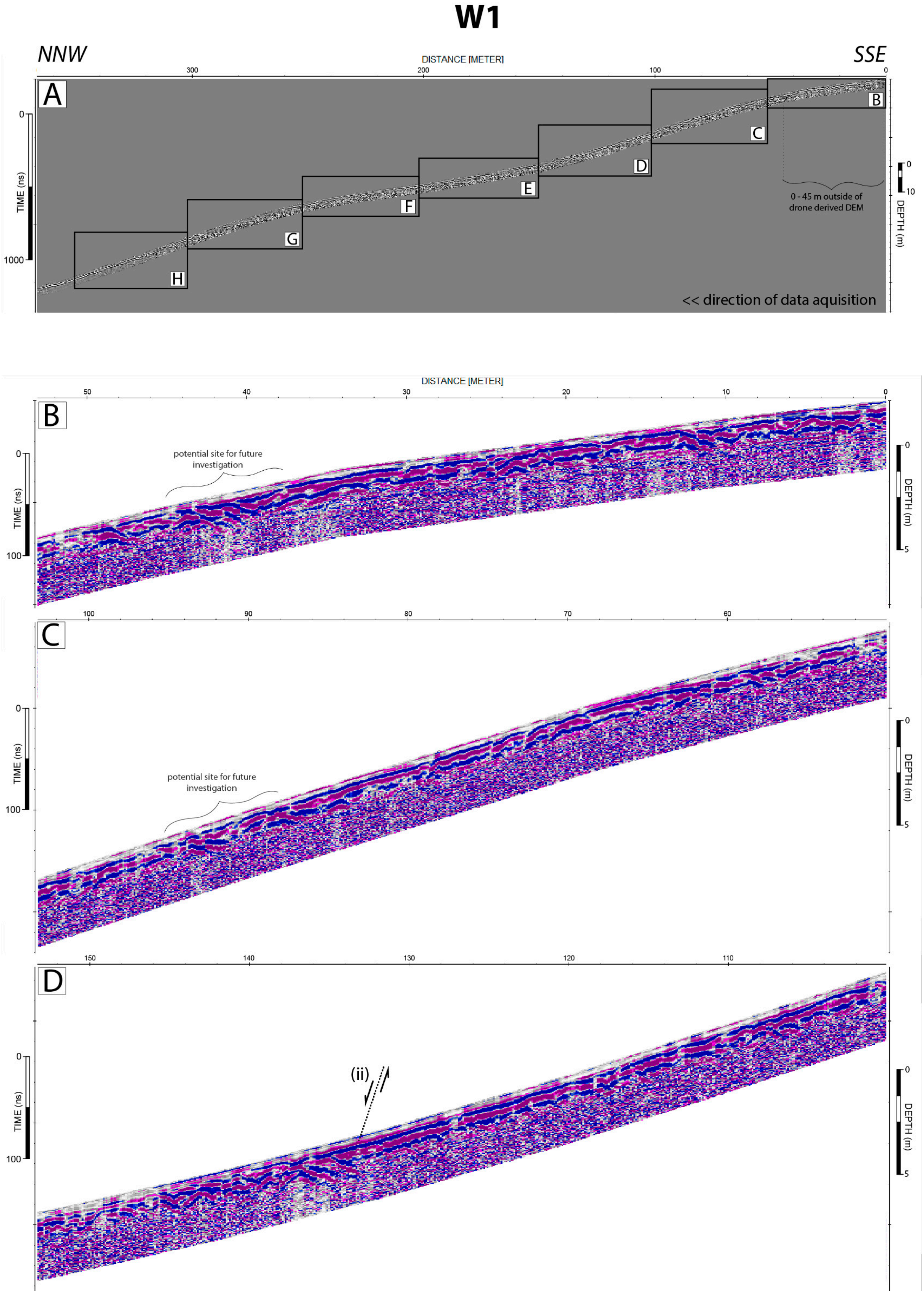
SUPPLEMENTARY MATERIALS

Interpreted Willunga transects, Figures S1 – S10


W1
NNW
SSE
DISTANCE [METER]
A
B
C
D
E
F
G
H
TIME (ns)
DEPTH (m)
0 - 45 m outside of drone derived DEM
<< direction of data aquisition
potential site for future investigation
(ii)

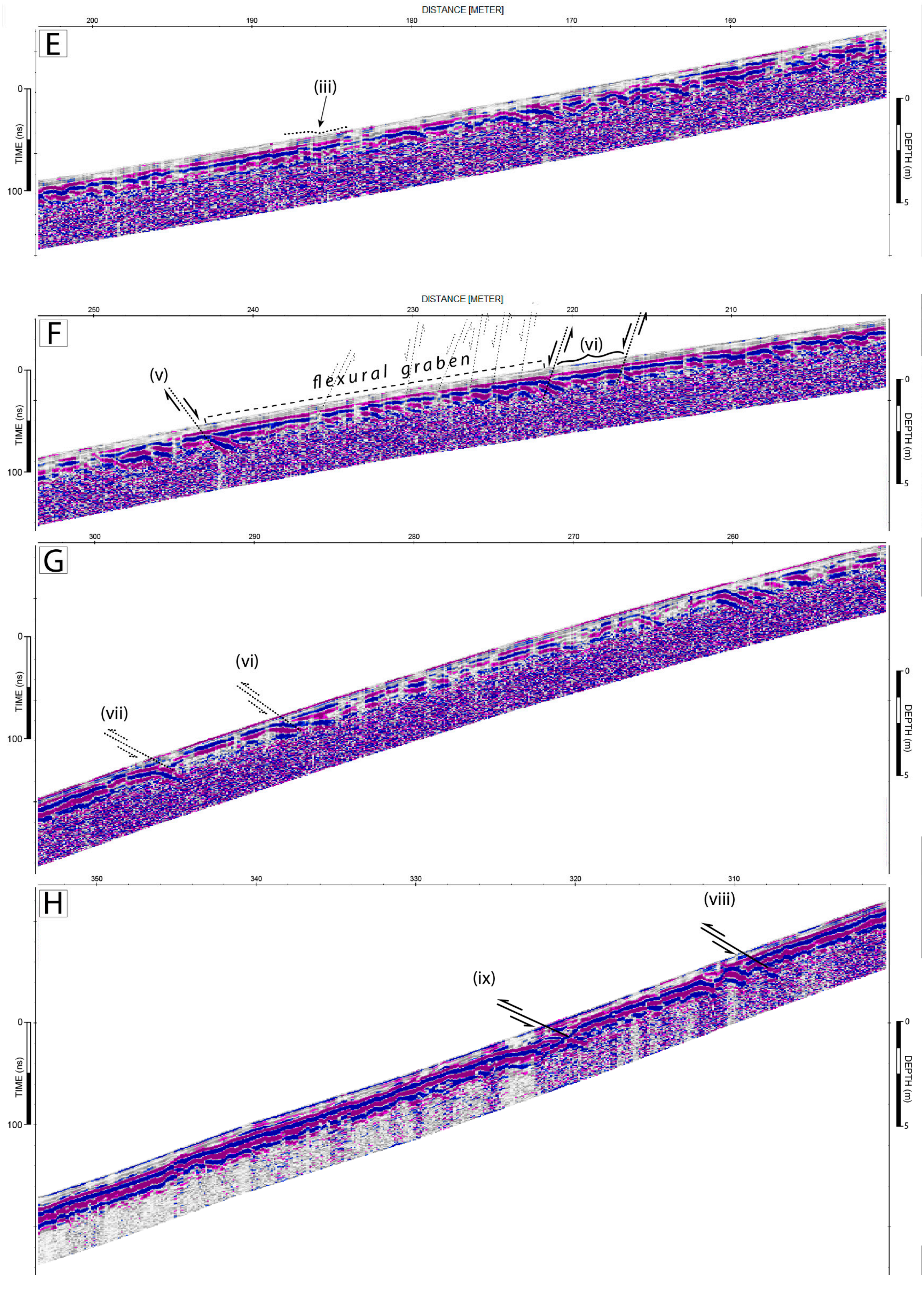

DISTANCE [METER]
200
190
180
170
160
E
(iii)
TIME (ns)
0
100
DEPTH (m)
0
5
DISTANCE [METER]
250
240
230
220
210
F
(v)
flexural graben
(vi)
TIME (ns)
0
100
DEPTH (m)
0
5
300
290
280
270
260
G
(vi)
(vii)
TIME (ns)
0
100
DEPTH (m)
0
5
350
340
330
320
310
H
(viii)
(ix)
TIME (ns)
0
100
DEPTH (m)
0
5

Figure S1 GPR transect W1;

(i) outside of drone derived high resolution DEM

(ii) transition from undisrupted to disrupted reflectors, incl. numerous hyperbolic diffractions, and thickening of reflector packages (~1 m to ~1.5 m) towards NNW, very subtle feature in DEM, as located on hangingwall of the Willunga fault normal faulting is expected due to flexure of the hangingwall.

(iii) feature projected from colinear features NE and SW of transect detected in DEM, but not obvious in GPR, topographic profiles parallel and ~20 m SW of GPR transect indicate surface undulation in the shape of the dotted black line.

(iv) two features visible in GPR involving disrupted/inclined reflectors and incremental thickening of reflector packages toward NNW (downslope). Previous remote DEM and field mapping revealed a single linear feature bounding a flexural graben, with the hangingwall in the NNW, i.e. representing a normal fault. The GPR data, however, implies that the previous single linear feature involves and is formed by at least two imbricate faults.

(v) local thickening of reflector package at location of inferred NW shoulder of flexural graben.

(vi) reflectors disrupted and inclined upslope, reflectors on SSE (upslope) side appear slightly folded, uplifted, and thinned, implying reverse faulting at this location. No clear linear feature in DEM, feature located at top edge of main scarp.

(vii) reflectors disrupted and inclined upslope, reflectors on SSE (upslope) side appear slightly folded, uplifted, and thinned, implying reverse faulting at this location. No clear linear feature in DEM, feature located at top edge of main scarp.

(viii) colinear with feature (ii) across line W2.

(ix) colinear with feature (i) across line W2.

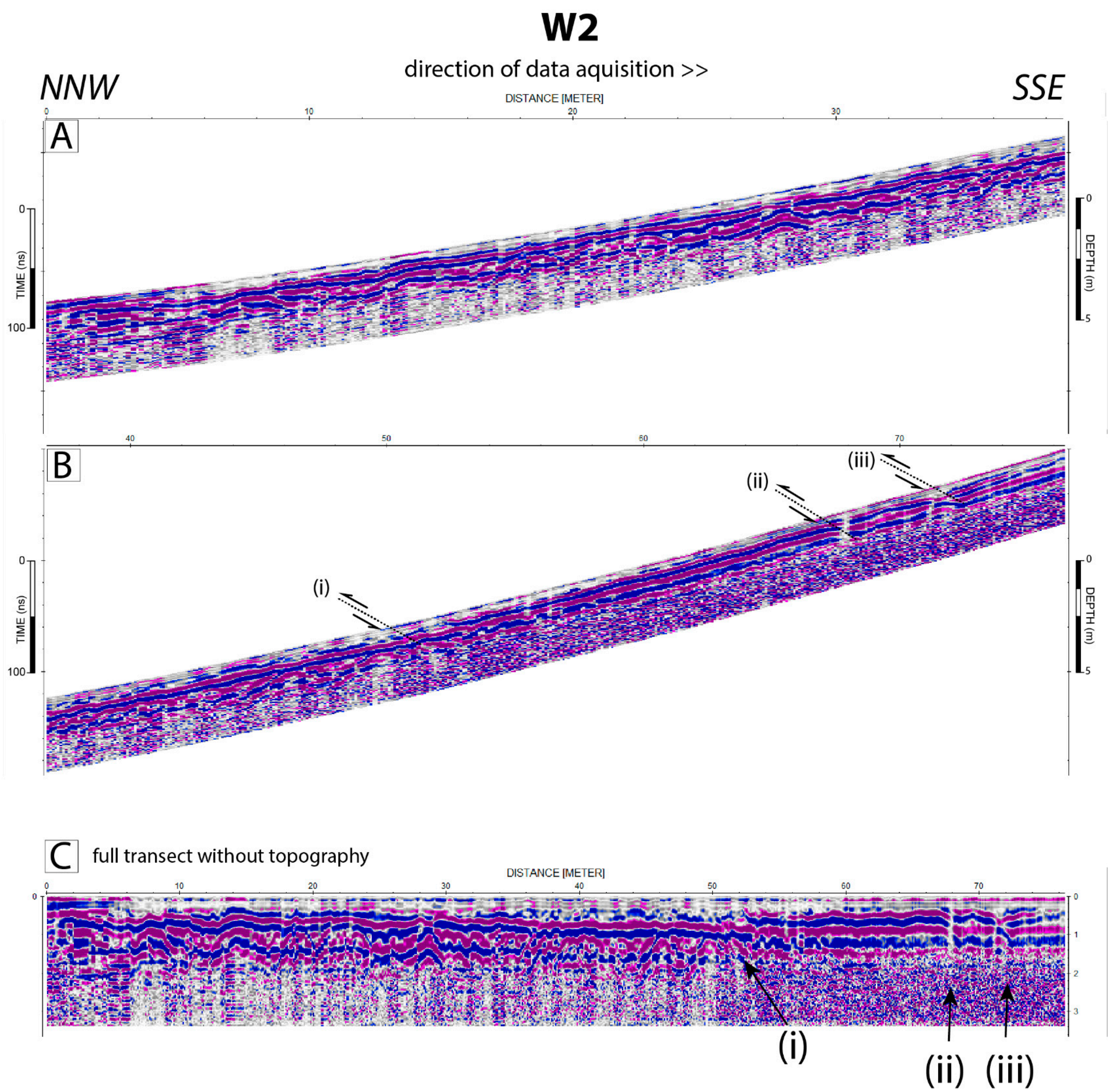


Figure S2 GPR transect W2;

(i) disruption and uplift of SSE side of reflector package best visible in (C). Slight thickening of reflector package on the footwall and folding of sediment on the hangingwall.

(ii) inclined/ disrupted reflectors correlate with feature (viii) identified along W1.

(iii) Zone with inclined/disrupted reflectors distinct from local trend, slight thinning of stratigraphy upslope (HW) of (iii).

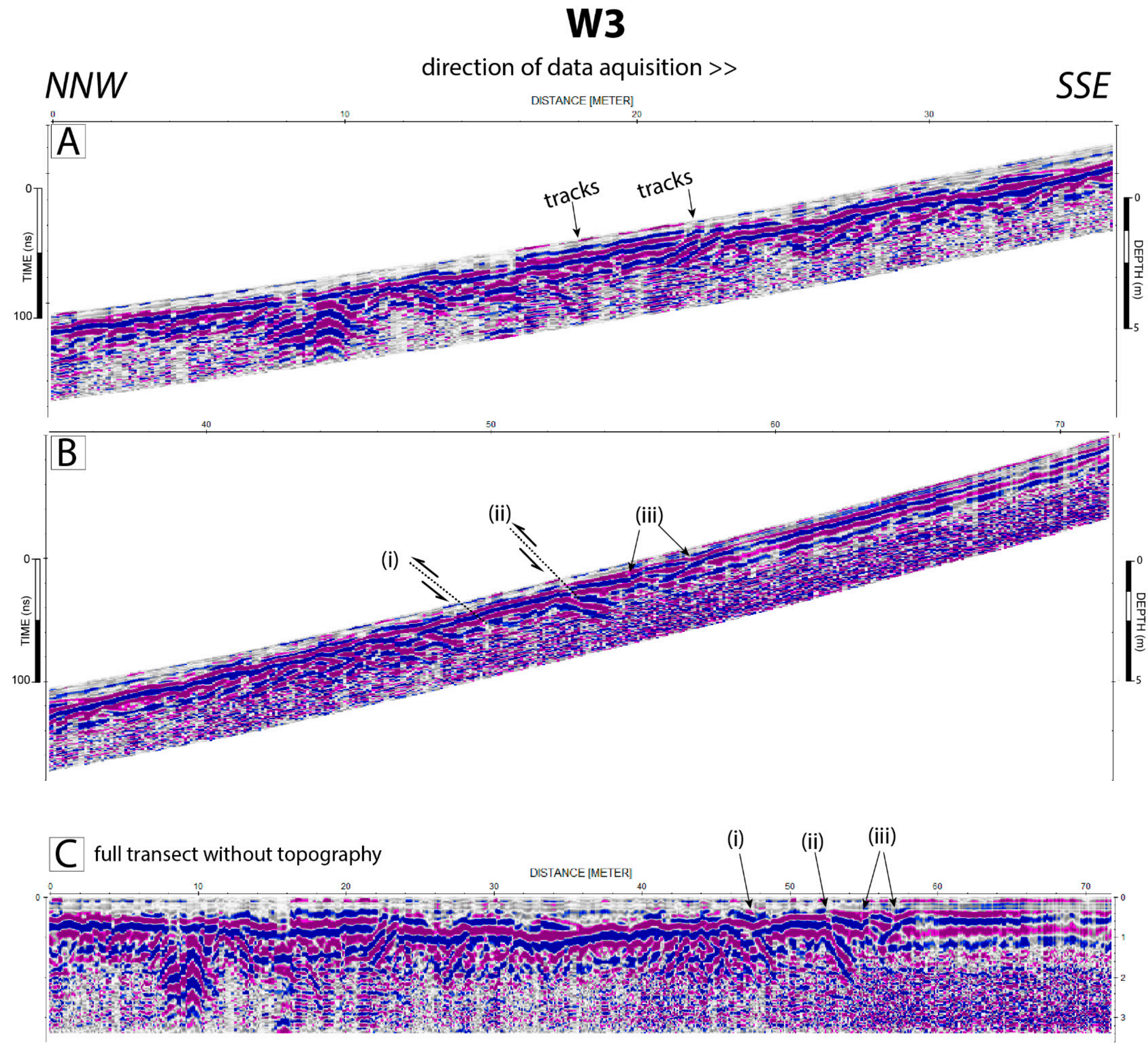


Figure S3 GPR transect W3;

(i) clear change in reflector package patterns from relatively undisturbed reflectors upslope to disturbed, thickening reflectors downslope

(ii) Zone with inclined reflectors distinct from local trend and extending to a depth of ~2m, inclined upslope direction, feature projects upward to surface scarp with subtle southeast side up, location collinear with feature (i) along W2

(iii) Zone of stratigraphic disturbance between (ii) and (iii)

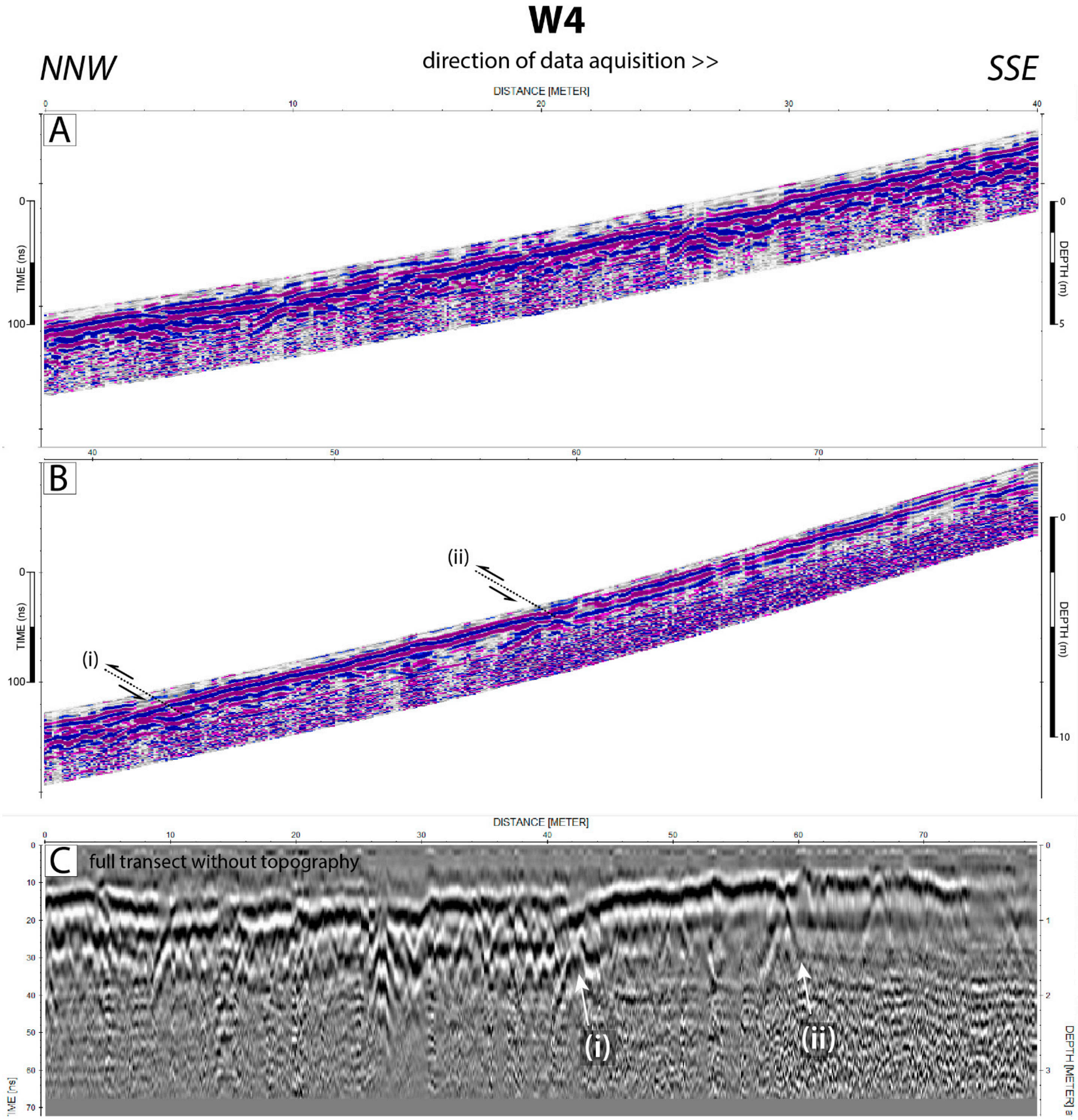


Figure S4 GPR transect W4;

(i) clear change in reflector package patterns from relatively undisturbed reflectors upslope to disturbed, thickening reflectors downslope

(ii) disruption of locally relatively undisturbed reflectors, indicated by hyperbolic diffraction and apparent folding on the hangingwall, colinear with features (ii) in W5 and W6.

Note: GPR transect proximate to dam, excavation of the latter may have a considerable impact on the subsurface features present in the GPR data

W5

direction of data aquisition >>

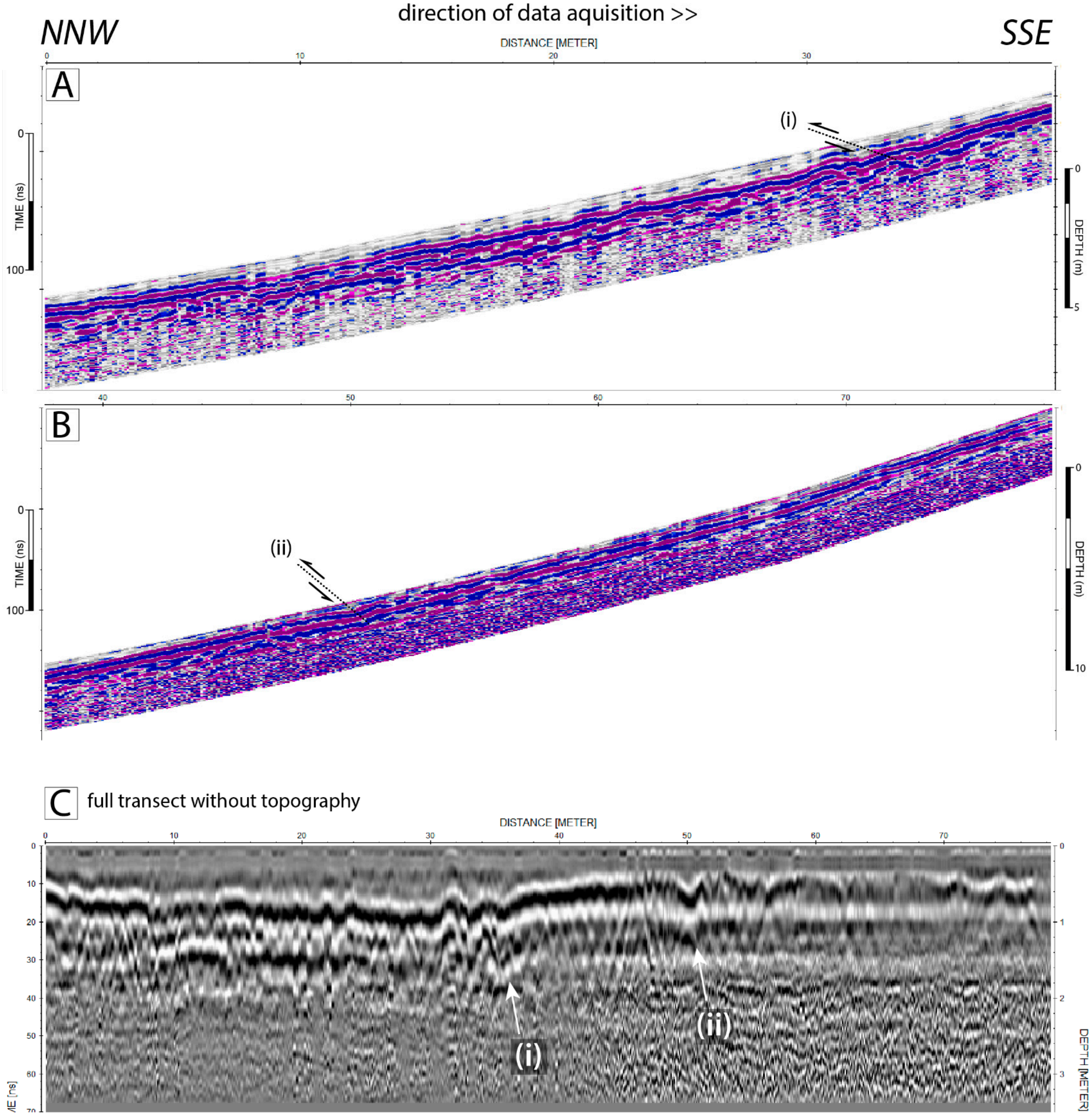


Figure S5 GPR transect W5;

(i) undulating reflectors at location of increasing penetration depth (i.e. 'thickening' of reflectors downslope) possibly indicating folding, feature colinear with features (i) at W3 and (i) at W4.

(ii) kinked and disrupted reflectors, slightly thickening downslope, location correlates with linear feature visible in DEM, also colinear with feature (ii) across line W4.

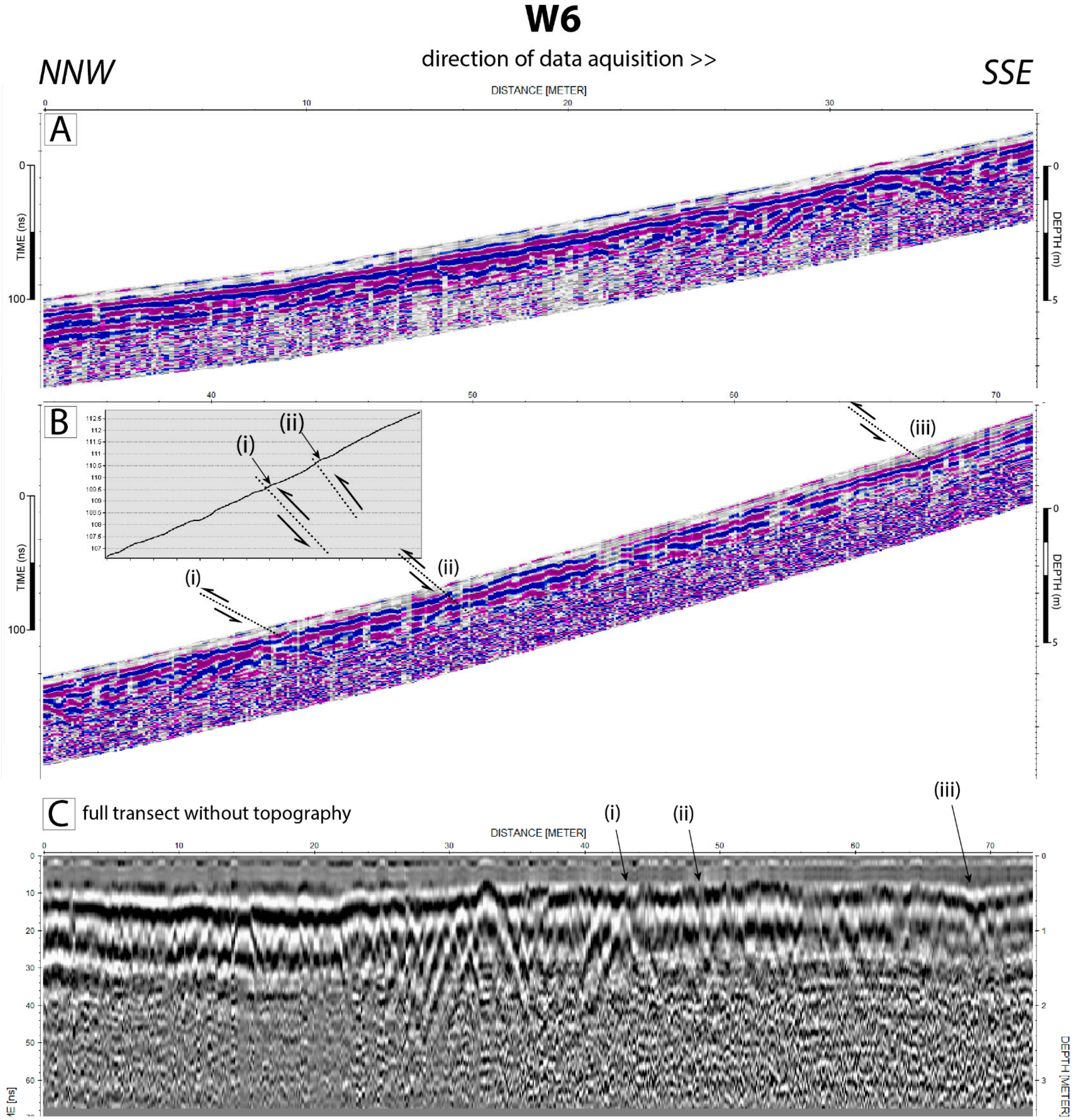


Figure S6 GPR transect W6;

(i) disrupted and thickening reflectors towards footwall, hangingwall undulation visible in DEM and topography and colinear with feature (ii) along W7 and (ix) along W8.

(ii) reflectors are kinked and undulating which likely indicates deformation of stratigraphy on the hangingwall. This is visible in the DEM and colinear with feature (ii) across W5 and W4, apparent localised thinning of reflectors.

(iii) reflectors are kinked and undulating which likely indicates deformation of stratigraphy on the hangingwall. colinear with feature (iii) along line W2 and with reverse fault observed in trench (1).

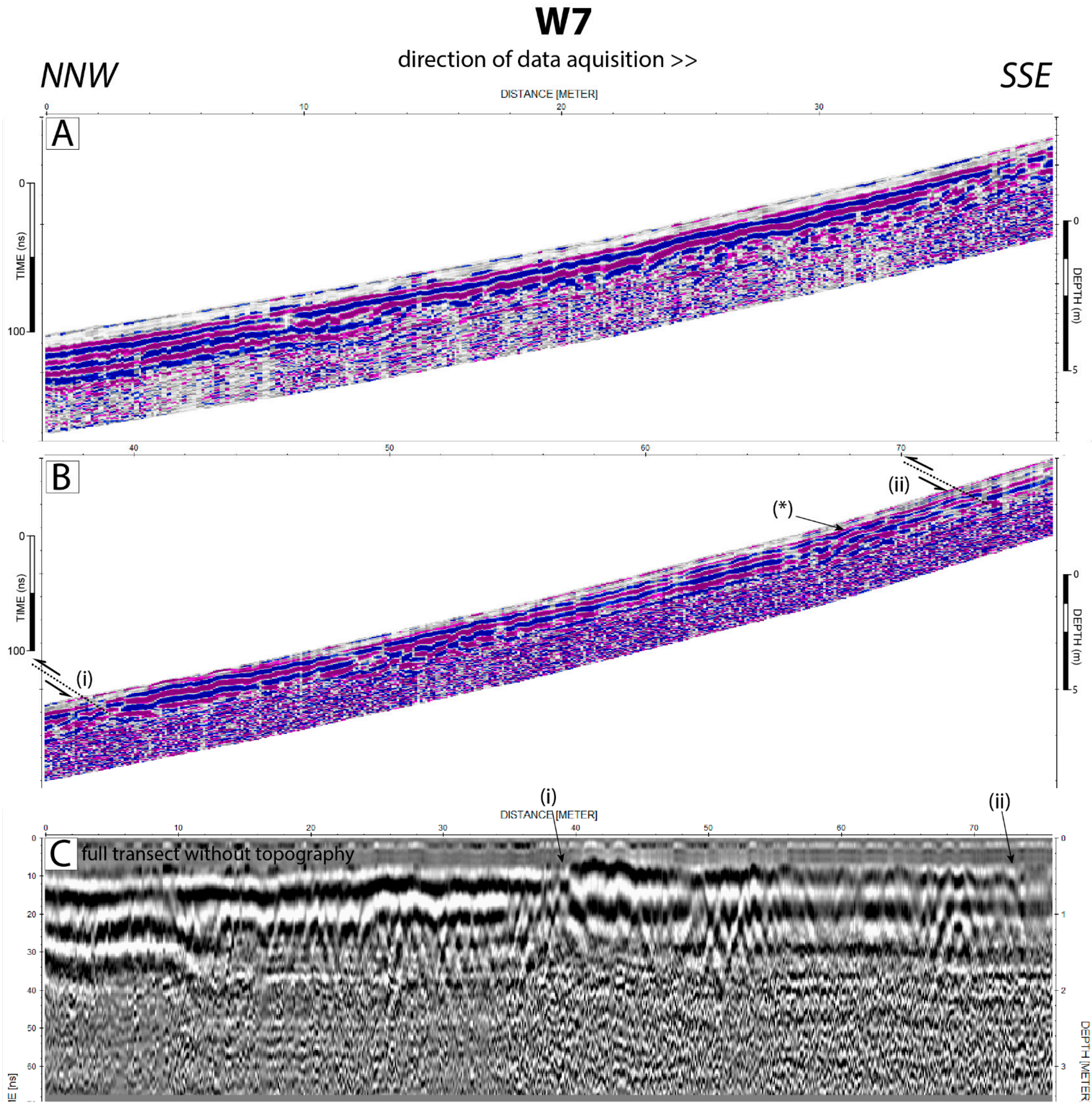


Figure S7 GPR transect W7;

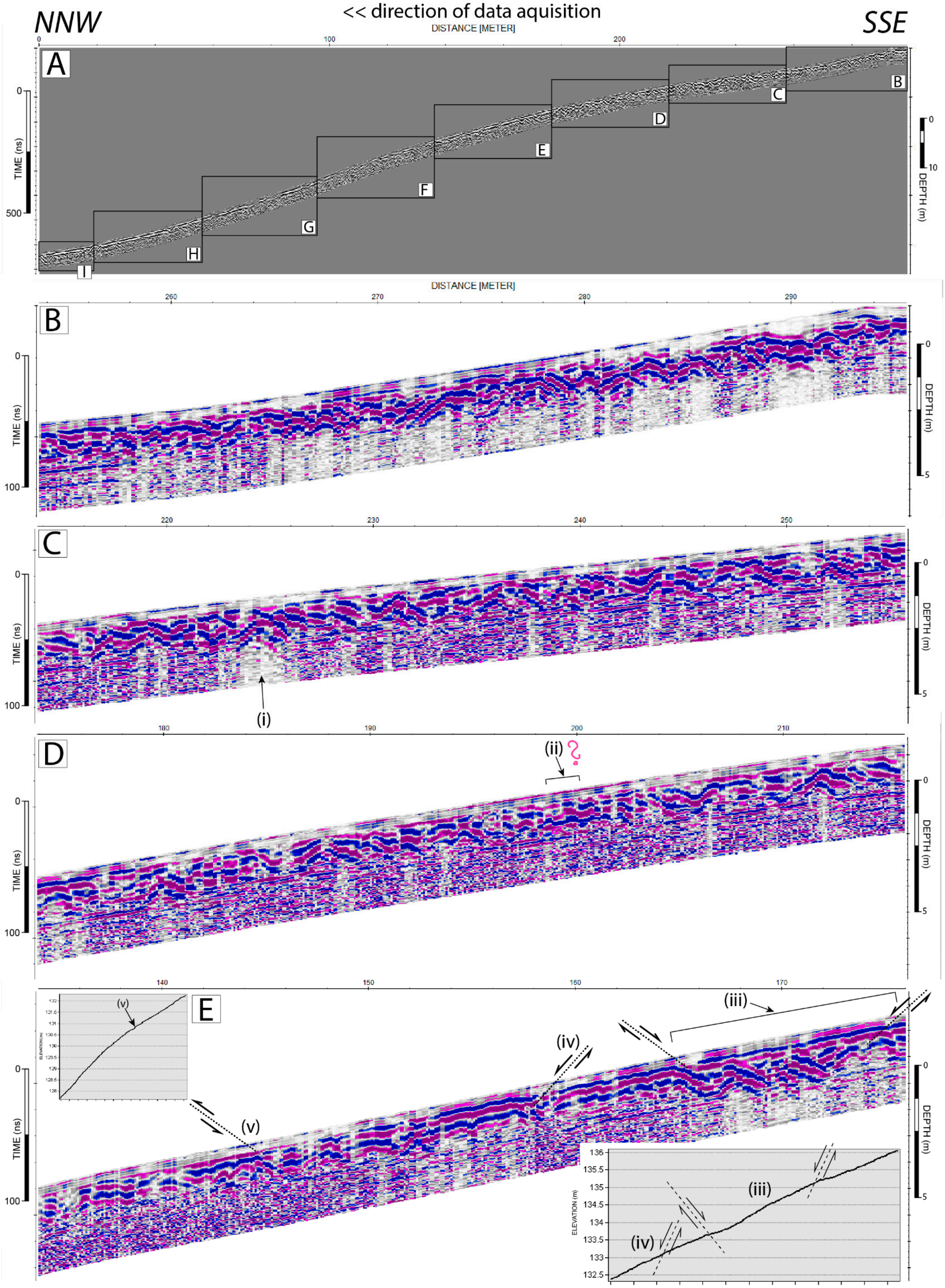
(i) zone of disrupted reflectors that aligns with feature (i) along W6 and thinning of reflectors. Transect without topography indicates uplift/folding of the hangingwall.

(ii) kinked and disrupted reflectors thickening towards footwall. Colinear with feature (iii) across line W6 and the observed reverse fault within proximate trench (1).

(*) inclined reflectors on the footwall of feature (ii) potentially image colluvial deposition

W8

<< direction of data aquisition



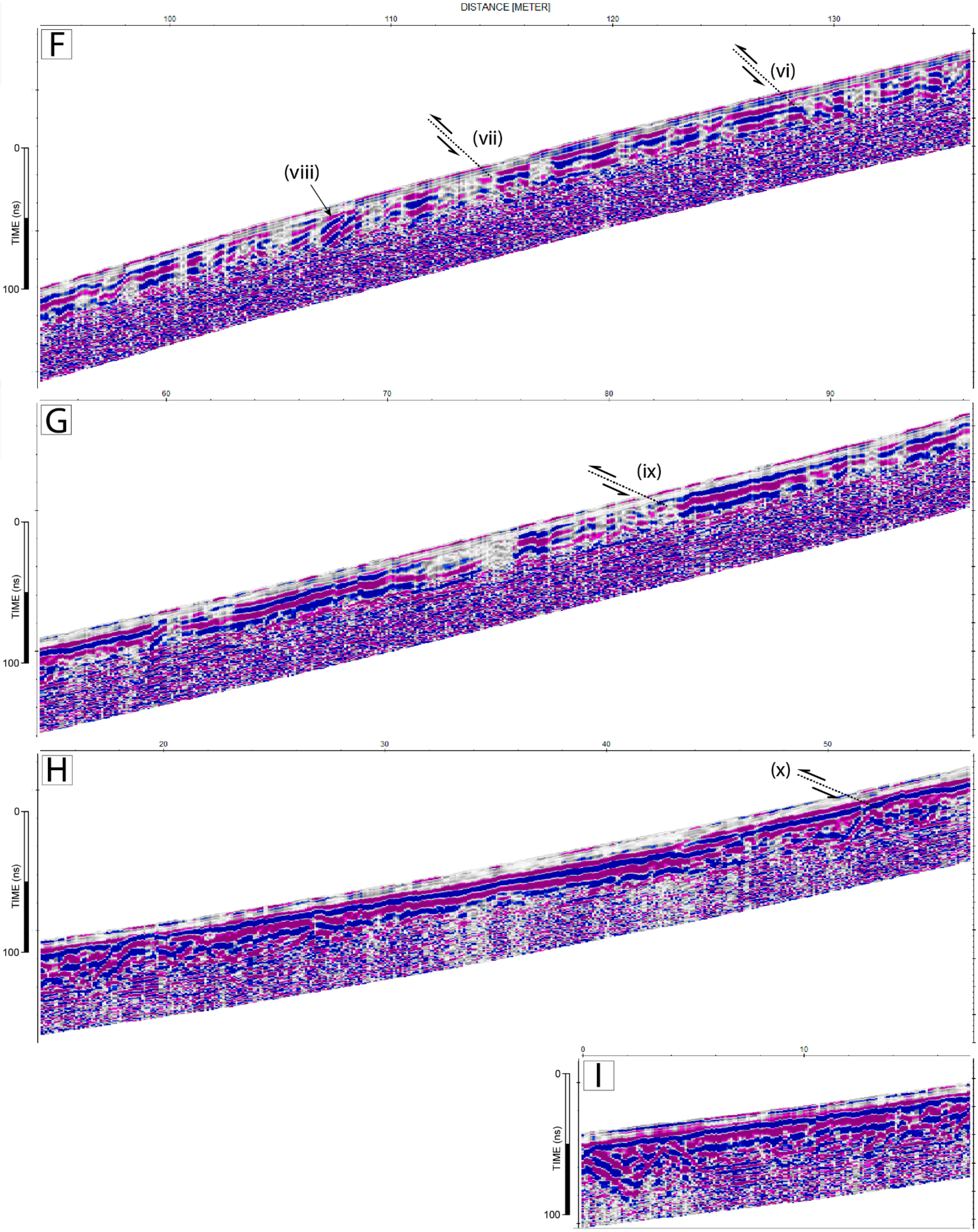

DISTANCE [METER]
F
G
H
I
TIME (ns)
DEPTH (m)
(vi)
(vii)
(viii)
(ix)
(x)

Figure S8 GPR transect W8;

(i) hyperbolic diffraction & 'trace gap' at depth coincides with north western-most ridge in a group of gentle ridges that are likely to be anthropogenic

(ii) possible linear feature mapped in DEM at approx. 199m potentially indicating normal faulting on the hanging wall. However, unclear in GPR

(iii) flexural graben clearly imaged by thickening and disturbed reflector package

(iv) kinked and disrupted reflectors on the hangingwall of the Willunga Fault possibly indicating normal faulting, a 'dip' is visible in DEM & topographic profile where the downthrown, i.e. the hangingwall of the normal fault would be expected.

(v) linear feature visible in DEM, possibly colinear with feature (v) across line W9. Small undulation visible in the topography where the possible upthrown side, i.e. the hangingwall of a potential reverse fault would be expected.

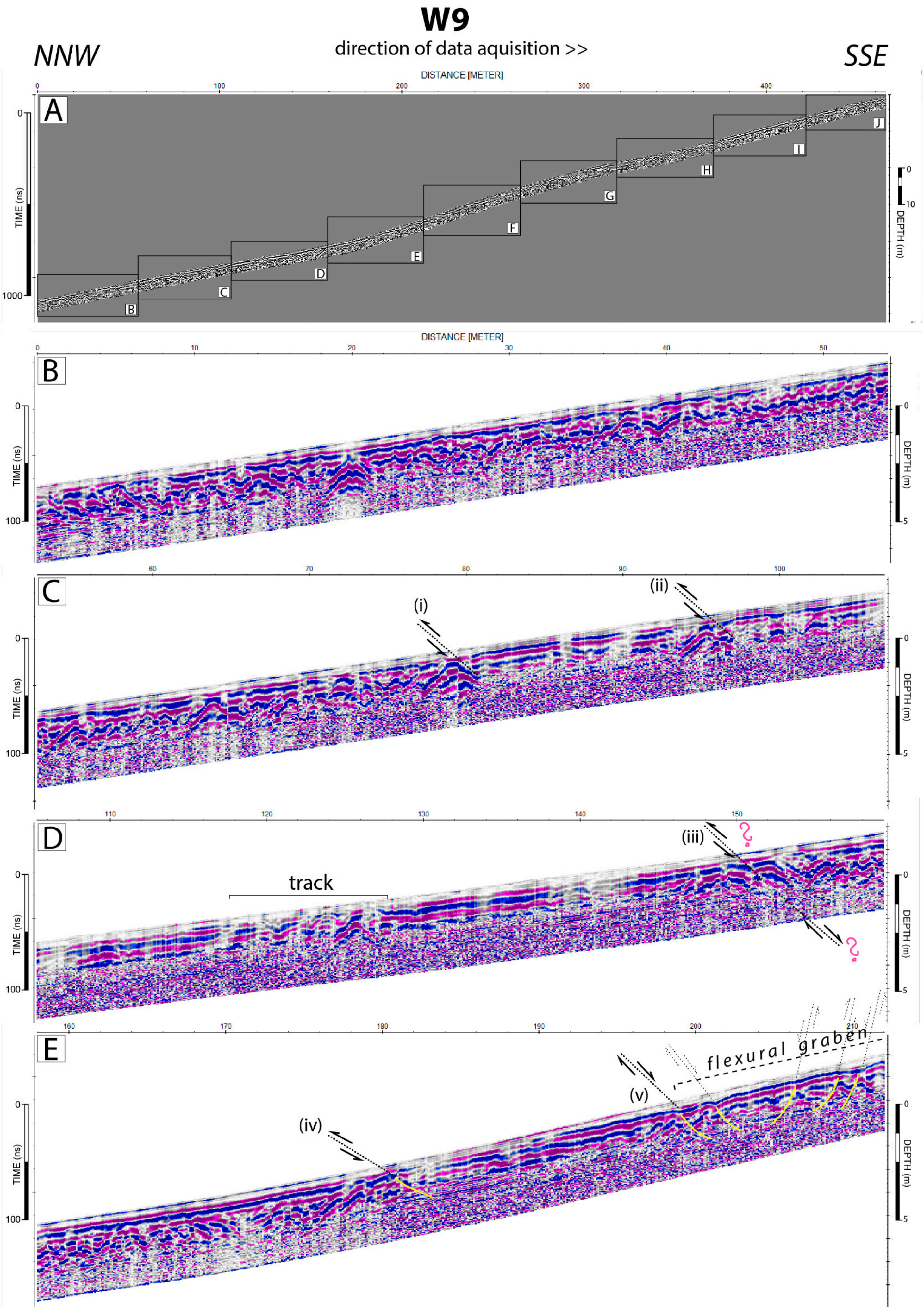
(vi) linear feature visible in DEM, and subtly expressed in GPR, reverse faulting may be indicated by reflectors on potential hangingwall being disturbed and forming a gentle anticline close to the potential fault plane, possibly colinear with (iv) along W9.

(vii) linear feature clearly visible in DEM, however no convincing evidence in GPR, subtle increase of penetration depth downslope may indicate reverse faulting, possibly colinear with (iv) along W9.

(viii) onlapping colluvium ???

(ix) where clear reflectors are disturbed by hyperbola towards NNW penetration depth increases. Although GPR data does not clearly resolve reverse faulting this location coincides with a reverse fault identified in proximate trench (1) to the NE, linear feature visible in DEM

(x) reverse faulting may be indicated by reflectors on potential hangingwall being disturbed and forming a gentle anticline close to the potential fault plane, slight thickening of reflectors on the footwall, colinear with feature (ii) along W4, W5 and W6.


W9
direction of data aquisition >>
NNW
SSE
DISTANCE [METER]
A
B
C
D
E
F
G
H
I
J
TIME (ns)
DEPTH (m)
(i)
(ii)
(iii)
track
(iv)
(v)
flexural graben

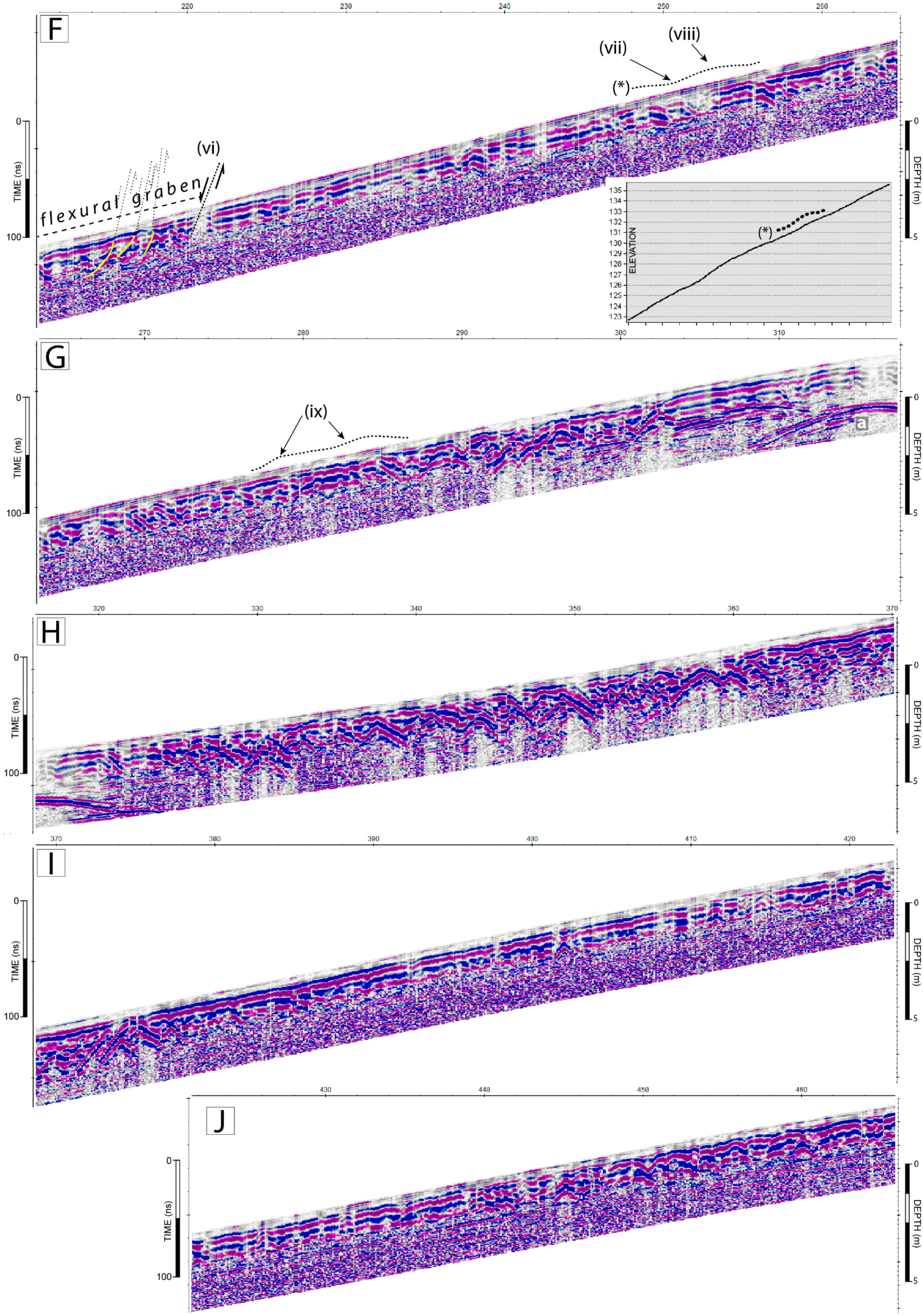

F
G
H
I
J
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
TIME (ns)
DEPTH (m)
0
100
5
(vi)
(vii)
(viii)
(*)
(ix)
flexural graben
ELEVATION
123
124
125
126
127
128
129
130
131
132
133
134
135
a

Figure S9 GPR transect W9;

(i) clear change in penetration depth and transition from undisturbed, however folded reflectors on the hangingwall and disturbed reflectors on the footwall. Feature not well resolved in DEM, however, colinear with interpreted features along other GPR transects (i.e. W3, W4, W5, W8).

(ii) zone of disturbance between ~93-97m, indicated by hyperbolic diffraction, and adjacent thinning of reflector packages <93m. Thinning downslope may indicate normal faulting, which is considered unlikely in this location at the bottom of the main Willunga scarp. Feature not well resolved in DEM, however, may correlate with interpreted features along other GPR transects (i.e. W6, W7, W8) and is therefore considered reverse.

(iii) clear change in penetration depth in GPR data upslope implying normal faulting. However, kinematics not clear, feature may link up with either interpreted reverse or normal fault across line W10 (features x and xi).

(iv) feature well supported by GPR data through transition from mostly undisturbed (upslope) to disturbed and thickening reflectors (downslope) and alignment with direction-change in the adjacent creek bed (creek bed exploits weak zone). Most likely extension of reverse fault observed in trench (2). Projection of this feature across the adjacent creek bed may link up with one of two potential reverse faults (see line W8).

(v) zone of disturbed reflectors indicating a slight increase in penetration depth (upslope towards SSE) and collinearity with NW shoulder of flexural graben, indicated by DEM and feature (viii) across line W10 imply normal faulting. Like (iv) this feature may still be considered to align with direction-change in the adjacent creek bed (creek bed exploits weak zone).

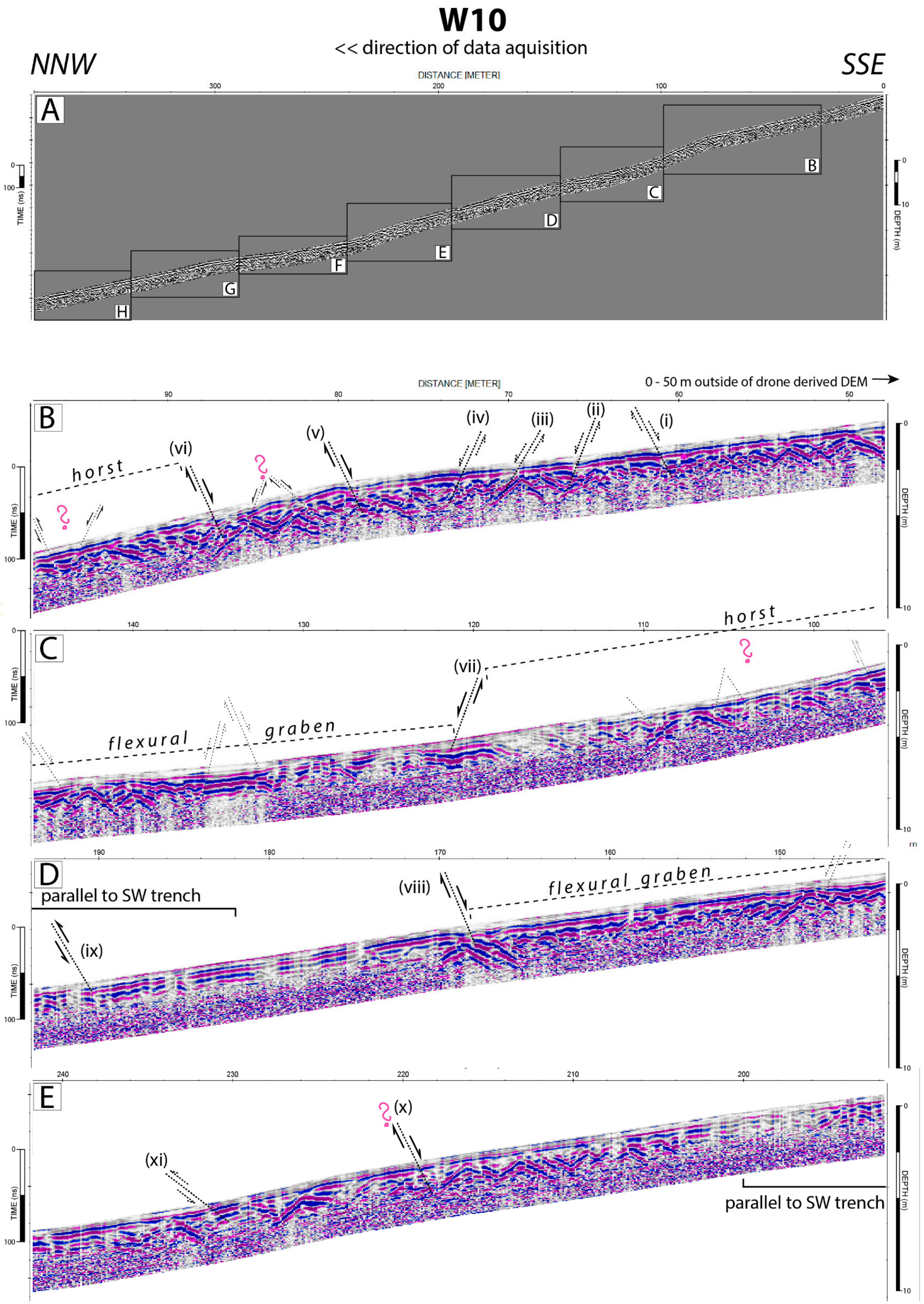
(vi) normal faulting at SE shoulder of flexural hangingwall graben supported by observations in proximate trench, GPR data and morphology. The graben is most likely sub-structured by additional normal faults, as marked in the GPR data, however these are not visible in the DEM.

(vii) expressed in GPR as disrupted, blurred zone of reflectors bound by inclined reflector that dip towards the feature, apparently forming a depression, visible in DEM

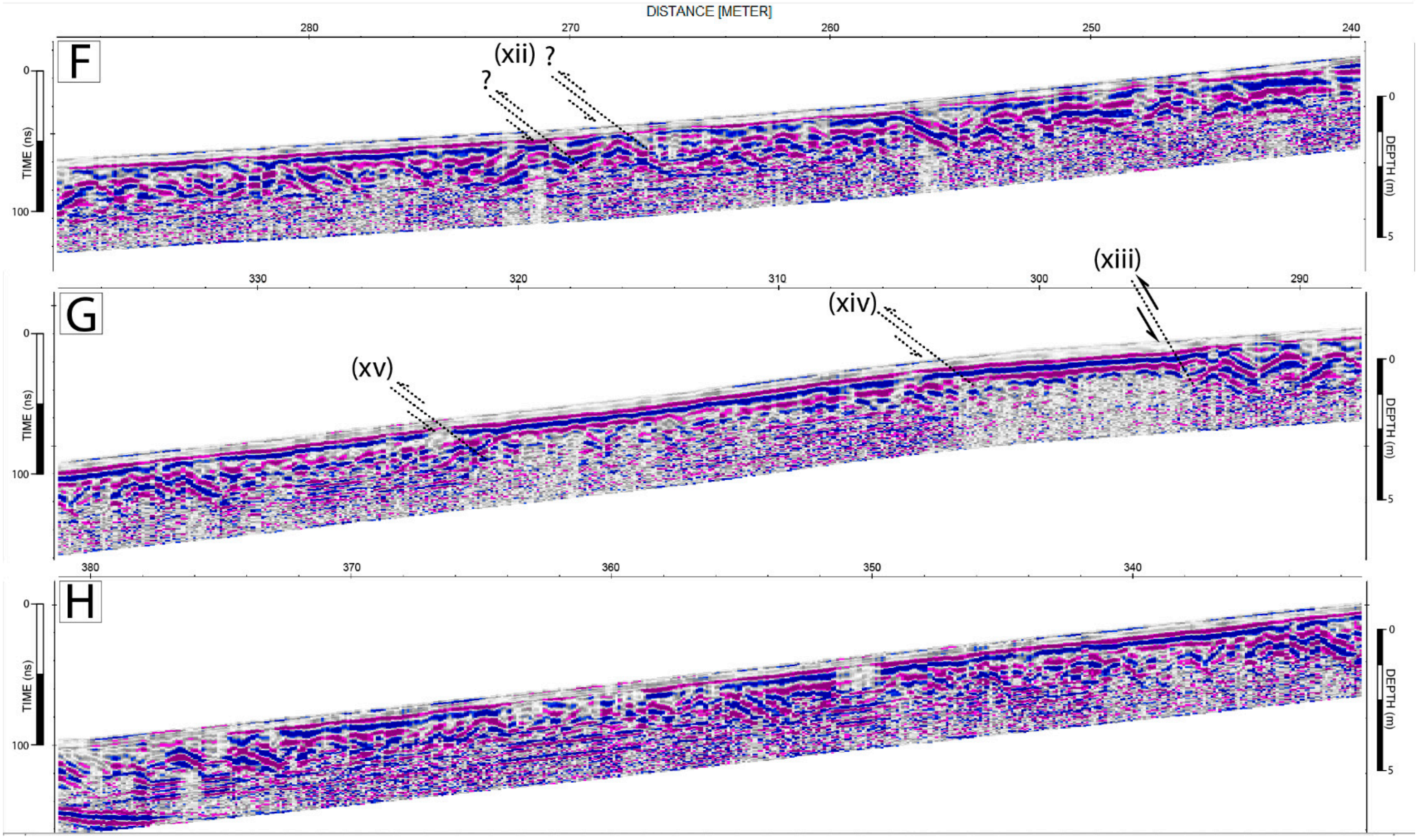
(viii) feature slightly elevated in relation to (vii) with clear, kinked reflectors that appear to form an anticline, visible in DEM

(ix) reflectors appear folded, marked small anticlines visible as ridges in DEM

a = wide hyperbolas imaging airwave reflections from trees



W10
<< direction of data aquisition
NNW
SSE
DISTANCE [METER]
A
B
C
D
E
F
G
H
TIME (ns)
DEPTH (m)
0 - 50 m outside of drone derived DEM
horst
flexural graben
parallel to SW trench
(i)
(ii)
(iii)
(iv)
(v)
(vi)
(vii)
(viii)
(ix)
(x)
(xi)



DISTANCE [METER]
280
270
260
250
240
F
(xii) ?
?
TIME (ns)
DEPTH (m)
0
100
5
330
320
310
300
290
G
(xiii)
(xiv)
(xv)
380
370
360
350
340
H

Figure S10 GPR transect W10;

(i), **(ii), (iii) & (iv)** interpreted features in zone of stratigraphic disturbance imaged by hyperbolic diffractions, visible in DEM as faint linear shades, uppermost horizontal reflectors kinked, where features are interpreted.

(v) disturbed reflectors, local thinning and apparent folding of reflector package on the NNW side of the feature implies normal faulting. Due to location on the hangingwall of the Willunga fault and proximity to other interpreted normal faults feature (v) is likely to represent another flexural hangingwall sub-strucutre.

(vi) SSE shoulder of horst structure clearly visible in DEM and slight thickening of reflector packages on the SSE side of the feature, i.e. the hangingwall. Potential sub-structures within the horst indicated by dotted fault movement indicators between features (vi) and (vii).

(vii) NNW shoulder of horst structure/ SSE shoulder of flexural graben clearly visible in DEM and indicated in the GPR data by kinked reflectors, which appear folded on the upthrown side of the feature. Projection of the feature observed in trench (3) and along W9, feature (vi)

(viii) normal faulting at NW shoulder of flexural hangingwall graben, indicated by hyperbolic diffractions and thickening of reflector packages on the SE side of the feature, i.e. the hanginwall. colinear with feature (v) along W9. The graben is most likely sub-structured by additional normal faults, as marked in the GPR data, however these are not visible in the DEM.

(ix) feature mainly interpreted from observed reverse fault in proximate trench (2), GPR data indicated thickening and disturbance of reflectors package on the downthrown, i.e. The footwall of the interpreted reverse fault.,

(x) feature clearly visible in DEM, however not clearly resolved in GPR, the upthrown block, i.e. the footwall appears slightly uplifted and the reflector package is slightly thinned compared to the hangingwall

(xi) Previous remote and field mapping of potential reverse fault at this location correlates with marked feature in GPR: reflectors are disrupted and folded, with the uplifted side in the SSE of the interpreted fault plane.

(xii) Previous remote and field mapping of potential reverse fault at this location correlates approximately with marked features in GPR: reflectors are disrupted and folded, with the uplifted side in the SSE of the interpreted fault planes. Due to the subtle and broad (~2 m) morphology of this feature it remains unclear whether one, or both features in the GPR data can be correlated with the remotely mapped structure.

(xiii) Previous remote and field mapping of potential reverse fault at this location correlates with marked feature in GPR: reflectors appear folded and uplifted on the SSE side of the interpreted fault plane. However, change in penetration depths, i.e. thickness of reflector packages decreases on the potential footwall, although the opposite would be expected for reverse deformation as indicated.

(xiv) zone of disrupted reflectors approximately colinear with feature (i) observed across line W9 and interpreted as reverse faulting. Reflector packages appear to thicken slightly downslope.

(xv) disruption and thickening of reflectors downslope approximately colinear with features observed across lines W6, W7, W8.

a = wide hyperbolas imaging airwave reflections from trees