FROM DEEP CRUST TO SHALLOW SUBSURFACE – BASIC AND APPLIED SEISMIC STUDIES AT INSTITUTE OF GEOLOGICAL SCIENCES, POLISH ACADEMY OF SCIENCES

Piotr Krzywiec

Institute of Geological Sciences, Polish Academy of Sciences

OUTLINE

1. Seismic reflection studies – very short intro
2. Crustal-scale studies
3. Sedimentary basins and fold-and-thrust belts
4. Shallow subsurface

OUTLINE

1. Seismic reflection studies – very short intro
2. Crustal-scale studies
3. Sedimentary basins and fold-and-thrust belts
4. Shallow subsurface

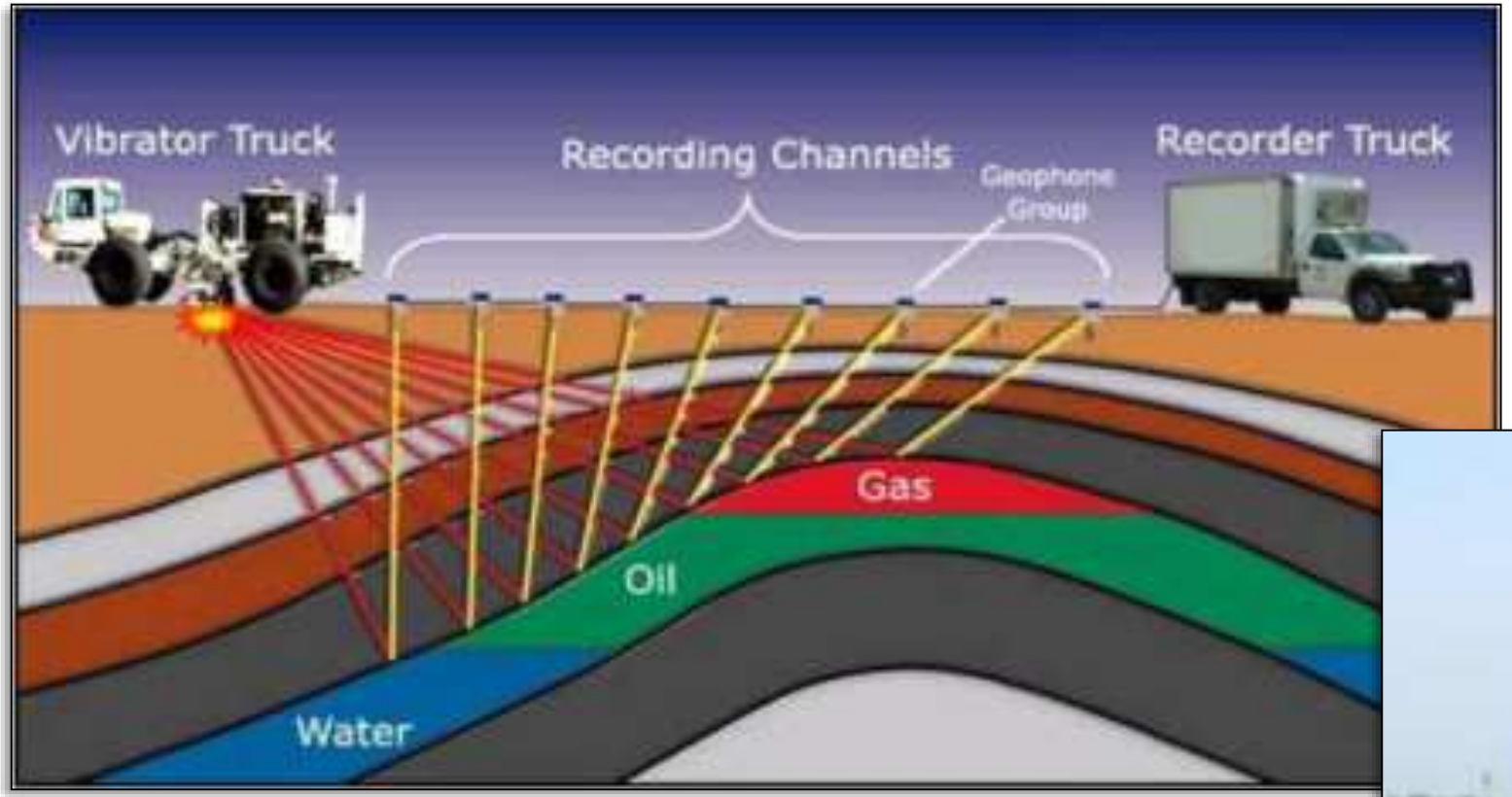
SEISMIC REFLECTION STUDIES

- Seismic studies enable recognition of Earth's subsurface using seismic waves generated at the surface and then reflected from geological boundaries
- Seismic surveying could be realized along 2D profiles or as a 3D imaging
- Depth range is from tens of kilometers to single meters (with different resolution)

SEISMIC REFLECTION STUDIES

Seismic reflection surveying is almost exact equivalent of USG / tomography in medicine

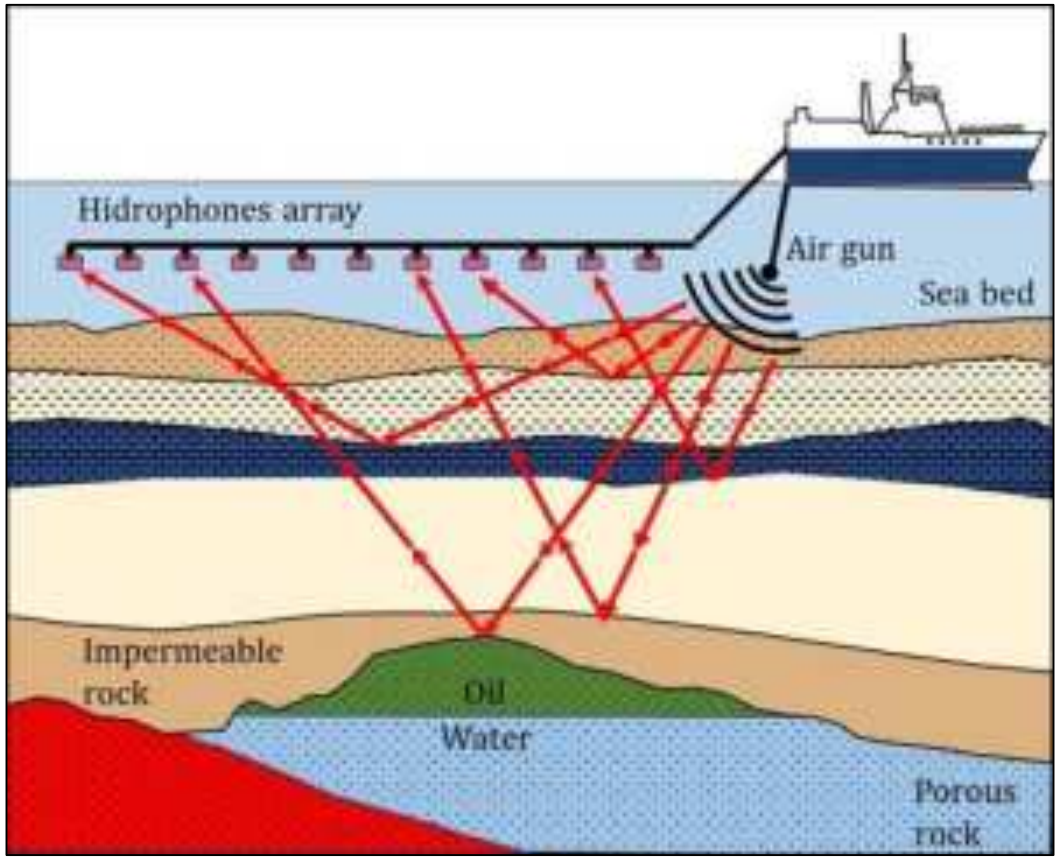
SEISMIC REFLECTION STUDIES



onshore seismic data acquisition

depth range: metres – tens of kilometers

SEISMIC REFLECTION STUDIES



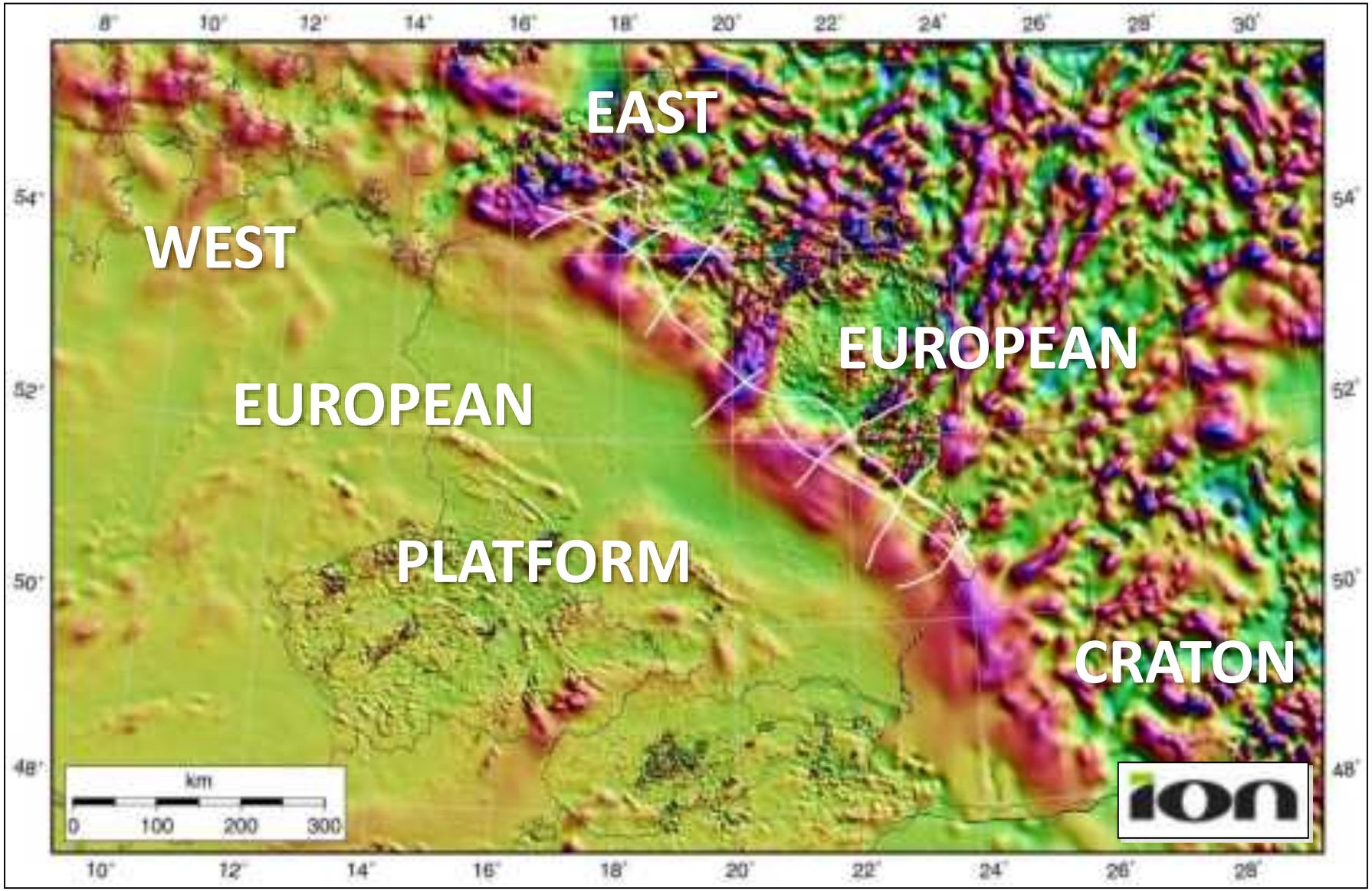
depth range: metres – tens of kilometers

offshore seismic data acquisition

OUTLINE

1. Seismic reflection studies – very short intro
2. Crustal-scale studies
3. Sedimentary basins and fold-and-thrust belts
4. Shallow subsurface

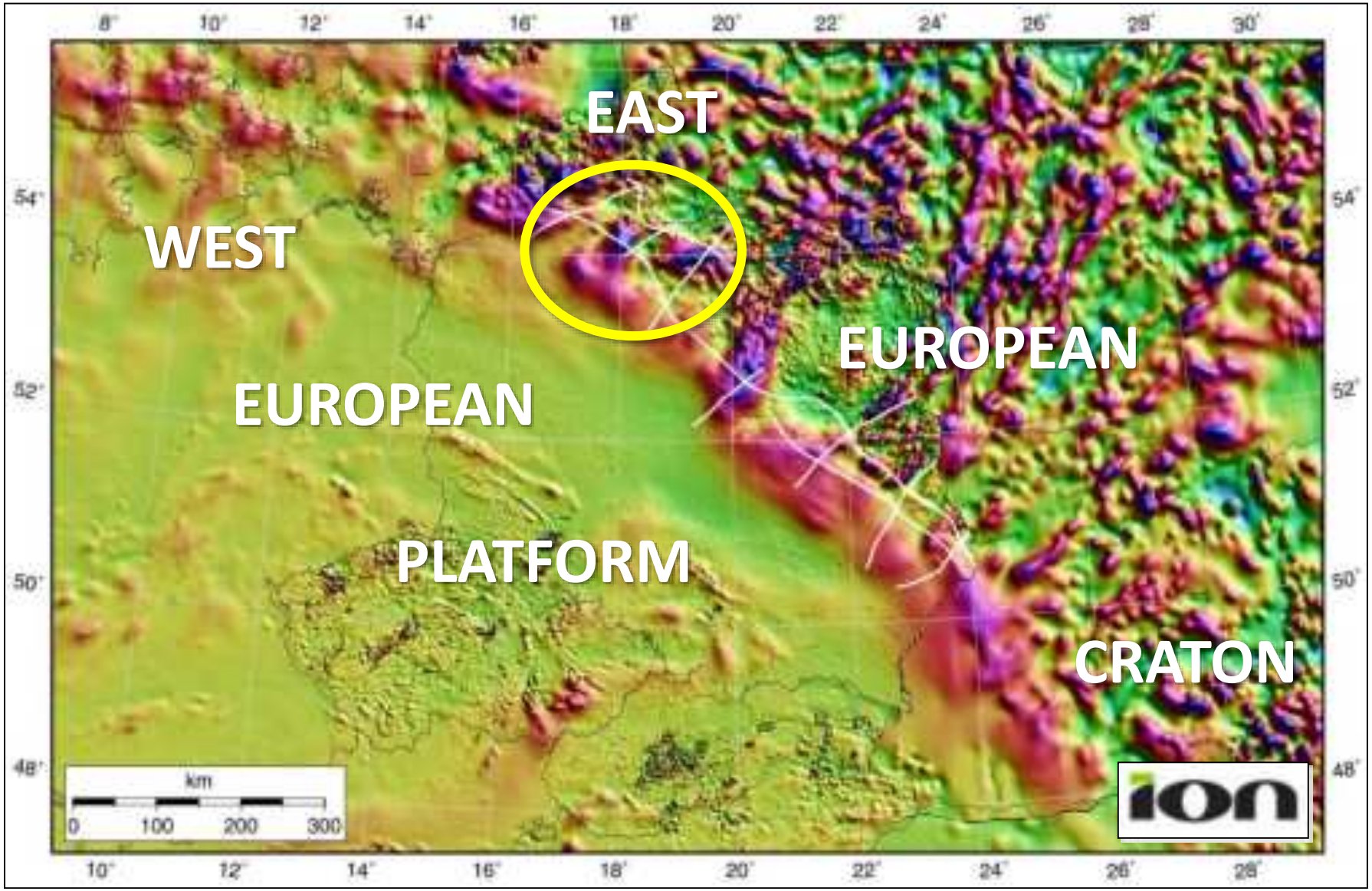
CRUSTAL-SCALE STUDIES



Magnetic map of central and E Europe

- **PolandSPAN**: regional seismic survey acquired during shale gas exploration by ION Geophysical, Houston, USA
- approx. 2200 km of 2D seismic data
- long offsets (**12 kms**)
- tight station spacing (25 m)
- long record lengths (**12 s**), uncorrelated data
- high fold (**480**)
- processed up to PSDM
- calibrated by key deep research wells
- integrated with grav-mag data

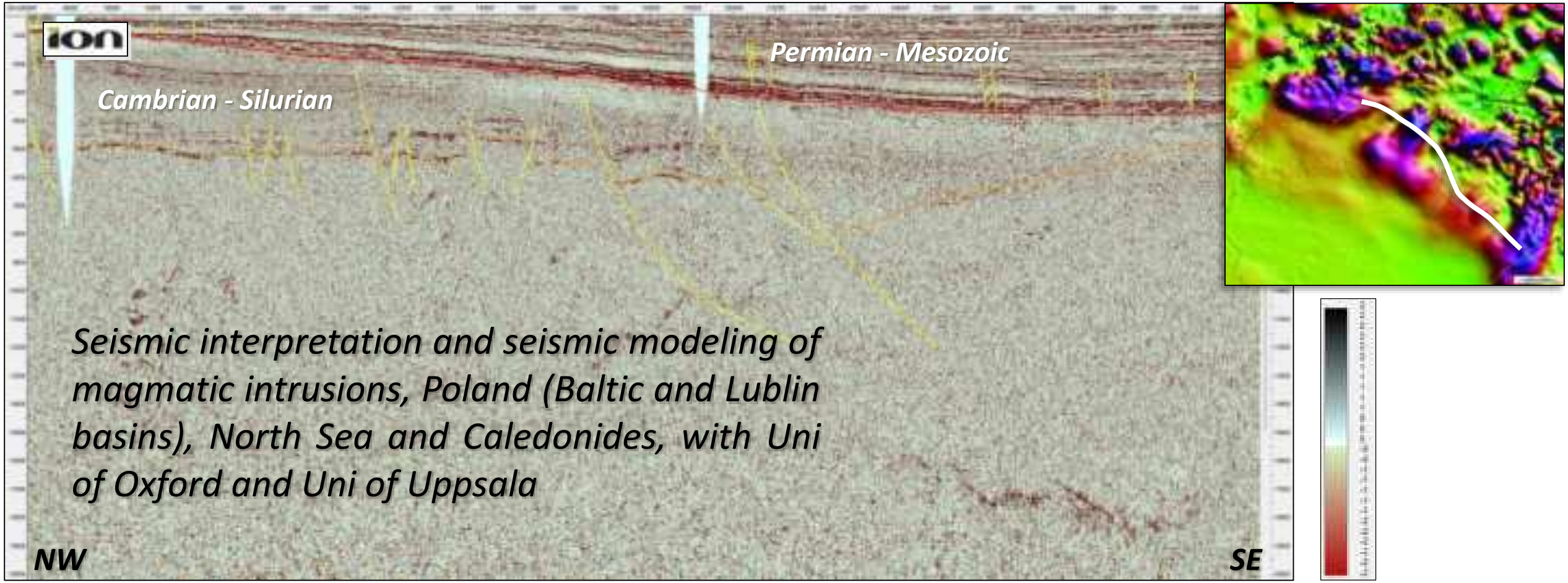
CRUSTAL-SCALE STUDIES



Magnetic map of central and E Europe

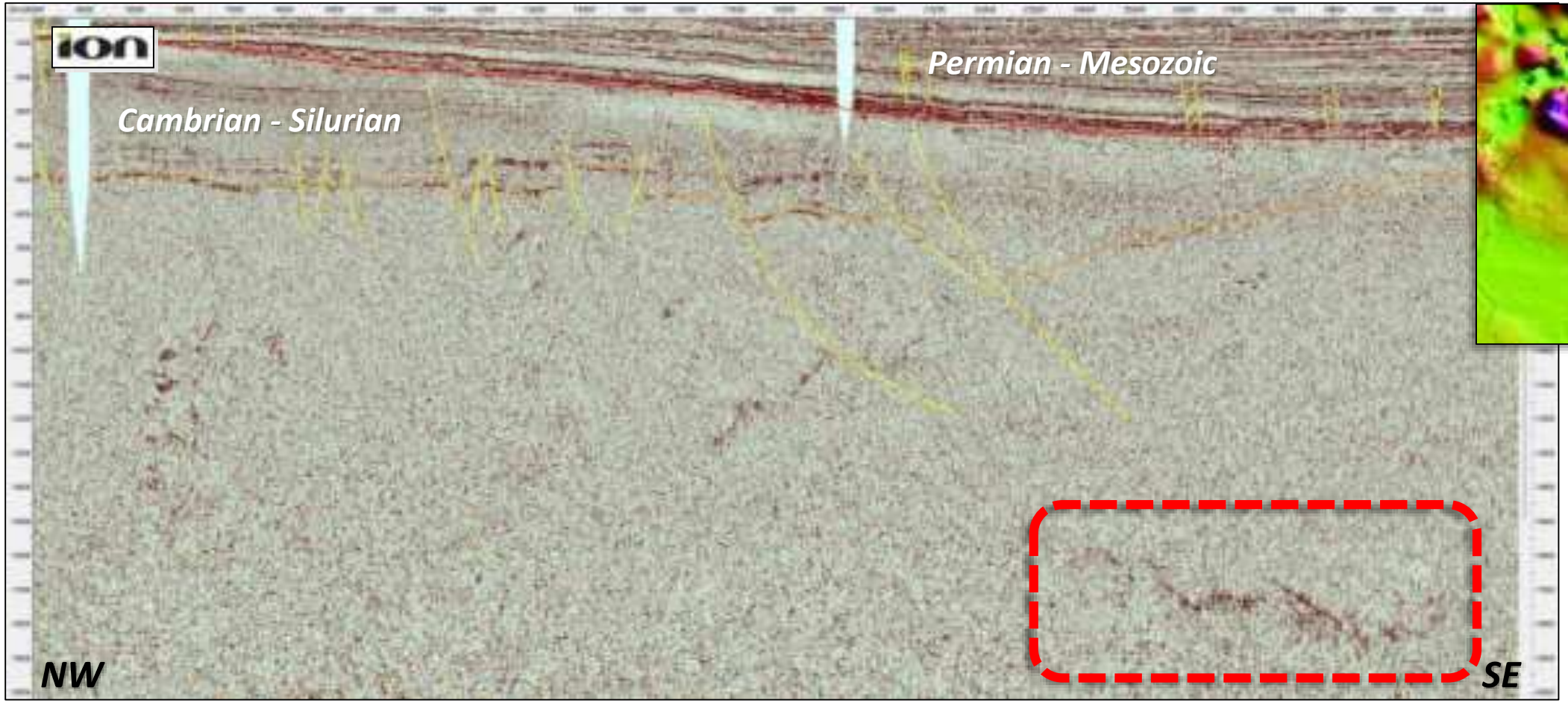
- **PolandSPAN**: regional seismic survey acquired during shale gas exploration by ION Geophysical, Houston, USA
- approx. 2200 km of 2D seismic data
- long offsets (**12 kms**)
- tight station spacing (25 m)
- long record lengths (**12 s**), uncorrelated data
- high fold (**480**)
- processed up to PSDM
- calibrated by key deep research wells
- integrated with grav-mag data

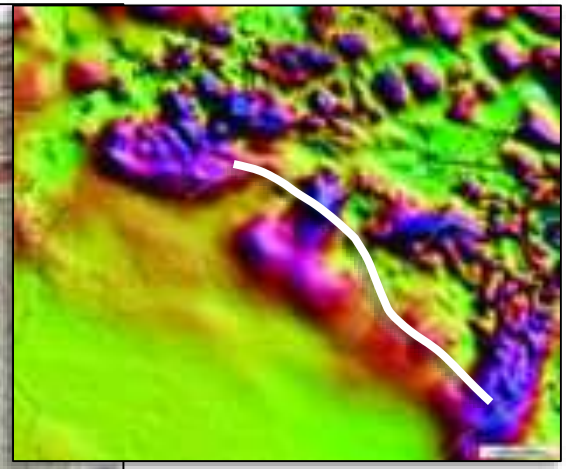
CRUSTAL-SCALE STUDIES

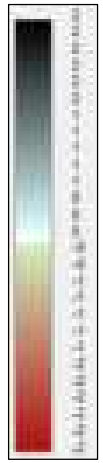


In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES

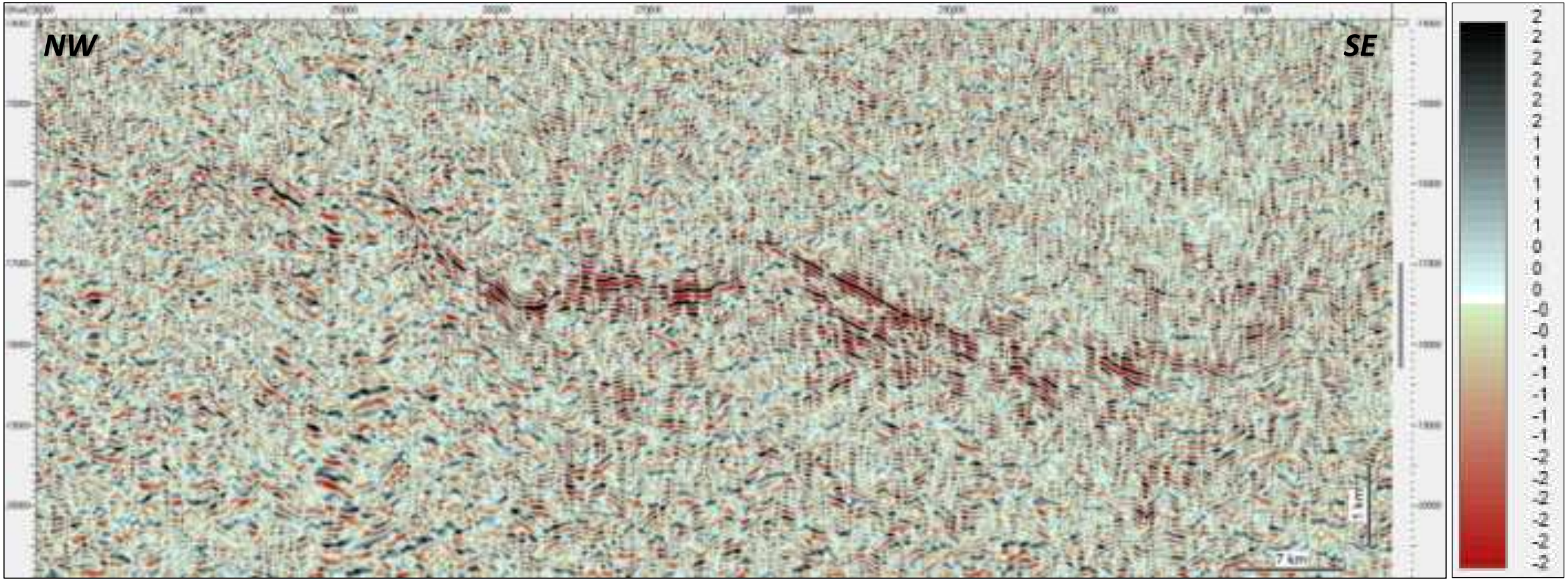






In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES

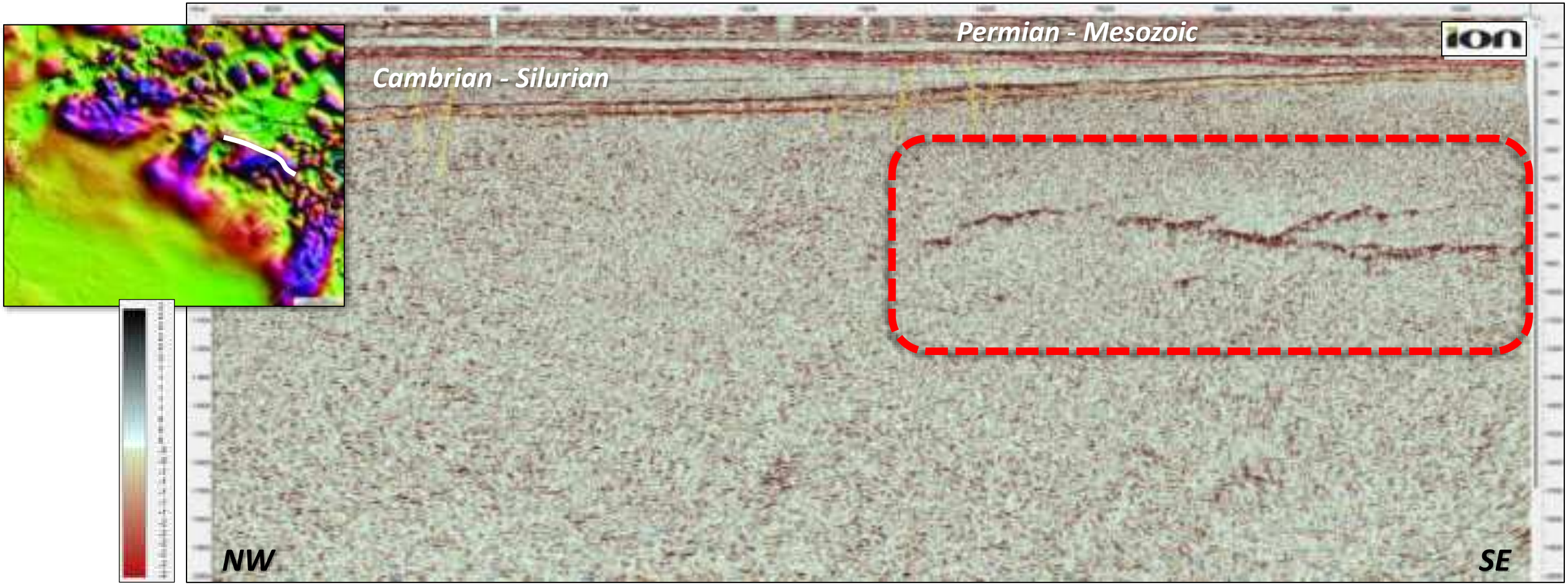


In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES

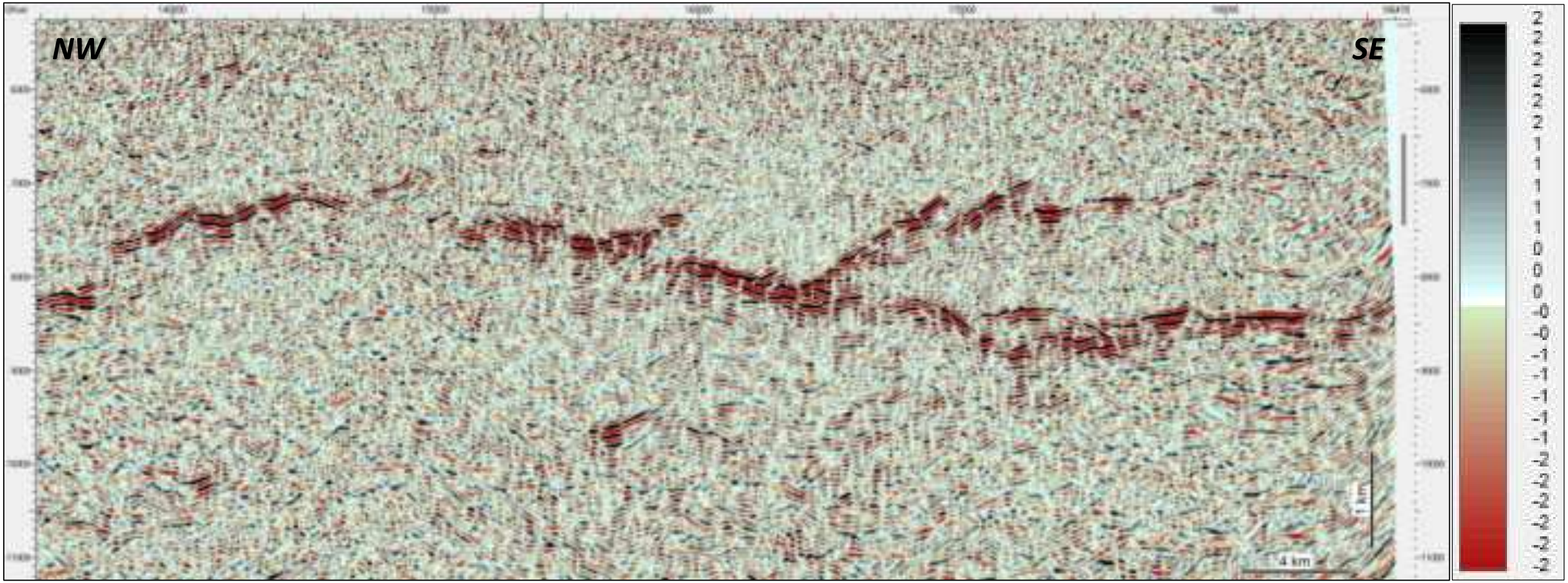
In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES



In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES



In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

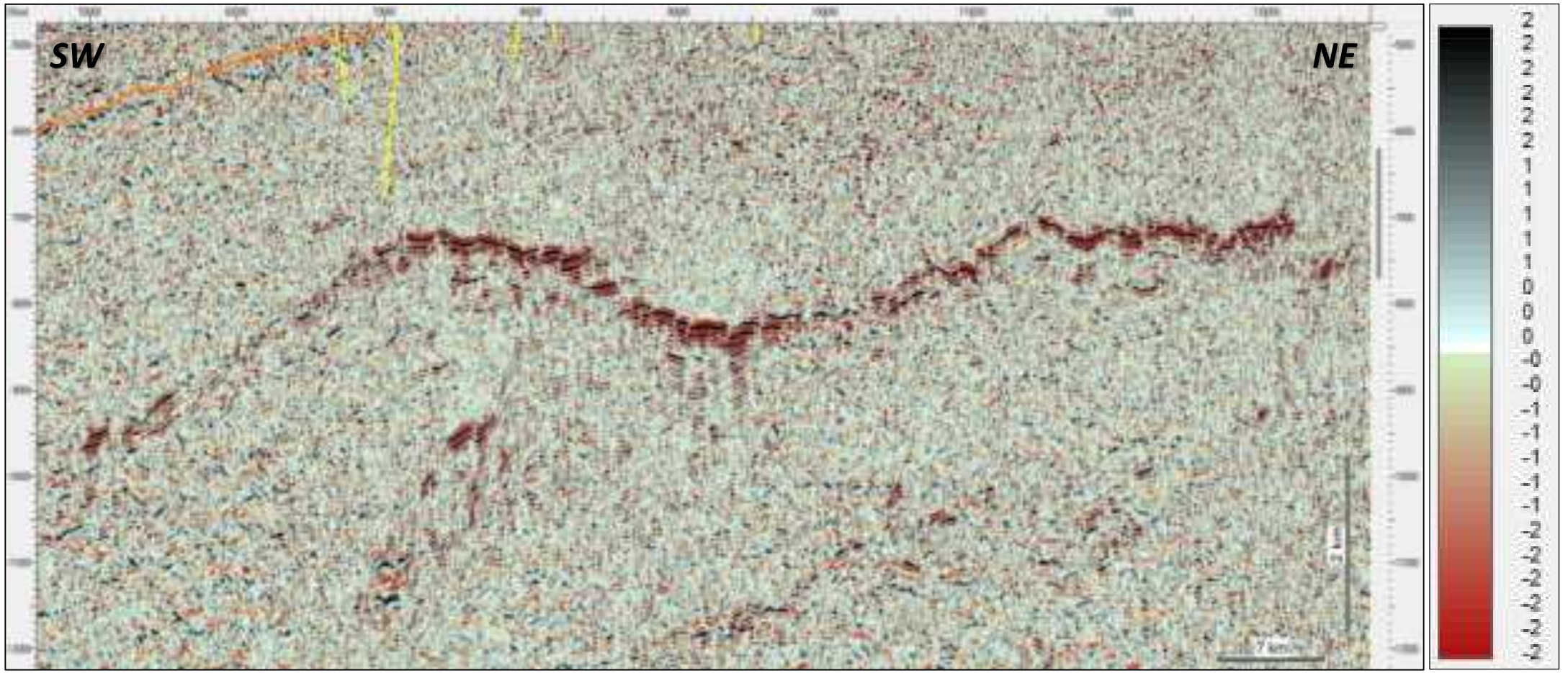
CRUSTAL-SCALE STUDIES

In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES

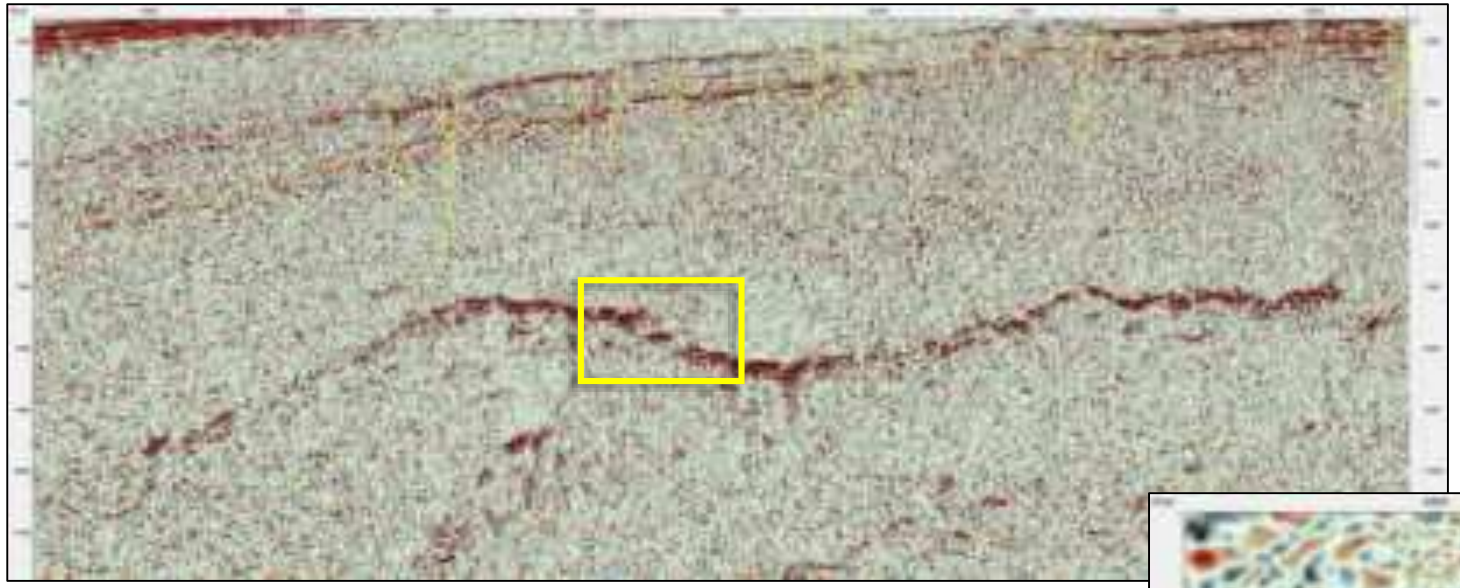
In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES



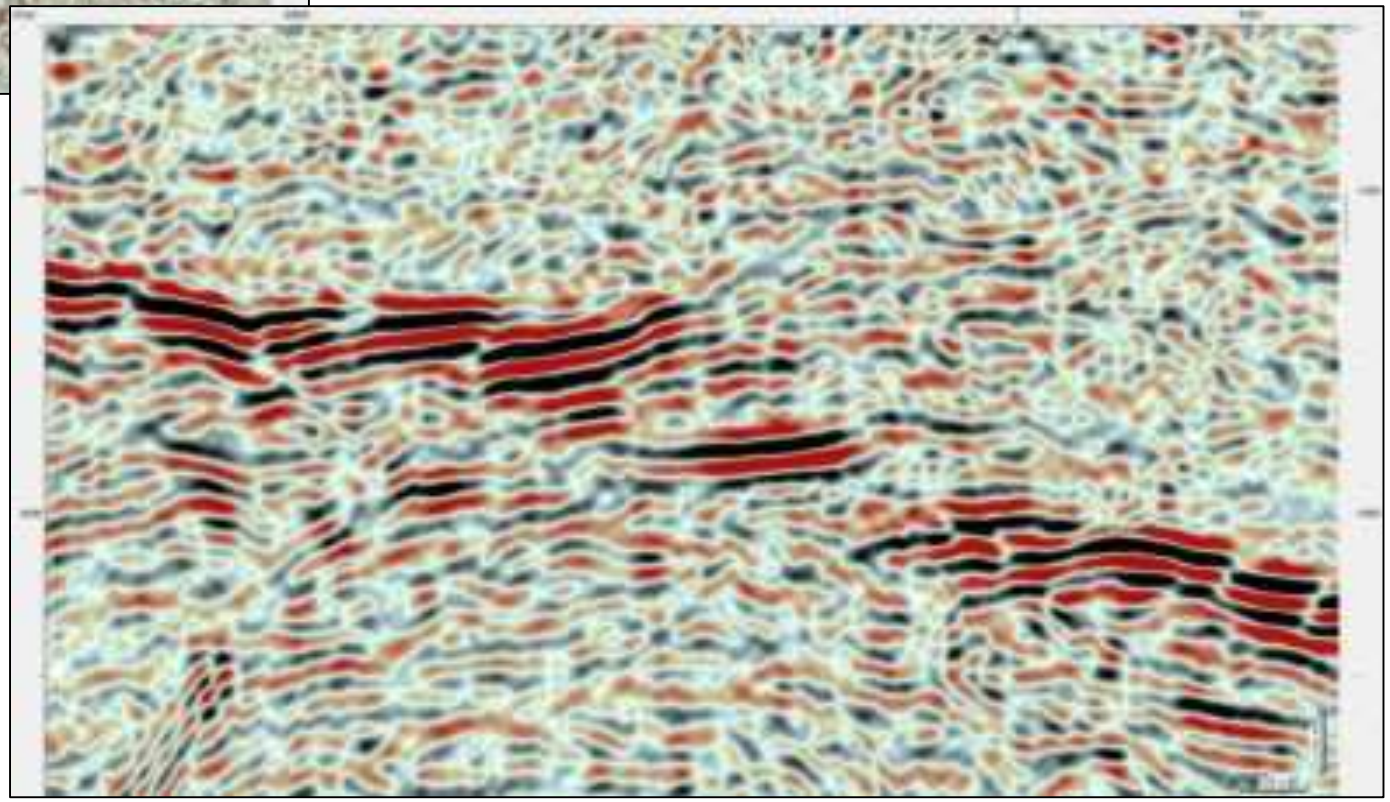
In the Baltic Basin numerous wells (e.g. Pasłęk IG-1) documented **lower Carboniferous doleritic sills**. In this area, a complex system of strong amplitude, deep (7-19 km) seismic reflectors up to 100 km long has been detected using PolandSPAN seismic data within the crystalline basement that resemble lower-crustal reflections (LCR) documented e.g. within the basement of the North Sea basin or the Scandinavian Caledonides

CRUSTAL-SCALE STUDIES

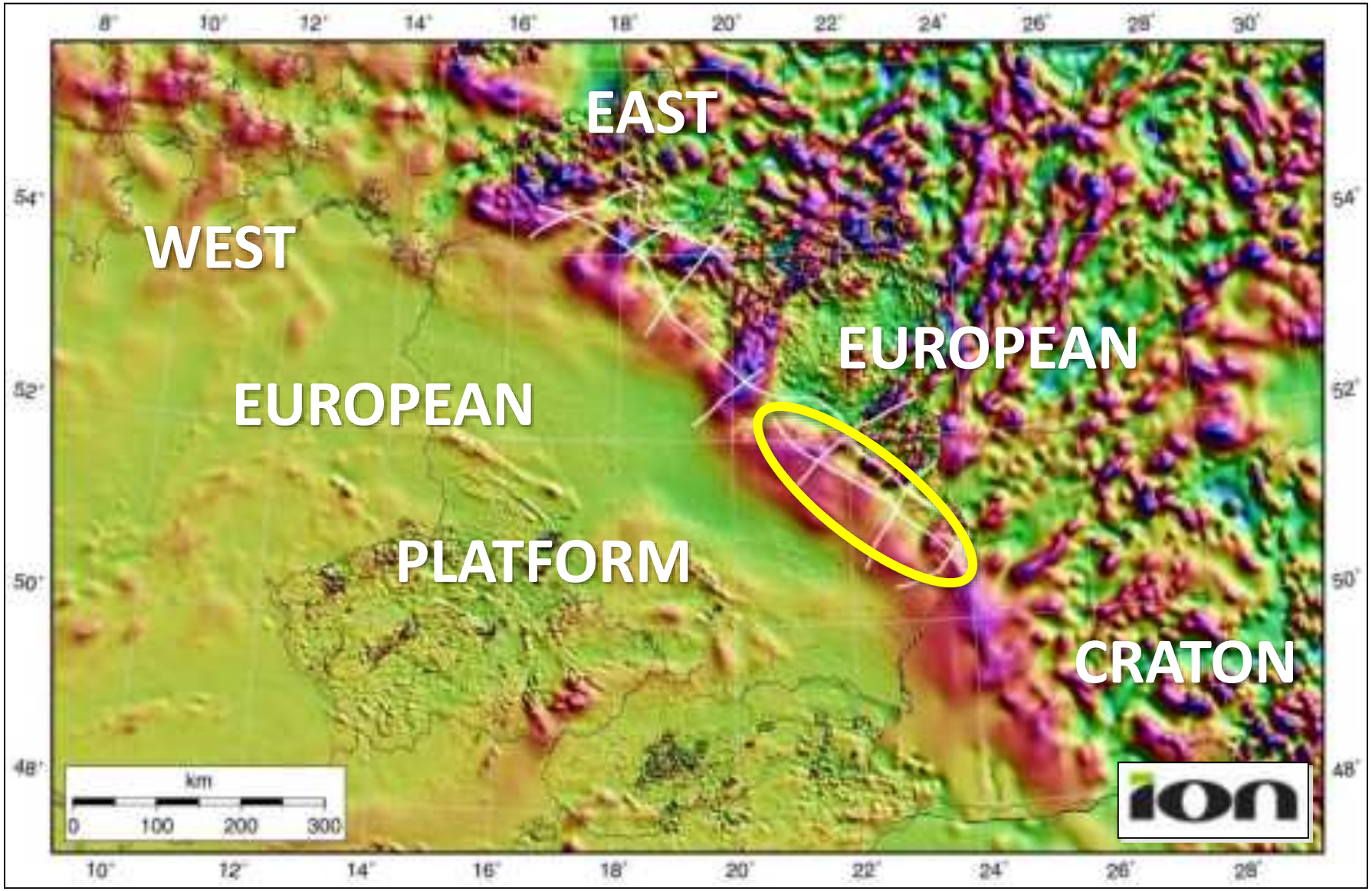


irregular seismic reflectors -> probably an effect of a „stepwise” geometry

„step-wise” mafic intrusion, Donegal, Ireland
(https://blogs.egu.eu/divisions/ts/2022/05/30/features-from-the-field-dikes-and-sills/).



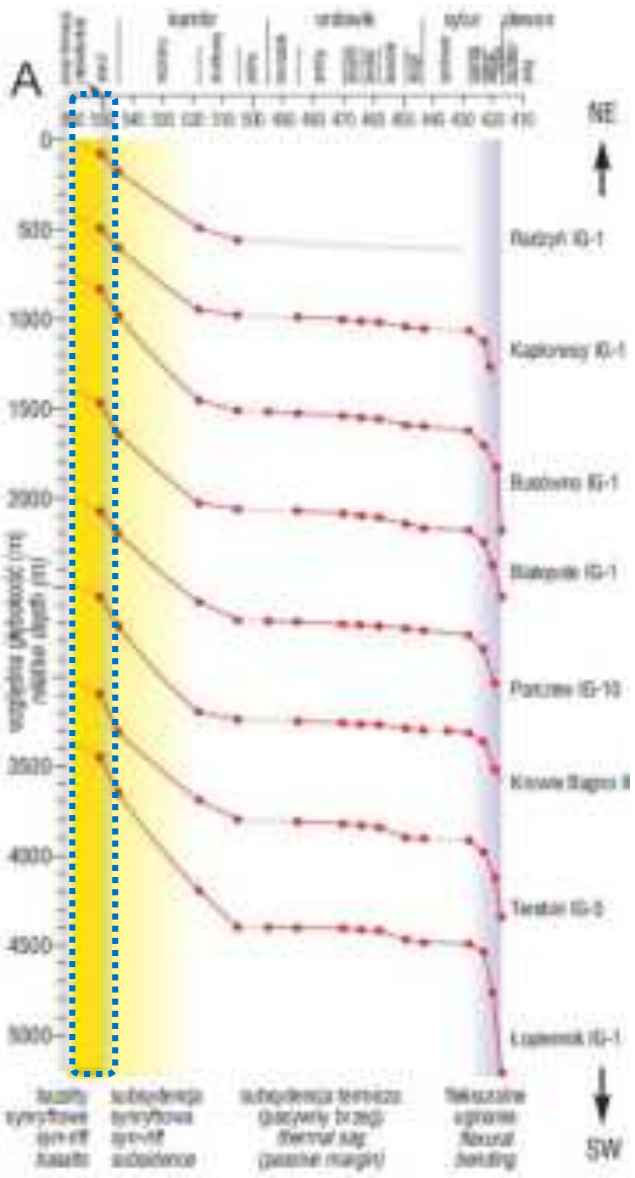
CRUSTAL-SCALE STUDIES

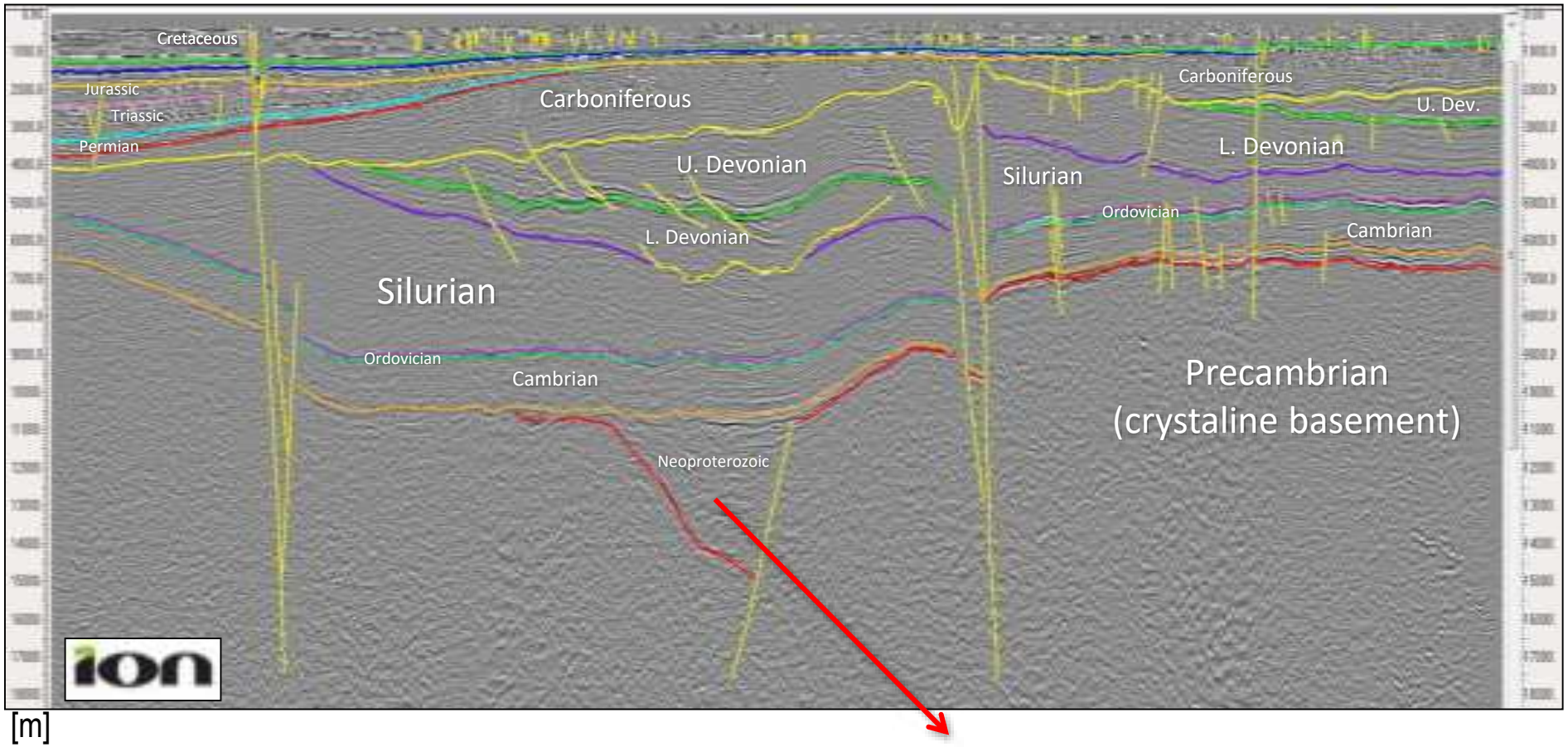


Magnetic map of central and E Europe

- **PolandSPAN**: regional seismic survey acquired during shale gas exploration by ION Geophysical, Houston, USA
- approx. 2200 km of 2D seismic data
- long offsets (**12 kms**)
- tight station spacing (25 m)
- long record lengths (**12 s**), uncorrelated data
- high fold (**480**)
- processed up to PSDM
- calibrated by key deep research wells
- integrated with grav-mag data

CRUSTAL-SCALE STUDIES



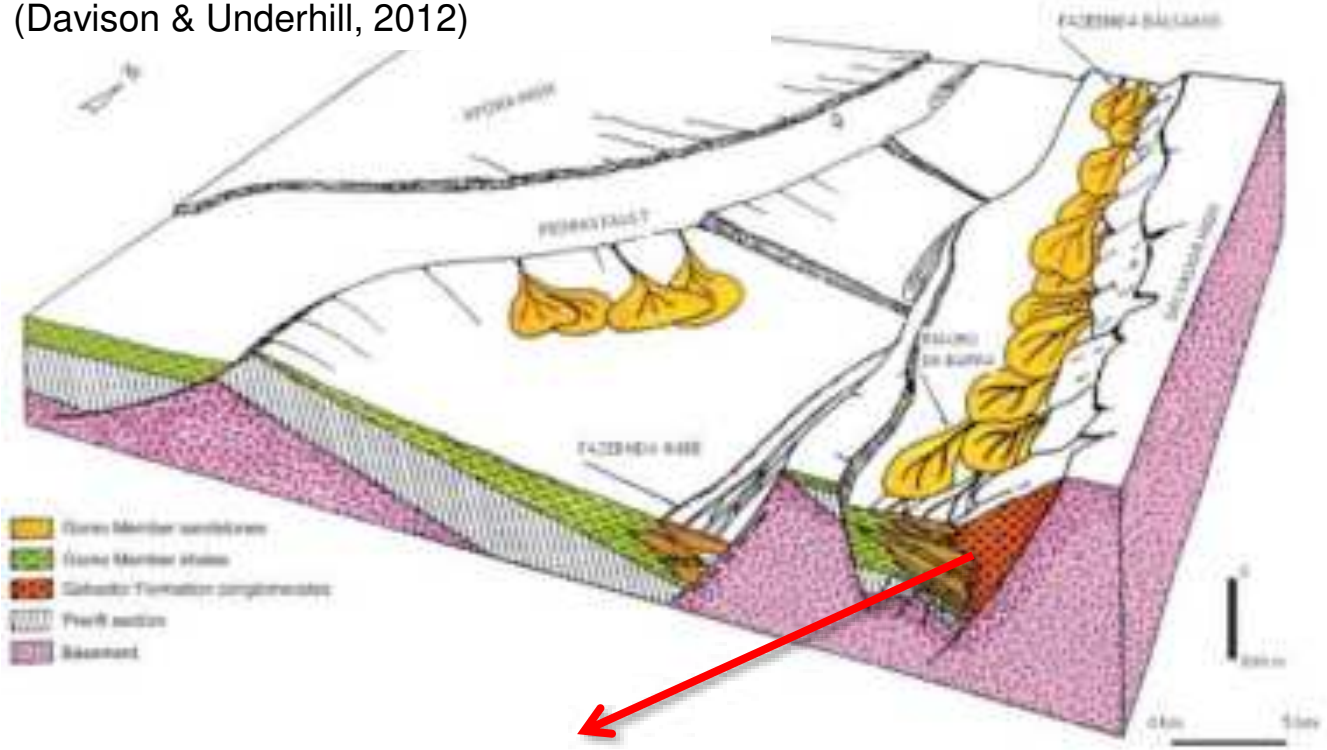


Neoproterozoic rift zone in SE Poland (depth 10-17km)

tectonic subsidence curves - East European Craton in SE Poland (Poprawa & Pacześna, 2002)

CRUSTAL-SCALE STUDIES

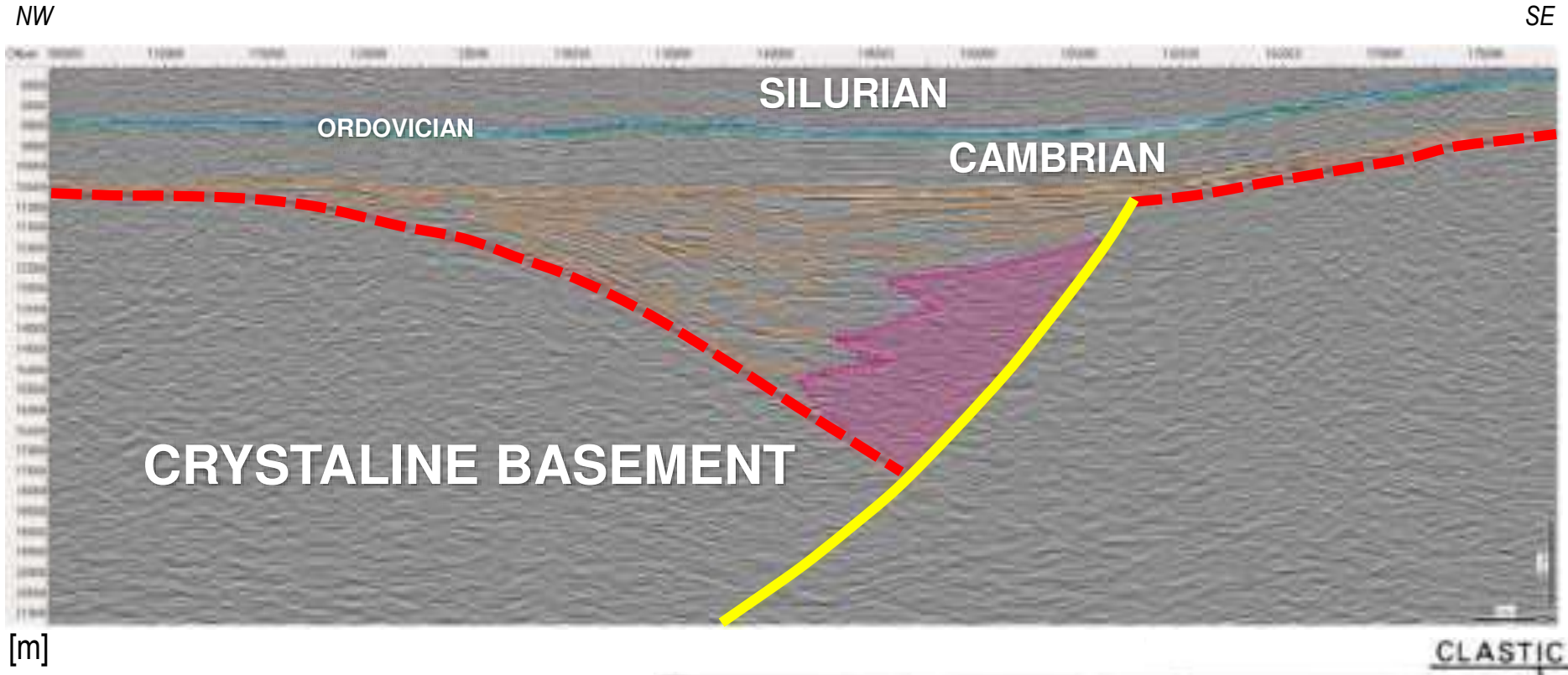
(Davison & Underhill, 2012)



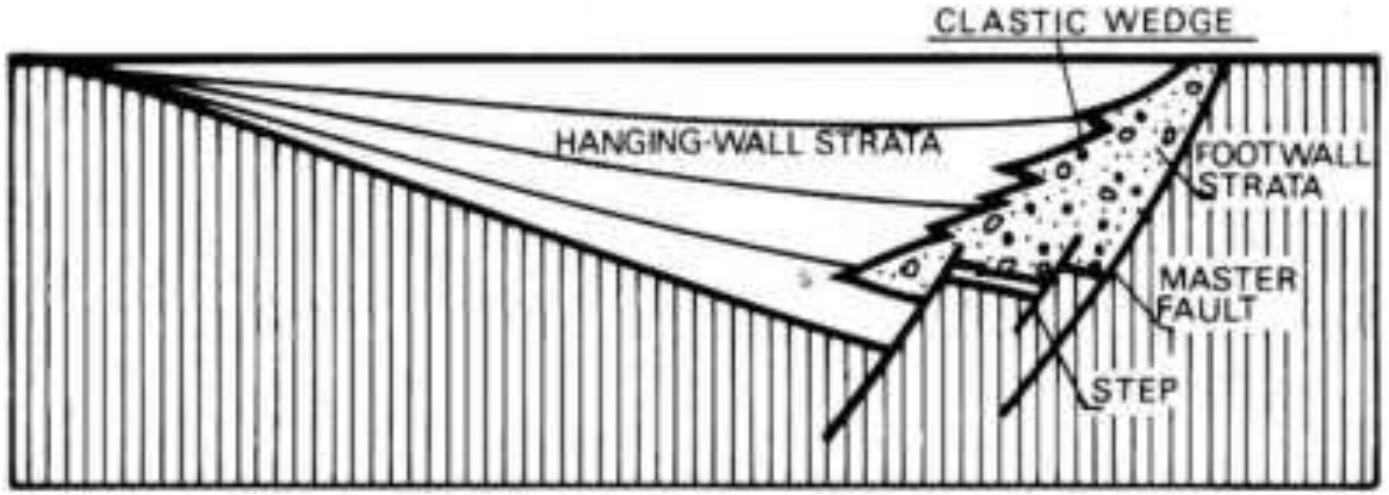
Hanging-wall conglomerates deposited during active rifting

Great Rift Valley

CRUSTAL-SCALE STUDIES



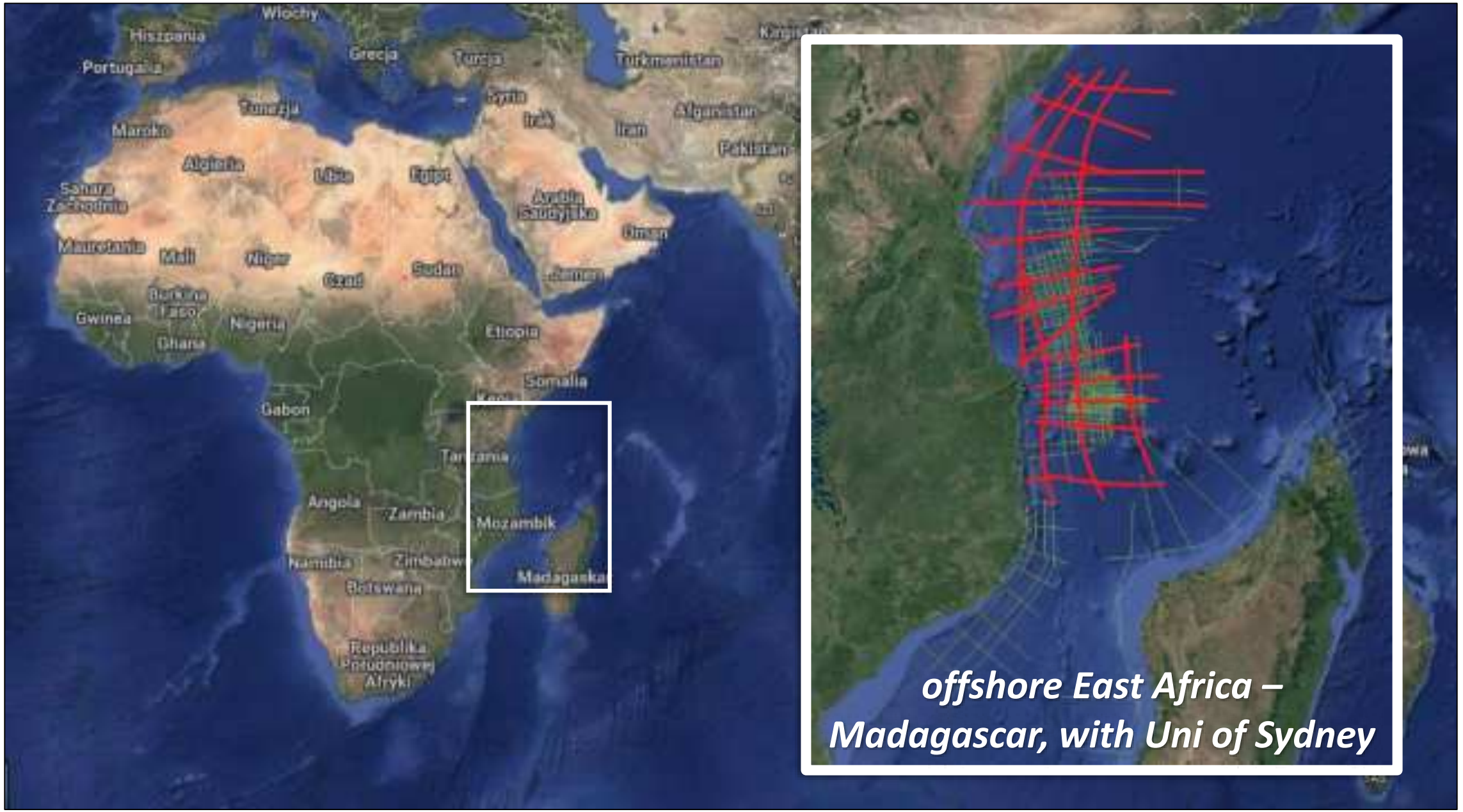
Neoproterozoic rift zone in SE Poland (depth 10-17km)



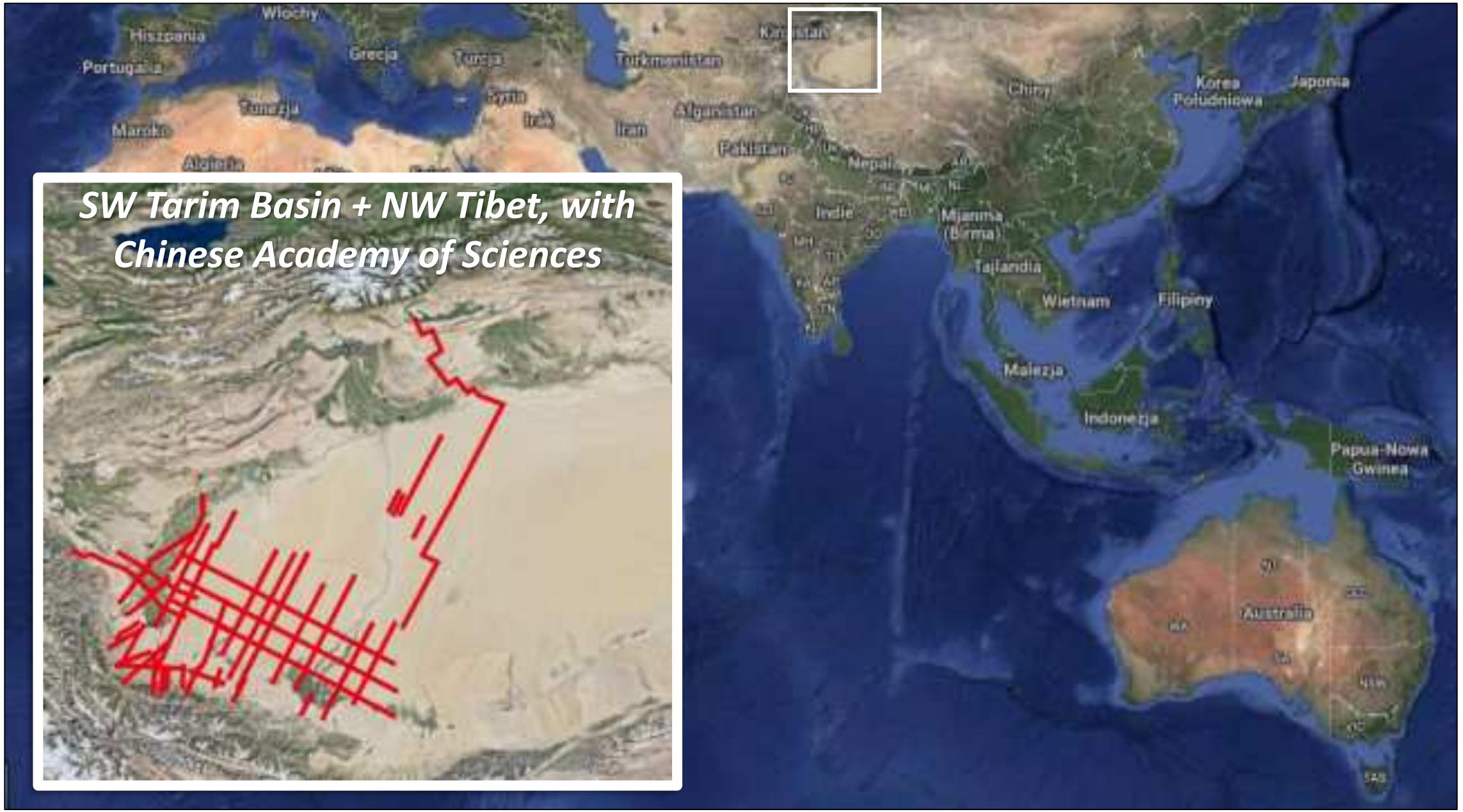
CRUSTAL-SCALE STUDIES

other on-going projects based on regional deep seismic data outside of Poland

CRUSTAL-SCALE STUDIES



CRUSTAL-SCALE STUDIES



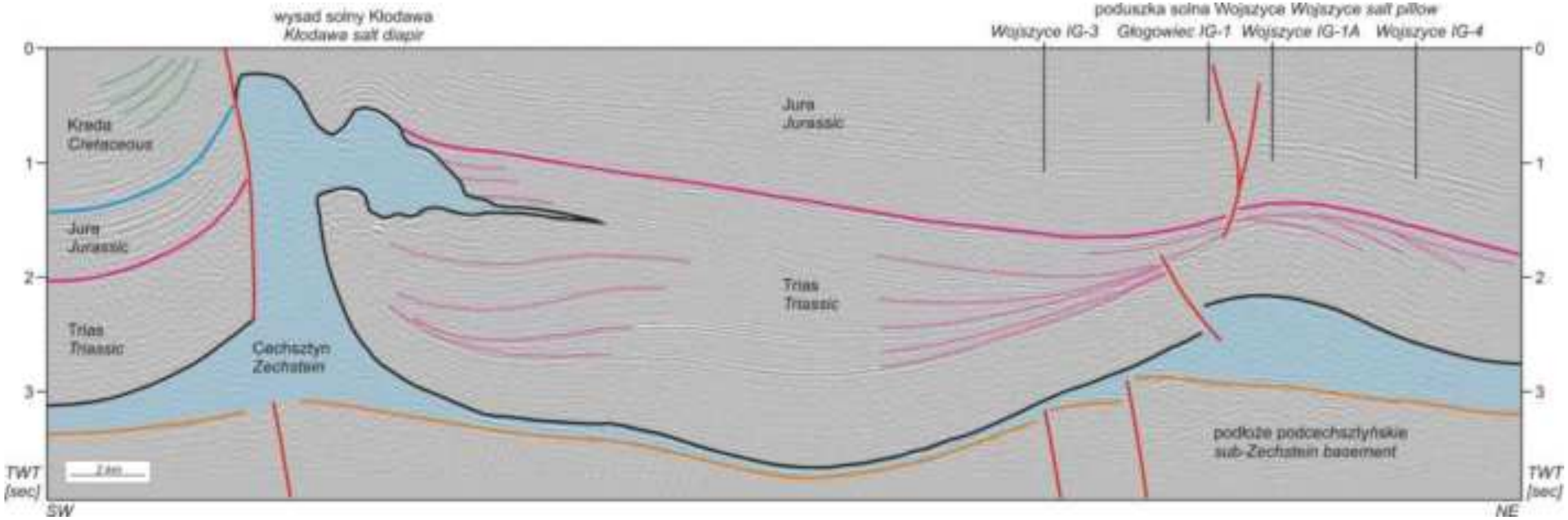
CRUSTAL-SCALE STUDIES

Flinders Ranges, with Uni of Texas El Paso & Uni of Barcelona

OUTLINE

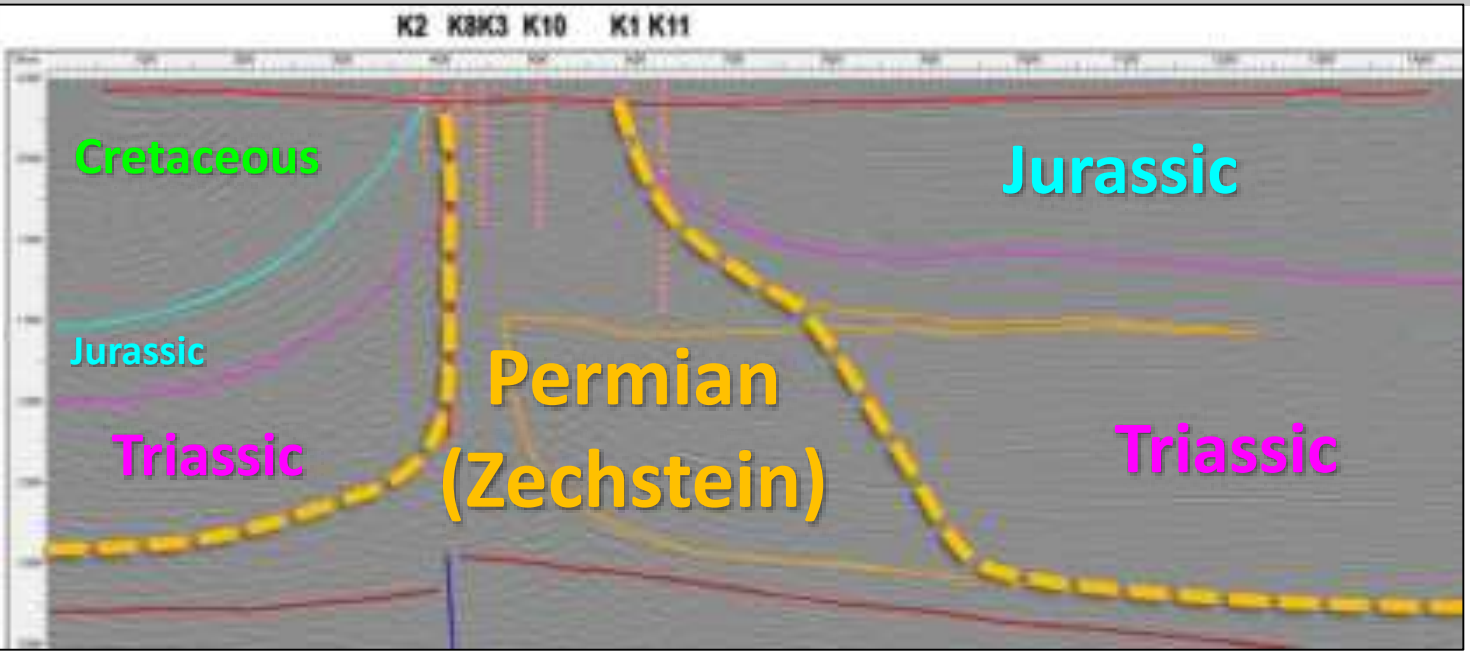
1. Seismic reflection studies – very short intro
2. Crustal-scale studies
3. Sedimentary basins and fold-and-thrust belts
4. Shallow subsurface

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS

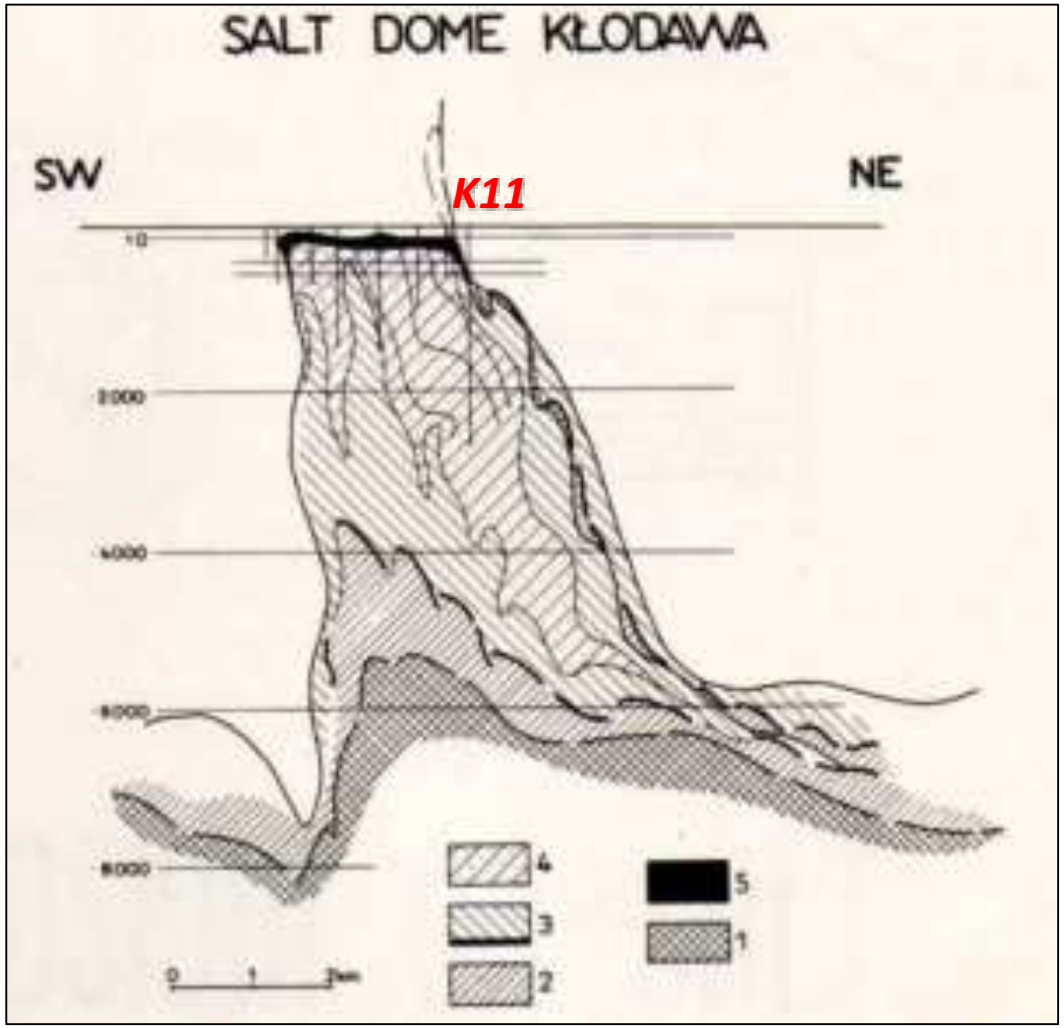


Kłodawa Salt Diapir, approx. 6 km tall (Krzywiec, 2012). Salt structures could be used for underground storage of oil & gas and nuclear waste, they are also very important for geothermal prospects

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS

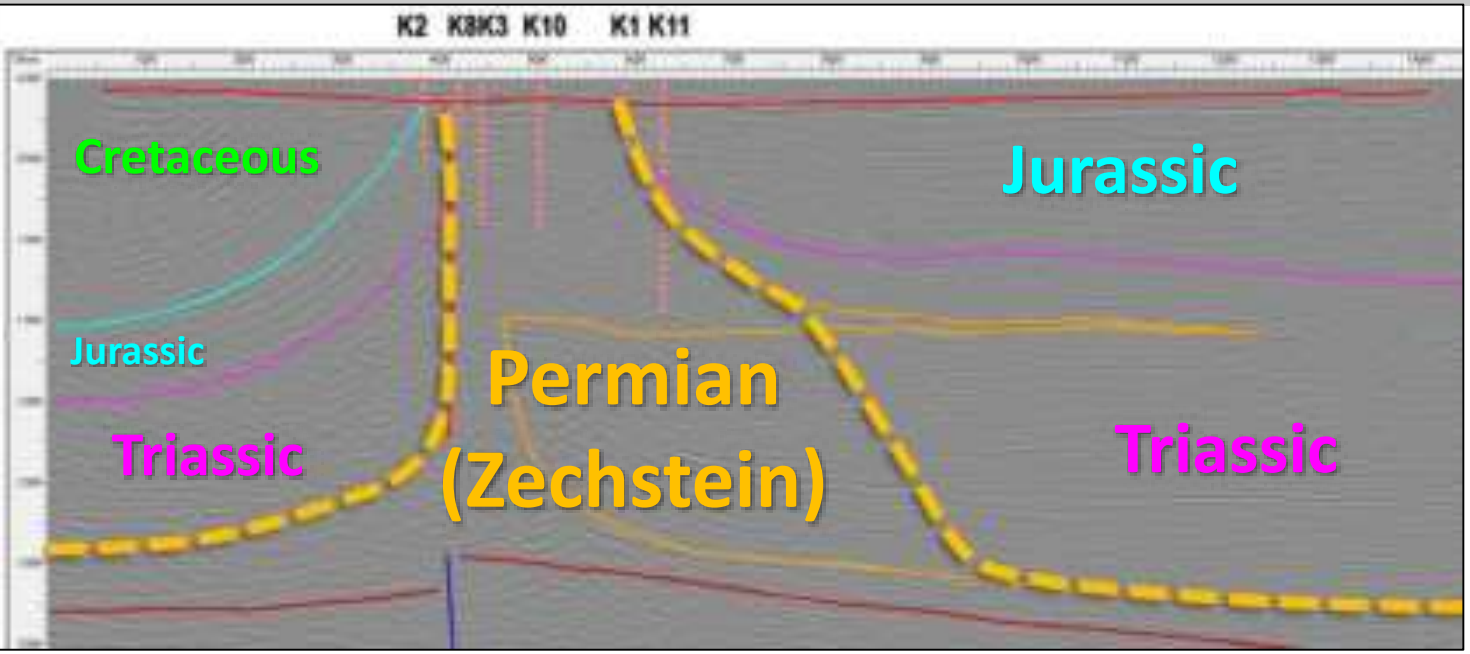


Outline of the „classic" Kłodawa salt diapir superimposed on seismic profile crossing Kłodawa salt mine



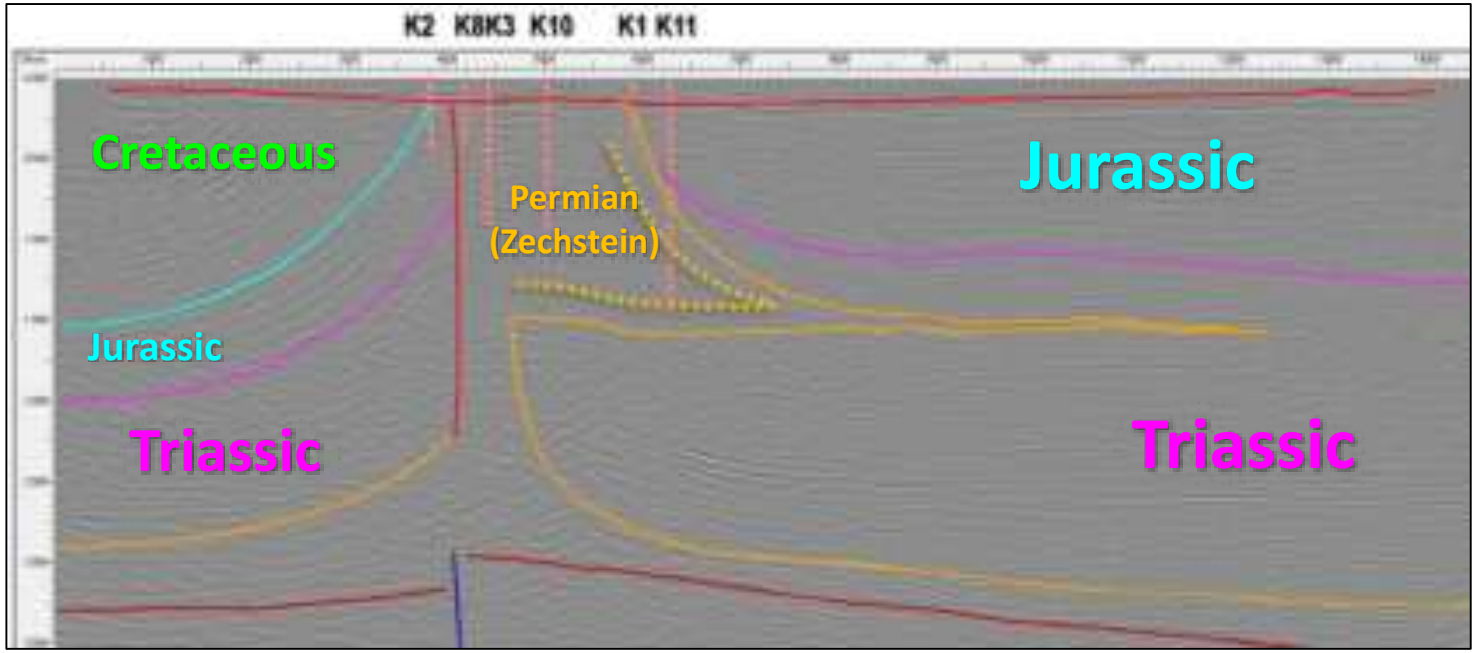
Classic model of the Kłodawa salt diapir by Poborski (1966) – still used (by some) …

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS

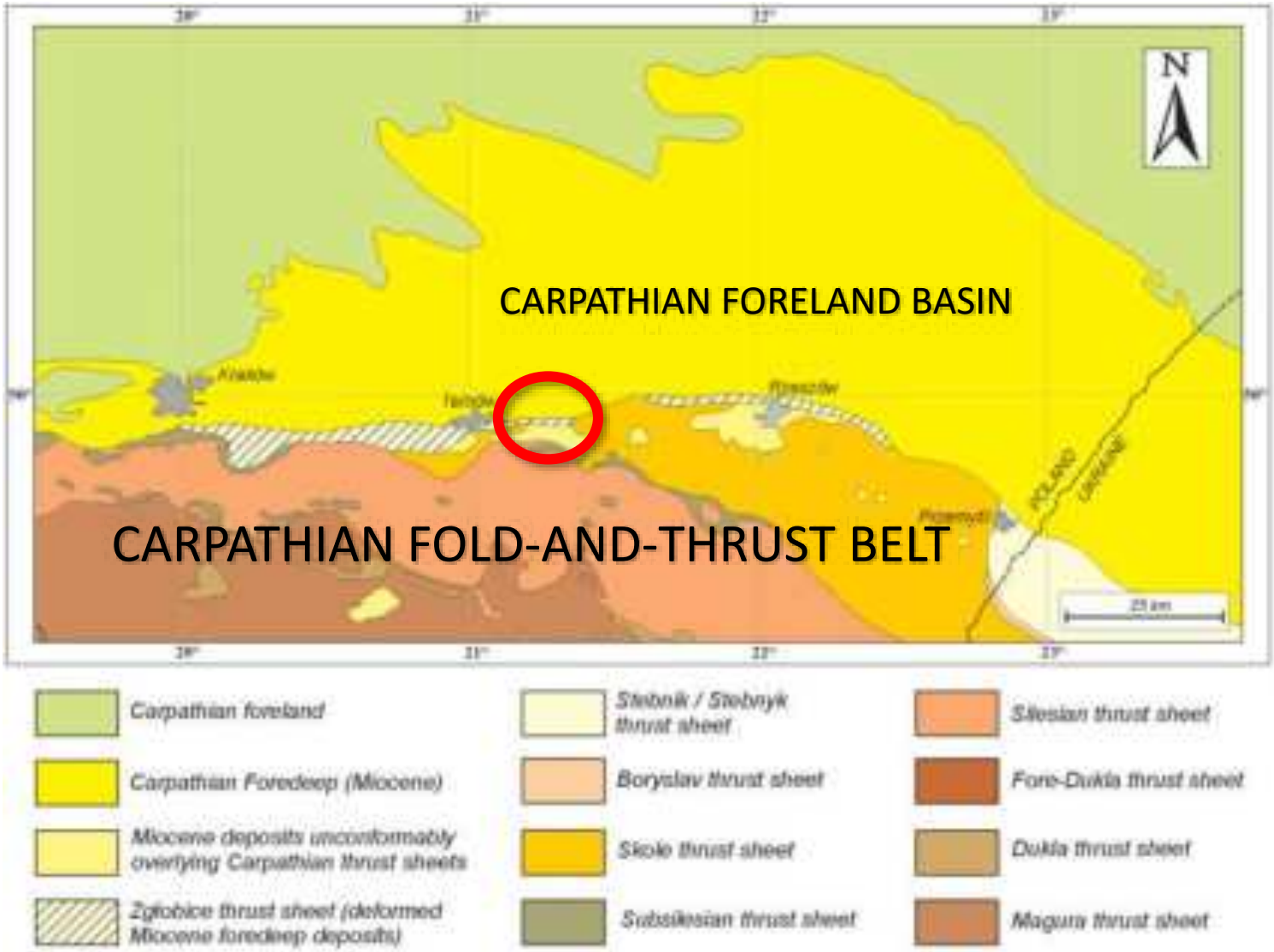


Outline of the „classic" Kłodawa salt diapir superimposed on seismic profile crossing Kłodawa salt mine

Correct outline of the Kłodawa salt diapir interpreted using seismic profile crossing Kłodawa salt mine – note large (approx. 6km long, up to 2km thick) salt wing developed along the NE side of the diapir. <u>2/3 of the mine is located in this wing, not in diapir itself</u>

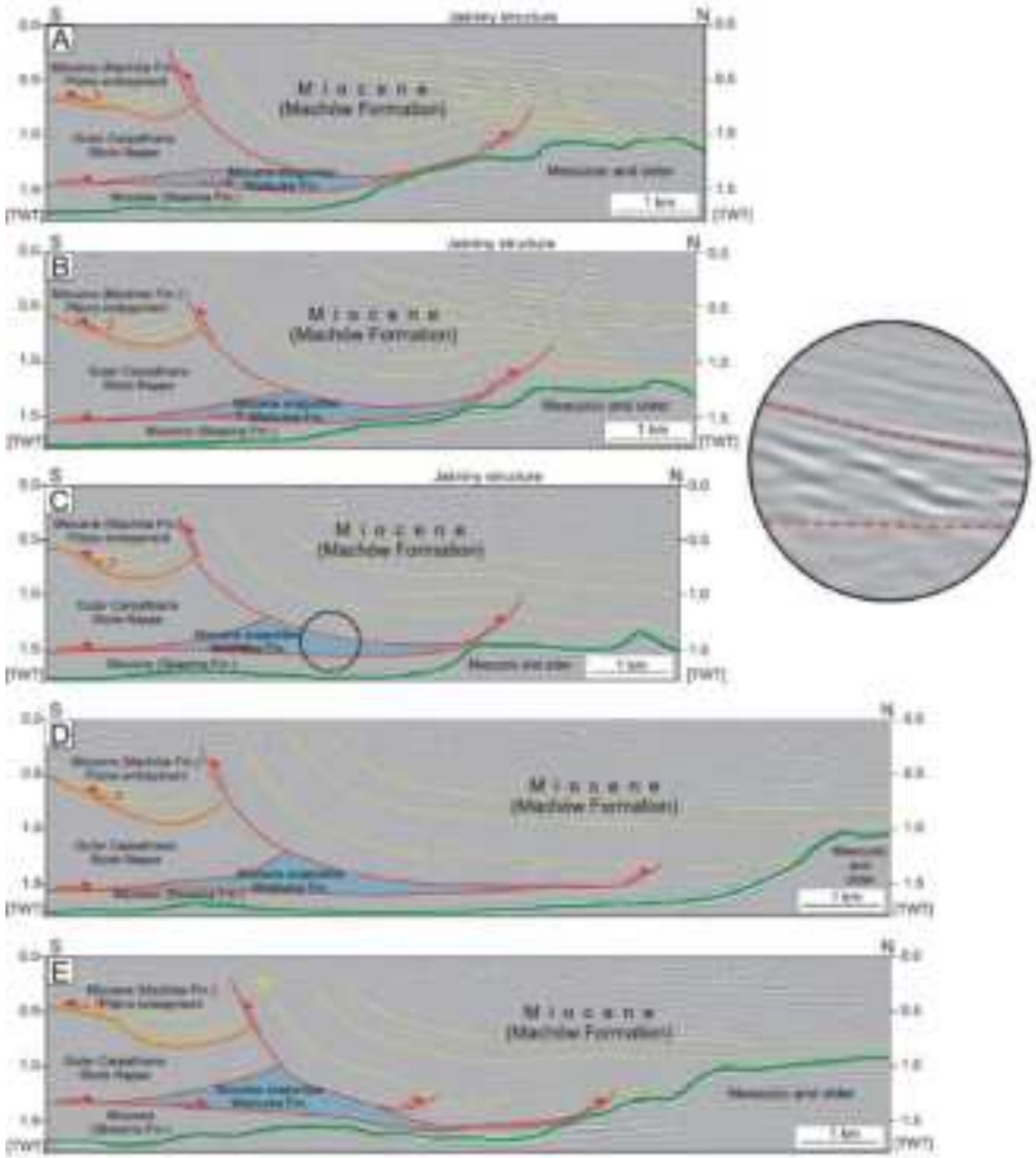


SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS



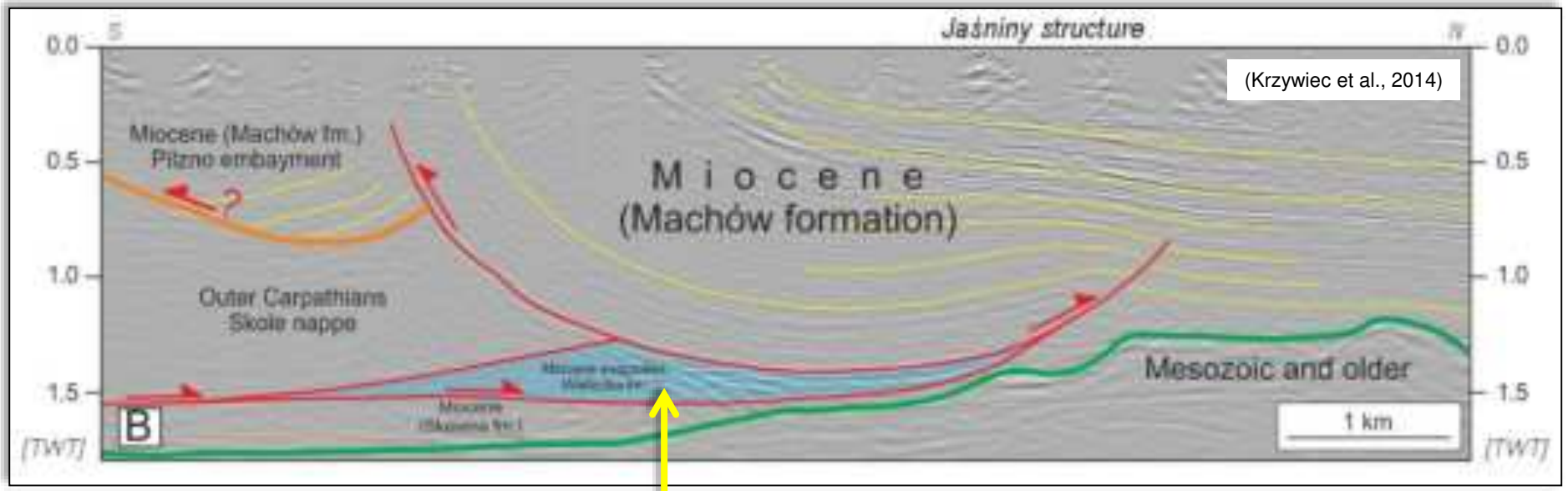
Structure of the frontal Carpathian fold-and-thrust belt in Pilzno area – role of Miocene evaporites of the Wieliczka formation in compressional tectonics (Krzywiec et al., 2014)

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS

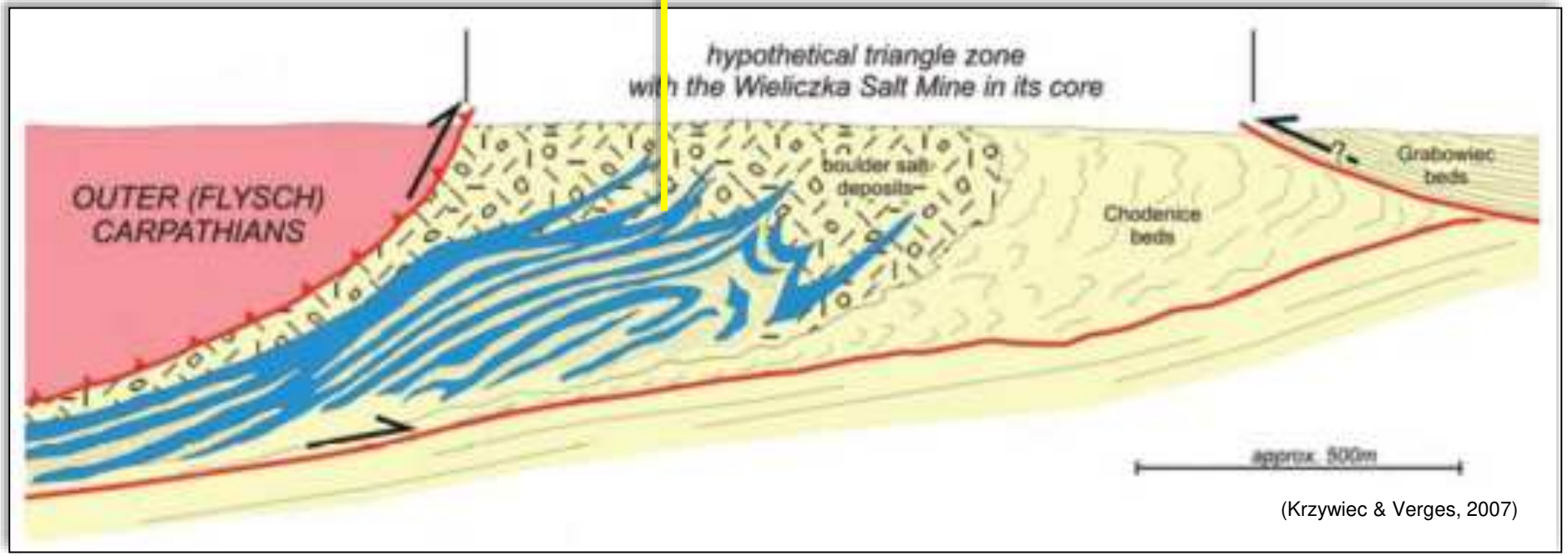


Structure of the frontal Carpathian fold-and-thrust belt in Pilzno area imaged by 3D seismic reflection data (Krzywiec et al., 2014) – triangle zone filled by strongly deformed Miocene evaporites that acted as tectonic „lubricant”.

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS

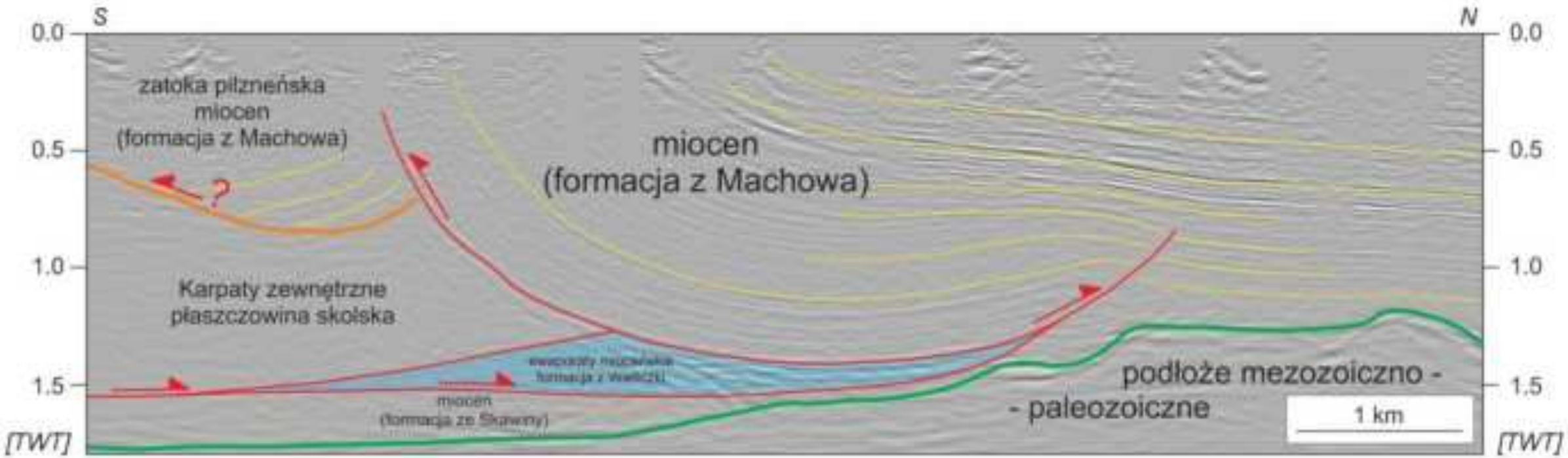


Pilzno area



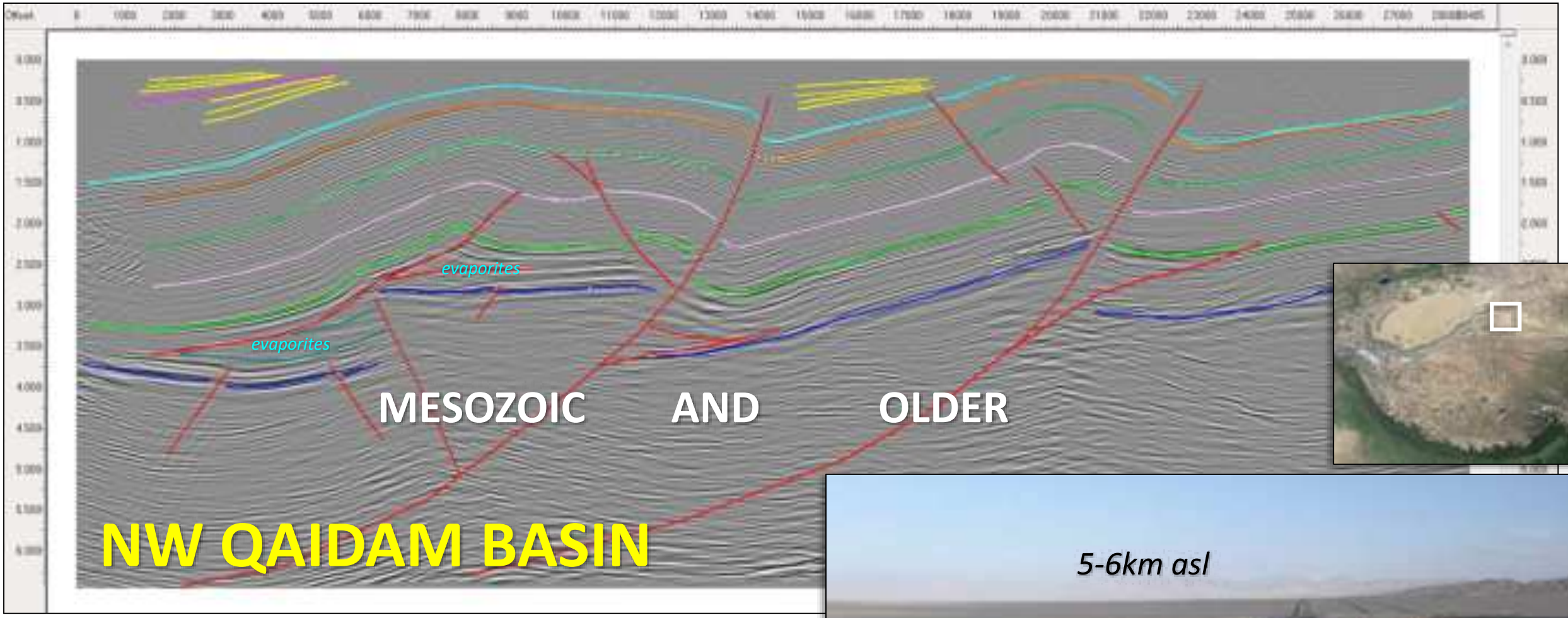
Wieliczka area

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS



In Pilzno area, there is another „Wieliczka” but at greater depth

SEDIMENTARY BASINS AND FOLD-AND-THRUST BELTS

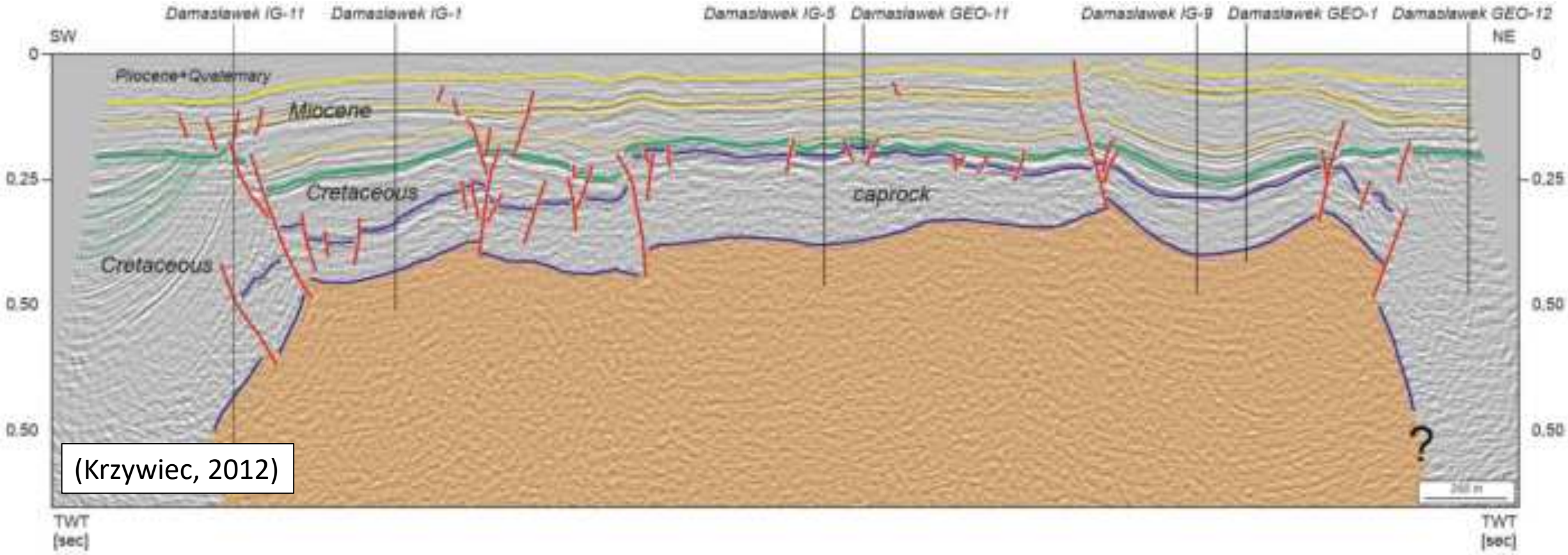


- system of complex compressional deformations, partly rooted in deeper basement (***thick-skinned***) and partly detached within the Eocene evaporites (***thin-skinned***)
- syn-compressional growth strata are clearly visible within the youngest (Pliocene – Holocene) deposits

OUTLINE

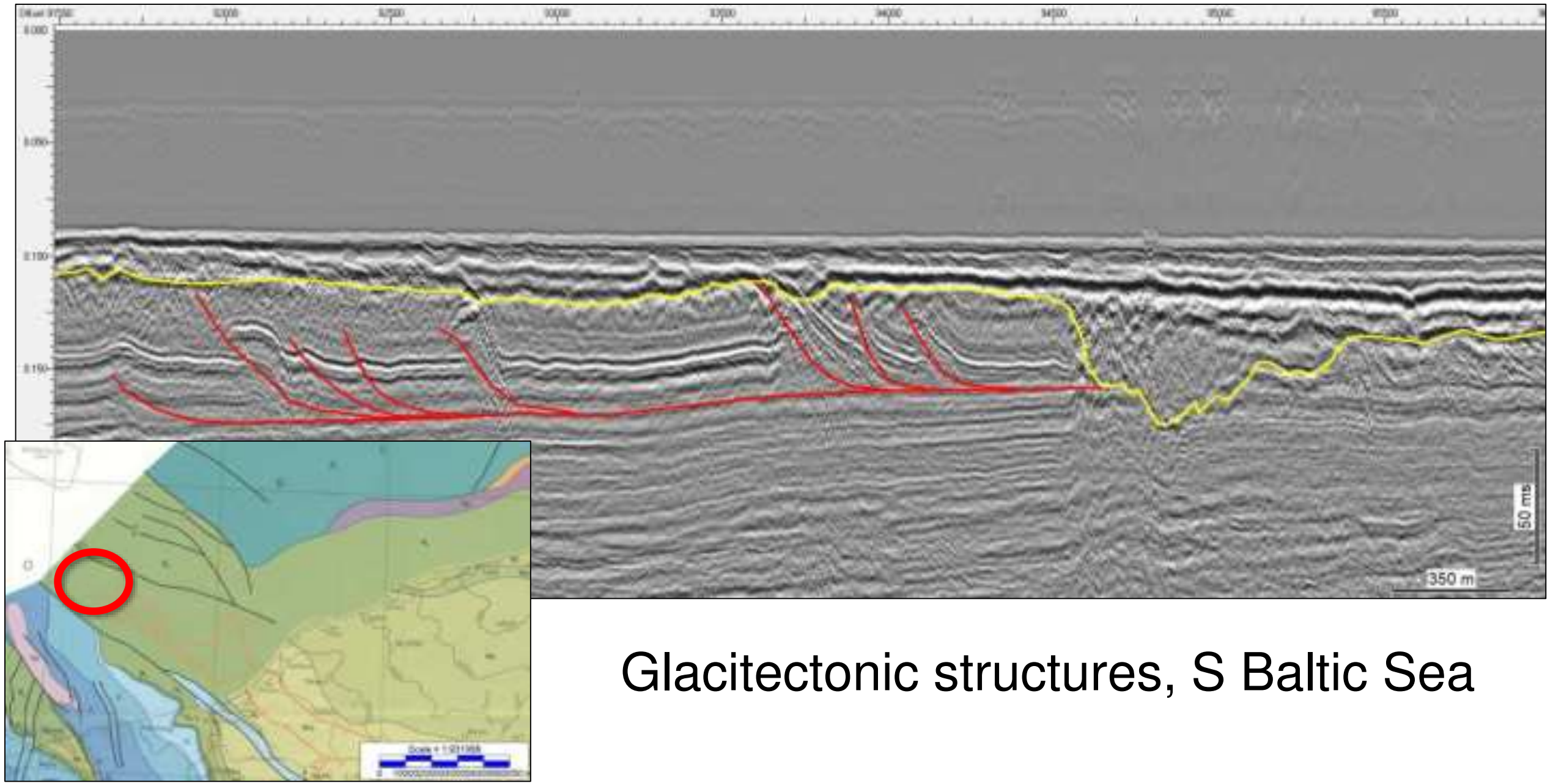
1. Seismic reflection studies – very short intro
2. Crustal-scale studies
3. Sedimentary basins and fold-and-thrust belts
4. Shallow subsurface

SHALLOW SUBSURFACE (ONSHORE)



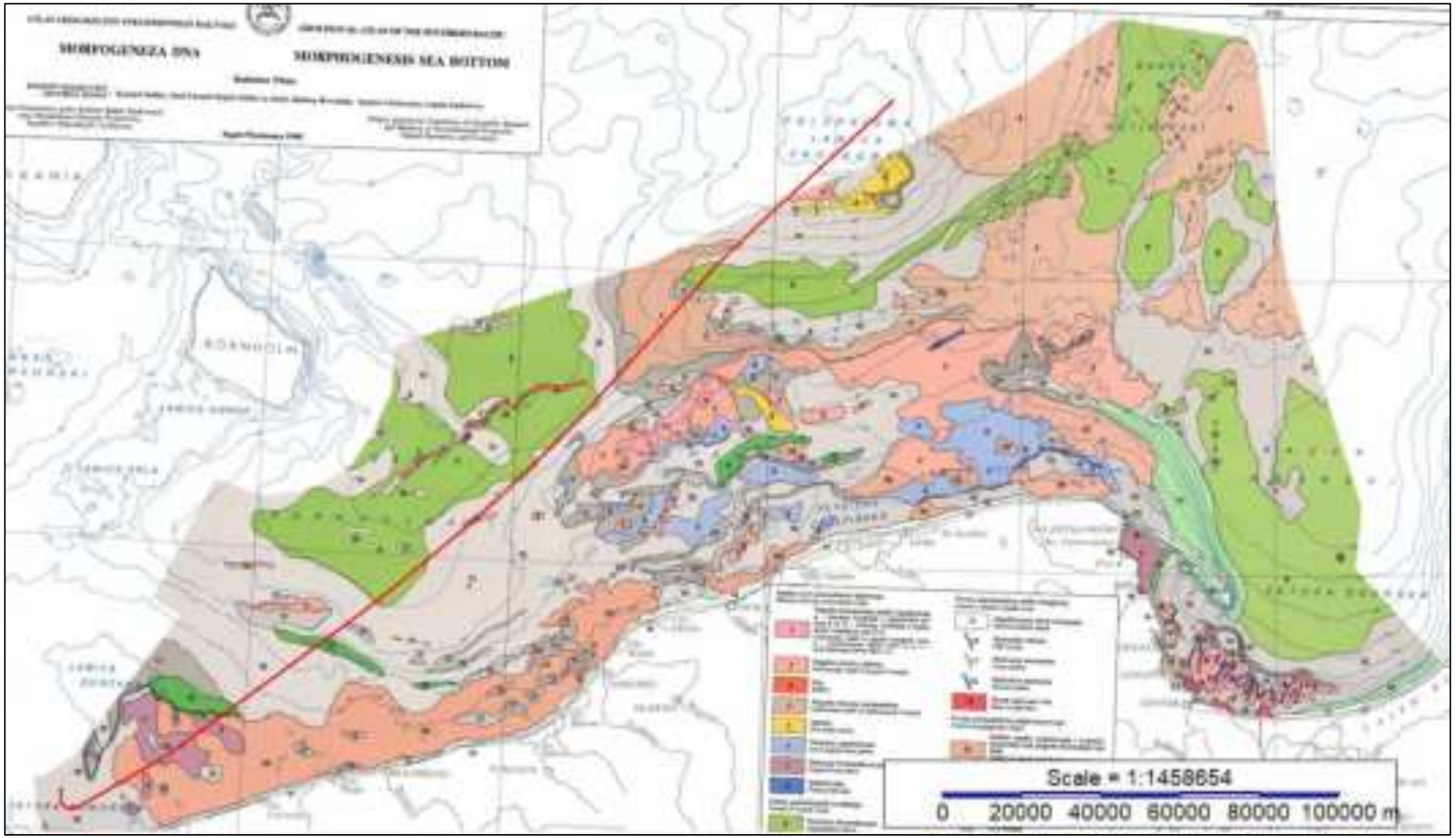
Cenozoic overburden of the **Damasławek salt diapir** is dissected by normal and reverse faults, some active in Pliocene – Quaternary -> very young tectonic activity. Studies of shallow tectonic zones are important for location of nuclear power plants, underground oil & gas storage, engineering works etc.

SHALLOW SUBSURFACE (OFFSHORE)



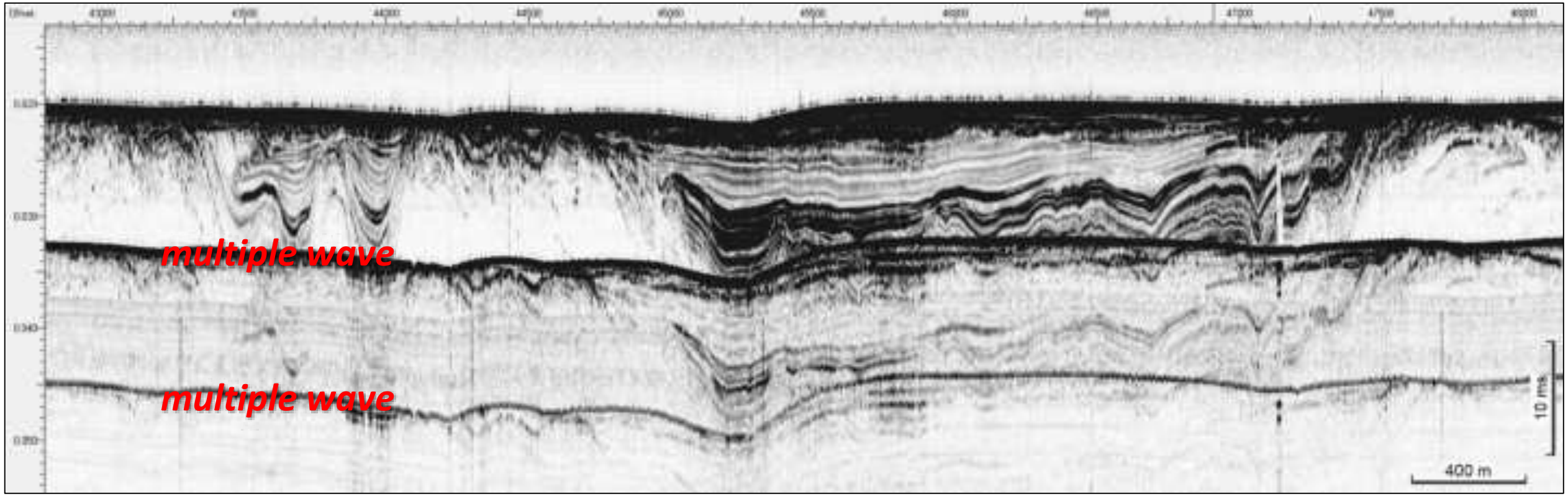
Glacitectonic structures, S Baltic Sea

SHALLOW SUBSURFACE (OFFSHORE)



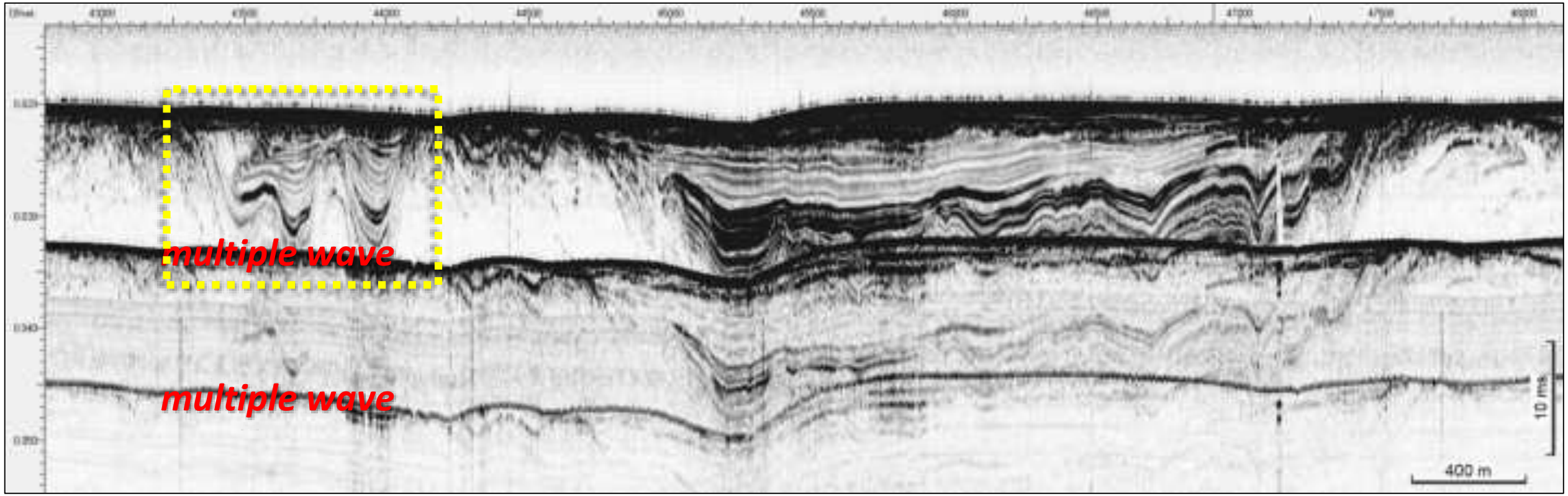
Regional, shallow, high-res profile – BalTec project (Institute of Geological Sciences PAS, Institute of Geophysics PAS, Polish Geological Institute, University of Hamburg)

SHALLOW SUBSURFACE (OFFSHORE)



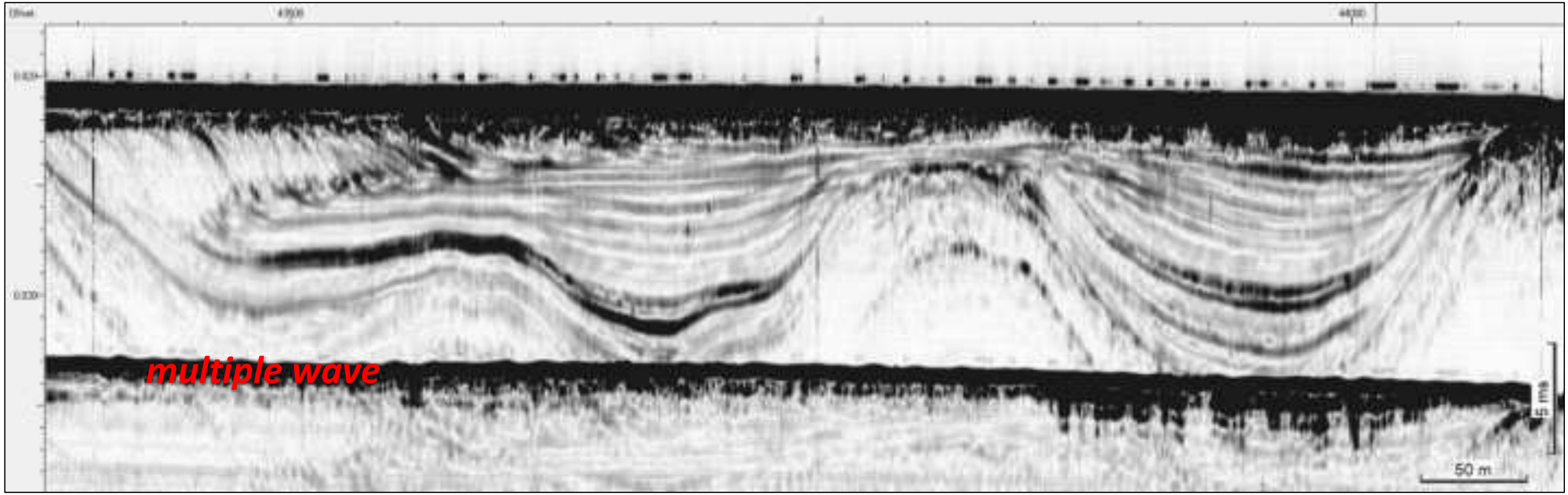
Morphological denivelations formed due to ice melting, filled by lake and swamp deposits. Results important for construction of offshore wind farms, pipelines etc.

SHALLOW SUBSURFACE (OFFSHORE)



Morphological denivelations formed due to ice melting, filled by lake and swamp deposits. Results important for construction of offshore wind farms, pipelines etc.

SHALLOW SUBSURFACE (OFFSHORE)



Morphological denivelations formed due to ice melting, filled by lake and swamp deposits. Results important for construction of offshore wind farms, pipelines etc.

THANK YOU FOR YOUR ATTENTION