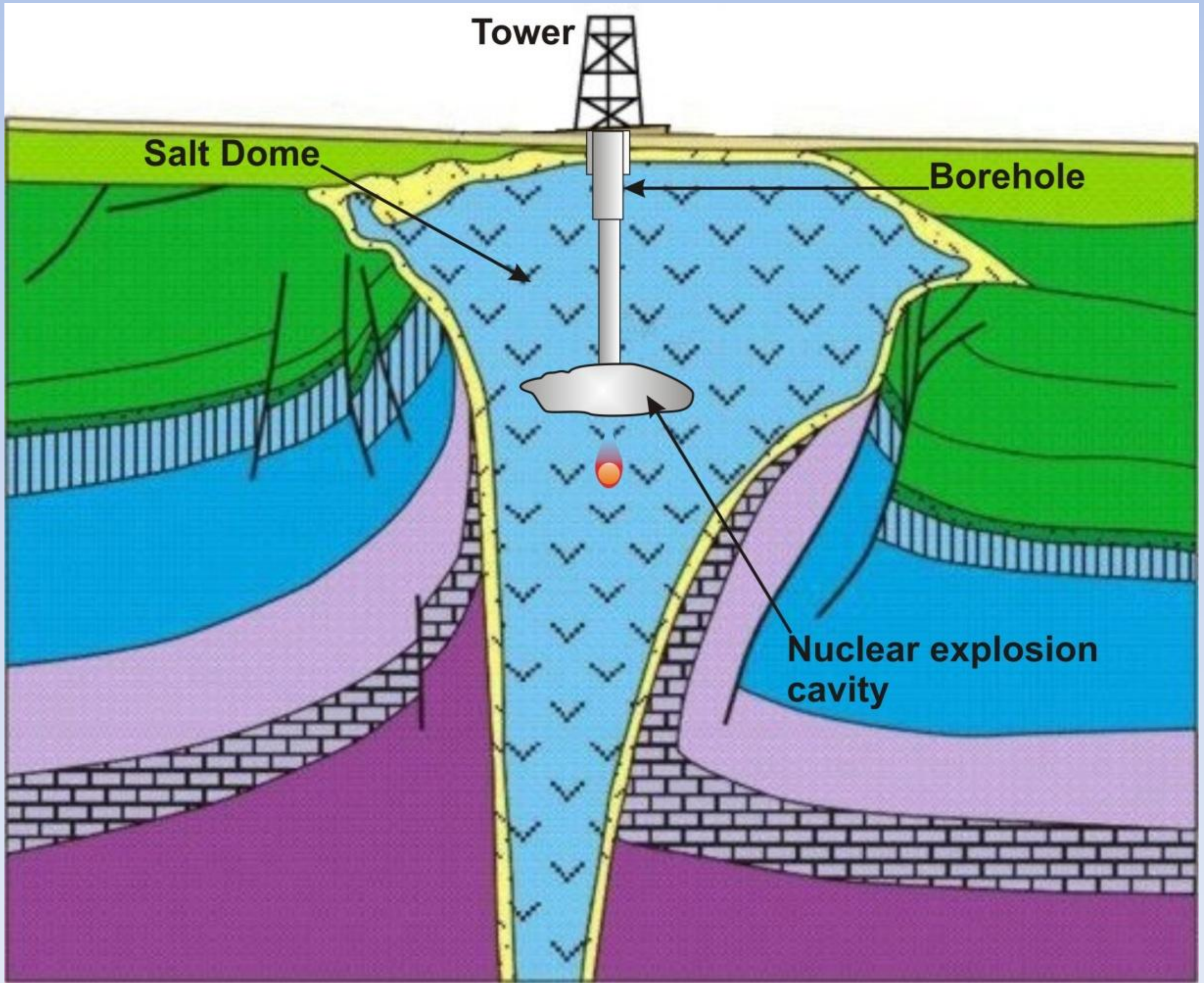
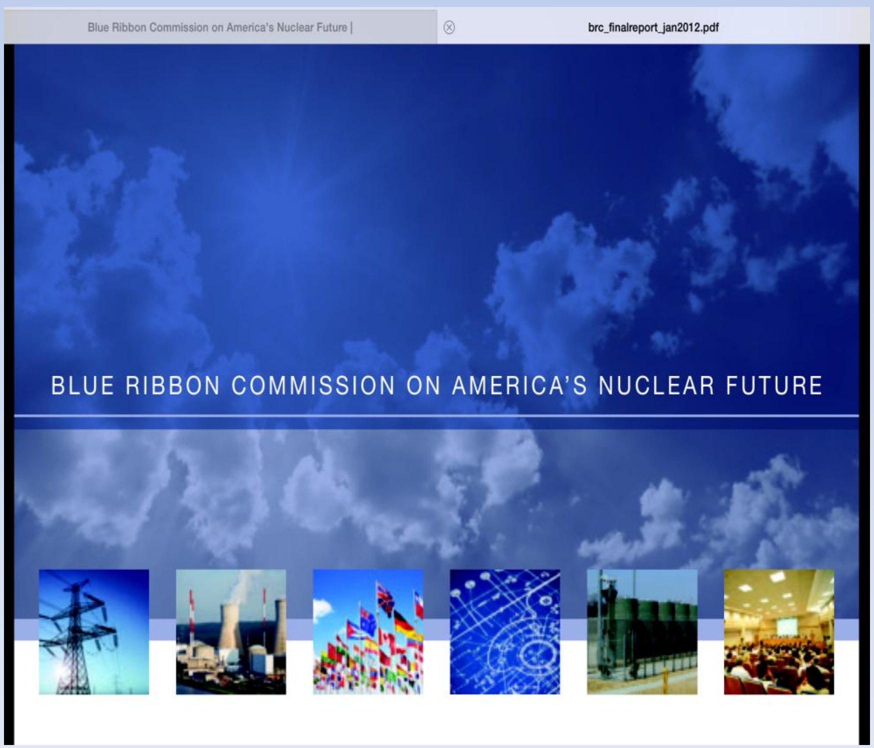
The technology of self-sinking heating source into earth's core by using the infrastructure of Azgyr nuclear polygon in Kazakhstan



Background

- The idea of self-burial started in 70’s –80’s of the past century
- For many years there was an ongoing initiative to develop the new technology of non-reversible removal of highly radioactive waste into very deep geological layers of the earth
- To date, there is no adequate solution and even conceptually, no technology has been identified



OTHER DISPOSAL CONCEPTS

A number of alternative disposal concepts or alternative types of sites for geologic disposal have been advanced over the years. For example, **disposal on or beneath unoccupied islands** has been considered in the context of options for siting an international repository or monitored storage facility.[58] Another option, **sub-seabed disposal** in stable clay sediments, was investigated in the 1970s and 1980s and was thought by a number of experts to hold potential advantages over land-based disposal. Other disposal concepts that have been proposed, at least for some forms of waste, include **disposal by *in situ* melting** (this was suggested in the 1970s as a way to dispose of liquid wastes from reprocessing, perhaps by using already contaminated underground nuclear test cavities) or **space disposal**—that is, shooting nuclear wastes into solar orbit or even into the sun. For reasons of practicality, public and international acceptance, and/or cost these options have generally not received as much attention as disposal in a deep, land-based, mined geologic repository. In sum, based on the evidence available to date, the Commission sees no reason to change the current focus of the U.S. program on developing mined geologic repositories.

Concept

- The technology is based on long-term emission of heat and high density (weight) of the active waste.

- The waste is placed inside a spherical container made of refractory material (wolfram, ceramics, glass) with melting temperature of 3000-4000 C.

- The container will maintain temperature of 1000-1500 C due to heat generated by active waste; this temperature is sufficient to melt practically any material inside earth’s crust (granite, salt and basalt).

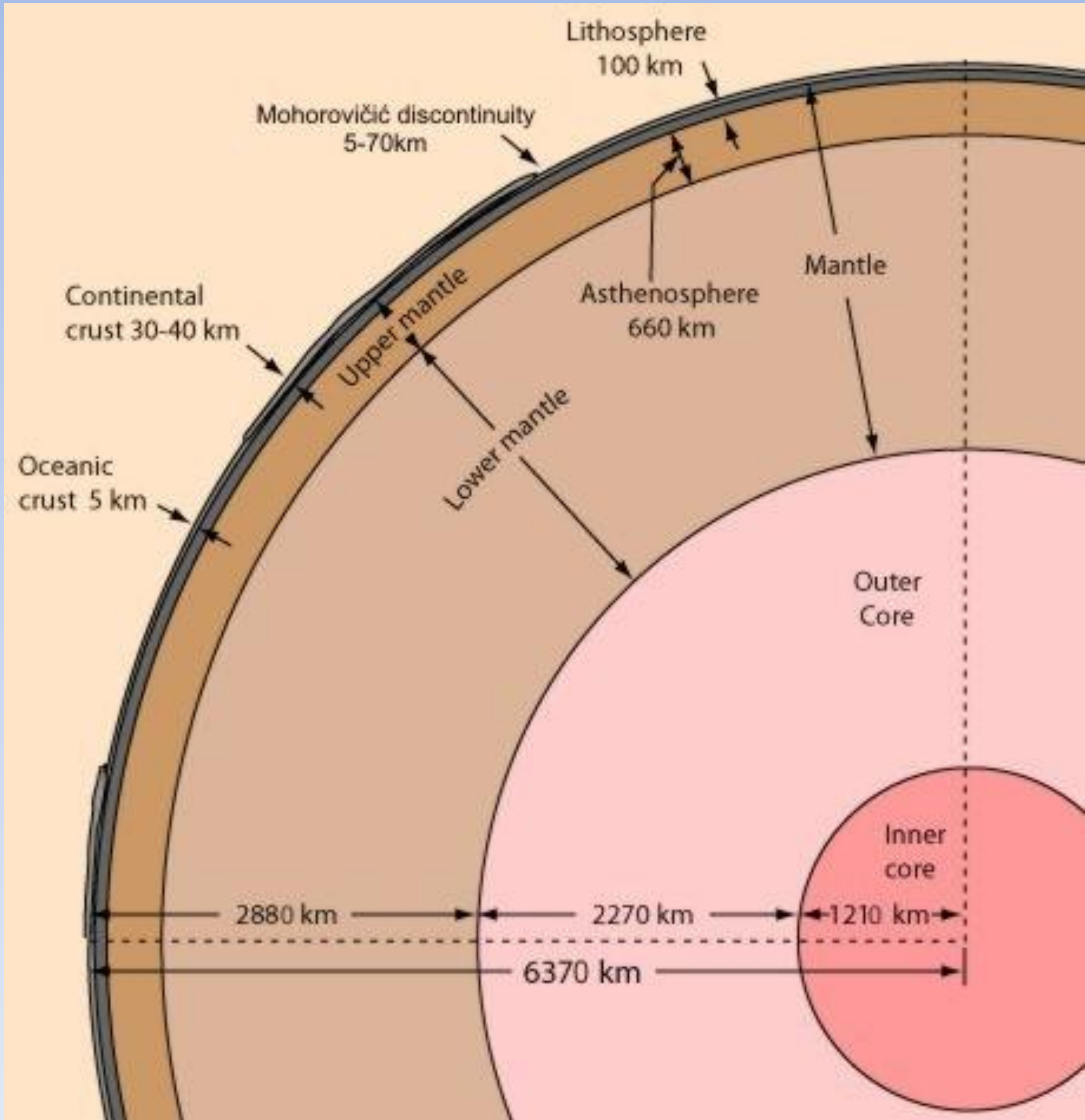
Structure of the Earth

- crust
- mantle
  (upper and lower)
- outer core
- inner core

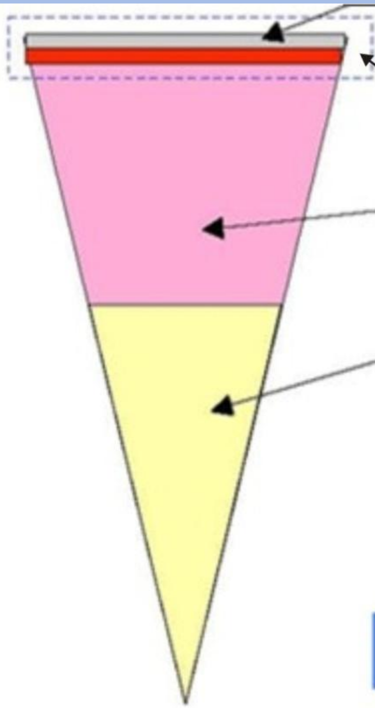
By material strength, the layering of the earth is categorized:

- lithosphere
- asthenosphere
- mesosphere
- outer core

and the inner core



75% of the earth's heat is formed due to the decay of natural radioactive elements



Crust	0 - 35 km	Radioactivity	8TW	(19%)
Lithosphere	0 - 100 km	Radioactivity	17 TW	(40%)
Mantle	35 - 3000 km	Radioactivity Gravitat. formation	21TW 10TW	(50%) (24%)
Core	3000 - 6370 km	Radioactivity + latent heat	3TW	(7%)
		Total	42TW	(100%)

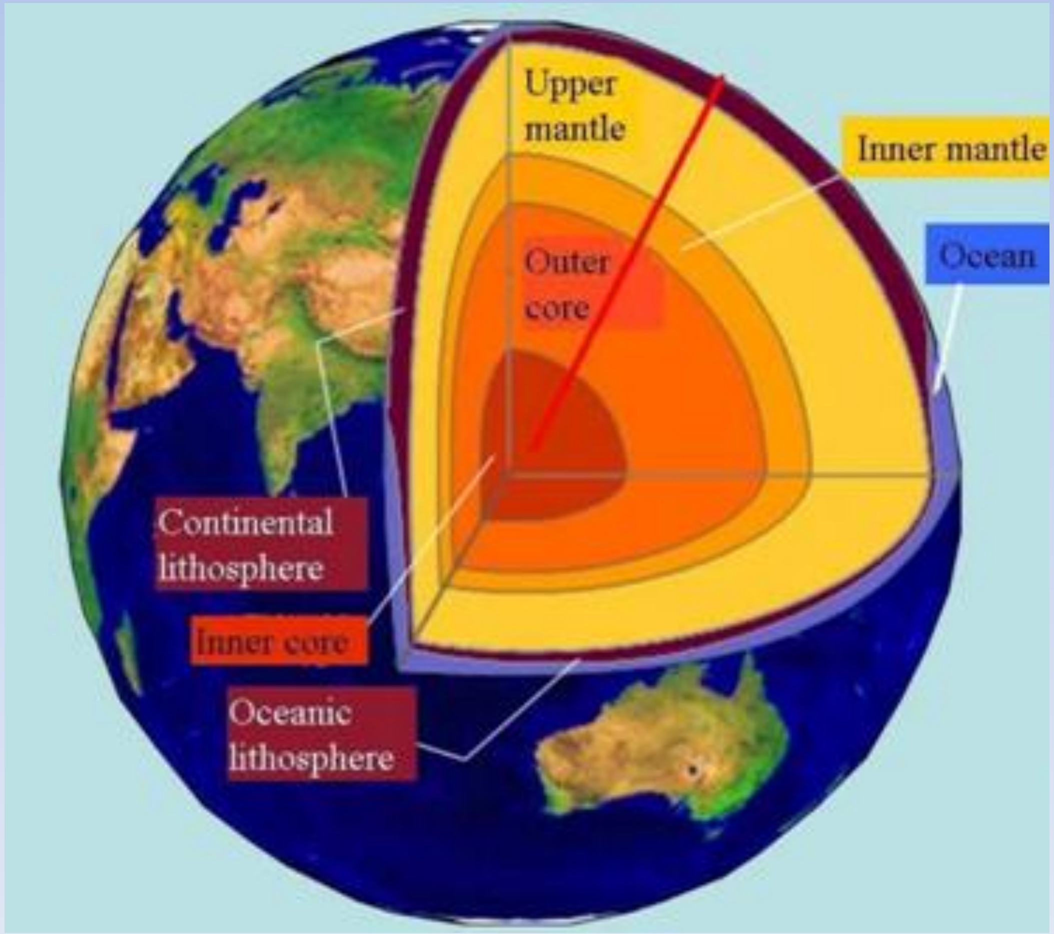
98% of the Radiogenic Heat is Due to Just Three Nuclides

	^{40}K	^{232}Th	^{238}U
Half-life (years)	1.25×10^{9}	14.0×10^{9}	4.47×10^{9}
Decay mode	β^-(90%), EC	$\alpha, \beta^-, \ldots$(chain)	$\alpha, \beta^-, \ldots$(chain)
Daughter decay products	^{40}Ca, ^{40}A	$^{208}Pb + 6\alpha$	$^{206}Pb + 6\alpha$
Total energy deposited* (MeV)	0.69	40.4	47.5
Fract. contrib.. to radiogenic heat	0.15	0.424	0.409
Specific heat rate in upper crust (10^{-10}W/kg)	0.931	2.78	2.36

Technology of self-sinking

Heated to such high temperatures and higher density than earth’s crust, the sphere melts and sinks through terrestrial rock.

Calculations and modeling demonstrate that even in least favorable conditions, speed of “self-sinking” is sufficient to reach earth‘s mantle (Mokhorovich level with depth of 40-70 km) within 1-3 years.



Later the capsule material will dissolve in earth mantle material. By this process, the man-made radioactive material will return to its initial natural condition.

Scientific novelty

- The principle of technology is based upon long-term separation release of heat power by active wastes and their high relative density (heaviness)

- Wastes are placed into a spherical container made of refractory substance with melting point of 3000- 4000 degrees C. Heating power at account of the heat generated by wastes is selected for maintaining the temperature of the container within the range of 1000-1500 degrees C.

- This is enough for penetrating almost any material of the crust of Earth (granite, basalt or salt). Heated to such temperatures heavy sphere with the significantly higher density than the Earth crust, penetrates the rock and "sinks" in it.

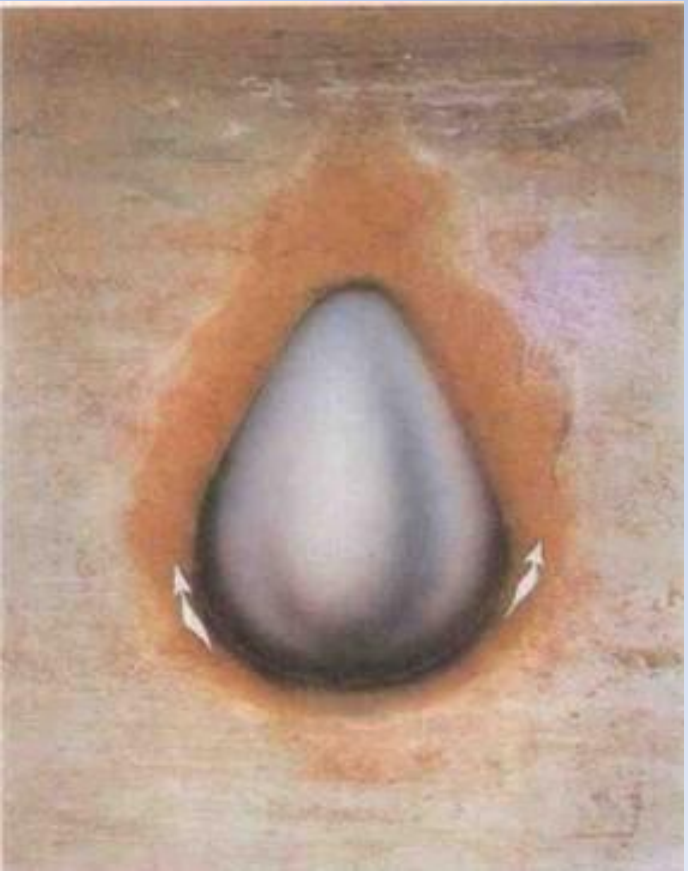
- Depths reached in the self-burial method can be more than tens of kilometers.

- Solids drilling never reached such depths before. Then, the capsule material will decompose in the material of the mantle.

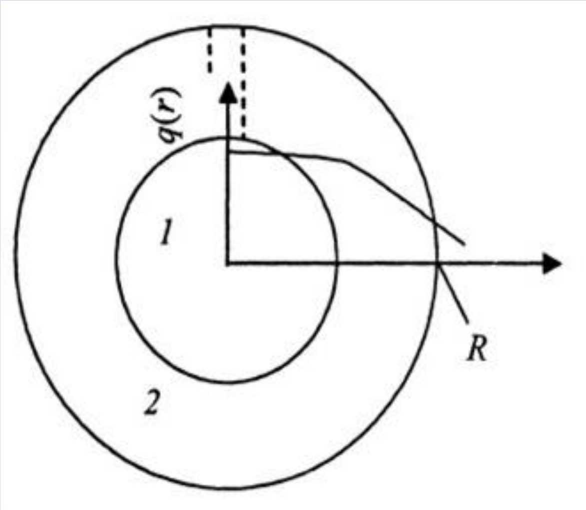
Critical factors

It is these decisions that are holding back the realization of the initiative. The most critical initial choices are regarding:

- the container configuration
- proper place for testing of the technology



Form of a self-sinking capsule:



1. Active material
2. Capsule

q(r) – distribution of heat sources in the capsule

Choice of the landfill

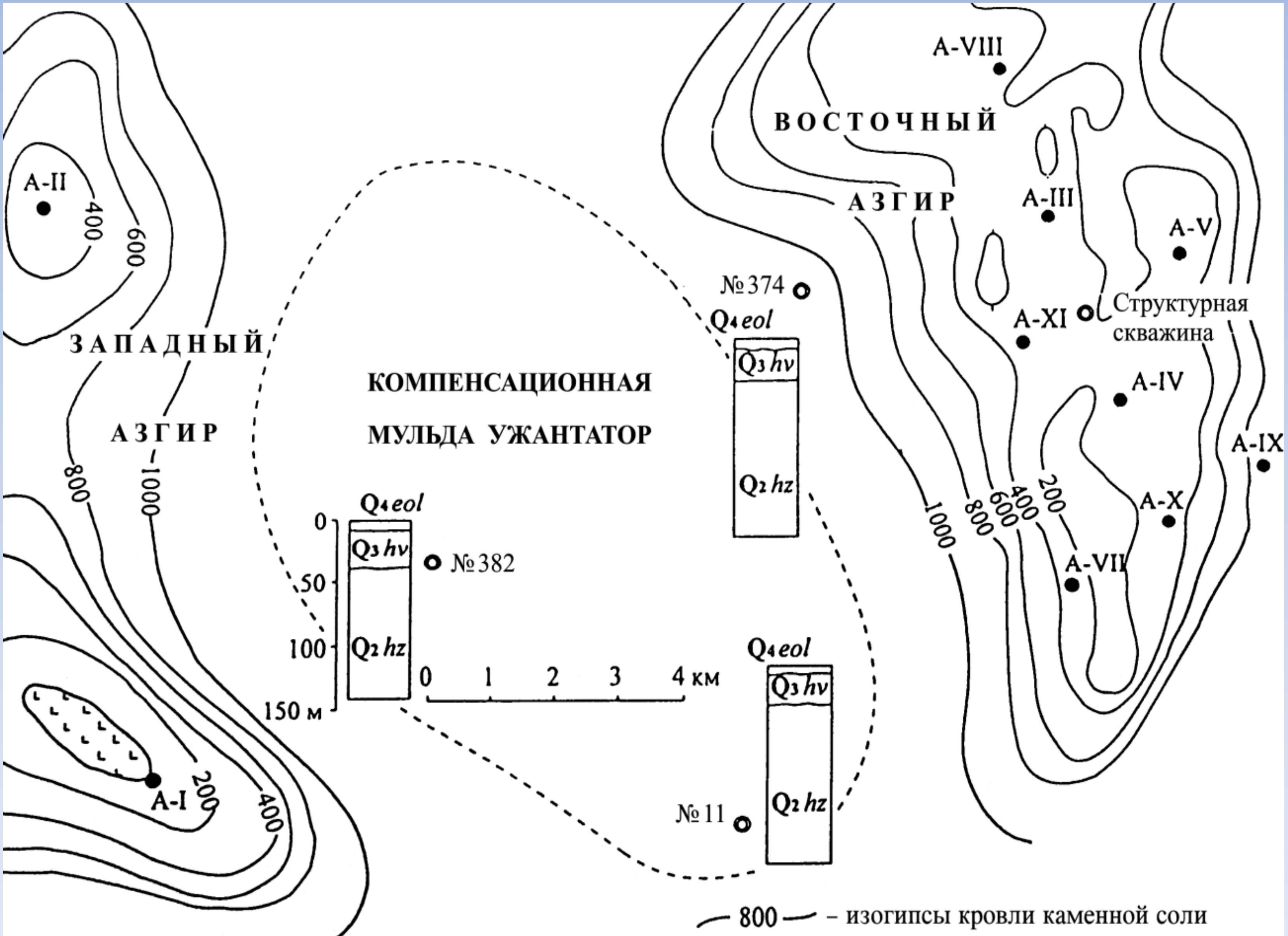
Optimal way – salt formations

Kazakhstan possesses such unique geological formations in its Azgyr polygon

- with depth of its salt formations up to 12-21 km
- Azgyr already has the nuclear polygon infrastructure, including deep shafts/tunnels and craters from numerous nuclear blasts
- detailed geological data/information

Salt-dome structure Azgir

A-I – A-X – wells that used to produce explosions



The list and parameters of underground nuclear explosions conducted in 1966-1979

The index of the explosions and cavity	Depth laying charge, m	Power explosion, kt	The radius of cavity, m	The status of cavity
A-I	161	1,1	~ 14	Completely filled with water
A-II	591	27	32	Completely filled with water
A-III	986	64	39	Completely filled with water
A-IV	997	58	38	Completely filled with water
A-V	1491	10	15	Completely filled with water
A-VII	986	20-150	35-50	Partially flooded
A-VIII	930	<20	18-38	The cavity is dry
A-IX	630	103		The explosion in the shallow clays with the formation of a collapse crater
A-X	917	<20	31	Partially flooded
A-XI	849	<20	18-25	The cavity is dry

Innovation

1. It is the first time when it’s supposed to use its own heat generation source (due to the long-term radioactive waste heat) in the capsule as a source of energy of the environment penetration. In the existing disposing wastes technologies either natural, or artificial wells, or tunnels are used, that essentially limit the depths and thus does not satisfy to the criterion of irreversible disposal of wastes from human activities.

2. The modern methods of specialized wells drilling are limited by the existing drilling technologies and can accumulate 101 m^3 of waste at the depths of 3-5 km.

3. The declared project has a high degree of an interdisciplinarity

Expecting Results

Scientific results

- consolidation theoretical results on the technology of self-burial of heat source into rock salt at account of rock melting or dissolution
- identification of processes and factors limiting the technology
- Investigation geology and geochemistry data of Azgyr rock salt (thermal and electrophysical properties, crystallization and recrystallization)
- preparation of baseline data for the structure (design) of test bench

Expecting Results

The social and economic effect for Kazakhstan

The safe liquidation of the nuclear wastes will have critically positive impact:

- on the ecological terms of the activities of the population of many countries of the world
- on the health of Kazakhstan' population
- the acquiring by Kazakhstan its own technology of final recycling of radioactive wastes
- the possession of the unique Azgyr field for such works performance

Expecting Results

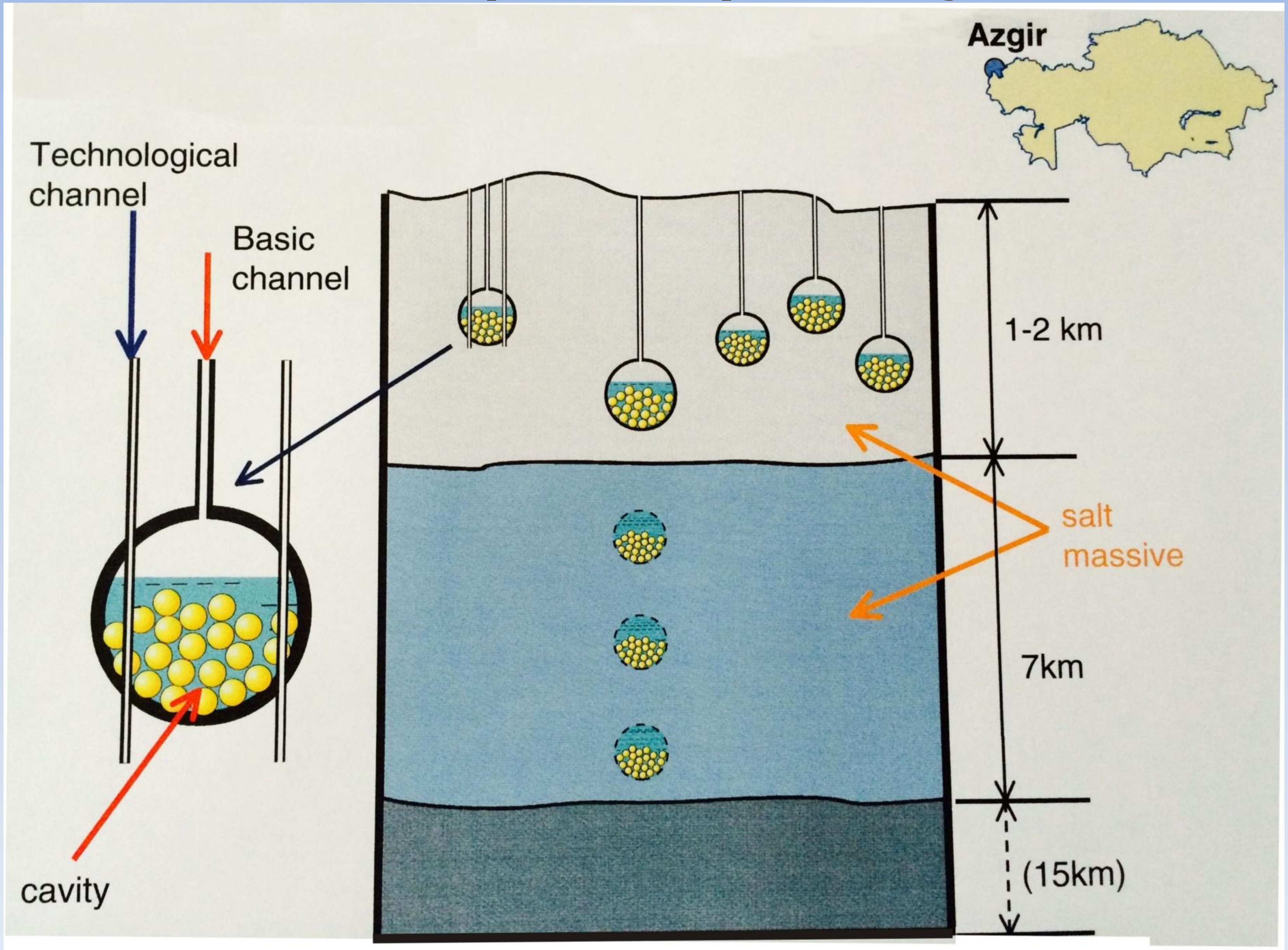
International co-operation

It is important to note that the project is aimed to develop and demonstrate a new technology of global scale.

- Kazakhstan is well positioned to carry out the initiative of developing a solution. Thanks to the country’s unique geological infrastructure for testing of potential technologies (i.e. Semipalatinsk and Azgyr nuclear polygons), Kazakhstan is the best candidate to address the issue of removal of nuclear waste from the biosphere.

- Kazakhstan could establish on Azgyr base “The International Centre for development and implementation of new technologies of irreversible removal of supertoxicants into very deep geological layers of the Earth".

International R&D center and pilot depository

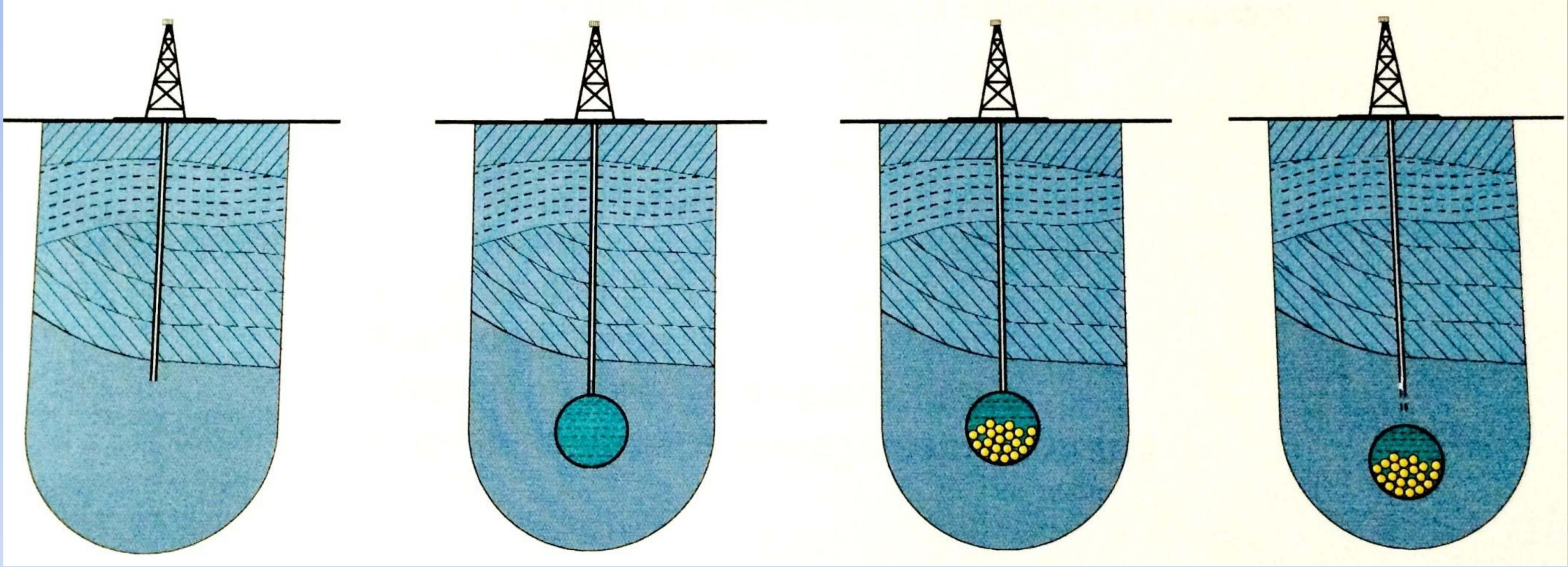


CONCEPT : IRREVERSIBLE deposition of radioactive wastes in rock-salt massive

TECHNOLOGY:

- super deep
- irreversible
- self-deposition
- based on existing infrastructure
- on-line long-term management & control

Technological scheme



Creation of borehole

Preparing of spherical cavity

Filling of cavity with radioactive wastes

Self-deposition