineering in order to be able to construct such a weapon.

Basically overnight – within a few months – uranium turned into a much sought after commodity, with few sources or suppliers since there had been little use for it before.

A "uranium rush" ensued.

Further readings:

- **Hahn, Meitner and the discovery of nuclear fission,** by Mike Sutton, 5. November 2018
  www.chemistryworld.com/features/hahn-meitner-and-the-discovery-of-nuclear-fission/3009604.article
- **December 1938: Discovery of Nuclear Fission,** December 2007 (Volume 16, Number 11)
  www.aps.org/publications/apsnews/200712/physicshistory.cfm
- **"Lise Meitner – the forgotten woman of nuclear physics who deserved a Nobel Prize",** by Timothy J Jorgensen, February 7, 2019
  https://theconversation.com/lise-meitner-the-forgotten-woman-of-nuclear-physics-who-deserved-a-nobel-prize-106220
- **"A Lifetime of Fission: The Discovery of Nuclear Energy",** 11/02/2019 by Judith M. Reichel
  www.lindau-nobel.org/blog-lifetime-of-fission
- **Uranium Mining and the US Nuclear Weapons Program,** by Robert Alvarez, 14. Nov. 2013
  https://fas.org/pir-pubs/uranium-mining-u-s-nuclear-weapons-program-3

See also:

- The Discovery of Fission: Hahn and Strassmann
  www.atomicarchive.com
  www.atomicarchive.com/History/mp/p1s4.shtml

Source:

- The Manhattan Project: Making the Atomic Bomb
  www.atomicarchive.com/History/mp/introduction.shtml

- ***For detailed scientific description of nuclear fission, see:***
  www.atomicarchive.com/Fission/Fission1.shtml

4

C H A P T E R **F O U R**

Animation

A ... so ... where was uranium mined in the beginning?
B In Africa, Uranium was first mined in Congo, Shinkolobwe and it was used in the bomb dropped on Hiroshima in 1945. The US continued to mine uranium in Katanga province until June 1960 – when BELGIAN Congo became independent. Mining is still an issue in the Democratic Republic of Congo today.
A The Americans had no uranium of their own?
B Well, not enough at that time; some uranium had been mined in the "Four Corners area", in the Southwest United States, on land which traditionally belonged to Native Americans, like the Hopi's and the Dineh. Another part of the uranium was actually mined in the North of Canada, at Port Radium. ...
A ... and this uranium from Shinkolobwe was also used for nuclear weapons?
B Yes, unfortunately ... and uranium from Canada and the US – where Native people were suffering most from the mining activities.

4. Brief History of Uranium Mining

4.1. Uranium in the Earth's Crust

Basically, uranium is present nearly everywhere in the Earth's crust (→ Ch. 1.).
The Earth's crust – about 100km thick – contains very small traces of uranium. Only in a limited number of locations, the concentration of uranium is higher – and considered worth mining.
Geologists and mining companies then speak of "deposits". Over millions of years in Earth's history, uranium accumulated in different ways; There are different classifications of uranium ore deposits.

Further readings:

- WISE Uranium Project: Types of Uranium Ore Deposits
  www.wise-uranium.org/uod.html
- IAEA Classification of Uranium Ore Deposits (2014)
  www-pub.iaea.org/iaeameetings/cn216pn/Monday/Session1/187-Bruneton.pdf
- World Nuclear Association
  Geology of Uranium Deposits (July 2018)
  www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/geology-of-uranium-deposits.aspx

4.2. Uranium deposits

A uranium occurrence is often referred to as a 'deposit' when it is economically recoverable; however, the economy around uranium exploitation has changed over the years and deposits not considered worth exploiting in the past are now considered for exploitation as deposits cheap to exploit become rarer.
Many deposits have only a very small concentration of uranium in the rock/ore: currently, deposits with a concentration of 0.05 to 0.02 % uranium in the ore are exploited in some places.
In other locations, deposits have higher concentrations of uranium in the rock: at Cigar Lake mine in the North of Saskatchewan, Canada, the deposit contains up to 20 % of uranium; this, however, is exceptional.

The concentration of uranium in the ore is often indicated as "ppm" which means "parts per million".
1 ppm = 1 part per million → 0.0001 %
100 ppm = 100 parts per million → 0.01 %
200 ppm = 200 parts per million → 0.02 %
etc.

In most cases, uranium deposits are situated deep under the Earth's surface – dozens or hundreds of meters. The depth of the deposit normally determines the method of mining: deposits not too deep under the Earth's surface can be exploited by open-pit (or open cut) mining. (→ Ch. 8.3.). Deep deposits are exploited by underground mines (→ Ch. 8.4.).
In some cases, uranium deposits are so-called secondary deposits: Uranium has been eroded by rain over millions of years and settled in dips or depressions. Such deposits may be very close to the Earth's surface, only a few meters below. They can be exploited by simpler means – excavators and caterpillars, with no need for blasting and heavy equipment.

A more unconventional mining method, in-situ-leaching (ISL) or in-situ-recovery (ISR) is increasingly used (→ Ch. 8.4.).

After artificial nuclear fission had been discovered which can only be performed by uranium – more exactly U-235 – and with this new strategic importance, did uranium become a much sought-after material. Since radium is a decay product of uranium, it was clear to the experts that uranium must be present where radium had been mined: Shinkolobwe mine and material from it became of great interest, as did the Canadian company Eldorado which was exploiting radium-bearing pitchblende at the Great Bear lake are in Northern Canada. In the US, uranium was exploited in the Southwest US.

4.3. Uranium Exploitation in History

CONGO (DEMOCRATIC REPUBLIC OF CONGO)

(1908 – 1960 Belgian Congo, 1960 – 1970 Republic of Congo, 1971 – 1997 Zaire)

Uranium ore had been discovered in 1915 by an English geologist near the village of Shinkolobwe, Katanga province. Uranium was of little interest at the time – radium, a decay product of uranium, was the material of interest. The ore was initially exported to Belgium for the extraction of radium.

Actually, the uranium deposits of Shinkolobwe were exceptionally high grade, with pockets of 60 % uranium in the ore. Thus, only comparatively small quantities of ore had to be shipped. The US were highly interested in Congo's uranium and realized the importance of Shinkolobwe mine for their plans to build nuclear weapons, and started to purchase uranium from Union Miniere de Katanga.

In 1940, 1200 tons of uranium ore stockpiled at the mine, were shipped to the US by a subsidiary of Union Miniere. Later on, an average of 400 tons of ore were shipped to the US each month. This uranium – together with uranium from the US and Canada – became the important stock for building the nuclear bombs which were tested in the US and then dropped in 1945 on Hiroshima and Nagasaki.

"Most of the uranium used during World War II was from the Congolese mines, and the "Little Boy" bomb the U.S. dropped on Hiroshima on August 6, 1945 used Congolese uranium."

Source:

> "Shinkolobwe" on Wikipedia
https://en.wikipedia.org/wiki/Shinkolobwe

Sources:

> Atomic Heritage Foundation > Uranium Mining
www.atomicheritage.org/history/uranium-mining

> Tracing the Congolese Mine that fueled Hiroshima, The Telegraph, by Patrick Marnham, 04. Nov. 2013
www.telegraph.co.uk/culture/10416945/Tracing-the-Congolese-mine-that-fuelled-Hiroshima.html

After World War II, Union Minière du Haut Katanga continued to mine uranium in Shinkolobwe, and considerable quantities of uranium were shipped to the US for the nuclear weapons program.

Before Belgian Congo gained independence in 1960, the mine was closed and the shaft sealed due to fears that other states might get access to the remaining uranium reserves.

However, mining was soon resumed illegally; fears that uranium might be mined and traded illegally (smuggled) out of the country sparked an UN investigation.

Ores containing uranium and radium were also found in the North of Canada in Great Bear Lake and Great Slave Lake, as well as in Australia at Radium Hill.

Further readings:

> Final Report of the Panel on the Illegal Exploitation of Natural Resources and others Form of Wealth of the Democratic Republic of the Congo, , UN Report 2002 – 96819, 31. Oct. 2002
https://reliefweb.int/report/democratic-republic-congo/final-report-panel-experts-illegal-exploitation-natural-resources

> Geco Project – Geology for an economic sustainable development
www.gecoproject.org/?page=mining-sector

> The Conversation: How a rich uranium mine thrust the Congo into the centre of the Cold War, September 1, 2016
https://theconversation.com/how-a-rich-uranium-mine-thrust-the-congo-into-the-centre-of-the-cold-war-64761

> The Conversation: The link between uranium from the Congo and Hiroshima: a story of twin tragedies, August 24, 2016
https://theconversation.com/the-link-between-uranium-from-the-congo-and-hiroshima-a-story-of-twin-tragedies-64329

CANADA – FROM ELDORADO'S EXPLORATION FOR GOLD TO CAMECO

In Canada, the brothers LaBine planned to explore for gold. They founded a company and named it Eldorado Gold Mines Ltd. They ended up finding pitchblende from which radium could be extracted – an element many times more valuable than gold at the time. From 1933 to 1940, the company was refining pitchblende to extract radium and sell it. Due to the beginning of World War II, the mine closed.

Source:

> The Eldorado Radium Silver Express, by J.E. Arsenault, Canadian Nuclear Society (CNS) Bulletin, Vol. 26, No. 4, December 2005
www.cns-snc.ca/media/history/Bellanca/SilverExpress.html

With the discovery of artificial nuclear fission and plans to build a nuclear weapon with it, things changed: The mine reopened in 1942 but this time Eldorado focused on mining uranium. In 1943, Eldorado was nationalized for security reasons. Uranium from Port Radium at Great Bear Lake was delivered to the US military and finally used in the atomic bombs.

Many of the miners and workers were indigenous Dene people from the area; they were exposed to radiation when working in the mines and transporting the ore on their backs.

Later on, cases of cancer started to show up with the former workers, their village got the 'nickname' village of widows.

In 1998, the Dene people from Deline filed a complaint and sought compensation for the health hazards to which they had been exposed.

In 2005, the miners and their widows respectively, were denied any compensation.

In many situations, indigenous people were - and are - on the front lines of uranium exploitation – in the US, in Canada, India, Australia ...

Sources:

> The Dene people of Great Bear Lake call for a federal response to uranium deaths in Deline, March 25, 1998
www.ccnr.org/dene.html

> Calgary Herald, Echoes of the Atomic Age: Cancer kills fourteen aboriginal uranium workers and Uranium haunts a northern aboriginal village, by Andrew Nikiforuk, March 14, 1998
www.ccnr.org/deline_deaths.html

> CBC – Canadian Broadcasting Corporation Uranium exposure insufficient to cause cancer in Déline workers: report
www.cbc.ca/news/canada/north/uranium-exposure-insufficient-to-cause-cancer-in-deline-workers-report-1.551235

> Canada-Déline Uranium Table – Final Report Concerning Health and Environmental Issues Related to the Port Radium Mine, published by the Government of Canada, Minster of Indian Affairs and Northern Development, Sept 2005
https://assembly.nu.ca/library/Edocs/2005/001195-e.pdf

> CBC archives, 'Deline and the bomb' – 2008 radio documentary details connection of Dene people of Deline to Hiroshima atomic blast (Audio), CBC News · Posted: Aug 06, 2015 4:30 PM CT | Last Updated: August 7, 2015
www.cbc.ca/news/canada/north/from-the-cbc-archives-deline-and-the-bomb-1.3182188

In the 1960ies, when uranium was produced predominantly for use in nuclear power plants, the company was renamed into Eldorado Nuclear Fuel.

By 1988, Eldorado Nuclear Fuel was amalgamated with Saskatchewan Mining Development Corporation (SMDC) into CAMECO – A Canadian Mining and Energy Corporation.

Today, CAMECO is one of the big players in the uranium mining and trading business.

Further readings:

> University of Calgary Press – Mining and communities in Northern Canada: History, Politics and Memory edited by Arn Keeling and John Sandlos, 2015 ISBN 978-1-55238-805-1 (open access book)
https://prism.ucalgary.ca/bitstream/handle/1880/51021/UofCPress_Mining_2015_chapter02.pdf;jsessionid=26224CCAD86B7E2AFCF5EB8394852C6F?

> University of Toronto Press – Nuclear Portraits: Communities, the Environment, and Public Policy edited by Laurel Sefton MacDowell, 2017 ISBN 978-1-4426-4861-6 (cloth), 978-1-14426-2629-4 (paper)
https://books.google.de/books?isbn=1442626291

USA

In the US, uranium was first identified in pitchblende in a gold mine in Colorado in 1871. Radium was then exploited in the Uravan district, Colorado. Uranium was mined as a by-product of vanadium (the mining town's name was made up from the words uranium and vanadium). During World War II, uranium was mined on the Colorado plateau and adjacent areas, although the exploitation for uranium was kept secret like the Manhattan Project (the project to build a nuclear bomb).

"By the end of the war, the Colorado Plateau provided 2,698,000 pounds of uranium oxide, (about 14 percent of the project's uranium needs) with the rest coming from the Belgium Congo and Canada."

Many of the miners and mill-workers were Dine/Navajo, Native Americans, i.e. indigenous people of the area.

"The miners were never warned of the hazards of radioactivity in the mines in which they inhaled, ingested and brought home along with their contaminated clothing. Withholding information about the hazards of the workplace was deeply embedded in the bureaucratic culture of the nuclear weapons program."

After World War II, uranium mining in the US was mainly performed by private companies encouraged by the newly created Atomic Energy Commission (AEC) which bought up uranium at a guaranteed price.

> "By 1948, the AEC [Atomic Energy Commission, in the US] stimulated a uranium mining boom that led to the discovery of other important ore findings on the Navajo reservation and elsewhere. Mining companies promptly entered into agreements that included requirements to hire and train tribal members. In addition to the Colorado Plateau, uranium mining extended to the Black Hills of South Dakota, Northwest Nebraska, Spokane, Washington, the Wind River Indian Reservation and other sites in central Wyoming, the Powder River Basin in Wyoming and Montana, and the Texas Gulf coast. […]
>
> The AEC also encouraged private companies to establish mills and buying stations to process the ore."

Native people, among them Lakota, ("Sioux"), and other Native American Nations such Acoma and Laguna Pueblos, became victims on the frontlines of uranium mining.

By the end of the millennium, the town of Uravan was found to be beyond remediation, with high levels of radiation. Due to the contamination, the town became a US Superfund site: it was completely taken down, and the remains buried (by 2008).

Source:

- **Uranium Mining and the U.S. Nuclear Weapons Program,** Federation of American Scientists (FAS), posted on Nov. 14, 2013
  https://fas.org/pir-pubs/uranium-mining-u-s-nuclear-weapons-program-3

Further readings:

- **Poison Fire, Sacred Earth – Testimonies, Lectures, Conclusions,** Minutes of The World Uranium Hearing, Salzburg/Austria Sept. 1992 ISBN 3-928505-00-9
  https://ratical.org/radiation/WorldUraniumHearing
- **Memories Come To Us In The Wind And The Rain – Oral Histories and Photographes of Navajo Uranium Miners & Their Families,** by Timothy Benally (Author), Chenoa Bah Stilwell (Author), Phil Harrison (Author), 1996
  https://swuraniumimpacts.org/wp-content/uploads/2016/06/Memories-Come-To-Us.pdf
- **The History of Uranium Mining and the Navajo People,** US National Library of Medicine National Institutes of Health, by Doug Brugge, September 2002
  www.ncbi.nlm.nih.gov/pmc/articles/PMC3222290
- **The Navajo People and Uranium Mining** edited by Doug Brugge, Esther Yazzie-Lewis, Timothy H. Benally, 2009, University of New Mexico Press
  https://unmpress.com/books/navajo-people-and-uranium-mining/9780826337795

AUSTRALIA

In 1906, a deposit of radium/uranium was discovered at Radium Hill, South Australia. It was exploited for radium between 1906 and 1931, and for uranium between 1954 and 1961.

The underground mine was recommissioned in 1954 and operated by the South Australian Government. Uranium was mined by the Commonwealth and South Australian Governments with the UK-USA Combined Development Agency (CDA) for delivery of uranium oxide over seven years. The CDA was the agency responsible for obtaining uranium for the British and US nuclear weapons programs.

In 1982, the South Australian Health Commission and Adelaide University commenced a study of former miners of Radium Hill mine. The results of the health study were published nine years later, in 1991.

It concluded that radiation may have contributed to premature deaths among the workforce. The Federal Industrial Relations Minister, Peter Cook, held out the possibility of compensation to 56 families of victims of Radium Hill.

A study on the health impacts, particularly by radon and its decay products was later presented at an International Conference on Radon in the US.

The country at Radium Hill had previously been occupied by Aboriginal people. Uranium from Radium Hill was incorporated into British nuclear weapons later tested on Aboriginal land and people.

Films:

- **Das Uran gehört der Regenbogenschlange (Uranium belongs to the Rainbow Serpent),** by Nina Gladitz, 1979
  www.youtube.com/watch?v=jZxPI-9GFPw
- **Wo die Grünen Ameisen träumen (Where the Green Ants dream),** by Werner Herzog, 100 minutes, 1984, available in German and in English
- **Collisions,** a virtual reality film experience like no other, exploring the collision of science and spirit.
  www.collisionsvr.com

Source:

- **Radium Hill Mine,** Australia
  www.energymining.sa.gov.au/minerals/mining/former_mines/radium_hill_mine

Sources/further readings:

- **Radium Hill Mine,** Australia
  www.energymining.sa.gov.au/minerals/mining/former_mines/radium_hill_mine
- **Radium Hill former uranium-radium mine**
  https://australianmap.net/radium-hill

Source:

- **"Radon daughter exposures at the Radium Hill uranium mine and lung cancer rates among former workers, 1952-87",** Woodward et al., Cancer Causes and Control 2:91
  www.ncbi.nlm.nih.gov/pubmed/1873450

5

C H A P T E R **F I V E**

Animation

A So, couldn't we use Uranium from Africa, put it into a nuclear power plant and generate electricity for Tanzania, or South Africa or Namibia ... ? ?
B Well, it's not that simple.
It takes several steps from yellowcake – the final product of uranium mining – until it can be used in a nuclear power plant: it's called nuclear fuel chain.
Nuclear fission can only be done with ONE of the three kinds of uranium – Uranium-235.
Only a small part – 0.71 % – of Uranium is Uranium-235 – remember?
This part has to be increased if we want to produce nuclear power. This process of increasing the percentage of Uranium-235 is called enrichment, and is quite complicated.
Enrichment plants do not exist in Africa ... they are in the US, in France, in Russia, in Germany ... but not in Africa.

Narration

The nuclear fuel chain starts with uranium mining and extraction of uranium from the ore. In conventional mines, uranium ore is dug up from open pits or from underground mines.

Then, the ore is crushed in a mill and treated with chemicals, mostly sulphuric acid, to extract uranium. The final product of this process is YELLOWCAKE, also called U3O8.

The final product, YELLOWCAKE is then transported to a conversion plant for further purification, and it is converted into a gas, UF6. This is taken to an enrichment plant, and the concentration of Uranium-235 is increased to 3 – 5 %.

DAVID FIG (INTERVIEW)

That enrichment plant ... once you have the enrichment plant you are capable of making nuclear energy and nuclear weapons. Number 4, once you have enriched the uranium you turn it into fuel rods which are the elements that go into number 5 which is the actual power plant, the reactor ...

The enriched uranium is transported to fuel rod fabrication plants and carefully manufactured in nuclear fuel rods.

These are installed in a nuclear power station where the intense heat of the nuclear fission produces steam and drives turbines which produce electricity. The extreme heat, pressure and radiation in a nuclear reactor need constant monitoring and precise engineering.

In the end, there is highly radioactive nuclear waste.

DAVID FIG (PRESENTATION)

We are talking about isolating that waste from the environment for 244,000 years. Now as a human species we are living on the planet for a little bit over than that. Something like 300,000 years. We have only had agriculture for about 10 or 12,000 years. We only have cities for about 5,000 years. In general, we are a new species as humans. We do not have the knowledge how to separate something from the environment for such a long scale of period.

5. The Nuclear Fuel Chain

5.1. Nuclear Fuel CHAIN or Nuclear Fuel CYCLE?

The uranium and nuclear industry often use the term nuclear fuel CYCLE – implying that uranium fuel in a nuclear power plant can be "recycled" after use.

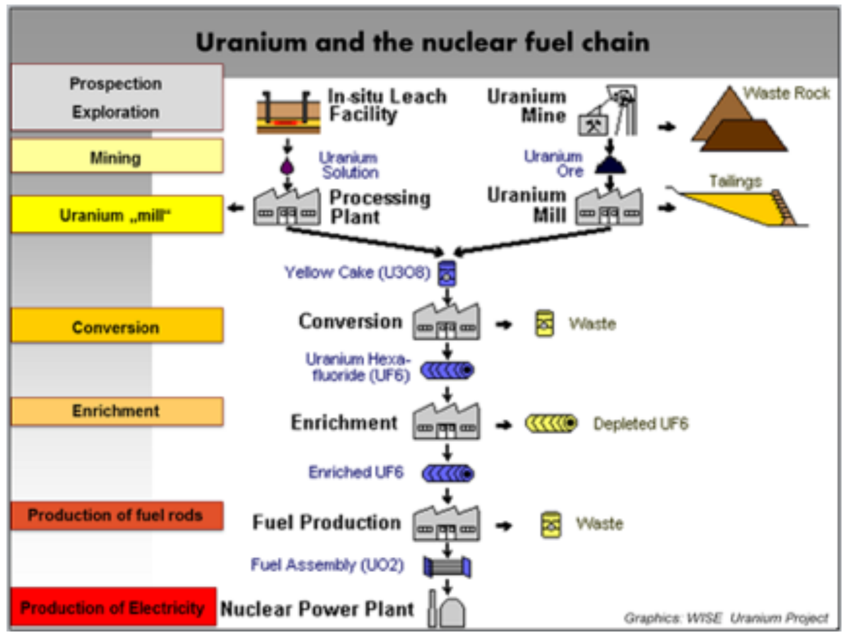
In a nuclear power plant, not all of the uranium is "consumed", i.e. split up. There is some uranium (U-235) which still could be used (in new fuel rods). However, during the splitting of the U-235 atoms, so-called transuranic elements were generated – elements which never before existed on Earth, e.g. plutonium. Some of these elements are highly radioactive (much more radioactive than the original uranium).

In order to 'recycle' the fuel, the fuel rods have to be taken apart. After use, they contain highly radioactive elements and can only be handled and taken apart by remote control equipment and heavy shielding; even then, the process remains dangerous. Worse still, the process generates even more nuclear waste.

Consequently, most countries using nuclear power do not recycle spent fuel rods. Only a very small fraction of the used fuel is recycled (for ex. in France's LaHague reprocessing plant).

Thus, there is no Nuclear Fuel Cycle. The path of uranium is a fuel CHAIN – with open ends: uranium mining and nuclear waste storage – which is, so far, an unresolved problem.

It is sometimes claimed that using uranium and thorium can create a "fuel cycle"; in fact, thorium reactors do not exist in reality, so far they are a model only.



NOTE

Detailed information on the 'Nuclear Fuel Chain' is kept short since the focus of film and booklet/information website is on uranium exploitation.

5.2. Nuclear Fuel Chain

EXPLORATION

Before mining can start, uranium deposits have to be found and identified (→ Ch. 7.1.)

MINING

The nuclear fuel chain begins with exploiting uranium – at times by open-pit or underground mining, at others by in-situ leaching (→ Ch. 8.)

Uranium can also be procured from so-called secondary sources: for some time, nuclear warheads were dismantled by the USA and the USSR/Russia. The highly enriched uranium was 'downblended' and then used as a fuel for nuclear power plants. This disarmament program, has ended, however.

Both mining methods – open pit and underground mining – produce uranium ore – rocks containing, in most cases, a low concentration of uranium, often less than 1 %. The ore is crushed and grinded to sand. Then leaching liquid is added, normally sulphuric acid to leach uranium – and other elements – out of the sand. The leaching process requires big quantities of water (→ Ch. 9.2.).

In the process, the leaching fluid becomes slurry contaminated with radioactive elements, and eventually with heavy metals. These leftovers of the uranium extraction process are called 'tailings'. They are discarded to tailings ponds.

The process differs from mine to mine, in some cases a part of the water is recycled and reused in the process (→ Ch. 9.2. Water consumption, Namibia, Rössing Mine).

The final product of the process is natural uranium, U3O8, also referred to as yellowcake. It is packed, mostly in 200-liter-barrels, then into containers and shipped to ports, from there to Europa, North America or to Asian countries. At present (2019), uranium from African mines is not processed in Africa.

Uranium from Namibia's uranium mines, for example, is shipped through Walvis Bay. Uranium from the mines at Arlit, Niger, is trucked 800km to Cotonou, Benin, and then shipped to France.

The waste of the uranium exploitation – most of it in form of liquid or slurry –amounts to the thousandfold or more of the quantity of uranium extracted and transported out of the country. The tailings contain approx. 80 % of the radioactivity of the original ore. The valuable – and less radioactive – uranium (yellowcake) is shipped out of the country, whereas the thousand-fold mass of radioactive material, containing 80 % of the original radioactivity of the ore, is left behind at the mining sites (→ Ch. 10.).

When the concentration of uranium in the ore is very low, companies sometimes use heap leaching (→ Ch. 8.5.), with the same result: huge amounts of radioactive tailings.

Animation

B … so there is a long way from mining uranium in a mine to the nuclear power plant …
A yes. Indeed, and there is a lot of transportation involved, too …
So, let us take a closer look at the beginning of the nuclear fuel chain: How to find uranium – exploration – and how to mine it …

CONVERSION AND ENRICHMENT

Only 0.72 % of the uranium (yellowcake) is fissile U-235. In order to maintain a chain reaction to produce heat and steam to generate electricity, the percentage of U-235 has to be increased to 3 – 5 %; this is achieved by conversion of uranium into UF6 (uranium hexafluoride) followed by enrichment.

When the enrichment is continued to 90 % U-235, nuclear weapons can be built (HEU – Highly Enriched Uranium). The enrichment technology is therefore a sensitive part of the nuclear fuel chain. If a country has access to this technology, it may use it to built nuclear weapons. These installations are controlled by the IAEA International Atomic Energy Agency in order to prevent enrichment to higher grades.

The enrichment process also generates "depleted uranium" (DU) with contains very little U-235. The DU is basically radioactive waste. However, it is also used for DU ammunition as well as for armoring of tanks. DU also has negative health impacts.

DU ammunition was used in the war in Yugoslavia and in the war against Iraq. It continues to contaminate battlefield areas in these countries. Negative health impacts are reported from the areas, from civilians (children playing with shells etc.) as well as from soldiers (Gulf war syndrome).

FUEL PRODUCTION, NUCLEAR POWER PLANT

Uranium with 3 – 5 % U-235 is made into pellets, arranged in fuel rods, assembled to fuel bundles and then inserted into the core of a nuclear power plant to generate electricity.

After a few years, a part of the fissile U-235 in the fuel rods is 'used up'. The fuel rods are then exchanged for new ones. The spent fuel rods are now highly radioactive (→ Ch. 5.1.).

The spent fuel rods must be kept for several years in cooling basins in or near nuclear power plants until radioactivity has diminished so far that they can be handled and transported; the spent fuel rods must be transported and stored in special containers. High radioactivity of these fuel rods will endure for thousands of years.

FINAL STORAGE OF SPENT NUCLEAR FUEL – UNRESOLVED

To date, there is no final storage place to keep the waste safely for thousands of years. In the film (18:54 – 19:45), David Fig refers in his presentation to the spent nuclear fuel rods – they need to be stored 'safely' for tens of thousands of years, he says "… for 244.000 years". This does not refer to waste/tailings from uranium mining, but to spent nuclear fuel.

CHAPTER SIX

Narration

When decisions about exploitation of resources are made, the question about land use – and conflict always arises: What is more important? Agriculture or mining?

Growing food for people – or exploiting uranium?

Traditional activities like gathering food and hunting – or mining some mineral deposits?

These questions cannot be considered without taking a look at

- WHO makes the decisions?
- WHO are the people effected by those decisions?
- WHO is profiting from those decisions and from the mining activities?

Often, one will find that the people who MAKE the decisions about mining issues are not the people affected first and foremost.

At the center of the issue are questions about LAND USE, land ownership, and jurisdiction over the land. Land used for mining of uranium can never again be used for agriculture; the impacts of mining are irreversible.

Globally, uranium ore deposits are widespread on all continents, with the largest deposits found in Australia, Kazakhstan, Canada and Niger.

6. Uranium Exploitation, the Land and Human Rights

6.1. Land and 'ownership'

Decisions about mining are always decisions about LAND USE, i.e. land ownership and land rights. The 'western' concept of land, land ownership and the decision making about land use implies that land can be owned by a person (or a company), that it can be sold or leased, and the owner (or leaseholder) can deal with the land more or less as he likes, although there may be legal restrictions.

The traditional understanding of many communities and by indigenous peoples, however, works differently: Land cannot be 'owned', bought or sold by a single person – it is owned by a community, a tribe, a village, and it is owned communally. It cannot be sold. People 'only' have the right to use the land, and land use is decided upon by the community, tribe or village.

This understanding of land use is not very well compatible with the 'western' concept of land and land ownership. In addition, national Governments regularly claim the (exclusive) right to subsurface resources such as minerals (e.g. oil, coal or uranium), and to deal with them at their discretion.

Laws and regulations, and thus the problems arising from them – differ from country to country; we list a couple of examples which came to our attention around the issue of uranium mining.

The UN Covenant on Economic, Social and Cultural Rights says:
"Article 1

2. All peoples may, for their own ends, freely dispose of their natural wealth and resources without prejudice to any obligations arising out of international economic co-operation, based upon the principle of mutual benefit, and international law. In no case may a people be deprived of its own means of subsistence."

Although the Covenant refers to 'peoples', the understanding of the Covenant has developed, and today it is widely accepted that the provision of the Covenant may also apply to entities smaller than 'peoples'.

In regard to indigenous peoples, the concept of free, prior and informed consent (FPIC) was developed. It is based on the UN Declaration of the Rights of Indigenous Peoples (UNDRIP).

The impact of uranium mining on indigenous peoples was a focus of THE WORLD URANIUM HEARING, 1992, Salzburg/Austria. The report "Poison Fire, Sacred Earth" is available on internet.

The Food and Agricultural Organization of the UN (FAO) says:

"Free, Prior and Informed Consent (FPIC) is a specific right that pertains to indigenous peoples and is recognized in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). It allows them to give or withhold consent to a project that may affect them or their territories. Once they have given their consent, they can withdraw it at any stage. Furthermore, FPIC enables them to negotiate the conditions under which the project will be designed, implemented, monitored and evaluated. This is also embedded within the universal right to self-determination."

Thus, decisions about land use touch on Human rights and may infringe on them; decisions endangering or taking away basic means of existence/subsistence from people – be they indigenous peoples or local communities – may be considered a Human Rights violation.

See:

> International Covenant on Economic, Social and Cultural Rights
www.ohchr.org/EN/professionalinterest/pages/cescr.aspx

> United Nations Declaration on the Rights of Indigenous Peoples
www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

> Free, Prior and Informed Consent of Indigenous Peoples, Office of the High Commissioner on Human Rights, , Sept. 2013
www.ohchr.org/Documents/Issues/ipeoples/freepriorandinformedconsent.pdf

> Poison Fire, Sacred Earth – Testimonies, Lectures, Conclusions, Minutes of THE WORLD URANIUM HEARING, Salzburg/Austria, Sept. 1992
https://ratical.org/radiation/WorldUraniumHearing

> Uranium mines harm Indigenous people – so why have we approved a new one?
by Jessica Urwin, May 1, 2019 6.41am BST
Updated May 6, 2019 2.38am BST
https://theconversation.com/uranium-mines-harm-indigenous-people-so-why-have-we-approved-a-new-one-116262

6.2. Land and the Exploitation of Uranium

Land used for (uranium) mining can no longer be used for agriculture, cattle raising or traditional activities such as hunting or gathering food anymore. The decision about land use is also an irreversible decision: Land once used for uranium mining can never be used for agriculture or other activities. Neither is the building of houses on such land, nor in its vicinity advisable. The tailings from mining can contaminate surrounding areas with radioactive materials which may get into the food chain and impact the health of humans long after closure of the mines.

Local communities are not always properly informed about the consequences of (uranium) exploration and uranium mining, and in many cases, they have little or no say in decision making. On the contrary, persons or NGOs critical of or opposed to uranium mining, in a number of cases experienced intimidation, harassment and repression.

NORTH AMERICA

In North America, land traditionally belonged to the Native/indigenous peoples of the area; the European concept of land ownership and buying and selling of land was alien to them. These opposing views have lead to conflicts about land ownership and land use to this day.

In Canada, Native people (First Nations) in some regions never ceded their territories; in other areas, they made treaties with the crown of England about shared land use. Today, however, both levels of Government in Canada (federal and provincial) widely ignore these treaties and their implications when it comes to land rights and resources. The exploitation of resources, including uranium, is licensed by the government (and was done by a Government company during World War II). Mining (and other) activities impact First Nations communities healthwise and in regard to following traditional occupations like hunting, fishing and gathering. The First Nations communities hardly profit, if at all, from the mining activities.

Further readings:

- **Uranium Mining On Navajo Indian Land** Doug Brugge, Timothy Benally, Esther Yazzie-Lewis www.culturalsurvival.org/publications/cultural-survival-quarterly/uranium-mining-navajo-indian-land
- **Uranium Mining on Sacred Land: the Case of Mount Taylor (NM, USA),** Susanne Berthier-Foglar, ELOHI [Online], 2 | 2012, Online since 01 July 2013 http://journals.openedition.org/elohi/304
- **Uranium Mining and Native Resistance: The Uranium Exploration and Mining Accountability Act,** by Curtis Kline, July 2, 2013 https://intercontinentalcry.org/uranium-mining-and-native-resistance-the-uranium-exploration-and-mining-accountability-act
- **"Becoming Onîkânîwak: Defending Nehithaw-Askiy from Saskatchewan's Uranium Industry",** by Kirstin Scansen, 2015 University of Victoria, Master of Arts https://pdfs.semanticscholar.org/32d2/09e8fcb64a5f734f83bc10bd7addfedc064b.pdf
- **"Voices from Wollaston Lake: Resistance against Uranium Mining and Genocide in Northern Saskatchewan",** by Miles Goldstick, 1987, Earth Embassy https://www.amazon.co.uk/voices-wollaston-lake-Miles-Goldstick/dp/907070207X
- **Global Justice – Indigenous Peoples and Uranium Mining (1997),** WISE Uranium Project www.wise-uranium.org/uip412.html

AUSTRALIA

In Australia, Aboriginal (indigenous) people were disregarded as land owners when British colonists started to settle. Aboriginal peoples' land was grabbed, and besides many other activities, mining ensued – with no regard for the Aboriginal peoples' right to their land.

Moreover, traditional Aboriginal beliefs demand that certain places remain untouched. However, mining companies paid no attention and started to dig for all kinds of resources – including uranium. Only in the 1970s, did an interest in the Aboriginal peoples' right to their ancestral lands start to emerge. The claims for recognition are ongoing. Aboriginal communities often opposed mining on their land, including mining of uranium.

In Australia's Northern Territory, then Senior Traditional Owner of the Mirarr people, Toby Gangale, opposed plans for uranium exploration and mining on his country in the 1970s. The Mirarr Aborginal people wanted to retain their land unspoiled. Their opposition was overruled by the Government. However, Ranger uranium mine started operations. A planned underground expansion of Ranger mine, Ranger Deeps, was halted in 2015.

Currently (2019), plans are prepared for the closure and rehabilitation of Ranger Mine; the area will later be returned to the Mirarr Aboriginal people.

Another project, Jabiluka uranium mine, in the vicinity of Ranger mine, was opposed by the traditional owners; they fought plans to mine there from 1998 on, for many years, supported by environmental organizations, taking their struggle to the international level. The project was finally stopped in 2003/2004.

Sources/further readings:

- **ERA pulls the plug on Ranger 3 Deeps,** Australian Mining Monthly www.miningmonthly.com/industrial-minerals/news/1266049/era-pulls-plug-ranger-deeps
- **"Australia's Decision": Uranium Mining and Aboriginal Communities Then and Now** by Sandrine Tolazzi, EASA – European Association for Studies of Australia, Vol. 3 No. 2, 2012
- **Broken Promises: Land Rights, Mining and the Mirrar People,** by Fagan, Mathew , IndigLawB 42; (2002) 5(18) Indigenous Law Bulletin 12 http://classic.austlii.edu.au/au/journals/IndigLawB/2002/42.html

Film:

- **Dirt Cheap 30 years on: the story of uranium mining in Kakadu** https://vimeo.com/73373709

Further readings:

- **What anti-Adani protestors can learn from the Jabiluka blockade,** by Scott Ludlam, 2. April 2018 www.theguardian.com/commentisfree/2018/apr/03/20-years-on-from-the-jabiluka-mine-protest-we-can-find-hope-in-its-success

Another project in Australia, Koongarra uranium mine, grinded to a halt when traditional land owner Jeffrey Lee refused to sell his ancestral land for uranium mining. In 2011, UNESCO included the site of Koongarra uranium deposit into World Heritage site Kakadu National Park, and the Australian Government included it into the existing National Park.

Sources/Further readings:

- **We stood with the Mirarr people to stop the Jabiluka uranium mine,** by Dave Sweeney, Australian Conservation Foundation (ACF) www.acf.org.au/jabiluka
- **Australia: Koongarra is now permanently protected from uranium companies,** by John Ahni Schertow, March 18, 2013 https://intercontinentalcry.org/australia-koongarra-is-now-permanently-protected-from-uranium-companies

AFRICA: MALI

Traditional communities share a similar understanding of land, as explained in an exhibition about the threat of uranium mining on the communities of Falea, Mali (Africa):

"Traditionally, land in Mali belongs to no one. The «Maitre de la terre» [Chief of the Soil/Land] hands over the land to those cultivating it. Those who are digging a well or planting a tree on a piece of land granted to them by the "Maitre de la terre" are recognized by common law as the cultivators of the land upon which he generates value . The traditional system is based on the ancient wisdom of refusing to allow land to become a commercial good or private property. Land is considered common to all and is not a commercial merchandise."

When an exploration license was issued for a uranium company by the Government , traditional land use schemes were disregarded.

Due to strong local resistance of the traditional community, international support and decreasing uranium prices, exploration in Falea region came to a halt and uranium mining plans have been postponed indefinitely.

Source:

- **Exhibition: Falea – Mali, West Africa – Before – After? Page 4** www.falea.info/wp-content/uploads/2012/09/falea-engl-minimal.pdf

Further readings:

- **Falea21 – Falea Mali, West Africa – The menace of uranium mining** Some information on the website is available in several languages www.falea.info

AFRICA: TANZANIA

The Tanzanian Village Land Act commands that all villagers decide on developments on their village land. However, the Government reserves the right to hand out exploration licenses to companies – obviously without consulting (or even informing) the people from the villages in question. There seems to be some concurrent legislation which is used to the disadvantage of villagers. Subsistence economy common and important in many parts of the world, is often regarded as inferior to industrial or mining activities.

In 2010, a Tanzania NGO, CESOPE – Civil Education is the Solution to Poverty and Environmental Management, issued a study on the "Economical and Ecological Research of Bahi Swamp" (swamp in this case means periodically flooded wetlands), a region threatened by uranium exploration and mining in the 2010th.

The study showed the considerable economic value of the area through agriculture, livestock raising, fishing and other activities. This example of a sustainable economy might well exceed the revenues the Government hopes to earn from uranium exploitation.

Further readings:

- **Economical and Ecological Resarach of Bahi Swamp,** by Dr. Damas K. Mbogoro and Mr.Augustino Mwakipesile, The University of Dodoma, Tanzania, December 2010 www.wise-uranium.org/pdf/BahiSwamp.pdf

CONCLUSION

The exploitation of uranium touches – among other issues – on the question of land, land use and land rights as well as on the concept of land ownership. In some parts, a different understanding of the world view lies at the core of the issue.

Decision making on uranium mining (or other extractive industries) goes far beyond the 'technical' questions of mining and dealing with environmental and health impacts. It touches on basic Human Rights.

In many situations there is high risk that Human Rights are infringed upon when decisions in regard to extractive industries are made.

Further readings:

- **Poison Fire, Sacred Earth – Testimonies, Lectures, Conclusions,** Minutes of THE WORLD URANIUM HEARING, Salzburg/Austria Sept. 1992 THE WORLD URANIUM HEARING https://ratical.org/radiation/WorldUraniumHearing

C H A P T E R **S E V E N**

Animation

A … Hhmm … How do they find those uranium deposits worth mining in the first place?
B That's a long process:
At first, geologists research geological formations, and find out which formations might contain uranium. Uranium deposits exhale Radon gas, a decay product of Uranium. Radon gas can be traced by sensitive devices, even if these devices are attached to helicopters or low-flying planes.
Thus, areas with higher levels of uranium underground can be identified.
In a next step samples are taken, by drilling holes with mobile drilling devices, mounted on trucks or trailers. Thus, one can find out whether there is a uranium deposit worthwhile mining.
A That costs a lot money, doesn't it?
B Right! Often some of the groundwork has been done by geologists, then companies come in to do the exploration work these are often smaller, young companies, called junior companies: they advertise good prospects and people who have some money set aside invest it in those companies hoping they will find uranium and they will become rich.

7. Uranium Exploration

7.1. Exploration

Before exploration starts in the field scientists, mainly geologists, explore the layers of the Earth and try to understand the geological structures. Some of this research may be for collecting scientific data, but parts of these data are used to identify the location of valuable minerals. Some of this work is done by universities and geological institutes.

For example, German BGR – Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources) is exploring resources in various parts of the World. It "… is the central geoscientific authority providing advice to the German Federal Government in all geo-relevant questions."

In the past, subsidiaries of the originally German Uranerzbergbau GmbH (literally translated: Uranium Ore Mining Company) explored for uranium resources on all continents, at the discretion of and funded partially by the German Government.

Data collected and insights won previously are, in part, used in current exploration activities of uranium exploration and mining companies.

Once an area is identified as (probably) uraniferous (having some uranium), closer examination is started. Whereas in former times prospectors surveyed the land and looked for signs of valuable minerals, today planes and helicopters are used, passing with radiation detection devices at low altitudes, searching for radiological abnormalities which may indicate uranium deposits.

Uranium deposits, although normally underground, exhale Radon-222, a radioactive gas and one of the decay products of uranium, through cracks and fissures in the rock. Gamma-radiation is also emitted. Both indicate the presence of uranium.

In the next step, test drillings are performed to confirm the existence of an underground deposit, identify the concentration of uranium in the ore, evaluate the size of the deposit and the overall quantity of uranium in the deposit.

These data are important to decide whether an uranium occurrence is considered worthwhile mining. Of course, the price of uranium on the world market is another important and determining factor for the economic feasibility of a uranium project.

Sources:

- BGR (Federal Institute for Geosciences and Natural Resources, Germany)
  www.bgr.bund.de/EN/Home/homepage_node_en.html
- Die Gründung der Uranerzbergbau-GmbH
  http://cdeilmann.de/timeline/die-gruendung-der-uranerz-bergbau-gmbh
- Bestand 150 Uranerzbergbau-GmbH & Co. KG, Bonn, Bergbau Archiv Bochum
  www.archive.nrw.de/LAV_NRW/jsp/bestand.jsp?archivNr=421&tektId=15&expandId=1

Animation

A *I heard that there were complaints about exploration activities … local people did not like it – you heard anything about this?*
B *Ya, that's right. In some places, the companies did not ask local communities and just walked into their fields and even into houses without permission; when asked about what they were doing, they did not tell the truth. People didn't like that and complained.*
A *Is this exploration dangerous, or why did they complain?*
B *People became aware that – should uranium mining come their way – they would loose their land – which is their basic means of existence: they grow rice, vegetables, herd cows and so on … but if the land is used for mining, agriculture or cattle raising are no more possible. So, it is a matter of land use. Actually, Native people in America and in Australia experienced the same: Government or corporations use their land for mining, chased them away – and they lost their main sources of income, of subsistence economy.*
A *Isn't that a Human Rights violation???*

ANTHONY LYAMUNDA (INTERVIEW)

Exploration had been done here, the company is not informing the society [the people] what is going on here, what is happening and about the hazard of the uranium mining. Because the company they say uranium mining is like mining any other mineral. And uranium mining is very environmentally friendly. So even you can have the mining here, also the water supply in the same place will be no problem.

Animation

B *Right that's a human rights violation; nobody is supposed to take away your basic means of existence and people really have the right to know what is happening on their land.*
A *Can this uranium exploration have negative impacts?*
B *Ya, that's the second aspect: When you drill down, you may hit a uranium deposit – and samples – they call them "carrots" – which may contain uranium and its decay products – these "carrots" need to be handled with care:*
Don't breathe in the dust, wear protective clothing, gloves, wash well before eating your lunch, and, basically, stay away from those "carrots".
The drilling may also intersect a water aquifer, then water may get in touch with the uranium deposit – then, you may find uranium and its decay products in your drinking water … not good for your health.
Drilling may also just hit a water aquifer and change the flow of the water; people in Falea/Mali had that experience – the spring fell dry. Another spring was contaminated with oil and chemicals from the drilling!
A *… doesn't sound good at all …*
B *Well, officials should monitor exploration activities … but often, it seems, they lack the capacity to do so.*
A *How, then, is the mining done?*

7.2. Impacts of Uranium Exploration

IMPACTS FROM TEST DRILLINGS

Test drillings may intersect a water aquifer. The groundwater may get in touch with the uranium deposit, and, as a result, uranium and its decay products will end up in the aquifer, contaminating the drinking water resource.

Test drilling may also hit a water aquifer and change the flow of the water.

In Falea/Mali people experienced a spring drying up after test drilling for a uranium-copper-gold deposit. Afterwards, women had to walk much further to haul water for their households. The original water flow could not be restored.

In another case in Falea/Mali, chemicals used with drilling and oil from the drilling rig kept running off and contaminated a spring in the vicinity.

In other cases, drillholes of test drillings were not closed and sealed, providing access to a uranium deposit, or allowing water containing radioactive contaminants to reach the surface.

(Falea/Mali, and personal communication with human rights and environmental defenders in N'Djamena, Chad)

In some cases, chemicals are used in test drillings. These chemicals may have negative impacts on the health of people and animals, and need to be disposed of properly.

In Falea/Mali, people complained that cows died after drinking polluted water. Most probably, chemicals are the cause.

Sources:

> Exhibition: Falea – Mali, West Africa – Before – After?, page 9 and 10
www.falea.info/wp-content/uploads/2012/09/falea-en-gl-minimal.pdf

HANDLING OF SAMPLES FROM DRILLHOLES

Samples recovered from the drillholes (sometimes referred to as "carrots") need to be handled with care as they may contain uranium and its decay products. Workers need to be advised to wear gloves and protective clothing, wash well before eating and be careful around dust from the 'carrots'.

In Tanzania, drilling was performed with few precautions. Workers were seen handling samples without gloves and eating their lunch on top of the samples. Samples which were not needed were disposed of in nearby bushes and small depressions. There was little radiation monitoring, if any.

In countries with some experience in uranium exploitation, test drillings are monitored, and more or less extensive guidelines are in place.

For example, the province of Saskatchewan, Canada, a 'uranium province', has extensive guidelines for radiation monitoring in uranium exploration. This is in the interests of both the workers as well as the environment.

Further readings:

> Guidelines for Radiation Protection during Exploration for Uranium, Occupational Health & Safety, Brief 8-page leaflet
www.pdac.ca/docs/default-source/priorities/responsible-exploration/e3-plus---common/e3-plus---toolkits---environmentl-stewardship/guidelines-for-radiation-protection-during-exploration-for-uranium.pdf?sfvrsn=913e7c21_4

CONCLUSION

Exploration activities pose a danger for aquifers and surface waters, and they may affect the health of people in the area.

Workers involved in any kind of exploration work should be well informed about the risks and educated in regard to safe handling of samples and chemicals.

Radiation monitoring by qualified radiation protection agencies should be obligatory as well as effective measures to protect workers, the general public in the area and the environment. Emergency response plans should also be available and easy to implement.

DAVE SWEENEY (INTERVIEW)

If you can find new places, if you can prove up a deposit, if you can sell it on to a bigger company, there's still money to be made out there, and in the south of Tanzania, Mkuju River, there is an example with an Australian company, Mantra Resources, which explored and proved up a deposit and sold the deposit then on to the Russian nuclear company [ROSATOM] and they sold it for 1 billion Australian dollars, one billion. When people hear that story of: here's a company that went over to Tanzania, poked around a little bit, drilled a little bit and then sold it to the Russians for a billion dollars, people get excited, small mining companies get excited, and they look at Africa, yes, like a gold rush a new frontier for a yellowcake rush …"

Narration

In fact, it is one true and successful story; the shareholders of Mantra had paid less than 2 Australian Dollars in 2008 for a share, and in June 2011, they received 6.87 Australian Dollars for a share – more than three times of what they had invested.

7.3. Exploration, Companies and Money

Exploration activities cause considerable costs – and, by themselves, yield no (quick) earnings. Thus, exploration is either performed by big companies who can afford to expend monies without immediate earnings, or exploration is done by small 'junior' companies.

Junior companies – typically with not much equity – depend on the ability to raise substantial funds before starting their work; they need to keep their shareholders well informed, and, in most cases, to raise more funds during their work, either by selling more shares or by taking loans. Whichever method of financing they choose, companies need to convince potential shareholders or creditors that their activities will lead to a positive result, enabling the company to reward its shareholders with some income (dividend) or, in case of loans taken, to be able to pay back the loans plus interest.

The result is that companies sometimes tend to give overly positive reports on the success of their exploration work.

Companies whose stocks are registered and traded at a stock exchange need to submit reports about their activities and results. And, in certain cases, these report are checked by technical experts before being accepted and published.

Further readings :

> "Uranium: War, Energy, and the Rock That Shaped the World", by Tom Zoellner, 2010

7.4. The long road from Exploration to Exploitation

Many companies explore for uranium, but only a few succeed in identifying deposits worth mining. In gas and oil business … "In reality, commercial exploration success rates worldwide range from 30-40 %."

Success rates of uranium exploration are hardly, if at all, documented. After the rise of the price of uranium in 2007/2008, dozens of companies started to explore for uranium – in Africa and all over the world – but only a few got lucky and were able to identify a mineable deposit.

Once a uranium deposit is identified, and considered worthwhile mining, there are usually two options: The company may decide to exploit the deposit on its own or, especially if it is a 'junior' company with not much funds at hand, the company may decide to sell the deposit (sometimes with the company altogether) to a senior mining company which will then exploit the deposit.

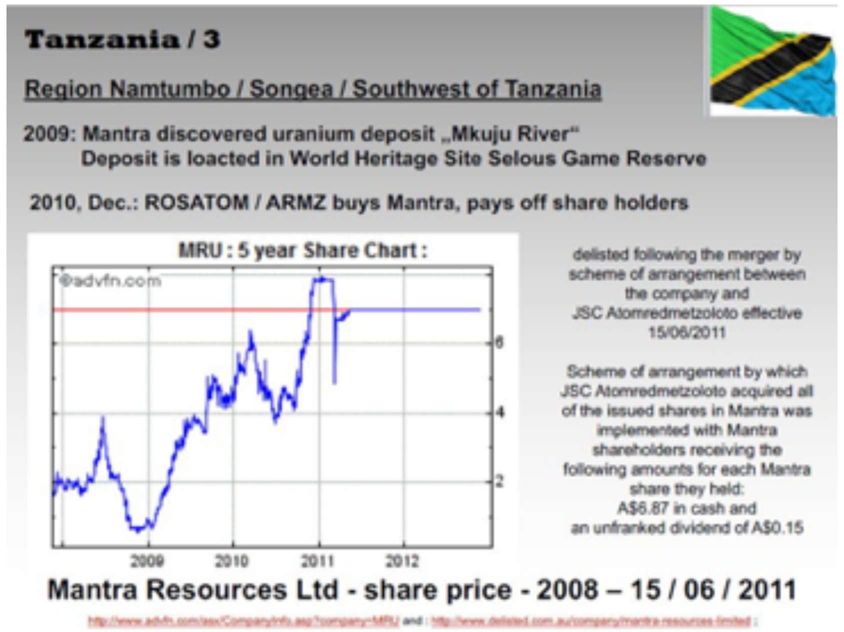
Source:

> Exploration Chance of Success Predictions – Statistical Concepts and Realities, by Balakrishnan Kunjan www.publish.csiro.au/EX/pdf/ASEG2016ab150

THREE EXAMPLES

(1) Identify a deposit and sell it …

MANTRA, a junior company from Australia, explored for uranium in Tanzania's World Heritage Site and National Park Selous Game Reserve. The company identified the Mkuju River uranium deposit and was able altogether to sell the company to ARMZ, the mining division of ROSATOM, the Russian state nuclear company for 1,16 billion Australian $ (1,15 Billion US$) in 2010.



Sources:

- Rosatom Buys Australia's Mantra
  Dec. 15, 2010, The Moscow Times
  www.themoscowtimes.com/2010/12/15/rosatom-buys-australias-mantra-a3770
- Rosatom To Pay AUD 1.2 Billion For Australia's Mantra Resources
  by David Dalton, 16 December 2010
  https://www.nucnet.org/news/rosatom-to-pay-aud-1-2-billion-for-australia-s-mantra-resources
- Share value chart, original source:
  www.advfn.com/asx/CompanyInfo.asp?company=MRU
  No more available on Internet since MANTRA has been delisted in 2011
  www.delisted.com.au/company/mantra-resources-limited

Shareholders of MANTRA who had bought shares in 2009 for 1 Australian $ or less, received over 7 Australian $ (including dividends) – a 700 % profit within four years.

However, there are only very few cases where a junior exploration company became lucky, identified a valuable deposit and was able to sell the deposit.

Another example is mining company UraMin which identified the Trekkopje uranium deposit in Namibia, and sold it to AREVA (now ORANO) for 2,5 billion US$ in June 2007. The deposit, however, was not worth the price AREVA/ORANO had paid for it, a 1.97 billion US$ writedown (depreciation) followed in 2011 and the mine was mothballed the same year.

The acquisition and over-payment of AREVA for UraMin unleashed a major scandal in France, involving French courts, the financial police, the dismissal of AREVA's then CEO Anne Lauvergeon. A part of the money was probably used to secure the support of persons around South Africa's then president Mbeki , with the aim of winning a contract with the South African Government to construct two nuclear power plants in S.A. (South Africa did not buy any nuclear power plants from AREVA, though).

The 1.97 Billion US$ writedown contributed largely to the near bankruptcy of AREVA and its 'restructuring' in 2016 – 2018; a 4.5 Billion € financial injection by the French Government was needed to make the restructuring possible and keep the companies afloat.

Sources:

- UraMin assets a nearly $2-billion drag on Areva
  by Peter Koven, Dec. 12, 2011, Financial Post
  https://business.financialpost.com/commodities/mining/uramin-assets-a-nearly-2-billion-drag-on-areva
- Areva & Uramin – La bombe à retardement du nucléaire français
  arte tv channel documentation (in French)
  www.arte.tv/sites/story/reportage/areva-uramin-bombe-a-retardement-du-nucleaire-francais
- Risks of International Natural Resource Investment projects – The UraMin case,
  by Sophie Reynaud, University of San Diego, April 19, 2017
  www.researchgate.net/publication/321455514_Risks_of_International_Natural_Resource_Investment_projects_-_The_UraMin_Casebe-a-retardement-du-nucleaire-francais

(2) Identify a deposit … and get nowhere with it …

URANEX, another junior company from Australia, explored for uranium in Bahi and Manyoni region, close to Dodoma, Tanzania's capital. The company also advertised for another area in Tanzania in its 2012 roadshow under the slogan "Developing an emerging energy district in Africa".

After locating a shallow deposit in the Bahi-Manyoni region, encountering strong local resistance and a decreasing price of uranium, the company changed its focus from uranium to graphite, and its name to Magnis Resources Ltd.

Source:

- **Uranex dumps uranium for graphite,** by Greg Roberts, May 13, 2014
  http://www.smh.com.au//breaking-news-business/uranex-dumps-uranium-for-graphite-20140513-386lo.html

Graphit mining, however, has so far not happened either. In 2019, Magnis Resources Ltd. changed its name and focus again, this time to Magnis Battery Technologies. The company had accumulated a 102 million Australian $ loss by June 2018.

"The 2011 Fukushima nuclear disaster killed the dreams of many an Australian uranium explorer. One of those, Uranex, has survived by changing commodities."

So far, neither the company nor any other company mined the deposits identified in the first place.

Source:

- Magnis Annual Report 2018
  https://drive.google.com/file/d/1tMGAhAjGpw6h4dMnC-qtrBm26QhlQGyj5/view

(3) Identify a deposit, decide to exploit it – and suffer a major loss …

In Niger, French state owned company AREVA (now ORANO), had discovered a major deposit at Imouraren, southwest of its existing mines in Arlit.

The mine was announced to become of the largest open-pit mines in the world in 2009. However, by 2011, the development had slowed down considerably, in 2013, AREVA had to pay 35 million € to the Niger Government for delaying the project (since Niger had fallen short of getting any taxes or profits from the new project).

By 2014, it became obvious that the deposit was difficult to mine, if mineable at all. "Proven reserves were transferred to probable reserves." According to a news outlet, equipment worth 800 million € was sitting in various locations. Having become useless, it was probably sold off at a loss.

From 2015 – 2017, AREVA wrote down the value of the deposit by 688 million € in total. Uranium has never been commercially mined at Imouraren so far.

Source:

- **2013 Reference Document, Areva,** March 31, 2014, page 72, right column. last but one paragraph
  www.sa.areva.com/finance/liblocal/docs/doc-ref-2014/DDR_EN_310315.pdf

7.5. Conclusion: Billions invested in exploration … with few results

After the dust had settled after the uranium rush starting in 2007/2008, it shows that only few companies were able to identify deposits worthwhile mining.

Most of the newcomers to the business disappeared without success. Supposedly, the success rate of exploration is far lower than the rate in the oil and gas business (estimated at 30 – 40 %, see above).

The investors/shareholders of the unsuccessful companies did not profit at all. Three companies (in Africa) actually had started mining – Paladin in Malawi (Kayelekera) and Namibia (Langer Heinrich), a consortium under Chinese leadership in Niger (Azelik), and China Guangdong Nuclear Power Holding Corporation (CGNPC) (Husab mine in Namibia).

Paladin's mines are now mothballed, the company itself barely evaded bankruptcy in 2017/2018. In Sept 2019, Paladin announced the sale of its Malawi mine, which will most probably be finalized in January 2020. Azelik in Niger has been mothballed as well since February 2015.

Only Chinese CGNPC's Husab mine has started and is operational (as of August 2019); however, CNNC CGNPC had not identified the deposit, but had bought the well-explored deposit from Rössing Uranium Ltd. (owned by Rio Tinto until 2019, then sold to China National Uranium Corporation Limited (CNUC)).

Local people in the exploration areas are left with promises of jobs and economic development – which never happened so far. Environmental problems, however, may still linger on.

8

CHAPTER EIGHT

Narration

In the past, most uranium production came from open-pit mining and underground mining; since the turn of the century, however, an unconventional mining method, in-situ leaching (ISL), also called in-situ recovery (ISR) has steadily increased.

By 2017, the share of ISL had risen to 50 %: half of the world's uranium production is obtained by ISL.

26 percent came from underground mines and less than 20 percent from open pit mining, 4 percent is a by-product of other processes.

8. Mining Methods

8.1. Introductory Note – Uranium Mining and the Environment

For all mining operations, no matter which method is used, the radiologic situation of the location will be irreversibly changed: uranium and other elements that are normally enclosed in rock, in most cases more or less deep underground, and are not very mobile, are set free. The original situation can never be restored.

Removing ore from underground deposits, grinding of uraniferous ore to sandlike consistence gives uranium and its decay products much easier access to the environment than before. Uranium and its decay products can now find more easily their way along different pathways to humans, animals and plants (→ Ch. 10.).

In addition, the chemical state of uranium compounds changes when in contact with air (oxygen). The compounds may oxidate and more uranium will be made more easily available for ingestion by both animals and humans.

"Rehabilitation" of mine sites does not mean that the original radiological state can be restored; rehabilitation or reclamation are merely about damage control.

8.2. Uranium Deposits in the World

Uranium deposits can be found all over the world. Detailed information is available on the following websites:

- **WISE Uranium Project**: (→ MAPS+STATS) Use "Select data set": Uranium resources, classified into certain categories and by country, uranium production, per year and country, tailings inventory by country and other data can be displayed.

> WISE Uranium Project > MAPS+STATS
www.wise-uranium.org/umaps.html

- The **World Nuclear Association (WNA)** also provides data on uranium resources and uranium production by countries.

> Uranium Production
www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx

> Uranium Resources
www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources.aspx

- The **International Atomic Energy Agency (IAEA)** launched in 2018 an interactive World Uranium Map.

> IAEA World Uranium Map
www.iaea.org/newscenter/news/iaea-unveils-unique-world-uranium-map

- The **Nuclear Energy Agency (NEA)** and the International Atomic Energy Agency regularly publish a very detailed report on uranium resources, mining and the future: "Uranium 2018 – Resources, Production and Demand" (new edition every two years).

> Uranium – Resources, Production and Demand 2018
www.oecd-nea.org/ndd/pubs/2018/7413-uranium-2018.pdf

- The IAEA holds specialized conferences: **URAM – Uranium Raw Materials Symposium**, in 2018: International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM 2018), anual conferences.

> URAM – Uranium Raw Materials Symposium
https://www.iaea.org/events/uram-2018

The nuclear agencies (IAEA, NEA, WNA) tend to exaggerate in their projections the future developments of nuclear energy and uranium demand.

The development of nuclear power and its projections into the future should be cross-checked with the annual **World Nuclear Industry Status Report (WNISR)**.

Another good independent source of information is the interactive **Global Nuclear Power Data Base** on the website of the **Bulletin of the Atomic Scientists**.

> World Nuclear Industry Status Report (WNISR)
www.worldnuclearreport.org

> Global Nuclear Power Data Base
https://thebulletin.org/global-nuclear-power-database

Narration

If a uranium deposit is not too deep underground, the mining company may choose open-pit-mining. First of all, the 'overburden'- the soil and rock covering the deposit – are removed and put aside.

The overburden normally contains only very small concentrations of uranium. Once the uranium deposit is reached, the rock is blasted, transported by huge trucks from the open pit, ground to sand, and treated in an uranium extraction plant with sulphuric acid and other chemicals. The final product, yellowcake, is in many cases less than 1 % of the ore mined. Up to 99 % – or more – of the rock exploited becomes waste, so called tailings – a serious problem we will look at later on.

Often, open pit mines reach a depth of 300 and more meters, and considerable diameters. Rössing uranium mine's open pit in Namibia is approximately 3.5 kilometers long, over 1.5 kilometers wide, and 330 meters deep.

The mines change the landscape, the change will in most cases be final; open-pit mines are often not refilled since the effort would be too great.

8.3. Open-pit-mining (open cast mining)

DEEP OPEN-PIT MINING

Open-pit or open-cut mining involves blasting and removing huge masses of rock (overburden) to get to the deposit. Huge piles of rock are created in the vicinity of the mine. The overburden mostly contains very little uranium and is usually not of serious radiological concern. Dust, however, is a problem.

The change of landscape is often irreversible because open-pit mines are rarely refilled due to the high costs. Moreover, mining companies often have gone bankrupt or been dissolved with the end of mining activities, and no – or not enough – funds have been set aside for rehabilitation.

The mining and tailings area cannot and should not be used again for any other activities. In France, for example, rehabilitation of uranium mine sites and tailings was done poorly in many cases, and this sparked the documentation "Uranium - Le Scandale de la France contaminee".

Once the ore body is reached, the uranium containing rock is blasted and transported out of the pit. Both activities create lots of dust which contains radioactive elements, and Radon-222 gas is set free.

SPECIAL RISKS OF OPEN-PIT MINING

(Radioactive) dust is a serious problem: Dust can cause silicosis, a typical miner's disease. Both radioactive dust, inhaled, as well as Radon-222 gas can also cause diseases such as cancer of the respiratory tract, lung cancer as well as other health problems (→ Ch. 11. Health Impacts).

Dust may also contaminate communities in the vicinity of the mine/tailings.

Mining may interfere with surface water (creeks, rivers) or with aquifers which may become contaminated with radioactive elements. In many cases, other toxic (poisonous) elements are released from the underground such as arsenic, mercury, selenium etc., depending on the geological situation.

An advantage of open-pit mining is better ventilation than in underground mines.

Open-pit mining is in most cases less expensive than underground mining.

EXAMPLES OF OPEN-PIT MINES

Rössing mine, Namibia: pit 3,5 km long, approx. 1,2 km wide, 390m deep (biggest open-pit uranium mine)

Arlit Mine, Niger: several pits, approx. 50 – 70 m deep

Ranger Mine, Australia (second biggest open-pit uranium)

Jackpile-Paguate Uranium mine, US, was one of the largest uranium open-pit mines in the US (1950s).

The deepest pit (Jackpile Mine) was 625 feet (approx. 120m), two other pits were 325 feet (100m) (South Paguate) and 200 feet (61 m) (North Paguate), it covers more than 4 .5 square miles (approx. 1165 hectares.)

"So, will the land ever be able to be useful? At this time, no one is allowed on the land. Not even grazing is permitted. In fact, farming and ranching will probably never be allowed because of the threat of radioactive contamination. People will never be allowed to live on the land, either.

Further readings:

> **Uranium — How Is It Mined?** https://geoinfo.nmt.edu/resources/uranium/mining.html

> **Uranium Mining,** Technical document by the IAEA https://teachnuclear.ca/all-things-nuclear/nuclear-energy/uranium-mining

> **Methods of exploitation of different types of uranium deposits,** World Nuclear Association www-pub.iaea.org/MTCD/publications/PDF/te_1174_prn.pdf

> **Uranium Mining Overview,** updated August 2019, TIAEA-TECDOC-1174, 2000 www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/uranium-mining-overview.aspx

Film:

> **"Uranium: Le Scandale de la France contaminee",** Documentary film by France3, Pieces a Conviction www.youtube.com/watch?v=-j2thGnU_Ik

> www.rossing.com/bullet/bulletpress64.htm

> https://www.google.de/search?q=uranium+mines+niger+orano+photo&tbm=isch&source=univ&sa=X&ved=2ahUKEwj455mksZzmAhVRsaQKHSfTB6IQ7A-l6BAgJECQ&biw=1701&bih=944#imgrc=gHmu60-89fewdQM:

> www.energyres.com.au/operations

Source:

> **Uranium mining and it's impact on Laguna Pueblo,** Philip Sittnick, July, 1998, page 15 & 20 https://miningwatch.ca/sites/default/files/umine.pdf

Narration

If uranium deposits are located very close to the Earth's surface, as for example, those found in Mauritania, from 1 to 5 meters depth – it makes it easy to access the ore using caterpillars and excavators; normally, there is no blasting needed.

However, large areas of land may be destroyed since the shallow deposits themselves may stretch out over large areas.

SHALLOW OPEN-PIT MINING

In some rarer cases, uranium deposits are located very close to the Earth's surface; they can be exploited by excavators and caterpillars. No blasting is needed. Since there is no or very little overburden to be removed, exploiting shallow deposits is less expensive. Dust remains a problem, deviation of surface waters may become necessary. Currently, there is no shallow uranium deposit exploited and there is little experience with this kind of mining.

Examples

Uranium deposits in Bahi and Manyoni area, Tanzania (near the capital of Tanzania, Dodoma).

Tiris uranium deposit (formerly named Reguibat), Mauretania, close to the border with Western Sahara/Morocco.

Both deposits are currently not exploited (Nov. 2019).

8.4. Underground Mining

In underground mines, Radon-222 gas (and its decay products) are a serious problem. If the tunnels and galleries are not well ventilated, miners will be exposed to high doses of Radon-222 gas which can cause lung cancer and diseases/cancer of the respiratory tract.

In Ch. 1., the "Schneeberger Lungenkrankheit" was mentioned, a disease caused by Radon-222 gas that leads to premature death of miners.

In the 1950's, uranium mines in the US, in the Four Corners area, were mostly not or not sufficiently ventilated, leading to numerous cases of diseases and deaths.

Underground mines often interfere with aquifers. Water pumped from the mine shafts and tunnels contains radioactive and toxic elements; it is necessary to treat the mine water before releasing it into the environment.

In certain geological situation, the mining activities may also lead to contamination of aquifers which are used for human consumption and / or irrigation etc.

Canyon Mine in the vicinity of the Grand Canyon, Colorado, USA, is an example: Uranium is found in a breccia-pipe-type deposit. The company, Energy Fuels, wants to mine it via shaft and tunnels. The flow of the underground water in the area is not very well known and understood. The aquifer is the main supply of water for the indigenous Havasupai people living in Havasu Canyon, a side canyon to the Grand Canyon. Mining uranium in the area might endanger their only source of water.

Sources:

- It's Time to Close a Contaminated Uranium Mine Near the Grand Canyon
  www.grandcanyontrust.org/blog/its-time-close-contaminated-uranium-mine-near-grand-canyon
- Study: Mining near Grand Canyon could threaten water
  https://fourcornersfreepress.com/study-mining-near-grand-canyon-could-threaten-water

8.5. Heap leaching

Heap leaching is not mentioned in the film since it has only been used recently in Africa (Trekkopje mine, Namibia). The method may be used in other places, too. Here is a short explanation.

Heap leaching "... may now be done if the uranium contents are too low for the ore to be economically processed in a uranium mill. The crushed ore is placed on a leaching pad with a liner. The leaching agent (alkaline, or sulfuric acid) is introduced on top of the pile and percolates down until it reaches the liner below the pile, where it is caught and pumped to a processing plant. After completion of the leaching process (which takes months to years), the leached ore is either left in place, or removed to a disposal site, and new ore is placed on the leach pad."

DOUG BRUGGE (INTERVIEW)

In-situ Leach mining is a new approach, it involves pumping chemicals down into the ore and the dissolve the uranium and then extracting it; that does eliminate underground mining, there are no miners going into a mine shaft where they are exposed to high levels of radon.

Narration

"in situ" refers to the fact that uranium ore is not removed from underground, but stays in its location.

In-situ recovery requires one pre-condition: The ore-body must be contained by a naturally impregnable (impermeable) layer, otherwise the leaching fluid used with ISL may seep into aquifers or contaminate surface waters.

To extract uranium, wells are drilled into the deposit, a leaching fluid, mostly, sulphuric acid with other components added, is injected into the ore body; the leaching fluid dissolves uranium from the rock.

The uranium bearing liquid – the miners call it "pregnant solution" – is pumped out through other boreholes, treated in a plant, the uranium extracted, dried and packed. Part of the leaching fluid cannot be re-used and is left to evaporate.

DOUG BRUGGE (INTERVIEW)

I think with in-situ leach mining, the concern turns to ground water contamination and whether the groundwater can be restored to its original state and whether that contamination spreads beyond the immediate mining area and maybe contaminates a water that is being used for drinking or for other human purposes. That's a concern, there is, you know, a body of evidence that drinking water contaminated with uranium as well as arsenic and radium present some health problems. So I think that would be less to the workers in that case and more fall into the area of concern for surrounding and neighboring residents and communities. In-situ leach is a fairly new mining process but the experience so far is that it has been hard to clean up and restore these water bodies that were leached of uranium – so I think that is a primary concern.

"During leaching, the piles present a hazard because of release of dust, radon gas and leaching liquid. After completion of the leaching process, a longterm problem may result from naturally induced leaching, if the ore contains the mineral pyrite (FeS2), as with the uranium deposits in Thuringia, Germany, for example). Then, acces of water and air may cause continuous bacterially induced production of sulfuric acid inside the pile, which results in the leaching of uranium and other contaminants for centuries and possibly permanent contamination of ground water."

Source:

> WISE Uranium Project
www.wise-uranium.org/uhl.html

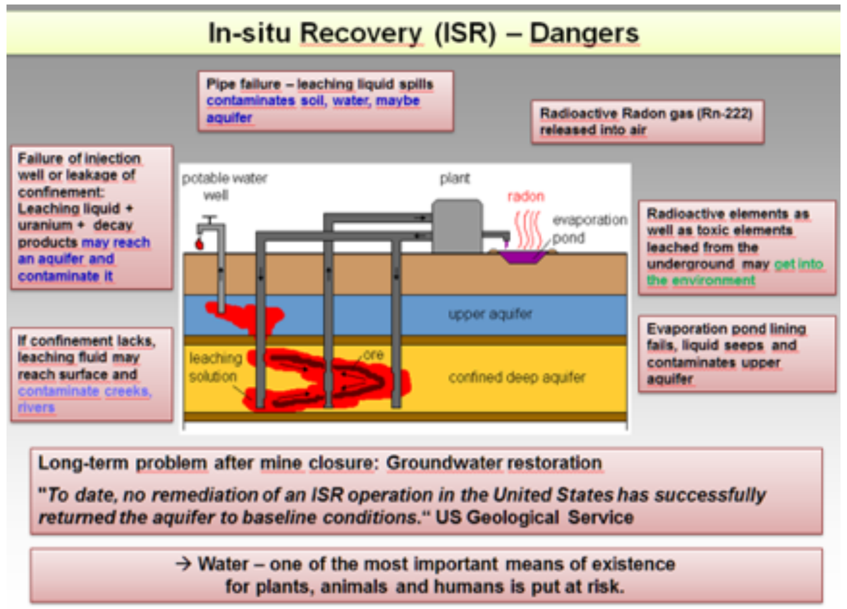
NOTE

Some companies claim heap leaching would be an environmentally friendly method. The contrary is the case: Heap leaching consumes large quantities of water.
Failure of the lining will lead to contamination of the surroundings. As with all conventional mining methods, huge quantities of taillings are generated.

8.6. In-situ leaching (ISL) or in-situ recovery (ISR)

The text of the film explains the method of ISL quite well (see left side). In recent years, the share of ISL in uranium exploitation has steadily increased and is now at approx 50% of the owrld uranium production.

The graph shows the risks associated with ISL (or ISR).



Although companies advertise ISL as 'environmentally friendly', it is not.

The main difference to open-pit or underground mining is that there are no huge piles of rock and no tailings visible. As a result all the problems created by separating uranium from the rock remain underground – and out of view.

Narration

In-situ recovery involves a variety of risks: Failure of a pipe may lead to a spill of leaching liquid and contamination of soil, water or an aquifer.

The failure of an injection borehole or leakage of the natural confinement can lead to leaching liquid, uranium and decay products contaminating aquifers or rivers.

Radioactive Radon gas is permanently released into the atmosphere.

Radioactive and toxic elements leached may get into the environment via evaporation or windborne dust. If the evaporation pond lining fails, liquid seeps out and may contaminate an upper aquifer.

Problems may continue after closure of the mine: the United States Geological Service stated: "To date, no remediation of an ISR operation in the United States has successfully returned the aquifer to baseline conditions."

Uranium ore in many cases contains not only the decay products of uranium, but also other elements such as arsenic, mercury, selenium etc. Through ISL, these elements are also dissolved from the rock and end up in the aquifer, polluting the water.

In many cases, the aquifers cannot be restored to pre-mining conditions. Repeatedly, companies then apply for 'relaxation' of standards since they were not able to meet the standards set by environmental protection agencies even after years.

The U.S. Geological Service concluded: "To date, no remediation of an ISR operation in the United States has successfully returned the aquifer to baseline conditions."

Further readings:

- WISE Uranium Project, Impacts of Uranium in-situ Leaching
  www.wise-uranium.org/uisl.html
- Animation on ISL failures
  www.wise-uranium.org/img/islf.gif
- In-situ recovery uranium mining in the United States: Overview of production and remediation issues, International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues,
  2009, by J.K. Otton, S. Hall page 129
  https://inis.iaea.org/collection/NCLCollectionStore/_Public/41/003/41003200.pdf?r=1&r=1

In a number of cases, the uranium concentration in the aquifers exceeded the drinking water limit of 0,03 milligram per litre. In short, ISL endangers aquifers and the drinking water supply.

In regard to acid ISL uranium mining, in a 2019 Inquiry by the Australian Government, it was stated:

"The use of acid ISL in the USA was considered problematic and has never been approved or used on a commercial scale ... The problems included higher salinity and some radionuclides in post-restoration monitoring of groundwater compared with pre-mining conditions."

(Critical review of acid in situ leach uranium minig: 1. USA and Australia, by Gavin Mudd)

"The experience of acid ISL uranium mining in areas controlled by former Soviet Union provides a stark contrast to experiences in America and Australia. In most applications of the technique, there have been extreme occurences of groundwater contamination. At some sites, this contamination has migrated considerable distances to impact on potable drinking water supplies."

(Critical review of acid in situ leach uranium minig: 2. Soviet Block and Asia, by Gavin Mudd)

Source:

- Inquiry into the prerequisites for nuclear energy in Australia Submission 225,
  by Assoc. Prof. Gavin M. Mudd
  www.aph.gov.au/DocumentStore.ashx?id=f56bb200-edcc-463c-9bd7-06357450c133&subId=670300

NOTE that some ISL mining operations use alkaline leaching fluids.

Narration

For an underground mine, a headframe is constructed, shafts are sunk and tunnels dug. Some use inclining ramps which allow trucks and mining equipment to drive into the mine.

One of the largest such mines is Akouta mine in Niger, operated by COMINAK, partially owned by AREVA, now re-named ORANO, with 250 km of underground tunnels.

8.7. Uranium as a by-product of Exploitation of other Minerals

This paragraph is only a brief excursion into the issue of uranium mined as a by-product (not a complete list of all possibilities). Uranium may be of concern even if it is not mined intentionally since it may emerge with other elements mined.

URANIUM – BY-PRODUCT OF SILVER MINING

Uranium may be associated with silver and mined together with it. Some of the oldest known occurrences of uranium – at the time not yet identified as a chemical element – go back to silver mines in Joachimsthal/Jachymov in the Erzgebirge (Ore mountains/today Czech Republic). Uranium and its decay products, lead to detrimental health impacts for the miners. (→ Ch. 1.).

Today, examples are the Olympic Dam Mine, Australia, or the Falea deposit in Mali, both containing silver (currently no mining activities in Falea/Mali).

URANIUM – BY-PRODUCT OF GOLD MINING

Uranium is sometimes associated with gold. Thus, in South Africa considerable quantities of uranium were mined, at first unintentionally, in the gold mines. At the time of the beginning of gold mining in S.A., uranium was of no value and cast aside as mining waste (tailings). Some tailings from gold mines in S.A. contain more uranium than some low-grade uranium deposits mined today. The tailings are a considerable risk to the environment and to health.

URANIUM – BY-PRODUCT OF VANADIUM MINING

Uranium can also be exploited together with vanadium (a mineral used to harden steel). The US uranium mines in Uravan area originally mined vanadium and uranium as a by-product.

URANIUM – BY-PRODUCT OF PHOSPHATE

Deposits of phosphate, normally used as fertilizer, can contain traces of uranium. If so, measures for the protection of workers should be taken.

For example, Minjingu Phosphate Mine in Tanzania contains a considerable concentration of uranium (and its decay products), and thus emits significant radiation: "The average [radiation] is about 28 times that of the global average background radiation from terrestrial sources, and about 12 times the allowed average dose limit for public exposure over five consecutive years."

In many cases, uranium in phosphate is not separated out. It is deployed with the fertilizer on fields. Thus, uranium in phosphate may cause problems not only in the country where phosphate is mined, but also in the countries where phosphate fertilizers are used in agriculture: agricultural soil are contaminated, and aquifers may be affected.

In addition, uranium from phosphate deposits may be used for nuclear weapons: "The paper presents a circumstantial case study on the recovery, use and fate of U derived from phosphate mining in the Negev desert and supports evidence that Israel's nuclear facility at Dimona might be fed by U derived from refining rock phosphates at the Rotem Amfert mine for food and fertilizers."

URANIUM – BY-PRODUCT OF COPPER

In Zambia, Lumwana mine in Solwezi District, in the North-east, exploits copper – and uranium as a by-product. However, the uranium is not sold on the world market since the company majority-owning the mine, Equinox, considers the price too low, and is stockpiling the uranium ore instead. Church groups have demanded uranium mines not go ahead.

In 2010, a booklet "Prosperity unto death: Is Zambia ready for uranium mining? - Review of the uranium mining policy in Zambia" was published highlighting the risks of uranium mining.

In Australia, Olympic Dam mine also exploits copper and uranium (it contains silver and gold as well).

Further readings:

> **An Assessment of Radiological Hazards from Gold Mine Tailings in the Province of Gauteng in South Africa,** by Caspah Kamunda, Manny Mathuthu, and Morgan Madhuku, 2016
www.ncbi.nlm.nih.gov/pmc/articles/PMC4730529

> **Floristic composition of gold and uranium tailings dams, and adjacent polluted areas, on South Africa's deep-level mines,** by I.M. WEIERS-BYE, E.T.F. WITKOWSKIand M. REICHARDT, 2006
https://pdfs.semanticscholar.org/f018/fe03296f263fc-0fa56551a4f100dc077f0c0.pdf

Source:

> **Natural radioactivity and radiation exposure at the Minjingu phosphate mine in Tanzania,** US National Library of Medicine National Institutes of Health, 2000, Banzi FP[1], Kifanga LD, Bundala FM.
www.ncbi.nlm.nih.gov/pubmed/10750954

Further readings:

> **Where has all the uranium gone? Or what feeds Dimona ...",** Conference Paper, 19. August 2014, Ewald Schnug
https://link.springer.com/chapter/10.1007/978-3-319-11059-2_84

> **Uranium, the Hidden Treasure in Phosphates,** Ewald Schnug, Nils Haneklaus
https://reader.elsevier.com/reader/sd/pii/S1877705814010947?token=03BDB85631F7F-C0137F2142485C7EA978537CCBCACB963AC-7C704E2B9938A5348012E7E8CA9373A5DE4354A-6DA9C2451

> **Fertilizer-Derived Uranium and its Threat to Human Health,** Ewald Schnug, Bernd G.Lottermoser
https://pubs.acs.org/doi/pdfplus/10.1021/es4002357

Source:

> **WISE Uranium Project > Zambia**
www.wise-uranium.org/upzm.html

Further readings:

> **Prosperity unto death: Is Zambia ready for uranium mining?,** 2010
www.scribd.com/document/38650866/Prosperity-Un-to-Death-Is-Zambia-Ready-for-Uranium-Mining

CHAPTER NINE

Narration

Over history, massive human rights violations, land confiscations or restrictions of basic democratic rights were common in many countries, as in the 1940s in the German Democratic Republic where uranium was mined for the nuclear bomb program of the Soviet Union.

Even today, uranium mining is shrouded in secrecy.

MICHAEL BELEITES (INTERVIEW)

In the uranium district, fear was prevailing. No one dared to talk about those things, although a majority of the population in Gera [town in East Germany] was employed in the uranium mines. People did not talk about it, once the word uranium fell – or Wismut, the camouflage name of the uranium company – were mentioned, conversations died. And everything connected to the radioactive contamination of the environment o primarily for the miners themselves, was absolutely secret, it was not allowed to talk about.

Animation

A *So, we have a lot of negative impacts from Uranium mining …*

B *Yes, and that's not the end of it … Uranium extraction is more a chemical process than a simple mill. Lots of power and lots of water are needed to extract uranium from the ore.*

In the more arid areas of the world, for example in the Sahara desert and adjacent areas, water is scarce and a much appreciated commodity …

A *There are Uranium mines in Niger – right in the Sahara desert – where do they get the water from?*

B *Well, the companies use different aquifers – some of them are very deep underground and have been there since thousands of years – once the water sources are depleted, they will not be replenished … The Niger mines have already used over 70 % of the water available in those aquifers.*

Narration

Water consumption for uranium production is a serious concern, although often disregarded in discussing environmental impacts of uranium mining and extraction.

The Olympic Dam Uranium Mine in South Australia, for example, consumes 33.000 tons of water a day, making it one of the largest water users in the country

DAVE SWEENEY (INTERVIEW)

And one the concerns that we had in Australia which is also a very dry country, is that uranium [industry] uses and abuses, it consumes and contaminates large volumes of water.

9. 'Side Effects' of Uranium Mining

9.1. Introductory Note

Uranium mines – like other mines – use major pieces of land. The issue of land, land use, land rights and decisions on land use is discussed in → Ch. 6.1.

Besides the use of land, uranium mines use lots of water, and they need energy (electricity) for their operation. Sometimes, less attention is paid to these issues as concerns tend to concentrate on the radiological impacts of uranium mining. However, the impacts from water consumption are severe, especially in dry regions. Water is about to become a scarce resource, and using hundreds of thousands of cubic meter for uranium extraction is no longer acceptable.

Energy consumption is of special interest in the times of climate change: How is this energy generated? What is its carbon footprint? Especially in a situation where the nuclear industry advertises itself as "low carbon", it is essential to take a look not only at nuclear power plants, but also at the production of the nuclear power plant's fuel – uranium.

In the film, both issues are rather briefly touched upon; here, you will find some more in-depth information as well as a couple of examples.

9.2. Water Consumption of Uranium Mining

The extraction of uranium from the ore requires big quantities of water. The water consumption depends to a certain degree on the concentration of uranium in the ore ("grade"), and on the mining or extraction method used. ISL mines and heap leaching need much more water than other mining and extraction methods. The film refers to Olympic Dam mine which consumes 33 – 35.000.000 liters water per day.

Just to give an idea how much 33,000,000 liter of water are: An average European uses 110 – 150 liters per day, Australians use approx. 250 liters per day, Canadians an average 329 liters per day. The water consumption of Olympic Dam mine equals that of 220,000 to 300,000 average Europeans, 132,000 Australians or 100,300 Canadians.

An African average household uses 50 litres per day (or less) – thus, the water consumption of one mine equals the consumption of 660,000 persons in Africa.

An article by Gavin Mudd and Mark Diesendorf gives an overview over water consumption of different uranium mines, mostly in Australia, in relation to their uranium production. There is a wide range of water consumption, depending on the 'ore grade', the concentration of uranium in the ore and the mining and extraction methods.

Table 1 – Summary of Normalised Energy and Water Consumption and Carbon Dioxide Emissions for Uranium Mines (Average ± Standard Deviation, number of years in brackets)

Uranium Project	Typical Ore Grade $\%U_3O_8$	Annual Prod. $t\ U_3O_8$	Consumption		Emissions
			Water	Energy C	arbon Dioxide
			kL/t U_3O_8 G	J/t U_3O_8 t	CO_2/t U_3O_8
Ranger 0	.28-0.35 5	,000 4	6.2 ± 8.2 (7)	181 ± 18 (9) 1	3.0 ± 1.8 (9)
Olympic (100%)	0.064-0.114	4,300	2,899 ± 503 (14)	1,389 ± 336 (14)	253 ± 67 (14)
Olympic (20%)			580 ± 101 (14) 2	78 ± 67 (14) 5	0.6 ± 13.5 (14)
Rössing ~	0.034-0.041	~3,700 8	63 ± 107 (11)	354 ± 35 (11)	45.3 ± 4.1 (11)
Cluff Lake 2	.71	(closed) 3	65 (1) 1	94 (1) 1	2.1 (1)
McLean Lake	1.45-2.29	~2,750 2	57 ± 62 (4)	202 ± 25 (4) † 8	.4 ± 1.2 (4)
Beverley	~0.18	~1,000 7	,731 ± 802 (5) 1	72 ± 29 (3) ‡ 8	.9 ± 1.5 (3)
Niger # ~	0.2-0.5	~3,100 n	o data ~	204	no data
Cameco § ~	0.9-4.0	~8,500 n	o data ~	178	no data

† Data given by (WNA, 2006) is 313 GJ/t U_3O_8.
‡ Different data for 2004-05 is given by (WNA, 2006) for Beverley as 187 and 221 GJ/t U_3O_8, respectively, compared to data reported by (HR, var.) and used in graphs and table above.
# Data for 2000, for Areva's (formerly Cogema) two mine/mill complexes (Somair and Cominak) (WNA, 2006).
§ Data average over 1992 to 2001 for 'Cameco mines' (WNA, 2006).

Source:

> Sustainability Aspects of Uranium Mining: Towards Accurate Accounting?
page 6 ff, in: Sustainability of uranium mining and milling: toward quantifying resources and eco-efficiency, 2008, Gavin M Mudd, Mark Diesendorf
www.thesustainabilitysociety.org.nz/conference/2007/papers/MUDD-Uranium-Mining.pdf

Sources:

> **La malédiction de l'uranium – Le Nord-Niger victime de ses richesses,**
Dossier d'information, collectif
https://www.sortirdunucleaire.org/IMG/pdf/tchinagh-en-2008-la_male_diction_de_l_uranium-le_nord_niger_victimes_de_ses_richesses.pdf

> **The uranium curse – The Northern Niger's suffering from its wealth (English translation of main part of the dossier),** by David Dalton, 16 December 2010. Dossier available in english
https://uranium-network.org/wp-content/uploads/2009/05/2009-Tchinaghen-TheUraniumCurse.pdf

NIGER

"The Agadez sandstones water-bearing stratum, the only water resource in this area, is fossile. The Carbon-14 of its waters shows that the last time it was recharged was during the last rainy Neolithic period, about 3000 years ago […].
Since, the water-level has been becoming inexorably empty, and especially more quickly as the resource, that's calculated to be about 1000 million m³, is getting more and more extracted.
Unfortunately, this area is abounding in uranium and later the mines managers settled down; their behaviour can be summed up by "take and leave".
For instance: 10.000 m³ a day have been piped at Arharous, since 1980, into the coal mines and Tchirozérine town.
Moreover, the uranium mines of COMINAK and the SOMAIR, respectively in Akokan and Arlit towns, have already used 70 % of the carboniferous water-bearing stratum Norther in the Tarat.
The mines are piping 22.000 m³ (22,000,000 litres) a day since 38 years.
Now they're lacking of water resources and they're planning to use a 30 km long pipeline and to move and pipe west, that's to say … from the Agadez sandstones water-level."

In Tchirozerine, a coal-fired power plant is operated, fed by coal mined on location, to provide energy for the mining operations near Arlit; the coal mine and the coal power plant need water.)

Sources:

> **Left in the Dust, AREVA's radioactive legacy in the desert towns of Niger,** Greenpeace, April 2010, page 21
www.greenpeace.org/archive-international/Global/international/publications/nuclear/2010/AREVA_Niger_report.pdf

"One of the harmful effects of uranium mining in Niger is its impact on water resources. Millions of litres of water are used daily in the mining operations, particularly in the leaching process to separate the uranium from the ore. The water is pumped from a groundwater table – the Tarat aquifer – which is 150 metres deep. This is a fossilaquifer, meaning the water is not easily renewed: it will take millions of years for it to fill up again Consequently, the water use in the mines and the mining towns causes a long-term depletion of the region's water resources. In 40 years of operation, a total of 270 billion litres of water have been used in Arlit and Akokan. […] there was an increase in water use in the SOMAIR mine in the past years. When asked for an explanation, AREVA said that more water is used in the new ore leaching process. Also, the water use is proportional to the increase in production: the more uranium produced, the more water used."

Sources:

> **"Synthese Hydrogeologique. La nappe du Tarat dans la region d'Arlit-Akokan",**
Cogema Niger ", May 2004, pg 58.,
reprinted in the Greenpeace booklet.

> **Communiqué de presse CRIIRAD,**
18 juin 2009, Nr. 3, 5 paragraph
www.criirad.org/actualites/dossier_09/gabon/communique.html

A hydrogeological study from 2004 establishes the significance of the water use in the mines. "In the section of the CK [COMINAK] mine, the water has been completely drained and its level has dropped to the wall of Tarat [aquifer] (decrease of 150 metres); this has sometimes led to an inability to operate the water wells dug near the mine, namely Comi_10, Comi_11 and Arli_987."

In case water supply is not sufficient, water for the inhabitants of Arlit is cut, as some report, up to a week or two, whereas the mines and processing plants are supplied with water.

In fact, AREVA also provides water for the inhabitants – but some of it has been found to be contaminated through the mining activities. There will be less water left for future generations.

In regard to the Imouraren Uranium Project, AREVA, now renamed ORANO, admits that the underground aquifer will be dried out by the end of the uranium exploitation in about 40 years.

No water will be left for the people or animals.

Further readings:

> **Left in the Dust, AREVA's radioactive legacy in the desert towns of Niger,** April 2010
www.greenpeace.de/sites/www.greenpeace.de/files/AREVA_Niger_report_0.pdf

> **Abandonnés dans la poussière l'héritage radioactif d'AREVA dans les villes du désert nigérien,** April 2010
https://cdn.greenpeace.fr/site/uploads/2017/02/abandonnes-dans-la-poussiere.pdfAREVA_Niger_report_0.pdf

Film:

> **Left in the Dust – Uranium Mining in Niger,**
April 2010
www.youtube.com/watch?v=ioRtzOWm07A

NAMIBIA

"The Rössing Uranium Mine […] currently the mining and milling process requires 2.4 million m³ of fresh water per year." This equals a water consumption of approx. 6,500,000 litres per day.

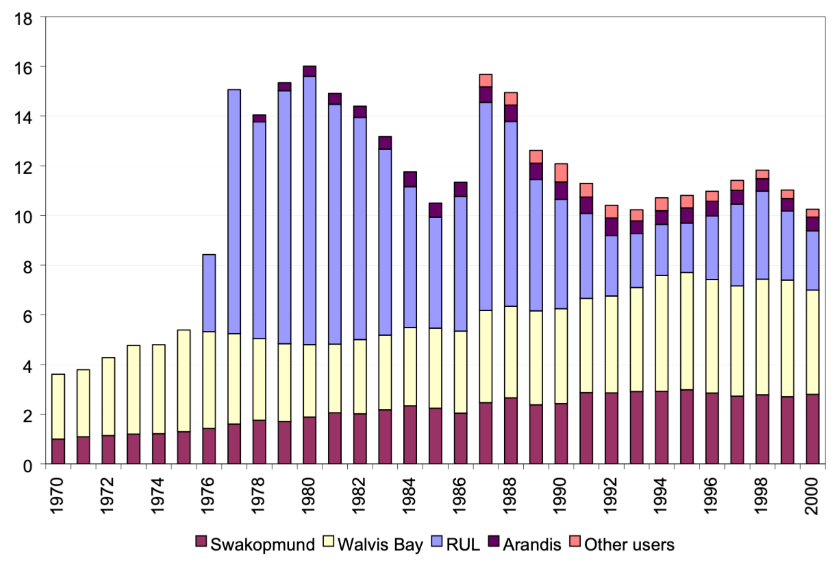


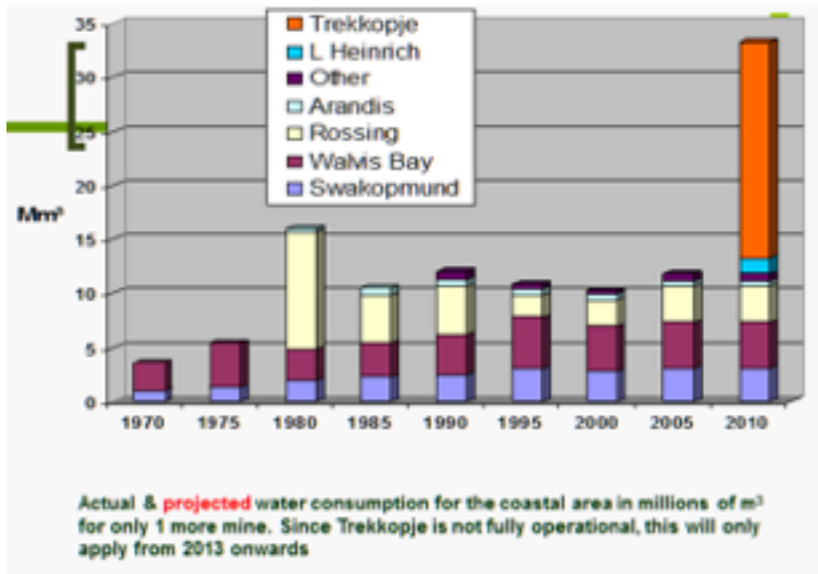
Figure 4: Water Consumption in the Central Namib Area in Mm³/year

Source:

> **Conservation of scarce water resources at Rössing Uranium Mine,**
by Rainer Schneeweiss, Sandra Müller
https://pubs.iied.org/pdfs/G02461.pdf

Water consumption of Rössing mine (blue; RUL = Rössing Uranium Ltd.), started in 1976, and exceeded by far the combined water consumption of the nearby towns of Swakopmund (red) and Walvis Bay (yellow) up to the mid-1980ies. Then, water consumption was reduced by introducing water recycling.

New uranium projects started up with the uranium rush of 2007/2008: Langer-Heinrich mine and Trekkopje (heap leaching). As the graph shows, water consumption of Trekkopje mine would exceed all existing water consumption (including new Langer Heinrich Mine).



Source:

> **"Uranium in Namibia – Blessing or Curse?"**
Presentation by Bertchen Kohrs, Earthlife Namibia, at the "Uranium, Health and Environment"-Conference, Bamako, Mali, 16th – 18th March 2012

Sources:

- **Namibia: Wasserverbrauch steigt durch Uranabbau rapide,** Allgemeine Zeitung (AZ), Namibia, 09.02.2009 www.az.com.na/wirtschaft/wasserverbrauch-steigt-rapide.80361.php
- **Namibian drought hits uranium mines** www.iol.co.za/business-report/international/namibian-drought-hits-uranium-mines-1609502

Namibian (German-language) newspaper Allgemeine Zeitung (AZ) titled: „Namibia: Wasserverbrauch steigt durch Uranabbau rapide" – "Namibia: Water consumption increases rapidly through uranium mining".

Due to the scarcity of water – the mines are located in the Namib desert, one of the most arid deserts in the world – discussions around building a seawater desalination plant commenced in 2007/2008 with then owner of Trekkopje mine, UraMin – mainly for the water consumption of the new uranium mines.

In April 2010, the desalination plant near Wlotzkasbaken, 30 km north of Swakopmund, was inaugurated by AREVA (which had by then bought UraMin's Trekkopje mine); it has a maximum capacity of 20 million m³ per year. Its primary purpose was to supply the Trekkopje and other uranium mines. However, after a very short period of production in 2012/2013, Trekkopje mine was mothballed.

Water shortage is not new to Namibia. After a water crisis in 2010, a similar situation happened in 2013.

Source:

- **Rio Tinto, Paladin Namibia Uranium Mines Face Water Shortage** www.bloomberg.com/news/articles/2013-11-18/rio-tin-to-paladin-uranium-mines-in-namibia-face-water-shortage

"Uranium mines in Namibia face water shortage

Uranium mines operated by companies including Rio Tinto Plc and Paladin Energy Ltd. in Namibia face a water shortage as a drought in the southwest African nation curbs supply to the operations and three coastal towns.

Volumes from the Omaruru Delta acquifer, [...] have declined to 4 million cubic meters this year from 9 million cubic meters a year earlier, said Nehemia Abraham, under-secretary for water and forestry in the Ministry of Agriculture. The source is in the semi-arid Erongo region [...] which suffers from severe shortages. Water from a desalination plant owned by Areva SA, the country's first such facility, isn't enough to meet needs of Paladin's Langer Heinrich uranium mine, China Guangdong Nuclear Power Co.'s Husab uranium project and Rio's Rössing complex."

The water consumption of the mines contributes strongly to the already existing problems in regard to water supply and exacerbates it.

Narration

The first step of the nuclear fuel chain – uranium mining – also uses lots of energy for grinding millions of tons of ore and for the extraction of uranium from the ore. The power is often generated by fossil fuels, by Diesel generators or coal-fired power plant as at Tchirozerine in Niger. Both emit large amounts of CO². The lower the concentration of uranium in the ore, the more fossil fuel is required to extract it.

Exploitation of deposits with only 0.01 percent uranium to produce nuclear power will generate as much CO² as fossil fuels in the first place. Nuclear power is by no means carbon free nor will it save the world from global warming.

MICHAEL BELEITES (INTERVIEW)

To me, it remains important to state that uranium mining in East Germany was not ended because uranium was all mined out, but uranium mining with its inevitable hazards to health and environment in such a densely populated area could not be enforced under democratic conditions. And once Germany imports uranium from other countries since it cannot be enforced politically in one's own country, then of course, this raises the moral question: How can we live responsibly on resources which endanger and destroy the health and environment of other human beings to an extent which is not acceptable anymore in our own country?

9.3. Energy Consumption of Uranium Mining

Uranium mines do not generate energy (as some politicians once suggested). They consume energy. The table on p. 61 shows – besides water consumption – the energy consumption and the CO_2 production of a number of mines. Often, uranium mines are located in remote areas with no access to the public electricity grid. Thus, mining operations often produce electricity on site or nearby.

In Niger, the mining companies built a coal-fired power plant at Tchirozerine, some 120km from the mines, producing electricity from coal with high sulphur concentration; people in the area now suffer from the dust and smoke.

In Namibia – as in the mines in other countries – mining trucks, excavators and caterpillars run on Diesel fuel: One of the big mining trucks at Rössing consumes 1.000 liters of Diesel per day, thus, there is a CO_2 footprint from mining.

For electricity, Namibia faces shortages and depends on imports. The energy consumption by uranium mines will not help that situation, but intensify it.

For Tanzania's Mkuju River Project, a coal-fired power plant was initially planned but later on, plans were changed in favor of a heavy-oil electricity generation plant – generating CO_2; the heavy oil also needs to be trucked in day by day – generating even more CO_2.

Further readings:

- **Sustainability Aspects of Uranium Mining: Towards Accurate Accounting?,** page 6 ff, in: Sustainability of uranium mining and milling: toward quantifying resources and eco-efficiency, 2008, Gavin M Mudd, Mark Diesendorf www.thesustainabilitysociety.org.nz/conference/2007/papers/MUDD-Uranium-Mining.pdf
- **False solution: Nuclear power is not 'low carbon',** by Keith Barnham, 5. February 2015 https://theecologist.org/2015/feb/05/false-solution-nuclear-power-not-low-carbon
- **Energy Balance of Nuclear power Generation – Life Cycle Analysis of Nuclear Power: Energy Balance and CO2 Emissions,** by Austrian Energy Agency, Wiener Umweltanwaltschaft, Klima+Energie Fonds, Österreichisches Ökologie Institut, 2011 www.energyagency.at/fileadmin/dam/pdf/publikationen/berichteBroschueren/Endbericht_LCA_Nuklearindustrie-engl.pdf
- **WISE Uranium Project,** links to studies on the CO² issue; Energy and CO² Balance www.wise-uranium.org/clit.html#ENERGYCO2
- **"Don't nuke the Climate"** https://dont-nuke-the-climate.org

CO_2 PRODUCTION FROM NUCLEAR POWER

Studies show that CO_2 production for producing nuclear fuel from uranium rises as uranium concentration in the ore decreases (since more ore has to be crushed and processed).

Enrichment of the concentration of U-235 requires even more energy (electricity) than mining itself.

In a report, the International Atomic Energy Agency (IAEA) states: "Nuclear power does not directly emit greenhouse gas emissions. Greenhouse gas emissions are, however, emitted indirectly as a result of uranium mining/milling and -enrichment as well as plant construction, -operation and -decommissioning. ... Uranium mining/milling already accounts for a considerable share of the environmental impact of nuclear power that may further increase with decreasing uranium ore grades."

"Recent analyses have examined the energy and water costs and greenhouse emissions associated with uranium production. [...] The corresponding greenhouse emissions of carbon dioxide ranges from 8.5 to 51 t CO_2/t U_3O_8. These environmental costs are particularly sensitive to ore grade, with higher values from lower grade ores."

Source:

- **On the Sustainability and Progress of Energy Neutral Mineral Processing,** by F. Reitsma et.al., 2018 www.mdpi.com/2071-1050/10/1/235
- **Uranium Mining: Australia and Globally,** by Gavin Mudd, Fact Sheet No. 6 www.energyscience.org.au/FS06%20Uranium%20Mining.pdf

NOTE

Producing nuclear fuel from uranium for nuclear power plants is not carbon-free. As deposits with less and less concentration of uranium are exploited, the CO² production of producing nuclear fuel will generate as much CO² as fossil fuels in the first place.
Thus, nuclear power cannot safe the world from the impacts of climate change.

CHAPTER TEN

Animation

B There is another big issue I haven´t mentioned so far: the left overs ... often, there is only one percent of uranium in the ore – and in some of the current mines, it is even less.
A ... that means you have to mine huge masses of rock to get a small quantity of uranium?
B Right. If you are lucky and have 0.1 % uranium in the ore, you need to mine 1000 tons of ore to get 1 ton of Uranium. In some cases, the concentration is even lower, that means you have to mine 5 – 10,000 tons of ore to produce 1 ton of uranium.
A ... and what about the rest? ?
B It is waste, radioactive, toxic and dangerous waste!

GÜNTER WIPPEL (PRESENTATION)

And there are also other toxic elements, that was mentioned before, like arsenic in those tailings. That makes them really difficult. For example there is a calculation how much of the original radiation will still be in the tailings after 1000, 10,000, 100,000 years, and so on. Even after 100.000 years nearly 60 % of the radioactivity are still in the tailings – that means they still are very dangerous.

That is an example from how it looks like in Niger, where they [AREVA] have been mining since more than 40 years. In Niger they dump the radioactive waste in the desert and this is what it will look like if they start mining somewhere here, be it in Bahi, be it in Mkuju river.

MARIETTE LIEFFERINK (INTERVIEW)

What often happens if a mine dam, for example, is not profitable or economically viable to the mine [company], that mine dam is often abandoned or put in a warehouse condition. There is no mitigation or management measure of the waste and that results in significant risks to communities.

BRUNO CHAREAYRON (INTERVIEW)

Well, for example in Africa you have the tailings produced by French company, called COMUF, in Gabon. It's really a mess like the tailings are still in the forest where the people are cultivating manioc, and you really can monitor the radiation emitted by the tailings in the forest. So this problem of tailings does exist in France, and also in Africa, at all uranium mines in the world. Nobody knows how to confine, maintain such huge amounts of radioactive material that will be radioactive for dozens of thousands of years.

Narration

At international conferences, people from different parts of the world reported about their experiences with uranium mining and its consequences. None of them could report good management of the dangerous tailings within their countries.

ABDOURAHAMANE MAOULI (INTERVIEW)

Mayor of ARLIT, Uranium mining town in Niger

This conference is very useful because we can learn a lot from it. What I have brought here is a cry for help because after 40 years of exploitation we still haven´t found a way out of the catastrophe, so I hope it serves as a message to those who are getting ready to open a new mine.

10. The Tailings and the Problems after Mining

10.1. Introductory Note

Whereas in former times valuable minerals and sometimes gemstones were chiselled out of the rock with a limited amount of waste generated, in today's mining operations, hundreds and thousands of tons of rock are mined, crushed and treated with chemicals in order to extract the desired raw materials – be it uranium, gold, rare earths or other elements.

This exploitation technique inevitably generates a huge mass of waste, so-called tailings, a hundred to a thousand-fold or more of the mass of valuable material that is extracted.

The tailings stay on location – in the places and countries where the resources are mined – leaving behind an often toxic, in the case of uranium mining, also radioactive legacy, whereas the valuable material is shipped out of the country and mostly taken to industrialized countries.

WHAT EXACTLY ARE 'TAILINGS'?

Miners refer to waste from mining operations as 'tailings' – the waste at the end. Before crushing uranium ore, the rock is checked for uranium content – and if the concentration is considered too low ("cut-off grade"), the payload is discarded → solid tailings. The ore with higher concentration of uranium is then crushed to a sandy consistency and treated with chemicals, mostly sulphuric acid (plus other chemicals) to leach uranium out of the sand; this process uses lots of water (→ Ch. 9.2.). The waste generated is radioactive and toxic slurry. It is disposed of behind tailings dams – often, small valleys or depressions dammed off, or, if no depressions are available, a square or similar pattern of dams is constructed.

The stability of such tailings dams is crucial for the safe storage of the sludgy tailings. Tailings dam breaks have disastrous consequences (→ Ch. 10.3. Tailings Dam Failures). Due to the sludgy consistency of the tailings, and failure or lack of lining, tailings dams are prone to seepage (→ Ch. 10.4.). From the tailings and from low-grade ore piles, Radon-222 gas is exhaled and dust blown away, spreading contamination (→ Ch. 10.5.).

Further Readings:

> Tailings Dams: Where Mining Waste is Stored Forever,
by Gretchen Gavett, July 30, 2012
www.pbs.org/wgbh/frontline/article/tailings-dams-where-mining-waste-is-stored-forever

> WISE Uranium Project website,
Uranium Tailings Management:
www.wise-uranium.org/indexu.html#UMMTM

10.2. Longevity of radioactive materials

Some of the elements in the decay chains of uranium have very long half-lives (→ Ch. 2. graph Decay Chain). Although most of the uranium is removed in the milling (extraction) process, many decay products with very long half-lives remain in the waste (tailings).

- Thorium-230 (from the U-238 decay series): half-life of 75,380 years
- Protactinium (from the U-235 series): half-life 32,760 years
- Actinium (from the U-235 series): half-life 21,772 years

Remember that "half-life" does not mean that the element has "evaporated". It means that half of the amount of the element has decayed – into another radioactive element – whereas the other half will decay later on – after the first half-life is over.

In addition, Radium-226 for example, emits about a million times more radiation than uranium itself.

Thus, the tailings retain 80 – 85 % of the original radioactivity of uranium.

Moreover, tailings contain small amounts of Uranium-238 and Uranium-235 which could not be extracted due to technical reasons (half-life 4,5 billion years, and 700 million years respectively). They continue to generate the long-lived elements in the decay chain in perpetuity.

Here is the graph from the film:

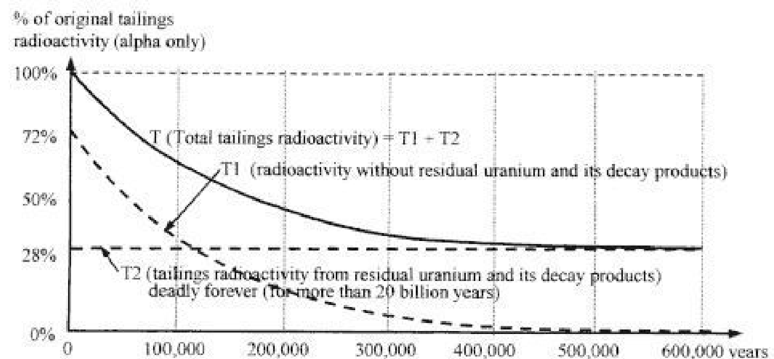


Fig.3: The Roxby tailings radioactivity (residual uranium in tailings: 23% of the ore's uranium)

Long-term Consequences of Uranium Mining by Hans-Peter Schnelbögl, Diplom Ingenieur (not available on internet)

The radioactivity of the Olympic Dam tailings is (% of the original tailings activity)**:**

- after 1,000 years 99 %
- after 10,000 years 93 %
- after 100,000 years 57 %
- after 1 million years 28 %
- after 1 billion years 22 %
- after 10 billion years 6 %

The calculations were prepared for an Australian mine, but due to the basics of physics for uranium and its decay products, they apply everywhere. In practical and human terms, uranium mine tailings stay radioactive forever. Due to their radioactivity, they must be kept separate from the environment for very long periods of time which exceed human engineering experience by far. The toxicity of some of the decay elements and of other elements leached from the ore (such as arsenic, lead, mercury etc.) add to the problem.

In order to avoid dealing with the problem that humans do not have the capability to store material for thousands of years safely, isolated from the environment, lawmakers cut down the period which is looked at, to 1000 years, in some cases to 200 years.

That means: Companies 'only' need assure the licensing authorities that safe storage of tailings can be provided for 1000 (or 200) years. Future generations beyond these time frames are left out of consideration.

10.3. Mass of tailings

Due to the low concentration of uranium in most deposits, the amount (mass) of tailings is thousand-fold or more the quantity of the uranium produced. The table shows the mass of tailings generated for the production of 1 ton of uranium:

To produce 1 t of uranium		
at a concentration of uranium in the ore of	tons of ore to be mined	Waste (Tailings) generated
1,00 %	100	99 tons waste
0,10 %	1,000	999 tons waste
0,05 %	2,000	1,999 tons waste
0,01 %	10,000	9,999 tons waste

Currently, many mines operate with a concentration of uranium in the ore of 0.1 % and less. In Canada, some miens operate at higher concentrations. Mines in Kazakhstan, currently the biggest producer of uranium, are all ISL.

NIGER
Arlit SOMAIR mines 0,064 to 0,24 %
Akouta mines 0,37 – 0,41 % (mine expected to close in 2021)

Source:
> WISE Uranium Project
Deposit information of respective mines

NAMIBIA
Rössing mine: 0,033 %
Langer Heinrich mine: 0,03 – 0,041 %
Trekkopje mine: 0,012 % (mothballed since 2014)

MALAWI
Kayelekera mine: 0,053 – 0,099 % (mothballed since 2014)

CANADA
Mc Arthur River: 1,91 – 6,04 % (currently closed down)
Cigar Lake mine: 10 – 13,35 % (exceptional high grade uranium deposit)

KAZAKHSTAN
(all mines are ISL): 0,05 – 0,09 %

The sheer mass of tailings – thousand-fold and more of the quantity of uranium produced – and the need to keep them separate from the environment is a serious problem that has not been solved so far. Most of the uranium mine tailings in the world are not stored safely. In many cases, they were simply discarded and not dealt with in any way.

On WISE Uranium Project website, the mass of tailings per country is shown:
WISE Uranium Project > MAPS and STATS > select: Uranium Mill Tailings Inventory

World TOTAL Uranium mine tailings (2019): 2,352 million tons

GÜNTER WIPPEL (PRESENTATION)

I just mention few more hazards from uranium mines very quickly: the risk that tailings dams are breaking. And this is not just theory, it has happened repeatedly, in the United States …

Narration

A study by the International Commission on Large Dams and the United Nations Environmental Program UNEP found that "one major tailings dam incident occurs each year" with fatal consequences for communities and the environment.

The mining industry is generally plagued by a considerable number of failures of tailings dams – to a degree that UNEP published a study in 2017 "MINE TAILINGS STORAGE: SAFETY IS NO ACCIDENT", calling, among other things, for better monitoring of tailings dams.

Regardless, on January 25th, 2019 the tailings dam of an iron ore mine in Brumadinho, Brasil collapsed, spilling some millions tons of mud, smashing a canteen, killing 186 persons, another 122 people missing. Many more lost their homes and the area is polluted for years.

10.4. Tailings Dam Failures

As explained in Chapter 10.1, a major part of the tailings is of sludgy consistency, and stored behind dams. In many cases, construction begins with a 'starter dam', then further dams are added on top during operation of the mine, affecting the stability of the dam.

Managing the inevitable tailings is probably viewed by mining companies as a nuisance, and dealt with little diligence – and with the less costly options available.

Repeated tailings dam failures instigated a study by the UN Environmental Program (UNEP) and the International Commission on Large Dams.

The study deals with tailings dams in general, it is not limited to uranium mine tailings dams.

There is an alarming number of tailings dam failures, 3 - 4 per year since 2000.

Tailings dam failures can have different causes, and can unroll in various ways. WISE Uranium Project systematically identified the causes and processes of tailings dam failures.

In regions with heavy seasonal rainfalls (monsoons etc.), tailings dams may also overflow. Radioactive and toxic material is then dispersed in the area flooded, and there is also a risk of a tailings dam failure through erosion of the dam.

As of August 2019, the WISE Uranium Project "Chronology of uranium tailings dam failures" lists 21 uranium mine tailings dam failures in a 61-year-period (1954 to 2017), on average, one uranium mine tailings dam failure every three years.

Source:

> WISE Uranium Project > Slidetalks
www.wise-uranium.org/stk.html?src=stkd01e
select: Tailings Dam Stability, show deals with it from slide 28

Further readings:

> "Mine tailings storage: safety is no accident",
by UNEP and International Commission on Large Dams, 2017
www.grida.no/publications/383
https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/371/original/RRA_MineTailings_lores.pdf?1510660693

> "Typical tailings dam failure modes",
WISE Uranium Project, for survery on tailings dam incidents, bibliography and case studies (scroll on page)
www.wise-uranium.org/mdas.html

> Chronology of uranium tailings dam failures,
WISE Uranium Project
www.wise-uranium.org/mdafu.html

Some examples

UNITED STATES

"In the morning of July 16, 1979, at United Nuclear Corporation's uranium processing mill, an earthen dam broke releasing more than 1,100 tons of uranium mining wastes-tailings along with 100 million gallons of radioactive water into the Pipeline Arroyo. The incident became known as the "Church Rock Tailings Spill.

Water from the spill traveled downstream from the Pipeline Arroyo along the Rio Puerco. By 8 a.m., radioactivity in the Rio Puerco was observed in Gallup, NM, nearly fifty miles downstream from the spill. Contaminated water continued its course along the river crossing state borders into Arizona. According to the Nuclear Regulatory Commission, the contaminated river measured 6,000 times the allowable standard of radioactivity below the broken dam shortly after the breach in the dam was repaired.

Wastewater from the spill had a pH of less than 2 and a gross alpha particle activity of 128,000 picocuries per liter (pCi/1) leaving deposits of radioactive uranium, thorium, radium, polonium, dregs of metals such as cadmium, aluminum, magnesium, manganese, molybdenum, nickel, selenium, sodium, vanadium, zinc, iron, lead and high concentrations of sulfates, in soils seventy miles downstream."

The dam break eventually released more radioactivity into the environment than the Three Mile Island meltdown a few weeks earlier but received much less public attention. The location is relatively remote in the Southwest US, New Mexico. The people affected first and foremost are Dine (Navajo), Native American/indigenous people, who herd their cattle in the area.

Author Traci Brynne Voyles argues in her book "Wastelanding – Legacies of Uranium Mining in Navajo Country" "that the presence of uranium mining on Diné (Navajo) land constitutes a clear case of environmental racism."

Source:

> Church Rock Tailings Spill: 16 July 1979,
http://newmexicohistory.org/2015/07/22/church-rock-tailings-spill-16-july-1979

Further Readings:

> Dam Break Investigated; Radiation of Spill Easing
The New York Times, by Molly Ivins, 07/28/1979
www.nytimes.com/1979/07/28/archives/dam-break-investigated-radiation-of-spill-easing.html

> Uranium Milling and the Church Rock Disaster,
Killing Our Own, by Harvey Wasserman and Norman Solomon
www.hanksville.org/voyage/misc/uranium/ChurchRock.html

> Church Rock, America's Forgotten Nuclear Disaster, Is Still Poisoning Navajo Lands 40 Years Later, by y Samuel Gilbert; photos by Ramsay de Give, Aug 12 2019
www.vice.com/en_us/article/ne8w4x/church-rock-americas-forgotten-nuclear-disaster-is-still-poisoning-navajo-lands-40-years-later

Source:

> Wastelanding: Legacies of Uranium Mining in Navajo Country, Traci Brynne Voyles, University of Minnesota Press, May 15, 2015
https://play.google.com/store/books/details?id=VzB-0DwAAQBAJ&rdid=book-VzB0DwAAQBAJ&rdot=1&source=gbs_vpt_read&pcampaignid=books_booksearch_viewport

Narration

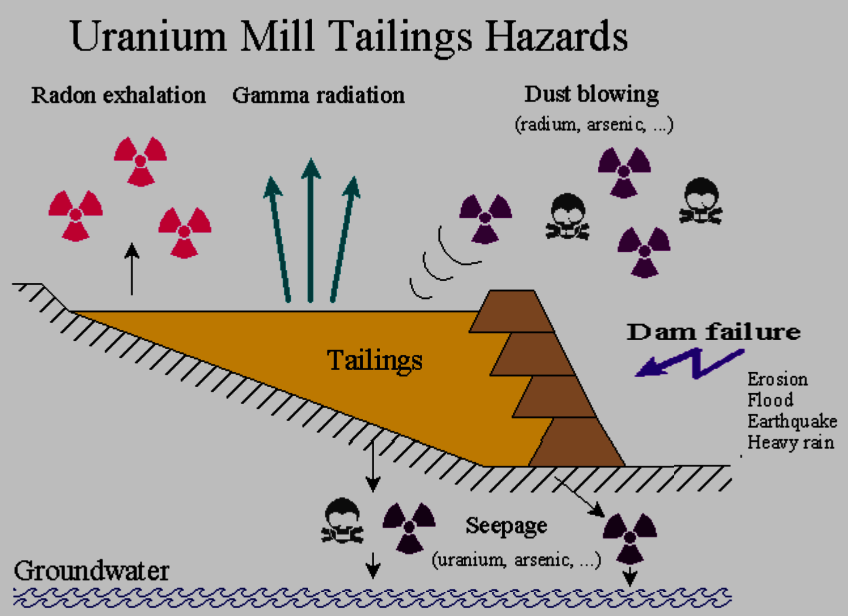
Besides catastrophic events such as tailings dams collapses, radioactive and toxic waste may seep into the ground on an everyday basis – and contaminate aquifers.

Various surveys provide proof of this.

Analysis of groundwater from wells in the vicinity of uranium mines in Arlit, Niger, found that water is contaminated with uranium and other radioactive elements.

In Namibia, Langer Heinrich Uranium mine, owned by Paladin, was newly constructed and produced yellowcake from March 2007. 10 years later, radioactive material is detectable in wells downstream of the ground water flow.

"Uranium has increased from 0.1 mg/L to 8.9 mg/L in ten years. In general, even though the uranium mines are located in theid region of Namibia, the current rate of groundwater flow could pose a risk ..."



Graphics: WISE Uranium Project

BRAZIL

The catastrophic failure of the tailings dam at Brumadinho iron ore mine (not a uranium mine) is – so far – the only footage of the moment of the actual breaking of a major tailings dam. The footage gives an idea of the cause (for details consult the Source named): The slurry behind the dam may have been holding too much water, the water destabilized the base of the dam and the base of the dam gave way. The dam collapsed releasing approx. 12 million cubic meters of sludge, rocks and liquid. The tailings wave travelled at up to 120 km/h, hit the mine's loading station and its administrative area, including a cafeteria where many workers had lunch at the time. The slurry wave traveled further on downhill, destroyed a bridge and spread to parts of the local community Vila Ferteco, near Brumadinho. The slurry traveled further downstream into Rio Paraopeba, thereby killing all life in the river.

As of October 2019, the catastrophe has left 249 persons dead, 21 are still missing.

Source:

> WISE Uranium Project, The Brumadinho tailings dam failure (Minas Gerais, Brazil)
www.wise-uranium.org/mdafbr.html

10.5. Seepage of liquid wastes into the ground water

From tailings ponds radioactive and toxic elements can easily seep into the underground and contaminate aquifers or surface waters.

Whereas tailings were not lined in the early days of uranium mining and seepage from old tailings is still a problem – newer tailings ponds need to be lined. Mostly, plastic materials are used for lining ponds but the durability of these liners for extended periods of time is questionable.

Once 'escaped' into the underground, radioactive materials wander with the groundwater movements slow or fast in the direction of groundwater movements and may contaminate areas outside the mine area, depending on the speed of the groundwater movement.

Basically, once radioactive materials seeped into an aquifer, there is almost no possibility to stop them. Big areas would have to be excavated deeply and if the tailings ponds are leaking, the problem will persist.

Some examples

AUSTRALIA – RANGER URANIUM MINE

"The Ranger uranium mine inside the World Heritage-listed Kakadu National Park is leaking 100,000 litres of contaminated water into the ground beneath the park every day, a Government appointed scientist has revealed."

Source:

> Polluted water leaking into Kakadu from uranium mine, The Sydney Morning Herald, by Lindsay Murdoch and Darwin, March 13, 2009
www.smh.com.au/national/polluted-water-leaking-into-kakadu-from-uranium-mine-20090312-8whw.html

"Contaminated water seeping from a mine in Kakadu National Park has a uranium concentration more than 5,000 times the normal level, a Senate estimates committee has heard.
[...]
The office today told the committee that water seeping from underneath the dam has about 5,400 times the level of uranium than the natural background level.
Greens Senator Scott Ludlam says the environmental regulator told the committee about 100,000 litres of water seeps from the tailings dam every day. Mr Ludlam says the water has been leaking from the dam for years. He says the regulator says it will be impossible to rehabilitate the site.
"The uranium concentration in the billabong surrounding the mine are about three to five parts per billion," he said. "But the uranium in the processed water that is leaking from beneath the tailings dam is 27,000 parts per billion."So it's roughly 5,500 times as much uranium in that water as there is the surrounding environment and that means the company has got a huge problem."

Source:

> Uranium mine leak '5400 times normal level', by Emma Masters, 9 Feb 2010
www.abc.net.au/news/2010-02-09/uranium-mine-leak-5400-times-normal-level/325276

AUSTRALIA – MARY KATHLEEN MINE, CLOSED DOWN IN 1982

The long-term problem generated by uranium mine tailings is illustrated by Australia's Mary Kathleen mine, closed down in 1982. The Australian newspaper Courier Mail reported:

"Queensland's last uranium mine still leaking radioactive water 30 years after production stopped.

The report says the Mary Kathleen mine's pit is still full of highly contaminated water to a depth of about 50m, and since the mine closed in 1982, several other studies have found "ongoing environmental legacy issues.

Those include the seepage of acidic, metal-rich, radioactive waters from the base of the tailings dam into the former evaporation ponds and local drainage system."

Source:

> **Queensland's last uranium mine still leaking radioactive water 30 years after production stopped,** Courier Mail, by John McCarthy, March 20, 2013
www.couriermail.com.au/news/queensland/queenslands-last-uranium-mine-still-leaking-radioactive-water-30-years-after-production-stopped/news-story/247685eafd061d321f6d44b9b8f81a2e

As early as 2003, scientists from James Cook University, Australia, had already found that radioactive water seeps from the tailings into the environment:

"However, seepage (~0.5 L s-1) of acid (pH 5.71), saline (0.31 per cent), high conductivity (8.8 mS cm-1), slightly oxygenated (DO 2.6 mg L-1), radioactive waters occurs from the toe of the tailings dam into the former evaporation ponds and local drainage system."

Source:

> **Tailings dam seepage at the rehabilitated Mary Kathleen Uranium mine, northwest Queensland, Australia,** Lottermoser, B.G., Costelloe, M.T., and Ashley, P.M. (2003).
https://researchonline.jcu.edu.au/3534

Remember that the radioactive materials in the tailings management facility will remain hazardous for thousands of years and should be kept safely and separate from the environment for an extended period of time.

However, already 30 years after closure, in spite of some rehabilitation work, radioactive and toxic materials find their way into the environment.

Further readings:

> Australian Map
https://australianmap.net/mary-kathleen-former-uranium-mine

> **Groundwater seepage from the Ranger uranium mine tailings dam: Radioisotopes of radium, thorium and actinium,** Supervising Scientist Report 106 Martin P and Akber RA
www.environment.gov.au/science/supervising-scientist/publications/ssr/groundwater-seepage-ranger-uranium-mine-tailings-dam

NAMIBIA – RÖSSING URANIUM MINE

"In the Khan river uspstream from Rössing Mine and in the Swakop river upstream the confluence with the Gawib river (Langer Heinrich mine potential influence), the uranium 238 concentrations are quite low (0.2 µg/l and 7.8 µg/l respectively). The uranium concentration downstream of the tailings dam is very high (between 554 and 3 164 µg/l).

The impact can occur through leakages occurring below the tailings dam and as discussed in section 2, through the waste rock dump (where uranium concentration is 430 µg/l). Both impacts have to be studied in detail."

Source:

> **Radiological Impact of Rössing Rio Tinto Uranium Mine. EJOLT & CRIIRAD Report, 2014t,** Chareyron, B.
www.criirad.org/mines-uranium/namibie/radiological-impactofriotintorossing-CRIIRAD-EJOLT.pdf

NAMIBIA – LANGER HEINRICH URANIUM MINE

"The 2015 water analysis for LHU 1049 borehole shows that the water quality has been highly deteriorated due to the mining activity, specifically contamination through seepage from the tailing facility and groundwater flow in the alluvial aquifer. A decade of time-span shows tremendous impact on the quality of groundwater, which is under the influence of constant seepage and flow within the alluvial aquifer. The parameters such as EC and Cl increased by over 60%, while the increase for others is over 100% (Table 3), which shows lack of attenuation in the sediments or overload of chemicals.

Uranium increased from 0.1 mg/L (background value) in 2005 to 8.9 mg/L in 2015, which represents about 8800% increase."

In their final conclusions, the authors say:

"The groundwater in the area is generally of poor quality […]. The expansion of uranium mines has contributed its share to the deterioration of quality of the groundwater through seepage from tailing dams and groundwater flow within the shallow aquifer system. The unlined tailing dams have major role in releasing uranium into the alluvial groundwater.

The metal concentrations trend analysis in borehole (LHU-1049) indicates that there is a huge impact on the groundwater quality of the borehole over the past ten years. Uranium has increased form 0.1 mg/L to 8.9 mg/L in ten years. In general, even though the uranium mines are located in the arid region of Namibia, the current rate of groundwater flow could pose a risk on the water supply aquifer of the region through water quality deterioration from tailing dams."

Source:

> **Radioactive Seepage through Groundwater Flow from the Uranium Mines, Namibia,** Tamiru Abiye and Ignatius Shaduka, in Hydrology 2017,4, 1111
https://pdfs.semanticscholar.org/fa26/40558186f8a500781409c92f0b394b79f8cc.pdf

NIGER

In Niger, the impact of uranium mining in Arlit area was researched by CRIIRAD and Greenpeace.

"In December 2003, within the framework of our exploratory mission in Arlit, we took 2 samples of 1.5 liters of water each with the assistance of the associations AGHIR IN'MAN and SHERPA:

Water called "Surpression ZI" (industrial zone)

Water called "Surpression ZU" (urban zone), taken by CRIIRAD from a faucet at the Social Security premises in Arlit

The global alpha activity measured for the 2 samples is high – respectively 1.0 Bq/l (ZU water) and 11 Bq/l (ZI water). This means that the values are 10 times and 110 times exceeding the 0.1 Bq/l limit recommended by the World Health Organization (and adopted by the French authorities). […]

Concluding, these analyses revealed that the water of the well 2002 is charged with uranium and its descendants exceeding the international standards for the potability of water."

Source:

> **Impact de l'exploitation de l'uranium par les filiales de COGEMA-AREVA au NIGER,** Bilan des analyses effectuées par le laboratoire de la CRIIRAD en 2004 et début 2005 Note CRIIRAD 0517 V2 AREVA ARLIT/20 Avril 2005
http://www.criirad.org/actualites/dossiers2005/niger/notecriiradarlit.pdf

Seepage of radioactive elements from uranium mine tailings is a serious concern. As the examples show, there is a high risk that seepage from tailings contaminates drinking water resources and the environment.

Narration

Not only is water contaminated, also the air is effected: Dust from tailings, carrying radioactive decay products, is often blown away with the wind. Radioactive elements attached to dust particles may contaminate the surroundings. Radioactive dust from Australian uranium mines has been found in Antarctica – 6000 miles away. Tailings also continuously emit Radon-222, the radioactive gas. It is known to cause lung cancer. Radon gas may travel up to 300km, thus possibly spreading contamination to distant areas.

10.6. Radon exhalation and 'flying dust'

RADON-222 GAS

Tailings also contaminate the air. They exhale Radon-222, the only gas in the decay chain. Although Radon-222 has a half-life of 'only' 3,5 days, it poses a serious risk. This is because it is generated continuously from Radium-226, Radon-222 is an alpha-emitter and can easily be inhaled by miners, workers and people in the vicinity. Companies claim that Radon-222 would pose a risk only locally, however, a study states:

"In a 10 km/hr breeze, it [Radon] can travel 960 km within 4 days; much further in higher winds. Radon gas decays sequentially into several other solid radioactive isotopes of polonium, bismuth and lead, before finally becoming the non-radioactive lead 206. These radioactive progeny of radon settle onto crops, bodies of water and soil. Their patterns of accumulation in the biosphere, including our food species, are not well known. The three isotopes of polonium produced by radon, in addition to being radioactive, are among the most toxic naturally occurring substances on earth. The toxicity of lead is well documented."

Source:

> Human Health Implications of Uranium Mining and Nuclear Power Generation, by Dr. Cathy Vakil M.D., C.C.F.P., F.C.F.P., Dr. Linda Harvey B.Sc., M.Sc., M.D., May 2009
www.abolition2000.org/a2000-files/Human_Health_Implications_Uranium_Mining_and_Nuclear_%20Power_Generation.pdf

Although it may be disputable how far radon gas can travel within its short half-life, its impact can definitely not be limited only to the mine area.

Tailings ponds also exhale Radon-222 gas. During operation of a mine, they should be well covered by water to minimize Radon-222 exhalation to avoid building of dust which may be blown away with the wind from dried-out areas. A lack of a water coverage of tailings ponds leads to more dust blown away and more Radon-222 exhalation.

In dry areas, procurement of the water to cover the tailings may turn into a problem.

In areas with heavy seasonal rainfalls, overflow of tailings ponds may become a problem for adjacent areas and water bodies.

DUST

The air is also contaminated with dust and radioactive elements attached to it.

Mining operations in dry areas and during dry season are especially affected by dust; dust particles may be contaminated with radioactive elements. Blasting adds to the creation of dust which is blown up high into the air and can travel longer distance before settling. Continued use of heavy equipment such as excavators, caterpillars, bulldozers and mining trucks also add to dust generation.

Mining companies are partially aware of the dust problem and invest in dust suppression – which is often done by spraying water and thus adds to the water consumption of the mining operations.

NAMIBIA

"CRIIRAD discovered that the finest fraction of the tailings dumped on Rössing tailings dam is blown away by the wind and contaminates the surrounding environment as shown by the contamination of top soil plotted on the graphs hereafter.

Radium 226 activities range between 960 Bq/kg and 7 400 Bq/kg in soil samples 1T, 20T, 23T and 24T collected up to 2 km away from the tailings dam fence. Contaminated top soil also contains high levels of thorium 230 (8 600 Bq/kg in sample 1T). As can be seen on some of the pictures (below) the contaminated dust is fine grained and therefore easily inhaled. In the picture at the bottom one can notice that the dust has been accumulating at the bottom of a small bush which is probably "catching" the contaminated aerosols."

Source:

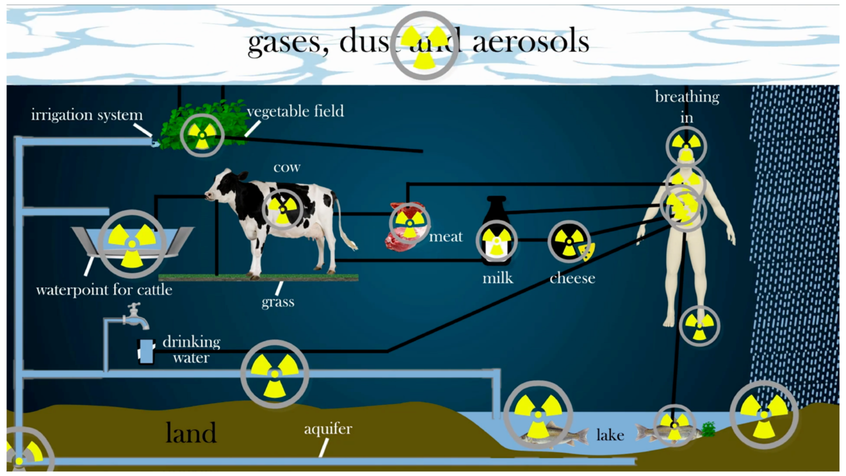
> Radiological Impact of Rössing Rio Tinto Uranium Mine. EJOLT & CRIIRAD Report, 2014, Bruno Chareyron, page 20
www.criirad.org/mines-uranium/namibie/radiological-impactofriotintorossing-CRIIRAD-EJOLT.pdf

10.7. The pathways of radioactive elements to the human body

How do the radioactive elements that have seeped into aquifers or blown away with the wind finally impact the health of humans (and animals)?

There is a number of pathways, known as exposure paths, which radioactive elements can take to reach the Human body:

Dust or Radon-222 gas traveling with the wind can be breathed in (→ Ch. 2.). Radioactive elements in drinking water enter the body when drinking water.



Radioactive materials which have ended up on pastures with the wind, can take the grass – cow – milk – human pathway, or, if the meat is eaten – grass – cow – meat – human.

Radioactive elements that have seeped into surface water can get via – water – plants – fish to humans, etc. (see graph).

In some cases, bio-accumulation plays an important role: Water may be only slightly contaminated, plants growing in this water may accumulate radioactive elements so that animals eating these plants may in turn accumulate the radioactive elements in their body. Once humans have eaten the meat or the fish, they will get a dose of radiation much higher than to be expected from the comparatively low concentration of radioactive elements in the water.

CONCLUSION

The leftovers of mines, the tailings, are one of the biggest problems in terms of mass and a long-term problem due to the longevity of radioactive elements in the tailings.

This demands a safe and secure isolation of tailings from the environment for a long period of time. There is – at maximum – a 60 years experience in dealing with uranium mine tailings and containing them.

The first decades of uranium mining, companies were oblivious in the extreme towards any proper mine closure or mine tailings rehabilitation, resulting in serious contaminations of larger areas.

Although since then things have changed to a certain degree, tailings and their safe handling remains the unresolved problem of HOW to store millions of tons of radioactive and toxic waste safely and keep them isolated from the environment for thousands of years?

CHAPTER ELEVEN

Narration

Therefore, not only the workers are directly affected by the dangers, the entire population living in the vicinity of mines and tailings is affected. Radioactive elements can get into rivers via seepage or dust, where living fish take these up.

When humans eat the fish, they ingest radioactive elements. Contaminated water from aquifers may be used for drinking, once again, enabling radioactive elements to enter the body. Water is also used for cattle or for irrigating fields.

Dust and aerosols may be deposited on the soil and on plants, animals eat the grass and may accumulate radioactive elements in their bodies. By eating the meat or drinking the milk of the animals, humans take up radioactive elements in their body. The same applies for vegetables from the fields.

DR. PETER WEISH (INTERVIEW)

It has been around 100 years since fundamental relationships were found between radiation and biological consequences, especially damage to genetic information, so-called mutations. And mutations are the cause of diseases which ultimately cannot be cured.

Radiation effects our body in many different ways. Depending on the kind of radiation and whether the dose is received from the outside or internally. Once embedded in our bodies, radioactive elements bombard nearby cells at close range with radiation – which may destroy the cells and – more importantly – damage the DNA, leading to cancer or leukemia.

Internal exposures are particularly dangerous since some radioactive elements accumulate in specific parts of our body. This can lead to cancer, organ failure, and a number of diseases which may show up only years after radiation exposure.

DR. PETER WEISH (INTERVIEW)

For late damages such as cancer, leukemia, hereditary defects and also malformations , there is no dose without harm ["harmless" is a mistake in the transcription]. Only the probability of the occurrence of such late damages decrease with low doses. But if I irradiate a large number of people with low doses, I get an increase in cancer, leukemia cases and genetic damages in future generations.

DR. PETER WEISH (INTERVIEW)

Usually, the water getting out of the uranium mines is contaminated, but this contamination is difficult to monitor as you see here. Why? Downstream the discharge of radioactive water, the bio-accumulation of radioactive metals in the plants, and sometimes also in the sediments or in the fish is really important as you see here. There is much more radiation in the plants than in the water. This is bio-accumulation.

DR. ANGELIKA CLAUSSEN (INTERVIEW)

In case of the WISMUT (former East German uranium mining company) only the workers were examined at that time. The population was not and never examined. Protective measures were never taken for the population, and for the workers only in a limited way.

11. Health Impacts of Uranium Mining

11.1. Introductory Note

The impacts of radiation on living tissue and human health were pointed out briefly in Ch. 2. In fact, there are a variety of health impacts and diseases related to uranium and uranium mining (→ Ch. 11.2.).

The negative health impacts of uranium and uranium mining have been investigated over a number of years but the impacts of uranium mining have never been systematically researched or analyzed in comprehensive health studies, neither for miners and workers nor for the general public in the surroundings of uranium mines and mills.

In the beginning years of uranium mining, little data on radiation exposure of miners and mill-workers was collected, if any at all. This lack of data basically helped – and helps – companies and sometimes governments to 'brush off' allegations of negative health impacts, and, consequently, any claims for compensation.

The lack of data acts as a buffer protecting companies until the present day, as noted by a journalist in 2010 in regard to uranium mining in Niger.

Gabrielle HECHT, professor of history, in her book "Being Nuclear: Africans and the Global Uranium Trade" (and a number of related articles) points out how radiation doses were fiddled with:

"After a few numerical gymnastics, Guizol wrote a report that justified the equivalent of a three-fold increase in radon MPLs and aligned these with ILO guidelines. The new levels, he remarked bluntly, were 'more advantageous' to the company. The effect was immediate. As of March 1970, not a single worker registered overexposure."

Note that, just by changing some figures, the workers were now, in the company's view, not exposed to too much radiation anymore – although the real situation and exposure had not changed at all.

Miners and workers at Rössing Uranium mine, Namibia, reported that they had difficulties to get access to their medical files and radiation exposure data.

A brief video, "Yellowcake Rising", reports that the data relating to the radiation exposure of mine workers at Paladin's Kayelekera Uranium Mine has been concealed from the workers, making any control over their radiation exposure impossible.

Moreover, many health impacts only show up 15 – 25 (or more) years after exposure to radiation, the so-called 'latency period'. This makes it more difficult to make the connection between the exposure to uranium, uranium mining and related diseases.

There is, however, some experience with the mining of uranium from silver mines in the Erzgebirge ("Ore Mountains") in Germany and adjacent areas (today Czech Republic, → Ch. 3.) where uranium had been mined as a by-product of silver unintentionally: miners died from an, at the time, inexplicable disease, known as Schneeberger lung disease. Today, we know it was caused by the decay products of uranium (especially by radon gas and, radium) on the miners internal organs.

Some of the early researchers of radiation and radioactive elements died prematurely from leukemia (Marie Curie) or contracted severe health problems. Eventually, it deemed on people that handling radioactive elements might pose a health hazard.

The founding of an international commission to deal with the health impacts and risks of uranium and other radioactive materials in 1928 indicates the growing awareness of the health risks associated with radioactive materials.

Source:

> **NIGER: Lack of Data on Causes of Death Buffers French Company,** by Julio Godoy, April 2010
www.ipsnews.net/2010/04/niger-lack-of-data-on-causes-of-death-buffers-french-company

Source:

> **Africa and the Nuclear World: Labor, Occupational Health, and the Transnational Production of Uranium,** by Gabrielle Hecht, Department of History, University of Michigan published in Society for the Comparative Study of Society and History, 2009;51(4):896–926.0010-4175/09

Further readings:

> **Being Nuclear: Africans and the Global Uranium Trade,** by Gabrielle Hecht, 2012

Source:

> **Yellowcake Rising,** Video trailer by Marty Otanez
https://vimeo.com/7494979

Animation

A … hm, now that I've heard all these things , what are the dangers for the workers ??
B *There are many ways how radioactivity may affect humans: workers are often exposed directly to gamma-radiation. In addition, radioactive elements can get into their body by ingestion or inhalation and then damage their organs.*
For example, you may breathe in Radon-222 (the radioactive gas) it gets into your lungs, then part of it decays into another element which emits alpha-radiation – and this will damage your lungs.
A *however, in the beginning we learned that alpha-radiation goes only a few centimeters and can be stopped even by a piece of paper …*
B *Right– but that won't help you if the element emitting alpha-radiation is INSIDE your respiratory tract or lungs … there, you can't shield the lung tissue …*
A *Oh, I see, of course … so, alpha-emitters are actually pretty dangerous when they get inside your body?*
B *correct … Radon-222 is known to cause lung cancer. There are many studies about this and it is a proven fact. Not every small dose of Radon-222 you breathe in will cause cancer but the more you are exposed to it, the higher the risk of contracting cancer.*

PROFESSOR DOUG BRUGGE (INTERVIEW)

Miners breathe the radon in as well as the decay products from radon, the radon daughter products, it gets stuck in the lungs and these products give off very high levels of alpha radiation that damages tissue in the lungs and can lead to lung cancer. So that is a very well established causal association and there are not many people, if any, who have ever questioned that. It is by far the most serious risk and hazard that underground miners face in terms of radiation.

PROFESSOR DOUG BRUGGE (PRESENTATION)

And if you are in in close spaces especially, in mines, where the ventilation is poor, or not existing, like in uranium mines, if the ventilation is poor the Radon levels will be extremely high in those mines.

HILMA SHINDONDOLA (PRESENTATION)

We believe that generally workers are creators of wealth. But many die poor in economic terms, they die from ill health due to their working conditions. Health and safety and environmental protection – we can talk about it all day here – is not always a priority of companies. We all know that their main priority is profit making.

Now our report of 2008 was titled „The Mystery of low- level radiation". Why did we call it that? We call it that because when we spoke to the mine doctors, who were the mine doctors in the 1970s, they told us the radiation levels at Rössing are not dangerous, because it is low-level. And therefore, if anybody said that workers are ill due to the exposure of the radiation, then they are not telling you the truth, because it is too low for anybody to get sick. However, when we spoke to the workers, they told us about a number of problems they are facing, and we had to get the truth between what the mining companies are saying and what the workers are saying.

In 1950, a previous commission was restructured into the International Commission on Radiological Protection (ICRP) (→ Ch. 2.6.).

When dealing with health impacts, it should be kept in mind that

- uranium – in its natural setting – is always accompanied by its decay products, such as radium and radon, their impacts to health have to be considered as well.
- uranium itself is not only radioactive but also a heavy metal. Heavy metals pose a health risk through their toxicity (poisonousness due to chemical properties).

Some of the health impacts of uranium are attributed more to its toxicity than to radiation. Both these harmful impacts may add to each other's. Conclusive studies about synergistic effects of both impacts are not available however.

THE ROLE OF MEDICAL DOCTORS

Medical doctors claim that it is the foremost task of physicians and the public health service to maintain the health of the people entrusted to them. They are obliged to diagnose and treat diseases according to clear rules. When changes in health are diagnosed frequently, it is the task of the public health system to investigate the causes. The search for these causes can be lengthy. An initial suspicion will be followed, if at all possible, by the search for the 'noxae', something that exerts a harmful effect on the body.

Individuals who have fallen sick need to be examined, so laboratory tests will follow. Then come the statistical procedures until a clear correlation between a – potentially – dangerous material (the noxa) and a certain negative health impact can be confirmed (or rejected). Often, there is only a weak correlation, which confirms an urgent suspicion but is not proof yet.

Hippocrates, whose oath all medical doctors must take, laid down some basic rules 2000 years ago:

1. Do no harm – be it through inactivity or dangerous interventions
2. Be careful. When in doubt apply the precautionary principle and avoid potentially dangerous materials or elements, even if there is no evidence yet.
3. Heal or stabilize the disease.

Translated into our times, this means:

1. The precautionary principle: if there is an urgent suspicion that a dangerous material (a noxa) is causing a disease, action must be taken, even if there is no clear scientific evidence yet.
2. If a disease has already been diagnosed according to recognized methods, possible causes must be analyzed and eliminated. The disease must be treated according to the "state of the art".
3. In the case of an accumulation of clinical pictures which do not correspond to the usual pattern, the public health system should take steps in the form of epidemiological investigations or studies, laboratory tests and collection of cases.

According to the precautionary principle, the National Institute of Public Health of Quebec, a province of Canada, stated in 2013 that the health impacts of uranium mining were not well enough researched to conclude that mining uranium was safe. They recommended not going ahead with uranium exploitation in the province.

Source:

> Les impacts sanitaires en lien avec les projets uranifères nord-côtiers, by Institut National de Santé Publique du Québec, Sept 2013
www.inspq.qc.ca/sites/default/files/publications/1714_impactssaniprojetsuraninordcotiers.pdf

PROFESSOR DOUG BRUGGE (PRESENTATION)

Particularly with cancer but also with silicosis and some other health outcomes, the symptoms and the overt disease could take 10, 20, even 30 or 40 years before it appears. The latency period for lung cancer is about 10 years, so in the first 10 years of exposure, very few, if any, people are going to get lung cancer even if they have high radon exposure. And that means that it may not be obvious that what they are doing is risky. Radon is, as I said earlier, invisible, odourless, you would have no idea whether you were in a room with very high levels of radon or in a room that had almost none. So you don't know what your exposure is unless someone measures it and tells you. Your risk could be quite high and you might not experience any symptoms for many years, even decades, until disease develops.

Narration

Only several diseases, such as lung cancer due to the exposure of radon gas, are scientifically proven and compensated. Often people struggle decades in order to have a disease acknowledged as caused by occupational exposure to radioactivity. In many cases, they do not receive compensation.

Also, compliance with international regulations and dose-limits is no guarantee (warranty) of protection from diseases. Any amount of radiation is harmful to the body.

Miners are not only exposed to one, but to a variety of radioactive elements – and some are toxic, too; often miners are exposed to radioactivity for a long time - their working life.

DR. PETER WEISH (INTERVIEW)

And the International Commission on Radiological Protection (ICRP), after declaring that the doses they recommend should not be taken too seriously since one does not know much about the consequences yes, says –that by recommending those does limits –they believe to have granted sufficient space for manouver to the nuclear industry for the foreseeable future. So it is really primarily about making a nuclear economy feasible.

DR. ANGELIKA CLAUSSEN (INTERVIEW)

If uranium mines are now operated in African countries such as Niger or South Africa, you cannot expect any radiation protection measures at all – unless the workers, the population make them happen. Here (in Germany) the population started to ask about the consequences with the beginning of the anti-nuclear movement. That did not happen before. And then we need to be clear when talking about studies: if we do not investigate, we will not find anything. What I am not looking for , I can't find out in a study because I don't research that at all. Here, we are dealing with a science guided by interests, especially as far as radiation protection is concerned, this is a science guided by interests that only investigates when there is a great deal of pressure from outside or when there are great many diseases and deaths. Then, there is movement.

11.2. Health impacts

In the US, the National Institute for Occupational Safety and Health (NIOSH) conducted health studies on uranium miners, results were published in 2000.

The studies found elevated numbers of deaths in uranium miners, compared to the general population.

A number of studies on various aspects of health impacts of uranium mining have been conducted in the US (see "Further readings" at the end of this chapter).

In Germany, the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) conducted a number of health studies on the miners and workers of the former uranium mines (WISMUT) in former German Democratic Republic (East Germany).

In India, Doctors for Peace and Development (IDPD) conducted a research into the health status of indigenous peoples (sometimes referred to as 'Adivasi') living in the vicinity of uranium mines in Jadugoda area. The results are compiled in "Black Magic of Uranium at Jadugoda, a study of Health Status of Indigenous Peoples around JADUGODA Uranium Mines in India".

SCIENTIFICALLY PROVEN IMPACTS

Cancer of the lungs

This occurs due to radon and radium exposure in all underground and open-pit mining areas. The problem is that both radon and radium are alpha emitters. Thus only a few particles, which attach themselves to dust and are stuck in the bronchial system, are sufficient to cause harm. There, mucous membrane cells are irradiated, die or survive but change their DNA. These cells can still lead to lung cancer up to 25 years later. Smokers are exposed to a considerably greater risk (up to 10 times higher).

In the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) cohort study, 9100 lung cases of lung cancers were recognized until 2014. Similar results can be seen in other large studies. There is a major number of studies from different parts of the world in regard to the health impacts of Radon gas and radium.

For practicial reasons, we put the list of scientific articles at the end of this Chapter.

Silicosis

In underground and open pit mining, workers are exposed to dust all day long. Both mining methods involve drilling, blasting and the transport of rock. This dust is inhaled, leading to silicosis. Due to the heat, the workers often find it hard to tolerate the breathing masks although they are often formally prescribed. Thus they end up inhaling coarse and fine dust. The coarse dust particles can be coughed up, while the fine dust remains in the respiratory system for a long time. A part of the radioactive dust may be absorbed into the blood circulation.

Studies show that only when the mining areas were permanently sprayed with water, did the pollution decrease.

Silicosis leads to the reduction of the breathing surface following the bursting of the alveoli. The persons affected have difficulty breathing, initially under stress, later also when at rest. The suffering will last for years.

In addition to personal suffering, early incapacity to work may push the miners and workers affected into poverty, also impacting the families. It may also place a large financial burden on the general public and on pension funds, if existing at all.

The German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) cohort study had recognized 17,000 cases of silicosis by 2014.

Further readings:

- Worker Health Study Summaries
  www.cdc.gov/niosh/pgms/worknotify/uranium.html

Further readings:

- Wismut Uranium Miners Cohort Study
  www.bfs.de/EN/bfs/science-research/projects/wismut/wismut-study.html
- List of Publications on the German Wismut Uranium Miners Cohort Study
  www.bfs.de/EN/bfs/science-research/projects/wismut/publications.html

Source:

- Black Magic of Uranium at Jadugoda, by Indian Doctors for Peace and Development (IDPD)
  http://nonuclear.se/files/black-magic-at-jadugoda2007idpd.pdf

Video:

- WUS2015 Black magic? Health issues & Jadugoda uranium mines in India, Presentation by Shakeel Ur Rahman, India. Indian Doctors for Peace and Development at the World Uranium Summit, Quebec City, 2015
  www.youtube.com/watch?v=GE6YA3kCE5g

Narration

In 2015, the National Institute of Public Health in Quebec, Canada, concluded that the impacts of uranium mining are not well enough researched to decide that mining is safe.

Later on, a Government panel suggested a moratorium on uranium mining in Quebec.

Nasopharyngeal cancer

The causes are the same as for silicosis: Radon and radium, both alpha-emitters, also have an effect in this case. These carcinomas (cancers) are often detected early on and can be operated on or treated in other ways. As a result, the individuals affected often do not die from the disease.

Since most epidemiological studies only take the number of deaths into account (mortality), but not the number of sicknesses (morbidity), there is no clear evidence around the significance for this type of cancer.

Genetic damage to newborn babies

As mentioned above, uranium is also a heavy metal, which makes it genetically toxic. It can damage the genetic material. This has been shown in laboratory experiments in egg cells (oocytes) *(Encyclopedia of Toxicity)*. The consequences can be less frequent pregnancies, miscarriages, delayed growth and lower intelligence (the 'black magic' of uranium).

Source:

> **Encyclopedia of Toxicology,** by Brugge, D, Uranium. In: Wexler, P. (Ed.), 3rd edition vol 4. Elsevier Inc., Academic Press, 2014:883–884

> **Black Magic of Uranium at Jadugoda,** Study of Health Status of Indigenous Peoples around JADUGODA Uranium Mines in India by Indian Doctors for Peace and Develoment (IDPD) *http://nonuclear.se/files/black-magic-at-jadugo-da2007idpd.pdf*

IMPACTS GENERALLY ACCEPTED BY THE SCIENTIFIC COMMUNITY, BUT NOT YET SUFFICIENTLY SECURED EPIDEMIOLOGICALLY

There is an overall increase in cancers of the internal organs and skeleton due to the accumulation of radioactive decay products of uranium in various organs. Compare also the graph in Ch. 2.3. (page 15).

The *'Encyclopedia of Toxicity'* states in regard to uranium: "Note, however, that radon and radium, present together in uranium ore are unequivocally associated with cancer." (Chapter on uranium, paragraph on carcinogenicity)

Source:

> **Radium in the environment: exposure pathways and health effects,** by Doug Brugge and and Virginia Buchner, Rev Environ Health 2012;27(1):1–17, 2012 by Walter de Gruyter, Berlin, Boston. DOI 10.1515/reveh-2012-0001 Elsevier Inc., Academic Press, 2014:883–884

Both diseases originate from high exposure to uranium. The impacts are due to its toxicity as a heavy metal. Uranium is excreted from the body only very slowly and can accumulate there. The hypothesis that negative impacts also occur at low exposures to uranium could not be confirmed.

The '*Encyclopedia of Toxicity*' states:

"It is proven in animal studies that uranium causes damage to the proximal tubules of the kidney, making this organ a primary target for uranium's biological effects."

Further readings:

> **Renal Effects and Carcinogenicity of Occupational Exposure to Uranium: A Meta-Analysis,** by Leonhard Stammler, Andreas Uhl, Benjamin Mayer, Frieder Keller in: Nephron Extra 2016;6:1–11, DOI: 10.1159/000442827, Published online: February 11, 2016

Uranium in the bones

"In the body, uranium acts similar to calcium, but it is poorly absorbed from the intestines. It is deposited in bone where it can be relatively well retained, with 80 – 90 % removal in 1.5 years." *(Encyclopedia of Toxicity)*

A fraction of the uranium is used by the body like calcium and deposited in the bone. It may remain in the bones for years. In this case, the uranium in the bones will irradiate the bone marrow, which is crucial for the blood-building process and can affect it negatively. Diseases of the blood (leukemia) may follow.

(Note that uranium miners and workers are, in most cases, not only exposed once to uranium, but often continuously over many years.)

Uranium Toxicity

As mentioned before, uranium is also a heavy metal and thus toxic (poisonous) to humans.

"Studies, mostly in cell lines, are quite recent, but show that uranium compounds are capable of causing up- and downregulation of many genes, including genes for calcium release channels and cytokines, and others involved in bone resorption, liver detoxification, mitochondrial metabolism, and DNA double strand break repair." *(Encyclopedia of Toxicity)*

Genotoxicity

Genotoxicity means that an element (such as uranium) can have negative impacts on reproduction in various ways. One of the impacts may damage the DNA (the genes), which may then be passed on to the next generation.

"Numerous studies in humans, animals, and cell lines have shown uranium is genotoxically active, probably mostly through its heavy metal properties. Among the findings are increased micronuclei, sister chromatid exchanges, chromosomal aberrations, abnormal sperm, increased comet tail length, genomic instability, transformation of cells, oxidative damage to DNA, DNA adducts, and others." *(Encyclopedia of Toxicity)*

Although the impacts mentioned here are not outright diseases, they will definitely have an implication for health and reproduction.

"Reproductive and Developmental Toxicity

Evidence in mice shows that uranium is a developmental toxicant, causing decreased fertility, increased number of deaths at birth and day 4 of lactation, teratogenicity, and reduced growth. There is also evidence of a decreased fertility in exposed male mice." *(Encyclopedia of Toxicity)*

11.3. Uranium, Women and Children

Exposure of women to uranium and radiation

The situation of women in connection with uranium, uranium mining and radiation exposure is often neglected. Indeed, both mining and research on the uses of uranium in nuclear weapons or nuclear power plants is mainly a male domain.

Women have also been involved in different ways, however.

Dine (Navajo) uranium miners used to take their clothes which were covered with dust from the uranium mines to their homes, where the women would wash them, thus carrying the radioactive contamination right into their homes where children might come into contact with the radioactive dust. As far as we know, miners in other countries also took their clothes home to be cleaned by the women.

Although these practices were later discontinued, the harm was already done.

In rare cases, women would also work in mines, sometimes driving mining trucks or working on other jobs on mine sites.

In many situations, families live in the vicinity of the mines and / or tailings, and women and children are exposed to radiation via dust, air, and water. Mining towns such as Arlit and Akokan in Niger or Arandis in Namibia were specifically built in previously uninhabited areas; miners live there with their families for many years, sometimes most of their lifetime, with the risk of exposure to radiation for all members of the family. In the US, in Canada and in former East Germany uranium mines were sometimes placed next to villages.

Higher Sensitivity of Women in regard to radiation

Moreover, the fact that women – and the unborn – are much more sensitive to radiation is widely ignored. Radiation dose limits use a middle-aged male as a point of reference, while women were disregarded until recently. It was only in the year 2000 that a study took the gender difference into account. Since then, it has slowly been accepted that women are approximately twice as susceptible to developing cancer or other radiation related diseases than are males.

The unborn child within the woman's body may also be seriously at risk. Possible impacts might be miscarriages and stillbirths, low birth weight of newborns, higher infant mortality, malformations, mental retardation, Down syndrome and childhood diseases.

Source/Further readings:

- **Spricht man(n) über Uran, bleiben Frauen unsichtbar,** by Angelika Claussen, published in STANDPUNKTE of Rosa Luxemburg Stiftung 6/2019
  www.rosalux.de/fileadmin/rls_uploads/pdfs/Standpunkte/Standpunkte_06-2019.pdf
  currently only available in German

Uranium in newborn – Dineh (Navajo)

In October 2019, new epidemiological studies on the health effects on Native American communities living near abandoned uranium mines were published. In them elevated levels of uranium were detected in the urine of newborns.

Dr. Loretta Christensen, Chief Medical Officer, Navajo Area Office of the Indian Health Service, stated before the US Committee on Indian Affairs on October 7, 2019:

"a. 36% of males and 26% of women in Navajo Nation have concentrations of uranium in the urine that exceed those found in the highest 5% of the U.S. population.

b. Some babies are born with concentrations of uranium at those extremes and exposures continue in the first year of life."

Sources and further readings:

- **America's Nuclear Past: Examining the Effects of Radiation in Indian Country,** Statement by Dr. Loretta Christensen, Chief Medical Officer, Navajo Area Office, Indian Health Service, U. S. Department of Health and Human Services before the US Committee on Indian Affairs, Oct 7, 2019
  www.indian.senate.gov/sites/default/files/10.07.19%20Dr.%20Christensen%20IHS%20Testimony%20on%20Radiation%20in%20Indian%20Country.pdf
- **Mining and Environmental Health Disparities in Native American Communities,** by Johnnye Lewis, Joseph Hoover and Debra MacKenzie, published in: Curr Envir Health Rpt (2017) 4:130–141, DOI 10.1007/s40572-017-0140-5
  https://link.springer.com/content/pdf/10.1007%2Fs40572-017-0140-5.pdf
- **A brief introduction and overview to health impacts: IPPNW – Fact Sheet Uranium Mining: Health Effects of Uranium Mining**
  www.ippnw.org/pdf/uranium-factsheet4.pdf
- **Impacts of Mining-related Pollutants on Human Health,** by Jacques Diezi, Günter Baitsch and Thomas Niederberger in: The open cut-mining, transnational corporations and local populations, edited by Thomas Niederberger, Tobias Haller, Helen Gambon, Madlen Kobi and Irina Wenk
  https://d-nb.info/1116610108/04
- **Health effects of uranium: new research findings,** by Doug Brugge and Virginia Buchner, in: Rev Environ Health 2011;26(4):231–249, 2011 by Walter de Gruyter, Berlin, Boston. DOI 10.1515/REVEH.2011.032
  www.ncbi.nlm.nih.gov/pubmed/22435323
- **„Lung cancer risk among German male uranium miners: a cohort study, 1946 -1998",** Grosche B et al., Br J Cancer, 2006 Nov 6;95(9):1280-7
  www.ncbi.nlm.nih.gov/pmc/articles/PMC2360564
- **„Lung cancer in Radon-exposed miners and estimation of risk from indoor exposure",** Lubin JH et al., Journal of the National Cancer Institute 1995, 87 (11) 817-827
  www.ncbi.nlm.nih.gov/pubmed/7791231
- **„Mortality from lung cancer in Ontario uranium miners",** Kusiak et al., Br J Ind Med 1993;50:920-928
  www.ncbi.nlm.nih.gov/pmc/articles/PMC1035522/pdf/brjindmed00010-0056.pdf
- **„Uranium Mining and Lung Cancer Among Navajo Men in New Mexico and Arizona",** Gilliland et al., J Occup Environ Med 42(3):278-283, March 2000
  www.ncbi.nlm.nih.gov/pubmed/10738707
- **„Radon daughter exposures at the Radium Hill uranium mine and lung cancer rates among former workers, 1952-87",** Woodward et al., Cancer Causes and Control 2:91
  www.ncbi.nlm.nih.gov/pubmed/1873450
- **„Unexpected Rates of Chromosomal Instabilities and Alterations of Hormone Levels in Namibian Uranium Miners",** Zaire et al., Rad Res 1997 May;147(5):579-84
  www.ncbi.nlm.nih.gov/pubmed/9146703
- **„Mortality (1950 – 1999) and Cancer Incidence (1969 –1999) in the Cohort of Eldorado Uranium Workers",** Rachel et al., Radiation Research, December 2010, Vol. 174, No. 6A
  https://bioone.org/journals/radiation-research/volume-174/issue-6a/RR2237.1/Mortality-19501999-and-Cancer-Incidence-19691999-in-the-Cohort-of/10.1667/RR2237.1.full
- **„Radioactive contamination around Jadugoda uranium mine in India",** Koide H., Research Reactor Institute, Kyoto University, 8.7.02
  www.rri.kyoto-u.ac.jp/NSRG/genpatu/india/JADFINAL.pdf
- **„Ionising radiation and risk of death from leukaemia and lymphoma in radiation-monitored workers (INWORKS): an international cohort study",** Leuraud K et al., The Lancet Haematology, Volume 2, Issue 7, e276 – e281
  www.ncbi.nlm.nih.gov/pubmed/26436129
- **„Risk of cancer after low-doses of ionising radiation: retrospective cohort study in 15 countries",** Cardis E et al., BMJ 2005; 331:77
  www.ncbi.nlm.nih.gov/pubmed/15987704
- **„Residential radon and risk of lung cancer: a combined analysis of 7 North American case-control studies",** Krewski D et a., Epidemiology 2005 Mar; 16(2):137-45
  www.ncbi.nlm.nih.gov/pubmed/15703527

CONCLUSION

Health impacts of uranium mining are serious, and often show up only many years after exposure. As time goes by, more health impacts show up and are recognized as caused by exposure to uranium and its decay products.

There are few, if any, comprehensive health studies on the impacts of uranium mining. This holds true specifically for people living in the vicinity of mines and tailings and for the families of miners and workers.

Most studies have been conducted in western industrialized countries. Uranium mining impacts in Africa, South America and other countries in the 'Global South' have rarely been researched (except India), leaving people in those countries in an even worse and unclear situation.

C H A P T E R **T W E L V E**

Narration

Governments and companies often argue that uranium mining will bring jobs and thus prosperity to a country or region. Governments argue the country would profit in terms of taxes and royalties paid by the mining companies.

A look at Niger, one of the African countries where uranium has been mined for over 40 years, shows that this has not been the case in the long term: Niger ranged among one of the five poorest countries in the past – after 40 years of uranium exploitation by majority French-owned companies, Niger still ranges at the very end of the Human Development index.

ALMOUSTAPHA ALHACEN (INTERVIEW – TRANSLATED)

The uranium mining was supposed to offer a solution to poverty. But unfortunately after forty years we have to conclude is that these problems have only increased.

People are not afraid. That's because they do not know what radioactivity is. The priority for people here really is poverty. Even so, people should not loose sight of this problem. Radioactivity increases poverty because it creates victims.

ABDOURAHAMANE MAOULI (INTERVIEW)

Mayor of ARLIT, Uranium mining town in Niger

In my case if today for example a company like AREVA comes and wants to open a new mine i would probably say no because my experience is that they do not manage the bad consequences for the environment and the population.

ALMOUSTAPHA ALHACEN (INTERVIEW – TRANSLATED)

As you will have noticed the wildlife has disappeared. The plant life around the village of Arlit is gone too. This may indeed be a desert country but even the desert has some trees. So the legacy for us is enduring pollution.

DR. RIANNE TEULE (INTERVIEW)

Greenpeace Radiation expert

Within a few days we found that people of those villages are exposed to uneacceptable high levels of radiation, caused by radioactive materials in the street, radioactive scrap metal in the market. And it clearly shows that the mining companies owned by AREVA are not taking care of the promise.

Narration

Soil and water samples taken by Greenpeace were investigated by the French Nuclear Research Institute CRIIRAD in Valence. It´s findings further confirmed the radioactive contamination in the region of Arlit

BRUNO CHAREYRON (INTERVIEW)

The analyses we have performed shows that the uranium contamination in four out of five water samples is exceeding WHO limits. Furthermore we found evidence of Radon, a radioactive gas dissolved in water. And then, there is the pollution by chemicals elements such as nitrates, ammonia and molybdenum at levels which again exceed WHO limits. Even so, this water is still being distributed to the population and the workers for consumption.

12. Social and Cultural Impacts

12.1 Social Impacts of Uranium Mining in History

Social impacts from uranium mining have many different facets, depending on the country and the era. The impacts are often long-lasting since uranium mines leave a serious legacy.

During World War II, and for some time afterwards, uranium was mainly mined for the nuclear weapons programs of the United States, the USSR (Russia), as well as France and England, later on (→ Ch. 4.).

Due to the military use of uranium, uranium mining was shrouded in secrecy and health issues were hardly taken into account. The most important thing was to mine as much uranium as quickly as possible.

Some of the secrecy around uranium mining still prevails today.

In the German Democratic Republic (East Germany) uranium was mined for the USSR nuclear weapons program. At the time, the region of the Erzgebirge ("Ore Mountains", → Ch. 4.3.) was the only area where the USSR had located considerable uranium deposits. These were exploited by the Soviet (East-)German cooperation company, SDAG Wismut, a cover name to avoid mentioning the word uranium.

In the years after 1945, whoever was able to work underground was hired. So prisoners were urged to work in the mines as well, in the GDR as well as in neighboring Czechoslovakia.

Further Readings:

> **Uranium Mining in Eastern Germany: The WISMUT Legacy** by Peter Diehl
www.wise-uranium.org/uwis.html

> **Bundesamt für Strahlenschutz,** English literature:
www.bfs.de/DE/bfs/wissenschaft-forschung/projekte/wismut/publikationen.html

Working conditions in the mines lead to hundreds of cases of lung cancer and other radiation-related diseases as well as to typical miners' diseases such as silicosis. After the reunification of the GDR (East Germany) with West Germany/Federal Republic of Germany (FRG) in 1990, a number of miners became eligible for compensation.

The German Radiation Protection Agency (BfS – Bundesamt für Strahlenschutz) conducted a number of studies on the former Wismut uranium miners and workers (see link below).

Film:

> **Der Uranberg,** 2011, 1h20min, German
www.filmstarts.de/kritiken/189094.html
[Although a fiction, not a documentary, the film draws an interesting picture of the situation in the first years of uranium mining in East Germany/GDR after World War II.]

During World war II, and up to 1960, the US imported uranium from Shinkolobwe mine in Congo (→ Ch. 4.3.). Later on, the US Government fixed a comparatively high price for uranium, instigating many people – mining experts or not – to seek for uranium, mainly in the Southwest US. A "uranium rush" ensued as boomtowns based on uranium mining went up. Most of the prospectors did not make a fortune however but lost their money instead.

When the US Government realized that it had enough uranium at hand to build nuclear weapons, the policy of buying uranium at a high, fixed price was abolished and the boomtowns collapsed.

One example is the town of Uravan in the Southwest US. Here uranium was mined together with vanadium (which gave the town its name). The homes were partially built with rocks from tailings – and therefore radioactive. When the uranium boom declined, the town was abandoned and later scrapped completely since radioactive contamination was so bad that it was beyond repair.

Further Readings:

> **Uravan, Colorado,** by Jason Zasky, Nov 21, 2012
http://failuremag.com/article/uravan-colorado

> **Uravan: The Uranium Town That Was,** by Dan Boyce Dan Boyce, August 31, 2017
http://insideenergy.org/2017/08/31/uravan-the-uranium-town-that-was

> **The Uranium Widows, Why would a community want to return to milling a radio-active element?,** The New Yorker, by Peter Hessler, September 6, 2010
www.newyorker.com/magazine/2010/09/13/the-uranium-widows

Film:

> **Colorado Experience: Uranium Mania,** Nov 2, 2017
www.youtube.com/watch?v=zUF4fljsPQ8

Narration

But it's not that it only ends in catastrophic conditions in countries like Niger. Also the population in South Africa or even countries like the US have got to feel fatal consequences by the uranium mining in their country. Damage to health and social consequences can hardly be separated, as damaged health usually also causes economic problems for those affected, including their families.

STEPHANIE MALIN (INTERVIEW)

Even in a democratic country like the United States there have been such issues here with communities treated horribly. There is the Radiation Exposure Compensation Act or RECA that has covered and compensated some people who were miners or millers or downwinders – but there has been contestation that that has covered everyone, especially in terms of Navajo women who might be widowed. There were things that they had to proof, that they had to provide that they have been married, for example, that just did not jive with their life ways and their cultural norms, things like marriage certificates …

So there are lots of ways, in which the legacies, even with RECA and compensation, those have not been adequately addressed. I already mentioned the abandoned uranium mines: there are sites that are half cleaned up, there are enormous tailings piles next to the Colorado river in Moab. So this is an ongoing project, each of these sites costs multimillion dollars if not billion dollars, at least a billion dollars to clean up.

There are ongoing, unremediated abandoned sites that are leading to this exposure, and just like with other communities during the uranium boom, these communities were encouraged to build parts of their towns out of the uranium tailings, the waste from the mining process and the milling process. So there are many areas that are still heavily contaminated and radioactive because hogans or homes were built out of that material at the advice of officials sometimes.

It's very controversial … to be in a position to say, to discourage communities from developing this area because the folks who would like to see … and the firms who would like to see that development to occur, are quite powerful. Not just this firms but the state, depending on the location, can use what we call in sociology environmental blackmail. They can say exactly what you are describing: We need that extractive industry to

develop in your community or this waste site or whatever and it will bring jobs and it will bring prosperity and so you have to choose it, right?

And it is in these areas that are often prone to poverty and so they are vulnerable to that sort of argument; and this boom-bust-prone extractive economies are not going to provide the sustainable long-term even development that these communities are being promised.

Narration

In a global context, this situation applies for developing countries: In order to get out of their poverty situation, they are encouraged and finally coerced into accepting extractive industries and conditions which would never be accepted and applied in well-to-do Western countries.

In Canada the uranium boom started with Eldorado's finding uranium at Great Bear Lake (→ Ch. 4.3.). In 1949, uranium was discovered in the Lake Athabasca region, sparking intense mining activities. By 1960, the state-owned company Eldorado started to build a town with all facilities and services. It was called Uranium City and was situated on the North shore of Lake Athabasca, in Canada's province Saskatchewan. The town grew to a 5 – 6,000 population and comprised a school, a hospital and other facilities.

In 1982, the mines closed – and the population diminished very quickly from over 4,000 inhabitants to 50. The mines and their tailings were left behind without any rehabilitation.

The uranium mining boom had not brought a stable or sustainable economic development for the area – it was a boom-and-bust-story, leaving behind masses of radioactive tailings as well as people struggling to make a living.

Film:

> The Lesson: The Traumas and Futures of Uranium City, Canada,
www.youtube.com/watch?v=2LjS8QPPpkQ

Further Readings:

> Nuclear Avenue: "Cyclonic Development", Abandonment, and Relations in Uranium City, Canada, by Robert Boschman and Bill Bunn, 2018, in Humanities 2018 7(1), 5
https://doi.org/10.3390/h7010005

The East German (GDR) uranium mining region fared slightly better. Here uranium mining was kept up for political reasons, although economically not profitable, until German reunification in 1990. With reunification, uranium mining was basically closed down – and the miners lost their jobs.

However, later, the German Government started to rehabilitate the mines and tailings in a 6 – 7 billion €, 20-year operation. Some of the former miners were – and some still are – employed in the mine rehabilitation work.

In Niger, uranium mining started in 1971. The company, French state-owned COGEMA (later renamed AREVA, and renamed again ORANO in 2018) promised Arlit would become a "second Paris".

Film:

> "Arlit – deuxieme Paris", by Idrissou Mora-Kpai, 2005, 1h18 min, available in English and French
https://vimeo.com/ondemand/arlitdeuxiemeparis
www.youtube.com/watch?v=1A0vV3Zjz0c

Further Readings:

> Paris, deuxieme Paris, Arlit: Deuxieme Paris (Article in English)
http://newsreel.org/video/arlit-deuxieme-paris
https://filmthreat.com/uncategorized/arlit-deuxieme-paris

In fact, the mining town flourished for a short time due to the high price of uranium. Then, in the late 1970s, the price went down and the economy of Arlit crumbled. The mining towns of Arlit and Akokan had grown to a population of an estimated 100 – 120,000.

After laying off hundreds of workers, AREVA/ORANO, as of mid-2019, has now (October 2019) announced the closing one of its two Niger mines (Akouta), laying off more workers again.

Overall, Niger was one of the poorest countries when mining started in the early 1970s – 40 years later, it is, still one of the poorest countries according to the UN Human Development Index (HDI). In the UN HDI 2018 up-date, Niger is last in the ranking of 189 states in the World.

Source:

> *United Nations Development Program*
http://hdr.undp.org/en/2018-update

Further readings:

> A forgotten community: The little town in Niger keeping the lights on in France, by Lucas Destrijcker & Mahadi Diouara, July 18, 2017
https://africanarguments.org/2017/07/18/a-forgotten-community-the-little-town-in-niger-keeping-the-lights-on-in-france-uranium-arlit-areva

In Namibia, miners were – and are – also concerned about the health impacts of their work. In the early 1990s, medical research was done and results published in "Past exposure: revealing health and environmental risks of Rössing Uranium".

A court case against Rössing and its mother company Rio Tinto, London, followed. Several miners fought for compensation of health damages but in the end the court cases did not succeed, mainly due to formalities.

The Windhoek-based LaRRI – Labour Resource and Research Institute investigated the miners social situation in 2009 and the results were published in a study: "URANIUM MINING IN NAMIBIA - The mystery behind 'low level radiation'".

The social situation of miners who fell sick after having worked for Rössing is disquieting.

Further readings:

> Past exposure: revealing health and environmental risks of Rössing Uranium, by Greg Dropkin (Author), David Clark (Author), 1992

> Uranium mining in Namibia – The mystery behind 'low level radiation', b< Hilam Shindondola-Mote / LaRRI, 2009
https://uranium-network.org/wp-content/uploads/2019/01/2009.pdf

12.2. Social Impacts of Uranium Mining

The social impacts of uranium mining are multi-faceted, as mentioned above. They are often interconnected and sometimes hard to separate from one another. Due to the wide range of impacts, we highlight some of the aspects below.

SOCIAL IMPACTS RELATED TO HEALTH IMPACTS

Health impacts (→ Ch. 11.) often lead to social impacts, affecting and often impoverishing the families.

• In some cases, miners or mill workers experience deteriorating health. Diagnosis is difficult since access to medical files is not easy for them and is sometimes even denied. In addition, hospitals run by the mining companies obviously have no doctors on staff who are authorized to diagnose occupational diseases. In this case there is no acknowledgement of the disease as 'occupational' – and hence no compensation.

• In other situations, mine workers undergo annual health check-ups and are either declared "fit for work" or "not fit", with the second scenario leading to dismissal. Whereas the mining company previously took care of the workers' medical bills, they will now receive a pension – but then will have to take care of their medical bills themselves, often putting them and their families in a worse situation than before. (Rössing Mine, Namibia)

Source:

> Left in the Dust – AREVA's radioactive legacy in the desert towns of Niger,
by Greenpeace, April 2010
www.greenpeace.org/archive-international/Global/international/publications/nuclear/2010/AREVA_Niger_report.pdf

> Abandonnés dans la poussière – L'héritage radioactif d'AREVA dans les villes du désert nigérien, (French)
https://www.greenpeace.org/archive-international/Global/international/publications/nuclear/2010/LeftinthedustF.pdf

INDEPENDENT (SUBSISTENCE) FARMERS BECOME DEPENDENT WAGE LABORERS

In some situations, independent (subsistence) farmers start working in the mines and become dependent wage laborers. Although they may earn more cash money, the change is profound.

They become dependent on their employer, often a transnational mining company which will hire – and fire – according to world market prices and the demand for commodities.

As history shows (→ Ch. 13.1.), the uranium market is very volatile Major changes in price can happen overnight, leaving workers without jobs or any source of income.

And if they decide to go back to farming etc., they may find their land is gone or contaminated.

The Dominion Reefs Uranium Mine (DRUM) in South Africa is an informative example of promises of prosperity given – and broken.

Says a community organizer: "We want work, but we want our health also. In the past, we had land for our children. Now we don't have anything. The mine has taken our land and contaminated our water."

In November 2007, government inspectors called on Uranium One "to halt all mining operations" until minimum legal health and safety precautions could be met.

The company responded by firing all workers, 1,400 persons (!), and sold the mine.

Source:

> Uranium Company Accused of "Killing Communities" in South Africa,
by John Ahni Schertow, March 8, 2009
https://intercontinentalcry.org/uranium-company-accused-of-killing-communites-in-south-africa

Source:

> Uranium Mining Nightmare Story,
http://klerksdorpaction.blogspot.de/2011/03/uranium-mining-nightmare-story.html

The company who had run DRUM, Uranium One, then went to Tanzania, where it got a share in the controversial Mkuju River Uranium Project and was finally bought up by ROSATOM's ARMZ.

In other situations, people are afraid to lose their land – their main basis of existence – be it farming, cattle raising, fishing (as in the Bahi region of Tanzania, in Falea/Mali (→ Ch. 6.1. and → Ch. 6.2.) or in hunting and gathering food (e.g. in the area of Northern Saskatchewan, Canada).

AN IMBALANCE OF INFORMATION

People in local communities often lack knowledge and experience in regard to radioactive materials and the dangers of radiation. Companies (and sometimes governments) are, to some extent, aware of the risks, but do not necessarily share their knowledge.

Thus, people may be lured into risky jobs without being aware of the dangers to their health.The long latency period of radiation-induced diseases such as cancer, leukemia etc. (10 – 20 years) aggravates the problem.

IMPACT OF URANIUM MINING ON INDIGENOUS PEOPLES

Indigenous peoples throughout the world are heavily impacted by uranium mining: In many cases, uranium is mined on indigenous peoples' lands or is affecting them seriously, be it in the US, Canada, Australia or India.

Besides the social impacts described above, the inroads by uranium exploration and mining are sometimes seen by indigenous peoples as a continuation of colonization.

A 'clash of cultures', of world views ensues. In addition to already-mentioned impacts, the culture and the way of life of indigenous peoples are put at risk.

For example, their traditional means of subsistence – in the North of Canada, hunting, trapping and fishing, in Africa, agriculture and cattle raising – are put in danger by mining operations taking away land or contaminating rivers and/or aquifers and drinking water.

The culture and way of life of indigenous peoples are in danger in a variety of ways. Their traditional understanding of land, land ownership and land use (→ Ch. 6.) is being gravely disregarded and violated. And this contributes to social problems.

The 1992 WORLD URANIUM HEARING in Salzburg, Austria, focused on the impacts of uranium mining on indigenous peoples. The minutes of the Hearing, "Poison Fire, Sacred Earth" are available on internet.

Further readings:

> Voices from Wollaston Lake: Resistance against Uranium Mining and Genocide in Northern Saskatchewan,
by Miles Goldstick, page 38

> Becoming Oníkânîwak: Defending Nehithaw-Askiy from Saskatchewan's Uranium Industry, by Kirstin Scansen, page 38
https://pdfs.semanticscholar.org/32d2/09e8fcb64a5f734f83bc10bd7addfedc064b.pdf

> Cold war colonialism: The serpent river first nation and uranium mining, 1953-1988,
by Lianne C. Leddy, Dissertation, 2011
https://central.bac-lac.gc.ca/.item?id=NR81496&op=pdf&app=Library

> This Is My Homeland : Stories of the Effects of Nuclear Industries by the People of Serpent River and the North Shore of Lake Huron, by Lorraine Rekmans, Keith Lewis, Anabel Dwyer (Editors), 2003

> Nuclear genocide in Canada,
by Pat McNamara, 2014
www.porthopehistory.com/nucleargenocide/nucleargenocide_index.htm

> Poison Fire, Sacred Earth
https://ratical.org/radiation/WorldUraniumHearing

Films:

> "Uranium", by Magnus Isaacson, published by the National Film Board of Canada, 1990, 48 min
www.nfb.ca/film/uranium

> "Uranium Thirst", by Norbert G. Suchanek & Marcia Gomes de Oliveira, 2010, 27 min, English with German subtitles
www.business-humanrights.org/sites/default/files/media/uranium-film-festival-berlin-programm-2012-english.pdf

INFLUX OF 'OUTSIDERS'

In other cases, people fear the influx of workers from 'outside', people who earn good money at the mines, fearing that they might easily influence young girls and women in the local communities by luring them into 'inappropriate sexual behavior' (prostitution).

The danger of women being outright raped is also a concern.

12.3. Compensations for Uranium Miners and Workers

UNITED STATES

> Radiation Exposure Compensation Act (RECA), USA
www.justice.gov/civil/common/reca

In the film, Stephanie MALIN refers to the Radiation Exposure Compensation Act (RECA), a law in the US which provides for compensation for health damages to uranium miners, mill workers and downwinders (people who were exposed to radioactive fallout from the US nuclear weapons tests). The law came into power in 1990, after year-long struggles. Under certain circumstances, it provides for a compensation for uranium miners and mill workers of US$ 100,000 per person.

The law – which is basically positive since it provides for compensation – has a number of challenges and shortcomings. By April 2018, 691,624,560US$ had been paid to 8,494 uranium miners, mill works and ore transporters.

Source:

> US Department of Justice,
Compensations paid according to RECA
www.justice.gov/civil/awards-date-04192018

GERMANY

At one point in time up to 500,000 people worked in the GDR (East German) uranium mines of SDAG WISMUT. But after the wall had come down in 1990 (reunification of East and West Germany), only 165,000 could still be tracked. 31.000 cases of occupational diseases had been recognized in the GDR (East Germany) before 1990. After 1990, the FRG (West Germany) dealt with the legacy. Thus between 1990 and 2012, an additional 7,800 cases of occupational diseases were recognized. The total expenses 1990 – 2012 for diagnostics, therapy and compensations were 950 million € (by 2012).

Source:

> Entschädigung in Milliarden-Höhe für frühere Wismut-Kumpel
www.derwesten.de/gesundheit/entschaedigung-in-milliarden-hoehe-fuer-fruehere-wismut-kumpel-id6608178.html

Former miners are often dissatisfied by the compensation regulations because their health problems are sometimes not acknowledged as an occupational diseases, and hence, compensation is denied. Unlike in the US, compensation matters are dealt with by the German 'Berufsgenossenschaften,' an Employers' Liability Insurance, supported by the Federal Government.

Further readings:

> WISE Uranium Project > Uranium Mine and Mill Workers - Current Issues
www.wise-uranium.org/uim.html

12.4. "Environmental Blackmail" Coercion into accepting risky projects

As Stephanie MALIN highlights in the interview (in the film) and in her book (→ Further readings), people in poor towns or areas are sometimes coerced into accepting projects dangerous to the environment and to their health when told that the project in question is "the only game in town", their only chance to evade poverty.

The issue of 'environmental blackmail' is discussed by sociologists dealing with environmental issues and described as "... 5. the environmental blackmail that arises when workers are coerced or forced to choose between hazardous jobs and environmental standards".

Further readings:

> The Rise of the Environmental Justice Paradigm – Injustice Framing and the Social Construction of Environmental Discourses,
by Dorceta E. Taylor, University of Michigan in American Behavioral Scientist, Vol. 43 No. 4, January 2000 508-580
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.452.7534&rep=rep1&type=pdf

> The Price of Nuclear Power: Uranium Communities and Environmental Justice,
by Stephanie A. Malin, 2015, New Brunswick: Rutgers University Press, ISBN 978-0-8135-6978-9

Whereas Stephanie MALIN observed this phenomenon in the Southwest US (and documented it in her book), and Dorceta T. TAYLOR applies it to individual workers, the same applies on a global level:

Poorer countries in the 'Global South', such as those in Africa or South America, are at times coerced into accepting extractive industries, such as uranium or gold mining, oil exploitation etc. as the 'only way' to alleviate their poverty situation and to 'develop'.

Often, the contrary is the case. **Prosperity promised by mining companies, and sometimes by governments, does not materialise or happened only in a short 'boom', followed by a 'bust'. Clearly, sustainable development has not taken place**.

12.5. The "bad old days" and the "better new days"

Sometimes, the uranium industry points out that ... yes, in the 'bad old days' of uranium mining, things were not very good (for the health of workers and the environment) but today, things are much better ...

In fact, some of the health and social impacts go back to the 'Cold War', which followed World War II, when uranium was mined for nuclear weapons with little regard for miners' health or the environment. By now, in Central European countries, in the US and Australia, strict regulations for uranium mining have come into force. One of the consequences of the mining companies was to move to Africa. John Borshoff (at the time CEO of PALADIN) puts it clearly:

"Australia and Canada have become overly sophisticated. (...) but I think there has been a sort of overcompensation in terms of thinking about environmental issues, social issues, way beyond what is necessary to achieve good practice."

Source:

> John Borshoff's statement at the Joint Standing Committee on Foreign Affairs, Defence and Trade Reference: Australia's relationship with the countries of Africa,
Thursday, 6 may 2010, Melbourne
https://parlinfo.aph.gov.au/parlInfo/download/committees/commjnt/12858/toc_pdf/7599-2.pdf;-file-Type=application%2Fpdf#search=%22committees/commjnt/12858/0004%22

Paladin has developed a NEW mine, Kayelekera, since around 2000 – in the 'better new days'.

The track record of the mine, its development, its closure (referred to as 'putting the mine on care and maintenance'), and finally its intended sale (in 2019), are problematic:

The initial Environmental Impacts Statement would not have passed in Australia (Paladin's country of origin) and the objections of NGOs before the start of the mine were brushed aside. During construction works, two workers died of burns, while others were killed in accidents at the mine. Repeated strikes, due to bad payment and bad working conditions, occurred while striking workers were fired upon with teargas by the police. And at some stage the mine's packaging plant had to be relocated due to a landslide.

In 2014 the mine was closed, temporarily at first. Environmental problems ensued, drinking and surface water were endangered. A nearby river showed high concentrations of uranium in spite of a zero-effluent policy on the part of the mine. Nevertheless, the company announced later on plans to release wastewater into this river, again, a risk of contamination

By the winter of 2017/2018, Paladin was barely evading bankruptcy. The company promised it would rehabilitate the Kayelekera mine but sold the mine in June 2019 to another Australian company – with no reclamation work done at all. A US$ 10 Million bond which Paladin had deposited with the Malawian government to cover the costs of reclamation was returned to Paladin when the mine was sold, thus exonerating the company of any responsibility to reclaim the mine.

Source and Further readings:

> WISE Uranium Project > Malawi
www.wise-uranium.org/umopafr.html#KAYELEKERA

> Australian uranium miner goes bust – so who cleans up its mess in Africa?, by Morgan Somerville and Jim Green, Wednesday, Nov. 8 2017
https://onlineopinion.com.au/view.asp?article=19394&page=1

The reclamation of the tailings and the plant, which has by now (2019) been out of service for 5 years remains unclear.

The chances are that the mine and its tailings will be the latest addition to uranium mines not-reclaimed in Africa – putting a new long-lasting source of contamination on the map.

12.6. Uranium Mining and Human Rights

The social and cultural impacts of uranium mining are serious, with some qualifying as Human Rights violations. Uranium mining may violate the right to health (UN Universal Declaration on Human Rights: Art. 3 – Right to Life) as well as the right to social security, and economic, social and cultural rights (Art. 22).

Taking away the basic means of existence, such as land, may be seen as a violation of the UN Covenant on Economic, Social and Cultural Rights (→ Ch. 6.). The rights of Indigenous Peoples to their land and their culture may also be endangered (→ Ch. 6.).

Moreover, NGOs and individuals who are critical of or opposed to uranium mining developments in their countries may be threatened, attacked, incarcerated or otherwise oppressed - another Human Rights violation.

Source:

> United Nations – Universal Declaration of Human Rights
www.ohchr.org/EN/UDHR/Pages/Language.aspx?LangID=eng

> International Covenant on Economic, Social and Cultural Rights (UN)
www.ohchr.org/EN/professionalinterest/pages/cescr.aspx

> United Nations Declaration on the Rights of Indigenous Peoples
www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

CHAPTER THIRTEEN

13

13. Decommissioning and Tailings Management

13.1. Introductory Note

"Decommissioning" generally means that a machine or plant is withdrawn from service and eventually dismantled. In the case of uranium mines, the term is used to describe the dismantling of head frames (with underground mines) , the dismantling of the machinery of the uranium mill (e.g. ore crushers etc.) and other parts of the mill, as well as the selling of mining vehicles, caterpillars and other equipment, including taking down buildings.

Many of these are contaminated with radioactive dust or yellowcake and must be taken care of in an appropriate way to make sure contamination will not spread throughout the environment and put people's health at risk. The longevity of radioactive elements must be taken into account.

Decommissioning is a short term activity and ends after some months – once the mining equipment is dismantled and disposed of.

'Tailings management', however, refers to the handling of the tailings (→ Ch. 10.2.).

Tailings management deals with the long-term storage of radioactive and toxic mine waste. Given the long half-lives of some radioactive elements, tailings management needs to take into account time frames of many thousands of years, or longer. It continues for a long time after decommissioning. Terms such as remediation, rehabilitation and reclamation give rise to the impression that the impacts of (uranium) mining can be 'undone', so that a site could be 'restored' to its former conditions. This is wrong.

The impacts of uranium mining are, for the most part, irreversible (→ Ch. 6.2., → Ch. 8.1.) as well as long-lasting. Below we use the word "reclamation", for lack of a better term, with all the reservations indicated above.

In the face of the longevity of the radioactive elements (and the mass of tailings), the achievements can only be limited to damage control. The goal of 'managing tailings' is to keep them separated from the environment and from human activities for a very long time:

Storage of tailings should be 'safe' for time frames of several half-lives of the radioactive elements contained in the tailings. Given the half-lives (→ Ch. 10.2.), the time frame for safe storage of tailings is many thousands, if not hundreds of thousands of years. If Uranium (U-238) is taken into account – and traces of uranium will remain in the tailings – the time frame will be billions of years.

(Compared to high-level nuclear waste such as spent fuel rods (= used uranium fuel) from nuclear power plants, tailings from uranium mining give off less radiation in a certain period of time. However, they will give off radiation for an extremely long time.)

Further reading:

> WISE Uranium Project, > Uranium Mill Tailings Deposits > graph: Uranium Mill Tailings Activity Impacts from Uranium Mining and Milling
www.wise-uranium.org/uwai.html
Note: The scale on the horizontal axis is logarithmic: 1E+06 = 1 million year, 1E+09 = 1 billion years

13.2. Tailings Management

Further readings:

> **WISE Uranium Project** > Uranium Mill Tailings Deposits > links to the UMTRCA: www.wise-uranium.org/ulus.html

In the United States, due to the mass of tailings spread over several states, the problem was acknowledged after hard work from advocacy groups that led to legislation in 1978:
the Uranium Mill Tailings Radiation Control Act (UMTRCA).

Standards were set for the management of uranium mill tailings.

RECLAMATION OF URANIUM MILL TAILINGS DEPOSITS

To reclaim an uranium mill tailings pile according to principles of a safe long-term isolation, detailed investigations have to be performed in advance to assess the site.

In case the tailings pile presents an immediate hazard, then intermediate protective measures can be taken in parallel, such as installation of a cover against windblown dust, or collection of seepage waters. These measures, however, should not conflict with long-term measures to be taken later.

The site must be appropriate for tailings disposal from the view of geology and hydrology:

- *it should not be located on a geologic fault*
- *it should not be threatened by the risk of earthquakes*
- *natural impermeable layers should be present*
- *the site should not be located in the flood plain of rivers*
- *the phreatic level should be rather deep*
- *any seepage should not present a risk to ground water*
- *deposits of clay materials appropriate for lining and covering the deposit should not be located too far away*
- *the site should be remote from residential areas, and so on*

During investigation of the site, ground water flow has to be monitored, to allow development of computer based three- dimensional ground water models. These models can be used for prediction of effects of supposed or real contaminant releases. In some circumstances, it may become necessary to move all of the material to an intermediate storage place to allow for the installation of a liner below the final deposit. In some very unfortunate circumstances, it even may become necessary to move the whole material to a safer site for permanent disposal. This procedure was preferred at 11 sites in the U.S., involving a total of 14.36 million cubic meters of tailings.

To prevent seepage of contaminated water, a liner must be installed below the deposit in many cases, if no natural impermeable layer is present. Appropriate lining materials have to be selected. A multi-layer liner may become necessary.

To increase mechanical stability, the following management options may be applied:
dewatering of the sludge, smoothing of the slopes, and installation of erosion protection.

On top of the pile, an appropriate cover has to be installed for protection against release of gamma radiation and radon gas, infiltration of precipitation, intrusion of plants and animals, and erosion. This cover in most cases consists of several different layers to meet all requirements.

Moreover, the catchment, collection and treatment of seepage water is necessary to release purified waters to the surface water only.

In the long term however, water treatment should no longer be necessary.

Finally, it has to be determined if, and to what extent, contaminated material was used in the surrounding area for construction or landfill purposes. Such contaminated properties should be included in the reclamation program.

Source:

> **WISE Uranium Project**
www.wise-uranium.org/uwai.html
> scroll down

An appropriate tailings management concept will include tailings dam stability (→ Ch. 10.4.) and the control of tailings dams.

Water pumped from the area needs to be treated, radioactive elements must be removed (to a certain extent) before the water is released into creeks or rivers.

The problems around achieving a 'safe' storage of tailings over an extended period of time are obvious.

Although lawmakers are aware that tailings will be dangerous for a very long time, beyond existing human experience, the time frames which need to be taken into account legally have been reduced to 1000 years, 200 years, or 100 years respectively, differing from country to country. In most cases, companies operating an uranium mine and mill 'only' need to show that the containment of the tailings will last 100 or 200 years. Anything beyond this time horizon is not regarded.

Managing tailings according to the UMCTRA standards is a costly matter (→ Ch. 14.).

The US UMCTRA standards were partially used in the clean-up of German uranium mine tailings of former SDAG WISMUT in East Germany.

On an international level, there are no binding laws or regulations on how to manage tailings.

IAEA and other agencies operate with a concept of "best practice". "Best practice" means methods that are 'generally accepted' as "best", better than other methods.

Besides, radiation exposure after tailings management may not exceed the radiation dose limits fixed in the laws and regulations of the respective country. However, it is very difficult to evaluate situations 50 or 100 years down the line, let alone in a thousand or hundreds of thousands of years.

In fact, the burden of dealing with future problems with uranium tailings has been imposed, for the most part, on future generations.

13.3. Experiences with Tailings Management

Source:

> **WISE Uranium Project** > MAPS and STATS > select: Uranium Mill Tailings Inventory
www.wise-uranium.org/umaps.html
Mass of tailings per country and world total are shown.

Globally, there are about 2,352 million tons of uranium tailings.
What about the status of these tailings?

UNITED STATES

The US hold an estimated 235 million tons of tailings. It took several decades until reclamation of uranium mine tailings was started. Some uranium tailings have been reclaimed.

Example: Moab uranium mill tailings pile: The tailings pile is located close to the Colorado River, a source of water for cities in California. Thus it was decided to move the tailings (approx. 10 million tons) to another location. As of October 2019, ten years after start of moving the tailings, about 60% of the tailings have been moved to a safer location. Work will have to be continued for approx. 10 years more. Costs are expected to rise to 1 billion US$.

> **The United States Superfund**
www.epa.gov/superfund/what-superfund

The US government created in 1980 the 'Superfund' to deal with and pay for the clean-up of polluted and contaminated sites: If the polluter (often a company) cannot be found (sometimes, companies declared bankruptcy or dissolved otherwise), or is unable to pay, clean-up will be done and paid for by the state, i.e. by the taxpayer. Some of the uranium mine and mill sites have become 'Superfund' sites.

Source:

> **Uranium Mine Clean-up Movement Claims Victory, Vows To Go National,** by Talli Nauman, June 12, 2014
https://popularresistance.org/uranium-mine-clean-up-movement-claims-victory-vows-to-go-national

> **Clean Up The Mines!**
https://cleanupthemines.org

A comparatively small number of mines and tailings have been cleaned up, at considerable cost. A large number of mines (including exploration sites etc.) remain un-reclaimed. They continue to contaminate the environment, posing a risk to human health for generations to come. "More than 10,000 abandoned uranium mines have been identified across the United States, primarily in the West, and more than 10 million people live within a 50-mile radius of one, they said. According to the draft report to the U.S. Congress, the six states that have the most abandoned uranium mines within their boundaries are Arizona (416), Colorado (1,347), New Mexico (249), South Dakota (155), Utah (1,376), and Wyoming (319)."

CANADA

Canada has an estimated 202 million tons of uranium tailings, much of it in Ontario and Saskatchewan. A part of Canada's uranium industry was – and is – located in Northern Saskatchewan. With the downfall of the price of uranium in the early 1980s, the mines in the far North of the province were abandoned, in most cases, without any precautions or decommissioning.

It was not until 30 years later that the Province of Saskatchewan and the Federal Government started an attempt to clean up some of the mine and mill sites.

Source:

> **Saskatchewan Research Council (SRC), Gunnar Mine and Mill site**
www.src.sk.ca/project-cleans/gunnar-mine-and-mill-site

> **Saskatchewan, feds at odds over abandoned uranium mine remediation,** by Kyle Benning Global News , Posted June 4, 2019 8:16 pm
https://globalnews.ca/news/5353076/saskatchewan-feds-odds-abandoned-uranium-mine

> **Saskatchewan Research Council (SRC), Lorado Mill site**
www.src.sk.ca/project-cleans/lorado-mill-site

The Saskatchewan Research Council (SRC) advocated reclaiming mine sites. As of 2019, three sites have been reclaimed while many more are waiting. Former Gunnar Mine site, on the north shore of Lake Athabasca, southwest of Uranium City, was in operation from 1955-1963 and officially closed in 1964 with little to no decommissioning. Approx. 4.4 million tons of tailings were left. It took more than 50 years to start cleaning up Gunnar Mine.

Currently, the Province and the Federal government are in court about sharing the costs of clean-up for former Gunnar Mine; costs are estimated at Can$ 280 Mio.

The Lorado mill site is another example: "The mill operated from 1957 to 1960. Tailings were deposited adjacent to Nero Lake, with some flowing into the lake. (...) The volume of tailings produced is estimated to be 227,000 cubic meters, of which 50,000 cubic meters lie within Nero Lake. The exposed tailings cover approximately 14 hectares."

The mill site was cleaned up by 2016 – 56 years after closure. For newer mines (started in the 1980s and 1990s etc.) plans for reclamation were designed before the start of mining. Whether the funds set aside will be enough to pay for the reclamation of the mine sites is still to be seen.

FRANCE

France has an estimated 29,318 million tons of uranium tailings, spread over 210 sites in France. By 2001, the mines were exhausted and uranium mining in France stopped.

The reclamation of uranium mine and mill sites in France was in many cases insufficient; radioactive waste was disposed of improperly, and people were still exposed to radiation doses beyond the legal limits.

The situation is recorded in a 2009 documentary by France 3, "Uranium – Le Scandale de la France contaminee". French state-owned company AREVA (formerly COGEMA, now renamed ORANO), responsible for the mining activities, tried to block the broadcasting of the documentary by a court order, without success.

The current situation (2019) is far from satisfying, with radiation levels at some mine sites 10 – 50 times above background radiation in spite of reclamation activities.

Film and Further readings:

> **„Uranium – Le Scandale de la France conta-minee",** (French), Documentary film by France3, Pieces a Conviction
www.youtube.com/watch?v=-j2thGnU_lk

> **Les conséquences de l'exploitation de l'uranium en France,** (mostly in French), by CRIIRAD
www.criirad.org/actualites/uraniumfrance/somuranium-france1.html

Source:

> **WISE Uranium Project** > Decommissioning Projects France > General
www.wise-uranium.org/udfr.html#FRGEN

NAMIBIA/AFRICA

Namibia has approx. 300 million tons of tailings. Most of the tailings were generated by Rössing Uranium Mine, which was the only mine until 2010/2011 when other mines started to produce uranium (Langer Heinrich, Trekoppje, Husab). Impacts of and problems with Rössing's tailings are outlined in → Ch. 10.

Rössing mine is still operating, although a closure had already been foreseen. In 2019, China General Nuclear Power Holding Corporation (CNPGC) bought a majority share in Rössing from Rio Tinto, and CGNPC intends to operate the mine for another 10 years.

Tailings have already contaminated an aquifer. How a final long-term solution after closure of the mine will deal with this problem remains unclear.

NIGER/AFRICA

According to source WISE Uranium Project, there are 17. 2 million tons of tailings; other sources mention approx. 35 Mio tons of radioactive waste.

In Arlit, uranium mining started in the early 1970s. Tailings are dumped into the desert with little to no precautions and an underlying aquifer, the source of drinking water for the local people, is already contaminated. The liquid and slurry tailings dumped in the desert have developed a kind of 'crust' due to the dry climate. On one occasion, the company claimed that this 'crust' would be enough to protect the environment from the contaminants.

As of 2019, the company (AREVA, now re-named ORANO) is considering closure of one of its two Niger mines (Akouta). There are no plans known for reclamation of the mine and tailings.

Azelik mine, co-owned by a Chinese uranium company, was closed down in 2015 due to a poor financial situation – after about 3 years of producing uranium.

The state of tailings or reclamation is unknown.

Further readings:

> **Impact de l'exploitation de l'uranium par les filiales de COGEMA-AREVA au NIGER,** by CRIIRAD, en cooperation avec ONGs AGHIR'IN MAN et SHERPA
www.criirad.org/actualites/dossiers2005/niger/notecrii-radarlit.pdf
The CRIIRAD website contains additional documents

> **Left in the Dust – AREVA's radioactive legacy in the desert towns of Niger,** by Greenpeace, April 2010
www.greenpeace.org/archive-international/Global/international/publications/nuclear/2010/AREVA_Niger_report.pdf

> **Abandonnés dans la poussière – L'héritage radioactif d'AREVA dans les villes du désert nigérien,** (French)
https://www.greenpeace.org/archive-international/Global/international/publications/nuclear/2010/LeftinthedustF.pdf

Source and further readings:

> WISE Uranium Project > Gabon
www.wise-uranium.org/udafr.html#GA

> The inglorious legacy of COGEMA in Gabon – Decommissioning of the Mounana uranium mine and mill site
www.wise-uranium.org/udmoun.html

> Impacts de l'exploitation minière sur les populations locales et l'environnement, by BRAINFOREST, 2010 [BRAINFOREST is a local NGO in Gabon]

Film:

> Gabon: The impact of Areva's uranium mining, by France
www.youtube.com/watch?v=iw-igDQh8kY

GABON/AFRICA

Uranium tailings in Gabon amount to 6,5 Mio tons. A subsidiary of COGEMA (later AREVA, now re-named ORANO), COMUF, mined uranium in Gabon from 1928 to 1990. Tailings were dumped into a nearby river for most of the time of operation. Tailings are still in areas where people cultivate manioc (cassava) without reclamation.

SOUTH AFRICA

South Africa has approx. 700 million tons of radioactive tailings. Uranium was initially dug up unintentionally when mining gold and was discarded on tailings piles. Some tailings from these gold mines have uranium concentrations higher than some of today's uranium mines (!) (→ Ch. 8.7.). Most of the gold, and later on – uranium mine tailings have not been reclaimed in any way.

Source:

> WISE Uranium Project > South Africa
www.wise-uranium.org/udza.html

CENTRAL ASIA

In several countries of Central Asia, uranium had been exploited, mainly by the USSR: Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. After the disintegration of the USSR, the states became independent – and the catastrophic situation around the uranium mine tailings became apparent.

CONCLUSION

"In 2018, Resolving the legacy of uranium mining in Central Asia has become urgent. The countries with the support of the EU call for prompt and further action.
The international community is asked to provide assistance in resolutions adopted by the UN General Assembly respectively in December 2013 and in December 2018 as well as through numerous IAEA General Conference resolutions. Indeed, the UN resolution of December 2018 acknowledged that a number of States continue to have serious social, economic and environmental problems associated with former uranium mines. A repeated request was made for the international community to support the states of Central Asia in solving the problems."

Source:

> UN High Level International Forum on Uranium Tailings in Central Asia
www.undp.org/content/undp/en/home/presscenter/pressreleases/2009/06/29/governments-seek-to-avoid-radio-active-catastrophe-in-central-asia.html

> www.iaea.org/newscenter/news/high-level-international-forum-on-uranium-tailings-in-central-asia

Source:

> European Commission, International Cooperation and Development, People and Planet: Central Asia calls for International Solidarity, 8. May 2019
https://ec.europa.eu/europeaid/news-and-events/people-and-planet-central-asia-calls-international-solidarity_en

> Resolution adopted by the General Assembly on20December2018, on the report of the Second Committee (A/73/538/Add.11)
https://undocs.org/pdf?symbol=en/A/RES/73/238

It was not until 10 years later, that, in January 2019, the UN passed a resolution "The role of the international community in the prevention of the radiation threat in Central Asia".

Approx. 210 million € are needed to mitigate the impacts of former uranium mining. The European Bank for Reconstruction and Development, as well as the World Bank, provide financial support (Details on costs → Ch. 14.4. "Central Asia").

Uranium mine tailings must be rigorously kept separate from the environment for hundreds and thousands of years due to the longevity of radioactive elements. This requires diligent engineering, monitoring for an extended period time, and measures to ensure that the sites will be left undisturbed in the future.

A considerable part – most probably the majority – of uranium mine and mill tailings in the world have not been reclaimed properly, if at all.

In the industrialized western countries, such as the USA, Canada, Germany or France, reclamation only started 30 – 50 years after the mines were abandoned, with many mine sites still awaiting reclamation.

In the Central Asian countries mentioned above, very little remediation work was done. Now, institutions such as the World Bank or the European Bank for Reconstruction and Development are asked for funds.

In African countries, hardly any reclamation of uranium mine tailings has taken place so far.

13.4. Long term tailings Management, Future Generations and their Rights

In a paper, engineer Hans-Peter Schnelboegl, points out that due to the longevity of radioactive elements in uranium mine tailings, they will mainly affect, future generations:

"The effects of the uranium tailings will be particularly insidious. According to our estimates (Olympic Dam tailings), during the worst period some 150,000 years from now, the death toll for humans will be about 500 per year. These deaths will be spread out over thousands of kilometres, although they will be more concentrated in the region of the mine site. These large scales of time and space perfectly hide the dramatic death toll of many millions to billions of future humans from each of our uranium mines."

Source:

> Long-term Consequences of Uranium Mining, by Hans-Peter Schnelbögl, Diplom Ingenieur (not available on internet)

Schnelboegl in his paper points out that laws and licensing authorities in particular, as well as society at large, are blanking out the impact of today's activities on future generations. It is simply not being taken into account. Laws and licensing authorities cut off the time horizon in question after 100 or 200 years. Future generations are left to deal with the legacies of today's uranium mining.

At the "Nuclearisation-of-Africa"-conference 2015 in Johannesburg, South Africa, Prof. Emilie GAILLARD drew attention to the lack of taking future generations and their rights into account in current laws and regulations. She presented on the rights of future generations, and how these should be brought into legal frameworks.

Indigenous people, for example Native Americans of North America, in their traditional system, take the impacts of today's decisions on future generations into account: Within any decision making by today's generations, the impacts the decision and its consequences must be considered for the next seven generations.

Further readings:

> The Rights of Future Generations, A New Legal Humanism, Interview with Emilie GAILLARD by ID4D – Ideas for Development, 27 August 2019
https://ideas4development.org/en/rights-future-generations-legal-humanism

> What is the Seventh Generation Principle?
www.ictinc.ca/blog/seventh-generation-principle
http://7genfoundation.org/7th-generation

14

CHAPTER FOURTEEN

FRANK WINDE (PRESENTATION)

We had a widening gap between what was produced worldwide and what was needed by those increased nuclear power plants and in 2003 that reached the maximum. Whatever was the reason, we had a massive increase in uranium price levels from about 10 Dollars to 140. Now that triggered a huge kind of activity and many of those activities actually focused on Africa.

Narration

Looking at all the dangers and consequences associated with the mining of uranium, one wonders why countries still seek to extract it. The answer could be: as long as demand is there and the market price is high, it is about a purely economic calculation, about foreign exchange, tax revenues and the hope for economic development with well-paid jobs in the region. However, even here one has to refer to the reality, which looks different.

FRANK WINDE (PRESENTATION)

Over 60 exploration permits [have] been granted in 30 countries, and 120 were pending still in 2007. New mines concentrated in Namibia, we had Niger being a focal point, Malawi, as well as South Africa, Tanzania, Zambia, Botswana and Guinea. Wherever you see a yellow date behind that shows those projects are no longer running because of a drop in price.

GÜNTER WIPPEL (INTERVIEW)

Countries getting into uranium mining hope for increased tax revenues from mining companies. Often, it is also about so-called royalties, a fee or land lease companies have to pay to the governments, and, of course, it is always argued that jobs would be created, something which is essential in countries of the Global South.

GÜNTER WIPPEL (PRESENTATION)

But there is a few traps about that because this is not only something where we have profits, we also have some costs. This is what my presentation is focusing on: Costs of reclamation of tailings. First about costs: there is two kinds of costs, basically – I am an economist by trade – there is financial cost where you really spend money and there is so called 'social costs' that means costs which is are not directly related to money, for example diseases, people who need health care, people who have loss of wages, land which is contaminated which cannot be used, for example, for agriculture anymore etc. So you have social cost and you have monetary cost.

MARIETTE LIEFERINK (INTERVIEW)

It has definitely created jobs and it has also contributed to our gross domestic product. The problem however is that with mining waste is that it has created 47% of all waste in South Africa and it is widely accepted that waste from the mining sector poses the second grandest environmental risk next to global warming because of the profound and often irreversible impact of mining on ecosystems.

14. Economy of Uranium Exploitation

14.1. Financial costs and Social (external) costs

Companies and Governments often argue that (uranium) mining would bring jobs and hence prosperity for the local people. And that it would create income for the state through taxes and/or royalties from land lease agreements, etc.

However, although jobs are created, many of them are not for local people, who may lack the qualifications needed and who may end up with the most low-paid jobs.

Besides, as shown in the above chapters, the uranium industry is prone to be a boom-bust industry. This means that jobs which are available today may not be available tomorrow.

Uranium mining in particular brings dangers for the health of miners, and sometimes for their families, from working in the mines and mills. Deteriorating health and premature deaths may result from working in and around uranium mines and mills.

The concept of 'social costs' was developed by K. William KAPP, a professor of economics, in the 1960s with regard to the impacts of industrialization which are not reflected in the market price of a product. These costs are 'externalized' onto society as a whole, who ends up paying one way or the other.

“

External costs are costs that are NOT included in what the business bases its price on. These include:

- the cost of disposing of the product at the end of its useful life
- the environmental degradation caused by the emissions, pollutants and wastes from production
- the cost of health problems caused by harmful materials and ingredients
- social costs associated with increasing unemployment due to increasing automation

Even though external costs are not included in the price of the product they still have to be paid. It is society as a whole that ends up paying external costs through taxes, accident compensation, medical payments, insurance payments, as well as through losses in environmental quality and natural capital.

”

Source:

> ECONATION: External costs vs Internal costs
https://econation.co.nz/external-costs

Some of the external (or externalized) costs can be computed into dollars or euros: research, some of it onsite; the planning of remediation activities, expenses for reclamation work of mine and mill taillings sites, the monitoring of the sites and measures to ensure long-term safety.

For some of these social (external) costs, it is very difficult, or next to impossible, to estimate adequate amounts in dollars or euros. These costs are, e.g. premature deaths due to sickness, birth defects in the next generation, environmental degradation and loss of agricultural land. None of these can be measured by money alone.

Some impacts – especially health impacts like cancer – will show up years after the closure of a mine. Yet they are not – or not appropriately – taken into account in feasibiltiy studies, nor in Environmental Impact Assessments.

Instead, they are simply imposed on the general public and the generations to come.

GÜNTER WIPPEL (PRESENTATION)

All these costs of reclamation and all those social costs are never taken into account appropriately by governments when they make decisions about uranium mining. They see the tax income they may have, hopefully, within the next few years but they don't think about the costs that does incur when they do reclamation and they don't think about the social cost about human health and so on. So if you take all this things into account – probably uranium mining is not a good plan.

In the United States we have an example from the mine in the Rocky Mountains area. As you can see the tailings are very close to a river. The company had set aside for the reclamation 10 million US Dollars and they thought that's good enough. At that time it was estimated that reclamation would cost 19 million US Dollars – another 9 million dollars – where to take from? But then it was found that it´s not a wise idea to leave those uranium tailings close to the river which is the major source of water and drinking water for people in California. It was decided to move those tailings to another location. And that time they estimated it will cost 155 million US Dollars. Now they started also moving tailings by trucks [and railway] to another place; that's millions of tons and now they estimate about 1 billion US Dollars that this reclamation will cost.

This is just one example. Germany just paid over 6 billion Euros for the reclamation of the old mines in East Germany. Now, 20 years later, we were told this will soon be done with; but 20 years later it´s still not finished completely and the company itself has admitted that they don't know how long they will still have to monitor water samples and to collect and pump water from the old mine shafts.

MARIETTE LIEFERINK (INTERVIEW)

What is of significant concern to us is that often mining companies come, they then extract the gold, they maximise their profit by not internalising the impacts or the costs. And often when they declare bankruptcy or call for winding-up or when they sell to other mining companies or abandon the mining activities, then the communities' future generations and the mute environment are then left to carry the costs and also the impacts which can of course last for hundreds of years.

GÜNTER WIPPEL (INTERVIEW)

Normally, uranium mining companies have to submit a feasibility study in countries where they apply for permits, and they have to show that the project is economically feasible. What is normally not considered it the long-term safe disposal of mine tailings. This causes considerable costs – which, however, are in no way taken into account in the profitability calculations. This leads to the approval of projects which are not sustainable [economically not acceptable] under long-term view.

GÜNTER WIPPEL (PRESENTATION)

So what we see, as I said, is that in many cases the cleanup becomes the task of the government and the tax payer will have to pay for it in the end. So profits are internalized by the companies, by the shareholders of those companies – but lots of the costs are externalized.

14.2. The Cost of the Reclamation of Uranium Mines, Mills and Tailings

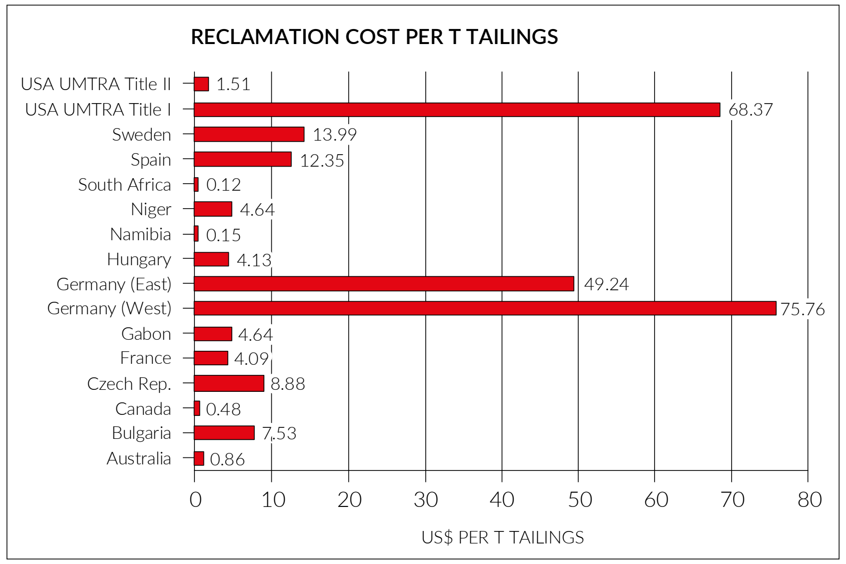
During the operation of a mine, the tailings have to be dealt with one way or another. Often, however, they are not managed appropriately and lead to contamination of the environment, aquifers etc. (→ Ch. 10.).

After closure of a mine and mill site, millions of tons of radioactive and toxic tailings must be managed and kept separate from the environment for long periods of time. Besides the factual and technical difficulties in achieving some acceptable results, it is an expensive task.

There are few comprehensive studies of the costs of tailings management/damage control.

THE 1995 STUDY BY GERMAN BMWI

In 1995, the German Ministry of Economic Affairs (BMWi) published a study "Costs of Closure and Reclamation of Uranium Extraction Projects in an International Comparison" (henceforth referred to as the "BMWi-Study")



WISE Uranium Project

Source:

> "Kosten der Stillegung und Sanierung von Urangewinnungsprojekten im internationalen Vergleich", Costs of Closure and Reclamation of Uranium Extraction Projects in an International Comparison), by the Bundeswirtschaftsministerium (German Ministry of Economic Affairs) , March 1995, research conducted by German Uranerzbergbau GmbH (a former German uranium mining company) (not available on internet; summary on WISE Uranium Project:
www.wise-uranium.org/udcos.html

The results show a wide variation of the costs of tailings reclamation (per ton of tailings). They indicate that costs were lowest in South African (US$ 0.12 per ton of tailings), with little reclamation work done by the early 1990s. By far the highest costs were incurred by the reclamation of (small) West German uranium mining sites (US$ 75.76). US uranium tailings sites, reclaimed under the UMTCRA (Title II), with US$ 68.37, and the East Germany sites (former WISMUT), with an (estimated) US$ 49.24, are in the middle range.

BMWI-STUDY CONCLUSION

The BMWi-Study attempts to account for different situations in the various countries, as well as for different tonnages in the respective countries. The study uses a weighted average of the reclamation costs, and concludes that – on average – reclamation costs would be US$ 4.00 per ton tailings (if mines where uranium is produced as a by-product are not taken into account; 1993 costs).

Adjusted to 2019 costs (at a moderate inflation of 1% per year), reclamation costs would be US$ 5.08 per ton tailings.

BMWI-STUDY – AVERAGE

Since the BMWi-Study shows a wide margin, from US$ 0.12 to 75.76, for reasons of simplification, an average can be calculated, based on the minimum and the maximum costs in the BMWi-Study: the average costs would be US$ 37.94 per ton of tailings (1993 costs).

Adjusted to 2019 costs (at a moderate inflation of 1% per year), the average costs would be US$ 48.17 per ton tailings.

For mines with uranium production as a by-product of gold or copper mining, the study arrives at average costs of US$ 2.20 per ton of tailings (1993 costs).

Alternatively, the BMWi Study calculates reclamation costs in relation to the amount of uranium extracted as follows: US$ 1.25 US$ per pound U308 produced. (1993 costs). Adapted to 2019 costs (at a moderate inflation of 1% per year), costs would be US$ 1.59 per pound uranium produced; adapted to kg, costs are: US$ 3.51 per kilogram uranium produced.

RECLAMATION COSTS

		BMWi-Study (low estimate)		BMWi-Study, Average of Max and Min costs	
		at 1995 costs	adapted to 2019 costs	at 1995 costs	adapted to 2019 costs
	tons tailings	4,00 USD	5,08 USD	37,94 USD	48,17 USD
Namibia	350.000.000	1.400.000.000	1.778.000.000	13.279.000.000	16.859.500.000
Niger	17.000.000	68.000.000	86.360.000	644.980.000	818.890.000
South Africa	700.000.000	2.800.000.000	3.556.000.000	26.558.000.000	33.719.000.000
Gabon	6.500.000	26.000.000	33.020.000	246.610.000	313.105.000
USA	235.000.000	940.000.000	1.193.800.000	8.915.900.000	11.319.950.000
Canada	202.130.000	808.520.000	1.026.820.400	7.668.812.200	9.736.602.100
Germany	174.450.000	697.800.000	886.206.000	6.618.633.000	8.403.256.500
Australia	79.000.000	316.000.000	401.320.000	2.997.260.000	3.805.430.000

The table shows an estimate of the costs of reclamation of tailings for a selection of countries.
NOTE: The amounts are calculated only to show an order of magnitude of the costs of reclamation of uranium mine and mill tailings.

A BRIEF REALITY CHECK

In Germany, one big former uranium mining area is under reclamation (the former East-German WISMUT uranium mine operations). The reclamation has proceeded quite far, (2019) and figures for real costs are now available. Reclamation costs were at 6 – 7 billion € by 2018 and are expected to rise by another 2 billion €. The US$ 4.00/5.00 estimate of the "BMWi-study" suggests reclamation costs of US$ 697 to 886 million.

Based on the average of the BMWi's highest and lowest costs, the AVERAGE estimate, suggests reclamation costs for Germany between 6,618 billion and 8,403 billion US$. The estimate based on the average reclamation costs of US$ 37,94/48,17 per ton tailings is close to the real costs – much closer than the US$ 4/5.08 estimate.

THE 2002 OECD-IAEA STUDY

Another relevant paper is a joint study by OECD and IAEA "Environmental Remediation of Uranium Production Facilities – A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency", 2002, referred to as the "OECD/IAEA-Study" further on.

This study, unlike the "BMWi study", distinguishes between reclamation of mine tailings and uranium mill tailings and their costs. It suggests that the costs of storing uranium mine tailings vary between 0.55 and 13.62 US$ per ton of ore mined (2002 costs), the costs for storing tailings from uranium mills in relation to the amount of uranium extracted. These calculations arrive at a range of 3.10 – 32.90 US$ per kg uranium extracted.

The costs of decommissioning and remediation mill plants (again without water treatment) range of from 3.1 to 32.9 US$ per kg of uranium produced.

These costs do not include water treatment. But the study states that "inclusion of water treatment will push up costs between 10 and 50%".

The figures from both studies cannot be easily compared since they relate to different bases (tons of ore mined, pounds of uranium extracted). However, taking into account the result from the 'reality check', 10-fold higher reclamation costs than the lowest estimate are realistic, as the example of the German real costs shows. The cost analysis of Moab Uranium Mill Tailings reclamation confirms this:
The Moab reclamation arrives at 30.12 – 31.31 US$ per kg of produced yellowcake (→ Ch. 14.3.).

Source:

> Environmental Remediation of Uranium Production Facilities by OECD and International Atomic Energy Agency (IAEA), published by OECD 2002
www.oecd-nea.org/ndd/pubs/2002/3033-environmental-remediation.pdf

14.3. Some Examples of Costs of Reclamation

UNITED STATES

Much reclamation work has been done in the US, where, besides estimates of future costs, also some real figures are available.

"In 1998, DOE [the Department of Enregy of the US Government] testified to Congress that it would cost approximately $2.3 billion (in 1998 dollar value) to clean up the uranium ore processing facilities nationwide under UMTRCA. Because there are other uranium mines and overburdened sites not included in this estimate, the total cost of uranium site cleanup is expected to be much higher than this modest estimate."

Further readings:

> WISE Uranium Project > Costs of Uranium Mill Tailings Management
www.wise-uranium.org/udcos.html

Source:

> Abandoned Mines.gov, an official government website managed by the Bureau of Land Management (US)
www.abandonedmines.gov/about_uranium_mines > COST

> URANIUM MILL TAILINGS Status and Future Costs of Clean-up, Statement by Bernice Steinhardt (to Congress)
www.gao.gov/archive/1996/rc96085t.pdf

MOAB URANIUM MILL TAILINGS

An interesting example for mine reclamation is the (former) MOAB uranium mill in the US. Moab uranium mill operated until 1984. It produced approx. 33.5 Mio pounds of yellowcake, the sales of which totaled US$ 1,09 billion.

From 1988 – 1998, the company dismantled the mill and began reclamation work.

The company had set aside US$ 10 Mio for reclamation; estimated costs of reclamation on site were initially US$ 20 Mio.

In 1998, the company, Atlas, declared bankruptcy.

In order to deal with the hazardous tailings, the site was transferred to the jurisdiction of the US Department of Energy (DOE) and finally came under UMTRCA Title I in 2001. Reclamation had now become the task of the Government since the company had ceased to exist.

Due to the location close to the Colorado River, it was decided to take the tailings to another site. Initially the costs for this were estimated at US$ 155 Mio.

Currently (2019) about 60% of the tailings have been transported to another site. The costs are now estimated at US$ 1.01 to 1.05 billion – 100-fold the amount set aside initially. So the reclamation costs will nearly equal the value of the total sales of the company.

The Unit Remediation Costs (URC) are US$ 30.12 – 31.31 per kg of produced yellowcake.

The reclamation of Moab mill tailings may be an extreme example.
However a few things become clear:

- Funds set aside by the company were insufficient.
- Cost estimates of reclamation tend to be too low.
- The company declared bankruptcy and thus evaded its obligation to work on the reclamation.
- The site became the responsibility of the Government and will be reclaimed at taxpayers' expense.

Source:

> Presentation of Department of Energy

AUSTRALIA: RANGER MINE

The Ranger Uranium Mine is located in the Northern Territory of Australia, surrounded by the Kakadu National Park, 230 km east of Darwin. It is located on Aboriginal people's territory (the Mirarr), who opposed the mine from the start. The mine began operation in 1980. It is run by ERA - Energy Resources of Australia, a 68% subsidiary of the London-based Rio Tinto.

In 2018 plans for the closure of the mine were begun due to the ore having been mined out and because an underground extension (Ranger Deeps) was not fundable.

"The cost of rehabilitating a uranium mine surrounded by a World-Heritage-listed national park will be almost $300 million higher than previous estimates, uranium producer Energy Resources of Australia (ERA) has conceded. (…) The clean-up is now predicted to cost $808 million – $296 million more than ERA's initial $512-million estimate – according to an update released to the Australian Securities Exchange."

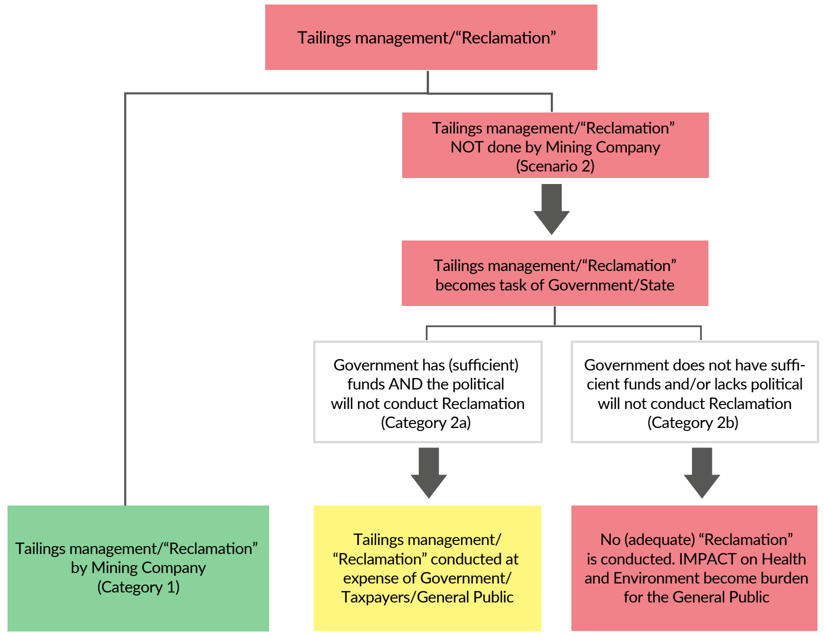
Source:

> **Ranger Uranium Mine rehabilitation costs blow out by $296m amid fears over long-term monitoring,** by Felicity James, ABC News, Posted 10 Dec 2018, 9:35pm
www.abc.net.au/news/2018-12-11/ranger-uranium-mine-rehabilitation-cost-blowout-jabiru/10601696

> **WISE Uranium Project** > Issues at Operating Uranium Mines and Mills - Ranger, Australia
www.wise-uranium.org/umopaura.html

14.4. Who will pay for 'Reclamation'?

As shown above, the costs of reclamation are considerable. WHO will pay for those costs?



Graph by the author, based on classification of the cases in the BMWi-Study

Several options are available:

According to the "polluter pays" principle, the company exploiting a uranium deposit is responsible for clean-up / reclamation and safe tailings management.

However, this is not always the case. Experience shows that, in a number of cases, mining companies are not 'cleaning up'. There are, again, two options: The government has the funds and the political will to clean-up – or - worst option - it lacks the will and/or the funds to do the reclamation work.

(1) RECLAMATION AND TAILINGS MANAGEMENT BY THE MINING COMPANY

Actually, there are some pre-conditions to get mining companies to 'clean up' mining sites and take proper care of long-term storage of tailings.

- Laws and regulations are in place, and enforced, holding the mining company responsible for cleaning up and providing for long-term appropriate storage of the tailings
- Good governance at state level is assured. Thus the administration is strong and qualified to monitor such a process, and able to enforce these laws and regulations.
- The mining company is still operational and has enough funds available to perform tailings management/reclamation

In such situations, the mining company will perform the reclamation and tailings management in compliance with existing laws.

The Ranger Mine, Australia (→ see above) is one example. Although the company, ERA, has not enough funds set aside, the holding company (Rio Tinto) has pledged to help with the funding of the reclamation work.

In the past, those conditions were often not given; in the 1950s and 1960s, uranium was mainly mined for military purposes, and environmental issues were of little to no concern.

In some cases, uranium was or is mined in African countries (Congo, Namibia, Gabon, Niger) by companies originating from the country of the former colonial power (France, United Kingdom), and there were either no laws for reclamation or they could not be enforced; sometimes superficial reclamation has been done which is insufficient.

(2) RECLAMATION AND TAILINGS MANAGEMENT NOT PERFORMED BY MINING COMPANY

In many cases, reclamation was not performed by the mining company,

- either due to lack of appropriate laws and regulations or enforcement
- or due to the insolvence or bankruptcy of the mining company.

Such situations have occurred many times. In the US, many small uranium mines and exploration sites have never been reclaimed since the companies went bankrupt when the price of uranium dropped. The same applies for the North of Saskatchwan, Canada. Central Asian countries are also plagued with similar problems (→ Ch. 10.).

In this situation, two possibilities arise:

(a) The Government has the political will and sufficient funds to deal with the tailings issue.

Sometimes governments need to be pushed by environmental organizations and advocacy groups. The costs are 'socialized', i.e. carried by the state and, finally, by the taxpayers.

Examples:
In the United States, the Government partially assumed responsibility to reclaim former uranium mines (see UMCTRA, → Ch. 10.), and is paying for the reclamation. In some cases, arrangements were made to enable company and Government to contribute to the reclamation costs. Since comprehensive up-to-date cost evaluations are not readily available for all of the US, here are some examples of some reclamation operations: Moab tailing remediation costs with a total of 1 billion US$: In 2014, the US Environmental Protection Agency and the Department of Justice secured approximately US$ 1 billion for a clean-up of approx. 10 % (!) of abandoned uranium mines on Navajo/Dine land. Currently (2019), the reclamation work is going on step by step.

Source:

> **Justice Department, EPA and The Navajo Nation Announce Settlement for Cleanup of 94 Abandoned Uranium Mines on The Navajo Nation**
> *www.justice.gov/opa/pr/justice-department-epa-and-navajo-nation-announce-settlement-cleanup-94-abandoned-uranium*

With the reunification of East and West Germany in 1990, West Germany took on the responsibility of cleaning up the former East Germany uranium mines. Soon after 1990, plans were started for extensive reclamation work funded by the (West) German Government. Costs for reclamation work are around € 7 billion (2019), and are expected to rise by another € 2 billion.

In Canada's Saskatchewan province, between 35 and 50 years after closure of mines in the Athabasca region, federal and provincial Government started clean-up efforts. For remediation of a small number of mine sites and mills in Saskatchewan, approx. Can$ 240 million are estimated.

In France, some reclamation work has been undertaken. Obviously, however, it was insufficient, triggering research by CRIIRAD and a documentary film "Uranium – Le Scandale de la France contaminee". Figures for reclamation costs are not available.

In Central Asian countries, uranium had been mined by the (former) USSR, with little to no remediation done after closure of the mines. A first step towards reclamation was taken in 2008/2009 at a UN High Level Forum. Governments of the affected countries appealed to the international community for financial support.

It took another 10 years to elaborate a "Strategic Masterplan for the Environmental Remediation of Uranium Legacy Sites in Central Asia"

"The overall costs of remediation of the uranium legacy sites included in the Plan, together with supporting activities, are estimated at round € 210 million. By far the majority of these costs (around € 180 million) are for actual remediation work, around € 17 for comprehensive evaluations of the risks and remediation options of the various sites, and around € 15 million to support capacity-building and other activities that are considered essential for ensuring the success of the remediation activities."

Source:

> **Environmental Remediation of Uranium Legacy Sites in Central Asia – Strategic Masterplan,** presented at the 61st IAEA General Conference, Vienna, Austria, 18. Sept. 2017, pages 17 and 77 – 79
> *www.iaea.org/sites/default/files/18/05/strategic_master_plan_v1_may_2018.pdf*

Video:

> **Environmental Remediation in Central Asia**
> *www.youtube.com/watch?v=2Idq0jZDAFA&feature=youtu.be*

Since the countries lack the financial means to pay for the reclamation, their governments called out to the International Community for help. The World Bank and the European Bank for Reconstruction and Development agreed to provide some funds.
As of 2018, there was a funding gap of € 50 million. Some reclamation work has been done.

(b) The Government lacks the political will and/or sufficient funds to deal with the tailings issue
In the worst case, the Government of a country with (closed down) uranium mines, does not have sufficient funds, or lacks the political will to conduct reclamation.

Thus, uranium mine and mill tailings continue to contaminate the environment and serious environmental damage to ground and surface water, air and soil may ensue. Human health will be affected, and certain diseases and premature deaths of people living in the surrounding areas will occur.

Examples:
Gabon, some areas in Canada, not reclaimed mines in the US, and in Central Asian countries (Kyrgyzstan, Kazakhstan, Tajikistan, Uzbekistan) etc.

In Niger and Namibia, major mines are still operating. In Niger, the closure of one of AREVA's/ORANO's mines, Akouta, has been announced for 2021. In spite of this, plans for reclamation and its funding are not on the horizon.

In Namibia, China Guangdong Nuclear Power Holding Corporation (CGNPC) bought a majority share in the Rössing mine and wants to continue operating the mine for another 10 years. But reclamation plans are not clear. Namibia holds, in addition, two mines on "care and maintenance" (Trekkopje by AREVA/ORANO and Langer Heinrich by PALADIN). Their future is unclear – as well as remediation of the sites and tailings.

In South Africa, millions of tons of tailings are sitting in densely inhabited areas, many in the town of Johannesburg and surroundings. The state, for the most part, lacks the funds or the will to clean up many of them.

Unfortunately, on a global level, many of the mines, mills and tailings sites fall into category 2 (b): The mining company did not perform remediation work, and governments do either not have (sufficient) funds available, or lack the awareness of the risks and the will to pay for remediation work. In some cases (e.g. Central Asian countries) the International Community is asked to help with the funding of remediation work.

In regard to African or South American countries, chances are high that uranium mine and mill tailings will not be reclaimed, or only with a big time lag, and thus leftovers and tailings will pose a serious danger to environment and human health.

14.5. Social (External) Costs of Uranium Exploitation

Besides the costs of reclamation, uranium mining activities also cause diseases, degradation of the environment, including agricultural land, and contamination of water sources. Huge quantities of water are consumed by mining and milling processes. Tailings may contaminate aquifers for future times, exhaust them or render them unusable.

These costs are, on one hand, difficult to estimate and it is questionable whether – and how – a money value can be attached to a human life and its loss, or to suffering from diseases such as cancer.

On the other hand, these impacts of (uranium) mining are hardly ever taken into account at all since they do not show up in the calculations of profits, taxes or royalties, and thus are simply ignored or left to oblivion.

In the end, the consequences are carried by miners and workers who get sick but receive no compensation, by people living in a radioactively contaminated vicinity of uranium mines, mills and tailings, and by future generations (→ Ch. 11.3. Health Impacts – Uranium, Women and Children).

Source:

> The social costs of uranium mining in the US Colorado Plateau cohort, 1960-2005,
by Benjamin A Jones
www.ncbi.nlm.nih.gov/pubmed/28251247

An attempt to calculate social costs of uranium mining was undertaken by Bejamin A. JONES in the US:"The social costs of uranium mining in the US Colorado Plateau cohort, 1960-2005"

The study arrives at a couple of billion (!) US$ social costs caused by premature deaths of uranium workers.

A study of the abandonded uranium mining are in the southwest of Romania, arrives at the conclusion:

Source:

> The assessment of social and economic impacts associated to an abandoned mining site. Case study: Ciudanovita (Romania),
by Merciu George-Laurentiua, Merciu Florentina-Cristinab,Cercleux Andreea-Loretab, 2016
www.sciencedirect.com/science/article/pii/S1878029616001973?via%3Dihub

“

4. Conclusions

The analysis of the impact of mining activity in the studied area revealed multiple effects produced both in the environment and in the socio-economic system. The authors underlined that the damages inflicted upon the environment directly affect the health of the population.

Based on the statistical data, the authors have highlighted the specificity of the professional morbidity within the population of Ciudanovita commune, caused by the exposure to hazards associated to the extracting industry. The miners represent the most affected population group by the exposure to risk factors, with a highlight on the large number of certain diseases which severely harm their health. At the same time, the occupational diseases alter the working capacity of the employees, diminish the working period (early retirement) and triggering the decrease inlife expectancy (high frequency in mortality by occupational diseases within the population aged 45 to 50 years).

There are also other population categories that can be affected by the exposure to radiations (the miners families, the population living near the mining sites and near the mining waste dumps).

”

Source:

> Evaluating Nuclear Energy from the view points of Social Costs, Social Capital, and Social Justice
www.isecoeco.org/wp-content/uploads/2016/09/Wada-Yoshihiko.pdf

Another view is offered by a Japanese professor, comparing the social costs of the Fukushima nuclear accident and Navajo (Dine) uranium miners.

“Evaluating Nuclear Energy from the view points of Social Costs, Social Capital, and Social Justice: Observing impacts to the communities in the Navajo Nation and Fukushima, Japan”, by Prof. Yoshihiko Wada, 2016, at the ISEE Conference in Washington, US.

In his conclusion he suggest that the use of nucear energy depends on an ideology that “victims” and “sacrifices” are justified “if the benefit is far greater than the costs to the victims,”.

He points out that the ICRP – International Commission on Radiological Protectsion basically promotes this ideology – and Prof. Yoshihiko Wada calls strongly for abandoning it.

14.6. Conclusions

The costs (in terms of cash expenses) of reclamation of uranium mine tailings are considerable. They are often not clear when mining starts and, as experience shows, are regularly underestimated.

In addition, there is a risk that mining companies will go bankrupt, dissolve otherwise, or leave the country without ‘cleaning up’ or performing adequate tailings management.

Industrialized countries such as the US, Canada, Australia and Central European countries have laws and regulations in place to govern the reclamation of uranium mines. To a major extent, they also have administrations in place which are able to enforce laws and regulations to a considerable degree.

Though these laws and regulations and the execution of the tailings reclamation and long-term safe tailings storage may have their shortcomings, it is difficult for companies to simply “walk away”.

In developing countries, however, laws and regulations are often neither in place nor are they effectively enforced.

Thus, it is likely that the reclamation of the uranium mines will become the responsibility of the government.The governments, however, often lack the awareness and / or political will, and, in many cases, the financial means to execute reclamation procedures.

Thus tailings remain unreclaimed or only superficially reclaimed, continuing to contaminate the environment and impact the health of people and generations to come.

Governments like to argue that mining will bring money to the country via taxes and royalties paid by the mining companies.

But in reality, mining companies often get tax breaks, or only pay low taxes since they allegedly make no profits.

“Malawi lost over US$ 12 million due to tax waivers for Kayelekera uranium mine, NGO report:

The Malawi government is estimated to have lost at least K4.2 billion [US$ 12 million] in would-have-been revenue from the Kayerekera Uranium Mine as a result of tax waivers offered under the development agreement with the Australian company operating the mine.

This is contained in the report by the African Forum and Network on Debt and Development (Afrodad) following its analysis on costs, revenues and benefits of Foreign Direct Investment (FDI) in the Extractive Industry in Malawi, focusing on Kayelekera. (Malawi - Daily Times May 31, 2013)”.

Source:

> WISE Uranium Project, Malawi
www.wise-uranium.org/umopafr.html#MW

Short-Term profit versus lang-term problems

And even if the mining companies pay taxes and royalties, these have to be compared to the costs of mine and tailings reclamation. The chances are that the costs of reclamation – if undertaken by the Government – will overshoot the income from taxes and royalties.

Governments need to consider carefully and impartially the profits they are hoping for from mining, and the costs these activities may incur later on in order not to trade short term proftis for long-term problems.

Often, short term income is traded off for long-term problems which will arise mainly in the future. This is neither ‘good business practice’ nor responsible politics. Besides, a big part of the negative impacts is imposed on generations who have had no say in the decision-making process.

Final Conclusion

In the end, the costs of reclamation may be as high or even higher than the taxes and royalties the Government of a uranium mining country has earned. As a result, there may be no profit at all for a country.

In the end, the mining company may go bankrupt or simply walk away and leave the tailings without any precautions – leaving tremendous environmental legacies for a developing country to clean it up.

Many uranium mine tailings – and most of those in Africa – have never been cleaned up appropriately: They pose a serious threat to the environment and to human health for many generations to come.

From the time the Earth came into being, uranium played an important role.

Unlike other elements, it decays, changes form, it turns from one element into another.

Unlike other elements, it sets free energy – radiation.

When companies exploit uranium, they take the desired uranium out of the ore and leave the waste.

The valuable yellowcake is taken to the industrialized countries and used to make nuclear bombs or generate electricity; the tailings are left behind in the countries where uranium was mined.

Tailings are often thousand-fold the quantity of the exported yellowcake. These tailings are a danger for many generations to come. How to handle those masses of radioactive wastes 'safely' for hundreds and thousands of years is not known.

Developing countries do not have the funds to clean up what has been left behind; they are left with heavy legacies.

Even developed countries took 30 to 40 years to start cleaning up – at billions of Dollars or Euros costs.

Miners and workers become sick or die prematurely – leaving families behind most of whom will most probably not see any compensation; they will not have profited.

Whether we look at communities in rich countries such as the United States and Canada, or in countries like Niger, Gabon, South Africa, or in Central Asian countries – no sustainable development has been achieved by uranium mining.

Animation

B *Now … are you still wondering why people protest against uranium mining and nuclear power plants after hearing all this?*

A *No … I understand. So … why then don't we just LEAVE URANIUM IN THE GROUND?*

A NUMBER OF STATES AND PROVINCES HAVE ISSUED BANS ON URANIUM MINING:

Sweden
Kyrgyzstan
British Columbia/Canada
Nova Scotia/Canada
Virginia/USA
Dineh – Navajo Nation/USA
New Zealand
and some states in Australia
Grand Canyon area/USA – 20 year uranium mining ban since 2012
Quebec/Canada – de facto moratorium since 2013
(as of March 2019)

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