Hydrological changes in response to the Tokachi-oki earthquake in 2003, Japan

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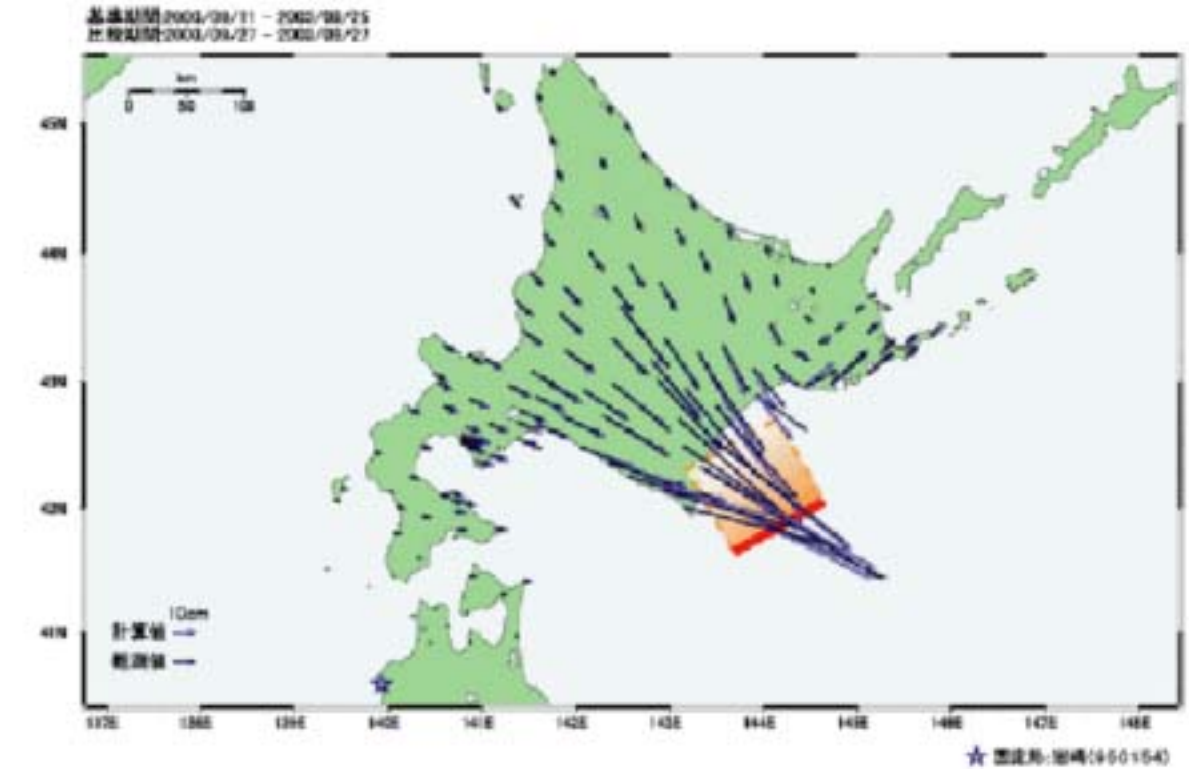
The Tokachi-oki earthquake in 2003 (M 8.0, 26 September, 2003)

Missing peoples: 2

Injured peoples: 847

Damage: 27 billion yen

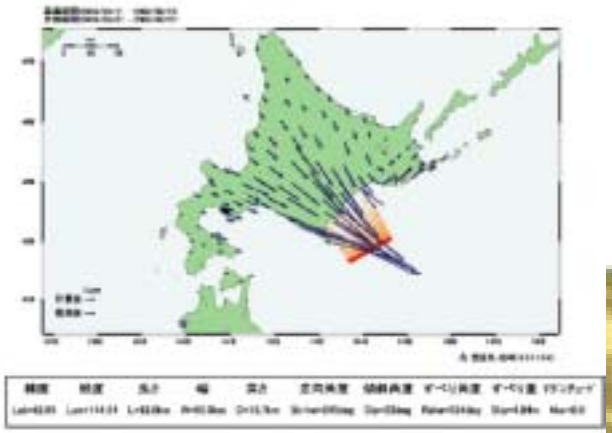
GPS observation and fault model of the Tokachi-oki earthquake



緯度	経度	長さ	幅	深さ	走向角度	傾斜角度	すべり角度	すべり量	マグニチュード
Lat=42.05	Lon=144.04	L=82.0km	W=60.0km	D=15.7km	Strike=241deg	Dip=23deg	Rake=124deg	Slip=4.84m	Mw=8.0

GSI, 2003

Fault model (cont'd, GSI, 2003)



depth:15.7 km

width:83.0 km

Fault plane

length:85.7 km

rake:23 degree

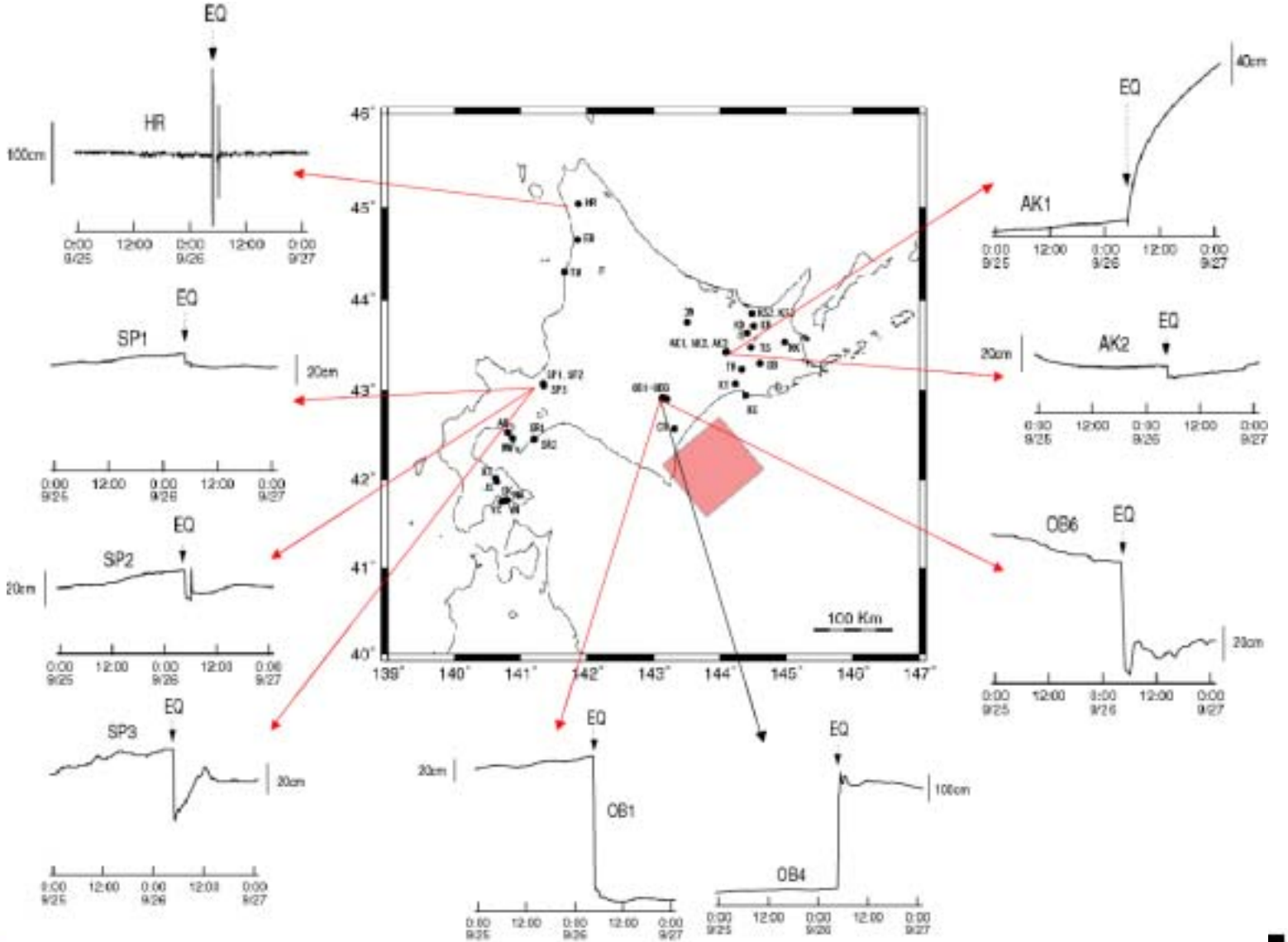
Typical inter-plate thrust earthquake

Observation wells

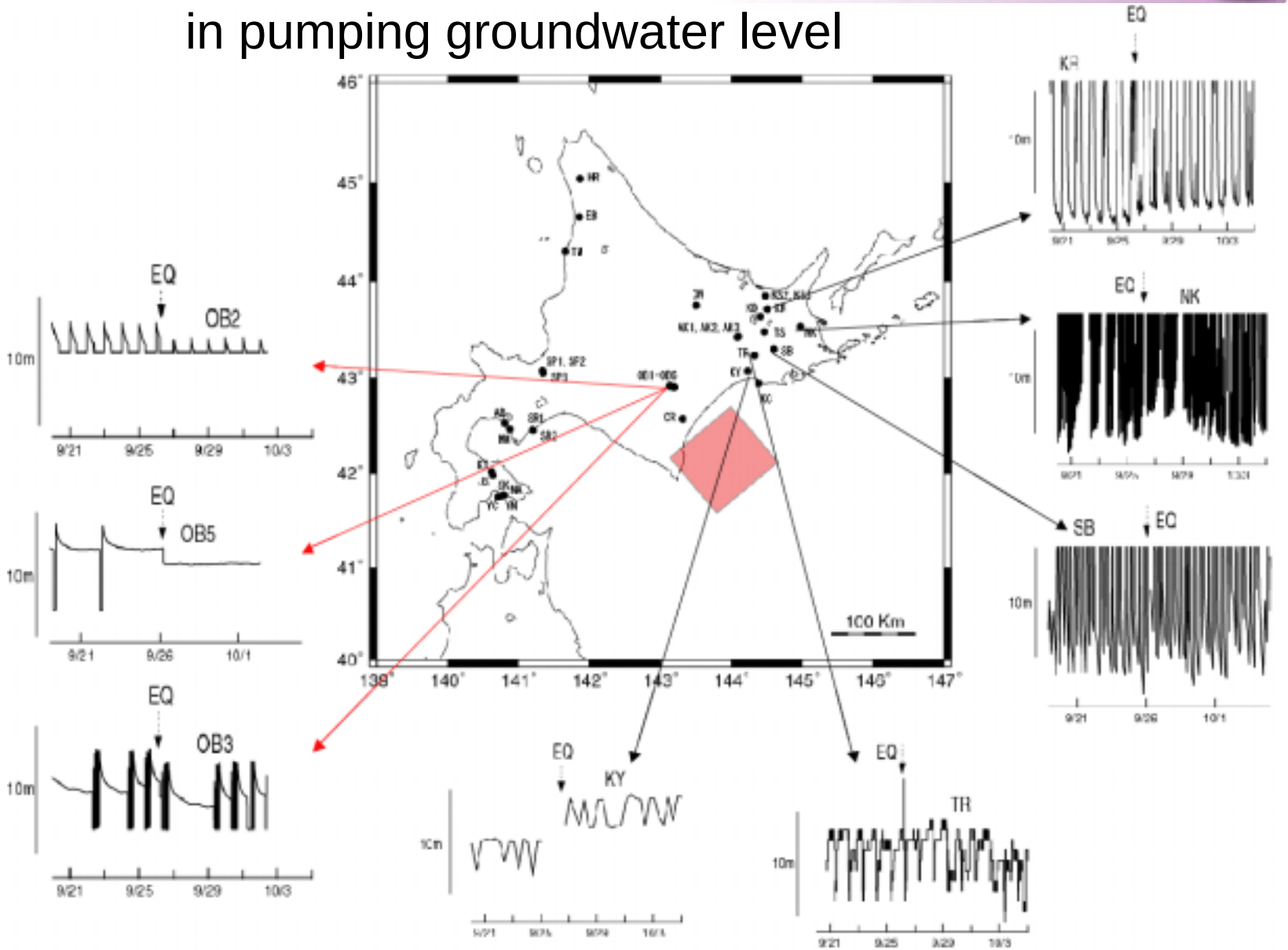
well name	Depth (m)	gwl change	strain (10-8)
AB	120	-59 cm	31.4
AK1	118.5	-4	12
AK3	91.8	-7	13.8
HR	720	0	11.5
JS	1103	-22	18.6
KT	974	-5	19.1
NW	1010	-55	33.4
OB1	1328	-130	191.4
OB4	1400	430	170.3
OB6	220	-65	190.3
SK	85	27	16.7
SP1	657	-6	53.2
SP2	657	-16	53.2
SP3	1001	-40	54.2
SR1	458	-22	48
SR2	508	-13	48.1

well name	Depth (m)	gwl change	Strain (10-8)
TS	416	4 cm	-21.8
YC	200	10	15.2
YN	68	-30	16.7
KD	826	-6	-6.8
KR	1000	100	-8.3
KY	1223	400	-80.8
NK	1330.5	250	-35.8
OB2	1506	-130	172.4
OB3	1502	-100	169.6
OB5	675	-170	189.8
SB	1502.3	120	-59.8
TR	1500	150	-47
CR	1206	130	-303
KS3	853.2	40	-2.5

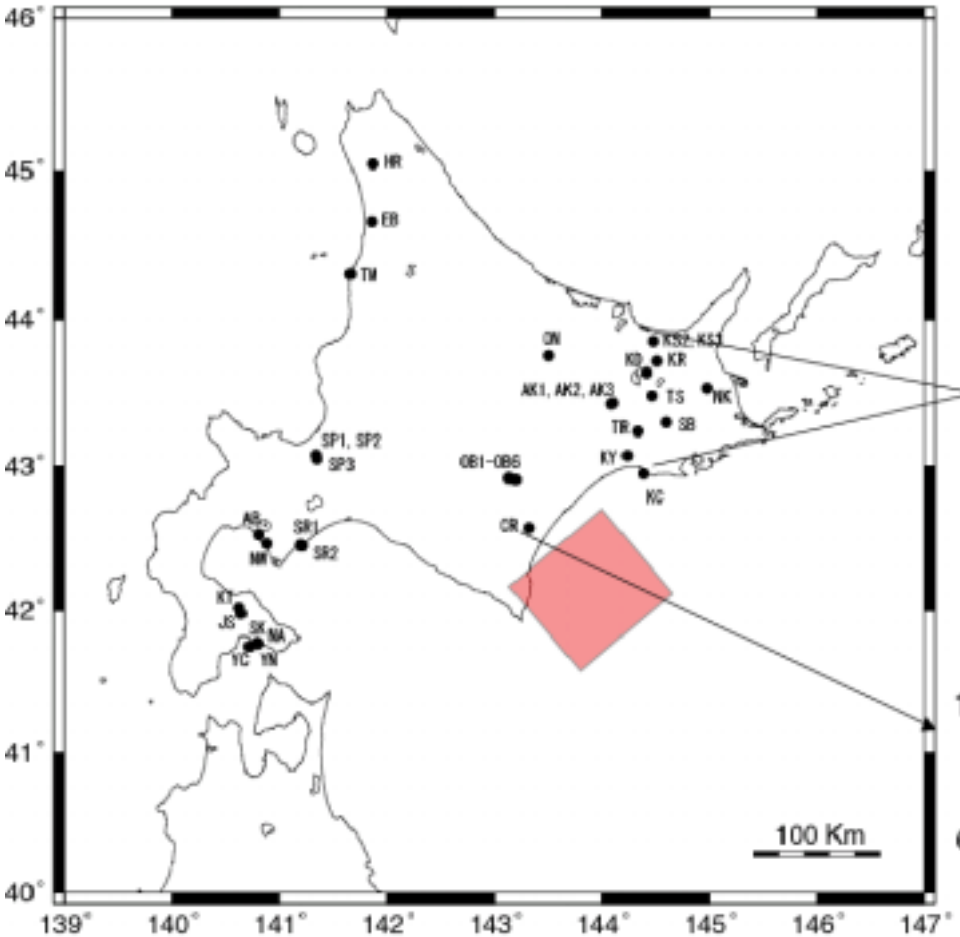
Observed coseismic changes in groundwater level

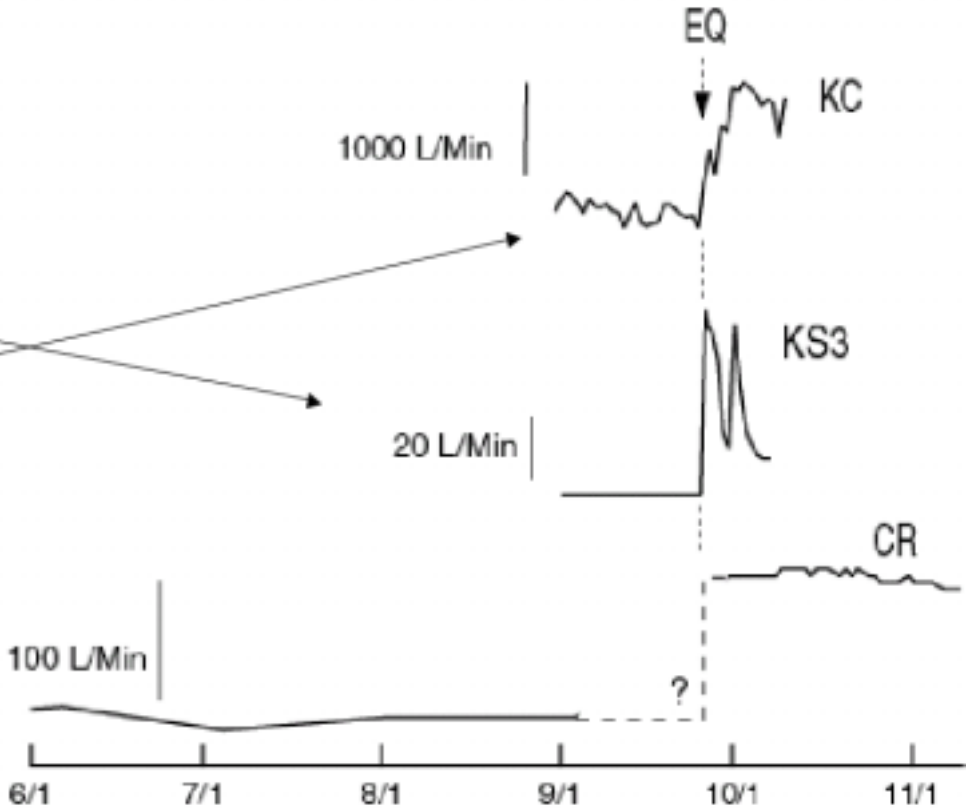


Observed coseismic changes in pumping groundwater level

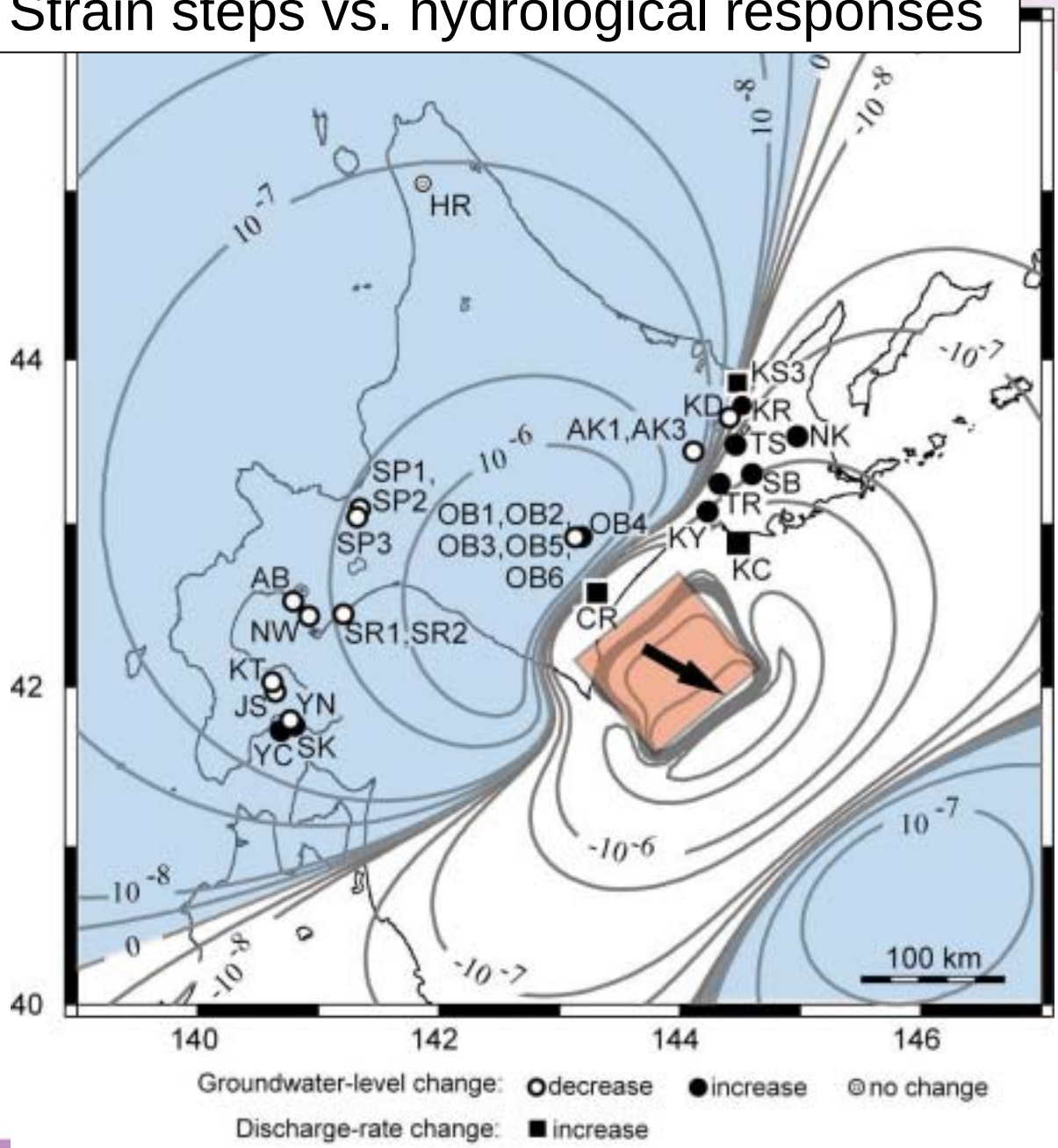


Observed coseismic changes in groundwater flow rate



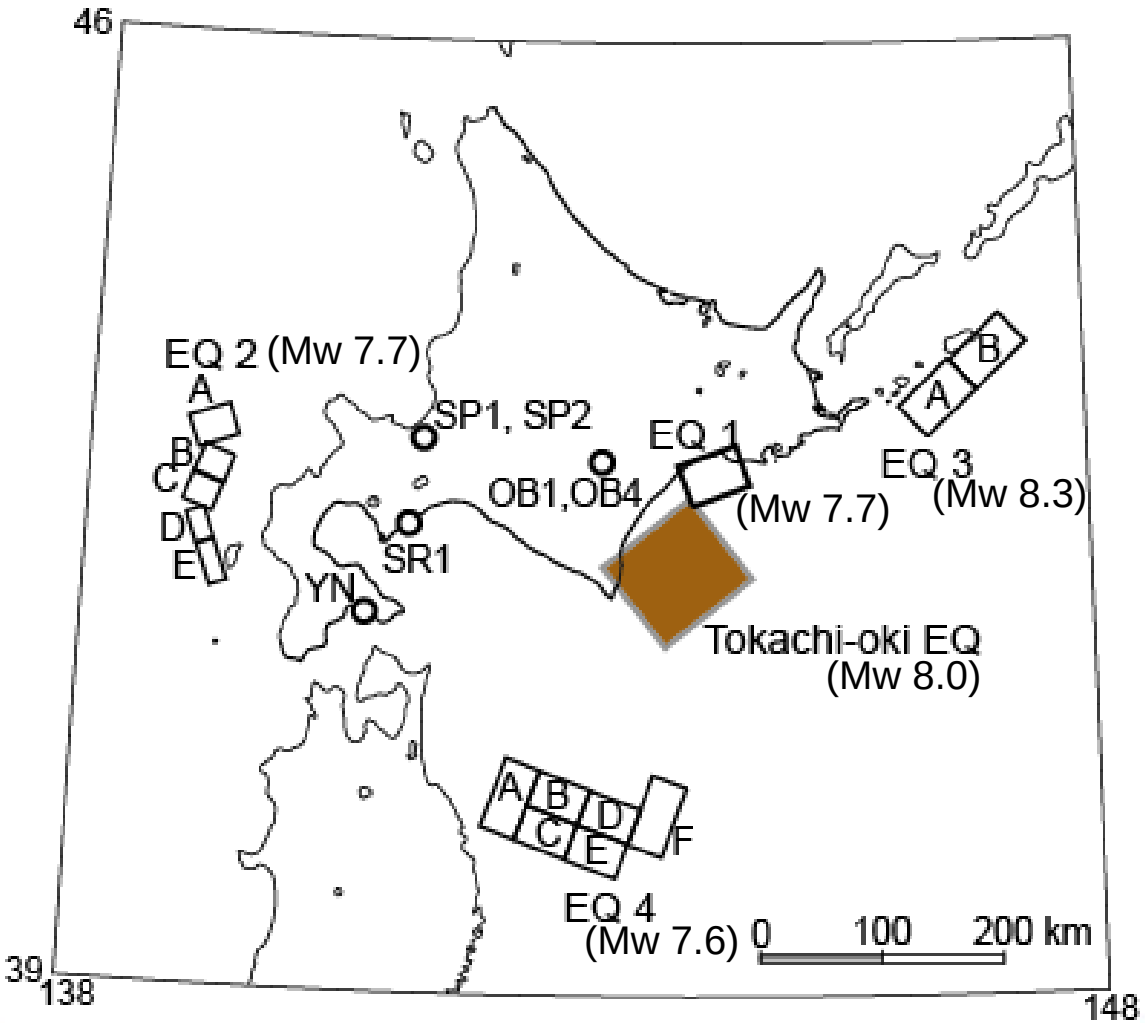


Strain steps vs. hydrological responses

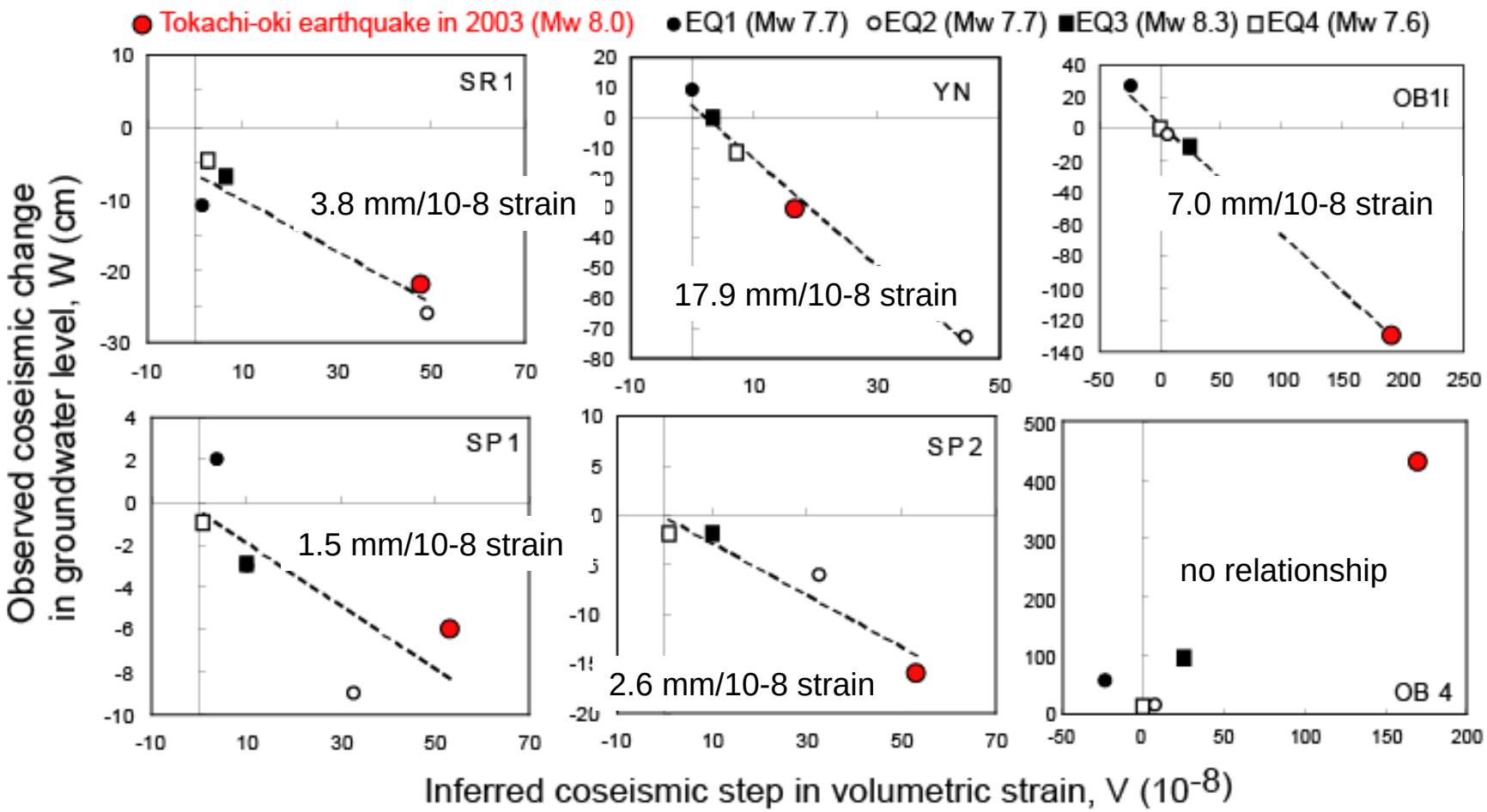


27 of the 30 hydrological anomalies can be explained
as a poroelastic responses to the earthquake-induced contractional or dilatational strain.

Four large earthquakes (M > 7.5) in 1993 -1994



Coseismic strain steps vs groundwater level changes in 6 wells after the 5 large earthquakes



Strain sensitivity of groundwater level : M2 tide vs coseismic strain

	OB1	SP1	SP2	SR1	YN
strain sensitivity determined by coseismic strain (mm/10-8)	7.0 ±0.3	1.5 ±0.7	2.7 ±0.7	3.6 ±0.7	17.9 ±1.3
strain sensitivity determined by M2 tide (mm/10-8)	9.4	3.9	3.0	14.3	45.3

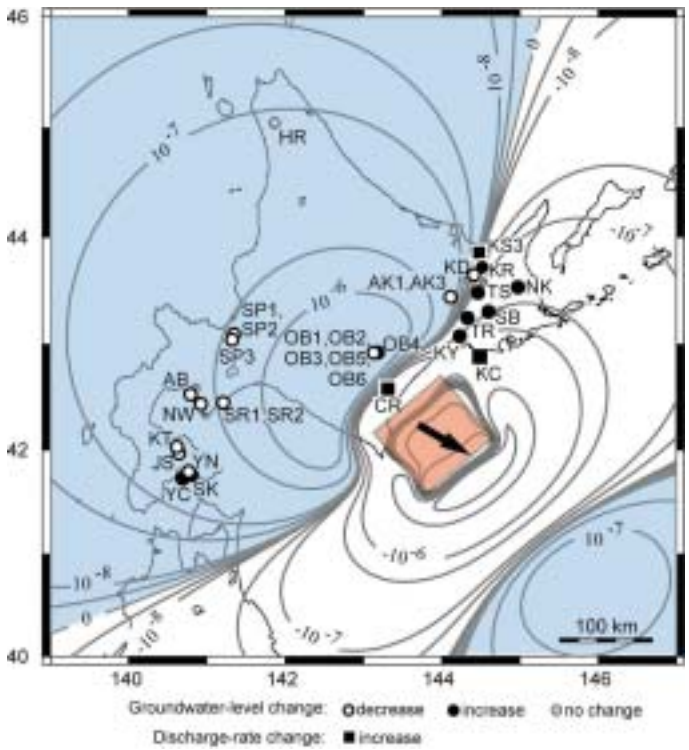
OB1, SP1, SP2: Coseismic changes in water level are constituent with strain sensitivities determined by M2 tidal constituent.

SR1 and YN: Smaller strain sensitivities determined by M2 tidal constituent

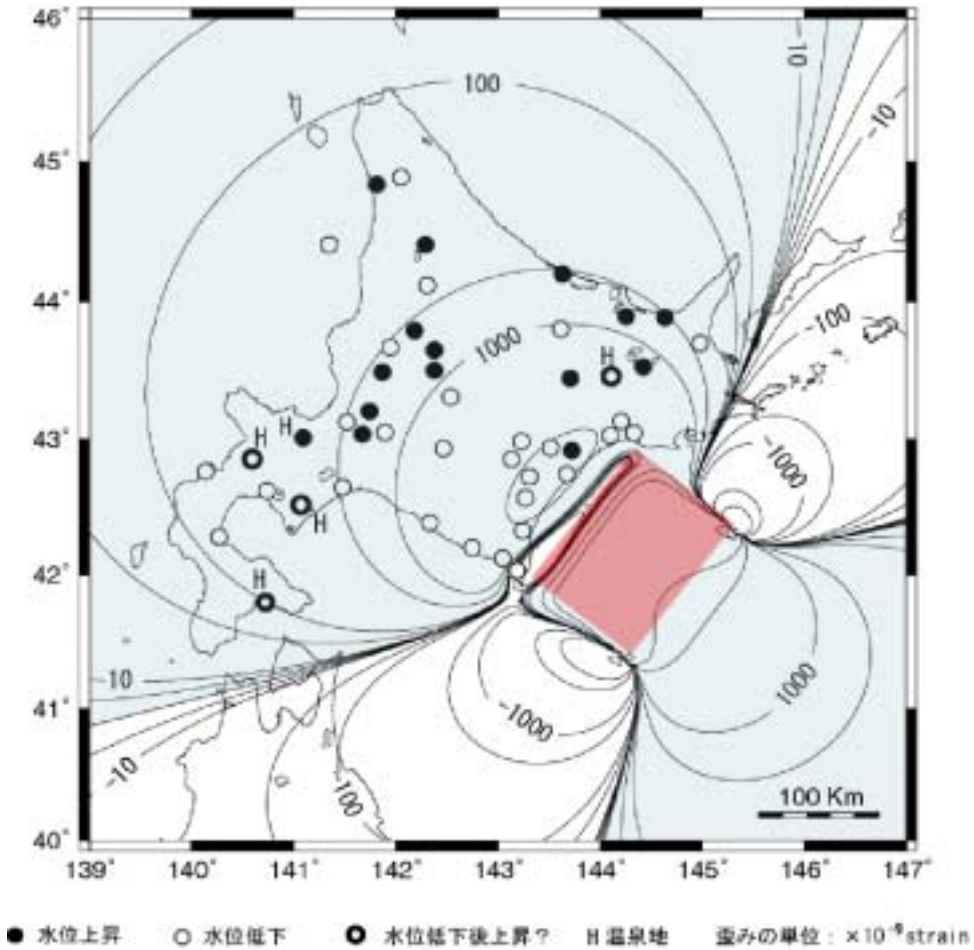
-- close to coast (900m, 50m)

-- underestimation of ocean tide effect

Hydrological response to the Tokachi-oki earthquakes in 1952 and 2003



2003 M8.0



1952 M8.2

Conclusions

Twenty-seven of the 30 changes in groundwater levels or discharge rates can be explained as aporoelastic responses to inferred volumetric strain after the M8.0 Tokachi-oki earthquake.

Observed groundwater level steps associated with the Tokachi-oki earthquake and four large earthquakes in 1993-1994 around the Hokkaido area are proportional to the inferred earthquake-induced coseismic strain steps in OB1, YN, SR1, SP1 and SP2 wells. Strain sensitivities determined by coseismic responses in groundwater levelare consistent with those estimated by M2 tidal strain in OB1, SP1 and SP2 wells.