

# **The DRD-method**

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***“Paleoseismicity of Sweden – a novel paradigm”*, 2003**  
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# **DRD**

(**D**ry **R**och **D**eposit)

**an accessible, controllable storage in the bedrock  
surrounded by artificial fracture zones draining the repository**

**which harmonises**

**with**

**Environmental concern**

**Energy concern**

**Modern scientific knowledge**

**(our new geodynamic picture)**

# **How to handle the highlevel nuclear waste**

**In view of**

- (1) the seismic-paleoseismic data recorded**
- (2) the observationally based "respect distances"**

**It seems very hard to find arguments**

**for a closed and final deposition in the bedrock**

**Instead, emerges a more attractive mode of deposition**

**in an accessible, controllable, retrievable deposit**

**in an artificially drained "Dry Rock Deposit"**

## **The Swedish–Finnish KBS-3 concept is based on the following:**

**(1) A very low seismicity**

**maximum 1 magnitude 7 event in 100,000 years**

**(2) A very short "safety distance" to regional faultlines**

**only 50–100 m**

**(3) Virtually no changes in the next 100,000 years**

**All these factors are challenged and shown to be wrong**

**therefore, a new concept must be formulated**

**this is the DRD-concept**

# What is a DRD repository?

- a "Dry Rock Deposit" in the bedrock
- where a rock unit is kept dry by artificial fracture zones
- a high relief area (hill, mountain) is selected
- the depth of deposition is set by the relief; some 50-300 m
- the repository is well sealed for unwanted intrusion
- still it remains accessible
  - for reparation, transmutation, further utilization
- it remains controllable
  - e.g. monitoring of radiation and corrosion
- the freedom of handling is sustained
- it is a significantly less expensive mode of bedrock deposit

**NATURE** - in this case the bedrock and its processes

cannot be concured

we have to learn its ruling processes

and try to follow them - not cuncur them

**TECHNOLOGY** (on the other hand)

can always be improved and advanced

here we can experience both hope and faith

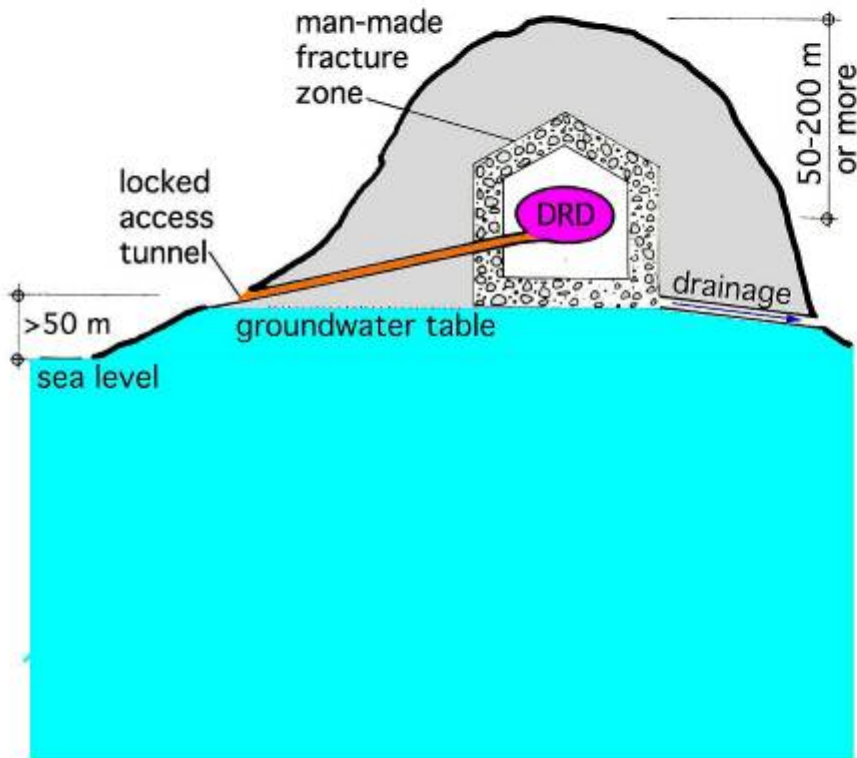
This is the basic thinking behind the proposition of

a dry and accessible DRD deposit

instead of a wet and closed KBS repository

## Dry Rock Deposit (DRD)

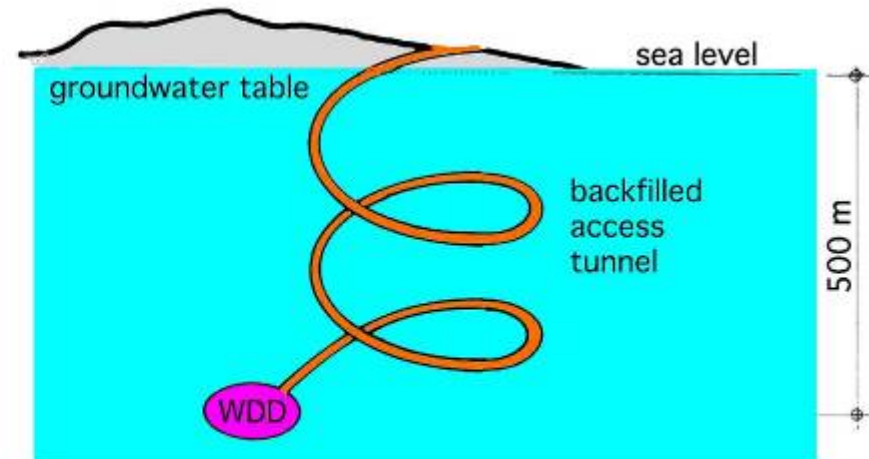
high relief area  
far above sea level



Accessible and Controllable

## Wet Deep Disposal (WDD) of KBS-3 type

low relief area  
close to sea level



Closed and Final

# Dry Rock Deposit argued in favour of Wet Deep Disposal

Björn Cronhjort & Nils-Axel Mörner

## *Radwaste Solutions*

May/June, 2004

### Comparison between alternative methods of disposal of high level nuclear waste in the bedrock

DRD – dry rock deposit according to our model

DOE – dry bedrock deposition in Yucca Mountain, USA

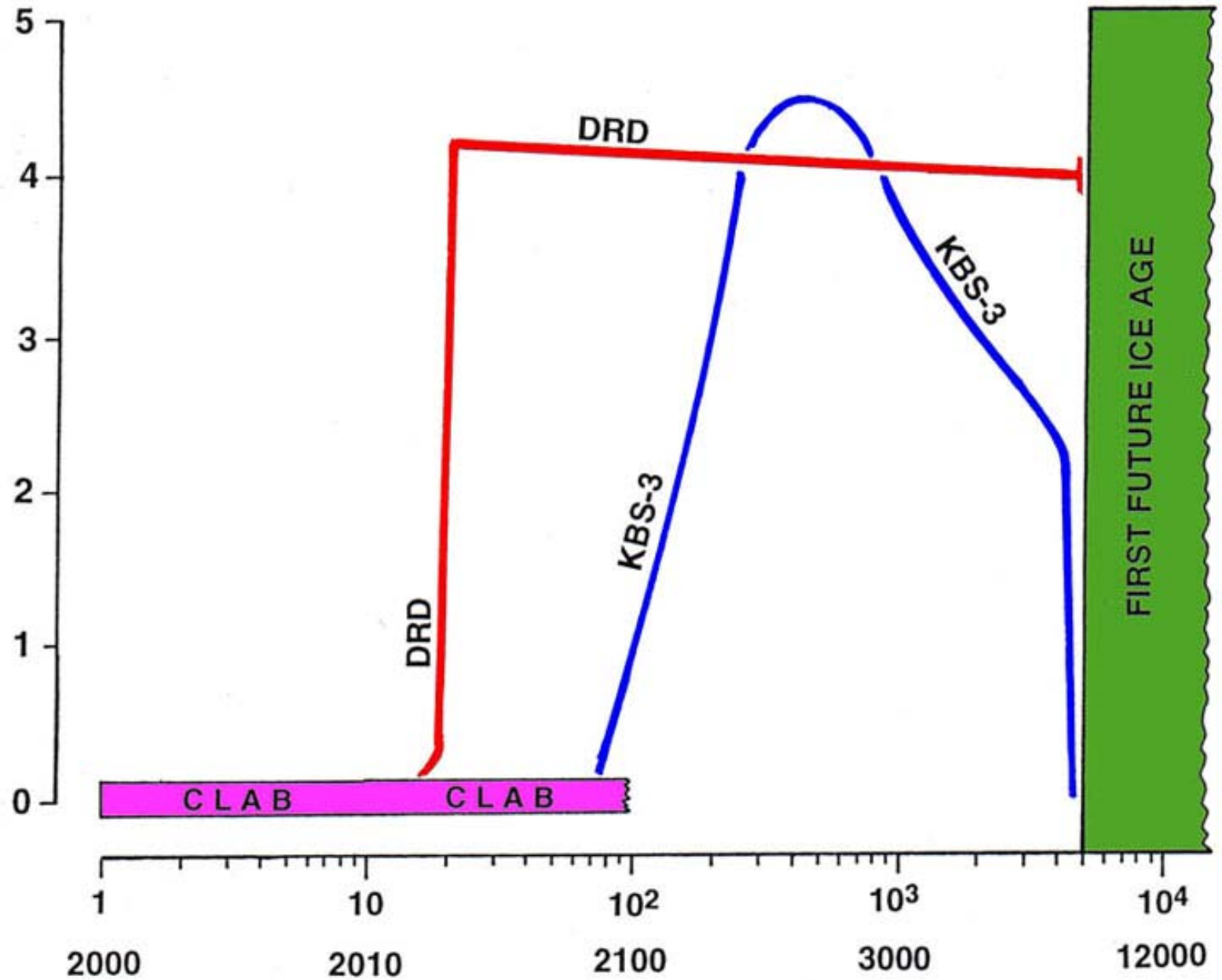
WDD – wet bedrock deposition according to the KBS-3 model

	<b>DRD</b>	<b>DOE</b>	<b>WDD</b>
Environment	dry	dry	wet
Depth (m)	50-200	300	500
Country	(SE)+	USA	SE-SF
Accessibility	yes	yes	no
Monitoring	yes	yes	no
Retrievability	yes	maybe	no
Transmutation	yes	maybe	no
Duration (yrs)	up to next Ice Age	up to 10,000	100,000 or more



Relative safety-scale from 0 to 5

"SAFETY"



Logarithmic time-scale up to First Future Ice Age

**CLAB** (surface storage in water basins lacking security),  
**DRD** (dry, accessible & controllable storage at 50–300 m depth)  
**KBS-3** (closed, final repository at 500 m depth)  
**SDB** (super deep boreholes at 3–5 km depth)

<b>CLAB</b>	<b>DRD</b>	<b>KBS-3</b>	<b>SDB</b>	<b>Parameters</b>
surface	50-300 m	500 m	3-5 km	depth
30-100 yrs	to Ice Age	to Ice Age	no limit	duration
no	ok	good	excellent	shielding
working	rapid	30-100 yrs	30-50 yrs	time frame
yes	yes	no	no	accessibility
yes	yes	no	no	controllability
yes	yes	no	no	transmutation
yes	yes	no	no	future energy
great	small	large	low?	burden
very bad	good	bad	good	environment

<i>Threat:</i>	<i>CLAB</i>	<i>KBS-3</i>	<i>DRD</i>	<i>SDB</i>
<b>Earthquakes</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>1</b>
<b>Terrorism</b>	<b>0</b>	<b>2</b>	<b>1</b>	<b>3</b>
<b>Leakage</b>	<b>0</b>	<b>1-2</b>	<b>2</b>	<b>3</b>
<b>Innovations</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>
<b>Freedom of action</b>	<b>0</b>	<b>(1)</b>	<b>3</b>	<b>0</b>
<b>Control</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>
<b>Coasts</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>
<i>organisation:</i>	<i>SKB</i>	<i>SKB</i>	<i>P&amp;G</i>	<i>MKG</i>

***Most important question?***

***Best method?***

**Intrusion & terrorism**

**SDB**

**Freedom of action & New technique**

**DRD**

**Final deposition – antiquated geodynamics**

**KBS-3**

**Best available storage – modern geodynamics**

**DRD**

**Full safety for 100,000 years**

**None !**

**Getting rid of CLAB (as soon as possible)**

**DRD**

**Economy (installation costs)**

**DRD**

**What is the aim of our handling?**

**– ”Final repository” in knowledge of 1978**

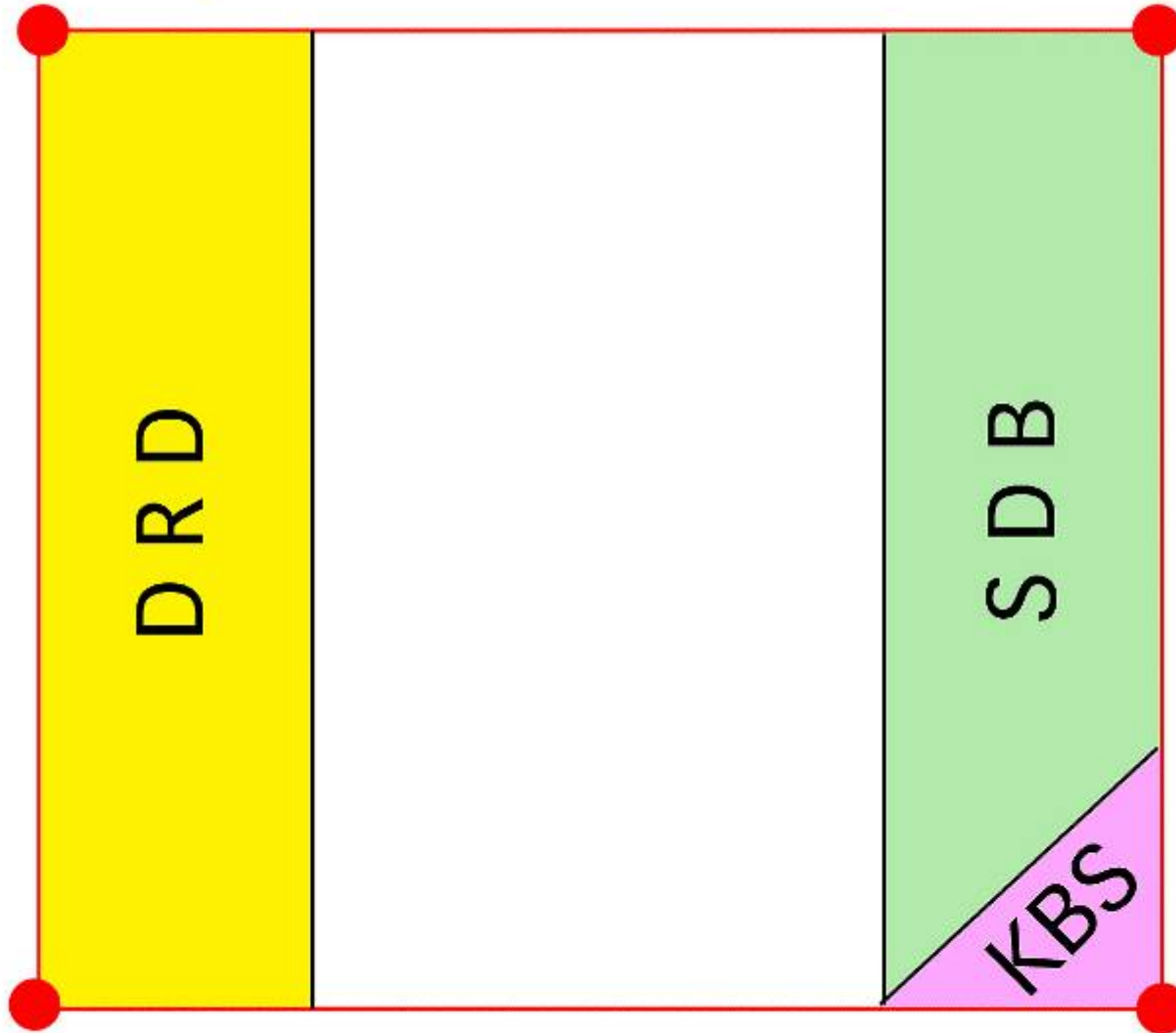
**KBS-3**

**– ”Best available storage” in today’s knowledge**

**DRD**

INNOVATIONS  
NEW TECHNIQUE

TERRORISM  
PLUTONIUM



EARTHQUAKES  
LAW OF NATURE

DECISIONS  
"FINAL DEPOSITION"

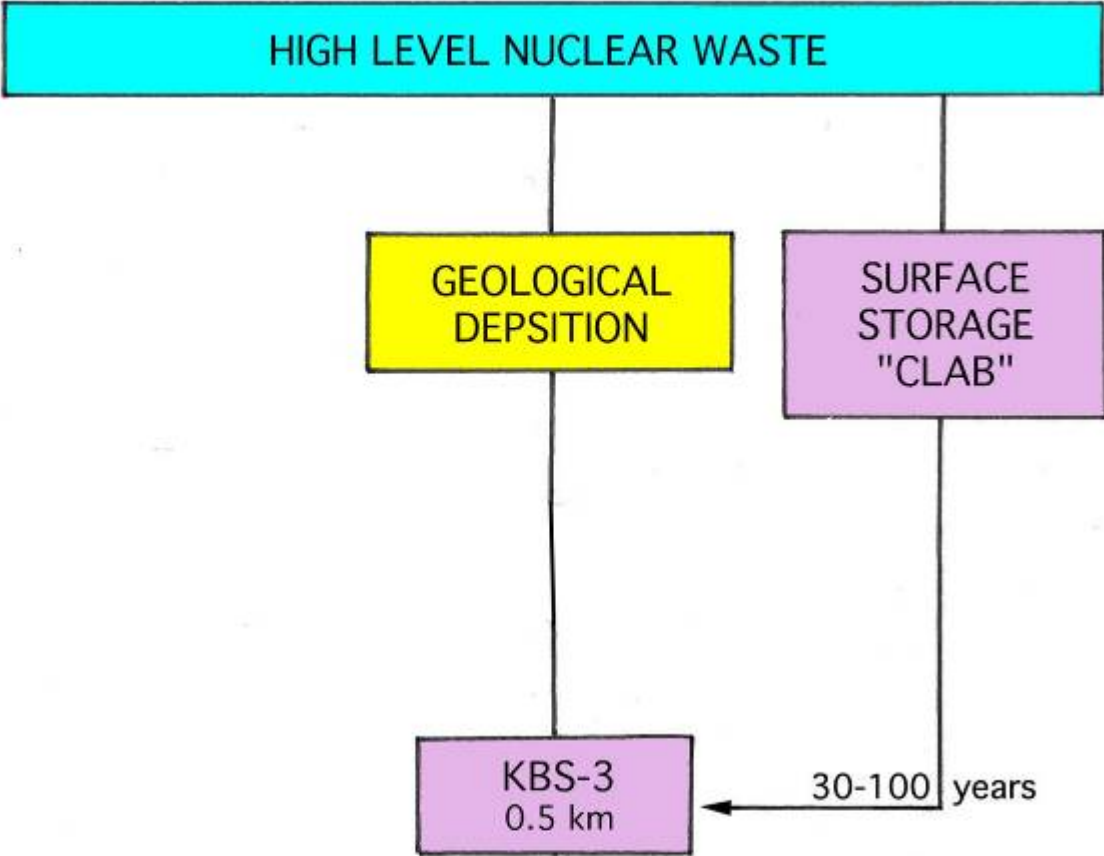
HIGH LEVEL NUCLEAR WASTE

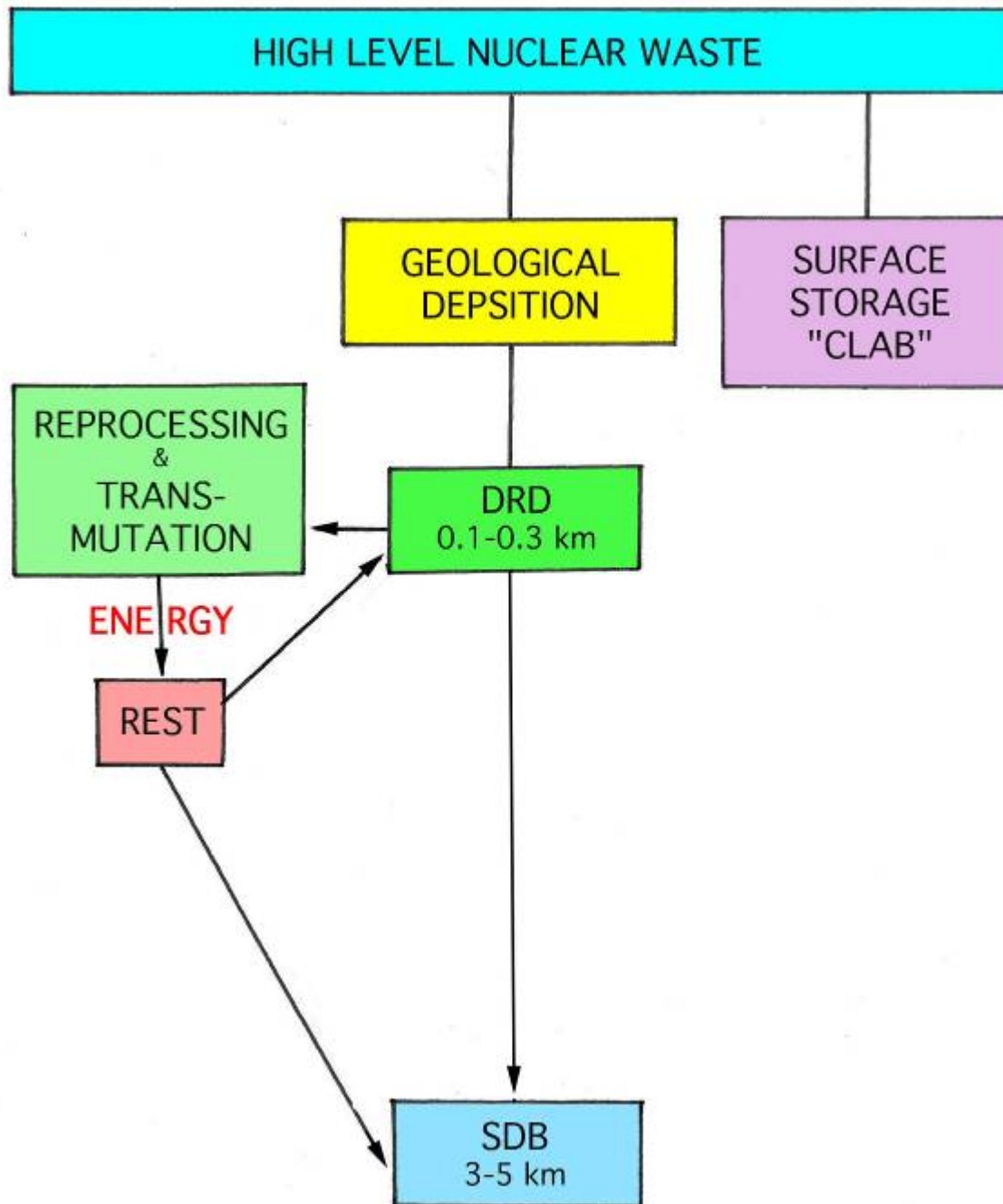
GEOLOGICAL  
DEPOSITION

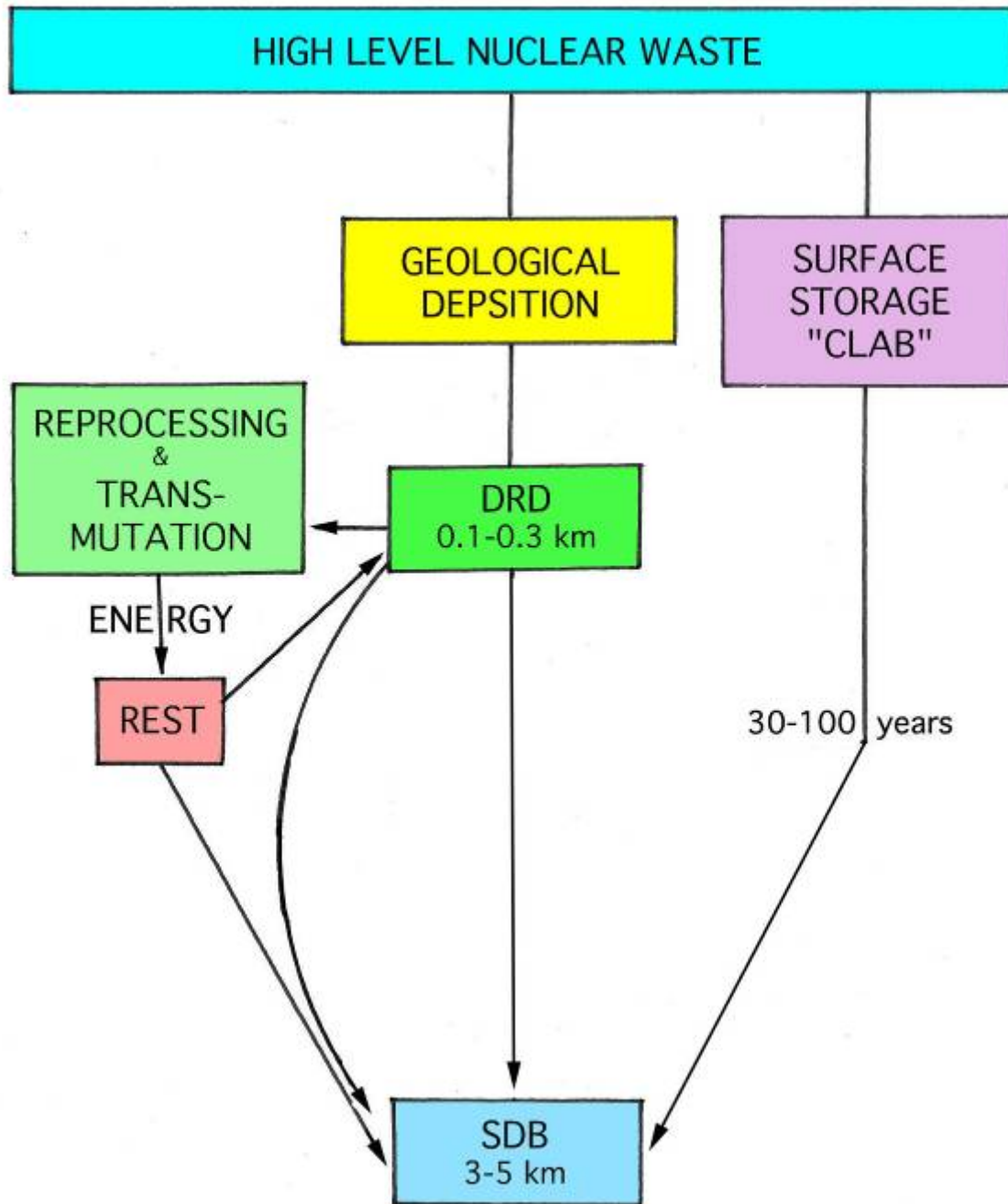
SURFACE  
STORAGE  
"CLAB"

KBS-3  
0.5 km

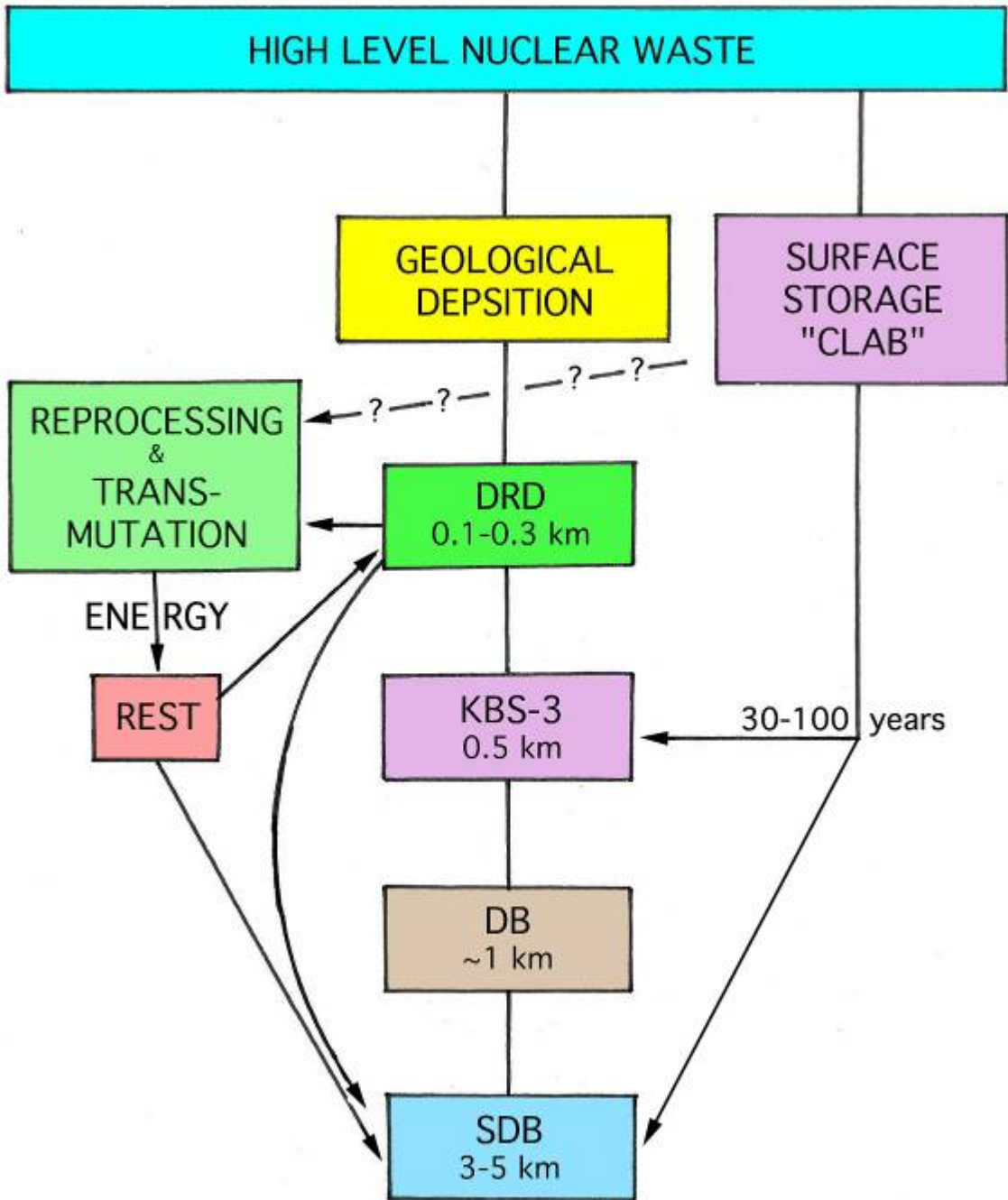
← 30-100 years

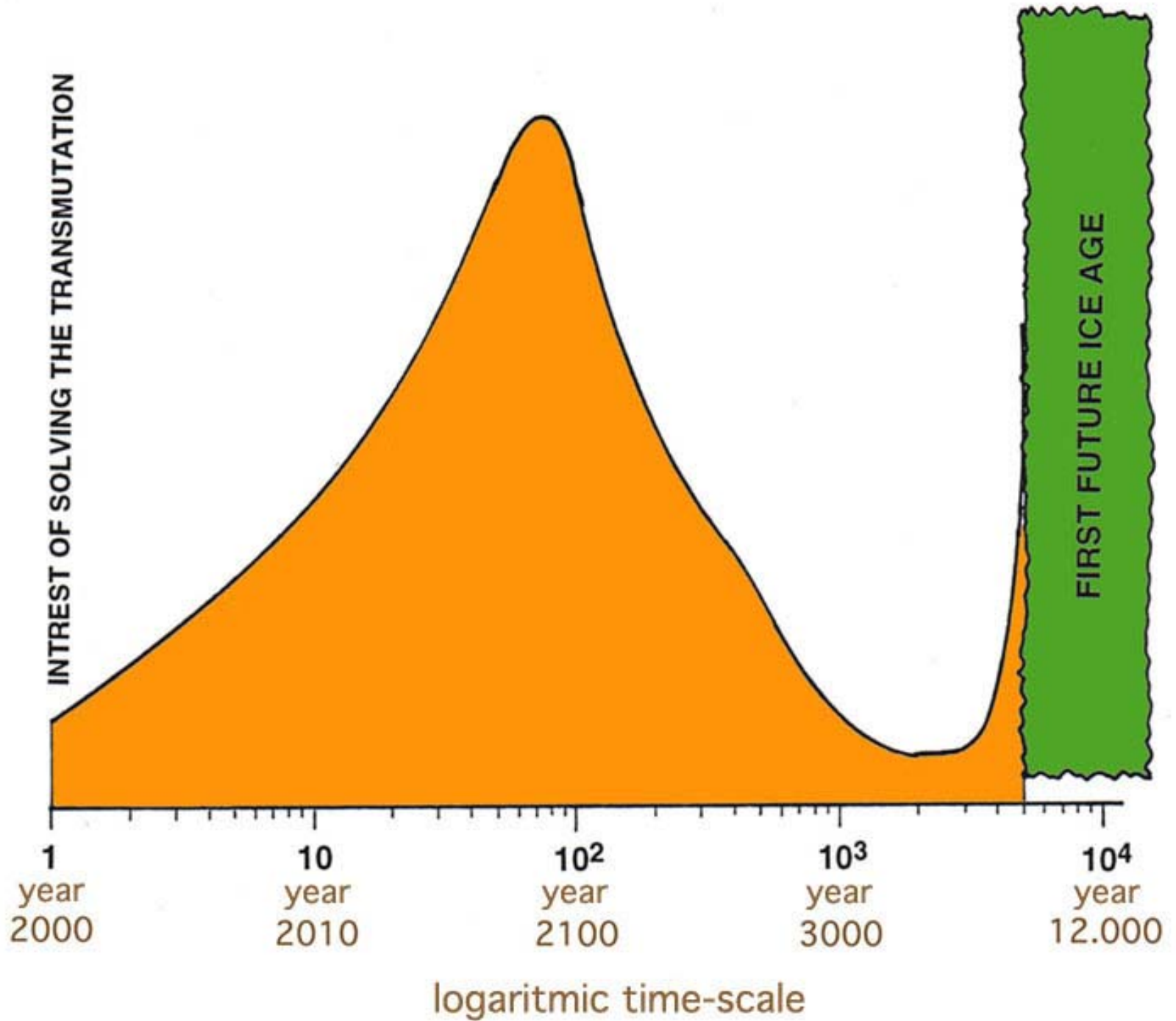








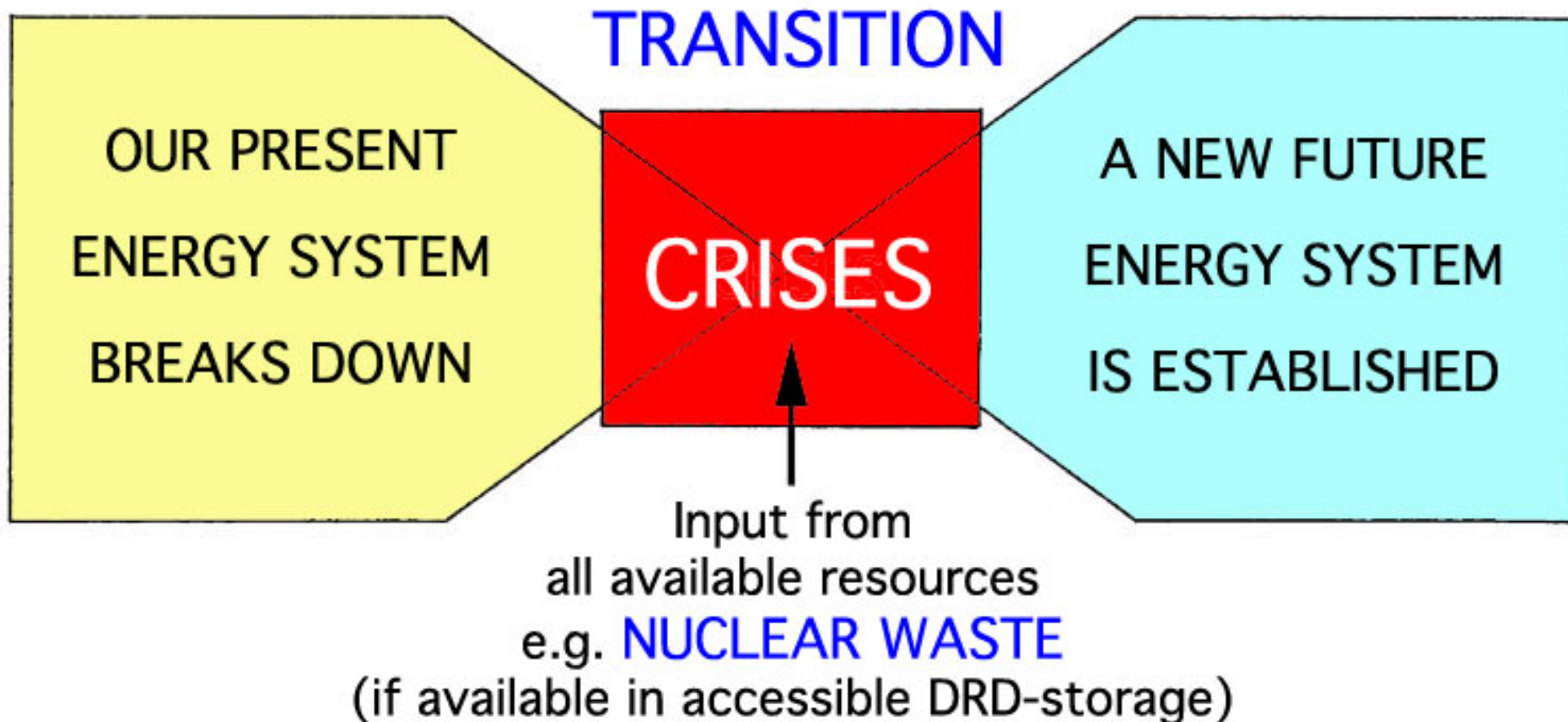


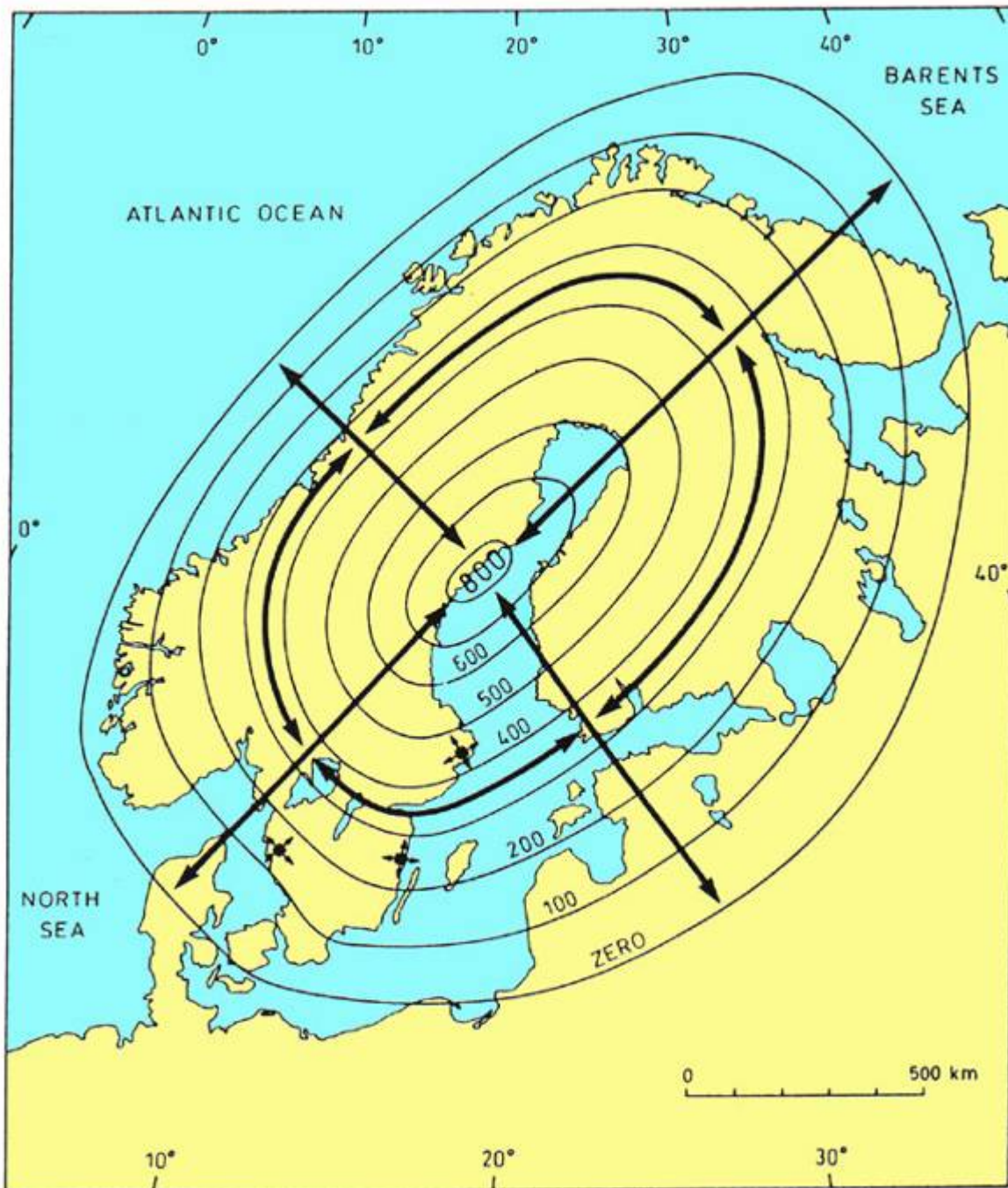


**In 100, at the most 200, years we must be in a New Energy System**

**In the transition period, we will face a major CRISIS**

**when the Nuclear Waste may be our deliverance**





After the Ice Age  
land has gone up  
**by 800 m**  
in the centre  
in Ångermanland  
and by 450 m  
at Stockholm

These movements  
(vertical & horizontal)  
made Sweden  
9000-10,000 years BP  
a

**high-seismic area**

**With increasing time units, the maximum earthquake magnitude increases dramatically; from below 4.5 to well above 8.**

<b>Seismology</b>	<b>&lt;100 years</b>	<b>&lt;4.5</b>
<b>Historical data</b>	<b>last 600 years</b>	<b>&lt;5.5</b>
<b>Late Holocene</b>	<b>last 5000 years</b>	<b>&gt;6 to ~7</b>
<b>Deglacial phase</b>	<b>9–11 Ka BP</b>	<b>&gt;&gt;8</b>

**This implies that we can only achieve a meaningful long-term seismic hazard assessment, if the paleoseismic records of past earthquake events are included.**

# Seismic Hazard Prediction for the next 100,000 years

A: Blue box – based on seismic data only (SKB)

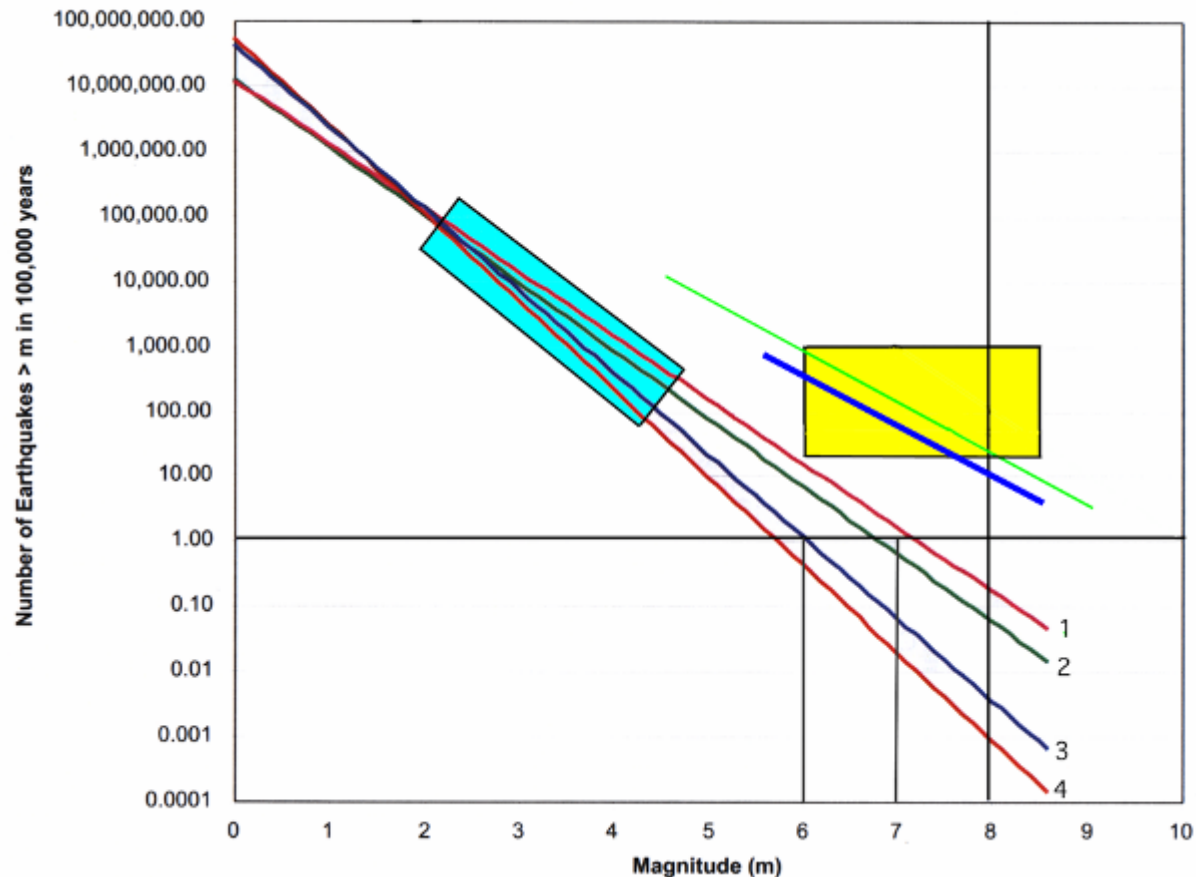
max 1 M 7 event in 100,000 years

B: Yellow box – based on paleoseismic data (Mörner)

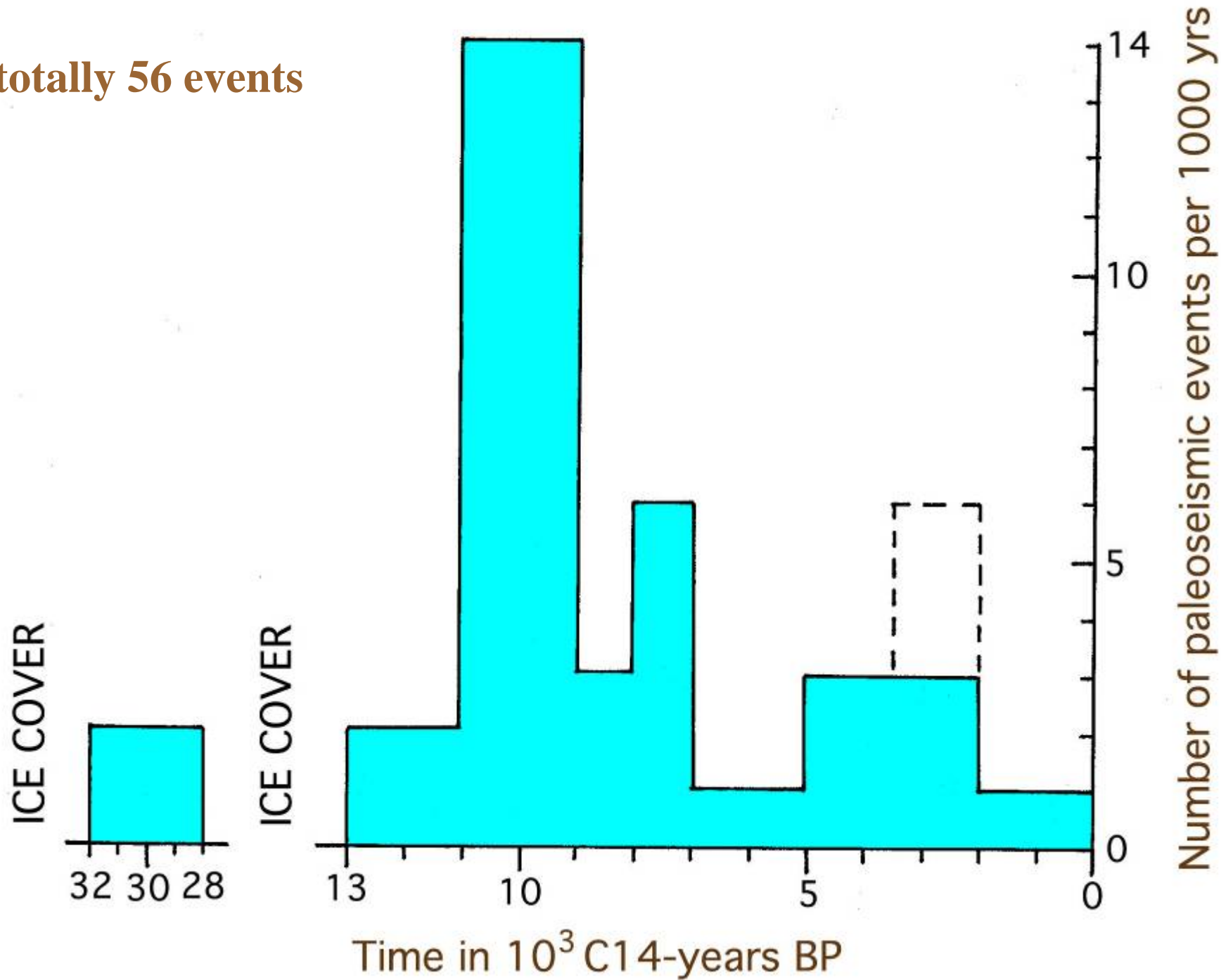
100–1000 M 7 events

~10 M 8 events

even some M ~9 events

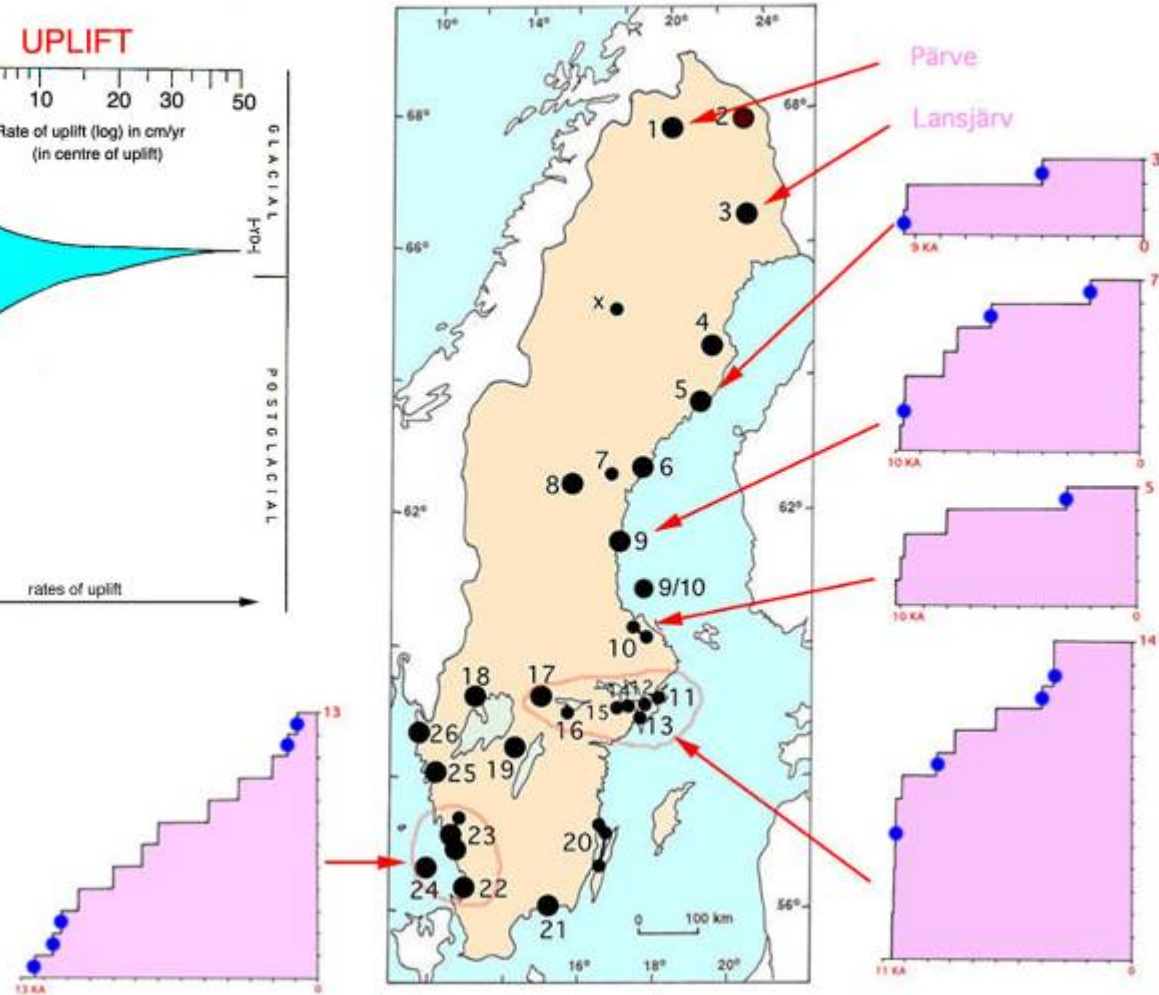
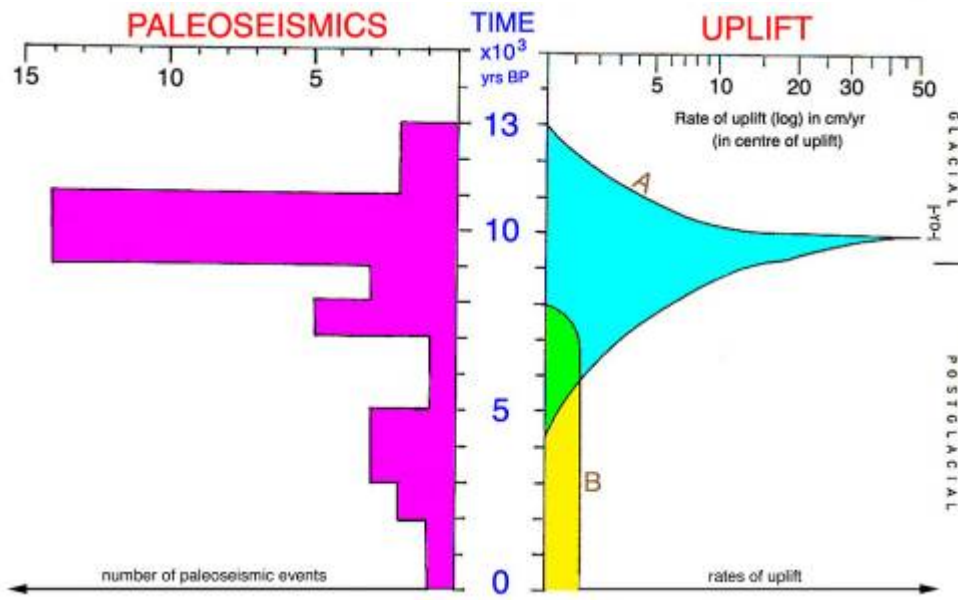


totally 56 events



In recent years it has become obvious that the deglacial period was associated with **violent earthquake** activity; both the magnitude and the frequency of events were exceptionally high.

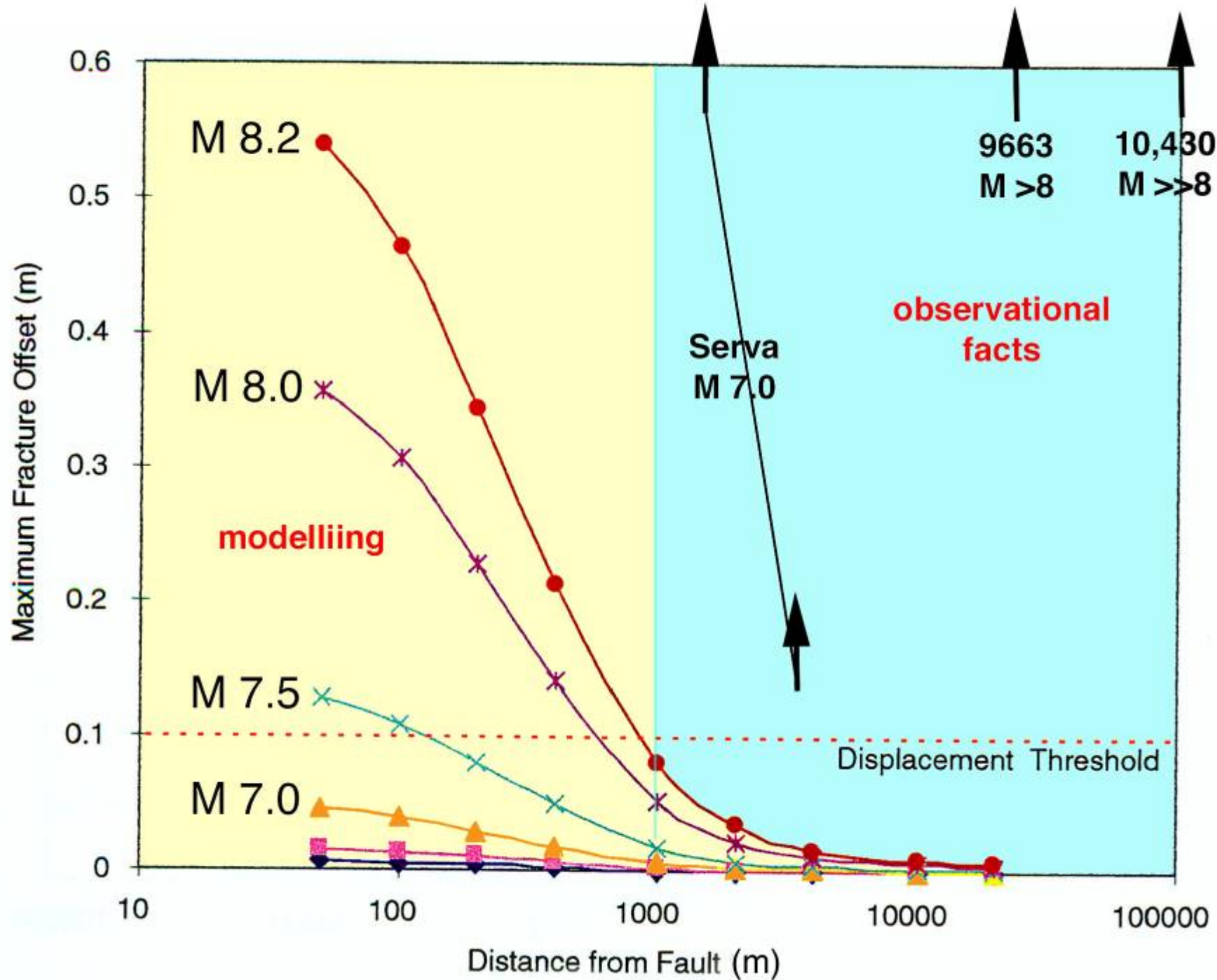
The Swedish Paleoseismic Catalogue includes **56** events, **16** of which were associated with **tsunami events**.



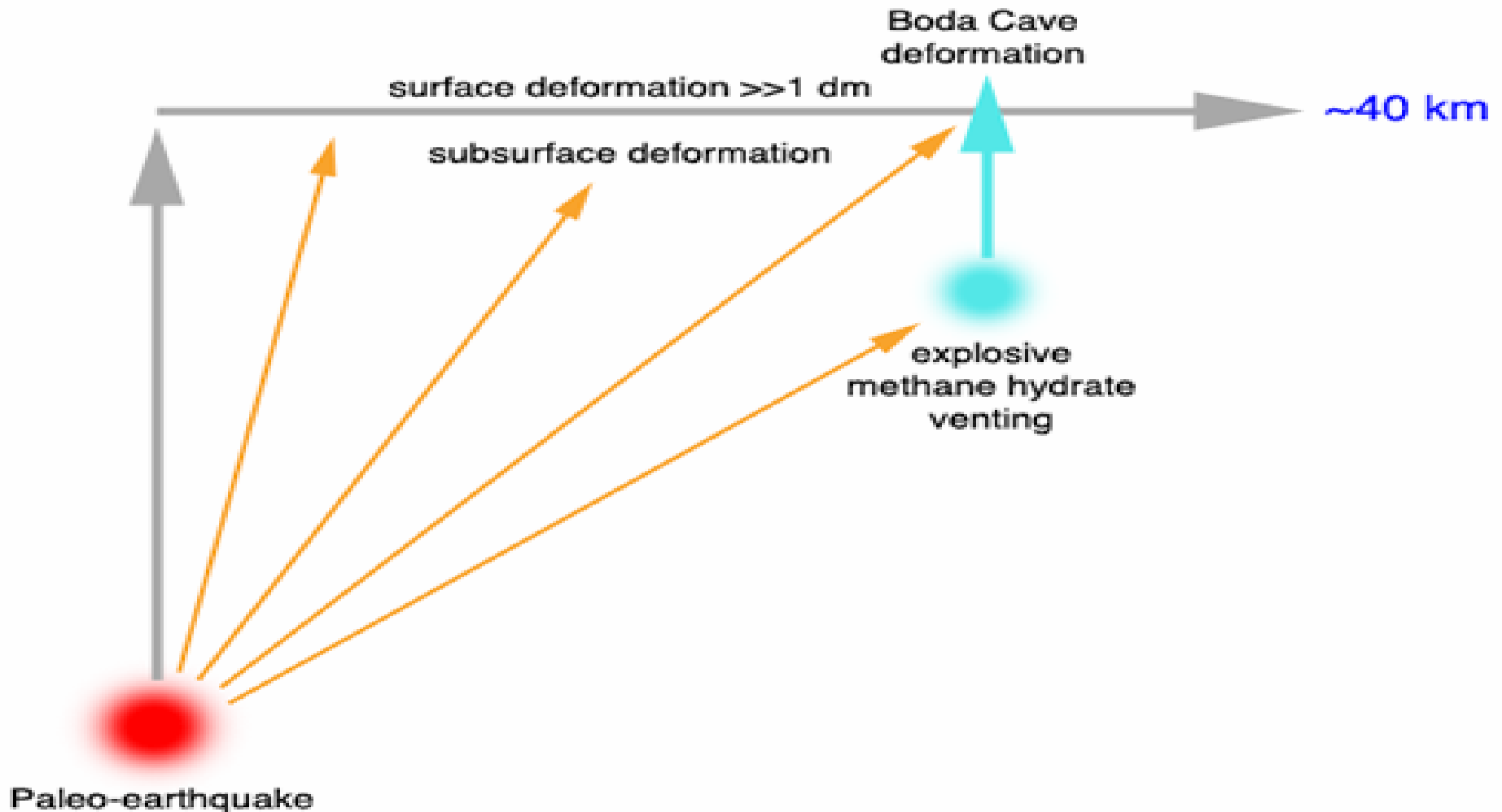


**Distribution of paleoseismic events in Sweden  
(the 2004 Catalogue of 54 events)  
in magnitude groups per 1000 years**

<b>Time in yrs BP</b>	<b>M5-6</b>	<b>M6-7</b>	<b>M7-8</b>	<b>M&gt;8</b>	<b>Total</b>
>12000	-	1	-	1	2
11000–12000	-	-	2	-	2
10000–11000	-	9	4	1	14
9000–10000	2	5	4	3	14
8000–9000	-	2	1	-	3
7000–8000	2	4	-	-	6
6000–7000	-	-	-	1	1
5000–6000	-	-	1	-	1
4000–5000	-	2	1	-	3
3000–4000	-	1	2	-	3
2000–3000	-	2	1	-	3
1000–2000	1	-	-	-	1
<1000	-	-	1	-	1
<b>total:</b>	<b>5</b>	<b>26</b>	<b>17</b>	<b>6</b>	<b>54</b>



the 9663 vBP Boda-Hudiksvall paleoseismic event  
with interaction of seismic and methane venting deformation



**Maybe nobler**  
**to decide the Handling after Reality**  
**than twist Reality**  
**after Expectations and Demands**

*”One should obey Nature  
more than People”*

**What is that?**

**If laws, regulations and instructions  
are found not to agree with Nature,**

**It is Nature and Observations that must count  
and the Laws and Regulations that have to be rewritten**

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