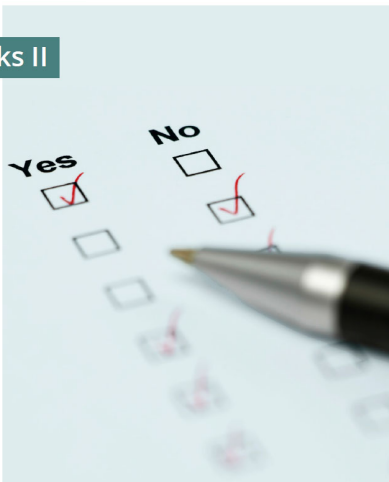


umweltbundesamt^U
ENVIRONMENT AGENCY AUSTRIA


NPP Paks II



K. Decker
E. Hintersberger

Kurt.Decker@univie.ac.at
Esther.Hintersberger@univie.ac.at


**Paleoseismological assessment of the Siting Report
and the Site License with respect to fault capability**

 **Federal Ministry
Republic of Austria**
Climate Action, Environmen
Energy, Mobility,
Innovation and Technology

Examined documents


Geological Site Report

Prepared by a large multi-disciplinary expert group




Site Safety Report

Distilled from the Geological Site Report by MVM Paks II Zrt. and submitted as basis for the site license



Site Permit

Issued by the Hungarian Atomic Energy Authority



**FÖLDTANI KUTATÁSI PROGRAM
ZÁRÓJELENTÉSE**
FELADATKÖD: (1.3.25.)
I. KÖTET
1-2 FEJEZET

2016. Szeptember 20.

Szerzők:
Tóth László, Hintersberger E.

TELEPHELY BIZTONSÁGI JELENTÉS


MVM Paks II Zrt.

II. KÖTET

5. FEJEZET

GEOLÓGIA, GEOFIZIKA, SZEIZMOLÓGIA,
GEOTECHNIKA ÉS HIDROGEOLOGIA

2016.10.18



1539 Budapest, 114. Pf. 675
Telefon: (1) 436-4881
Telefax: (1) 436-4852
E-mail: ogh@haza.gov.hu

HATÁROZAT

1. Az MVM Paks II. Atomerőmű Fejlesztő Zártkörűen Működő Részvénytársaság (a továbbiakban: Ügrelő) részére

telephelyengedély adok

az alábbi, az Égrendsz. Országos - Vésztési (ÉOV) rendszerben megadott koordinátákkal körühatárolt területre:

pontszám	X (m)	Y (m)
1	635623,2	138074,1
2	635648,4	138042,1
3	635648,3	137729,1
4	635636,7	137114,1
5	635205,8	137114,1
6	635296,5	137035,1
7	635205,4	137034,1
8	635205,8	136937,1
9	634733,5	136937,1
10	634733,5	137017,1
11	634998,2	138074,1

az alábbi feltételekkel:

1.1. Amennyiben a kiadott engedélytől eltérő határolt területre kiterjedő földrajzi vagy adminisztratív megjelölésekkel ellátott, de határolt, hogy a vállalkozás megvalósítsa a létesítmény konstrukcióját, összefüggésben megvalósuló védelmi nyújtásai a létesítmény teljes életciklusa alatt:

All documents published on <https://atlatso.hu/> (in Hungarian language)

Paleoseismological assessment of the siting documents focused on the potential of surface displacement by active geological faults. Such displacement may occur during strong earthquakes ("capable faults").

Hungarian Governmental Decree No. 118 of 2011 (VII.11.) on nuclear safety requirements:

7.3.1.0800. *"The potential occurrence of a permanent surface displacement on the site shall be analysed and evaluated. The examination must be sufficiently detailed to enable a substantive decision to be taken on the question of the possibility of discarding the site by the occurrence of permanent surface displacement."*

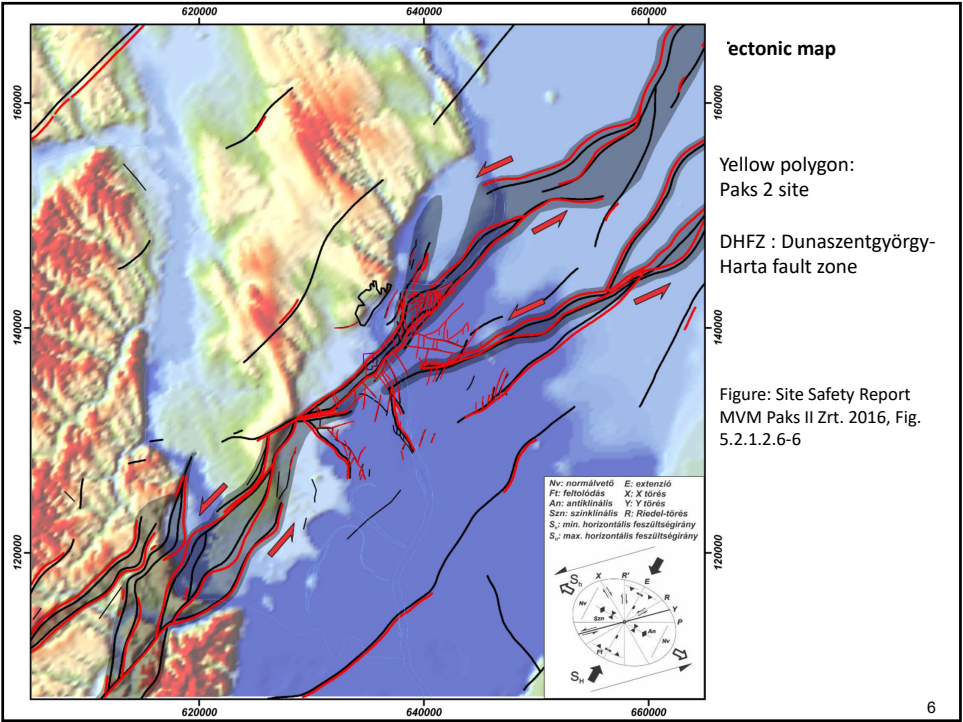
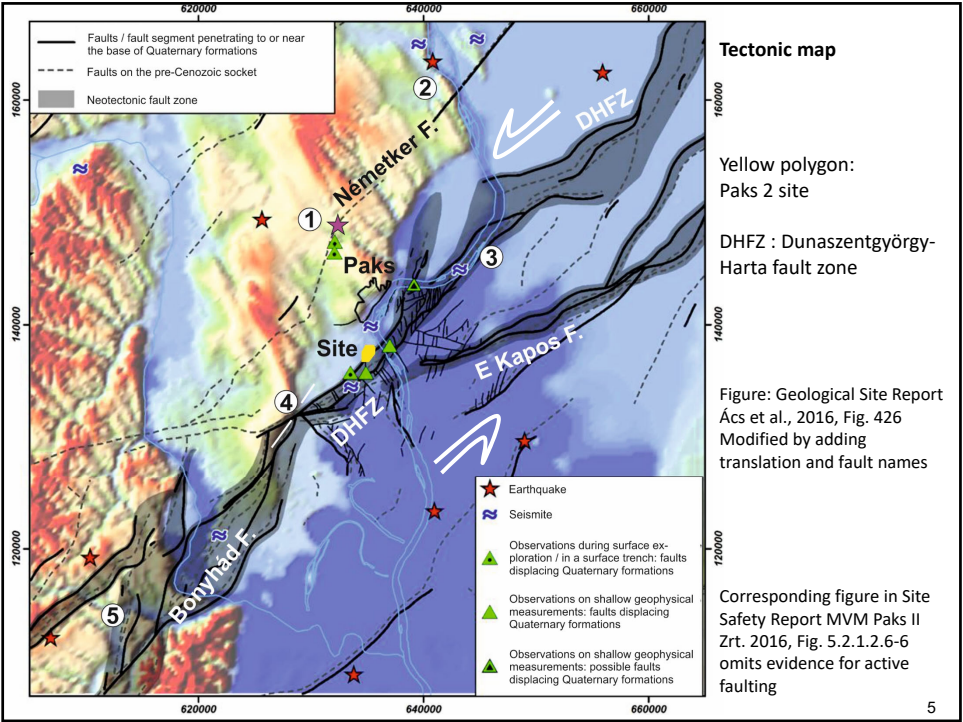
7.3.1.1100. *"If the potential of occurrence of a permanent surface displacement on the site cannot be reliably excluded by scientific evidences, and the displacement may affect the nuclear facility, the site shall be qualified as unsuitable."*

Can potential occurrences of permanent surface displacements (capable faults) be reliably excluded?

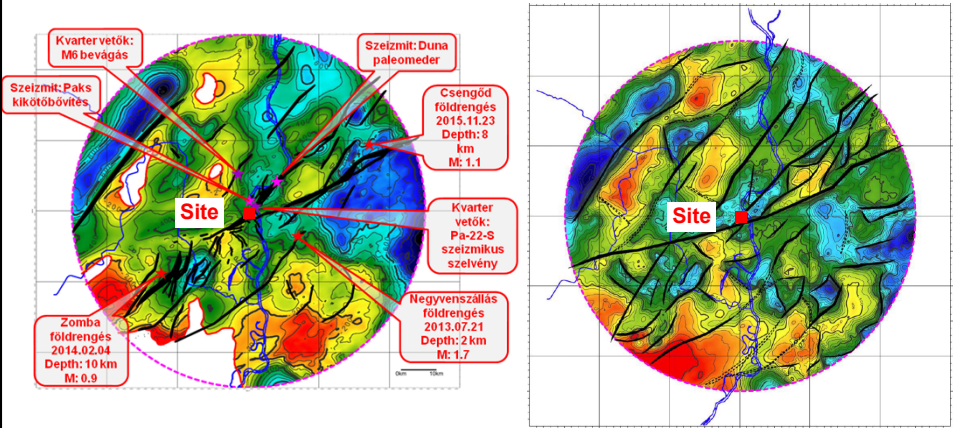
3

**Comparing the contents of the Geological Site Report
and the Site Safety Report**

4



Comparing the contents of the Geological Site Report with the Site Safety Report

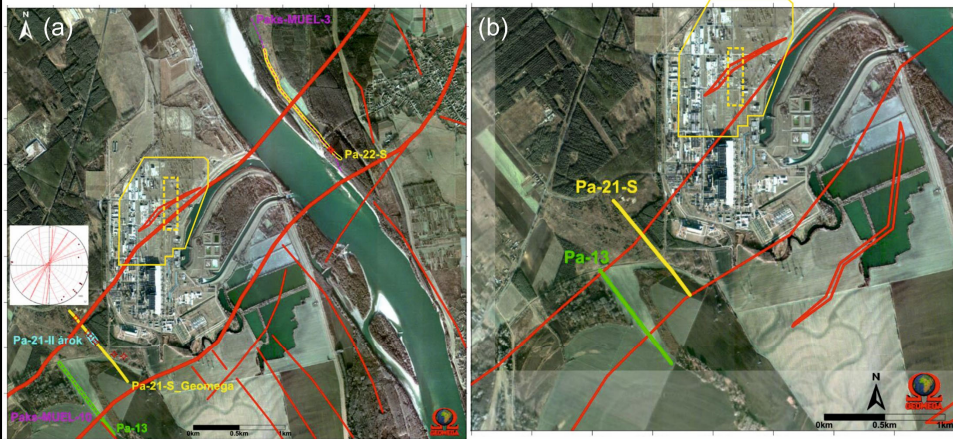


Geological Site Report, Tóth et al., 2016, Fig. 57

Site Safety Report, MVM Paks II ZRT., 2016, Fig. 5.2.1.2.1-6

Data proofing active (Quaternary) deformation of the Dunaszentgyörgy-Harta fault zone summarized in the Geological Site Report are not fully reflected in the Site Safety Report.

Comparing the contents of the Geological Site Report with the Site Safety Report

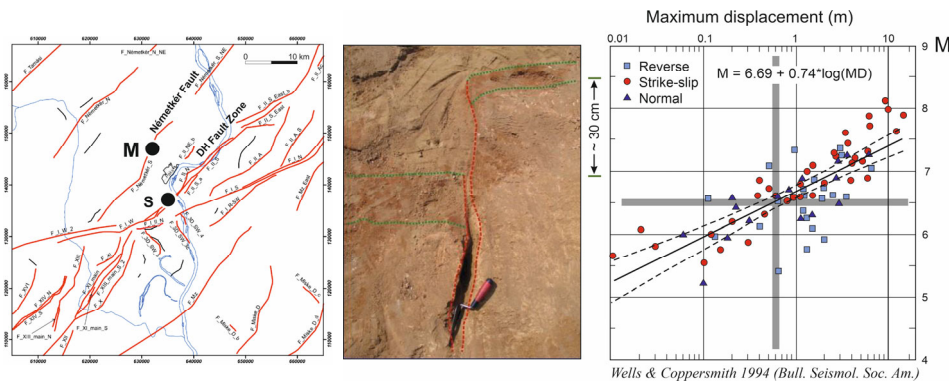


Geological Site Report, Ács et al., 2016, Fig. 418

Site Safety Report, MVM Paks II ZRT., 2016, Fig. 5.2.1.2.6-1

The fault zone indicated by Geological Site Report (left) extends farther North into the perimeter of the new reactor blocks (indicated by broken yellow line).

Comparing the contents of the Geological Site Report with the Site Safety Report



(A) Location of the paleoseismological outcrops along Highway M-6 (Magyari, 2016). Background map: MVM Paks II Zrt., 2016b, Fig. 5.2.1.2.6-3.

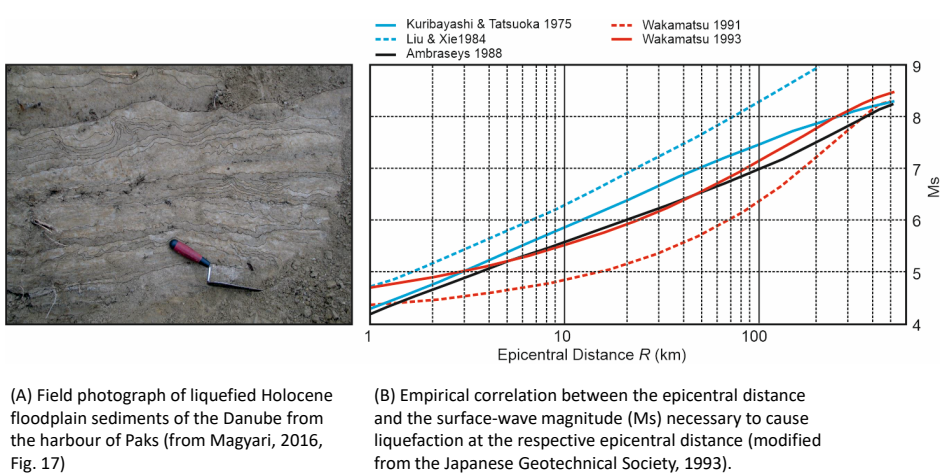
(B) Buried fault scarp with ca. 30 cm vertical offset of a red paleosol developed in loess (green lines; Magyari, 2016, Figure 5).

(C) Empirical correlation between surface displacement and earthquake magnitude. Grey bar denotes the surface displacement of 30 cm inferred from (A).

The paleoseismological results obtained from outcrops along Highway M-6 are not reported in MVM Paks II Zrt. (2016a).

9

Comparing the contents of the Geological Site Report with the Site Safety Report

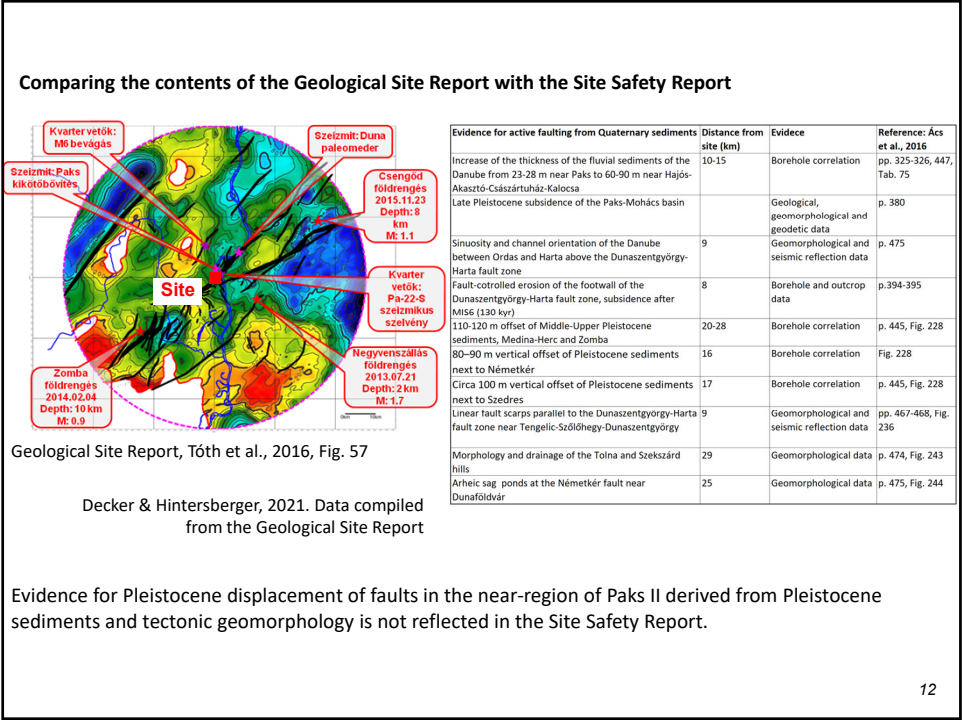
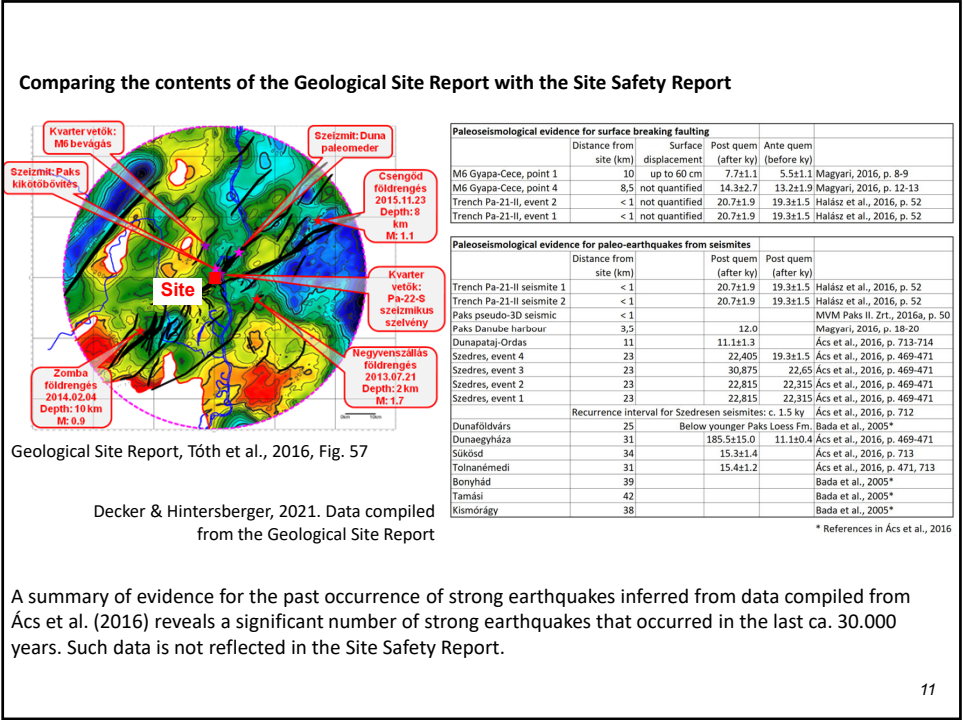


(A) Field photograph of liquefied Holocene floodplain sediments of the Danube from the harbour of Paks (from Magyari, 2016, Fig. 17)

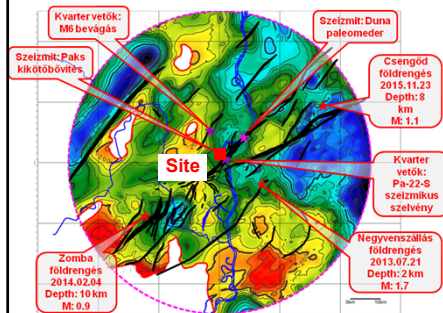
(B) Empirical correlation between the epicentral distance and the surface-wave magnitude (Ms) necessary to cause liquefaction at the respective epicentral distance (modified from the Japanese Geotechnical Society, 1993).

The paleoseismological results obtained from the harbor of Paks are not reported in MVM Paks II Zrt. (2016a).

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Comparing the contents of the Geological Site Report with the Site Safety Report



Geological Site Report, Tóth et al., 2016, Fig. 57

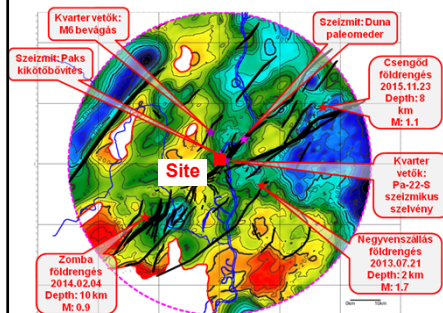
MVM Paks II. Zrt., 2016a, conclusion on active faults, chapter 5.8.2 p. 186):

"... The now extremely detailed data from the Paks area suggest that the Dunaszentgyörgy - Harta fault zone is a young and active tectonic element of the area. ... At the same time, it should be emphasized that even in this zone, which can be classified as tectonically active, no significant displacement has developed, that is, no impact on quaternary formations on site that are less than 100,000 years old in the form of a significant displacement."

The statement is not supported by data from the Geological Site Report. Data prove vertical offsets of Quaternary strata reaching up to several tens and even 100 m in the near-region of the site. The explicitly stated number of 100,000 years for the age of formations is not substantiated by data.

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Comparing the contents of the Geological Site Report with the Site Safety Report



Geological Site Report, Tóth et al., 2016, Fig. 57

HAEA (G. Fichtinger), 2017 Para. 1.12, justification, paragraph 3 ("A rendelkező Rész 1.12 pontjához", pp. 23–27):

"The complex investigations confirm that at the investigated site and within at least 10 km of its surroundings, no fault segment exists that led to surface displacement by faulting in the last 100,000 years."

The statement is factually wrong. Data in the Geological Site Report prove four surface-breaking earthquakes within a distance of 10 km from the site. Two events with $M > 6$ with ages between 14,000 and 5,000 years were documented in outcrops along Highway M-6 (Magyari, 2016). Two other paleoearthquake ruptures with ages between ca. 19,000 and 20,000 years were documented in trench Pa-21-II next to the site.

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Comparing the contents of the Geological Site Report with the Site Safety Report

The evidence of active faulting in the site vicinity of Paks II and the evidence of capable faulting at the Dunaszentgyörgy-Harta fault zone next to the Paks II site is not fully and not correctly reflected in the Site Safety Report compiled by MVM Paks II Zrt.

The Site Safety Report omits relevant data of the Geological Site Report such as virtually all paleoseismological data obtained from the near region of the site.

The Site Safety Report shows a location and width of the Dunaszentgyörgy-Harta fault zone at the site that differs from the data in the Geological Site Report.

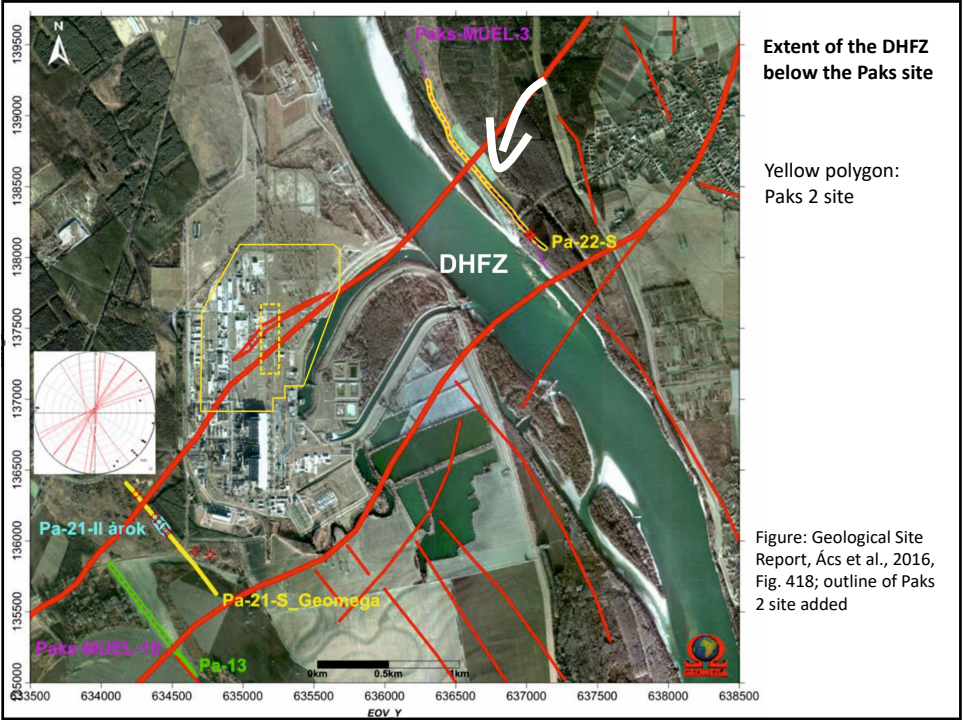
The contradictions between the Site Safety Report on the one hand, and the geological observations and the conclusions in the Geological Site Report, on the other hand, is contrary to the principles of good scientific practice.

15

Detail and completeness of investigations of the DHFZ on the Paks II site

7.3.1.0800. “.... The examination must be **sufficiently detailed** to enable a substantive decision to be taken on the question of the possibility of discarding the site by the occurrence of permanent surface displacement.”

16



Seismic profile Pa-22-S across part of the DHFZ (1500 m NE of the site)

The profile shows 16 individual faults (indicated by the red lines) that offset even the youngest sediments of the Danube. Fault sticks are shown to reach up to about 50 ms TWT (about 5 to 10 m below surface assuming vs 200-400 m/s).

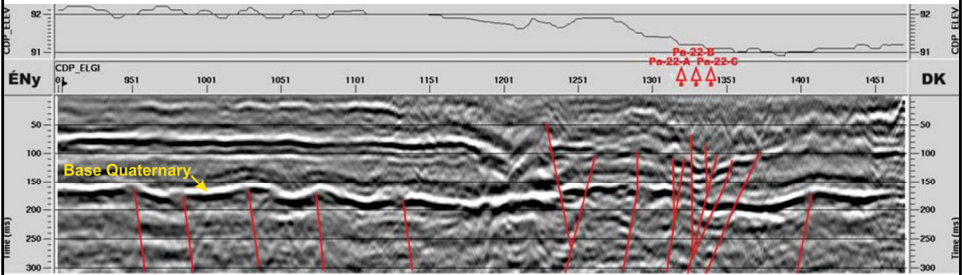
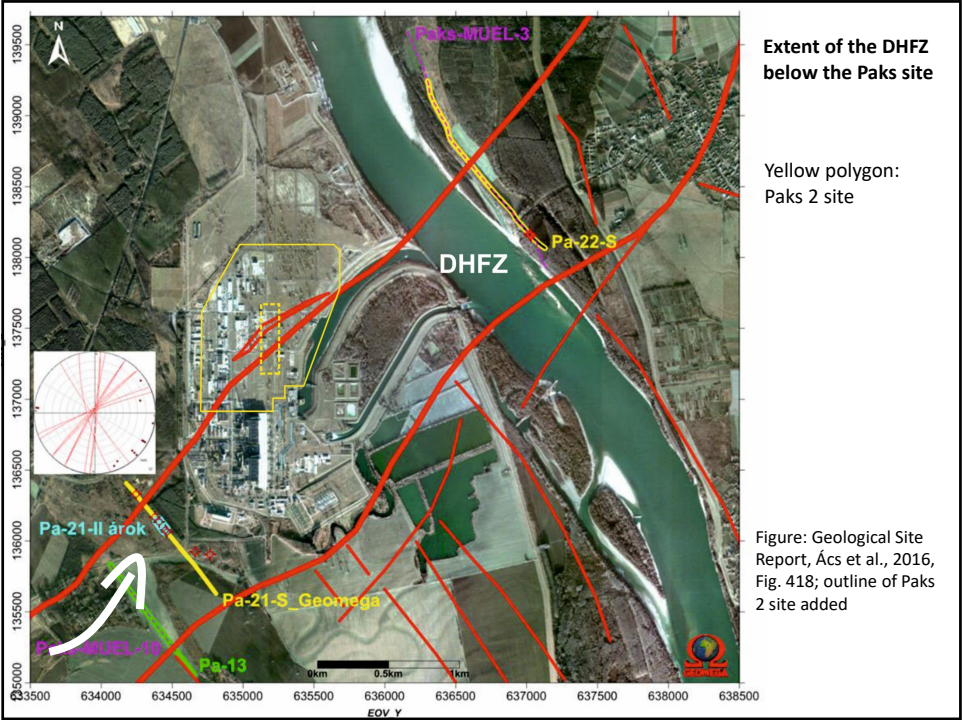


Figure: Geological Site Report, Ács et al., 2016, Fig. 422

Geological Site Report and Site Safety Report do not contain paleoseismological data from the faults imaged by seismic (and resistivity) profiles.

Figure and data are not shown in the MVM Paks II Site Safety Report that formed the basis of the site license application.



Seismic profile Pa-22-S across part of the DHFZ (1500 m NE of the site)

Geological profile derived from 7 shallow boreholes (Pa-21-A-G) and seismic section Pa-21-S-Geomega showing the vertical offset of the Tengelic Red Clay Fm. (Early Pleistocene, 1–2 Ma). The vertical offset of the base of the formation is about 20 m in the strike-slip environment of the Dunaszentgyörgy-Harta fault zone.

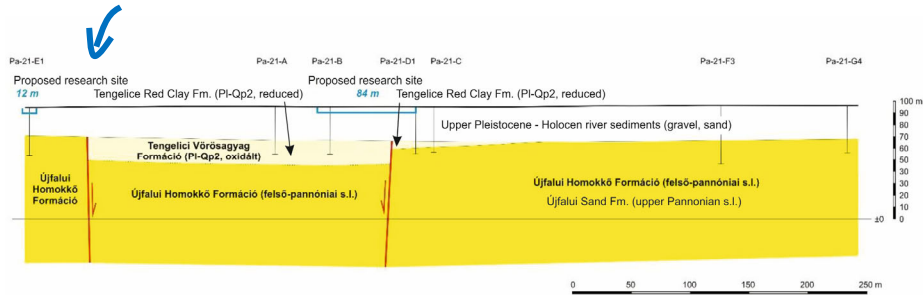


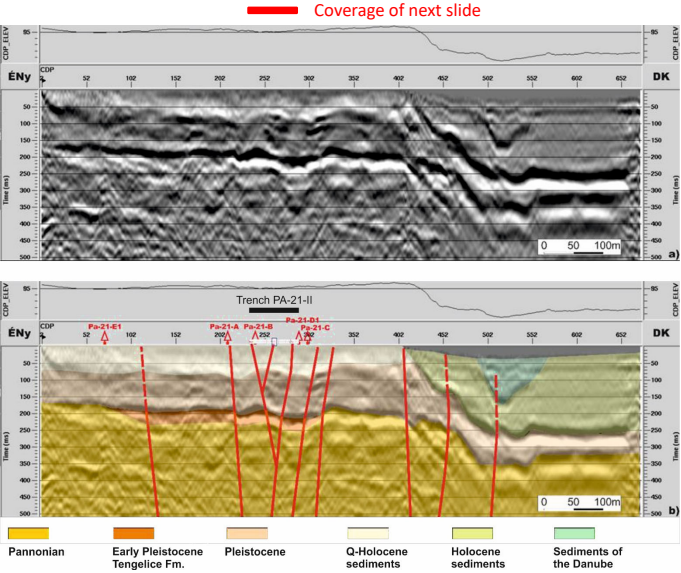
Figure: Geological Site Report, Hálasz et al., 2016, Fig. 9

Geological Site Report and Site Safety Report do not contain paleoseismological data from the fault(s) truncating the Tengelic Red Clay Fm. to the NW.

Figure and data are also shown in the MVM Paks II Site Safety Report (Figure 5.2.1.2.6-8.).

Seismic profile Pa-21-S across part of the DHFZ (700 m SE of the existing NPP Paks)

The profile shows 10 individual faults (indicated by the red lines) that offset even the youngest sediments of the Danube. These faults are shown to reach up to the surface.



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Detail and completeness of investigations of the DHFZ on the Paks II site

7.3.1.0800. “... The examination must be **sufficiently detailed** to enable a substantive decision to be taken on the question of the possibility of discarding the site by the occurrence of permanent surface displacement.”

Geological and geophysical data documented in the Geological Site Report and the Site Safety Report **are not sufficient to reliably exclude the potential of a permanent surface displacement.**

The 85 m long paleoseismological trench is regarded insufficient for a comprehensive assessment of the 1 km wide active fault zone that extends in the subsurface of the existing NPP as well as large parts of the Paks II site.

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Evidence from the paleoseismological trench Pa-21-II

7.3.1.1100. *"If the potential of occurrence of a permanent surface displacement on the site **cannot be reliably excluded by scientific evidences**, and the displacement may affect the nuclear facility, the site shall be qualified as unsuitable."*

23

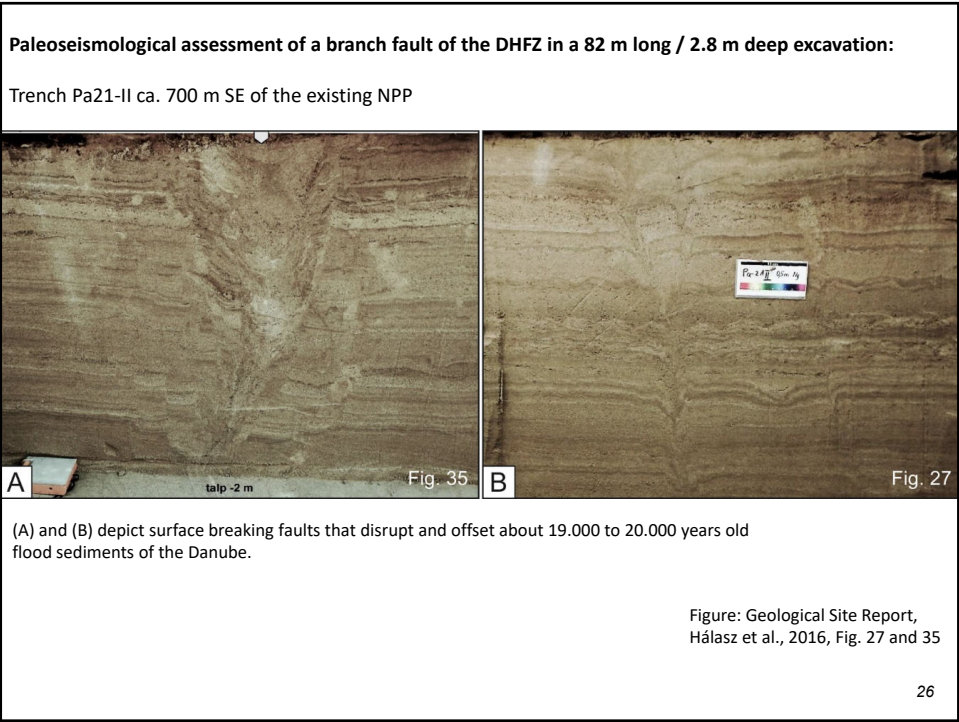
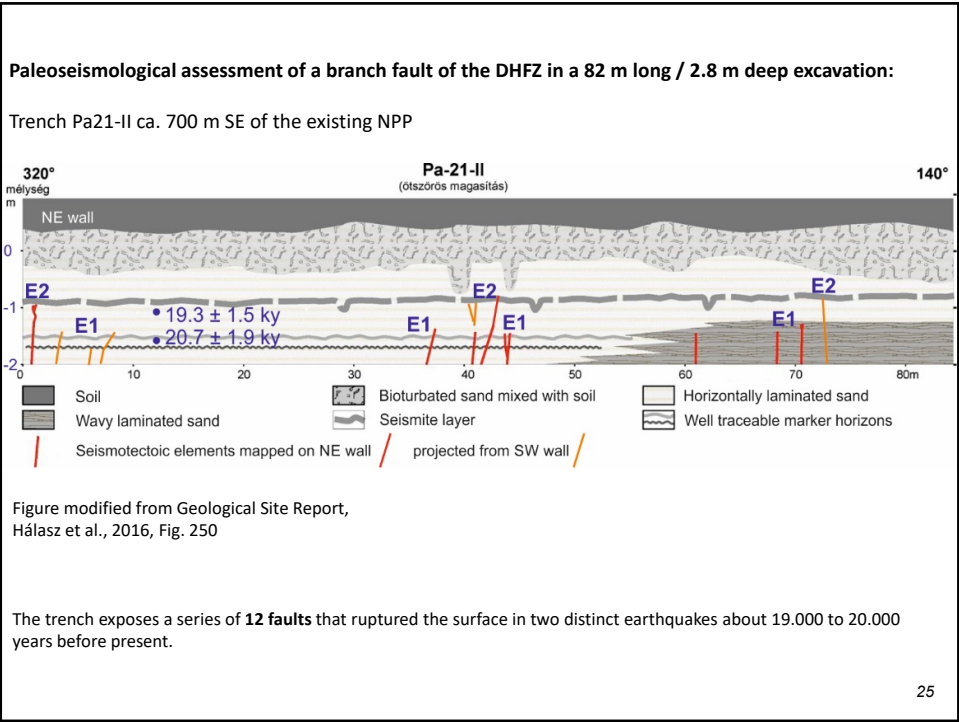
Paleoseismological assessment of a branch fault of the DHFZ in a 82 m long / 2.8 m deep excavation:

Trench Pa21-II ca. 700 m SE of the existing NPP



Figure: Geological Site Report, Hálás et al., 2016, Fig. 11 and 12

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Paleoseismological assessment of a branch fault of the DHFZ in a 82 m long / 2.8 m deep excavation:

Trench Pa21-II ca. 700 m SE of the existing NPP



(A) depicts a surface breaking fault that disrupts and offsets about 19.000 to 20.000 years old flood sediments of the Danube.

Figure: Geological Site Report,
Hálasz et al., 2016, Fig. 27 and 35

Link to photographs:

Surface ruptures caused by the 2010
Darfield Earthquake (New Zealand)

Modern structures are look-alikes of the
structure recovered by the trench Pa-21-II
(figure left)

<https://sciblogs.co.nz/app/uploads/2020/09/New-Zealand-earthquake-rips-a-new-fault-line-across-the-world...-moving-one-side-of-the-earth-11ft-to-the-right-1.jpg>

(B) Surface rupture of the 2010 Darfield Earthquake (New Zealand)

27

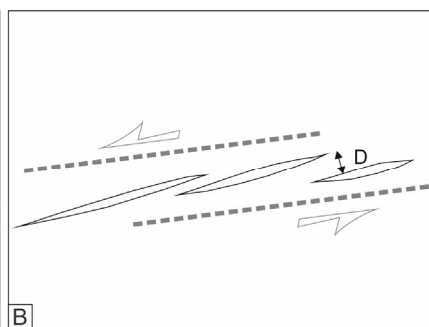
Paleoseismological assessment of a branch fault of the DHFZ in a 82 m long / 2.8 m deep excavation:

Trench Pa21-II ca. 700 m SE of the existing NPP



(A) Sediment filled en-échelon tension gashes erroneously interpreted to record sinistral slip and 2.5 cm horizontal displacement (from Hálasz et al., 2016, Fig. 32; Frank Horvath for scale).

Figure: Geological Site Report,
Hálasz et al., 2016, Fig. 32



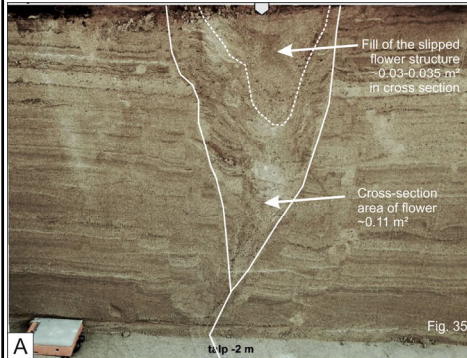
(B) schematic sketch of a sinistral shear zone with en-échelon tension gashes showing that the measurement in (A) measures the horizontal spacing of the sediment-filled tension gashes. The amount of sinistral displacement remains undetermined and may exceed the stated value significantly.

Figure: Decker & Hintersberger, 2021, Fig. 24

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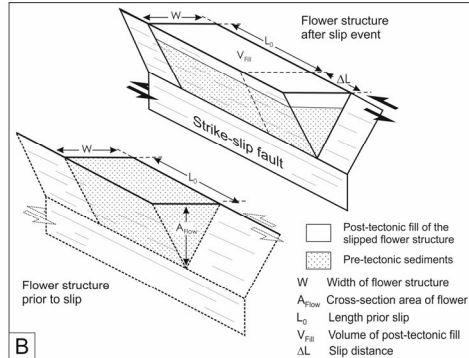
Paleoseismological assessment of a branch fault of the DHFZ in a 82 m long / 2.8 m deep excavation:

Trench Pa21-II ca. 700 m SE of the existing NPP



(A) Negative flower structure at 43.7 m of the trench Pa-21-II, interpretation by Decker & Hintersberger, 2021. The continuous white line indicates the boundary faults of the flower structure; the broken line delimits sediments of the post-tectonic fill.

Background photo: Halász et al., 2016, Fig. 35



(B) Schematic shoebox model illustrating the geometry of a negative flower structure. A slip distance of 0.3-0.4 m is calculated from the dimension of the trenched structure (cross-section area 0.03 to 0.035 m²; minimum length 1.3 m; minimum volume of sediment fill 0.039 to 0.046 m³).

Figure: Decker & Hintersberger, 2021, Fig. 24

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Evidence from the paleoseismological trench Pa-21-II

7.3.1.1100. "If the potential of occurrence of a permanent surface displacement on the site **cannot be reliably excluded by scientific evidences**, and the displacement may affect the nuclear facility, the site shall be qualified as unsuitable."

MVM Paks II Zrt. 2016, Site Safety Report: "Seismic events occurring in the research area ... are not able to significantly displace the surface, i.e., the fault planes cannot be considered capable."

The statement by MVM Paks II Zrt. is not in line with geological evidence described in the Geological Site Report. Interpreting the structures excavated in trench Pa-21-II as proofs of repetitive strong earthquakes with significant surface displacement is, at least, in the range of reasonable and scientifically defensible interpretations.

The occurrence of a permanent surface displacement can therefore not be reliably excluded by scientific evidences.

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Links to photographs:

Evidence of surface ruptures caused by the 2010 Darfield Earthquake (New Zealand)

Modern structures are look-alikes of the fractures recovered by the paleoseismological trench Pa-21-II next to the Paks site

https://static.dw.com/image/36379768_303.jpg

<https://sciblogs.co.nz/app/uploads/2020/09/New-Zealand-earthquake-rips-a-new-fault-line-across-the-world...moving-one-side-of-the-earth-11ft-to-the-right-1.jpg>

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