

Verbič, Technical Positons

Geology and Krško Basin Seismic
Hazard Issue

Verbič, Technical Positions

Geology and Krško Basin Seismic Hazard Issue

- Please explain the **age control** of presumed Quaternary deformations and indicate potential hold backs regarding the reliability of age control (methodological, potential spatial variability of alloformations distribution...).
 - Please explain the evidences or indications for presence of the **Brežice fault continuation from east of Drnovo** (across the Holocene plain and in the eastern part of the Krško Basin) to west of Veliki Podlog.
 - Please provide your thoughts on the relationship of the **Brežice fault** you have mapped to structures **at depth**
 - We would like to get your perspective of the **current tectonic framework** within the Krško near region (25 km radius of Krško)
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- *Periods and types of my involvement*
 - *My main technical position*
 - *Technical Positions: Age control*
 - *Technical Positions: Brežice fault west of Brežice*
 - *Technical Positions: Brežice fault at depth*
 - *Current tectonic framework, my perspective*

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Geology and Krško Basin Seismic Hazard Issue

- *Periods and types of involvement*
 - 1993 – 1996: *Q stratigraphy, sedimentology, geomorphology, soil profiles development; (by SNSA)*
 - 1997 – 1998: *Geological mapping (general); (by SNSA)*
 - 1999: *core logging along seismic lines KK-xx-99; by SNSA) ★★*
 - 2002 – 2003: *„Development of revised seismotectonic model ...“ lead by Geomatrix; (Consultant for Part 1; Seismotectonic model; by NEK)*
 - No common seismotectonic model was possible; my data and help available for all three teams (SLO, CRO, USA)
 - Interest showed only USA team (Swan, Hanson, Youngs)
 - *After 2003: not invited any more, no formal involvement*
 - *After 2003: preparation of two articles (2004, 2005) and, thanks to my friends, also PhD Thesis*
 - *After 2003: working mainly geoarchaeology and GPR. Free time also geology and Krško Basin Seismic Hazard Issue*

Časovnica mojega posredovanja 2015/2016

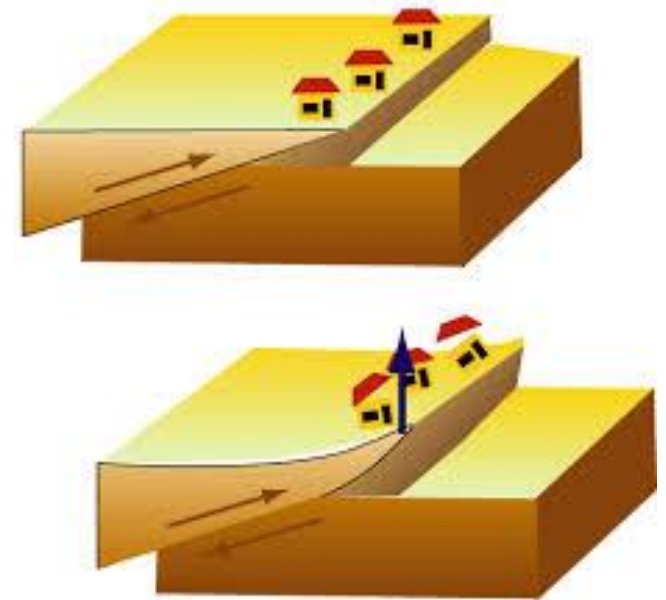
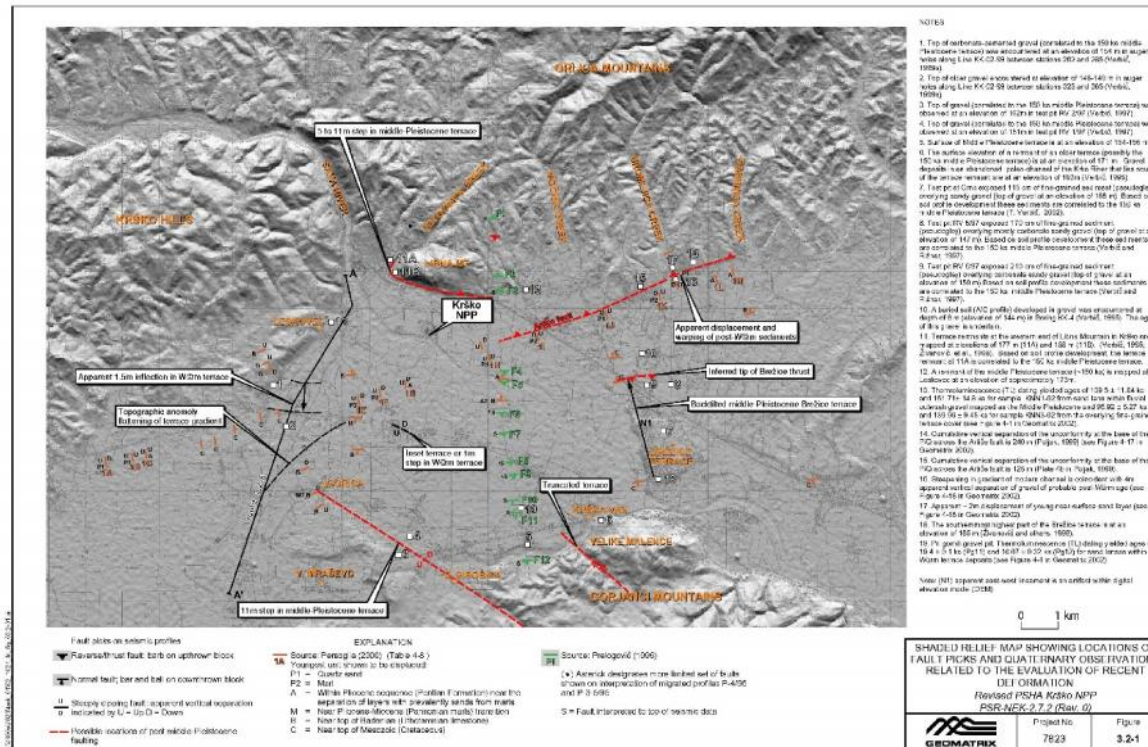
- 16.6.2015 sestanek na GEN energija (Špiler, Kurnik, Verbič) sklep
- 30.6.2015 oddaja projektne naloge „Does the Late Pleistocene Sava River terrace surface in the Krško Basin really not exhibit post-depositional tectonic deformation?“
- 6.7.2015 sestanek na GEN energija (Špiler, Kurnik, Bavec, Atanackov, Verbič) sklepi (še neizvršeni)
- 18.12.2015 sestanek na GeoZS, predstavitev LIDAR grafike, potrjuje topografsko anomalijo
- April 2016 delovni sestanek v Celovcu, izvedel iz spletne strani URSJV
- Avgust 2016 pismo dr. Stritarju (URSJV)
- September 2016 pismo in projektna naloga objavljena na spletni strani URSJV
- September 2016 – 2, 3 dni kasneje kontakt s strani dr. Bavca
- September 2016 začetek e-mail konverzacije z dr. M. Cline-om (RIZZO)
- 26. 10. 2016 sestanek RIZZO, GoZS, Verbič

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- Regarding seismic safety, the main question, on my opinion, was not even addressed by GeoZS and partners (after 2003):
 - Evidences of deformation of the Late Pleistocene surface as showed by Geomatrix (2003) and (Verbič 2005, 2008)
- RIZZO (2013,p6) even arbitrary neglect and negate evidences without any comentary: „***The Late Pleistocene and Holocene surfaces do not exhibit post-depositional tilt.***“
- My question: **what are your technical positions for such a decisive statement?** Were mentioned documents available for you at that time? Have you been informed about them?

Zakaj so dokazi za deformacije zahodno od NEK tako pomembni?



Interpretacija seizmičnih profilov

- Persoglia 2000, očitne razlike med tekstovnim opisom ...

6.6.2. Line KK-02-99

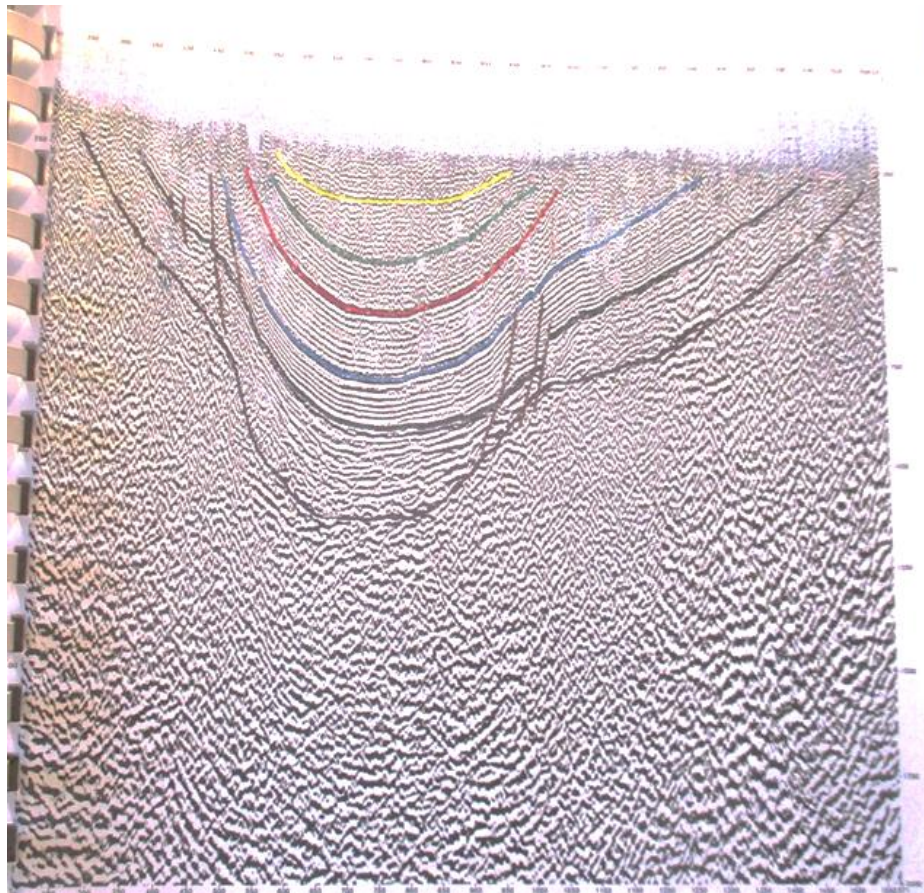
This line follows the strike of the Alpine deformations, superimposed on the SE-NW Dinaric folding.

The approximately north-south Alpine compression is clearly seen in all the lines crossing the basin in the north-south direction (KK-02-99, KK-03-99, partly in KK-05B-00), and can be recognised also on the profiles of previous investigations (P-84/59, P-3 and 4/95, P-84/59, P-83/59).

The Alpine compression with thrusts and folding are precisely represented on the KK-02-99 line (Fig. 2) with north- and south-verging thrusts moving the Mesozoic layers and with the folding of the whole Tertiary sequences. Gravity sliding phenomena are present at the level of Cretaceous flyschs with foldings within the C-B interval and of the Upper Miocene layers,

Interpretacija seizmičnih profilov

- ... in grafičnimi prilogami (Persoglia 2000)



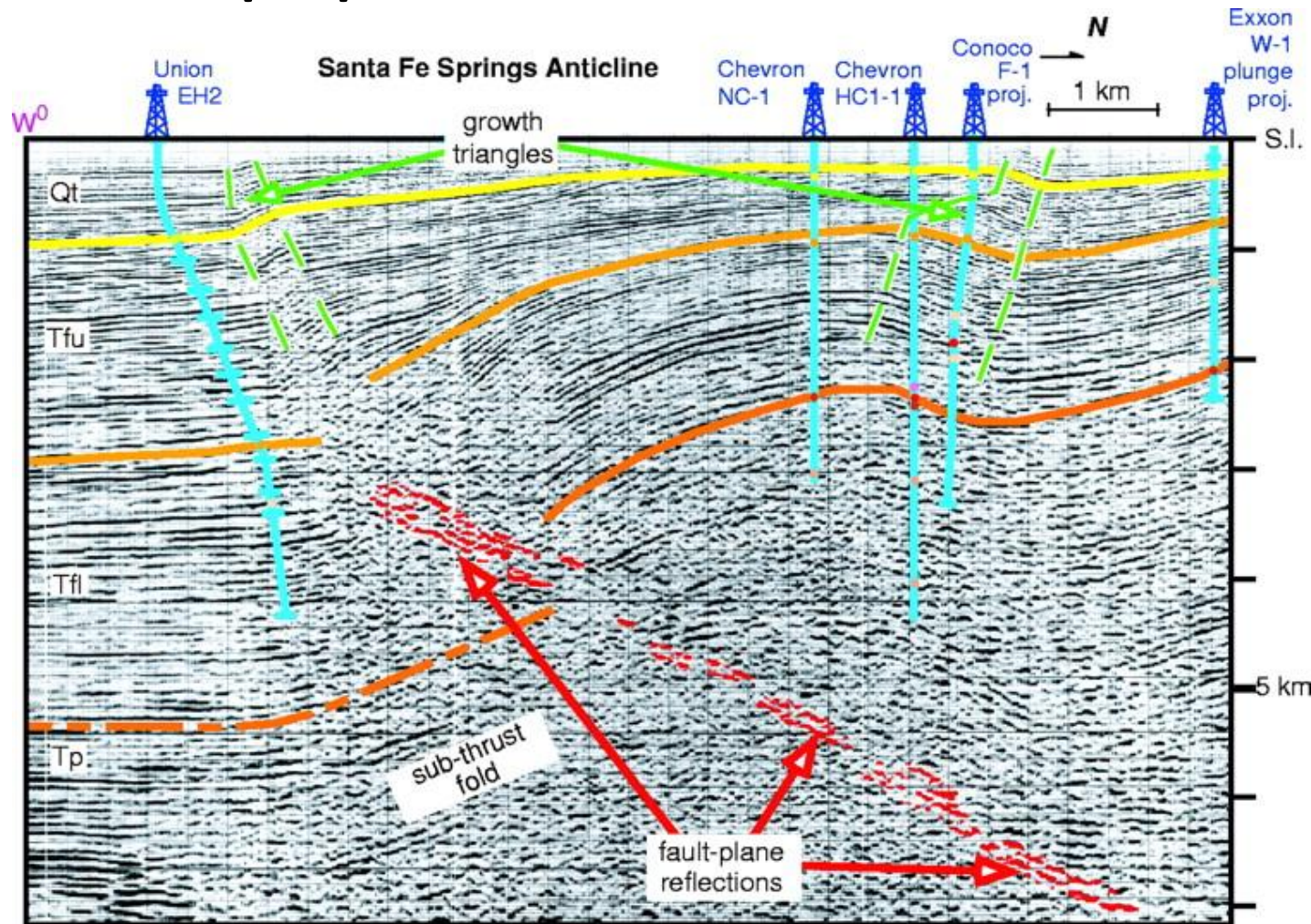
Interpretacija seizmičnih profilov

- Leta 2002 Geomatrix (M. Angell) naredi ponovno interpretacijo profilov iz let 1999 in 2000 (KK-xx/99 in KK-xx/00), prav zaradi izrazitega neskladja, izredno „zanikrne“ grafične priloge (vertikalno merilo cca 10 x previšano), ...
- Na ostro posredovanje naročnika (argument: reinterpretacija seizmičnih profilov ni predvidena v pogodbi) njihova interpretacija ne postane del „design input“ dokumentov – interpretacija nikjer ni dokumentirana

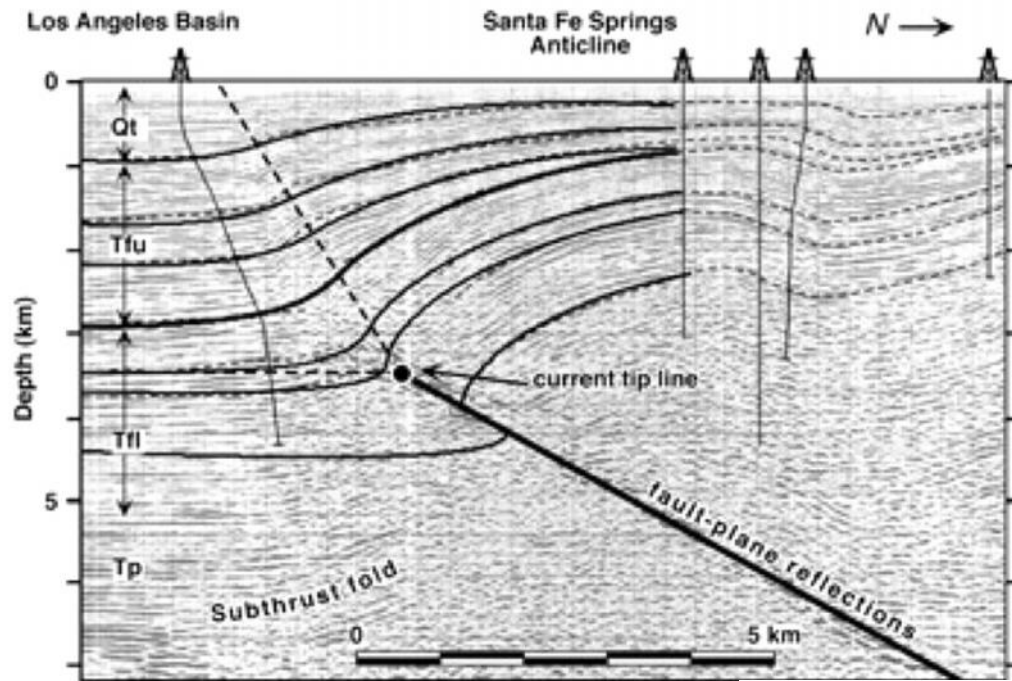
Interpretacija seizmičnih profilov

- Sama interpretacija seizmičnih profilov ne more ovreči prav nobene hipoteze, ki sloni, na primer, na geomorfoloških ali na plitvih geoloških dokazih. Uporabni seizmični (akustično valovanje) podatki zaradi same metode nikoli ne sežejo do površine, v najboljšem primeru je vsaj zgornjih 20 m „slepih“.
- Lahko ponudi le alternativno hipotezo
- Vprašanje, ki se postavlja je, zakaj se deformacije, vidne na površini in tik pod njo kot blage fleksure (upogibi), ne opazijo globlje na seizmičnih profilih
- To ni redek fenomen

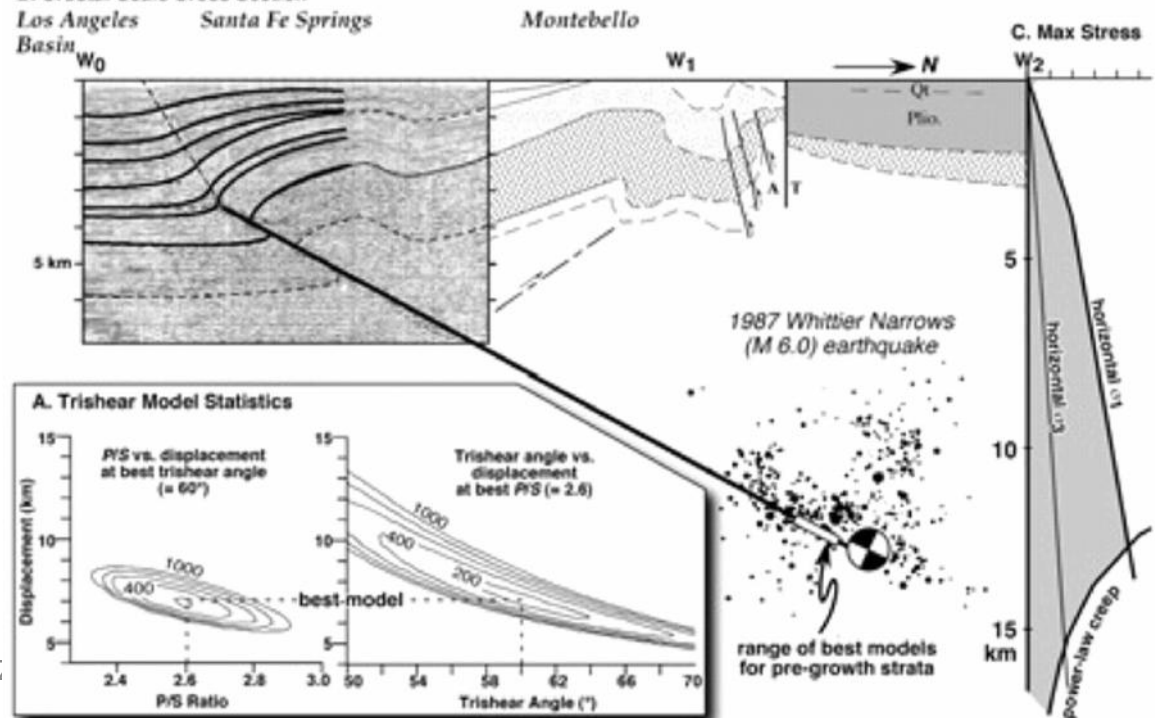
Interpretacija seizmičnih profilov – slepi prelomi (Santa Fe Springs anticline)



Interpretacija seizmičnih profilov – slepi prelomi (Santa Fe Springs anticline)



B. Crustal-Scale Cross Section
Los Angeles Basin Santa Fe Springs



Interpretacija seizmičnih profilov ...

- ... v primeru Krške kotline sama za sebe ne bo dala nobenih zaključkov

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Age control

- PIQ Sava river sediments/surfaces:
 - Expert opinion 1-2 million years (Verbič 2004, 2008): evidences
 - RIZZO (2013) CRN results fall into the interval
 - Large variability in soil profiles and local sediments cover
 - Highly dissected/eroded surfaces
 - Large variability in thickness, perhaps also in litology
 - Less important for seismic hazard than Middle and Late Pleistocene terraces remnants surfaces

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Geology and Krško Basin Seismic Hazard Issue

Age control

- Middle Pleistocene (Sava river) terrace remnants/surfaces:
 - TL results (Shannon Mahan; USGS, 2002)
 - Moderate spatial variability in soil profiles and local sediment cover
 - Moderate to low dissected/eroded surfaces
 - These terrace remnants probably needs the most intention in future (existed data are to be improved very effective): every remnant should sistematically be dated (luminiscence, ...) and every also studied with multiple soil profiles
 - Likely not only one Middle Pleistocene terrace/alloformation (Verbič, 2004, 2008)

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Geology and Krško Basin Seismic Hazard Issue
Age control

- Late Pleistocene Sava river terrace remnants/surfaces:
 - „My Late Pleistocene“ as meant also in RIZZO (2013) report – I guess!
 - TL and IRSL results (Shannon Mahan, USGS; 2002)
 - Holocene (last large) Sava river incision after (last) glaciofluvial gravel input (analogy everywhere in the Alps and Sub-Alps)
 - Spatal variability: (very) low variability in soil development throughout the surface
 - Needs a lot of work, too!

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Geology and Krško Basin Seismic Hazard Issue

Age control

- I'm aware existing age control of Q sediments/Sava terraces surfaces, especially Late and Middle Pleistocene, is not completely satisfactory, but it exist, anyway.
- During my formal involment, SNSA founds were extremely limited, almost no analyses were possible
- Last ten years were missed to reach the goal: to cover the Basin with needed data. There are a lot of areas where age control should be much better to control eventual displacements, several are described in my thesis. And, no doubt – that task is still waiting (if not done – have no information!)
- Meanwhile, several large seismic operations took place. OK! GeoZS's opinion: „This is the balanced approach ...“. Far from it, from my point of view! What are improvements of my Q geological map from 2002 (published in 2004)?

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Geology and Krško Basin Seismic Hazard Issue

Brežice fault west of Brežice

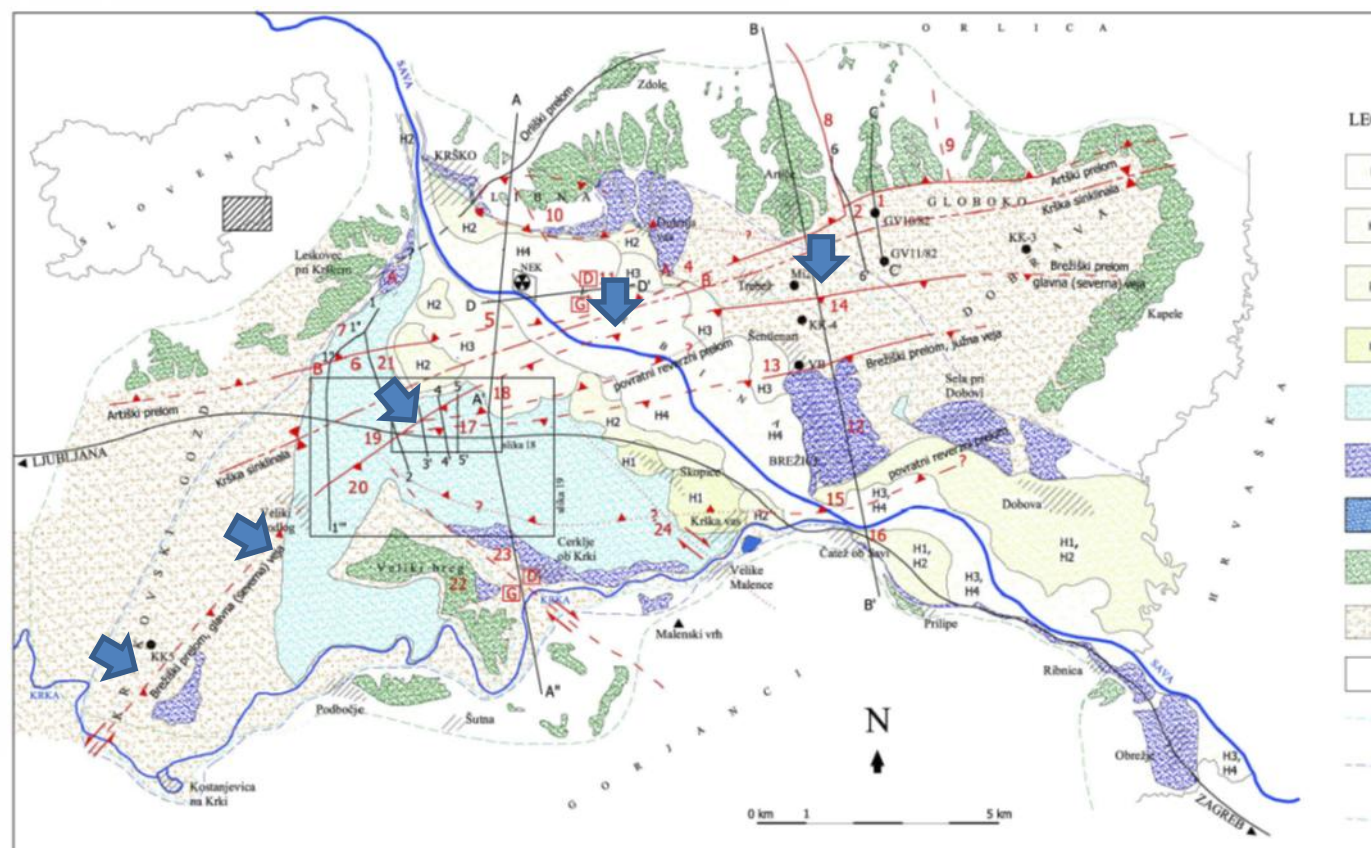
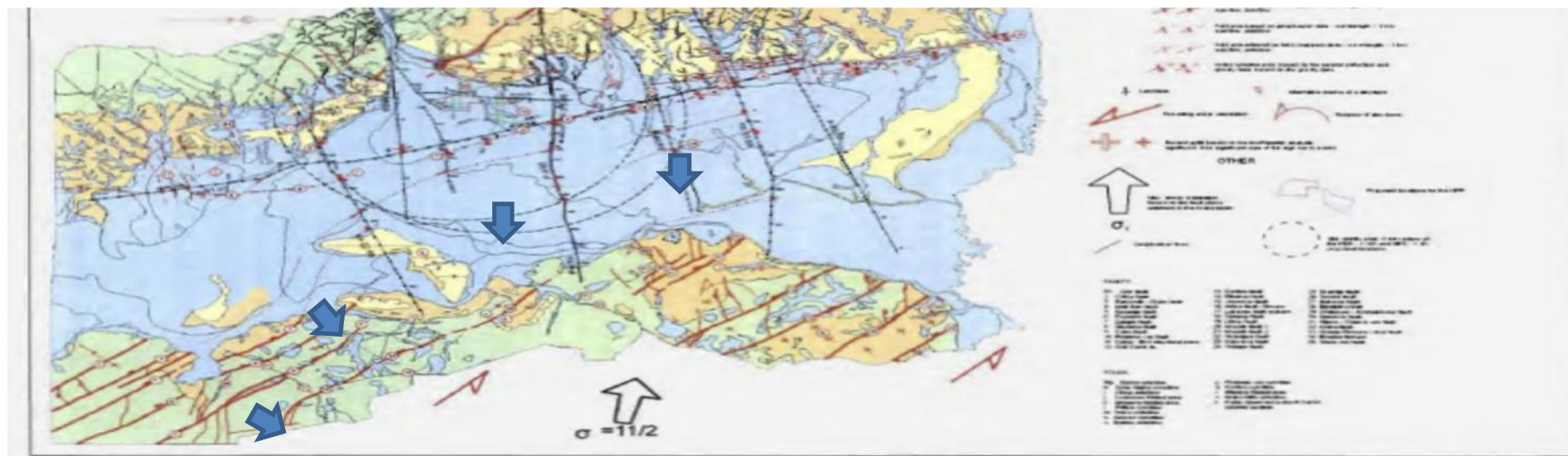
- Brežice fault on the E side: fault picks on geophysical profiles (Tomljenović & Csontos, 2001; Prelogović; GeoZS, 2010; ...); surface and borehole data N of Brežice terrace; and then:
 - *To the W follow first class geomorphic structure - Krško Basin; a little bit joke but usually helpful!*
- On W side we measured geomorphic anomaly on Late Pleistocene Surface: GPS measurements in 2003, later nice colorful LIDAR (GeoZS)
 - *Geomorphic evidences for tectonic interpretation of anomaly: erosion/sedimentation origin excluded (no one even try to explain it in that way – just saying: could be of erosional/sedimentation origin (GeoZS 2003, 2015) is not enough!*
- In between, surface fault projection fits with southern rim of largest Holocene Sava river meanders (Verbič, 2008, fig. 20); inset terrace near Drnovo (two weak geomorphic evidences, but there are!)
- The fault fits very nice with gravimetric structure of the basin (Verbič, 2008, fig. 27)
- Structure, facies and geometry of Q sediments between Artiče and Brežice faults (ongoing research)

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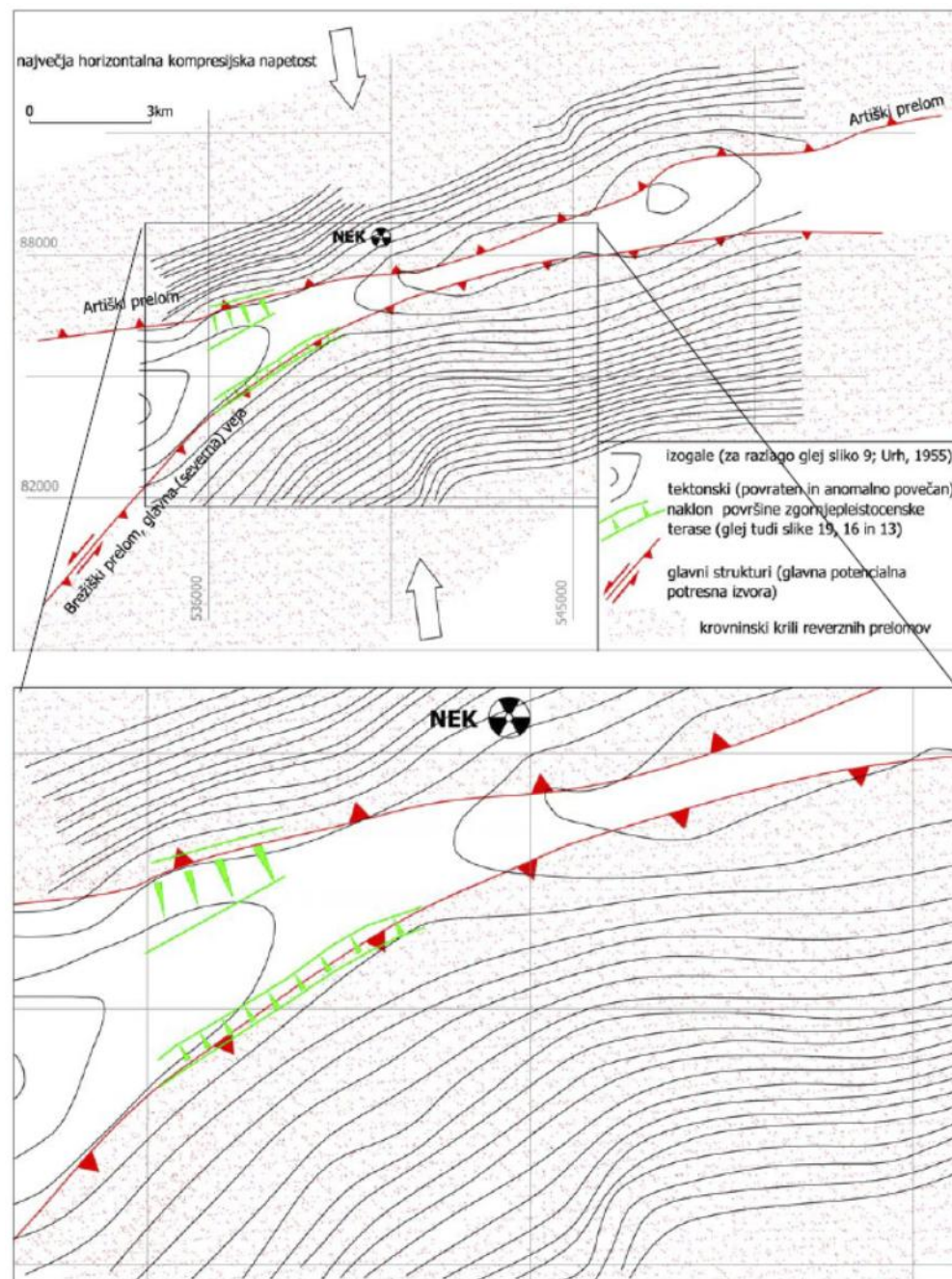
Brežice fault at depth

- Fault picks on (all) seismic lines (xx-59, xx-95, xx99, xx00; e.g. GeoZS, 2010)
- Gradually diminishing of vertical displacement on surface fault projection (topographic anomaly) along the fault from E to W, where curves for cca 30° , to NE-SW direction: from 1,6m to only 0,7m (Verbič, 2008, tab. 6): it is possible that fault continues to the SW, to the Gorjanci hills (as showed by GeoZS, 2010)
- The fault fits very nice with gravimetric structure of the basin (Verbič, 2008, fig. 27)
- Let us (not only me!) to interpret the seismic lines!



11.11.2016

Gravimetrične anomalije, topografske anomalije Brežiški in Artiški prelom



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Current tectonic framework

- Orlica fault: beside „deep“ valley: what else?
 - I have no argument for Orlica to call it active fault
- Hrastnik fault and increased seismicity: real or only impression? Perhaps something else? Need work to be done!
- Krško syncline with faulted limbs, coming from the E
- Artice (cca 55 km; Krško and Zagorje Basin) and Brežice (cca 65 km; Krško and Zagorje Basin) fault zones close to as in Tomljenović & Csontos (2001) and Verbič (2008). Needs improvement!
 - Segmentation? At seismogenic depths?
 - W of the gravimetric saddle syncline is „opening“ – we do not know a lot about geology there (e.g. vertical, even overturned miocene strata in W continuation of syncline near Bela cerkev)
 - Faulted southern limb: pattern? Backtrust?
 - Node of faults: maximum compression (shortening) S of the Drnovo/Brege, surface expression or artificial ilusion?

Neotektonski model

