Pa issues. Modeling and some critical parameters

Henrik Nordman

13 September 2012

PA = Performance assessment. Modeling needs

- Geosphere pathway data is needed.
- Reliable computer models are needed. Verification of models

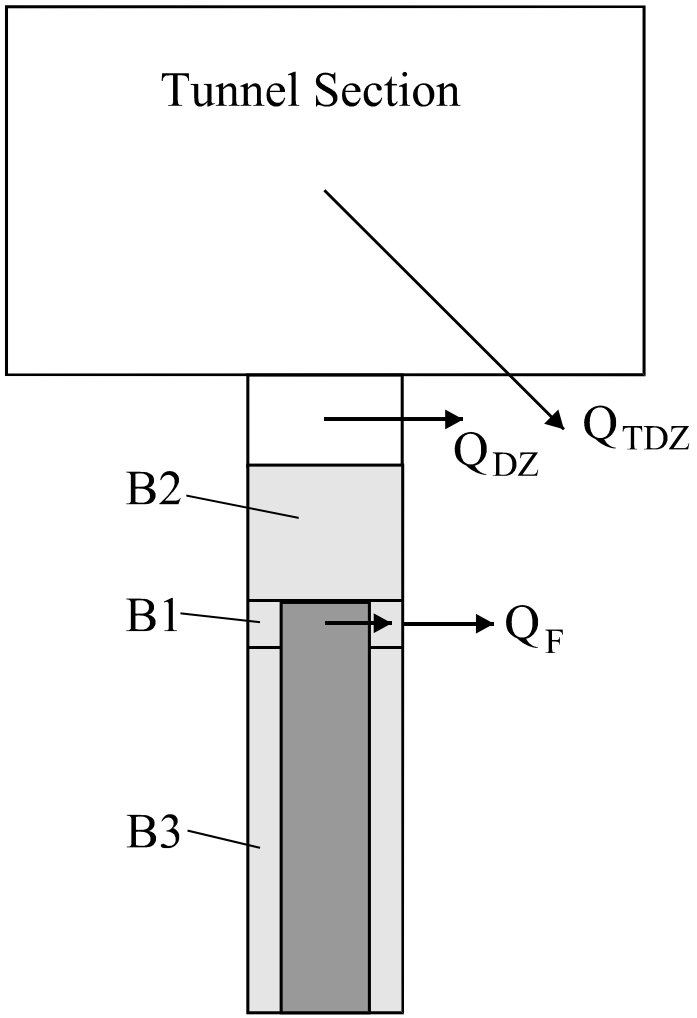
- The theoretical understanding of matrix structure etc is not compulsory for Pa calculations with models. Somebody will do the interpretation of in situ tests. RETROCK
- Models use conventional parameters which can be nuclide specific to some extent.

Modified RNT-2008 near field for C-14 and Ra-226 geosphere test.

- Modified RNT-2008 near field for C-14 test.
- Severely damaged canister at 10 000 years.
- C-14, only in metal parts, current high inventory and MOST **IMPORTANT: Corrosion rate of metal parts varied in spite of lack of hard new data. The choice from 20 years ago is still used.**

- Opposite to defect QF from bentonite to fracture in rock, 6.14 litres/yr, current value. QDZ from backfill in the deposition hole and QTDZ from the tunnel to the rock set to zero. See Next slide.

Severely damaged canister at 10000years.



Canister interior

Bentonite buffer

Tunnel backfill

$$t_{max} = t_w + \frac{2u^2}{3}$$
$$t_{max} = t_w + \frac{3^2 u^2}{3}$$

Well known analytical solution for constant inlet to geosphere. No dispersion.

- Constant input $C_f(L, t) = C_o \text{ erfc } [u\, t^{-1/2}]$
- $u = [D_e (\varepsilon_p + K_d \rho_s)]^{1/2} \times WL/Q$
- W = width of channel and L=length. Q is floe m3/yr
- $WL/Q = t_w /2b$, where t_w = travel time in channel and 2b is aperture of channel.

- For delta pulse $t_{max} = t_w + 2u^2/3$ and

$$m_{max} = 0.23/u^2$$

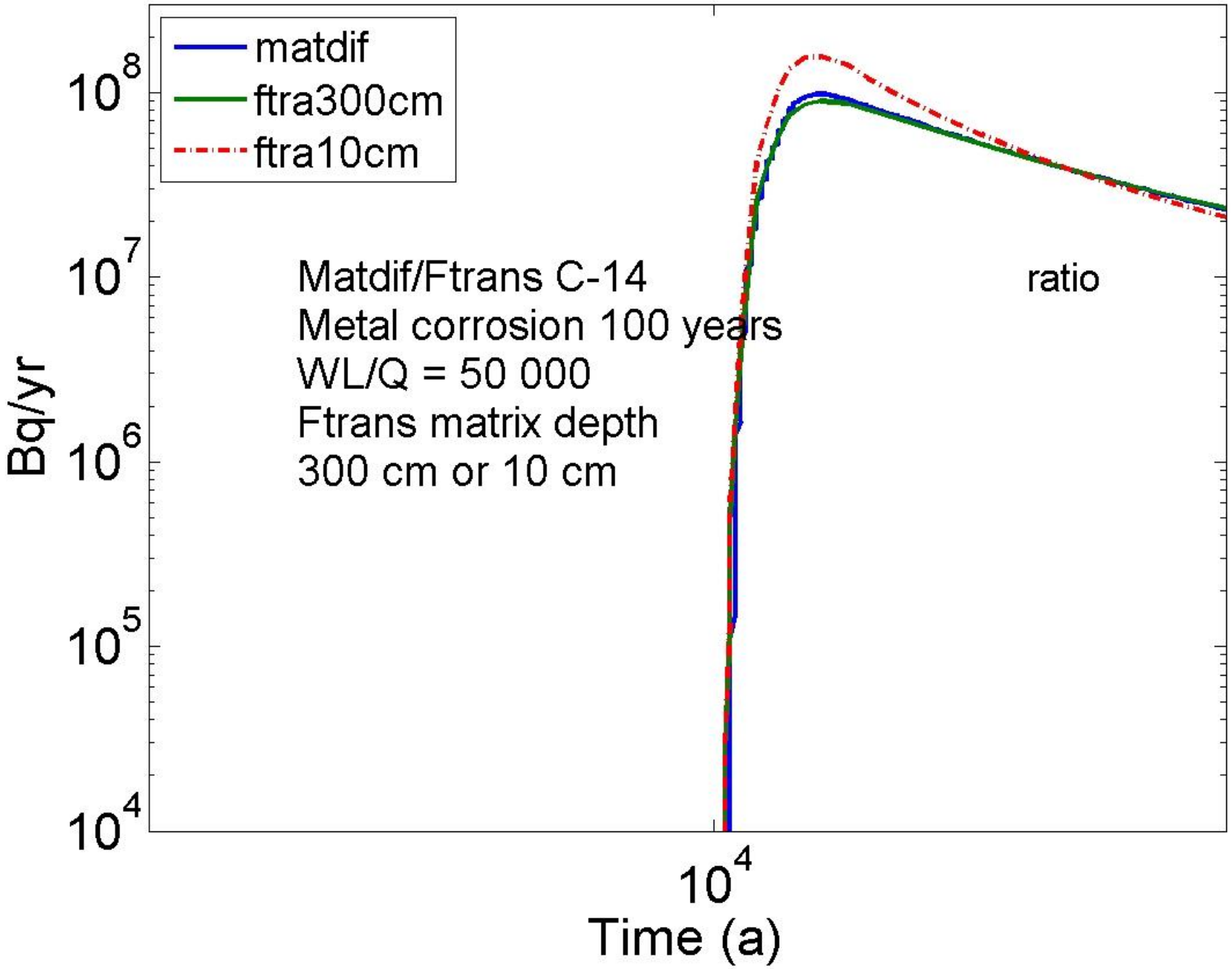
Geosphere models

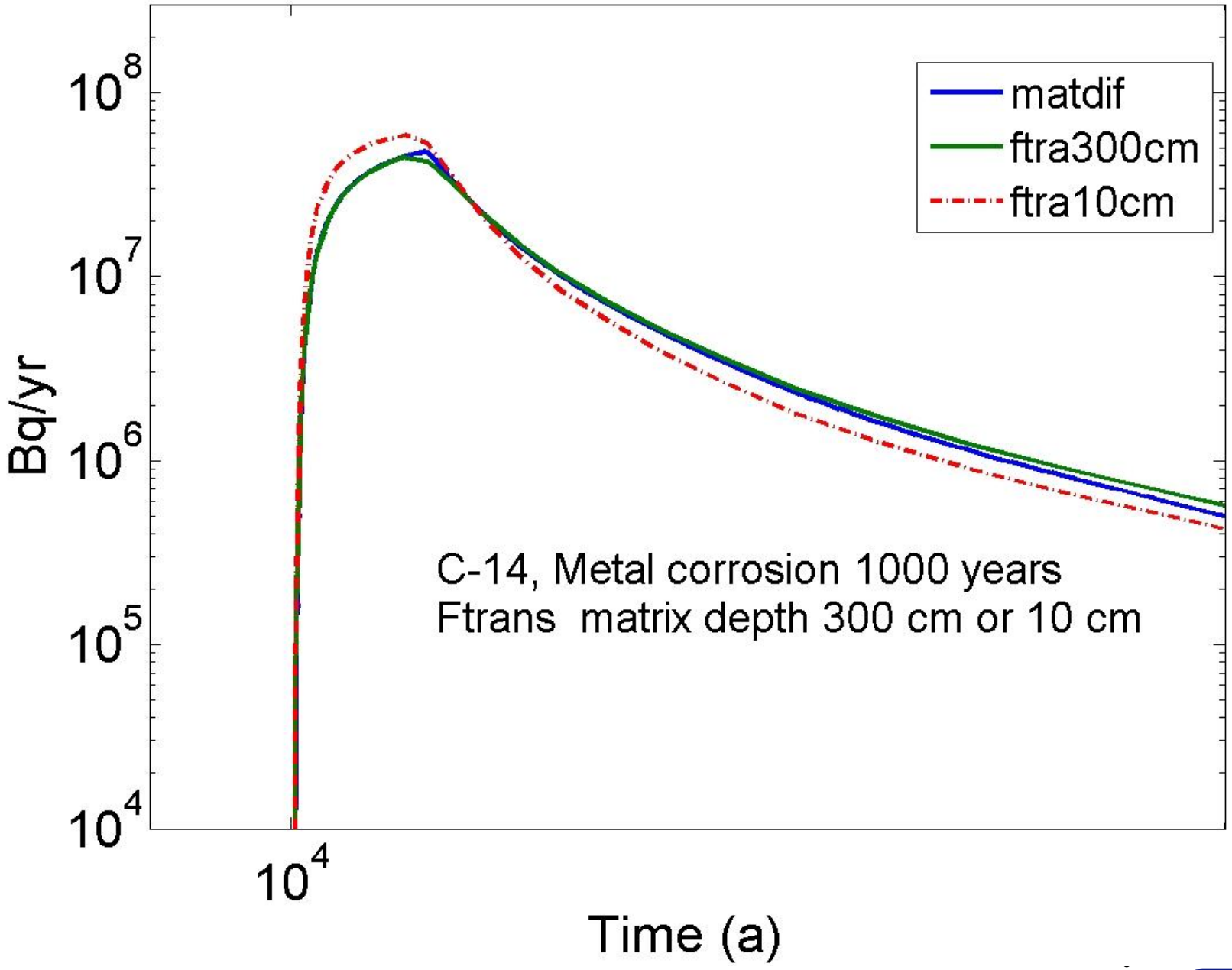
- MATDIFF, VTT in house model. Uses the analytical formula on previous slide, numerical convolution. Only single nuclide and one rock matrix layer. No dispersion.
- FTRANS. An old but good and flexible FEM code. **Nuclide chains** and several matrix layers. Diffusion and porosity of elements in a nuclide chain can differ from each other in addition to sorption.
- GoldSim. Uses Laplace transform numerically. **Nuclide chains** and only two rock matrix layers.

- MARFA. Particle tracing system. Main tool in current SC. Used by Antti Poteri

Non sorbing C-14 from metal parts. Inventory = 193 GBq. Geosphere effects

- WL/Q = 50000 yr/m. Valid value for lousy deposition hole number 381 in SC
- In current Safety Case the intact rock parameters. De = 6e-14 m2/s and porosity 0.5 %. In previous ones De was 1E-14 m2/yr and porosity 0.1 % for intact rock. Interesting.
- In Ftrans available matrix depth; 10 cm like in previous PA:s or 300 cm which is present used value. **Very interesting**.
- Corrosion 100 years; near field release 0.21 GBq/yr decreases 50 %
- Corrosion 1000 years; near field release 0.061 GBq/yr decreases 20 %
- With WL/Q value of 500 000 yr/m and corrosion in 1000 years, the decrease of output requires 50 cm allowed depth in matrix. (No picture)


matdif
ftra300cm
ftra10cm
Matdif/Ftrans C-14
Metal corrosion 100 years
WL/Q = 50 000
Ftrans matrix depth
300 cm or 10 cm
ratio
Bq/yr
10^8
10^7
10^6
10^5
10^4
10^4
Time (a)


matdif
ftra300cm
ftra10cm
C-14, Metal corrosion 1000 years
Ftrans matrix depth 300 cm or 10 cm
Bq/yr
10^8
10^7
10^6
10^5
10^4
10^4
Time (a)

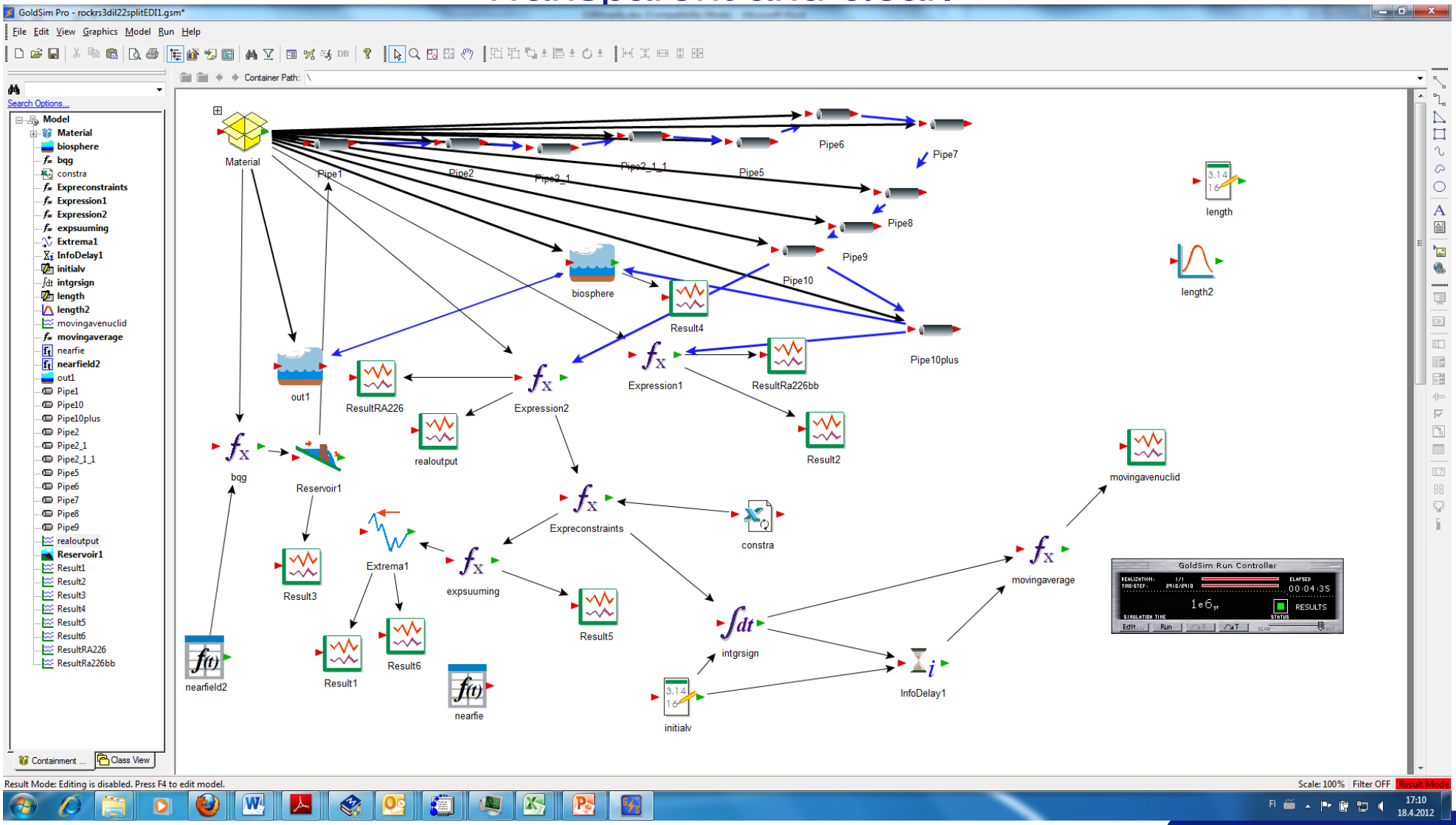
Ra-226 delta pulse. $t_{max} = t_w + 2u^2/3$

- Cocktail of parameters. De = 6E-14.
- If Kd is 0.0001 and WL/Q = 50000 yr/m. => tmax is 850 years
- Same with Kd = 0.001 and WL/Q = 16000 yr/m
- Present estimate for Kd of Ra-226 in brackish water is 0.0034 kg/m3

RNT-2008 near field case, Ra-226 . Set of geosphere parameters
Ra-266 maximum release rate from near-field was 4.13E+05 Bq/a

Case	Allowed depth (m)	WL/Q (a/m)	K_d (m^3/kg)	D_e (m^2/s)	u (a½)	t_{max} for delta pulse (Eq. 4)	t_{max} (a)	max. from geosphere (Bq/a)
Ra1	0.1	50 00	0.2	10^{-13}	206	2.8E+4	2.94E+5	9.14E+1
Ra2	0.1	5 000	0.2	10^{-14}	65	2.8E+3	2.90E+5	2.59E+4
Ra3	0.1	5 000	0.02	10^{-14}	20.6	2.8E+2	2.90E+5	1.70E+5
Ra4	1.0	5 000	0.02	10^{-14}	20.6	2.8E+2	2.90E+5	1.70E+5
Ra5	0.1	50 000	0.02	10^{-14}	206	2.8E+4	9.74E+5	8.32E+1
Ra6	0.1	50 000	0.02	10^{-14}	206	2.8E+4	2.94E+5	6.91E+1 (1
Ra7	0.1	50 000	0.2	10^{-14}	650	2.8E+5	3.14E+5	3.20E-7 (1

Time dependent chemistry parameters with GoldSim Pathway must be split into at least 10 separate pipes. Transparent and clear.



Verification of the need of GoldSim tube splitting. Rock shear variable flow and chemistry.

	TIME	Maximum (Bq/yr)
Gsim 1 tube	155400	15196
GSIM. Tube split 10	180200	6056
GSIM. Tube split 20	177230	6489
GSIM. Tube split 40	176015	6683
FTRANS result Restart option in FEM model is OK	175000	6240

Old TILA-99 result. Depth of matrix (10 cm, 4 cm or 1 cm) Longitudinal dispersion, Peclet number=2. WELL dose

- WL/Q = 50 000 cases
- time dose dose

DC-ns50	**$1.1 \cdot 10^{4}$**	**$3.2 \cdot 10^{-8}$**	**I-129**	**$2.9 \cdot 10^{-8}$**	**Sn-126**	**$5.7 \cdot 10^{-9}$**	**C-14**	**$4.4 \cdot 10^{-9}$**
m4cm	s	s	I-129	s	Sn-126	s	C-14	s
m1cm	s	$3.3 \cdot 10^{-8}$	I-129	s	Sn-126	$7.5 \cdot 10^{-9}$	C-14	$5.6 \cdot 10^{-9}$
Pe2	s	s	I-129	s	Sn-126	$5.5 \cdot 10^{-9}$	Ra-226	$4.8 \cdot 10^{-9}$

- High flow cases WL/Q = 5000
- time dose dose

DC-vhflowns	**$6.7 \cdot 10^{5}$**	**$4.8 \cdot 10^{-7}$**	**Ra-226**	**$3.4 \cdot 10^{-7}$**	**I-129**	**$2.7 \cdot 10^{-7}$**	**Pa-231**	**$9.2 \cdot 10^{-8}$**
m1cm	$6.3 \cdot 10^{5}$	$6.4 \cdot 10^{-7}$	Ra-226	$4.6 \cdot 10^{-7}$	I-129	s	Pa-231	$1.2 \cdot 10^{-8}$
Pe2	$6.1 \cdot 10^{5}$	$7.8 \cdot 10^{-7}$	Ra-226	$6.3 \cdot 10^{-7}$	I-129	s	Pu-239	$1.0 \cdot 10^{-7}$
DC-vhflowsal	**$6.1 \cdot 10^{5}$**	**$2.7 \cdot 10^{-6}$**	**Ra-226**	**$2.7 \cdot 10^{-6}$**	**I-129**	**$2.1 \cdot 10^{-7}$**	**Pa-231**	**$4.2 \cdot 10^{-8}$**
m1cm	$5.7 \cdot 10^{5}$	$5.3 \cdot 10^{-6}$	Ra-226	$5.2 \cdot 10^{-6}$	I-129	s	Pa-231	$7.0 \cdot 10^{-8}$
Pe2	$5.3 \cdot 10^{5}$	$1.2 \cdot 10^{-5}$	Ra-226	$1.2 \cdot 10^{-5}$	I-129	s	Pa-231	$5.2 \cdot 10^{-8}$

s = same as in the base case of the variant

Conclusion

The current choice of more favorable parameters than previous. Hopefully can be defended.

Risk

- 23 GBq U-238 + daughters precipitated in a deposition hole. Produces yearly 0.01 GBq Ra-226 (in 1 million years 10 000 GBq:s of Ra-226)
- YVL limit for yearly Ra-226 release is 0.03 GBq/yr
- Geosphere parameters for Ra-226 may be critical. Especially if earthquake damages several canisters in a tunnel.

AND in a PA

- We need good data; hopefully also empirical. And reasonable but conservative scenarios.
- Color graphics, Oxford English, playing with all kind of computer or nerd business are not so important.