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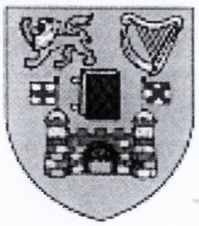
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MESOZOIC-TERTIARY TECTONICS OF SE IRELAND AND GENETIC LINK TO OFFSHORE EXTENSIONAL BASINS

Volume 3 of 3

By

Michael J. M. Cunningham

Submitted to the University of Dublin for the degree Doctor of Philosophy

November 2000

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VOLUME 3

Title Page

Chapter 6

Figure 6.1:- Regional LANDSAT draped over DEM.

Figure 6.2:- Corine image and lineaments.

Figure 6.3:- Regional HIS image.

Figure 6.4:- Regional LANDSAT lineament.

Figure 6.5:- Regional rose-diagram.

Figure 6.6:- Sub-cell rose diagram and faults.

Figure 6.7:- Entropy and faults.

Figure 6.8:- Intersection density and faults.

Figure 6.9:- Length density and faults.

Figure 6.10:- Lineament spacing and faults.

Figure 6.11a:- Landsat of Vartry area.

Figure 6.11b:- Landsat & DEM – facing NE.

Figure 6.11c:- Landsat & DEM – facing W.

Figure 6.12a:- Principal components analysis – Vartry area.

Figure 6.12b:- NE-SW spatial filter – Vartry area.

Figure 6.12c:- NW-SE spatial filter – Vartry area.

Figure 6.12d:- N-S spatial filter – Vartry area.

Figure 6.13a:- Landsat lineament.

Figure 6.13b:- Sub-Rose diagrams with faults – Vartry.

Figure 6.14:- Lineament direction, faults, geology – Vartry.

Figure 6.15a:- Landsat of Bunclody area.

Figure 6.15b:- Landsat & DEM – facing NNE.

Figure 6.15c:- Landsat & DEM – facing N.

Figure 6.16a:- Principal components analysis - Bunclody area.

Figure 6.16b:- NE-SW spatial filter - Bunclody area.

Figure 6.16c:- NW-SE spatial filter - Bunclody area.

Figure 6.16d:- N-S spatial filter - Bunclody area.

Figure 6.17a:- Landsat lineament - Bunclody area.

Figure 6.17b:- Sub-cell rose diagram with faults – Bunclody.

Figure 6.18:- Lineament direction, faults, geology – Bunclody.

Figure 6.19a:- Landsat of Glen of Imail area.

Figure 6.19b:- Landsat & DEM – facing NNE.

Figure 6.19c:- Landsat & DEM – facing N.

Figure 6.20a:- Principal components analysis – Glen of Imail.

Figure 6.20b:- NE-SW spatial filter – Glen of Imail.

Figure 6.20c:- NW-SE spatial filter – Glen of Imail.

Figure 6.20d:- N-S spatial filter – Glen of Imail.

Figure 6.21a:- Landsat lineament – Glen of Imail.

Figure 6.21b:- Rose diagram with faults – Glen of Imail.

Figure 6.22:- Lineament direction, faults, geology – Glen of Imail.

Chapter 7

Figure 7.1:- Diagram showing four simple thermal histories.

Figure 7.2:- Simple diagram showing concept of an exhumed partial annealing zone (PAZ).

Figure 7.3:- Map showing location of TULIP AFT samples.

Figure 7.4a,b:- Plots of AFT 'Central Age', 'Elevation' and MTL.

Figure 7.5:- Topographic image of the Wicklow Massif.

Figure 7.6:- Geological profile with AFT samples.

Figure 7.7:- Plot of central age against elevation.

Figure 7.8a,b:- Maps of a) vitrinite reflectance and b) derived palaeotemperature.

Figure 7.9:- Thermal modelling of AFT profile samples.

Figure 7.10:- Map showing AFT study of Keeley *et al.*, (1993) in SE Ireland.

Figure 7.11:- Profile showing modelled values of Tertiary denudation.

Chapter 8

Figure 8.1:- TULIP AFT database.

Figure 8.2:- Conceptual Model of Horsetail terminations.

Figure 8.3a,b:- Maps of Ireland showing a) AFT central age, and b) MTL.

Figure 8.4:- Plot of Elevation against AFT Central Age for Connemara.

Figure 8.5a,b:- Thermal modelled histories of TULIP samples.

Figure 8.6:- Duration that AFT samples were in the PAZ.

Figure 8.7:- Early Tertiary palaeotemperatures.

Figure 8.8a,b:- Denudation for Triassic to upper Lower Jurassic.

Figure 8.9:- Denudation for Early Cretaceous.

Figure 8.10:- Denudation for Palaeogene.

Figure 8.11:- Denudation for Neogene.

Figure 8.12:- Regional map of Porcupine basin and adjacent areas.

Figure 8.13:- Location map of seismic lines and wells.

Figure 8.14:- Regional E-W geoseismic interpretation showing typical steer's head profile.

Figure 8.15:- Tertiary isopach map of the Main Porcupine basin.

Figure 8.16:- Aeromagnetic anomaly map of the Porcupine basin.

Figure 8.17:- Fault styles in Porcupine Basin.

Figure 8.18:- Total Tertiary denudation based on AFT modelling.

Figure 8.19a,b:- Denudation rate and volumetric discharge for Ireland since the Triassic.

Figure 8.20:- DEM of Ireland at 1km cell resolution.

Figure 8.21:- Palaeotopography without eustacy.

Figure 8.22:- Palaeotopography with eustacy.

List of Plates

Chapter 1

Plate 1.1:- Tertiary Basalts overlying karstified Cretaceous surface.

Chapter 3

Plate 3.1:- View of Dalkey Quarry (facing NNW).

Plate 3.2:- Breccia on coast (Blackrock).

Plate 3.3:-Sigmoidal deformation of shear plane.

Plate 3.4:- S-C fabrics – locality 3 (Killiney Bay).

Plate 3.5:- Dextral reverse fish – locality 2 (semi-vertical face, viewed from NE).

Plate 3.6:- Reverse fish – locality 1.

Plate 3.7:- Tectonic fish with component of dextral shear (low vorticity, locality 2, near Bullock Harbour).

Plate 3.8:- Foliation and 'fish' – locality 2.

Plate 3.9:- Fault breccia-cataclasite – locality 1 (Seapoint).

Plate 3.10:- Slickenlines – locality 2 (Sandycove).

Plate 3.11:- Pegmatite sill intruding granite (locality 2).

Plate 3.12:- Sigmoidal drag fold (locality 1).

Plate 3.13:- Sandycove coastal exposures.

Plate 3.14:- Locality 2 (viewed from the east).

Plate 3.15:- Sandycove storm-drain and forty-foot bathing area.

Plate 3.16:- Dextral WNW-ESE shear plane (locality 1).

Plate 3.17:- WNW-ESE shear zone (viewed down line of transport).

Plate 3.18:- NW-SE dextral shear zone (locality 3, Sorrento Point).

Plate 3.19a,b:- Thin-section of Blackrock breccia; a) quartz showing undulose extinction and polygonisation of the margins, b) fine-grained ground-mass (XPL).

Plate 3.20a,b:- Thin-section of Seapoint cataclasite showing secondary muscovite that has been smeared between foliation planes (XPL).
Plate 3.21a,b:- Thin section (XPL) and meso-scale at Killiney Bay (locality 3). a) micro-plate of shear zone (horizontal) and b) meso-scale of secondary mica growth.
Plate 3.22:- Thin section (XPL) of non-sheared granite showing unstrained quartz polygon.
Plate 3.23:- Balscadden fault scarp (viewed from the west) truncating wind-gap.
Plate 3.24:- Balscadden Fault breccia.
Plate 3.25:- Balscadden Fault breccia showing reddened quartz grains.
Plate 3.26:- Thin section (XPL) of Balscadden fault breccia – quartz grains show undulose extinction on margins.
Plate 3.27:- Evidence for Tertiary weathering surface.
Plate 3.29:- Apparent offset of calcite vein evident from orthogonal stylolite.
Plate 3.30:- Strain softened matrix cut by late-stage (post-Hercynian) reddened calcite vein.
Plate 3.31:- Dextral reverse en-echelon calcite veins, cut by Hercynian stylolites.
Plate 3.32:- Strand of Southern Boundary Fault (near Rathcoole – N7 Cork road).
Plate 3.33a,b:- Clasts of Silurian greywacke in Carboniferous limestone.
Plate 3.34:- Profile of Hercynian open folds with wavelength of ~2-3m.
Plate 3.35:- Thin section of kinematic indictor taken from fault plane.

Chapter 5

Plate 5.1:- Pie-chart of Northern Pluton (Vartry area).
Plate 5.2:- Pie-chart of Northern Pluton (Glen of Imail area).
Plate 5.3:- Pie-chart of Lugnaquillia Pluton (Glen of Imail area).
Plate 5.4:- Pie-chart of Tullow Pluton (Bunclody area).
Plate 5.5:- Pie-chart of Tullow Pluton (Glen of Imail area).
Plate 5.6:- Pie-chart of Blackstairs Pluton (Bunclody area).
Plate 5.7:- Pie-chart of Ribband Group (Bunclody area).
Plate 5.6:- Pie-chart of Ribband Group (Vartry area).
Plate 5.9:- Pie-chart of Ribband Group (Glen of Imail area).

Plate 5.10:- Pie-chart of Bray Group (Vartry area).
Plate 5.11:- Pie-chart of Kilcullen Group (Glen of Imail area).
Plate 5.12:- Lithological correlation of three study areas.

Appendices

Appendix 1:- Model - Reactivation of Pre-existing fractures.
Appendix 2:- Structural Observations (Dalkey Quarry, Co. Dublin).
Appendix 3:- Outline of geology of SE Ireland with proportions of rock type in the Vartry, Bunclody and Glen of Imail areas of study.
Appendix 4:- Track-Length Distribution Histograms. 1μm bins for track lengths.
Appendix 5:- Time-Temperature profiles of TULIP AFT samples for SE Ireland.
Appendix 6:- TULIP AFT Database.
Appendix 7:- Well-logs for the Porcupine basin.
Appendix 8:- Seismic Reflection lines (Porcupine basin).
Appendix 9:- Two-way time maps of Porcupine basin.

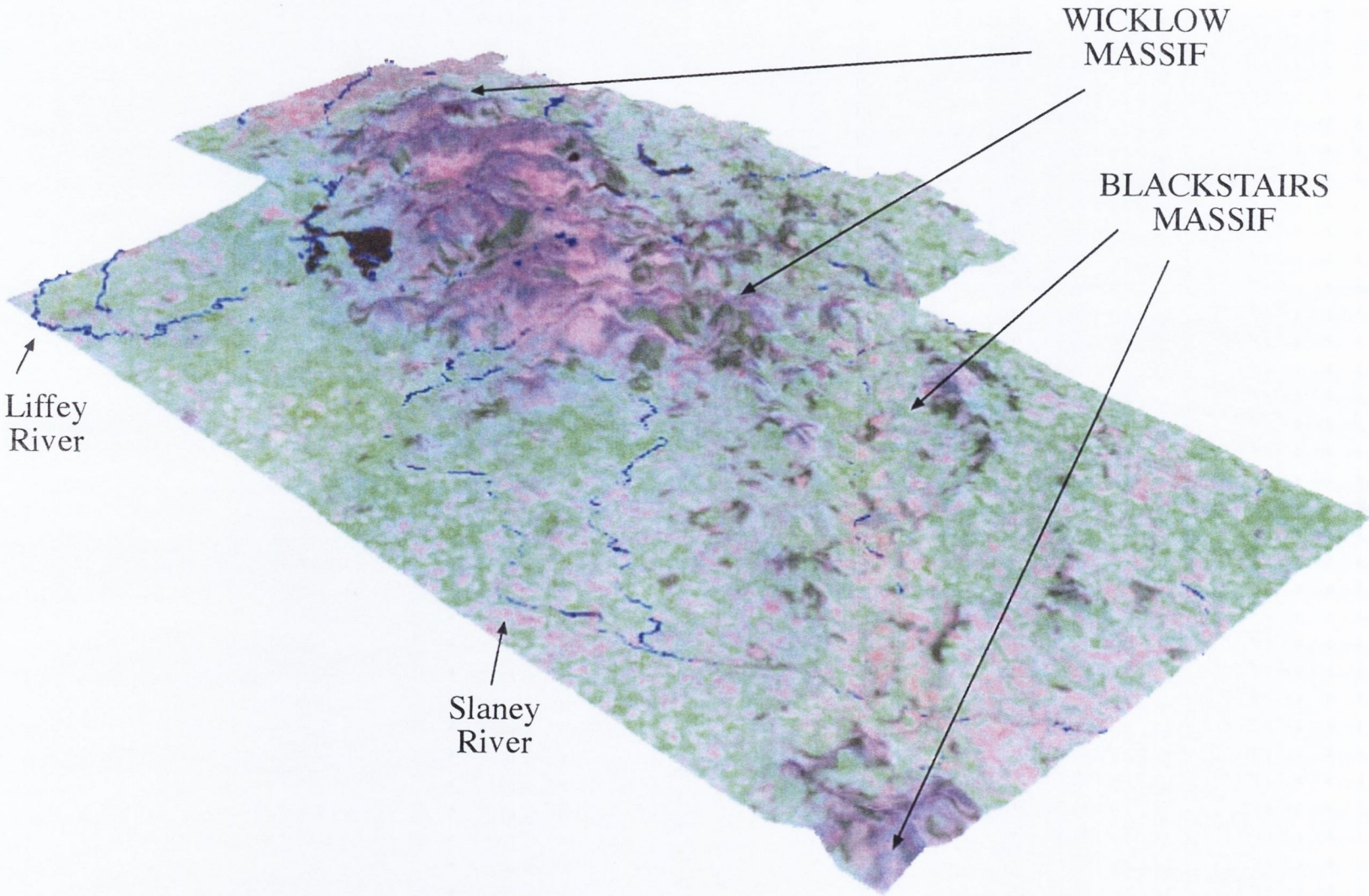
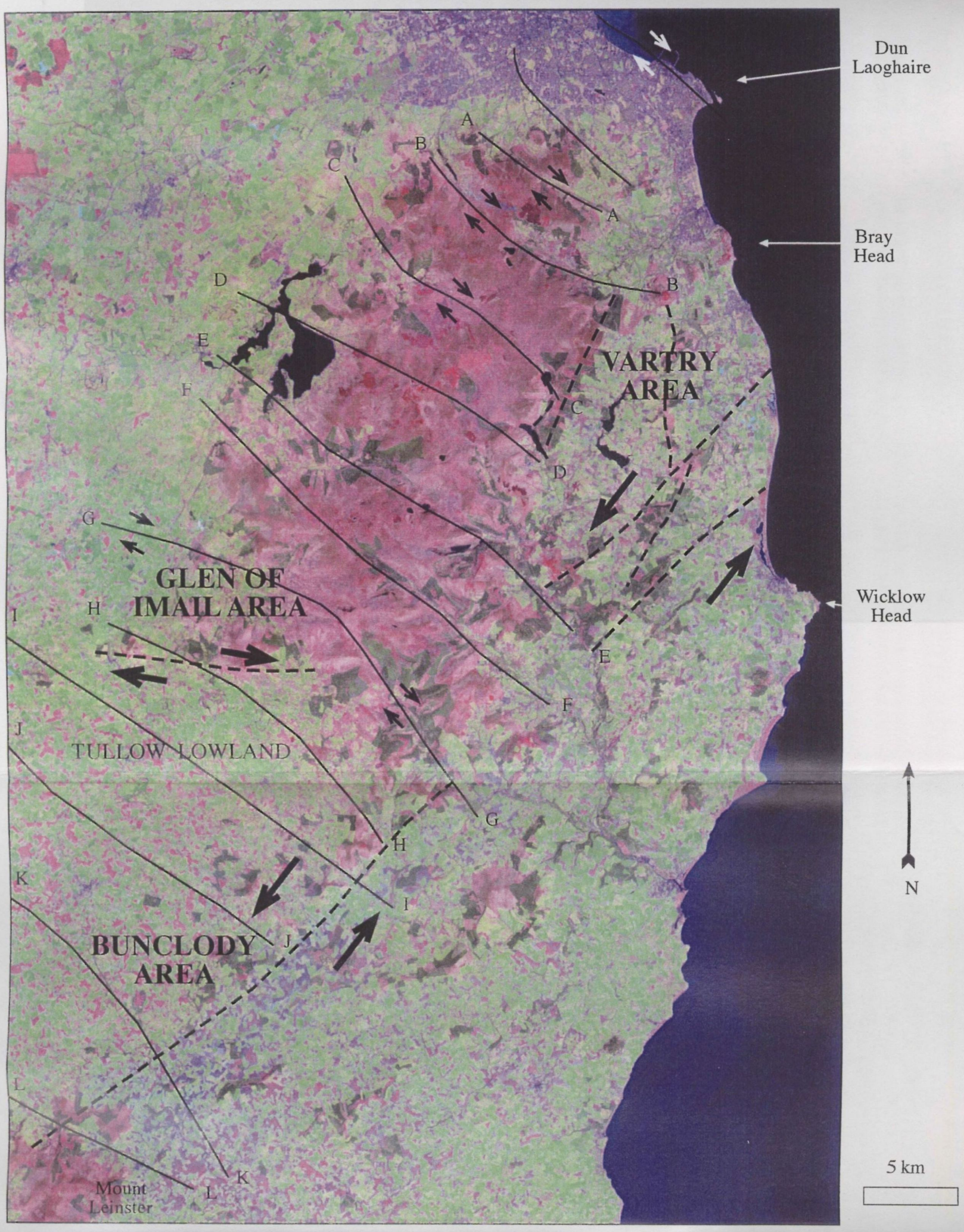


Figure 6.1:- Regional scene of CORINE Landsat image over DEM.



Major Lineaments/Faults

A - A: Glencullen
B - B: Glenasmole-Glencree
C - C: Sally Gap
D - D: Lough Dan
E - E: Glendasan
F - F: Glenmalure
G - G: Ow River
H - H: Moyne
I - I: Tinahely
J - J: Shillelagh
K - K: Slaney River
L - L: Clody River

– – – Major inferred structures (see chapter 5)

Figure 6.2:- CORINE image of SE Ireland showing major NNW-SSE to ENE-WSW lineaments (after Brück & O'Connor, 1980; 1981).

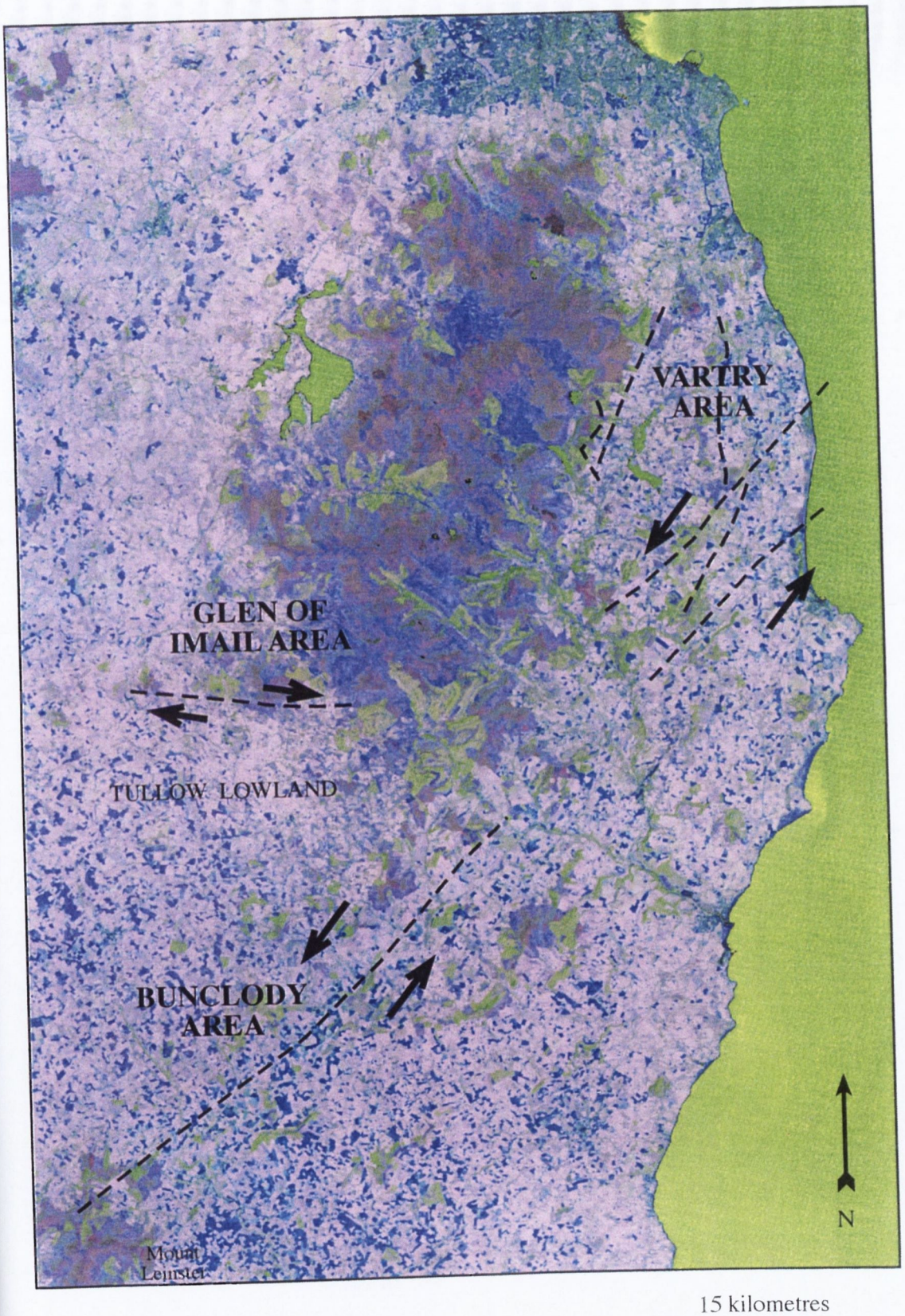
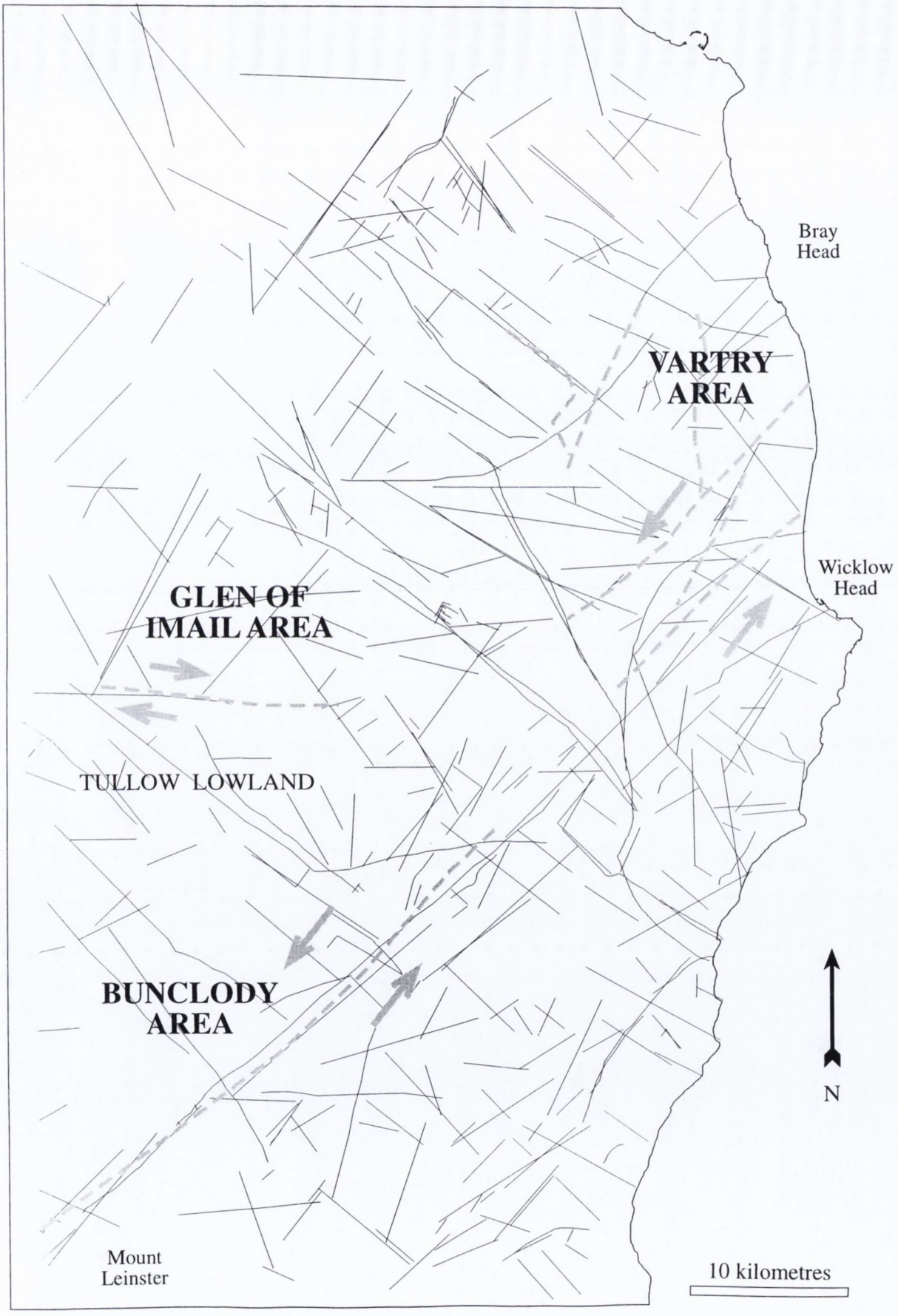


Figure 6.3:- Regional scene of intensity (I) hue (H) and saturation (S). See text for discussion.



– – – Major structures (chapter 5)

Figure 6.4:- Digitised lineaments on regional scale, previously recognised faults and inferred structures from chapter 5. See text for discussion.

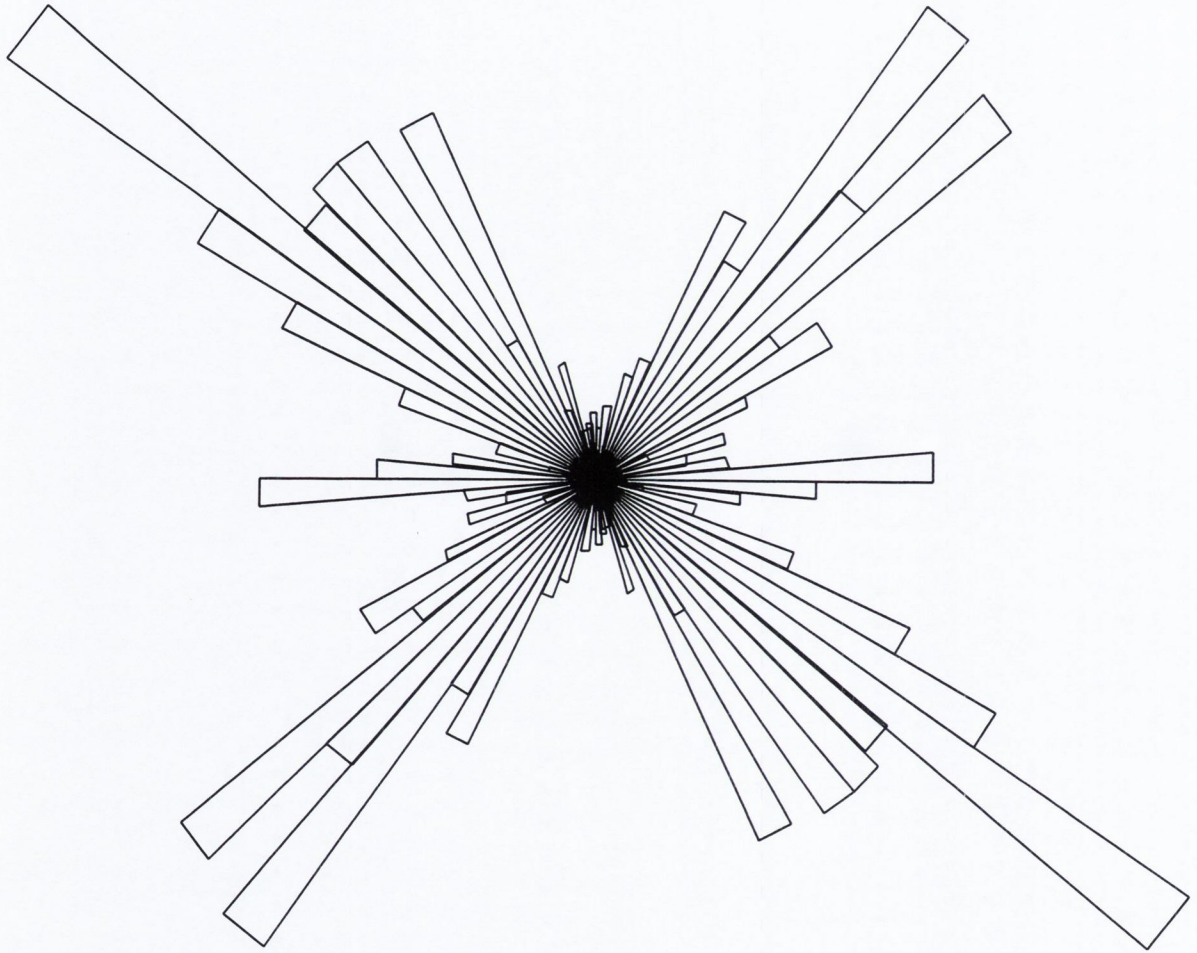


Figure 6.5:- Regional (Leinster Mountain chain) rose diagram of lineaments. Note that the NW-SE trend shows a greater peak than the NE-SW.

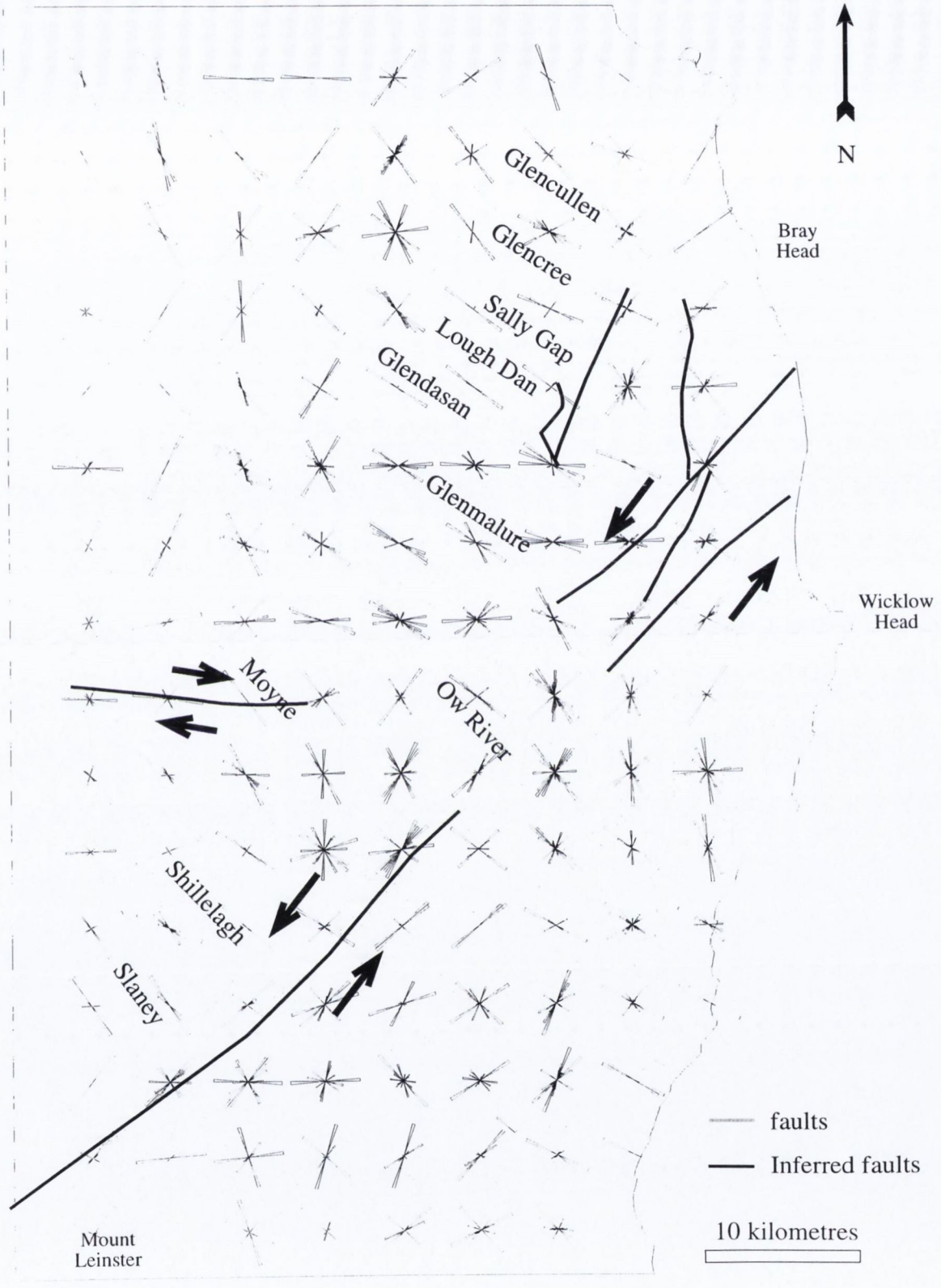


Figure 6.6:- Sub-cell rose diagrams of lineaments. Sub-cells are 25km^2.

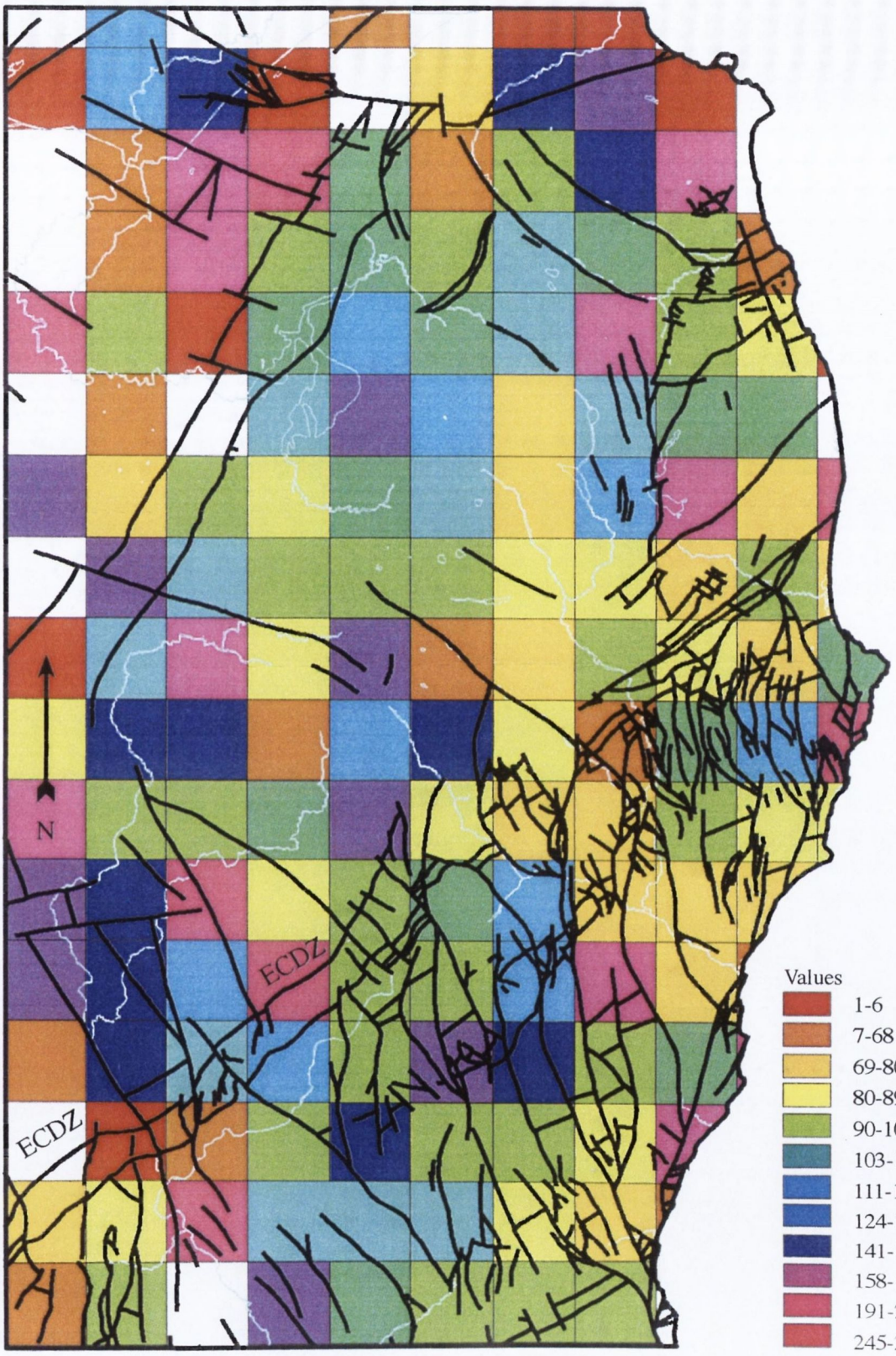


Figure 6.10:- Spacing of lineaments and known faults and shear zones (GSI). Sub-cells are 25km^2. ECDZ - East Carlow Deformation Zone.

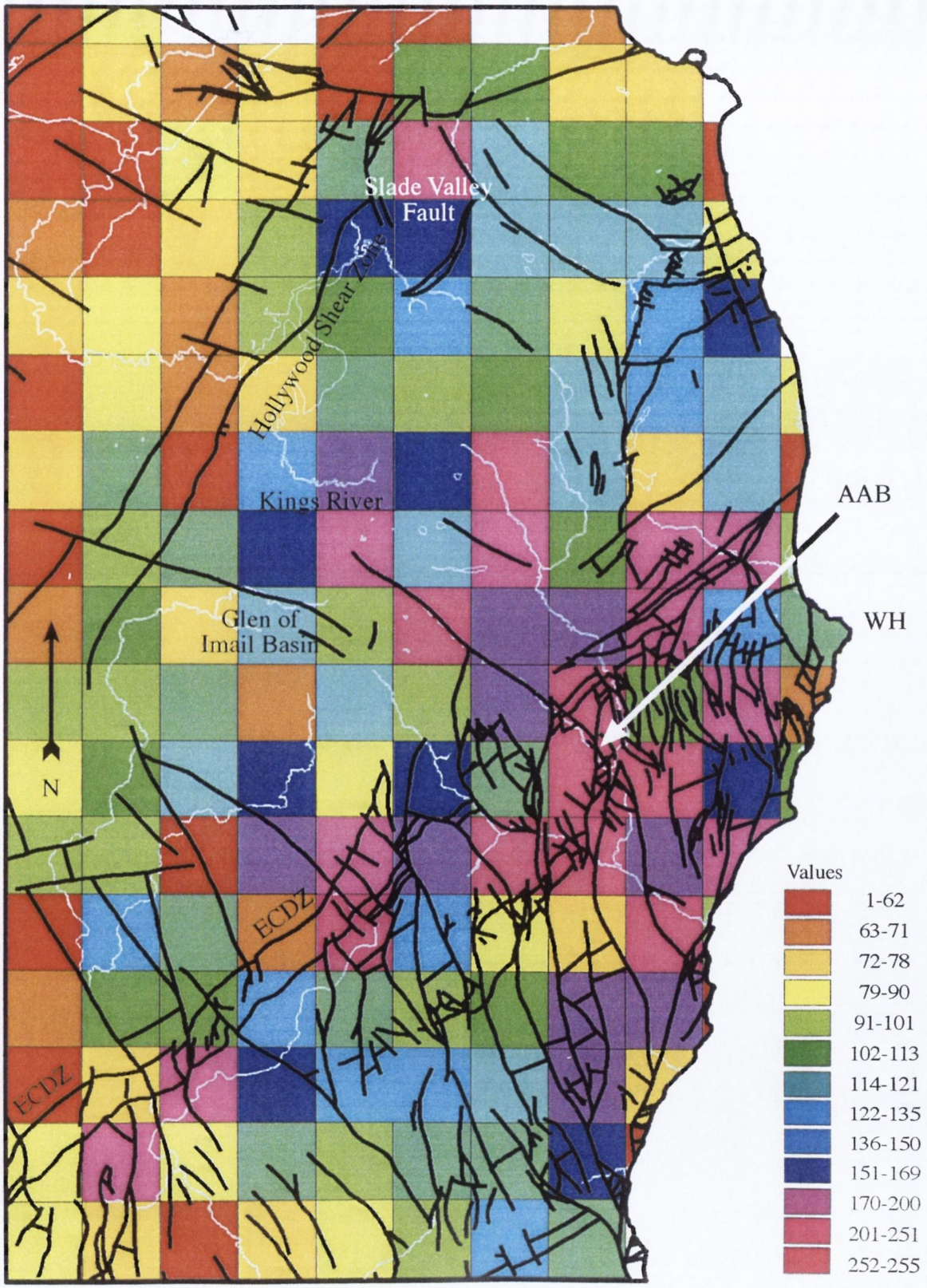


Figure 6.9:- Length density of lineaments and known faults and shear zones (GSI). Sub-cells are 25km^2. AAB – Aughrim-Avoca Block; ECDZ - East Carlow Deformation Zone; WH – Wicklow Head.

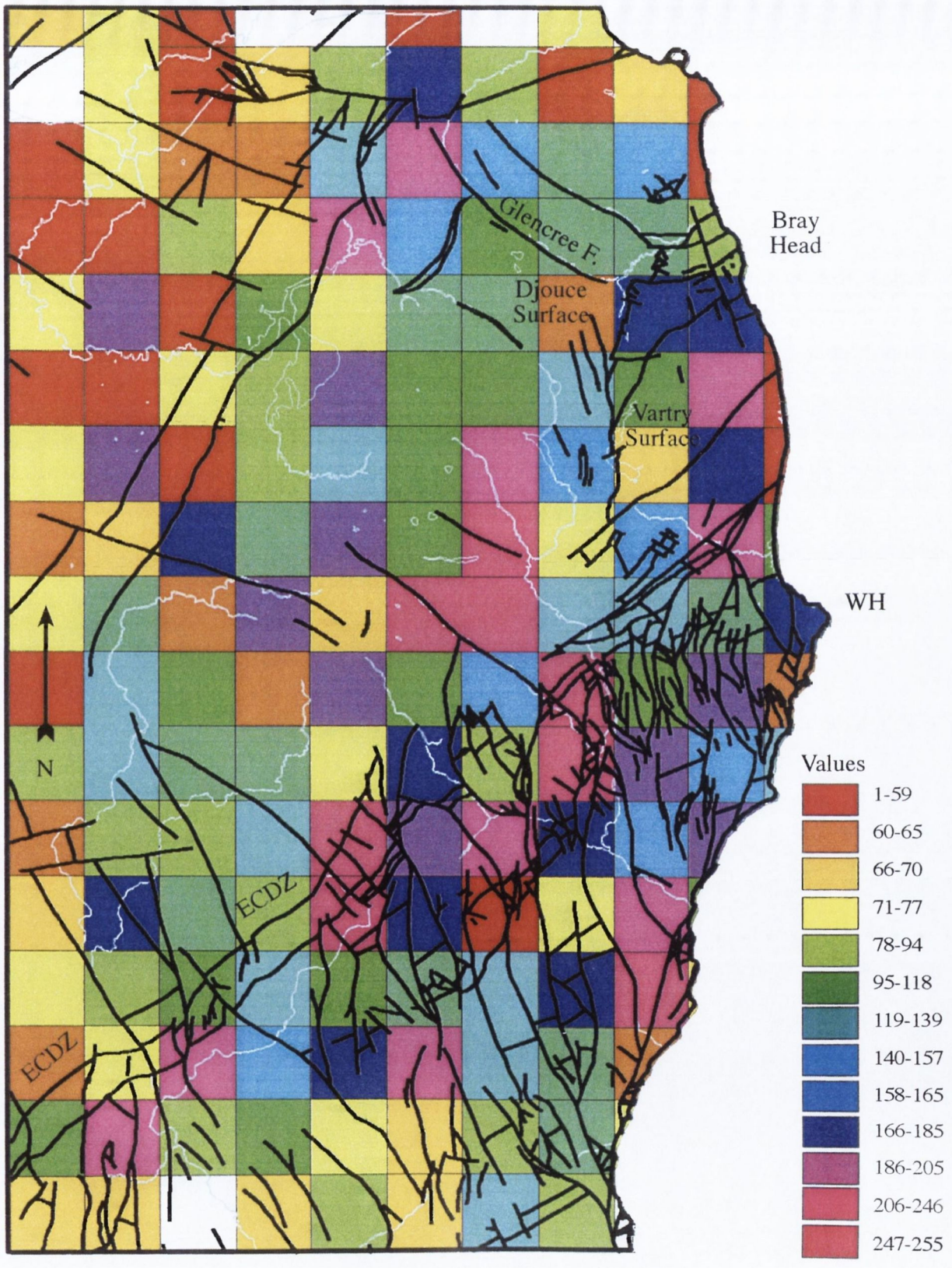


Figure 6.8:- Intersection density of lineaments and known faults and shear zones (GSI). Sub-cells are 25km^2. ECDZ - East Carlow Deformation Zone; WH - Wicklow Head.

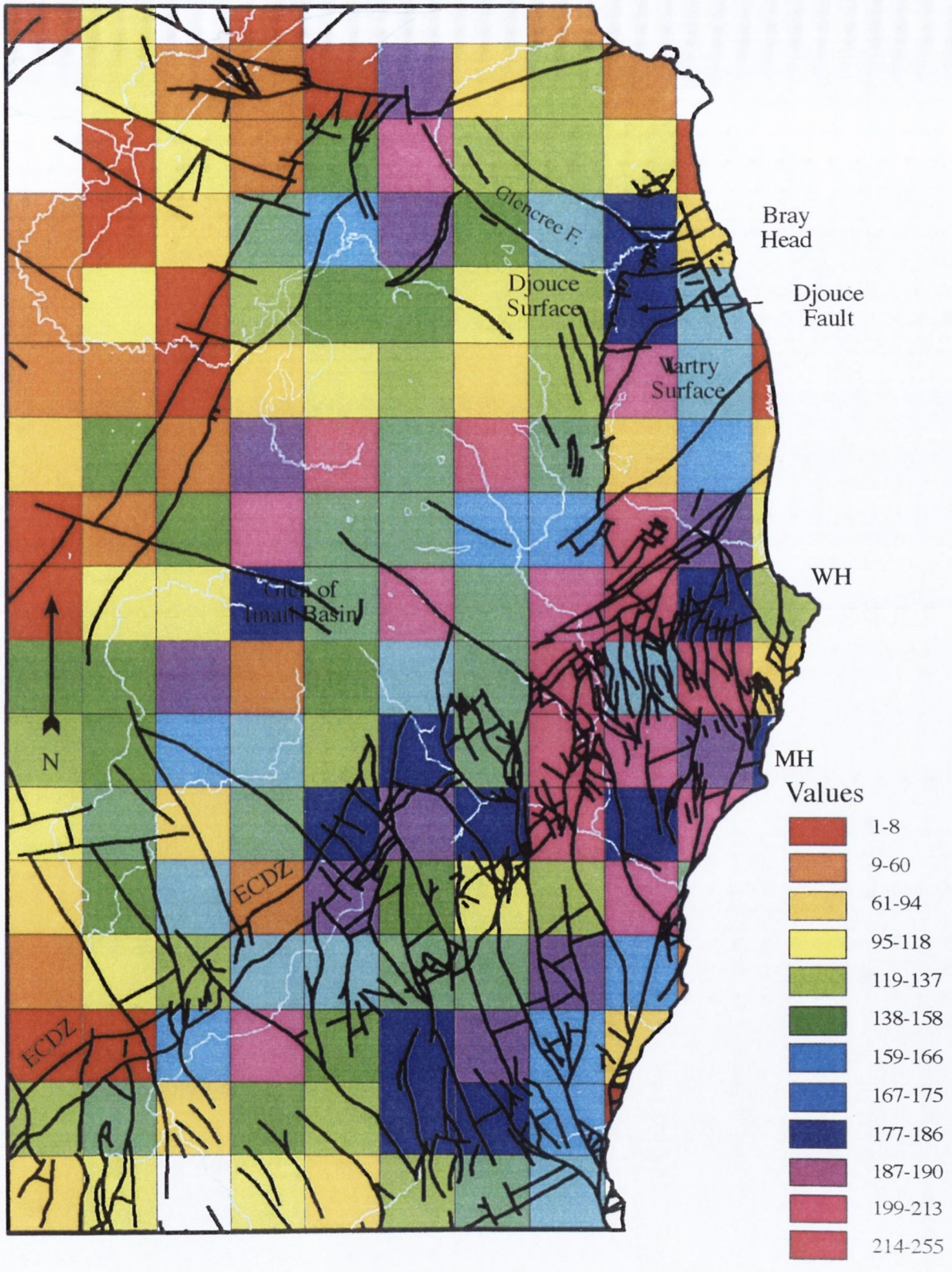
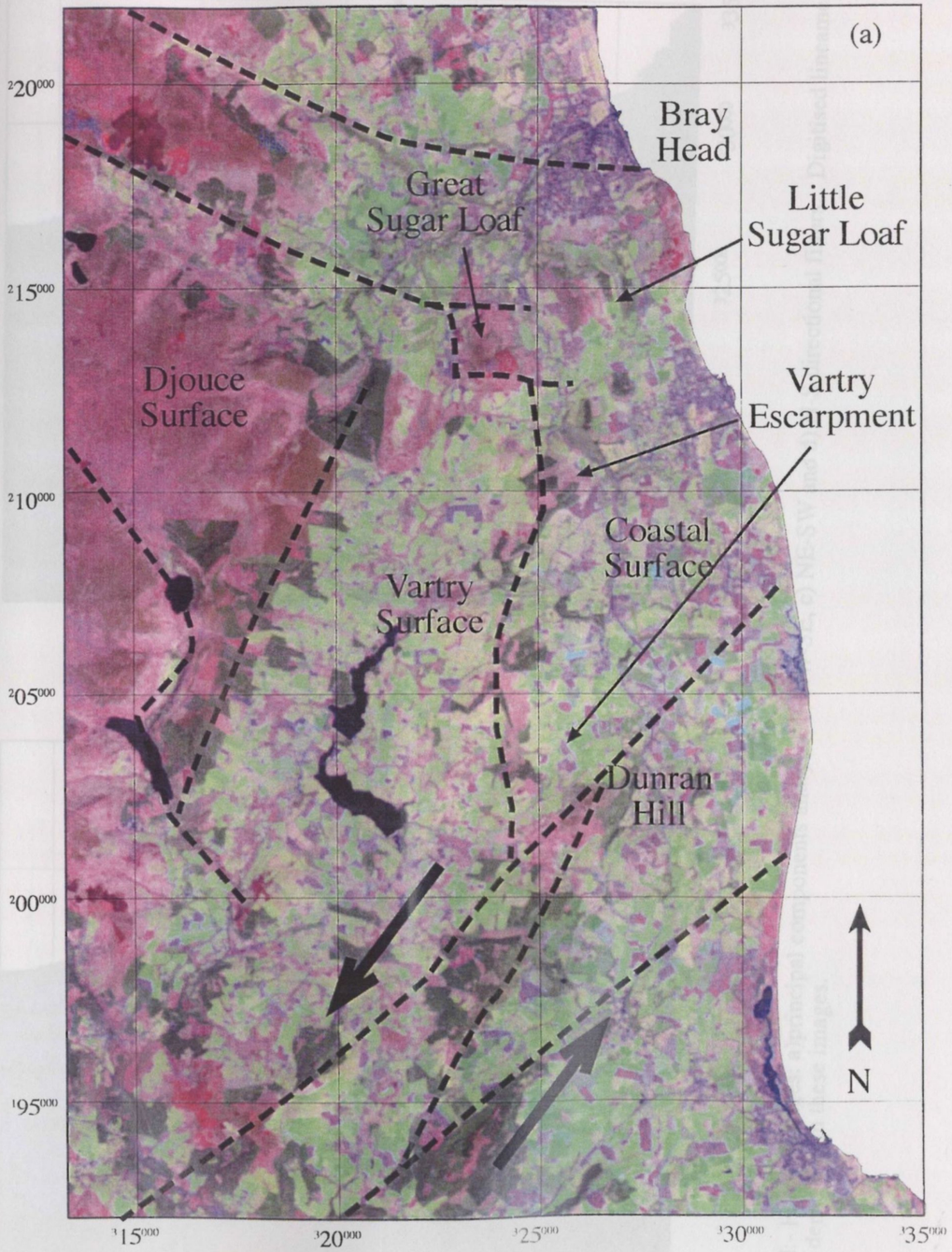


Figure 6.7:- Entropy of lineaments and known faults and shear zones (GSI). Sub-cells are 25km^2. ECDZ - East Carlow Deformation Zone; MH - Mixen Head; WH - Wicklow Head.





Major inferred faults (see chapter 5)

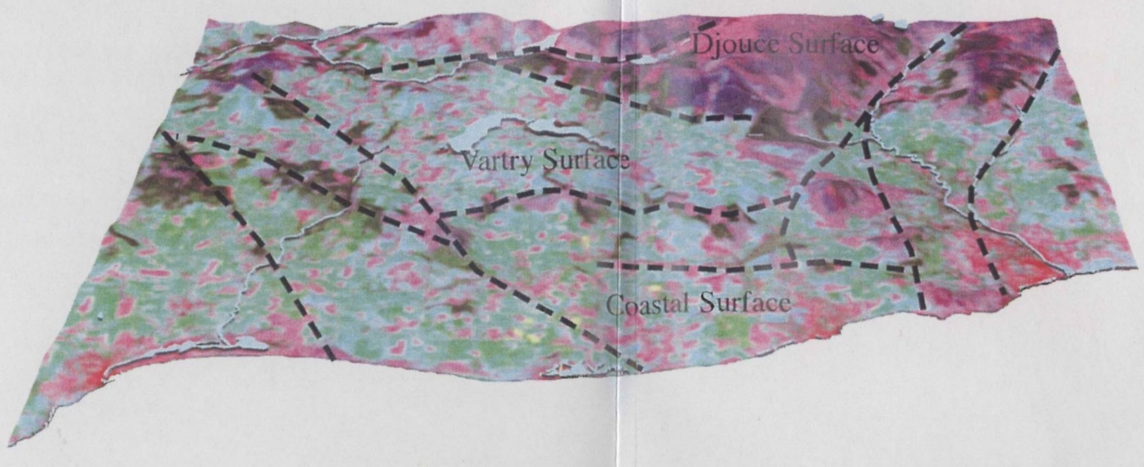


Figure 6.11a,b,c:- CORINE Landsat image of Vartry study area. Previously known faults and hitherto unrecognised fractures. b) image draped over DEM with x4 vertical exaggeration looking NE, c) image draped over DEM with x2 vertical exaggeration looking west.

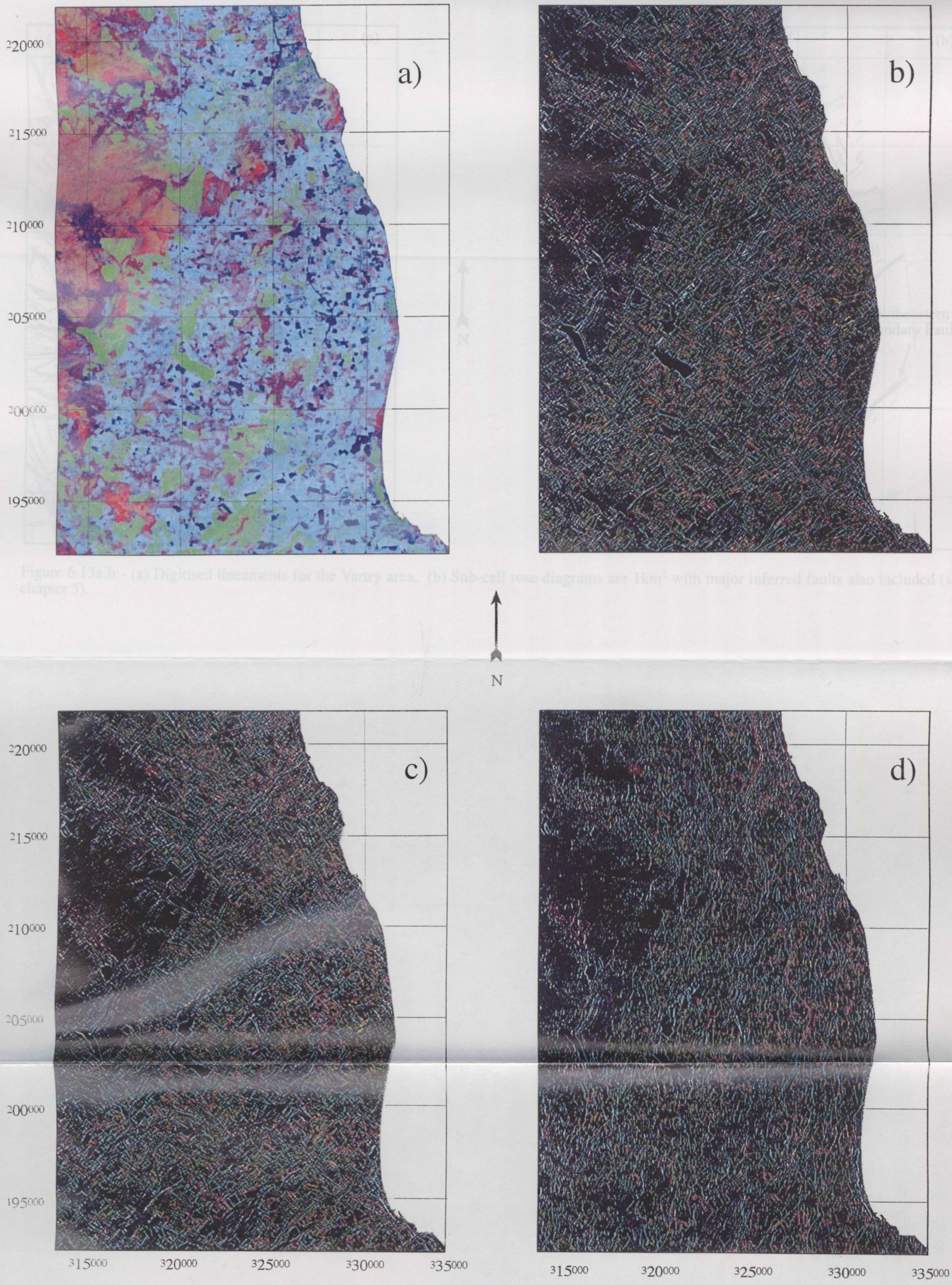


Figure 6.12,a,b,c,d:- Filtered images: a)principal components analysis, b) NW-SE, c) NE-SW and d) N-S directional filters. Digitised lineaments for the Vartry area derived from these images.

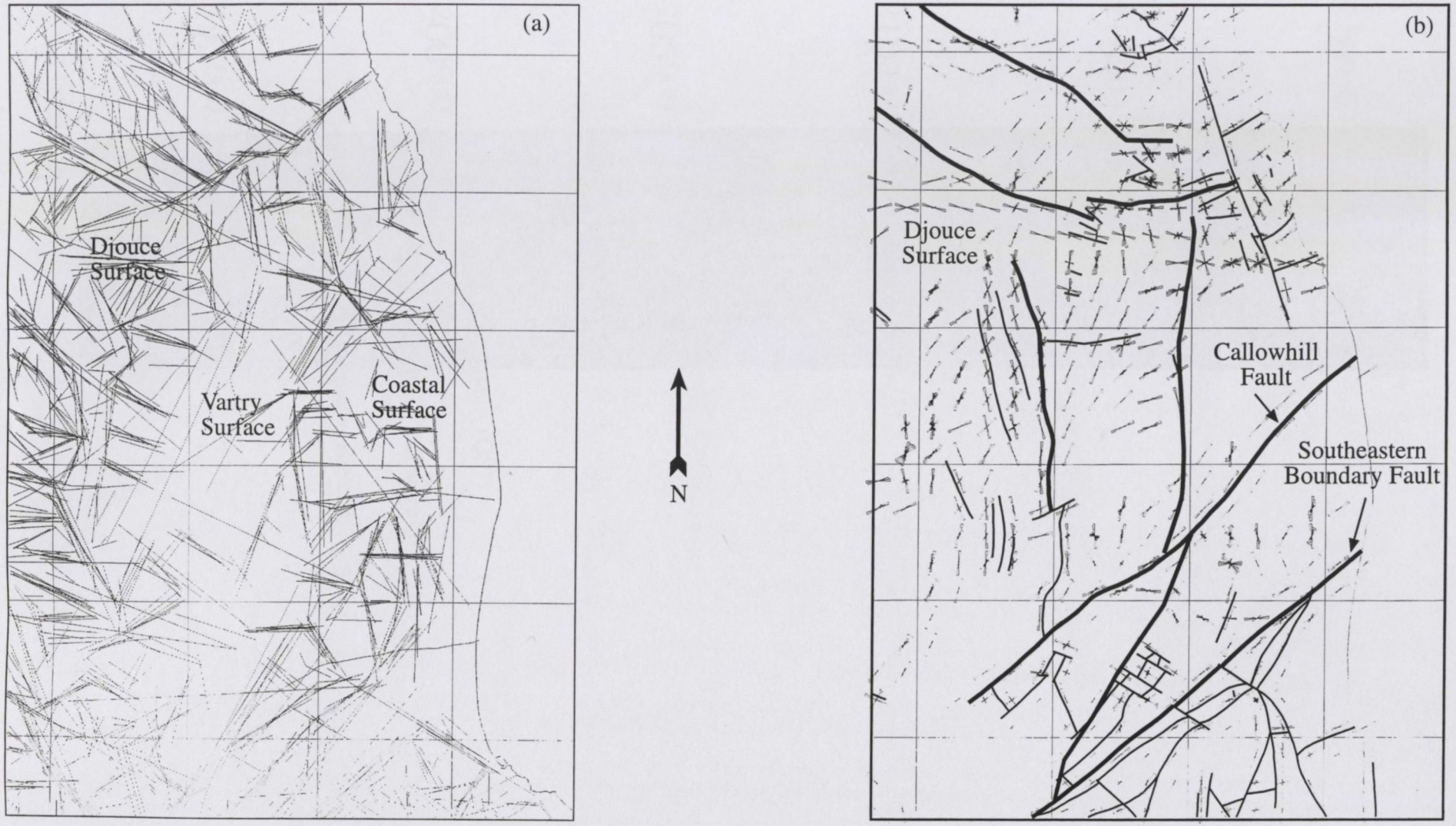


Figure 6.13a,b:- (a) Digitised lineaments for the Vartry area. (b) Sub-cell rose diagrams are 1km^2 with major inferred faults also included (see chapter 5).

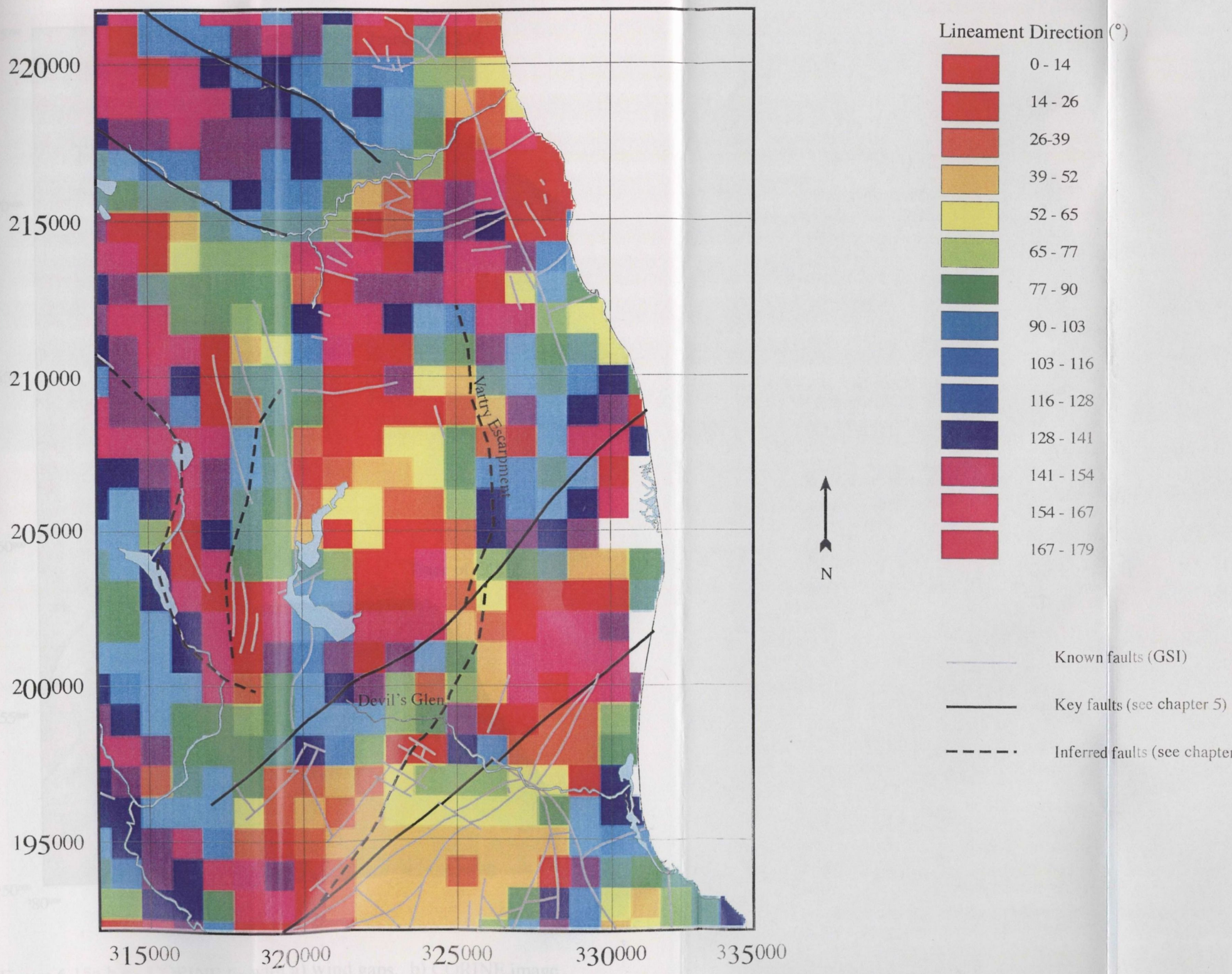
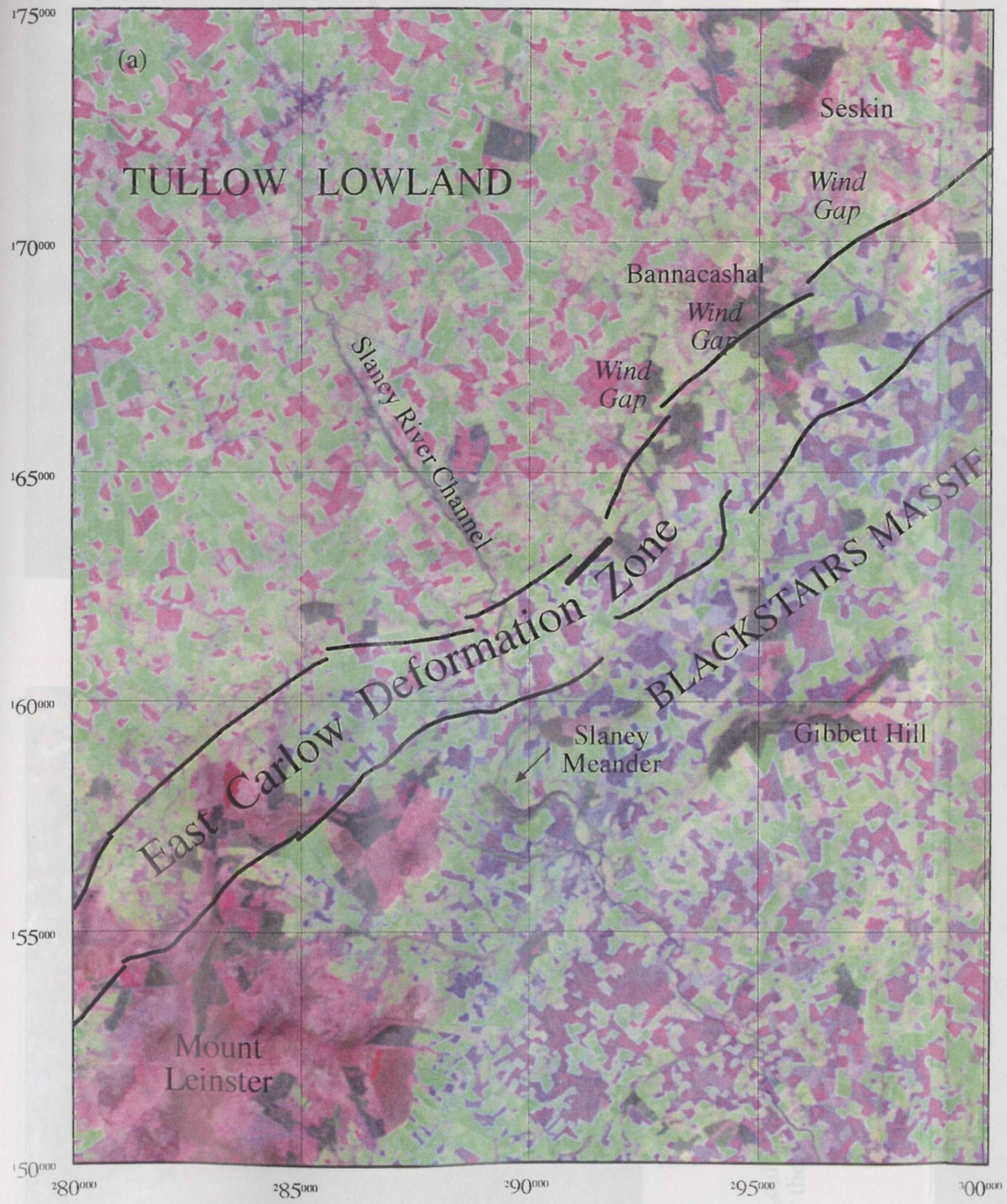
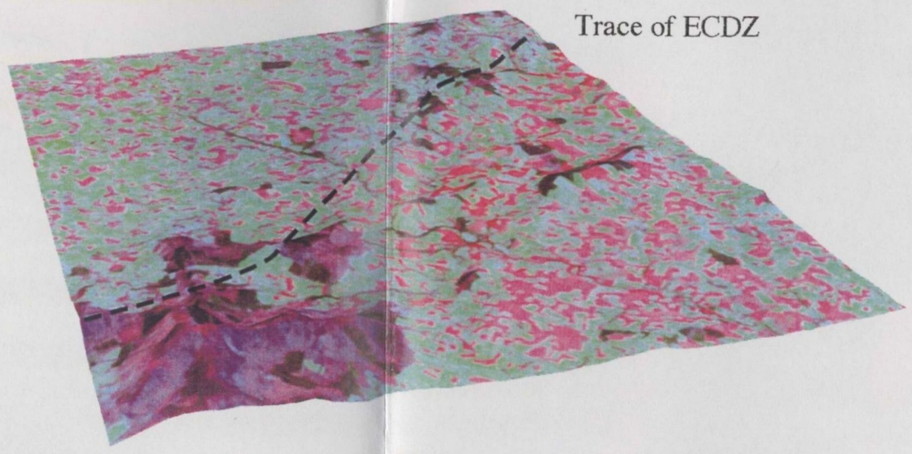


Figure 6.14:- Image showing lineament direction in 1km^2 cells.





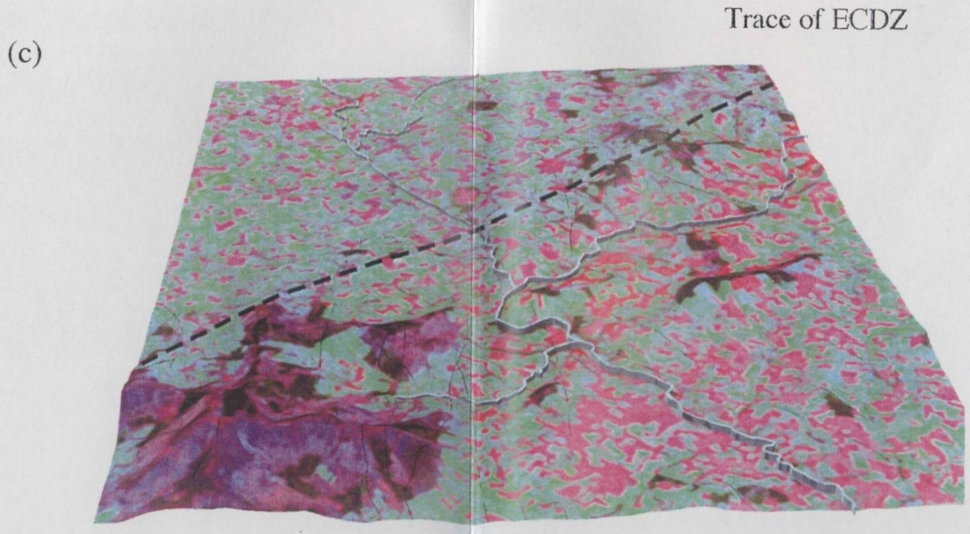


Figure 6.15a,b,c:- CORINE Landsat image of Bunclody study area. Previously known faults and East Carlow Deformation Zone (ECDZ) with a) wind gaps. b) CORINE image draped over DEM looking NNE, and c) looking north over general area. Vertical exaggeration of both images is x2.

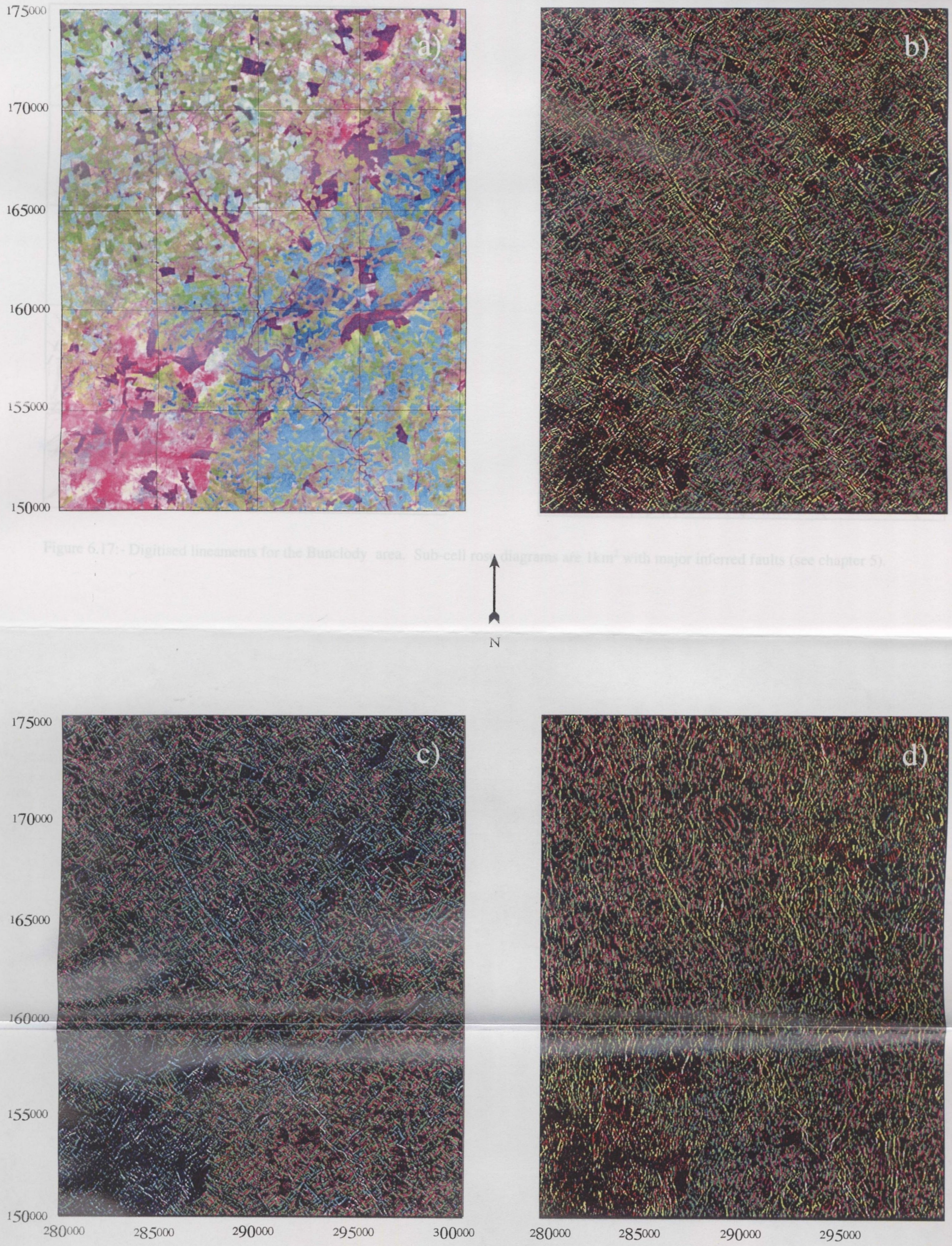


Figure 6.16a,b,c,d:- Filtered images: a) principal components analysis, b) NW-SE, c) NE-SW and d) N-S directional filters. Digitised lineaments for the Bunclody area are derived from these images.



Figure 6.17:- Digitised lineaments for the Bunclody area. Sub-cell rose diagrams are 1km^2 with major inferred faults (see chapter 5).

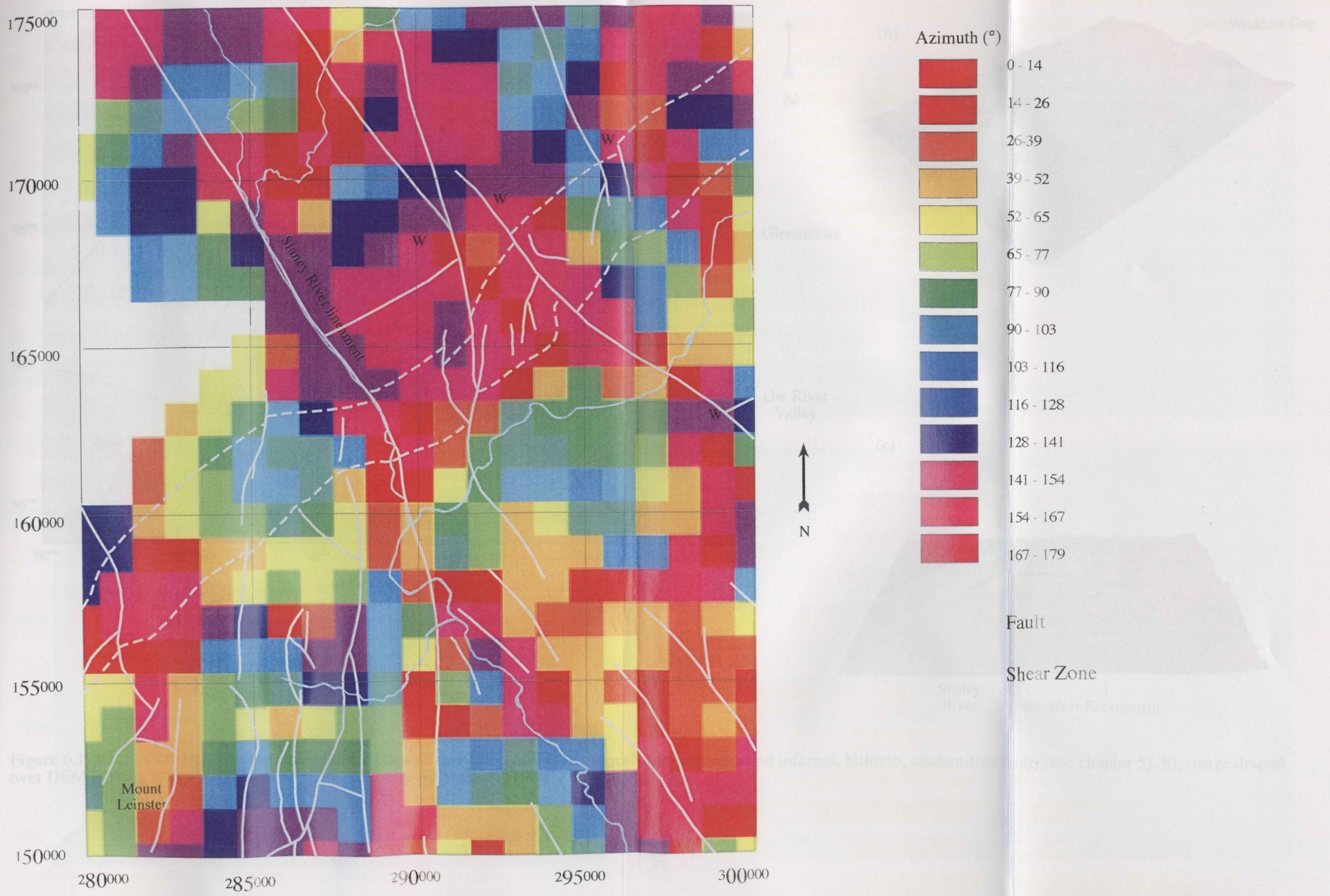
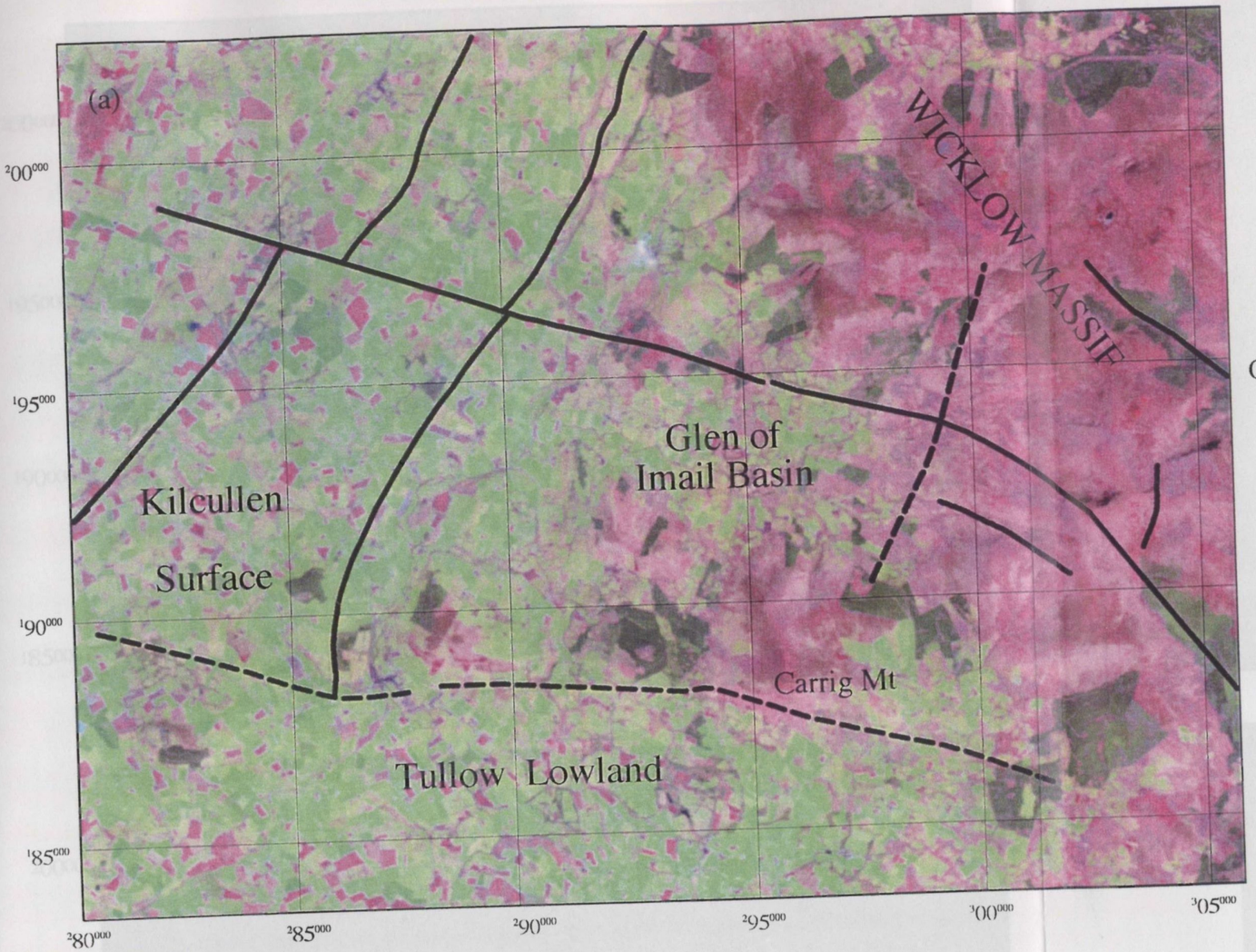
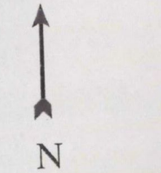
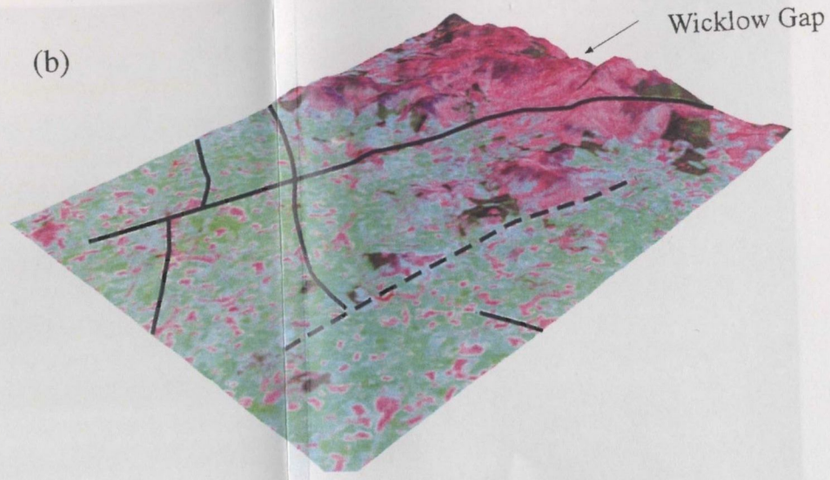
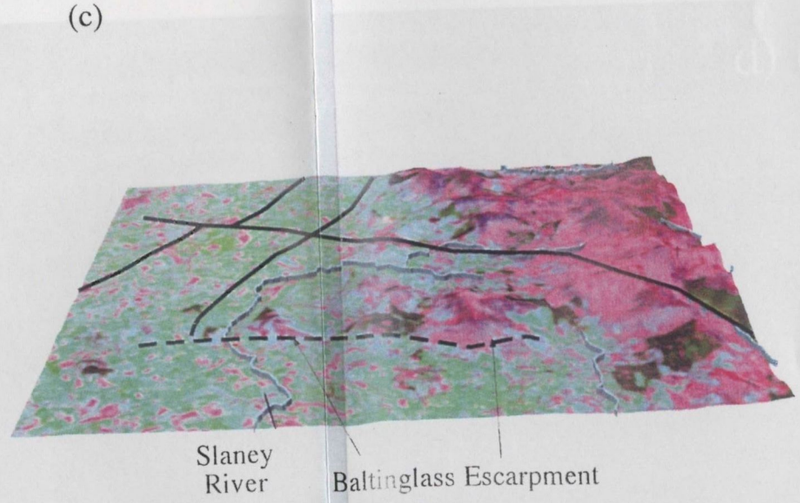


Figure 6.18:- Image showing lineament direction with 1km^2 cells. Note that this technique does not clearly pick out the ECDZ but instead shows the transverse NNW-SSE wind gaps.









– – – – – Inferred faults (see chapter 5)

Figure 6.19a,b,c:- CORINE Landsat image of the Glen of Imail study area. Previously known faults and inferred, hitherto, unidentified faults (see chapter 5). b), image draped over DEM looking NNE, and c), and north. Both image drapes are vertically exaggerated x2.

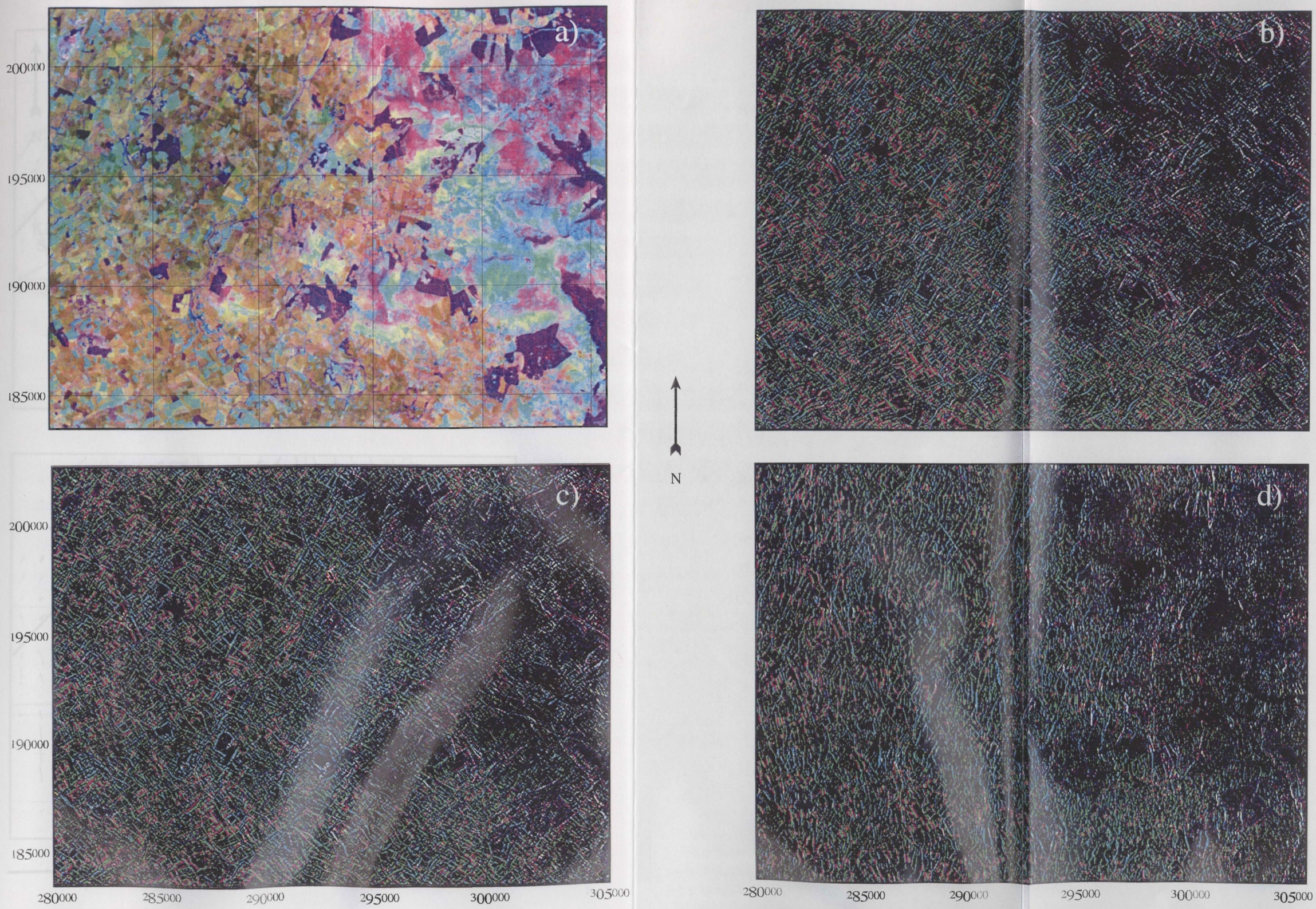


Figure 6.20a,b,c,d:- Filtered images: a) principal components analysis, b) NW-SE, c) NE-SW and d) N-S directional filters. Digitised lineaments for the Glen of Imail area derived from these images.

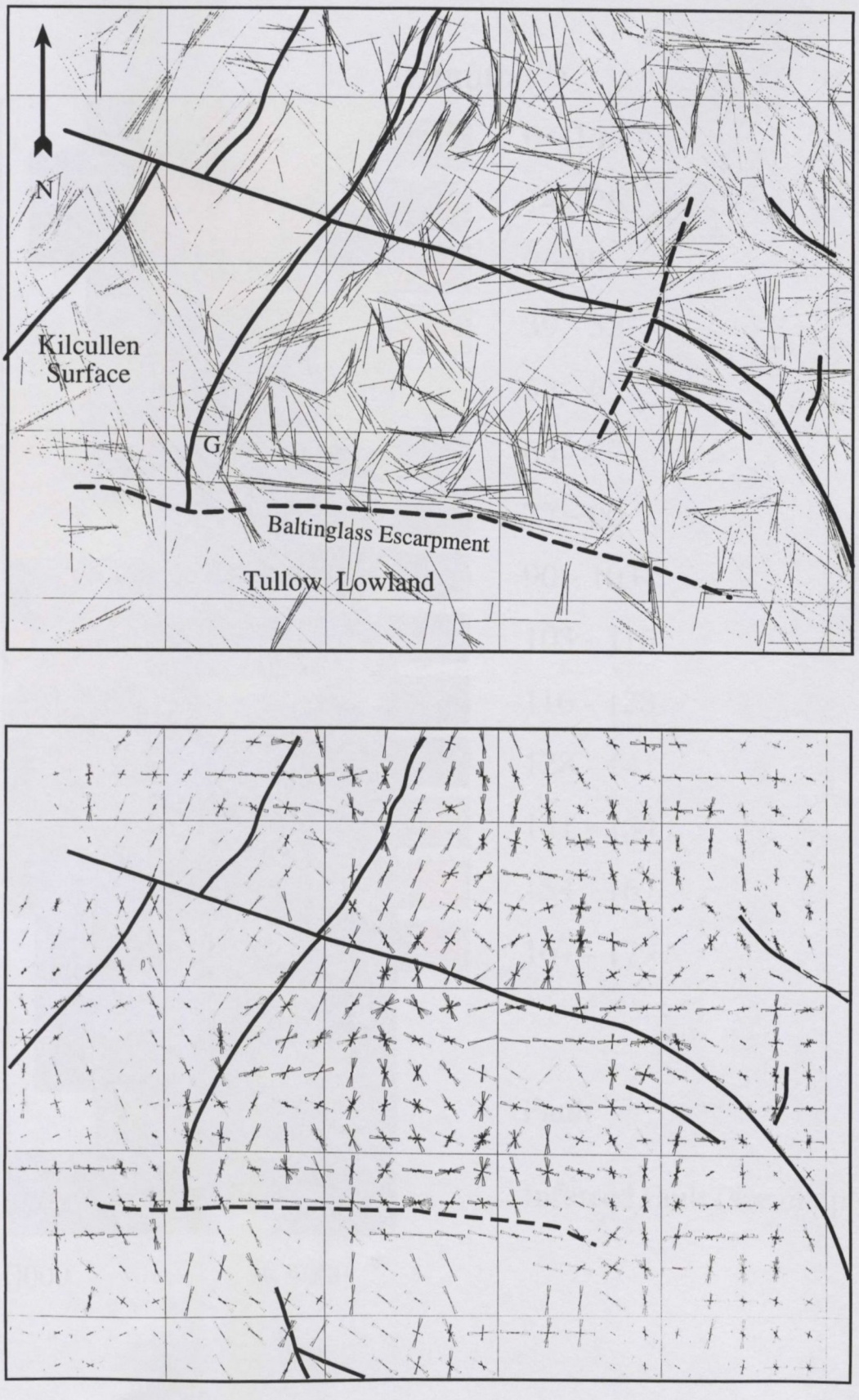
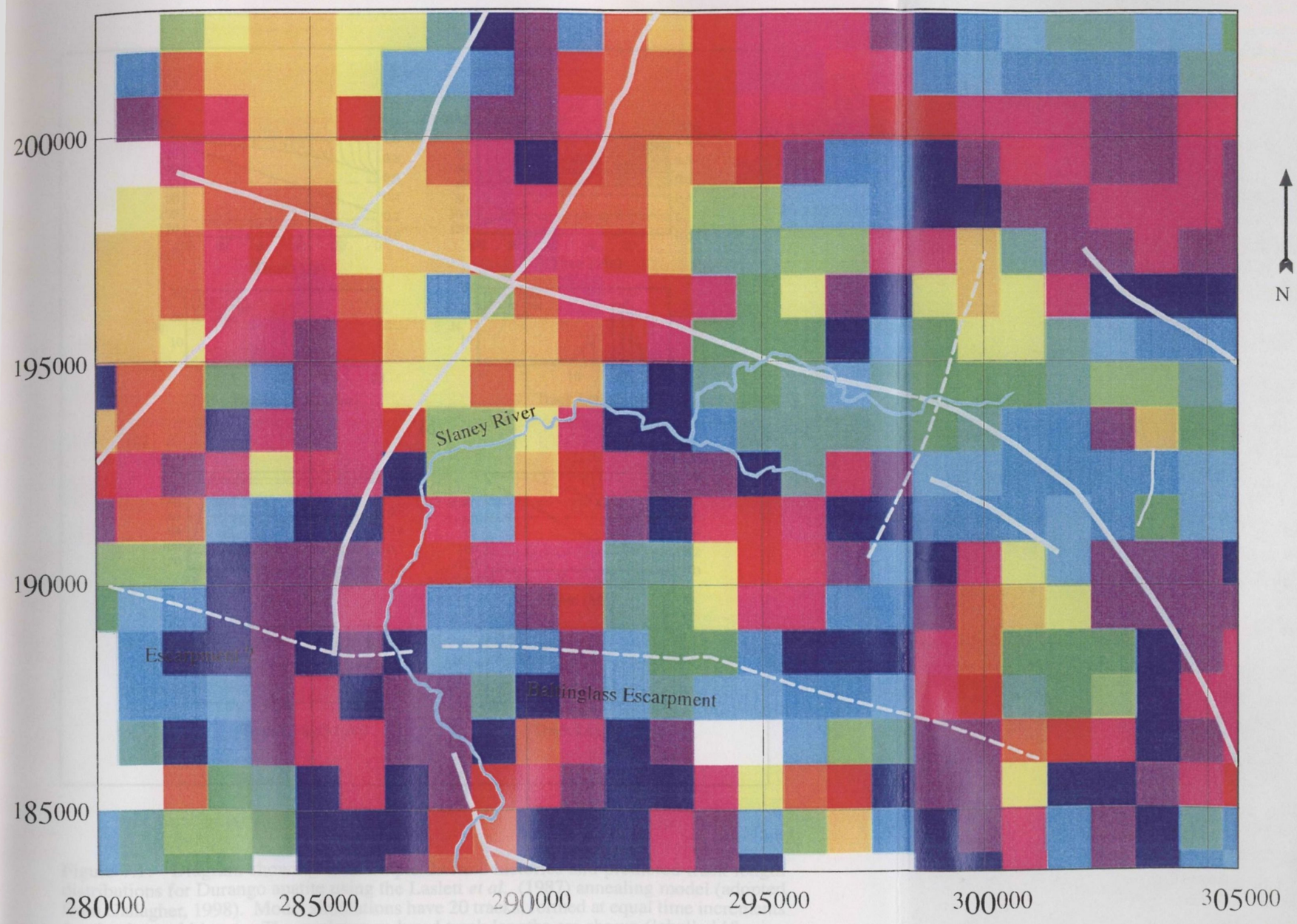
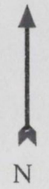
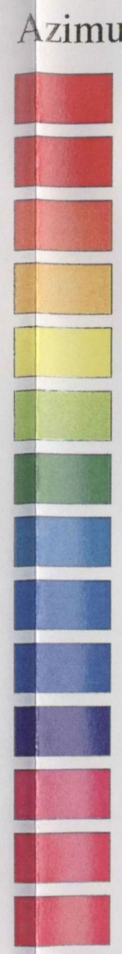


Figure 6.21:- Digitised lineaments for the Glen of Imail area. Sub-cell rose diagrams of 1km^2 area with known and inferred faults (see chapter 5).







Azimuth (°)

0 - 14
14 - 26
26-39
39 - 52
52 - 65
65 - 77
77 - 90
90 - 103
103 - 116
116 - 128
128 - 141
141 - 154
154 - 167
167 - 179

Fault

Inferred fault (see chapter 5)

Figure 6.22:- Image showing lineament direction in 1km^2 cells.

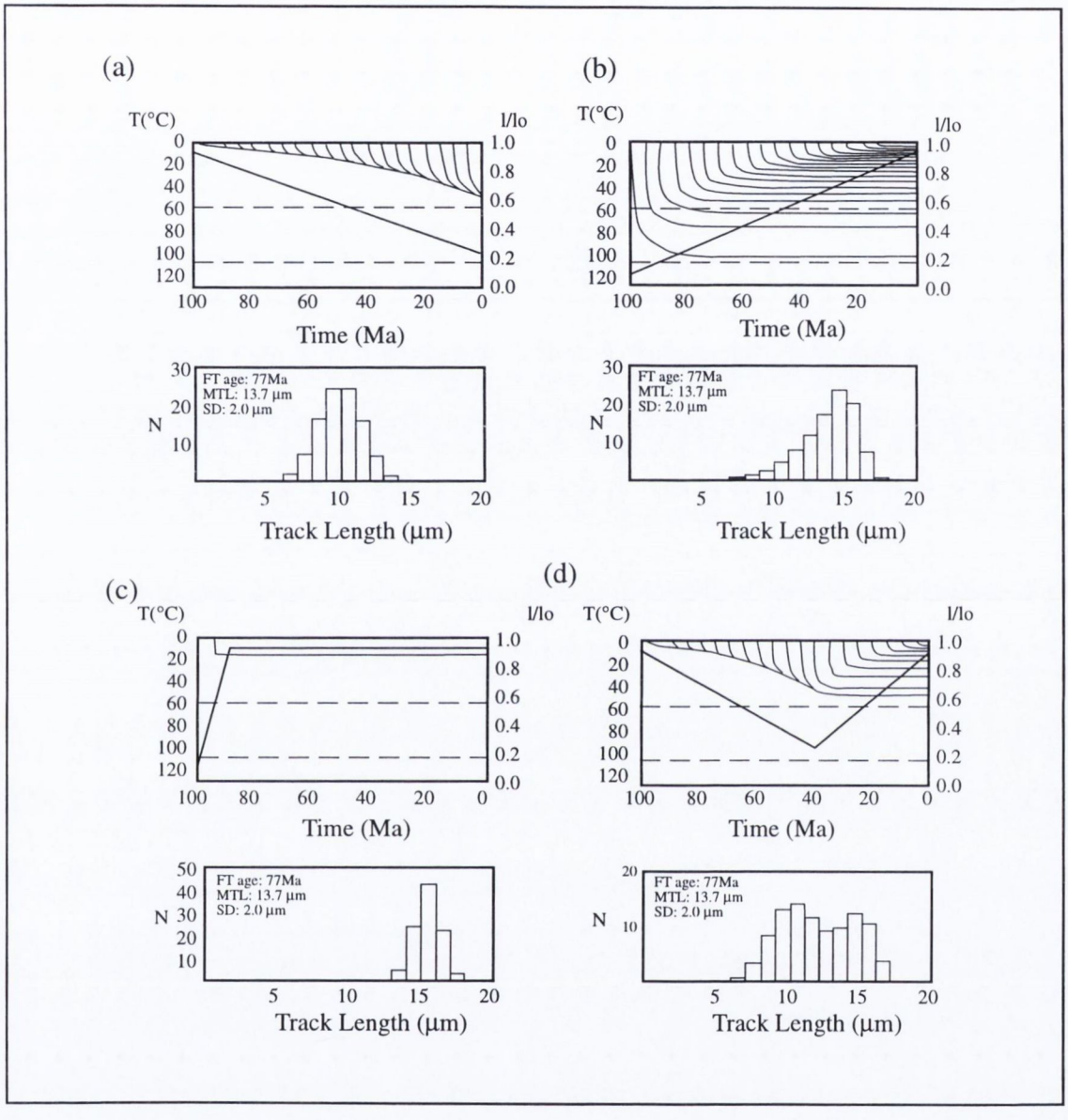


Figure 7.1:- Diagram showing four simple thermal histories and predicted track length distributions for Durango apatite using the Laslett *et al.*, (1987) annealing model (adopted from Gallagher, 1998). Model simulations have 20 tracks, formed at equal time increments for the thermal history. The evolving reduced track lengths are shown (labelled l/lo, i.e. present track length divided by the initial length). The two horizontal lines at 60°C and 110°C depict the partial annealing zone. (a) linear heating, (b) linear cooling, (c) rapid cooling, (d) heating/cooling cycles. See text for details.

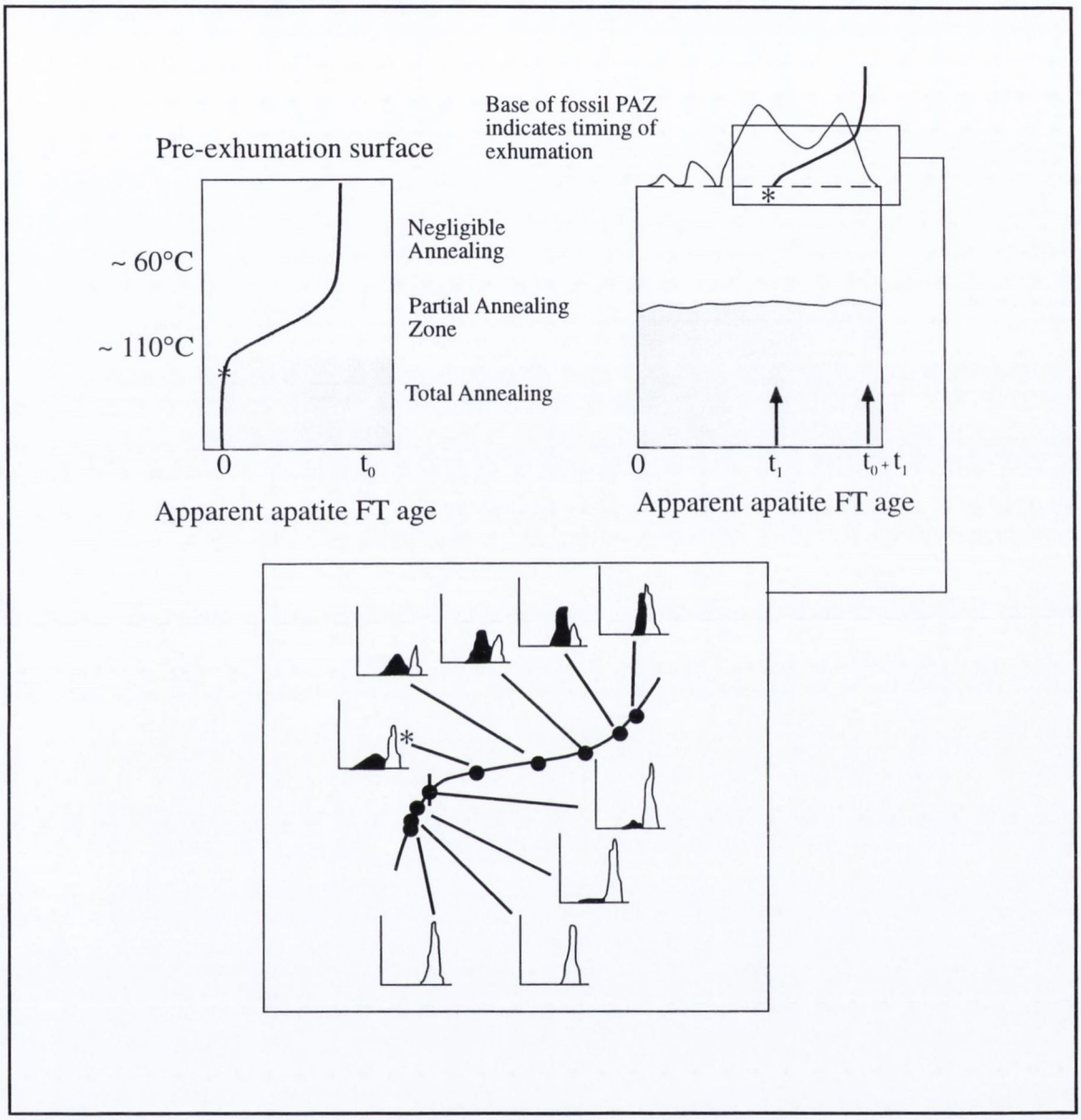


Figure 7.2:- Simple diagram showing concept of an exhumed partial annealing zone (PAZ). A sudden increase in the rate of denudation after a period of prolonged stability will result in the base of the existing PAZ profile moving upwards towards the new mean surface and hence producing an exhumed PAZ (Brown *et al.*, 1994; Fitzgerald *et al.*, 1995). The break of slope in the new profile indicates where the apatite ages were reduced to zero prior to exhumation (i.e. the AFT age will coincide with the time the rock cooled below 110±10°C).

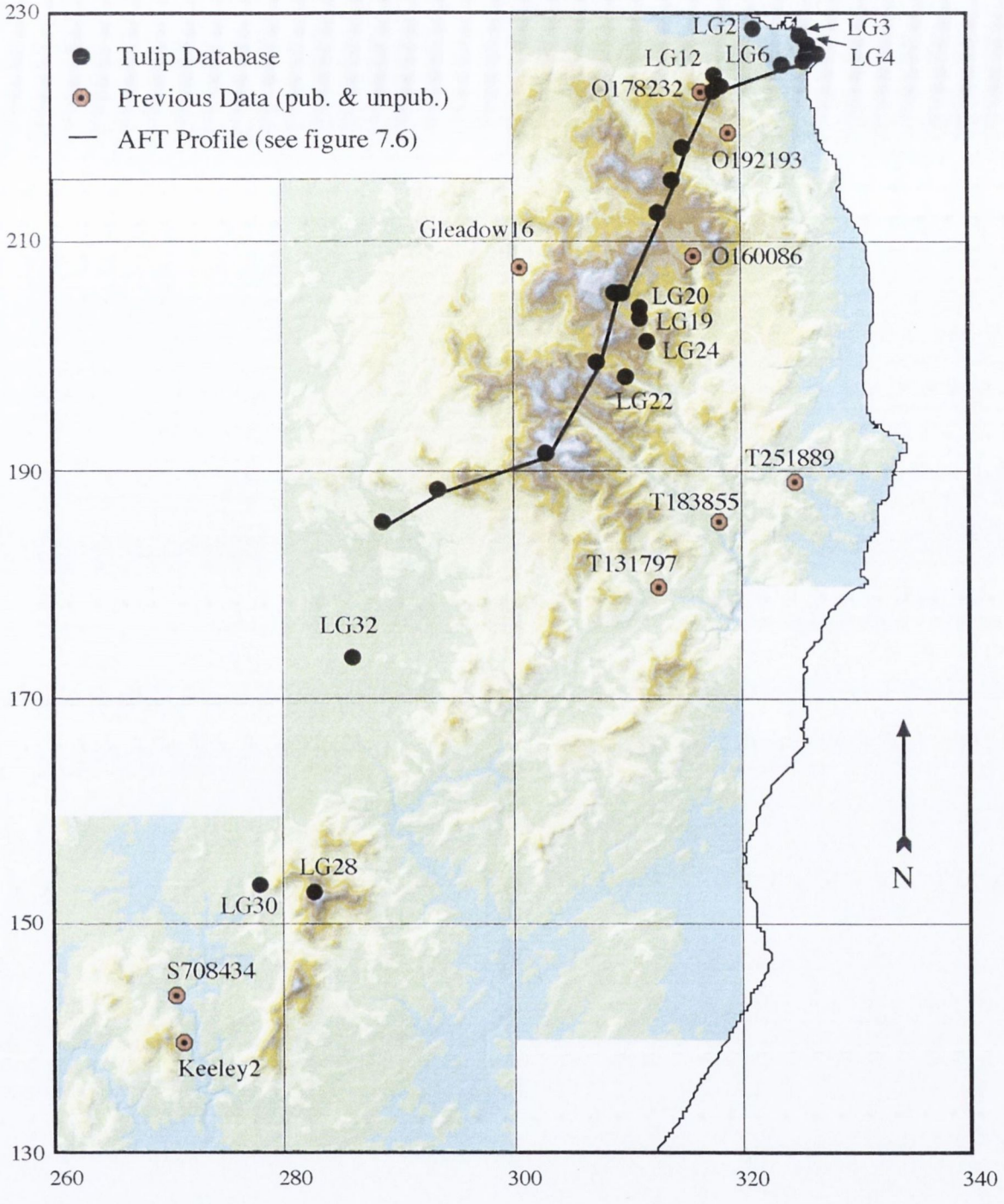


Figure 7.3:- Map showing location of published/unpublished (Keeley *et al.*, 1993; Gleadow, unpublished; McCulloch, unpublished; McCulloch, 1993, 1994) TULIP AFT samples in the Leinster Mountain chain. Note that the samples which fall along the ~NNE-SSW profile are not labelled (see figure 7.5 for these sample IDs).

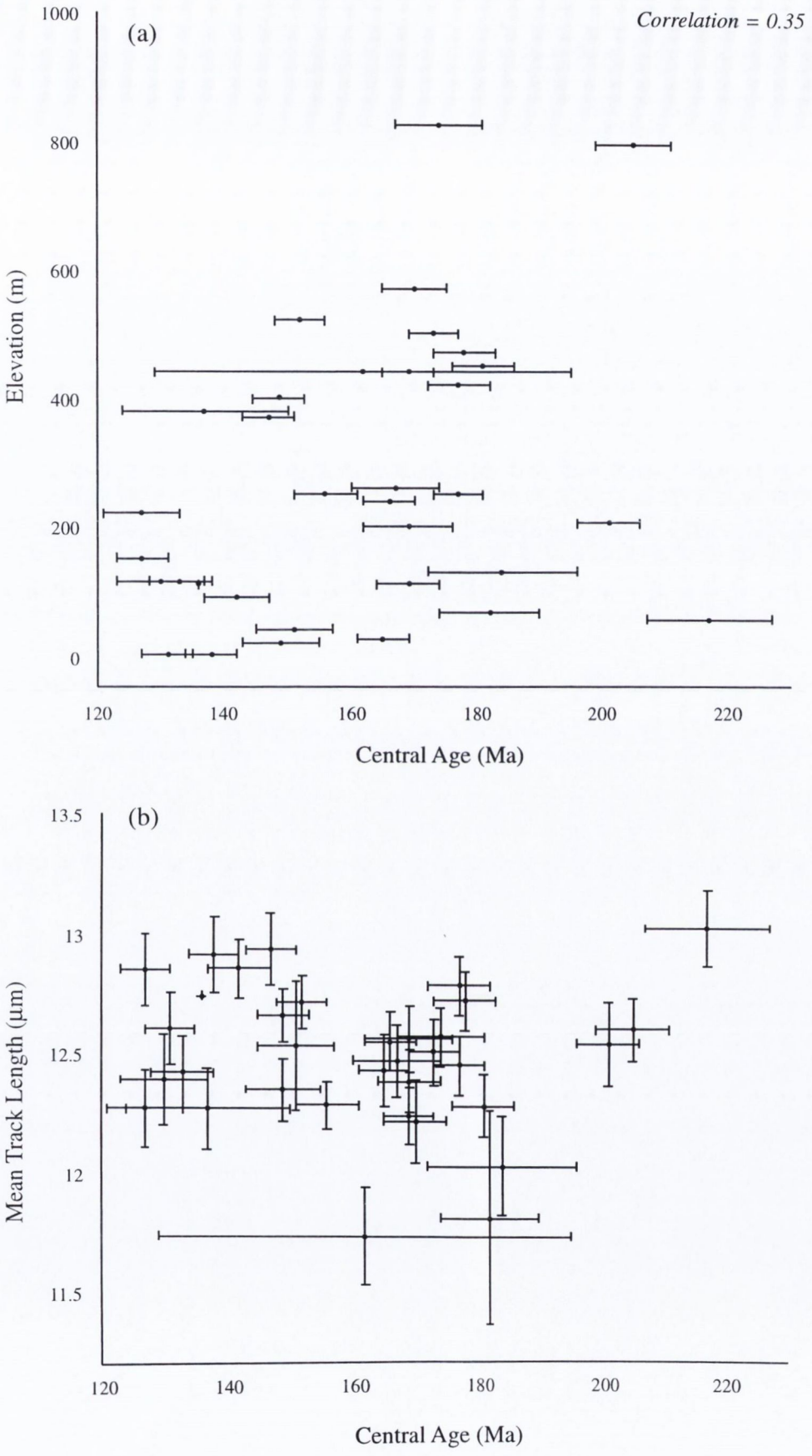


Figure 7.4a,b:- a) Plot of AFT 'Central Age' against 'Elevation' in the Leinster Mountain chain. Note the general linear relationship between age and elevation. b) Boomerang plot of these samples, shows that there was a major cooling episode during ~Late Triassic to Mid Jurassic times. See text for discussion.

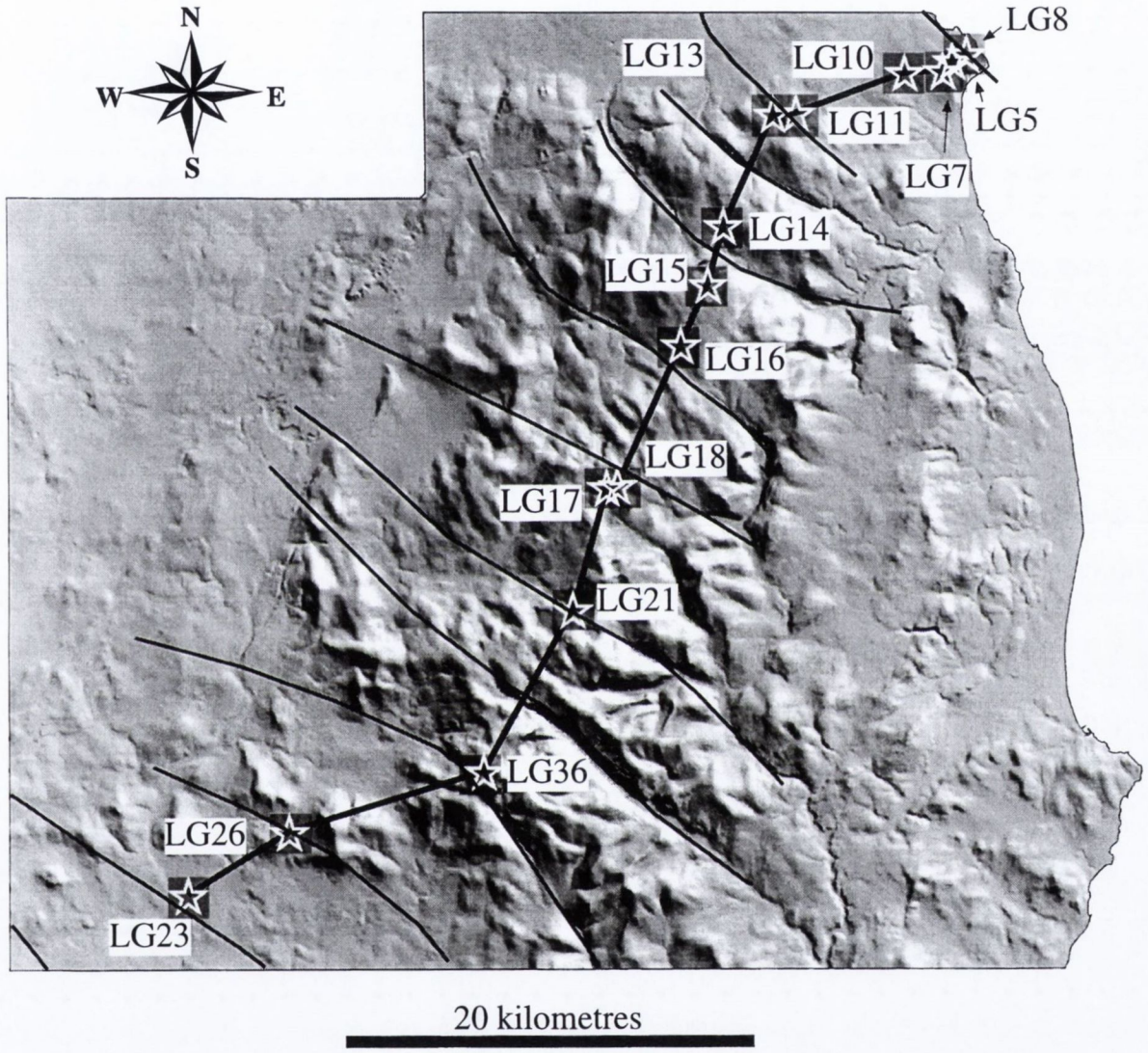
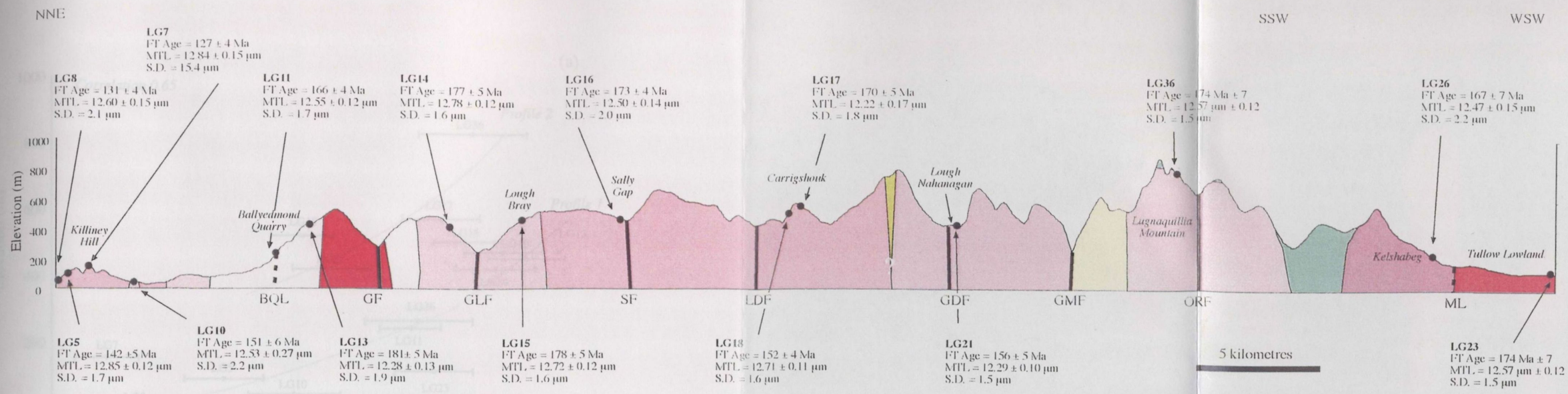


Figure 7.5:- NE shaded topographic image of the Wicklow Massif. The location of major NW to WNW fractures/linears (chapter 6) and a ~NNE-SSW geological profile, with location of AFT samples. The profile is partially coincident with the drainage divide of the Wicklow Massif.



Northern Pluton

- Type 4 muscovite/microcline porphyritic. Muscovite-microcline porphry granite.
- Type 3 muscovite porphyritic. Granite with phenocrysts.
- Type2e equigranular. Pale grey fine to coarse-grained granite.
- Type 2p microcline porphyritic. Granite with microcline phenocrysts.
- Type 1 granodiorite. Fine-grained granodiorite to granite.

Lugnaquillia Pluton

- Carrawaystick Aplite. White, saccharoidal garnetiferous aplite.
- Barravore Aplogranite. Fine-grained, mucovite-rich aplogranite.
- Glendalough Adamellite. Adamellite with microcline phenocrysts.
- Percy's table Granodiorite. Aphyric granodiorite.

Tullow Pluton

- Type 2 Equigranular. Pale, fine to coarse-grained granite.
- Maulin Formation (Ribband Group). Schist & pelites.
- Butter Mountain Formation (Ribband Group). Dark slate-schist.
- Fault & Satellite Lineament
- Lineament (Fault?)

Abbreviations

BQL: Ballyedmond Quarry Linear
GF: Glencullen Fracture
GLF: Glenasmole-Glencree Fracture
SF: Sally Gap Fracture
LDF: Lough Dan Fracture
GDF: Glendasan Fracture
GMF: Glenmalur Fracture
GIORF: Glen of Imail/Ow River Fracture
ML: Moyne Linear

Figure 7.6:- Geological profile showing location of AFT samples with central age, mean track length (mtl) and standard deviation. Vertical exaggeration x6.

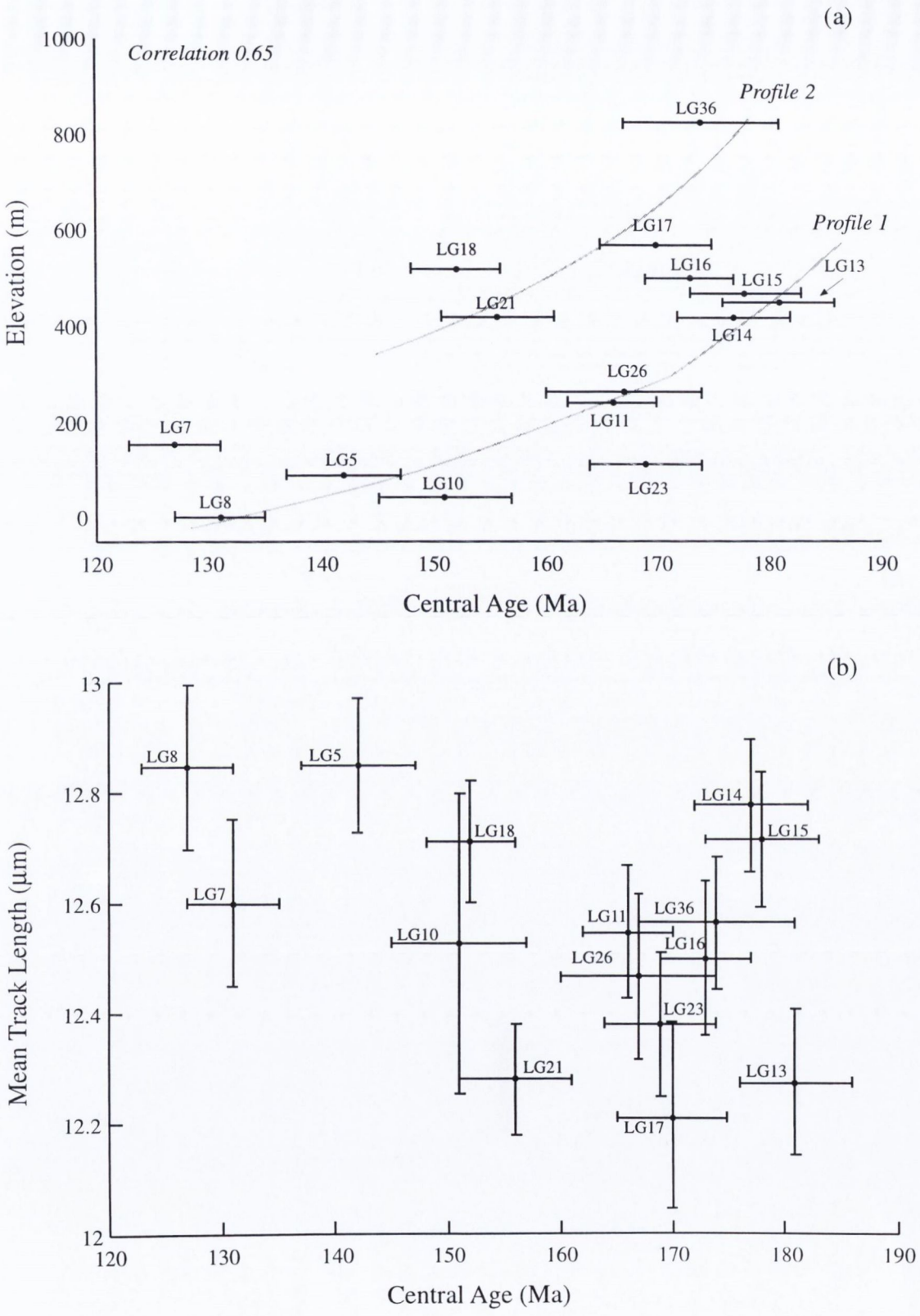


Figure 7.7a,b:- a) Plot of central age against elevation for the samples that fall along the profile. Note that there are two fossilised PAZ profiles that display spatial correlation with samples to the north and south of the Lough Dan fault. Note that sample LG23 (Tullow Lowland) forms an outlier to this relationship, compatible with faulting along the Baltinglass escarpment (chapters 5 & 6). b) Boomerang plot of profile samples indicating major ~Mid Jurassic cooling event.

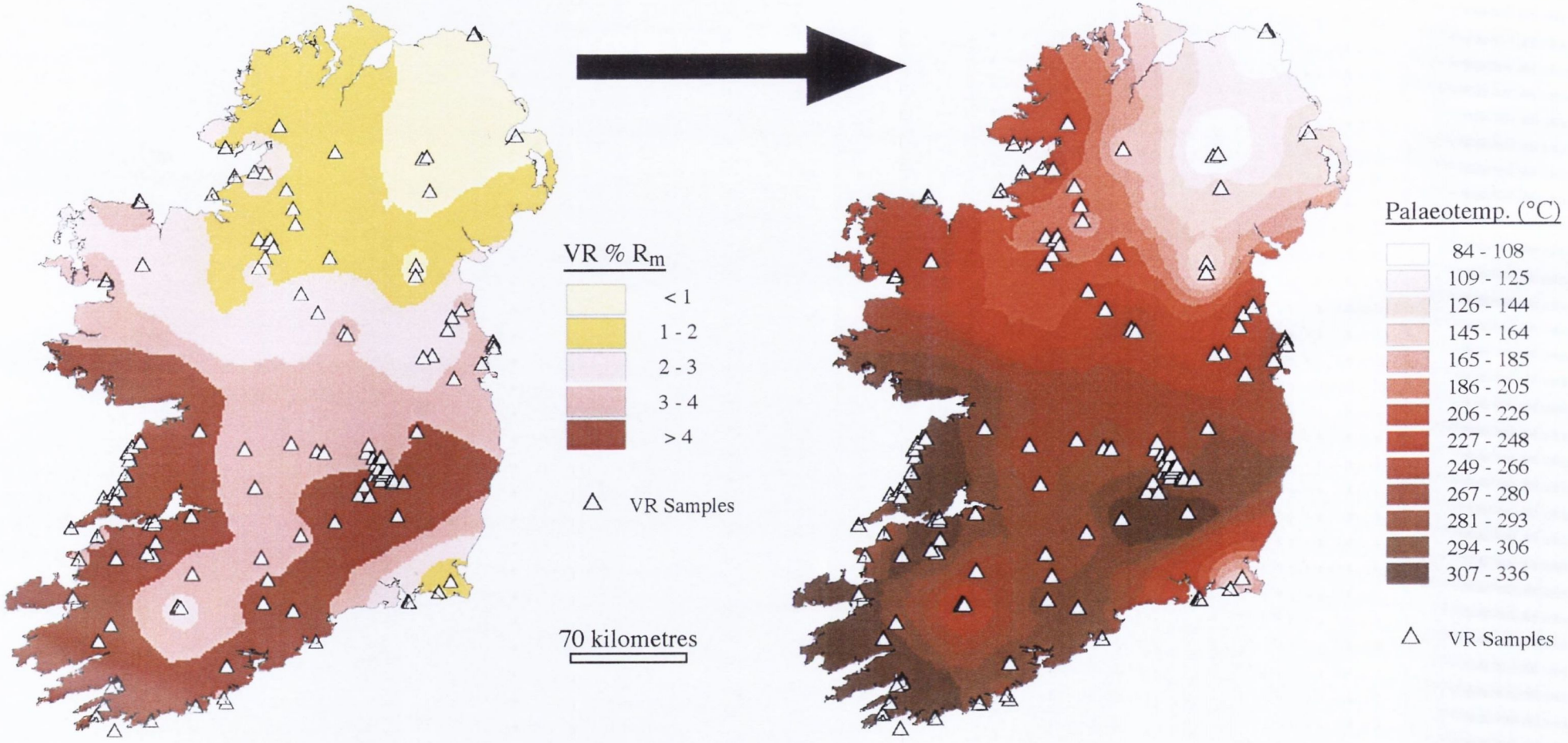


Figure 7.8a,b:- Maps of a) vitrinite reflectance [after Clayton *et al.*, 1989] and b) modelled palaeotemperature.

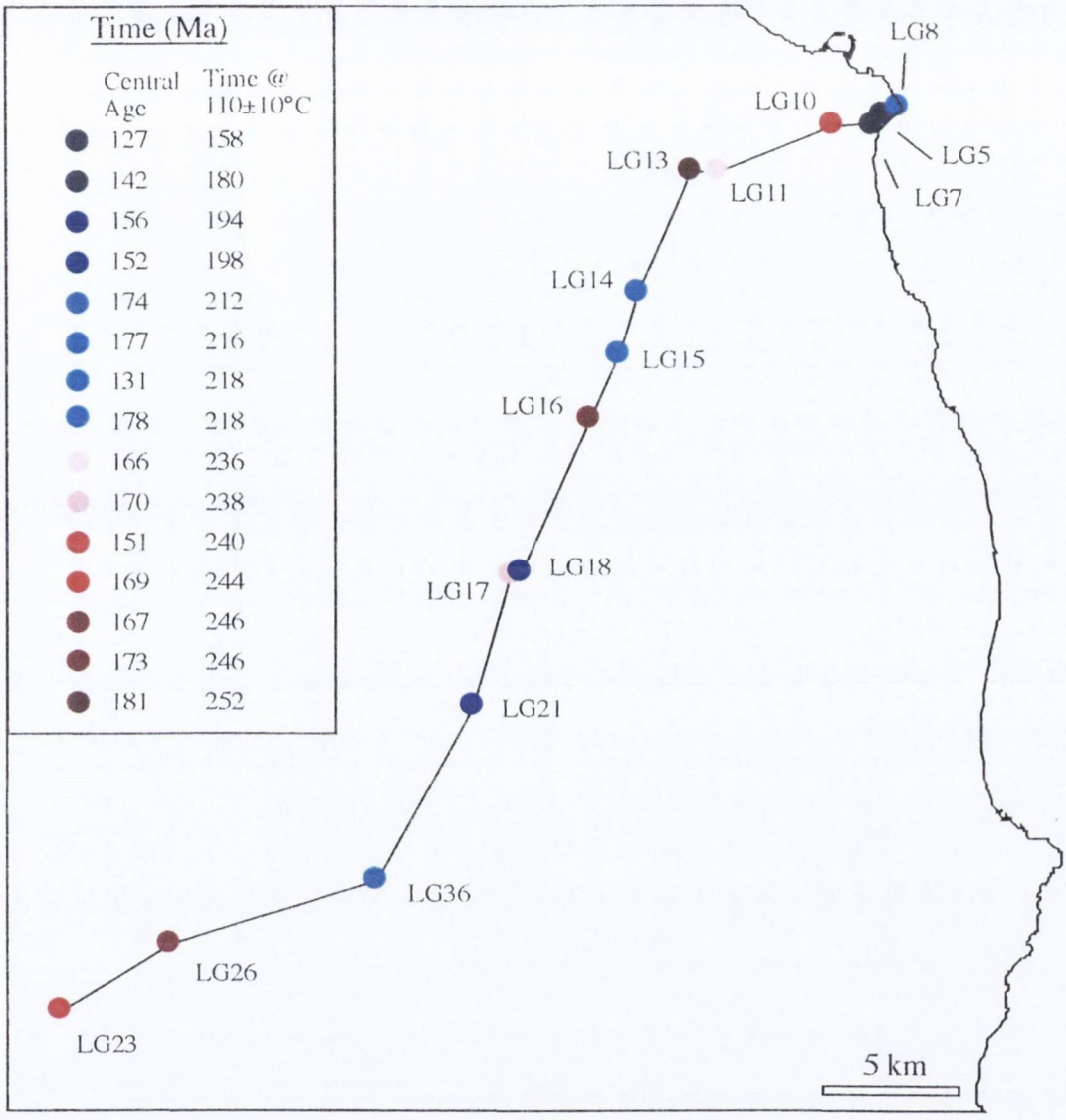


Figure 7.9:- Thermal modelling of AFT profile samples showing time of cooling to palaeotemperatures <110±10°C. Most samples began cooling at Mid Jurassic times.

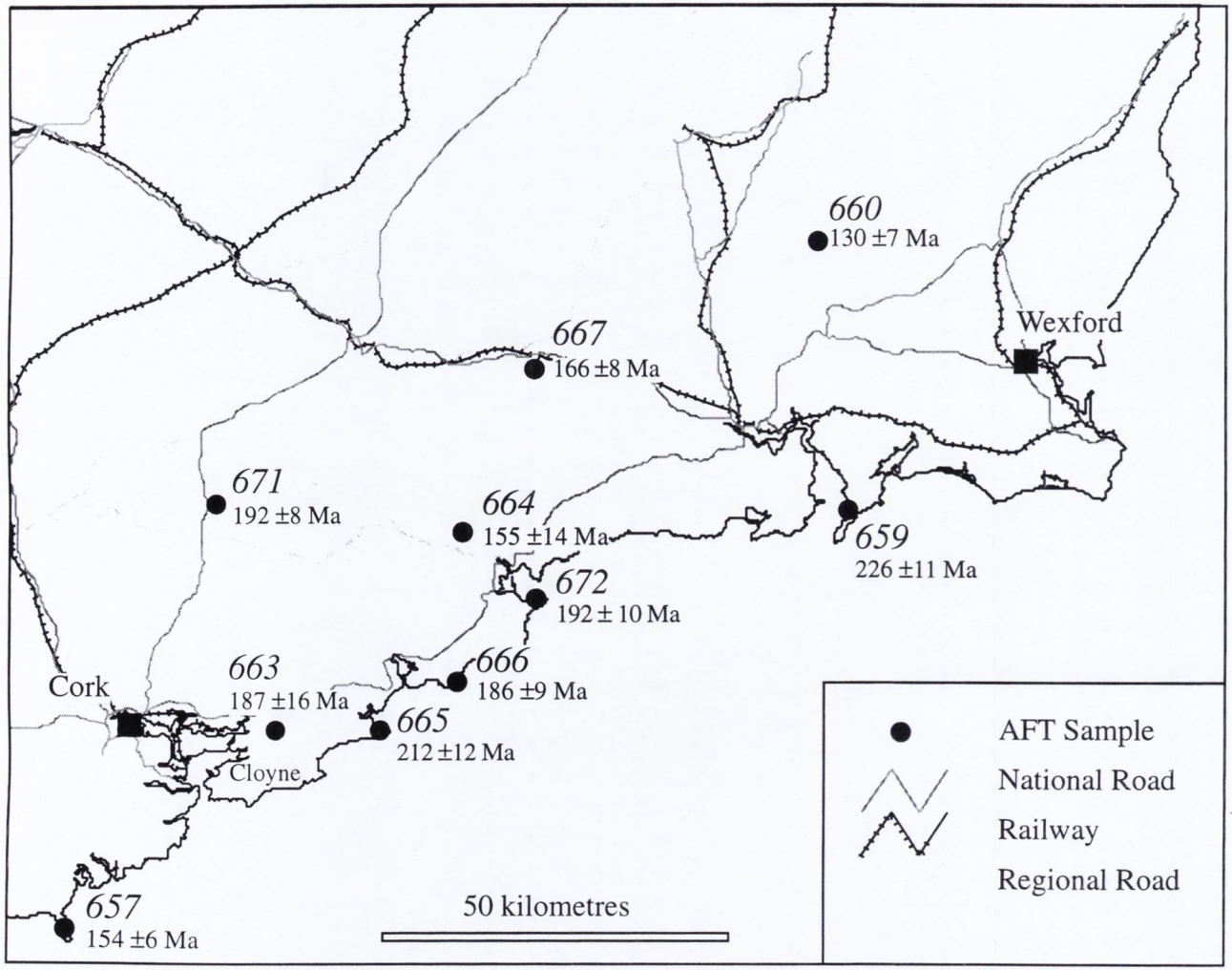


Figure 7.10:- Map showing AFT study of Keeley *et al.,* (1993) in SE Ireland. Note that they quote the 'pooled' ages.

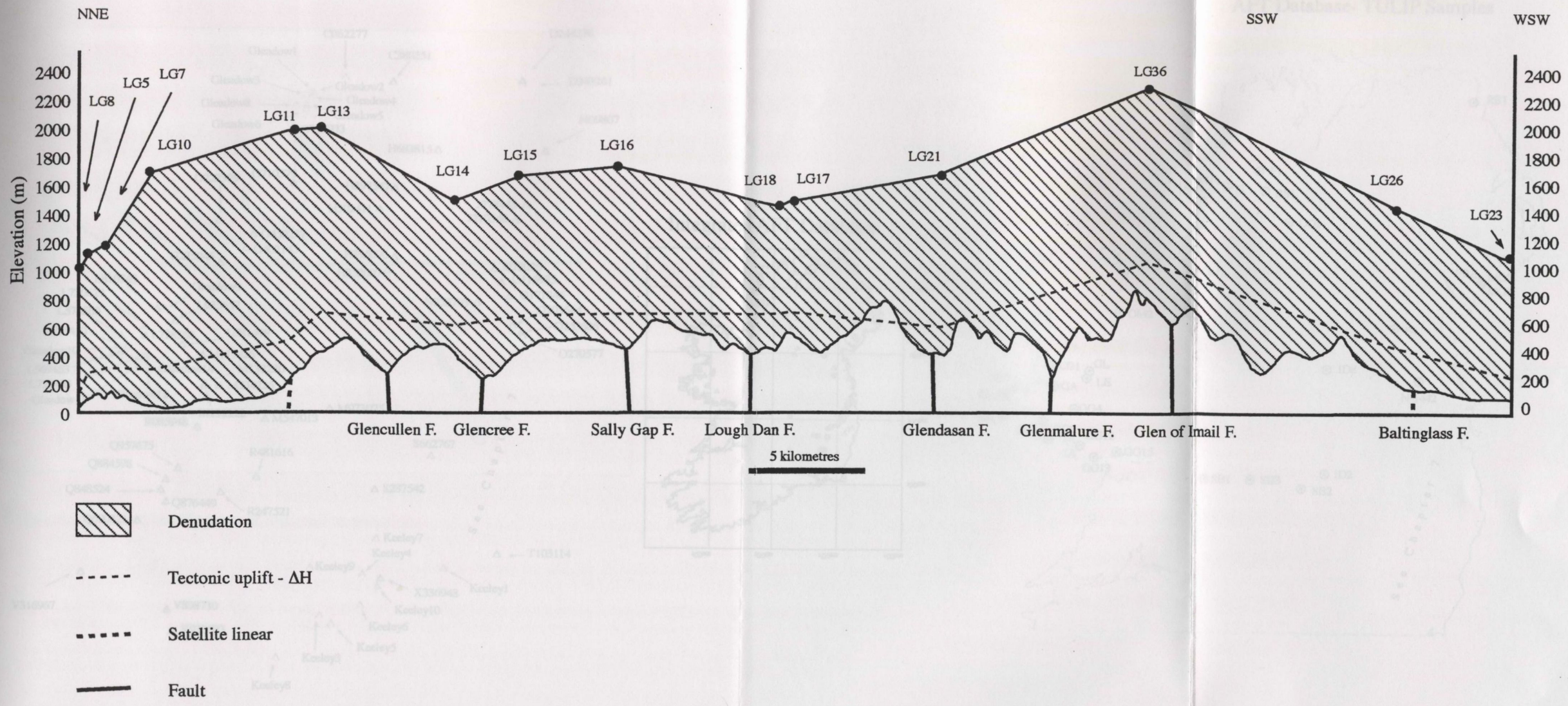
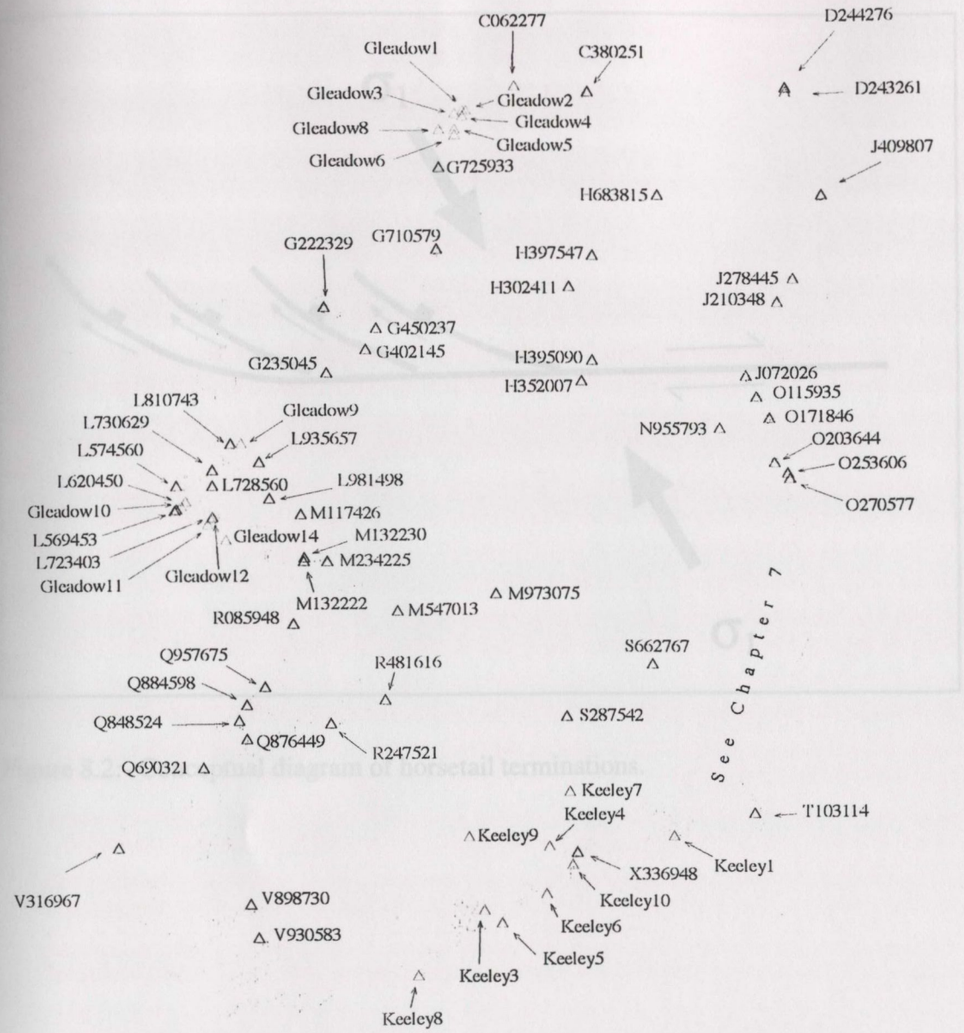


Figure 7.11:- Profile showing modelled values of Tertiary denudation (solid line) and tectonic uplift (dotted line) of AFT samples. Results based on Gallagher (in prep.) annealing model with a palaeogeothermal gradient of 22°C km^{-1}.

AFT Database - Public Domain



△ Keeley *et al.* 1993

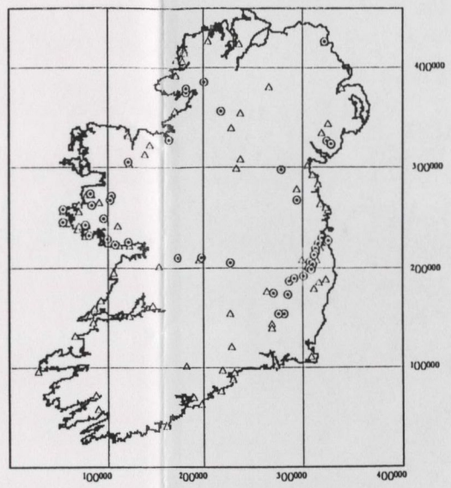
△ McCulloch 1993

△ McCulloch 1994

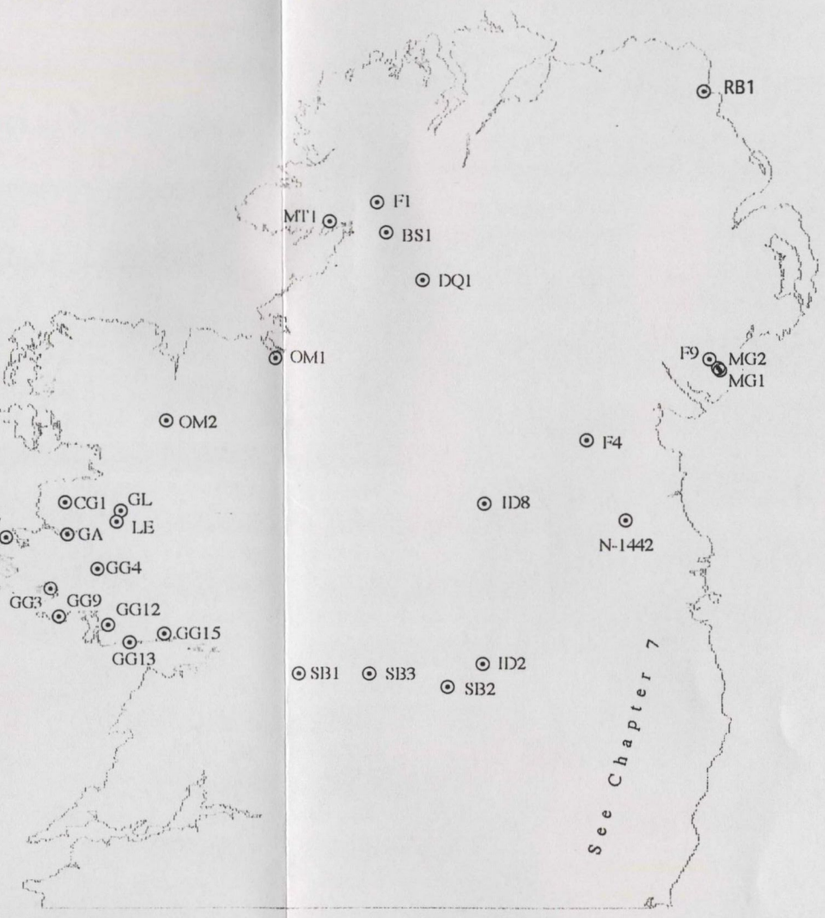
△ McCulloch Unpublished

△ Gleadow Unpublished

Integrated AFT Database



AFT Database- TULIP Samples



△ Samples - Public Domain

⊙ Samples - TULIP

Figure 8.1:- TULIP AFT database.

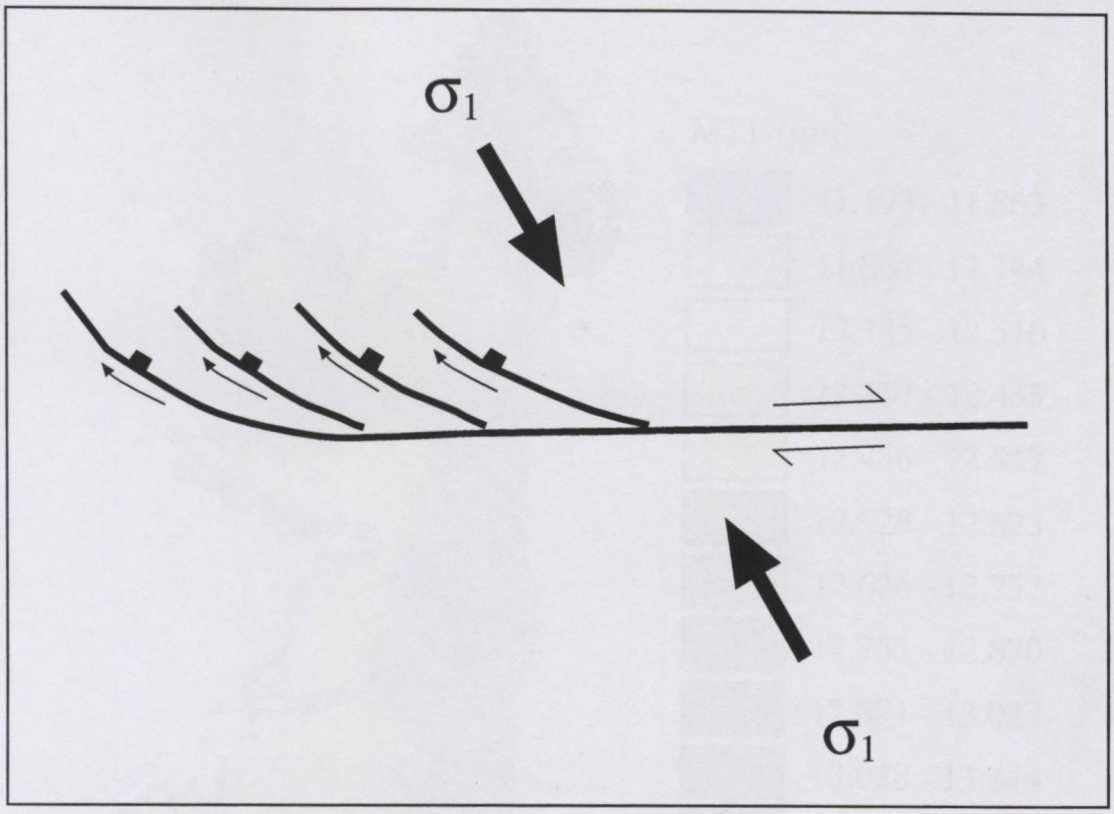


Figure 8.2:- Conceptual diagram of horsetail terminations.

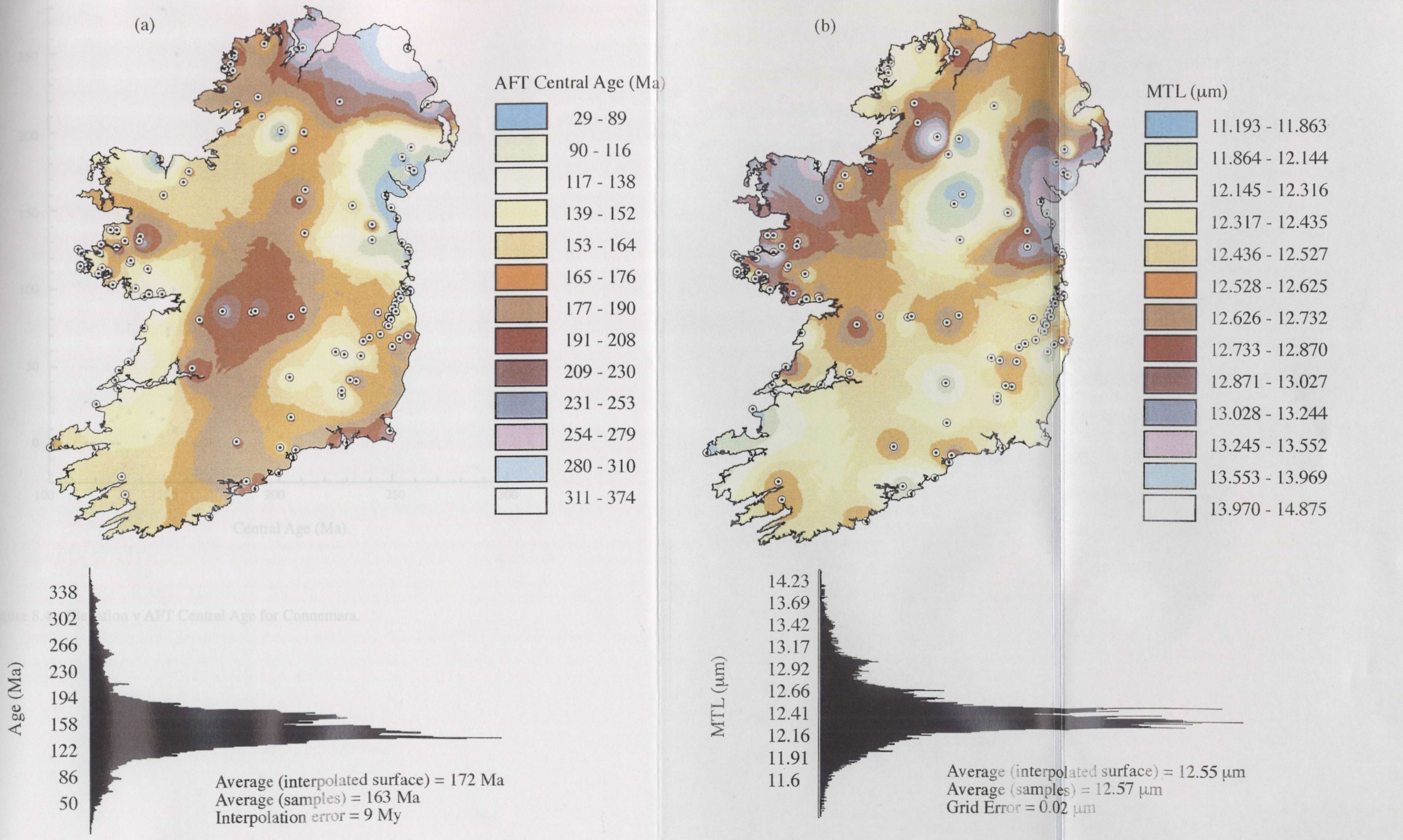


Figure 8.3a,b:- Maps of Ireland showing a) AFT central age , and b) MTL.

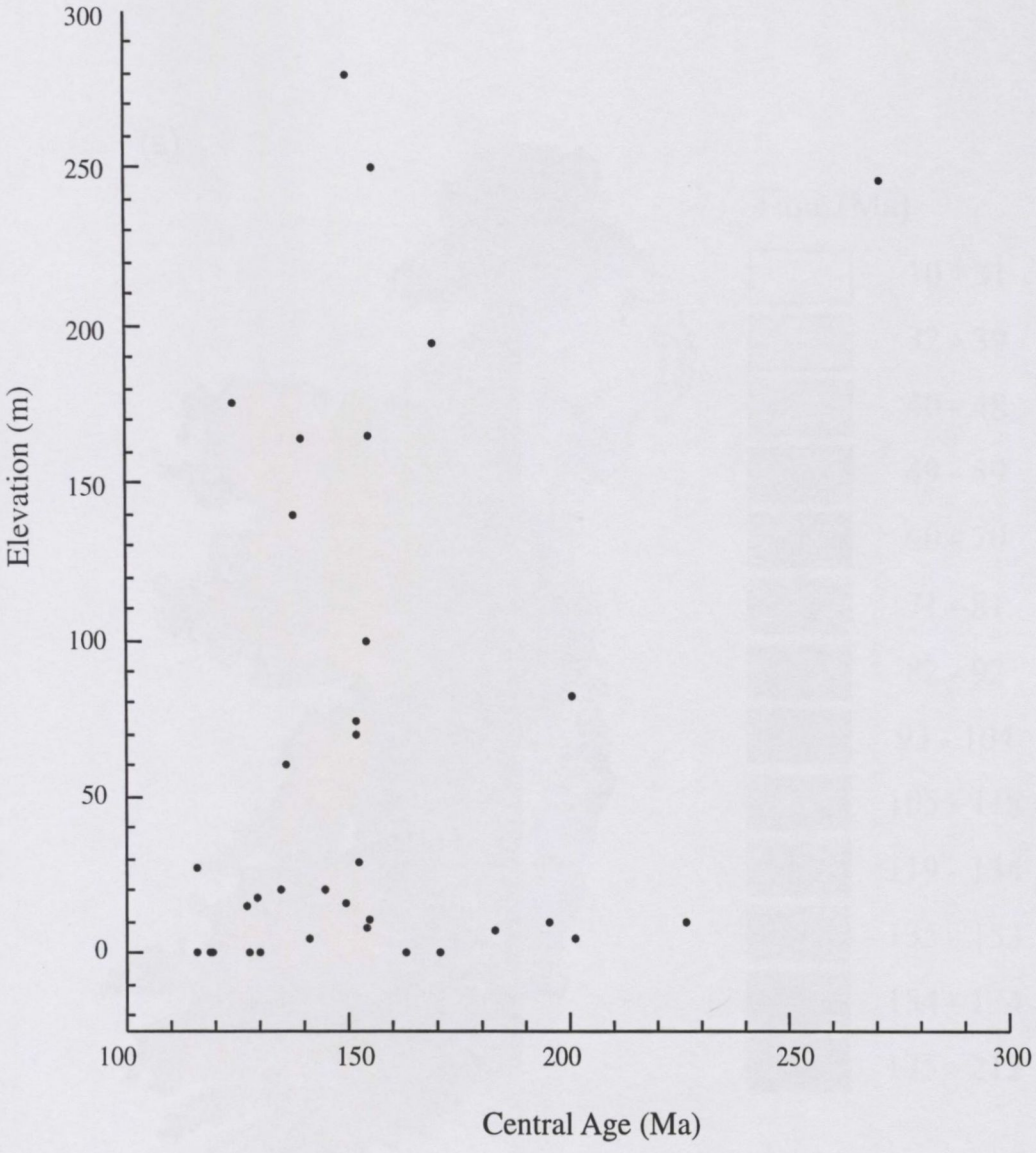


Figure 8.4:- Elevation v AFT Central Age for Connemara.

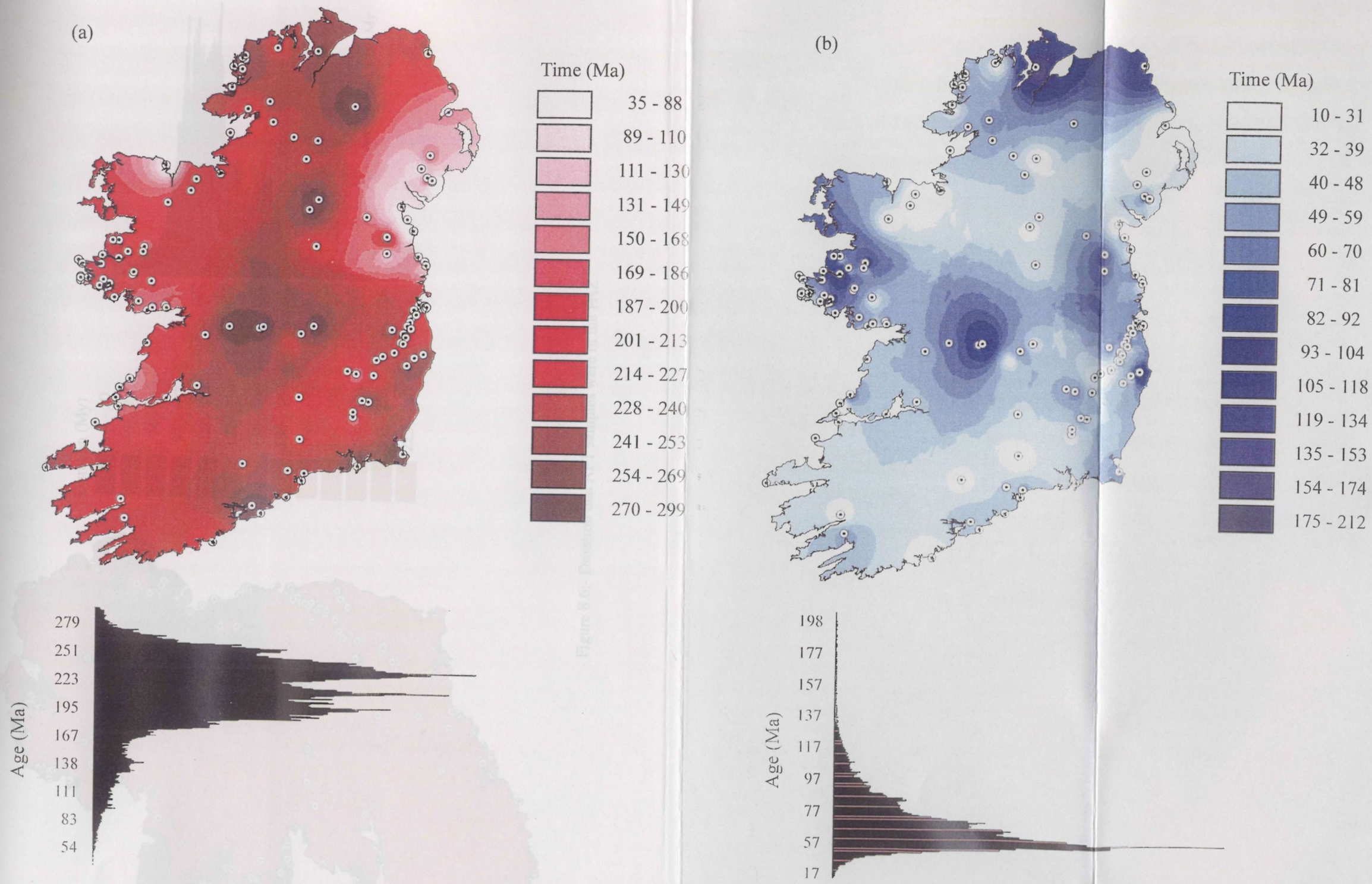


Figure 8.5a,b:- Thermal modelled histories of TULIP samples. a) Time at which samples entered the PAZ (<110±10°C), and; b) time at which samples left PAZ (<60±10°C).

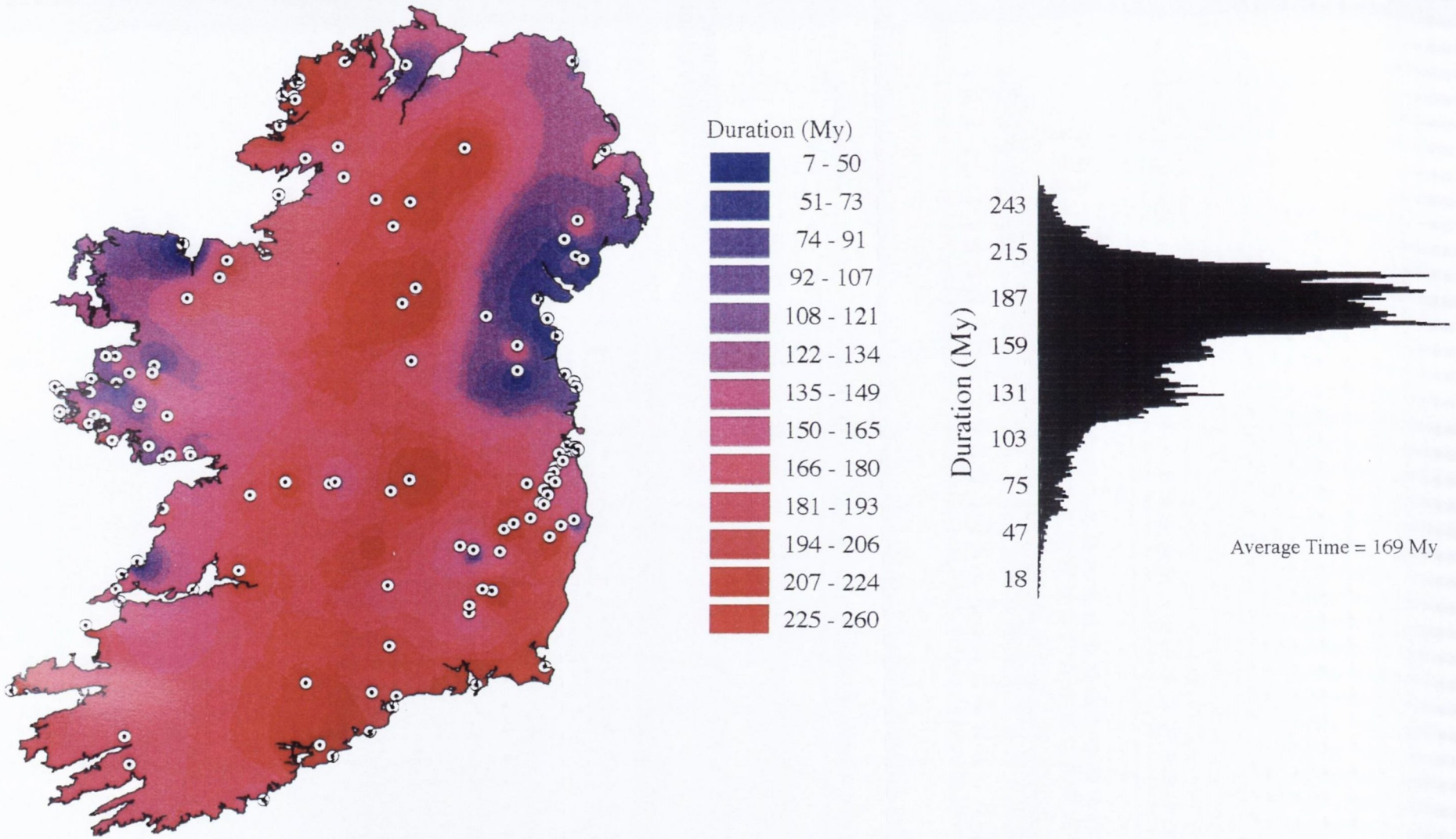


Figure 8.6:- Duration that AFT samples were in the PAZ.

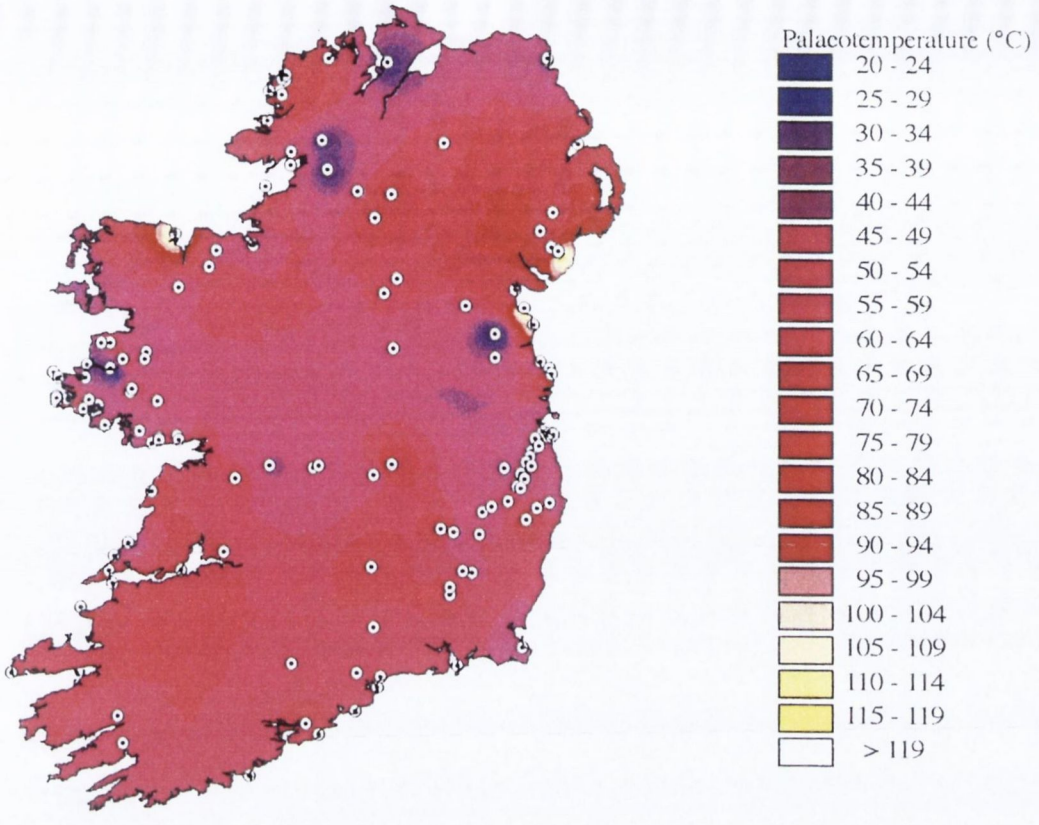


Figure 8.7:- Early Tertiary palaeotemperatures of contoured AFT modelled samples using the Laslett *et al.*, (1987) annealing model.

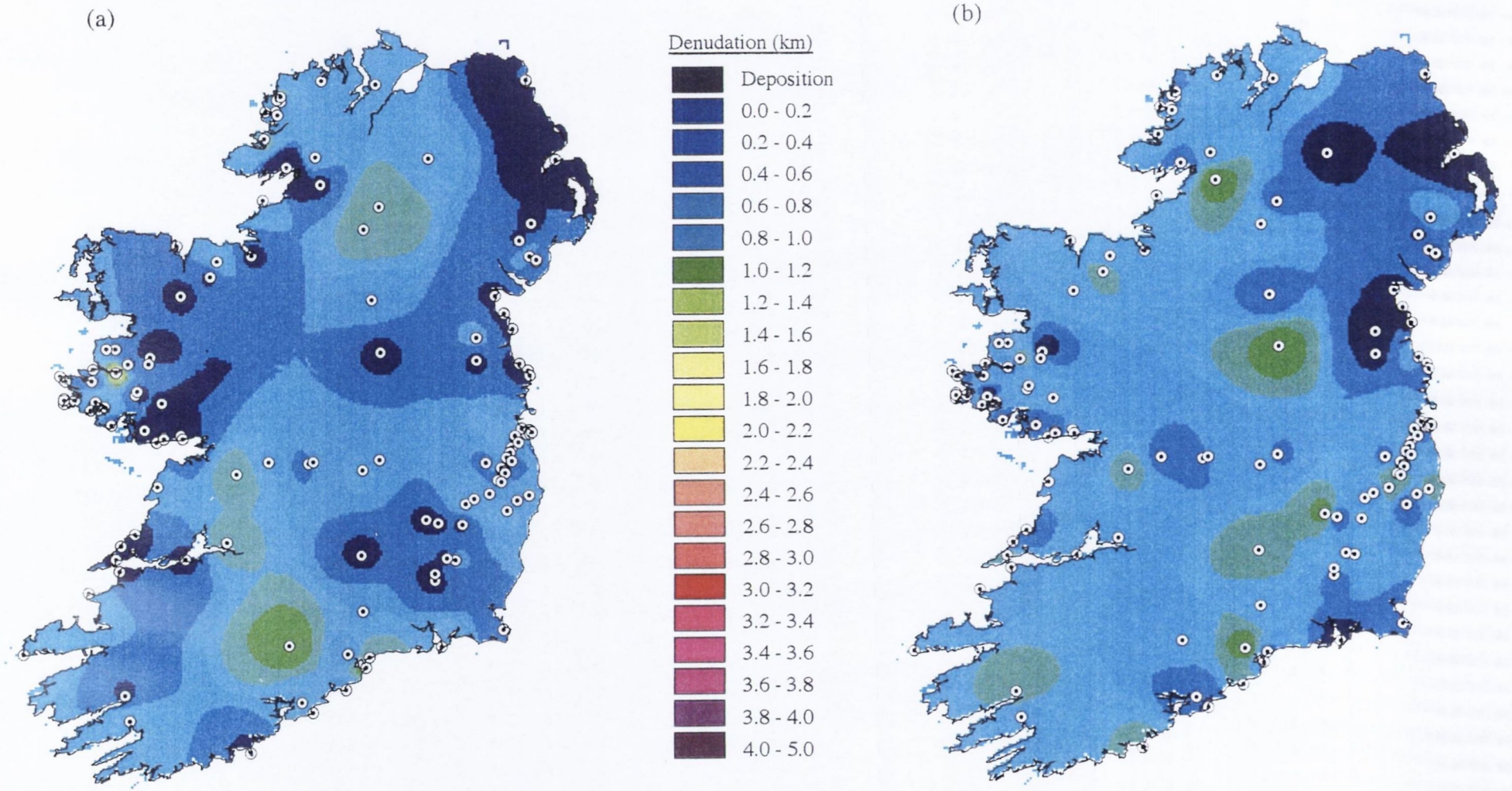


Figure 8.8a,b:- Denudation for Triassic to upper Lower Jurassic. a) computed using geothermal gradient of 40°C km^{-1}, b) computed using geothermal gradient of 36°C km^{-1}.

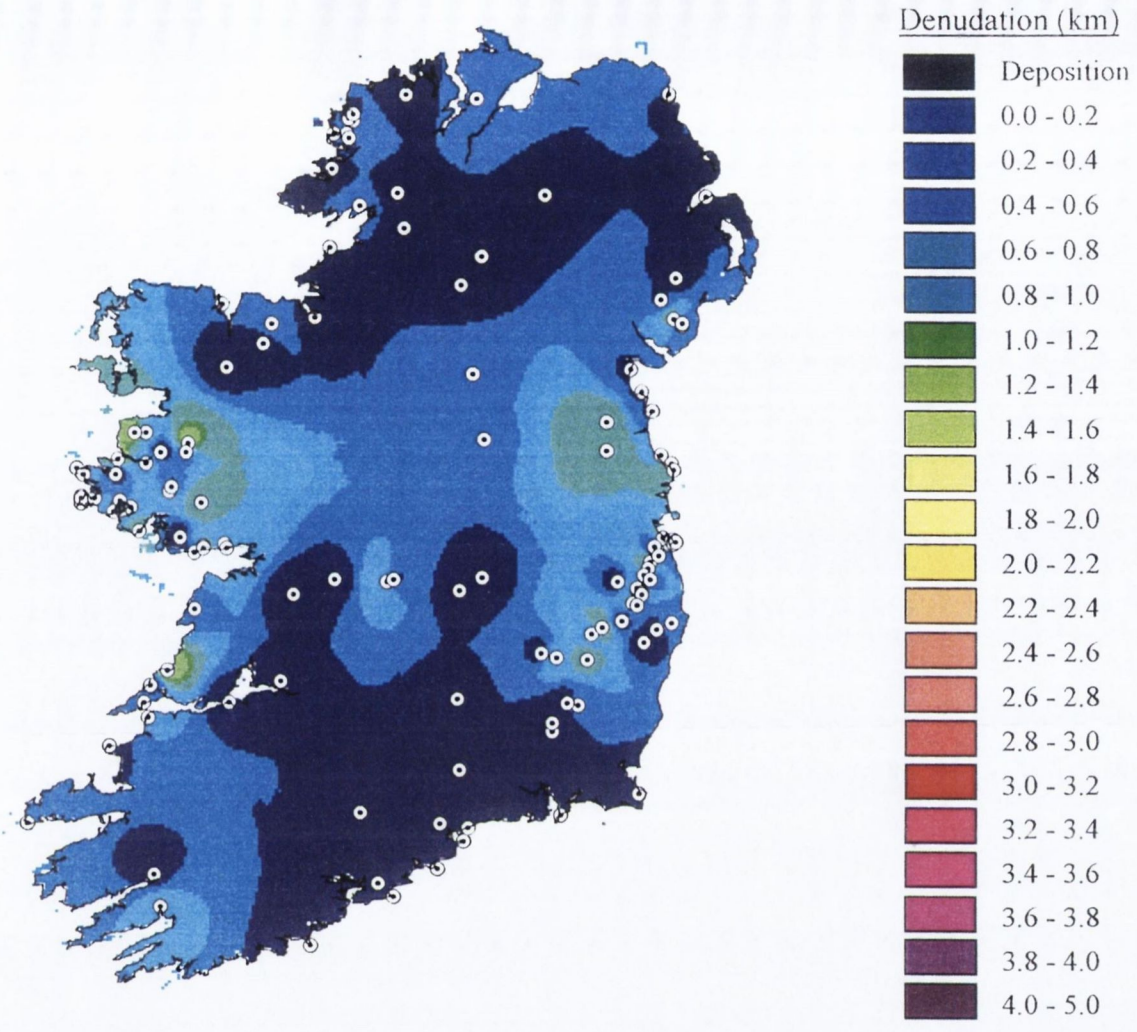


Figure 8.9:- Denudation for Early Cretaceous. Calculated using a geothermal gradient of 27°C km^{-1}.

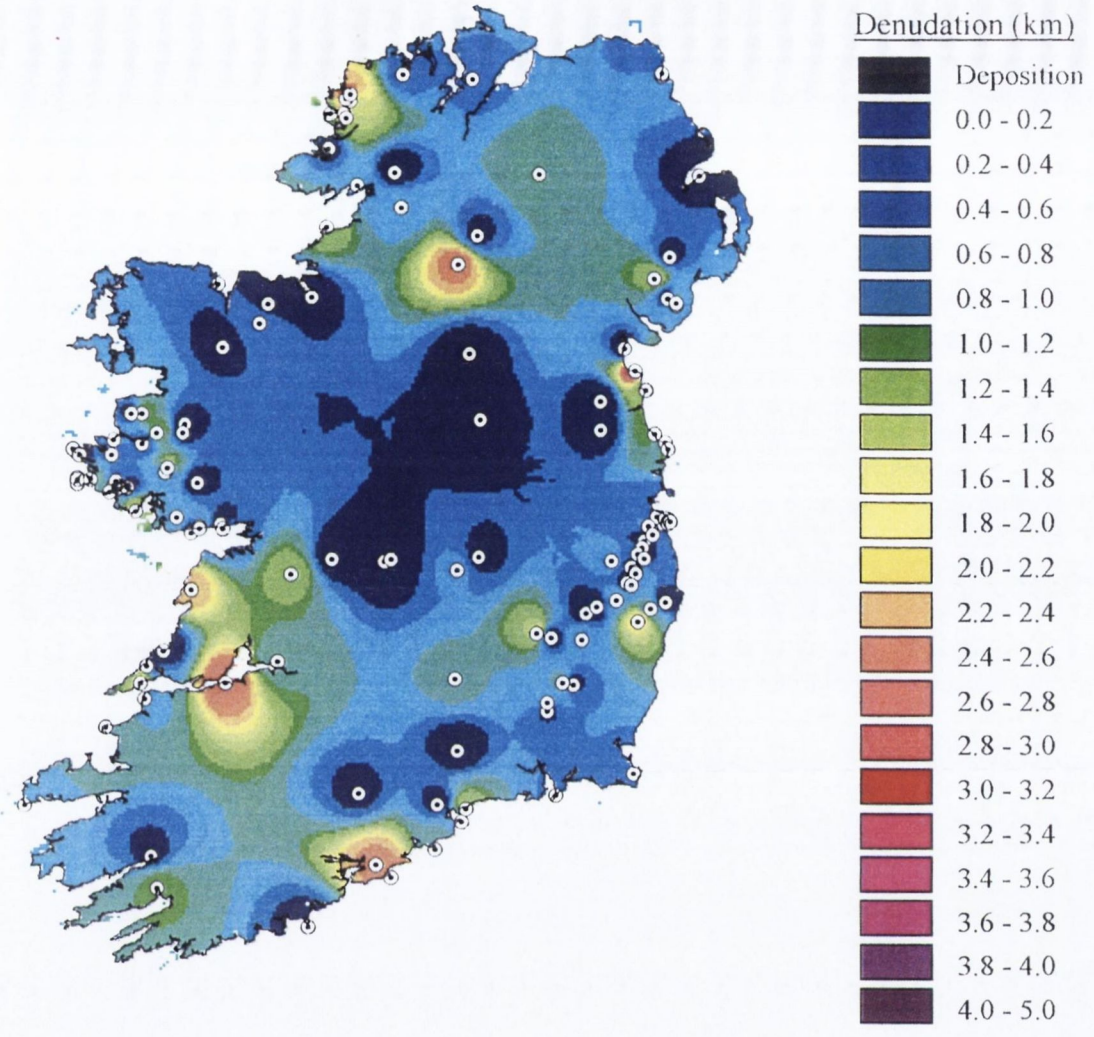


Figure 8.10:- Denudation for Palaeogene. Calculated using a geothermal gradient of 22°C km^{-1}.

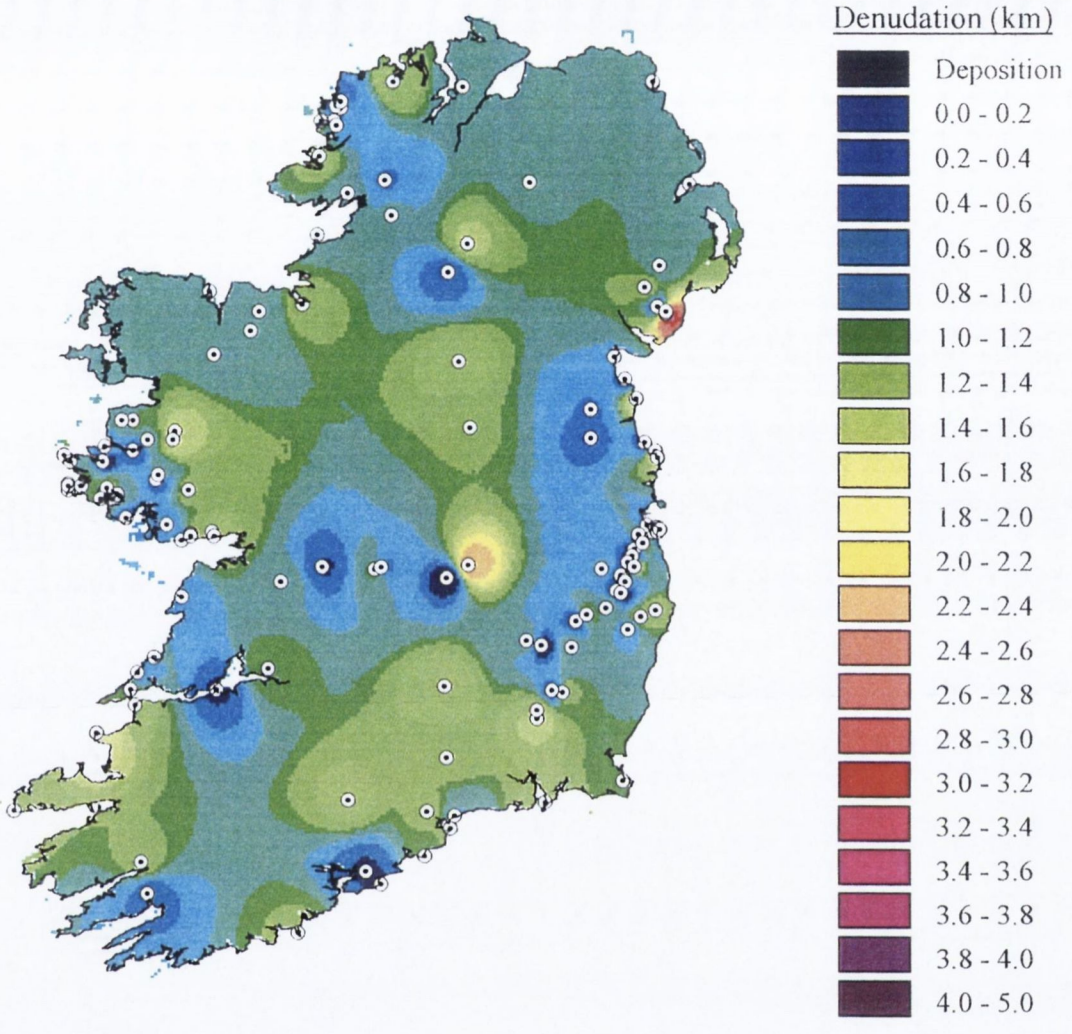


Figure 8.11:- Denudation for Neogene . Calculated using a geothermal gradient of 22°C km^{-1}.

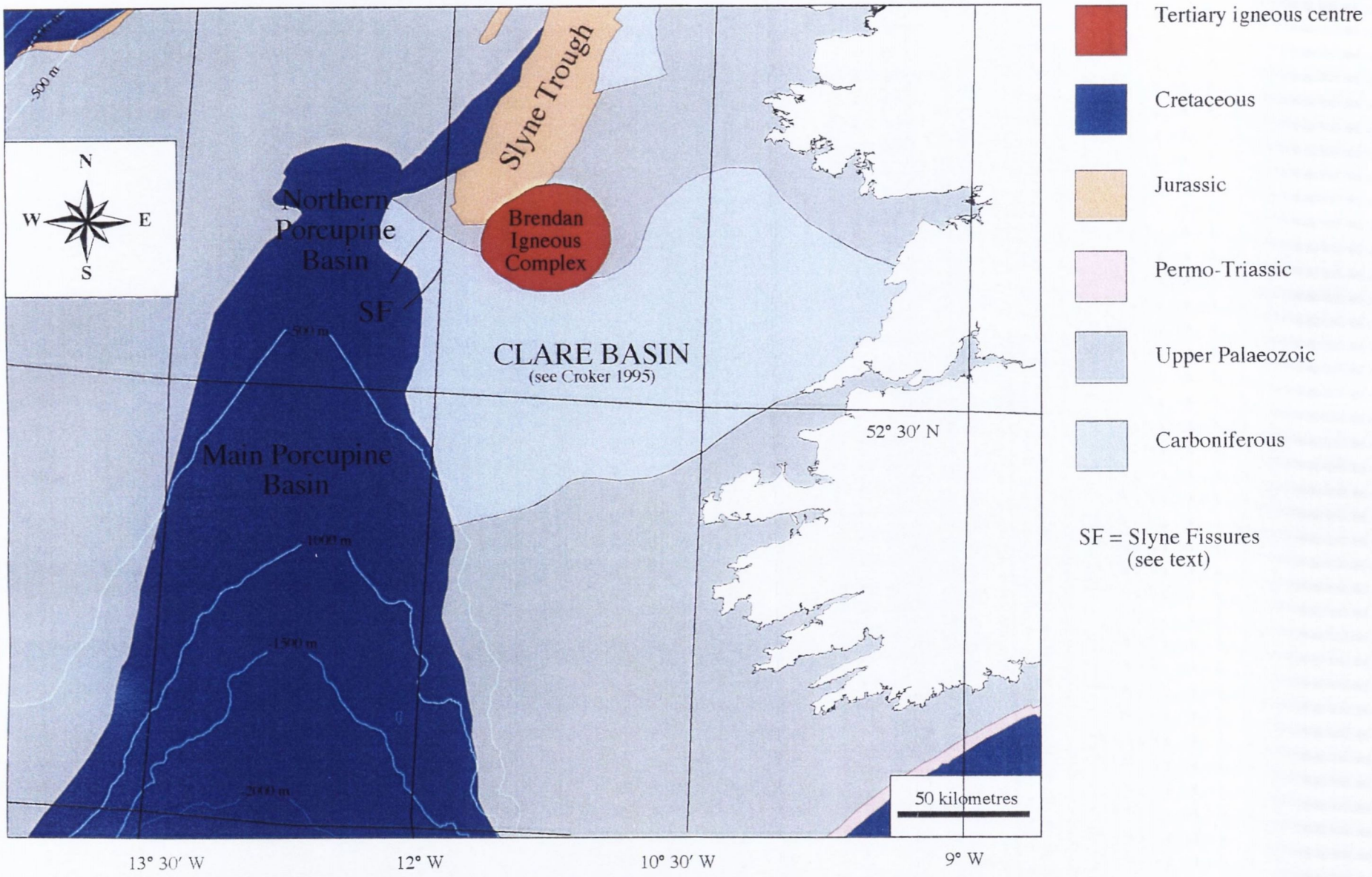
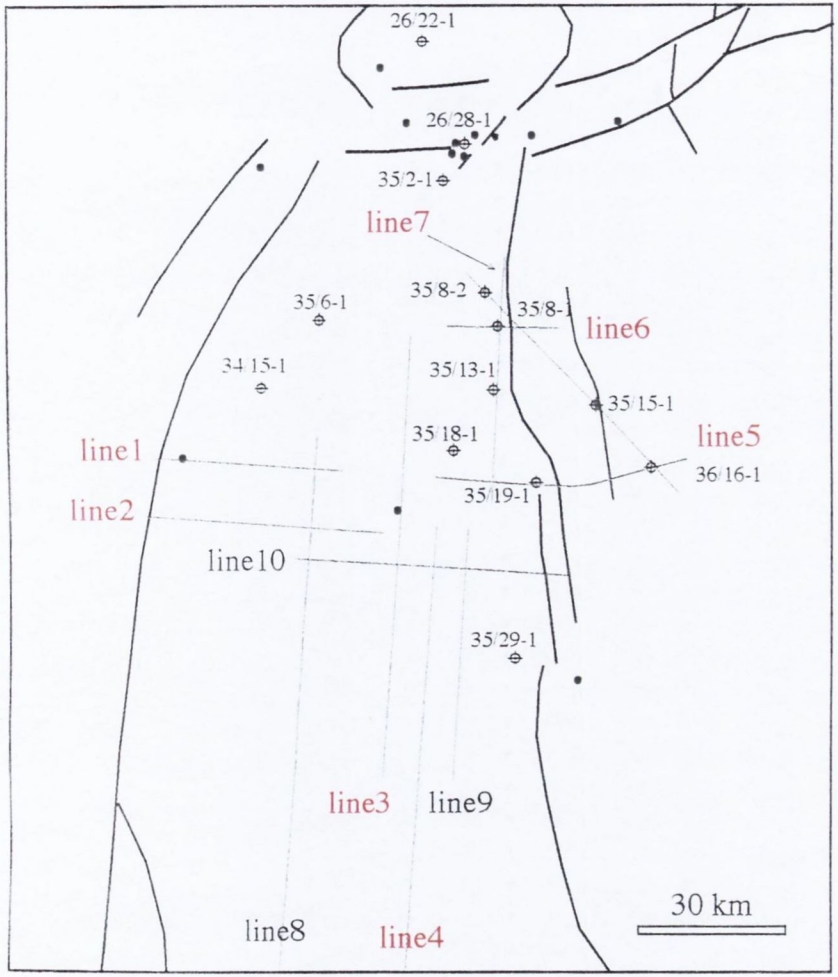
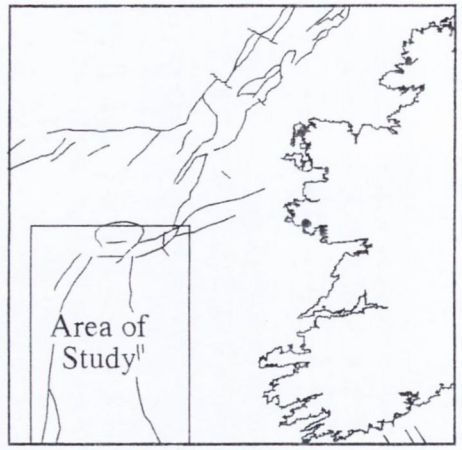


Figure 8.12:- Regional map of Porcupine Basin and adjacent areas.





⊕ Logged Wells (Appendix 7)

• Other Wells

—— Seismic lines (Appendix 8)

Figure 8.13:- Location map of seismic lines and wells. Note that all lines shown were used for interpretation of structure and deposition, but only those coloured red are shown in Appendix 8.

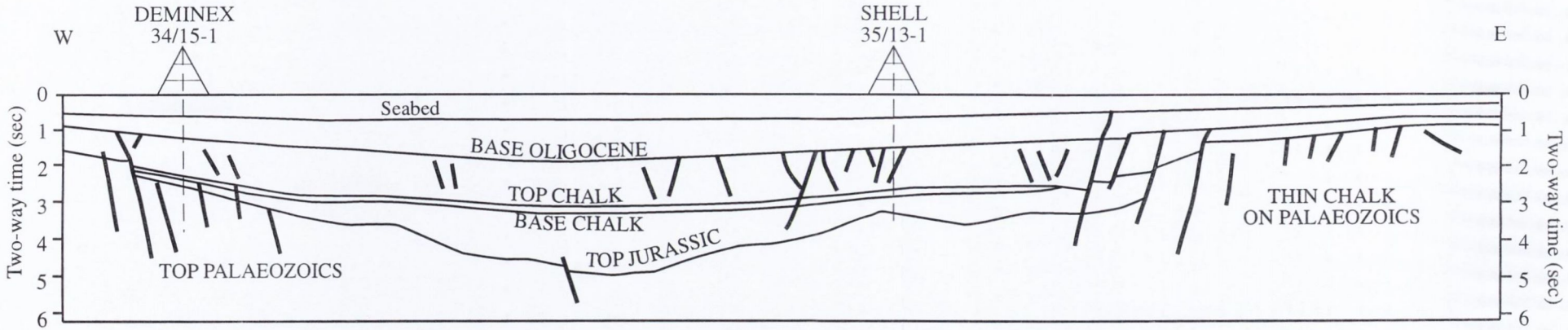


Figure 8.14:- Regional E-W geoseismic interpretation showing typical steer's head profile (after Croker & Shannon, 1987).

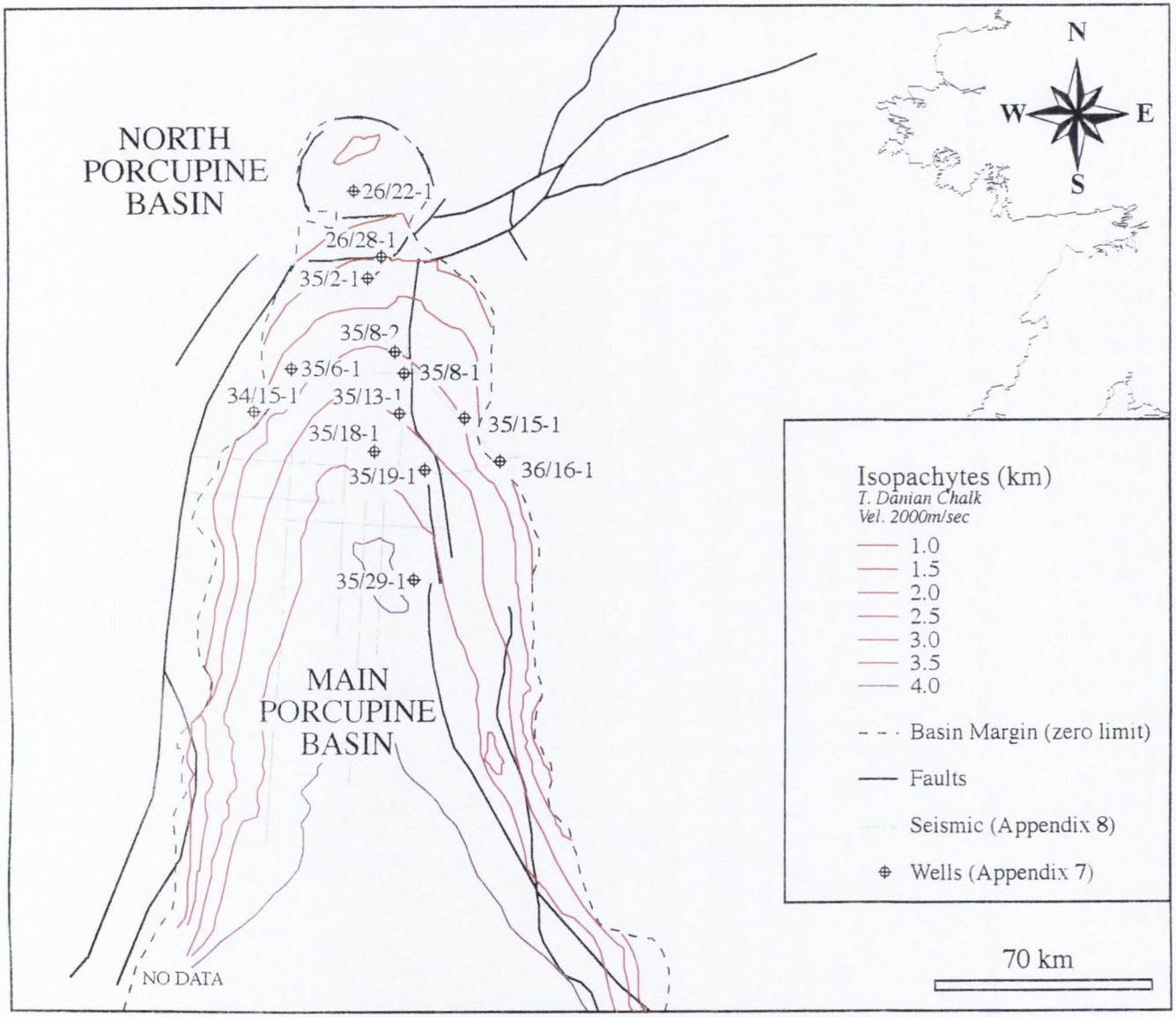


Figure 8.15:- Tertiary isopach map of the Main Porcupine Basin (after Tate, 1993).

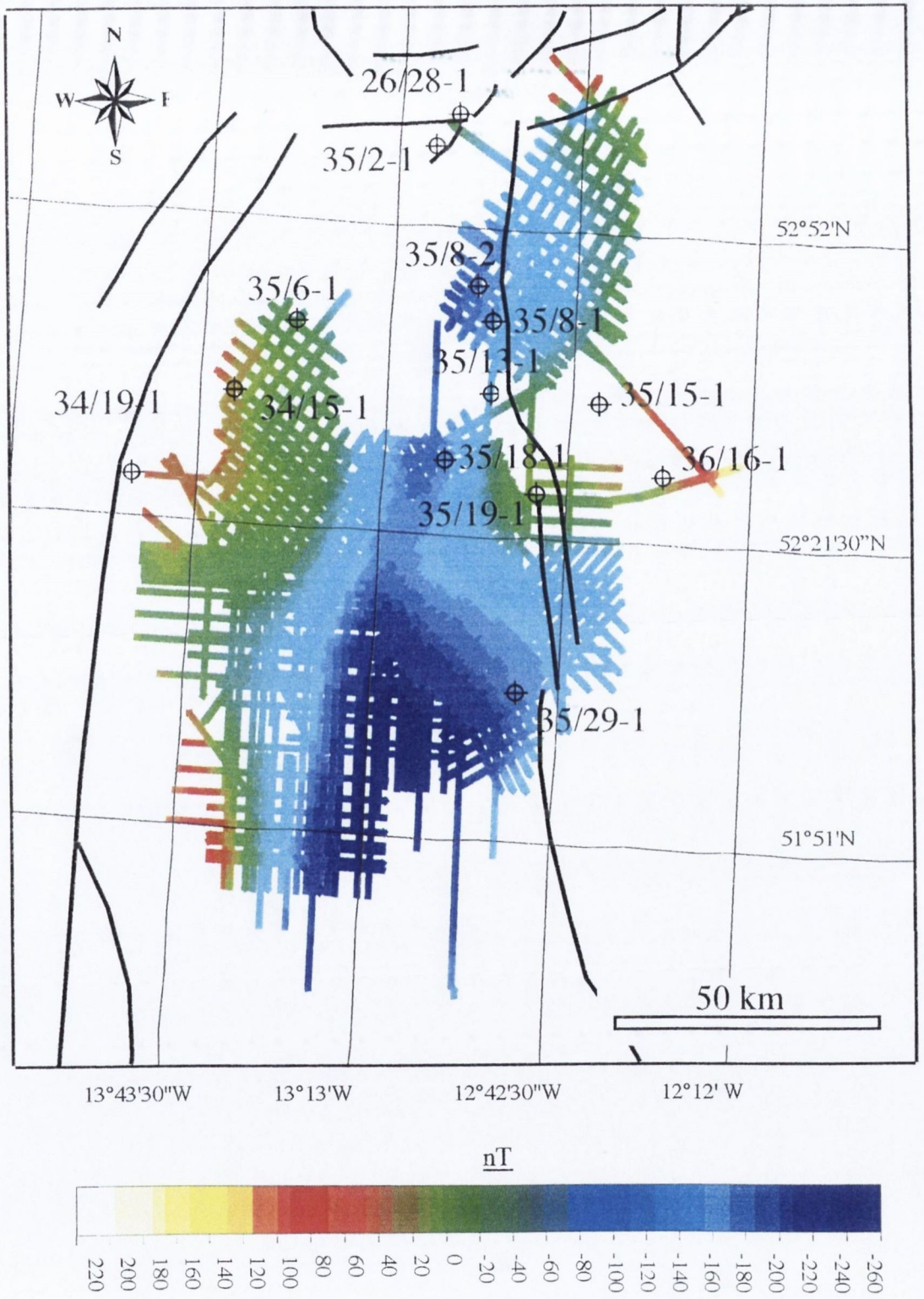


Figure 8.16:- Aeromagnetic (RTP) anomaly map of the Main Porcupine Basin.

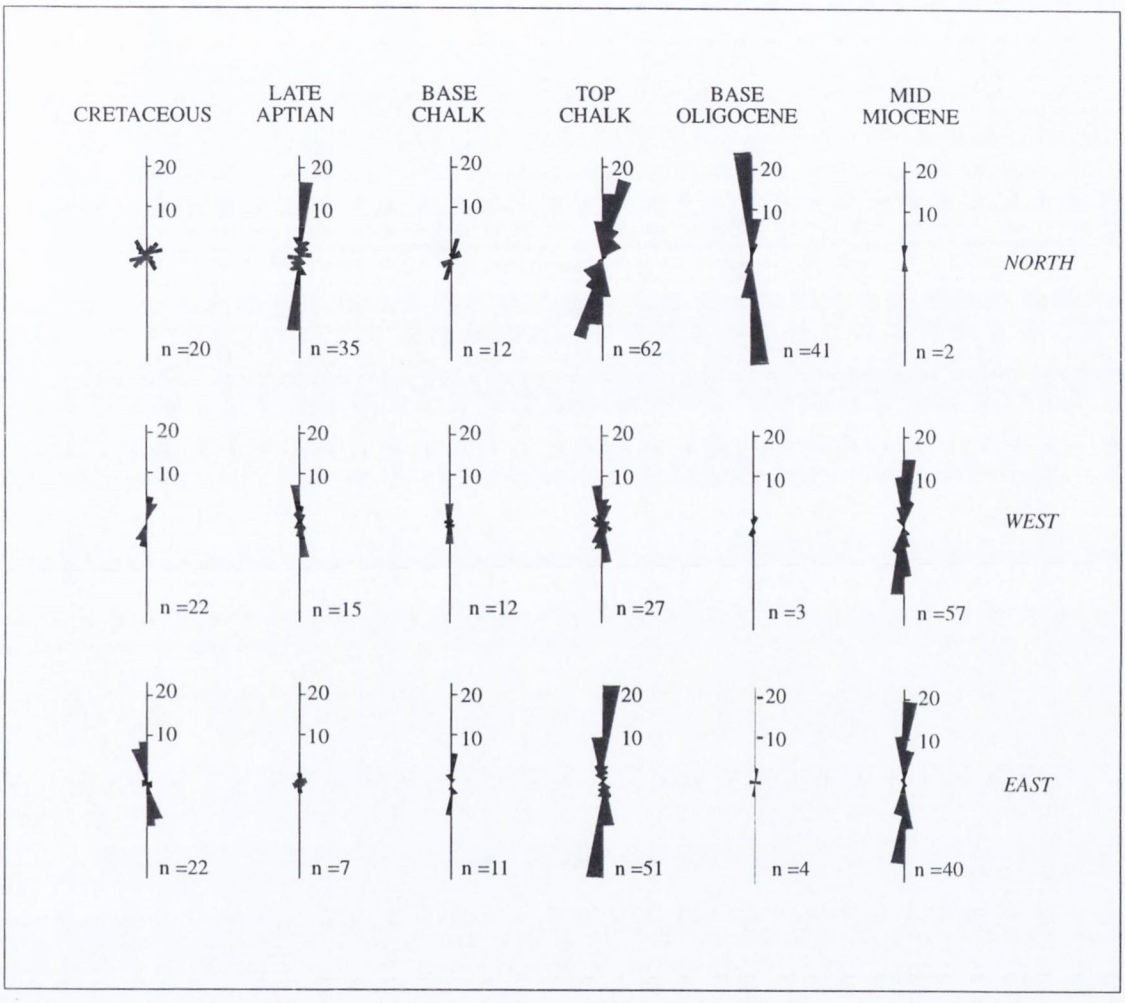


Figure 8.17:- Rose diagram of faults >5km - Porcupine Basin (after McCann *et al.,* 1995).

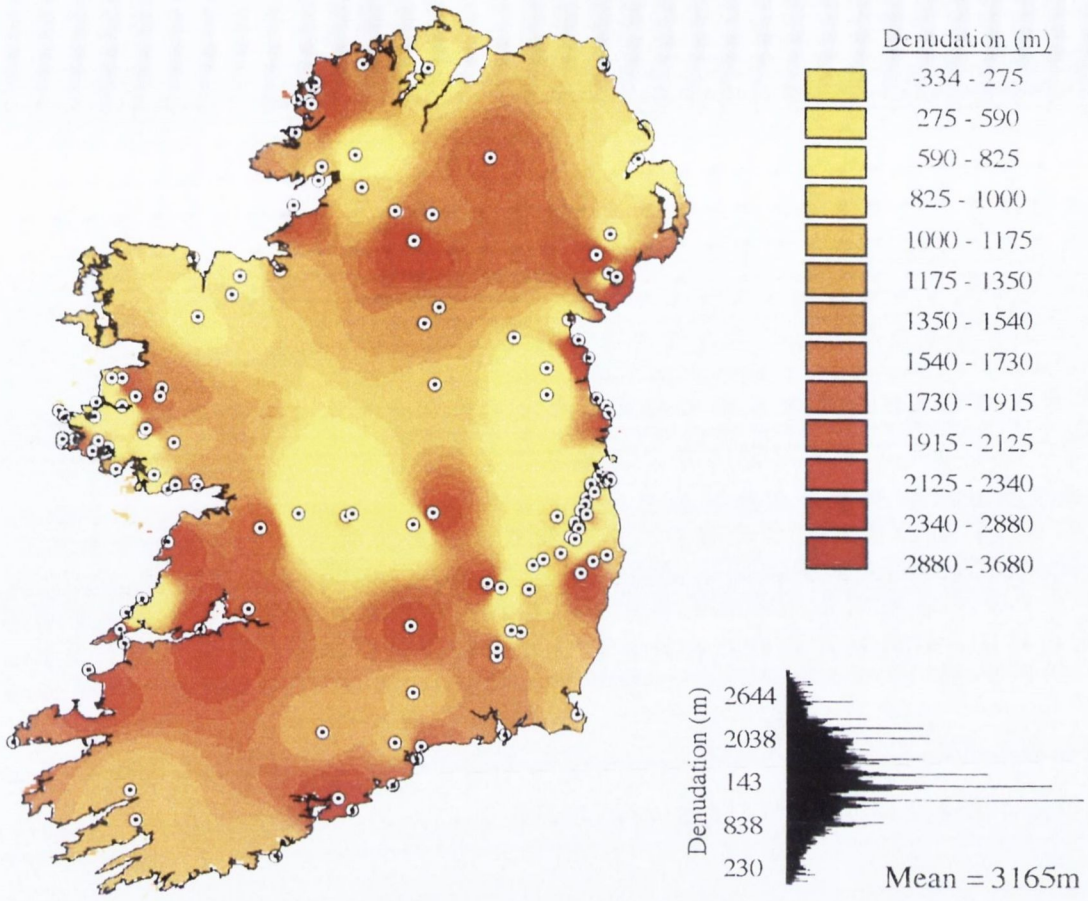


Figure 8.18:- Total Tertiary denudation based on AFT modelling (using the Laslett, *et al.*, (1987) annealing model).

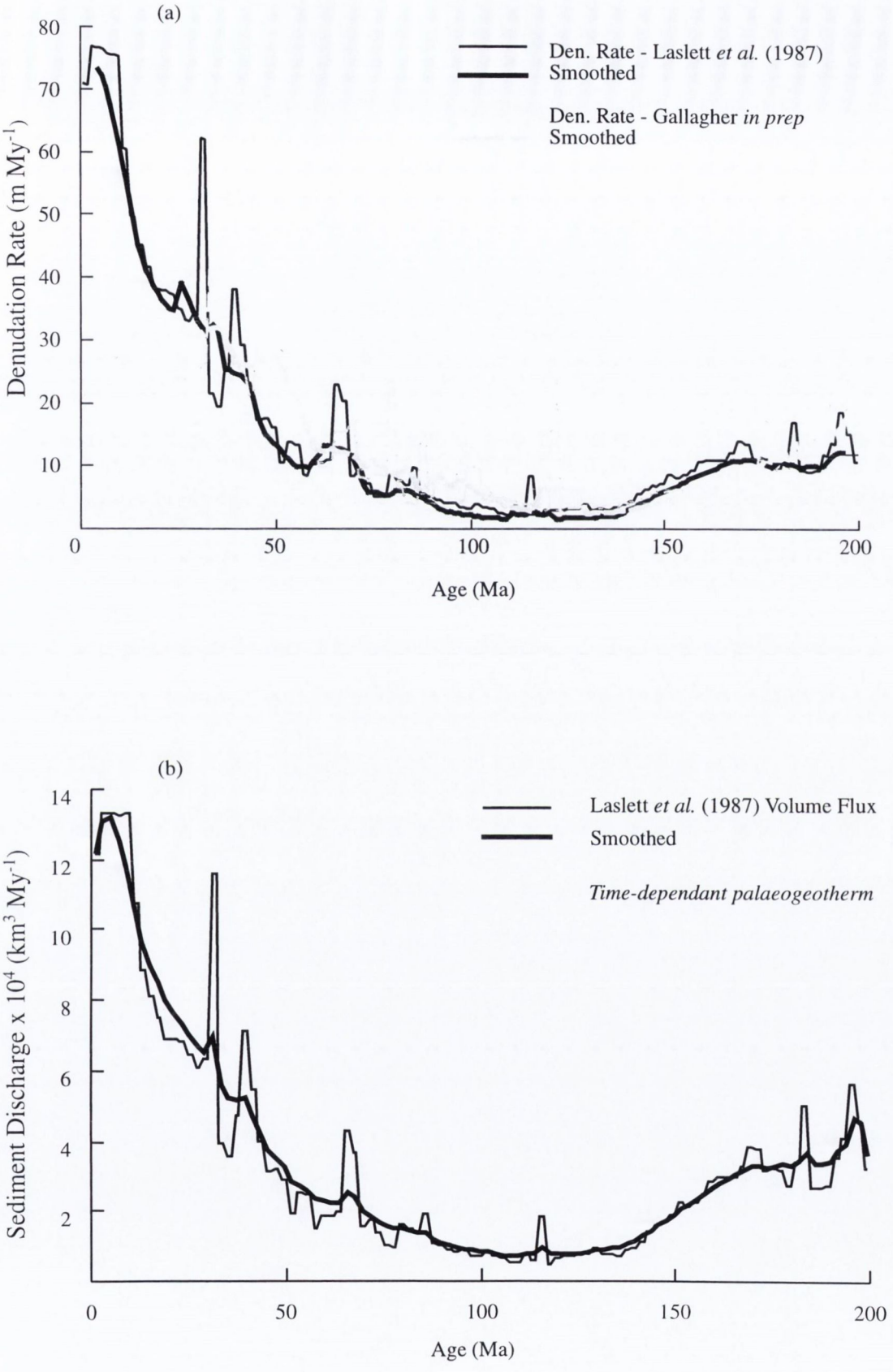


Figure 8.19a,b:- a) Average denudation rate and volumetric discharge for Ireland since the Triassic with a new annealing model (dashed line) that reduces the artefact of high denudation rates at temperatures < 60°C (Gallagher *in prep*); b) The volume of sediment exported from the area now occupied by the Irish landmass is an order of magnitude smaller than the preserved volume of Cenozoic sediment in the Porcupine-Rockall basin system.

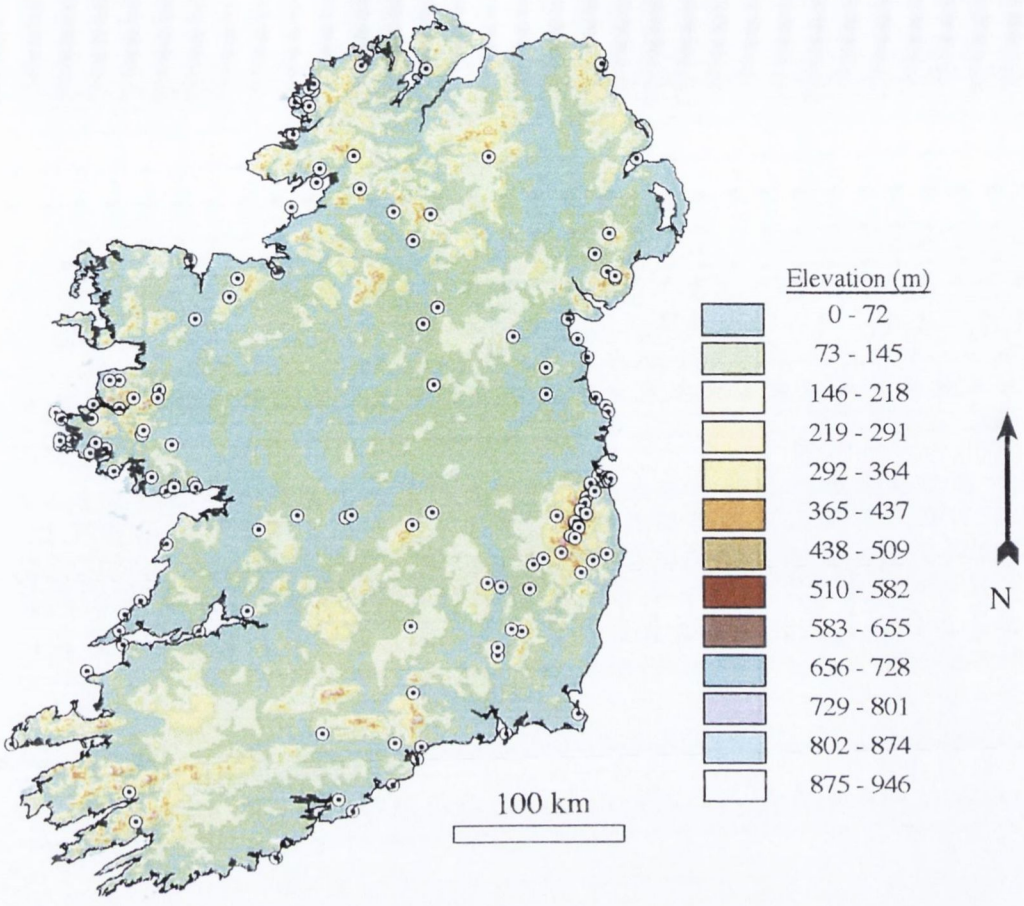


Figure 8.20:- DEM of Ireland at 1km^2 cell resolution.

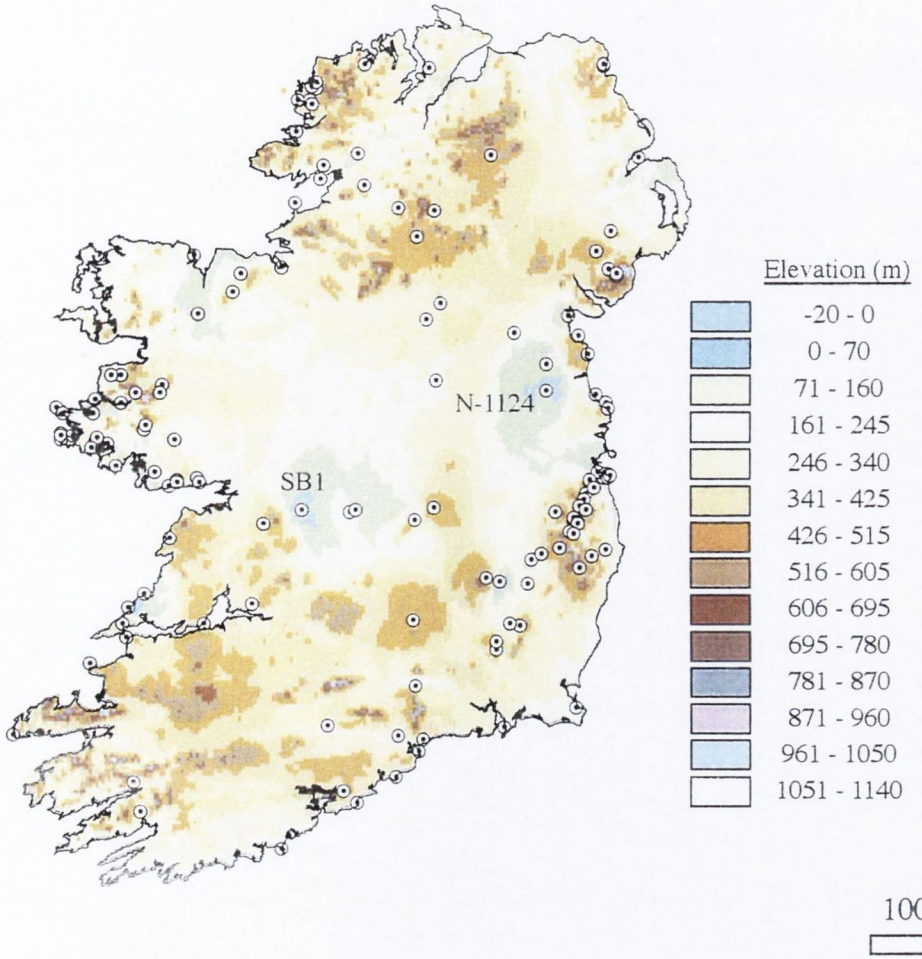


Figure 8.21:- Early Tertiary re-constructed palaeotopography without eustacy.

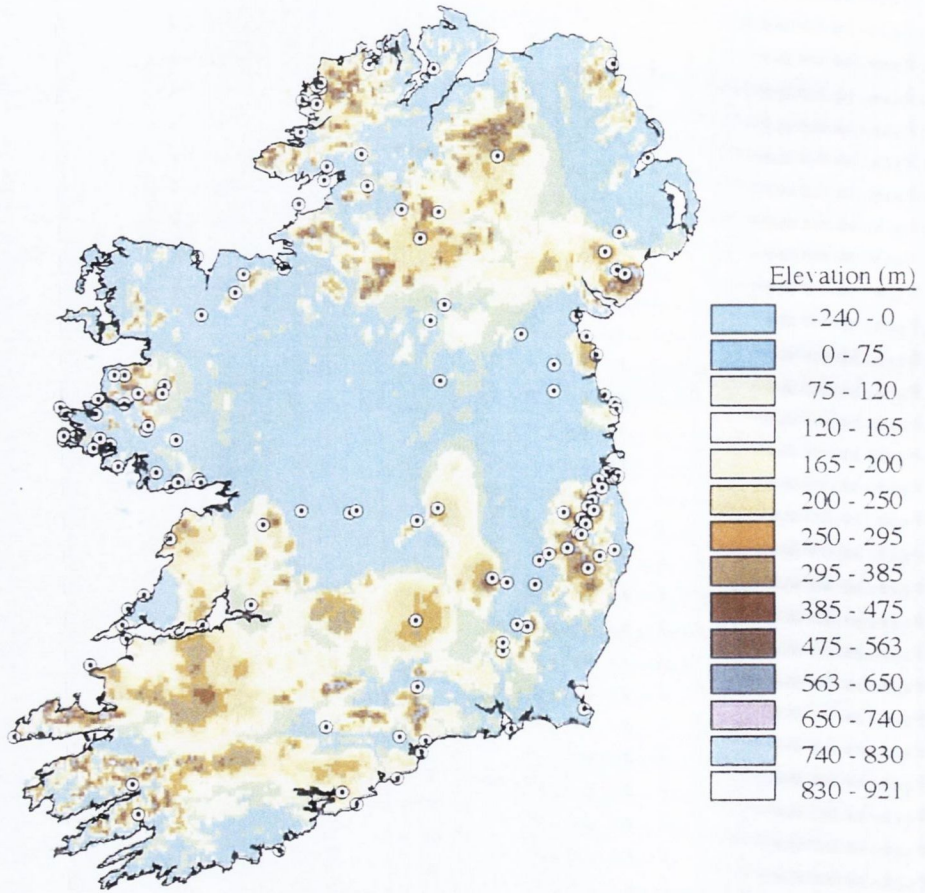


Figure 8.22:- Early Tertiary re-constructed Palaeotopography with eustacy.



Plate 1.1:- Basalts overlying Maastrichtian limestone (Garron Point, Co. Antrim).



Plate 3.1:- View of Dalkey Quarry (facing NNW).

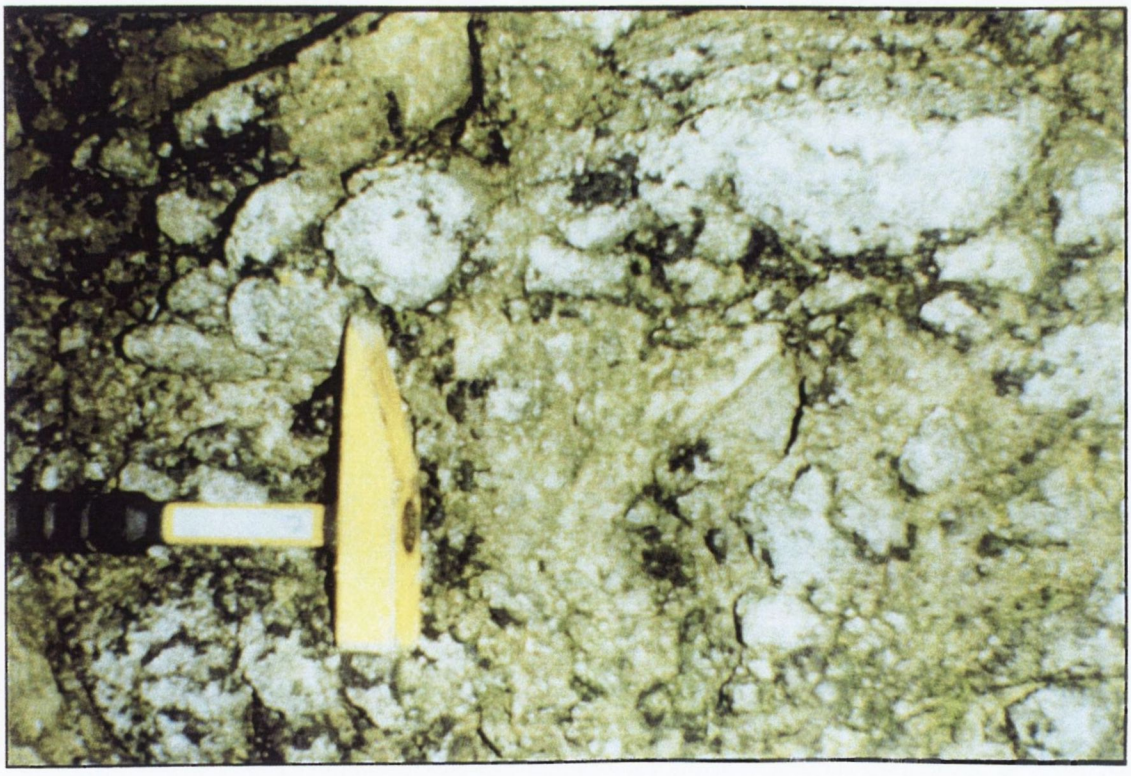


Plate 3.2:- Breccia on coast - locality 1 (Blackrock).



Plate 3.3:- Sigmoidal deformation of shear plane - locality 1.

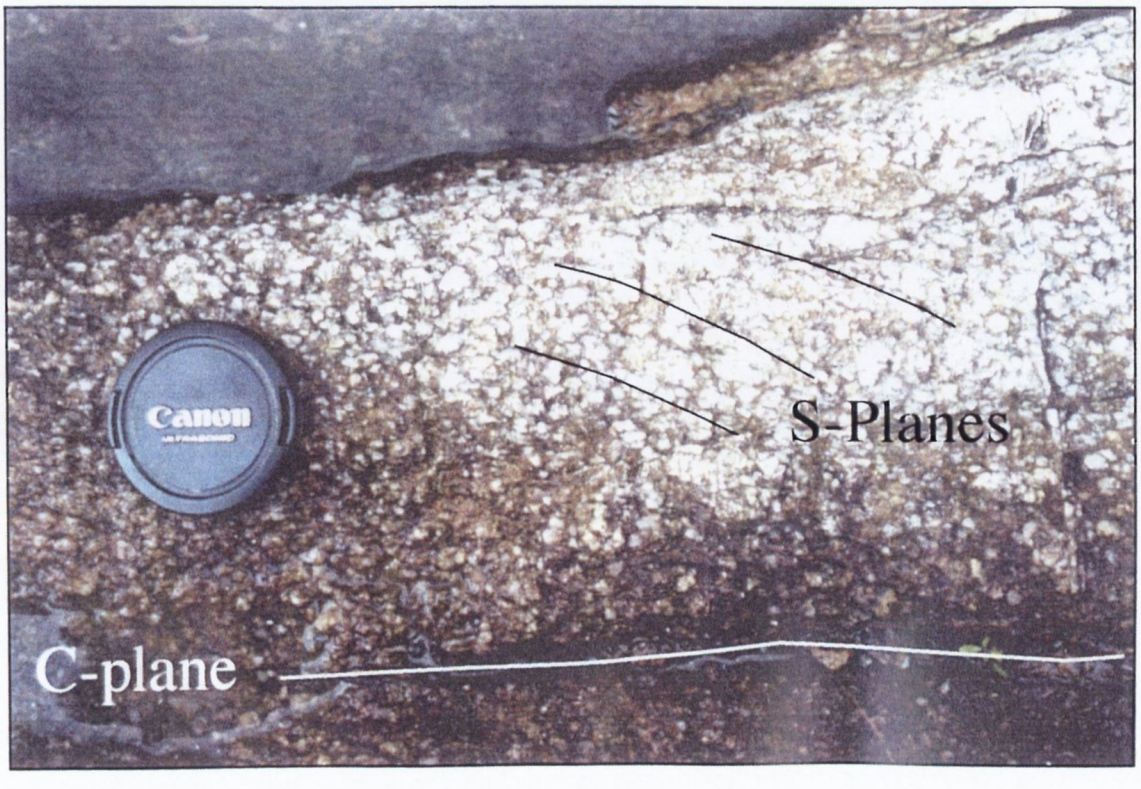


Plate 3.4:- S-C Fabrics - locality 3 (Killiney Bay).



Plate 3.5:- Dextral Reverse fish - locality 2 (semi-vertical face, viewed from NE).



Plate 3.6:- Reverse fish - locality 1 (Seapoint).



Plate 3.7:- Tectonic fish with component of dextral shear (with low vorticity) - locality 2, near Bullock Harbour.

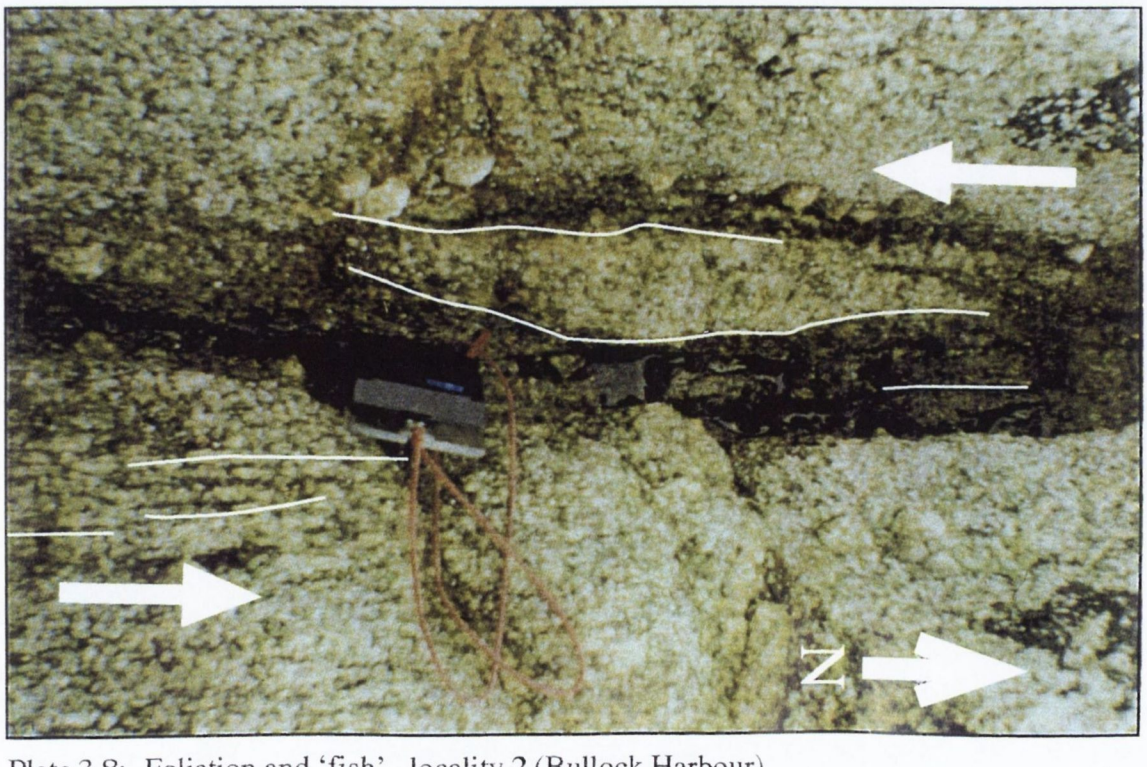


Plate 3.8:- Foliation and 'fish' - locality 2 (Bullock Harbour).



Plate 3.9:- Fault Breccia-Cataclasite - locality 1 (Seapoint).



Plate 3.10:- Slickensides - locality 2 (Sandycove).



Plate 3.11:- Pegmatite sill intruding granite - locality 2 (Sandycove).



Plate 3.12:- Sigmoidal drag fold - locality 1 (Blackrock).

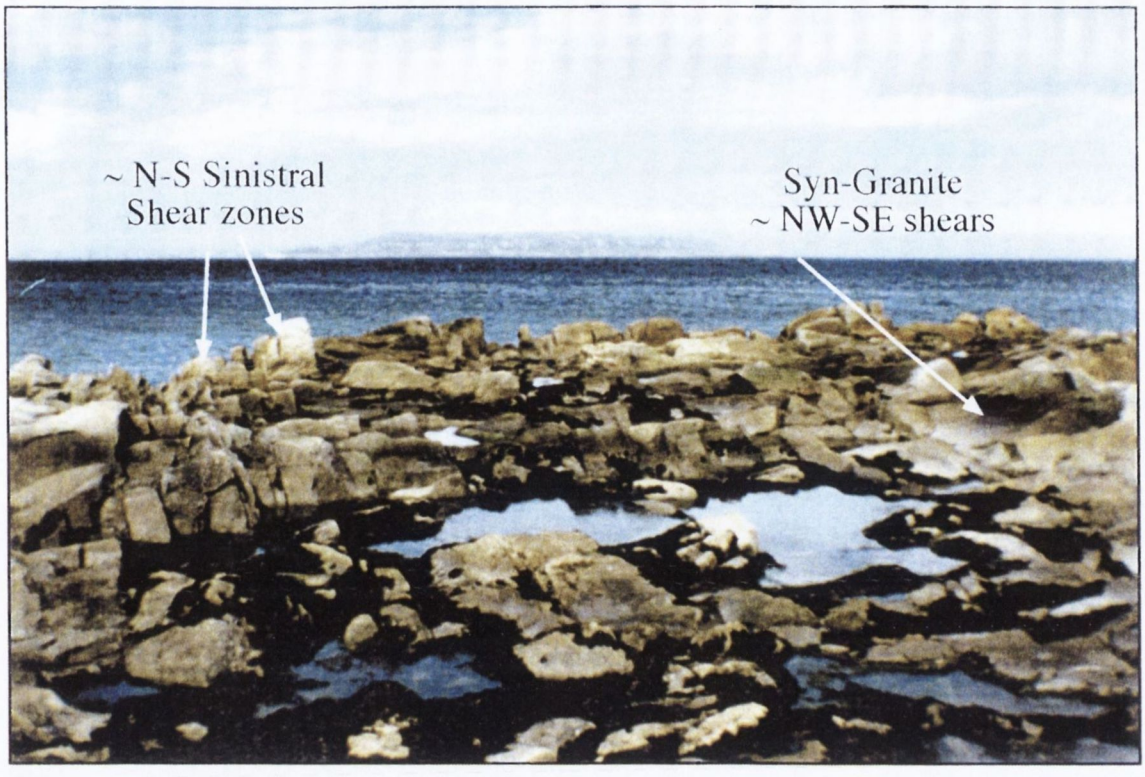


Plate 3.13:- Locality 2 - Sandycove coastal exposures.

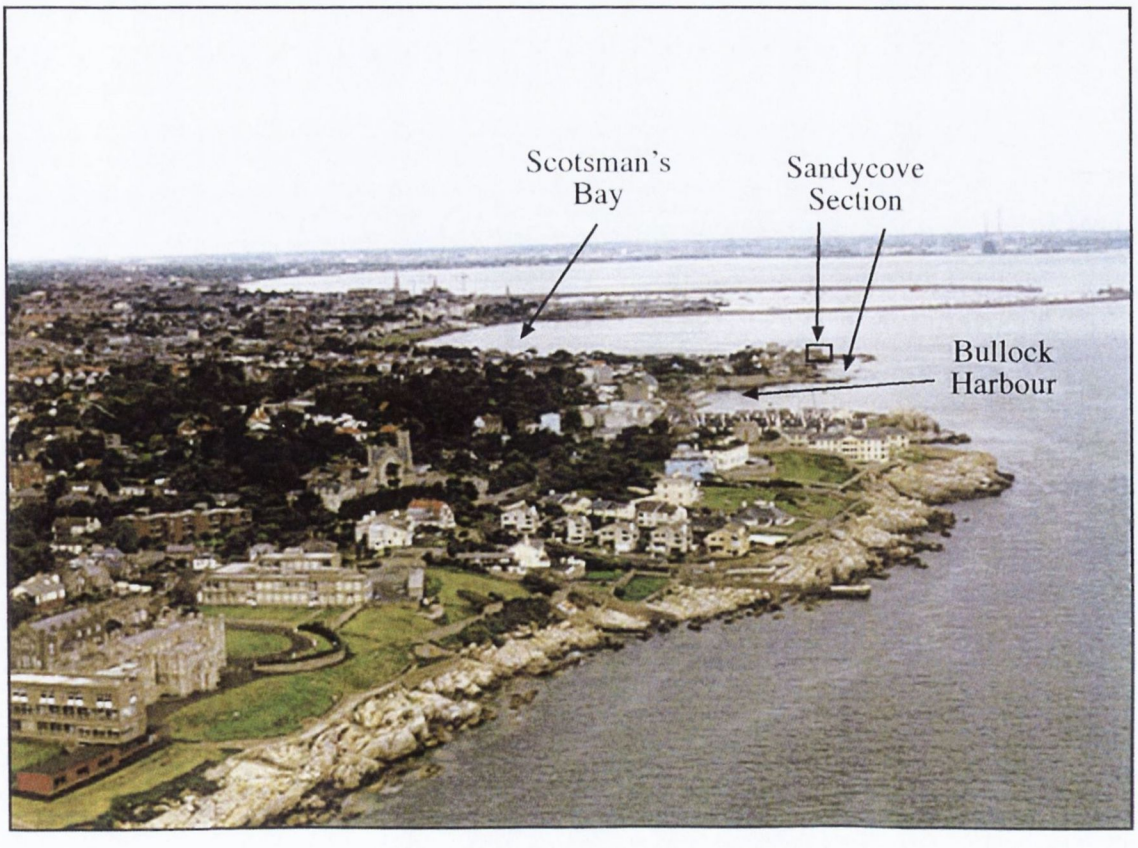


Plate 3.14:- Locality 2 (viewed from the east).

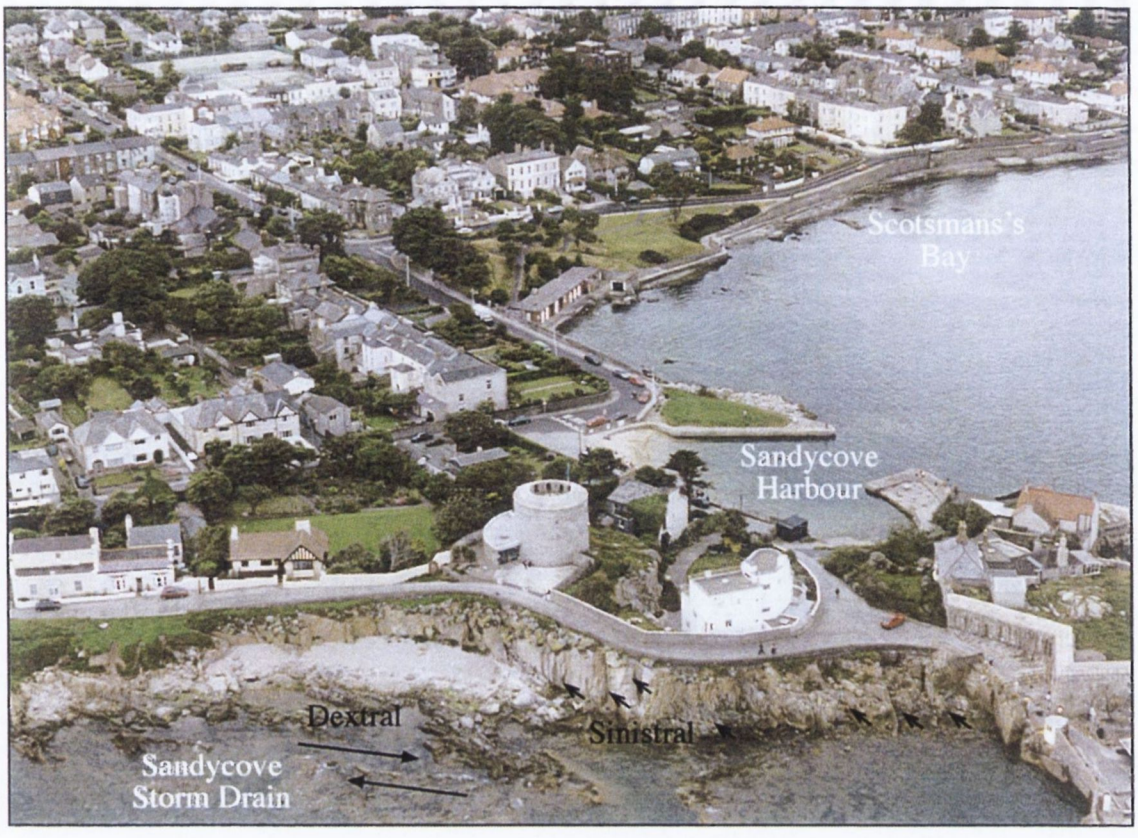


Plate 3.15:- Locality 2 - Sandycove storm-drain and forty-foot bathing area.

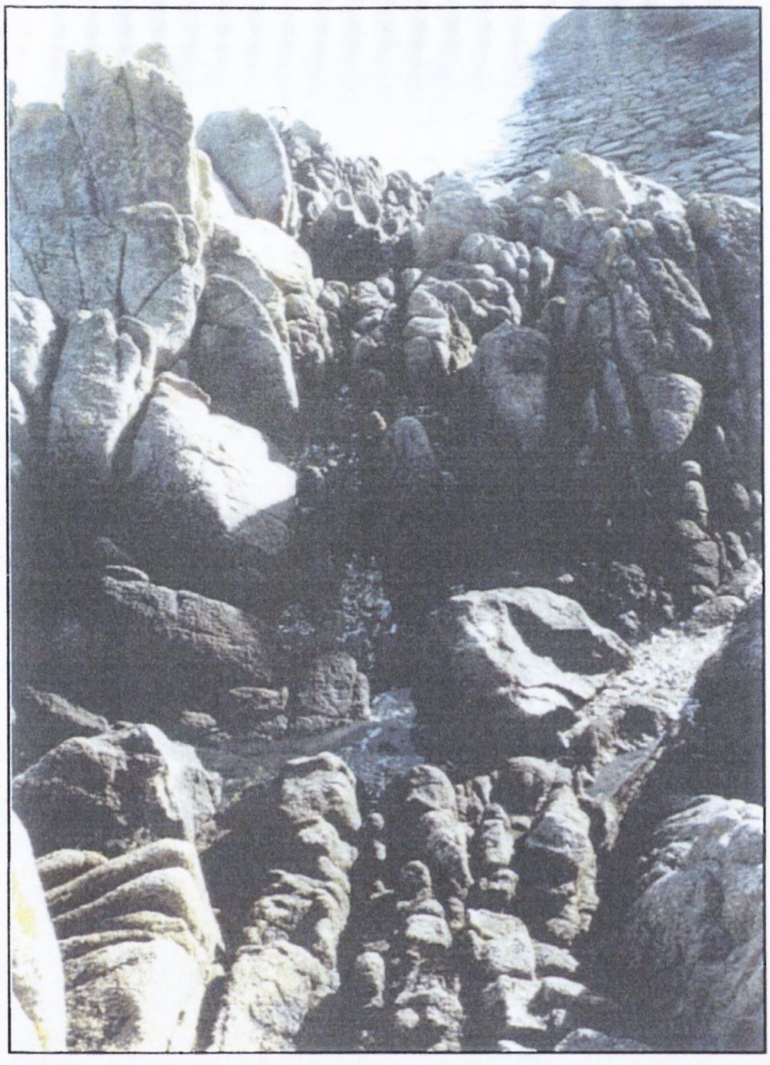


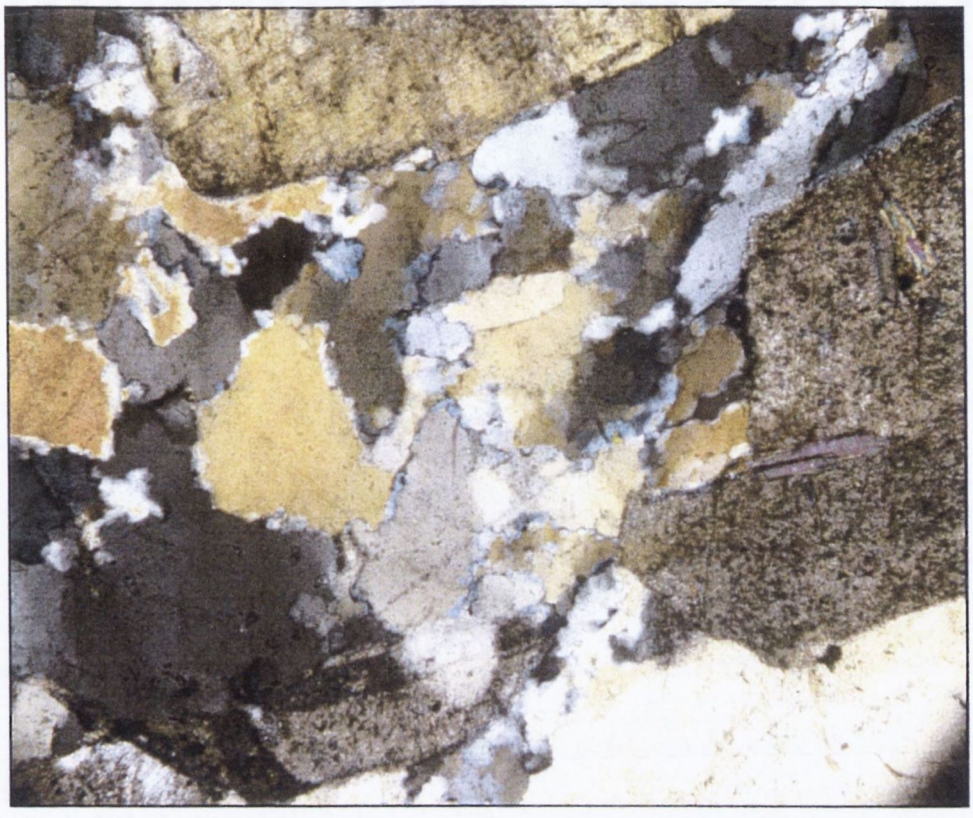
Plate 3.16:- Dextral WNW-ESE shear plane - locality 1 (Seapoint).



Plate 3.17:- WNW-ESE shear zone (viewed down line of transport) - locality 1 (Seapoint).

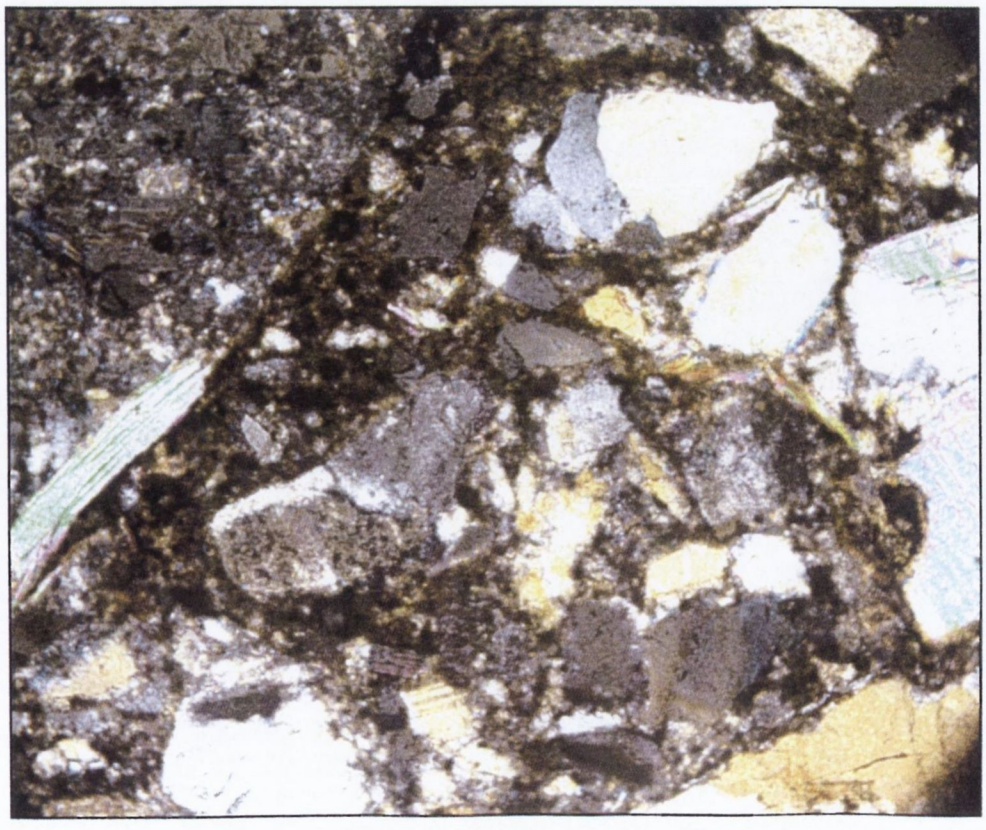


Plate 3.18:- NW-SE Dextral Shear zone - locality 3 (Sorrento Point).



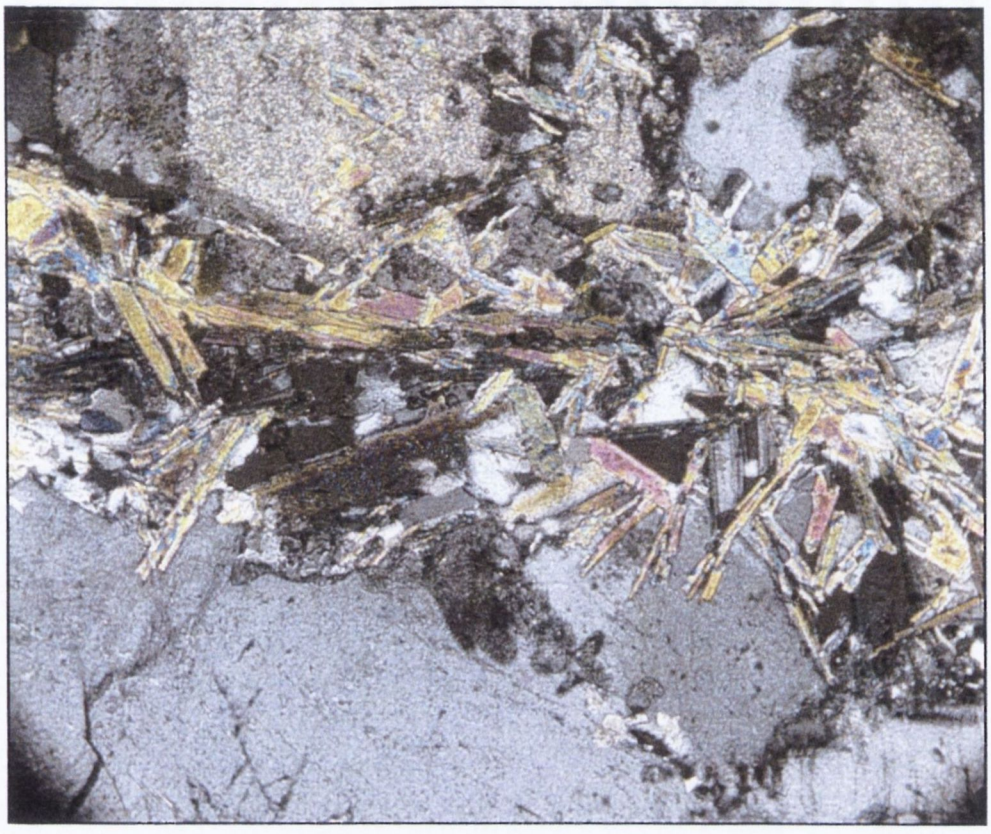
x10

Plate 3.19a:- Blackrock breccia (quartz showing undulose extinction and polygonisation of the margins) - locality 1.



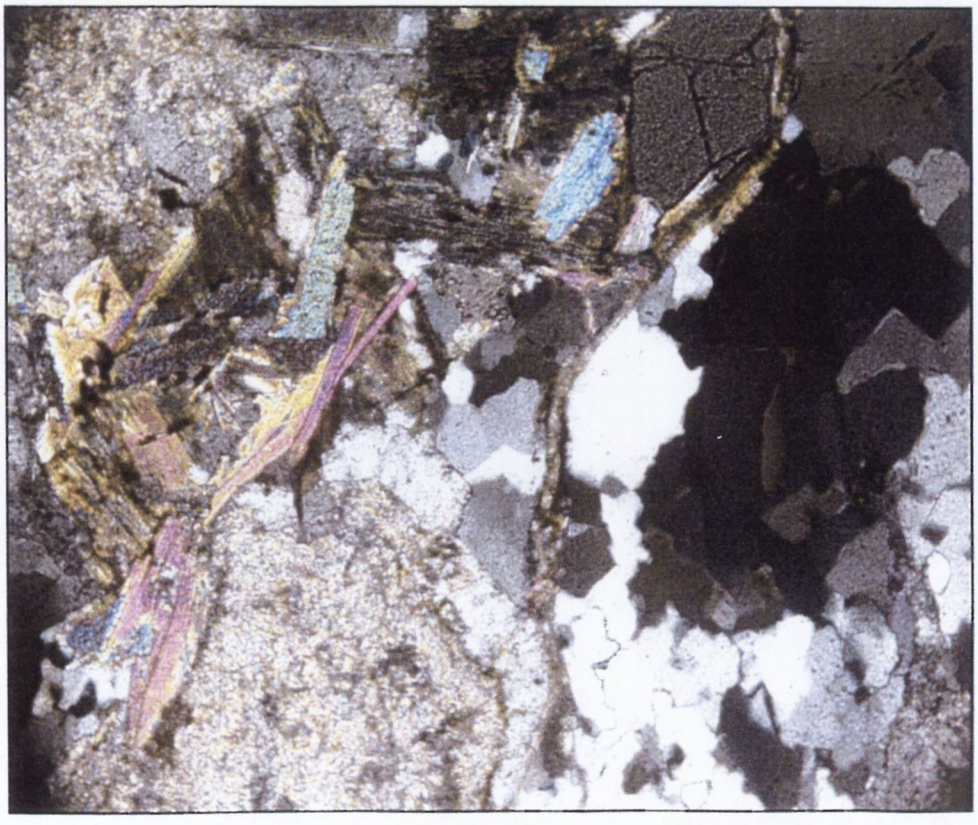
x10

Plate 3.19b:- Blackrock breccia (ground-mass) - locality 1.



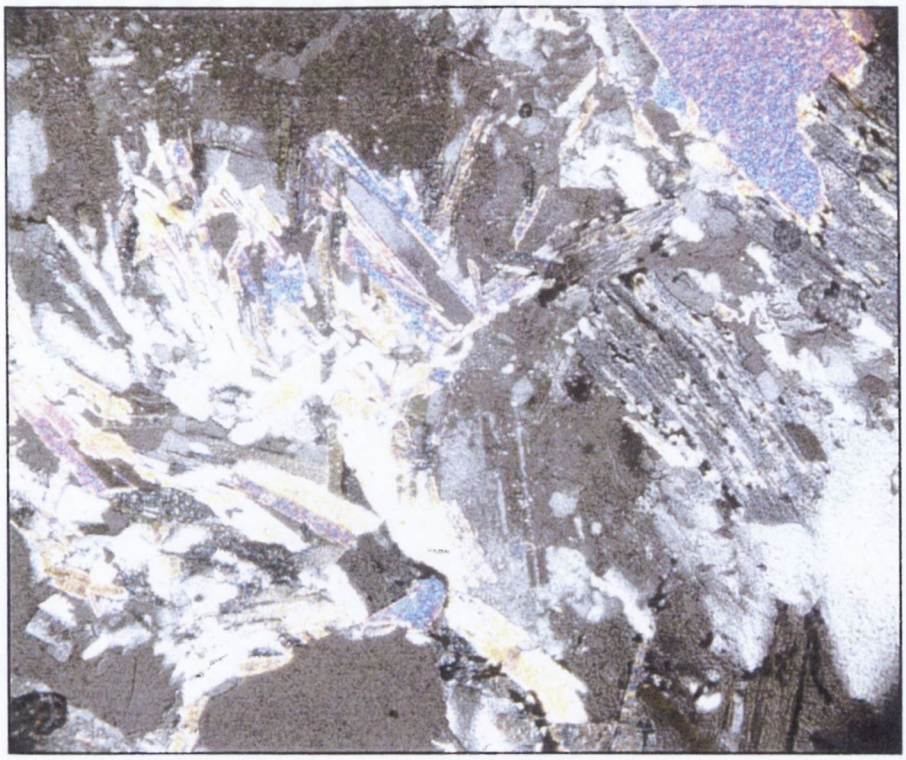
x10

Plate 3.20a:- Cataclasite (smeared muscovite) - locality 1 (Seapoint).



x10

Plate 3.20b:- Cataclasite (note undulose extinction in right of plate) - locality 1 (Seapoint).

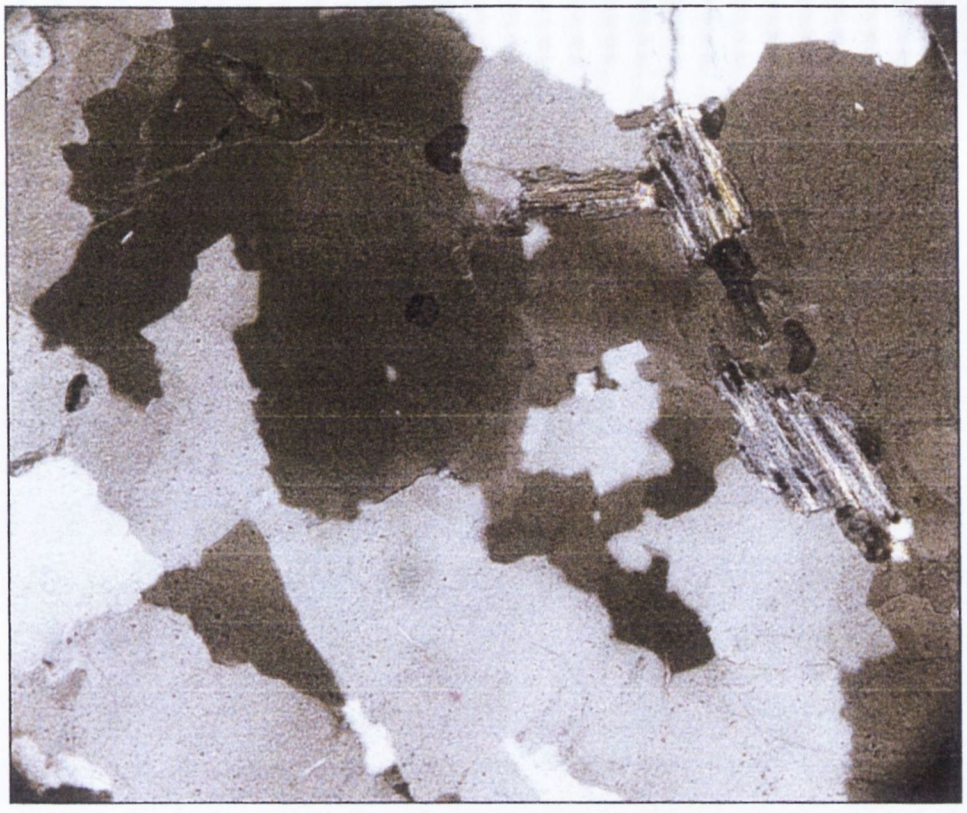


x10

Plate 3.21a:- Thin-section of sense of shear plane - locality 3 (Killiney Bay).



Plate 3.21b:- Meso-scale of secondary mica growth (vertical) - locality 3 (Killiney Bay).



x10

Plate 3.22:- Non-Sheared granite showing unstrained quartz polygon - locality 2 (Sandycove).



Plate 3.23:- Balscadden fault scarp (viewed from the west), Howth peninsula (study area 2 - see figure 3.1).



Plate 3.24:- Balscadden Fault, east of Howth Harbour.

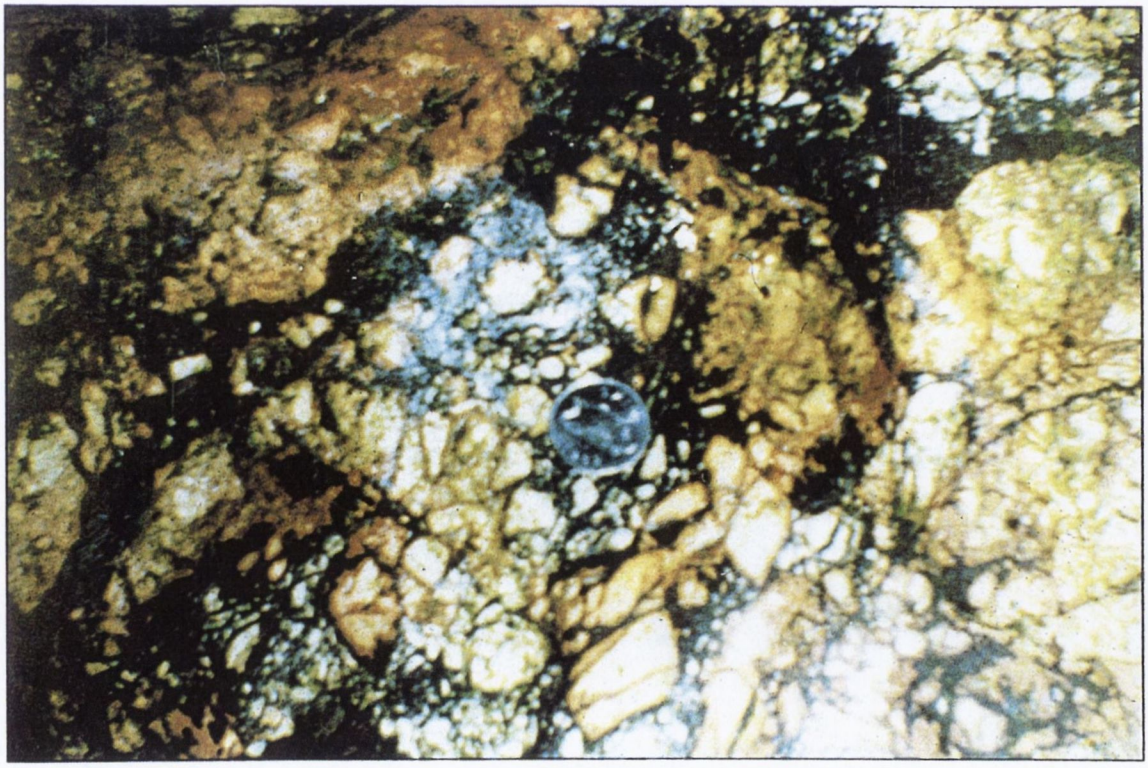
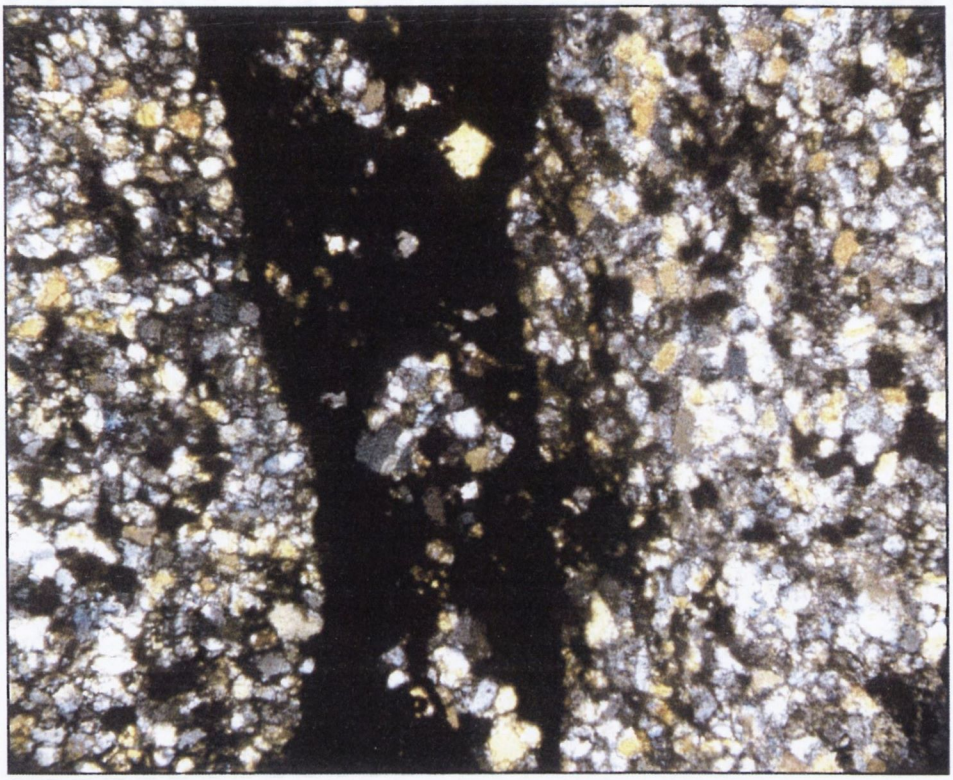


Plate 3.25:- Balscadden fault breccia.



x10

Plate 3.26:- Thin-section of Balscadden fault breccia - margins of quartz grains show undulose extinction.



Plate 3.27:- Reddened surface: probably the product of Tertiary weathering, Howth peninsula.

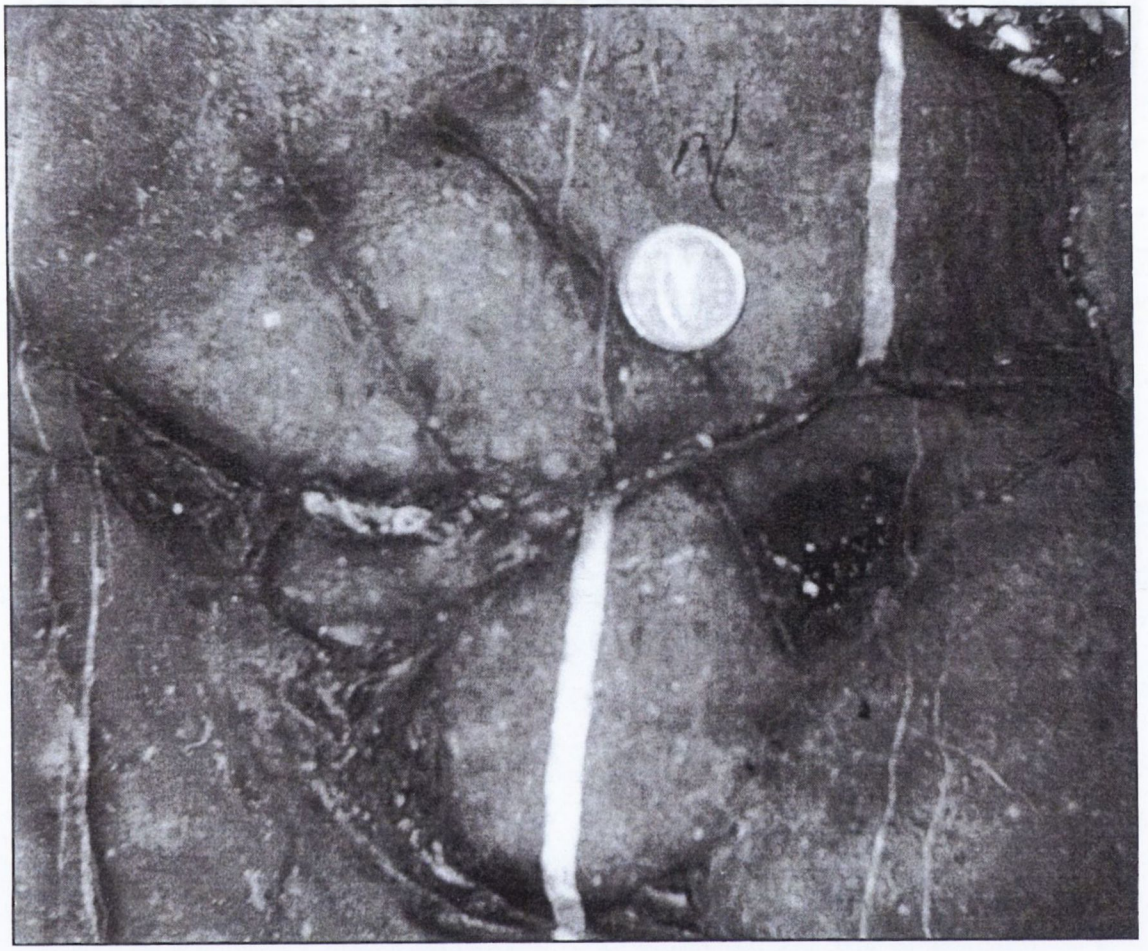


Plate 3.28:- Apparent offset of calcite vein evident from orthogonal stylolite, Balscadden bay.



Plate 3.29:- Strain softened matrix cut by late vein, Balscadden bay.

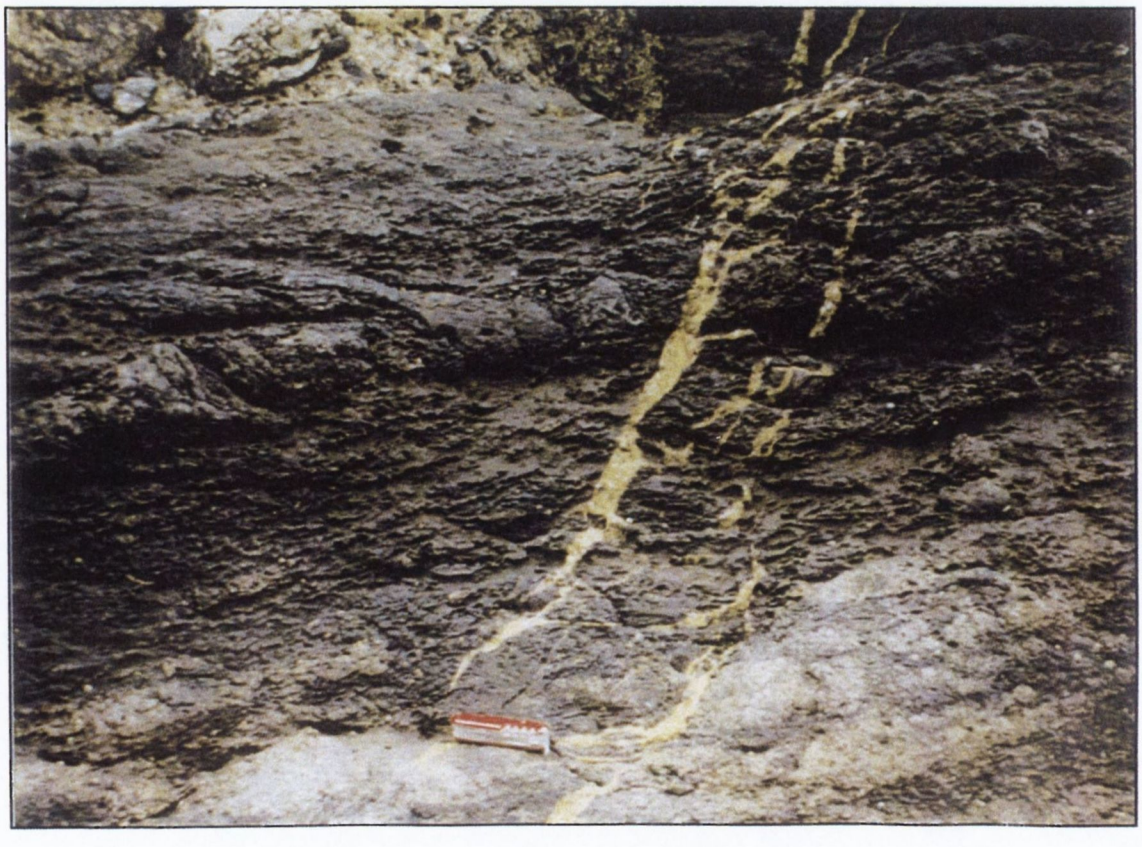


Plate 3.30:- En-echelon veins cut by stylolites, Balscadden bay.

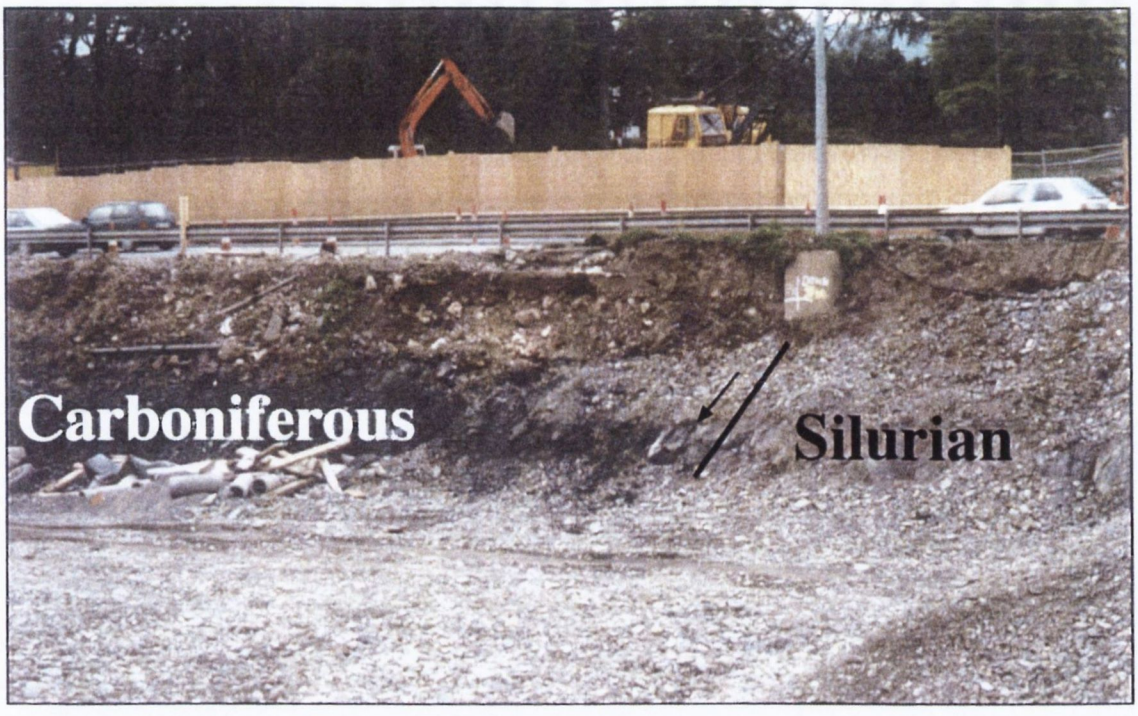


Plate 3.31:- Strand of southern boundary fault, Rathcoole (study area 3 - see figure 3.1).



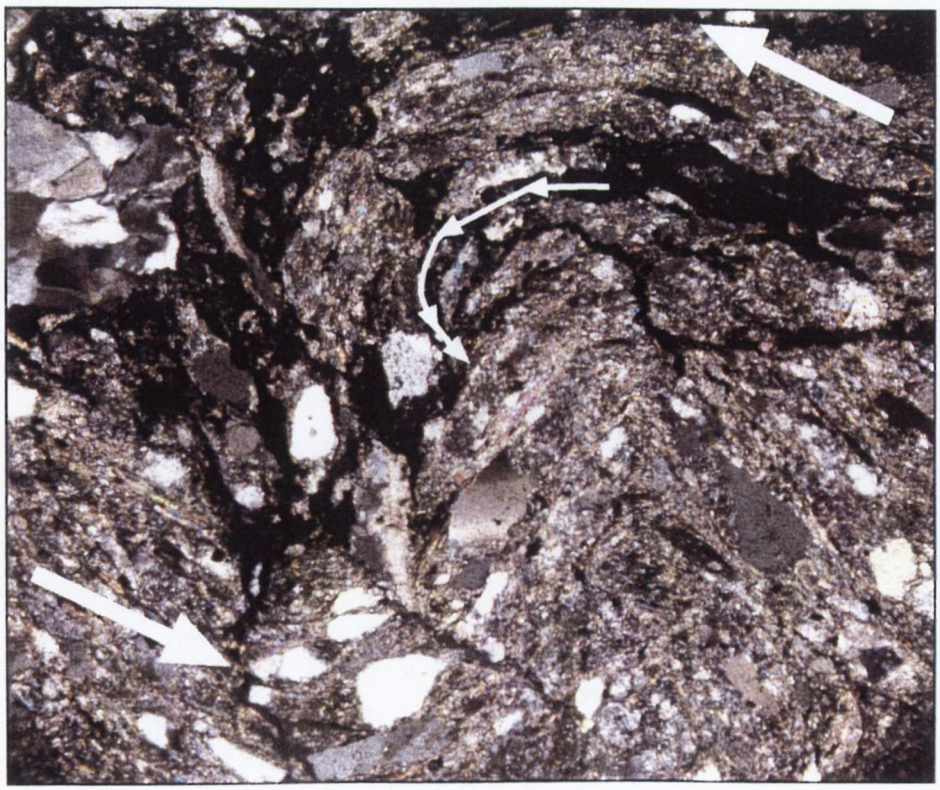
Plate 3.32a:- Large basement clast within limestones, Rathcoole.



Plate 3.32b:- Small basement clast within limestones, Rathcoole.



Plate 3.33:- Fold profiles (Hercynian), Rathcoole.



x10

Plate 3.34:- Thin-section of sense of shear plane, sinistral kinematics along the SBF, Rathcoole.

Plate 5.1:- Pie chart of Northern Pluton (Vartry area)

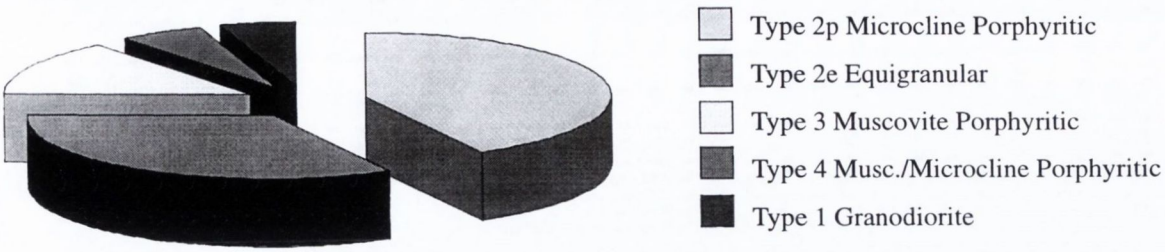


Plate 5.2:- Pie chart of Northern Pluton (Glen of Imail area)

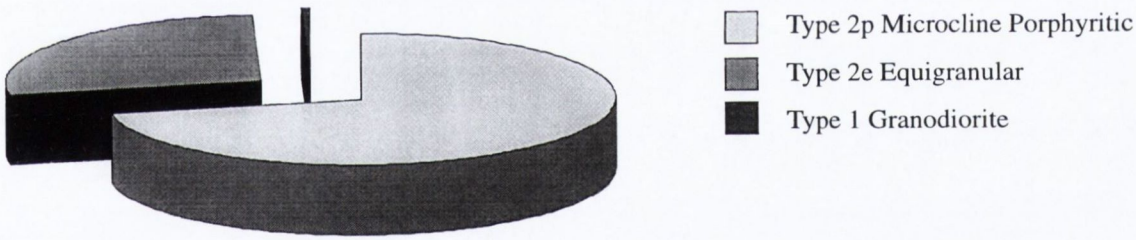


Plate 5.3:- Lugnaquillia Pluton (Glen of Imail area)

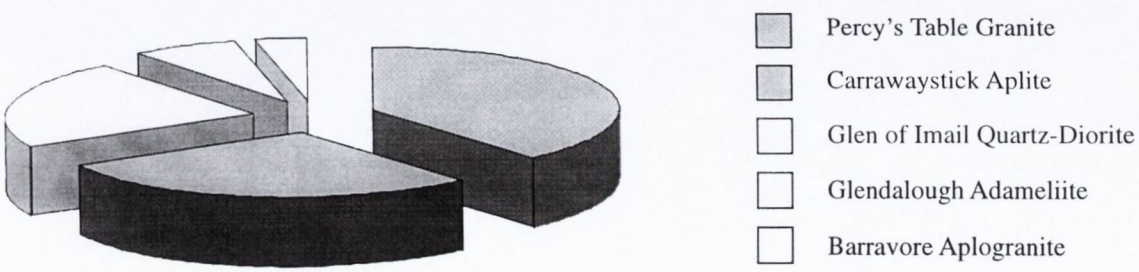


Plate 5.4:-Tullow Pluton (Bunclody area)

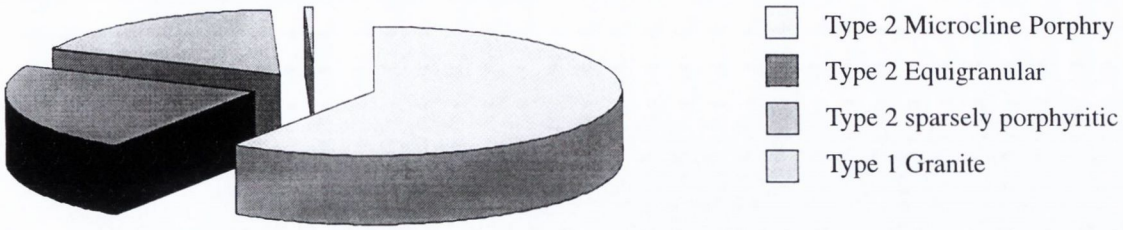


Plate 5.5:-Tullow Pluton (Glen of Imail area)

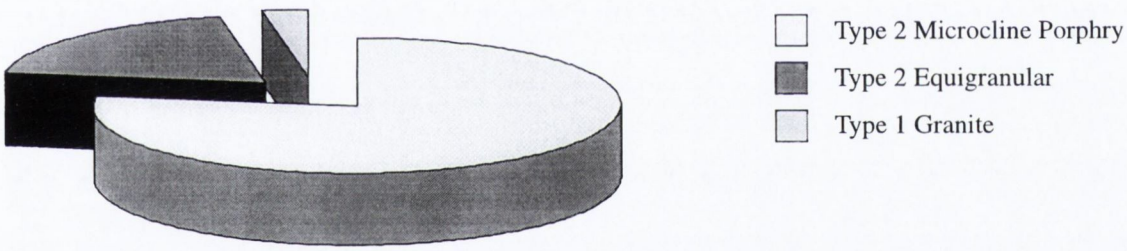


Plate 5.6:- Blackstairs Pluton (Bunclody area)

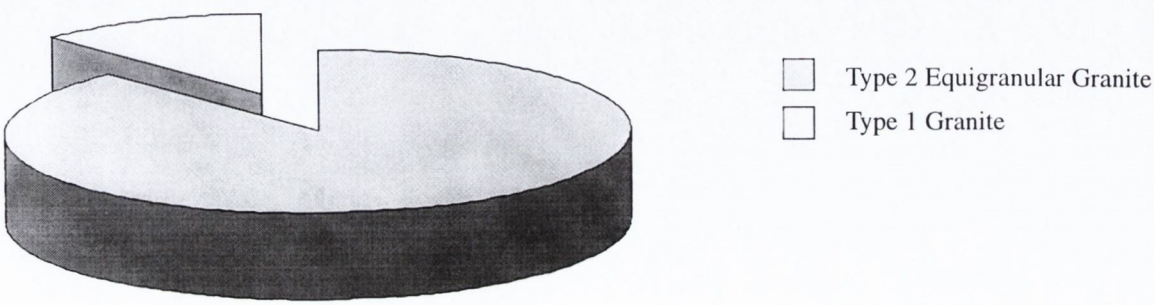


Plate 5.7:- Ribband Group (Bunclody area)

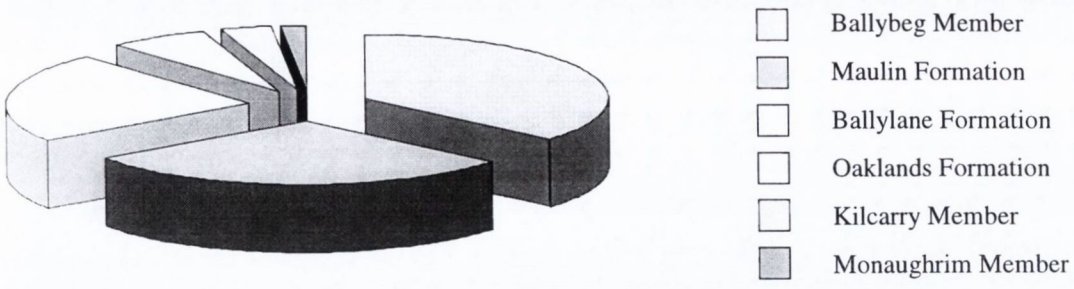


Plate 5.8:-Ribband Group (Vartry area)

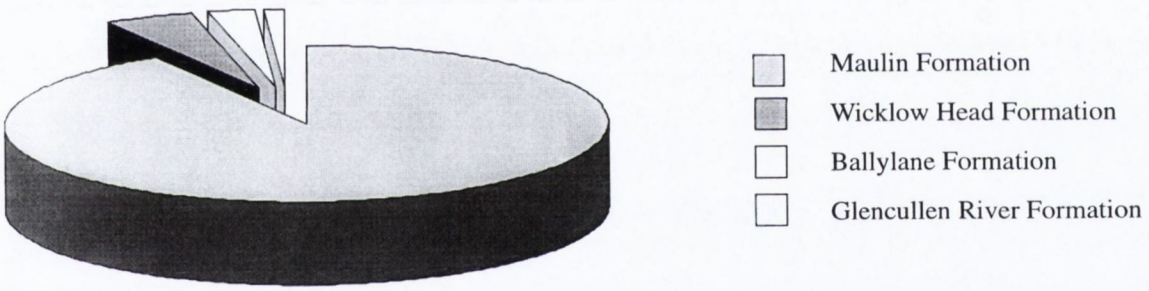


Plate 5.9:- Ribband Group (Glen of Imail area)

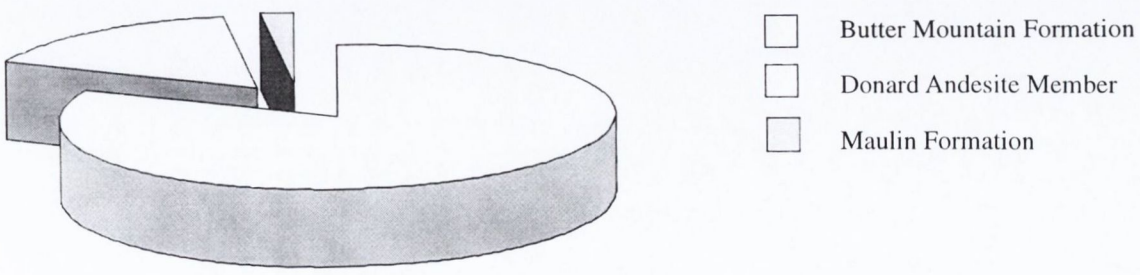


Plate 5.10:- Bray Group (Vartry area)

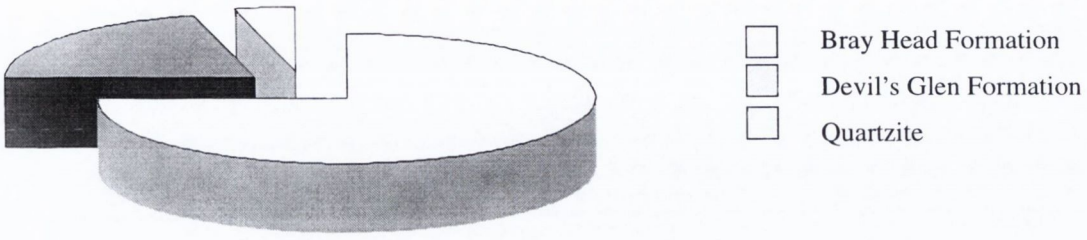


Plate 5.11:- Kilcullen Group (Glen of Imail area)

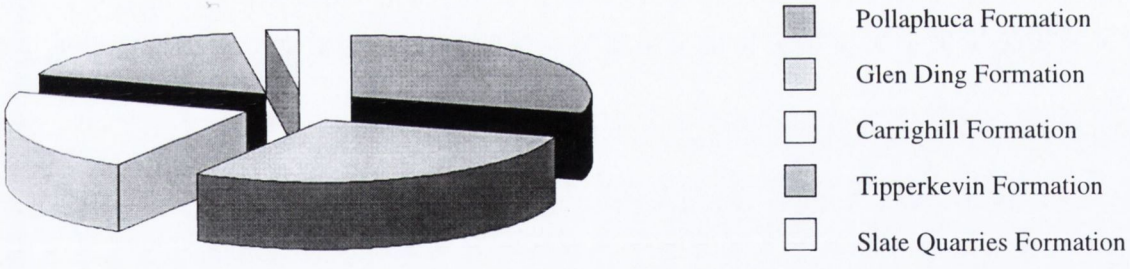


Plate 5.12:- Rock lithologies of the three study areas

Age	Gp.	Glen of Imail	Bunclody	Vartry	Formation/Member	Description
Llandovery (-Ludlow)	Kilcullen Group	CZ			Carrighill Formation	Calcareous, greywackes, siltstone and shale
		TK			Tipperkevin Formation	Greywacke and shale
		GD			Glen Ding Formation	Chloritic, feldspathic greywackes.
		SQ			Slate Quarries Formation	Slate and greywackes.
		PO			Pollaphuca Formation	Coarse, greywacke and shale.
Cambrian (Tremadoc-Llanvirn)	Ribband Group		OA		Oaklands Formation	Green, red-purple, buff slate, siltstone.
			BY	BY	Ballylane Formation	Green and grey slate with thin siltstone.
				GL	Glencullen River Formation	
		MN	MN	MN	Maulin Formation	Dark- grey semi-pelitic, psammitic schist.
			mo	rw	Members: Monaughrim (mo), Roundwood (rw), Kilcarry (ky), Knockree (km), Ballybeg (bb)	(mo) - Dark-grey psammitc schist. (rw) - Basalt breccia (ky) - Often porphyritic andesitic amphibolites. (km) - Quartzitc. (bb) - Dark-grey semi-pelitic, psammitic schist.
			ky	km		
			bb			
				WH	Wicklow Head Formation	Silver-grey mica schist.
		BZ			Butter Mountain Formation	Dark slate-schist, quartzite & coticule.
		do			Donard Andesite Member	Andesite & andesitic tuff.
Lr-M Cambrian	Bray Group			BR	Bray Head Formation	Greywackes and quartzite.
				DG	Devil Glen's Formation	Greywackes and shale.
				qz	Quartzite	Quartzite.

Glen of Imail Bunclody Vartry

Northern Pluton (c.404 Ma)

Nt4
Nt3
Nt2e Nt2e
Nt2p Nt2p
Nt1 Nt1

Lugnaquillia Pluton (c.404 Ma)

LqCw
LqBv
LqGd
LqPt
LqGi

Tullow Pluton (c.404 Ma)

Tw2i
Tw2m Tw2m
Tw2e Tw2e
Tw1 Tw1

Blackstairs Pluton (c.404 Ma)

Bs2e
Bs1

Other Igneous Rocks

Gr Gr
apl apl
app
D
mGr
mv
iv

Granite Type

Type 4 muscovite/microcline porphyritic. Muscovite-microcline porphry granite.
Type 3 muscovite porphyritic. Granite with phenocrysts.
Type2e equigranular. Pale grey fine to coarse-grained granite.
Type 2p microcline porphyritic. Granite with microcline phenocrysts.
Type 1 granodiorite. Fine-grained granodiorite to granite.

Carrawaystick Aplite. White, saccharoidal garnetiferous aplite.
Barravore Aplogranite. Fine-grained, mucovite-rich aplogranite.
Glendalough Adamellite. Adamellite with microcline phenocrysts.
Percy's table Granodiorite. Aphyric granodiorite.
Glen of Imail Quartz-Diorite. Dark aphyric quartz diorite.

Type 2 sparsely Porphyritic Granite. Granite, some microcline phenocrysts.
Type 2 Microcline Porphyritic Granite. Granite with microcline phenocrysts.
Type 2 Equigranular. Pale, fine to coarse-grained granite.
Type 1 Granite. Fine-grained granodiorite to granite.

Type 2 Equigranular Granite. Pale, fine to coarse-grained granite.
Type 1 Granite. Fine-grained granodiorite to granite.

Granite (undifferentiated).
Aplite.
Appanite.
Dolerite.
Microgranite.
Mafic volcanics.
Intermediate volcanics.

APPENDIX 1

Model - Reactivation of Pre-existing fractures

Appendix 1:- Mechanics of Fracture Reactivation

$$\sigma_c = \sigma_o + \tan\phi(\sigma_N)$$

σ_c - critical shear stress required for faulting
σ_o - cohesive strength
σ_N - normal stress
$\tan\phi$ - coefficient of internal friction

The Coulomb law of failure is based on dynamic/mechanical models, developed by Coulomb (1773) and Mohr (1900). The equation describes the height and slope of the linear envelope of failure for rocks in compression. The stress level required to produce fractures is strongly controlled by $\tan(\phi)$. The angle of internal friction (ϕ) for most rocks lies between 25° and 35° and have $\tan(\phi)$ values, ranging from 0.466 to 0.700 (Davies and Reynolds, 1996). Based on the geometry of the Mohr diagram:

$$\phi = 90^\circ - 2\theta$$

or,

$$\theta = \frac{90^\circ - \phi}{2}$$

Since a fractured rock has minimal cohesive strength, then:

$$\sigma_c = \tan\phi_f(\sigma_N)$$

ϕ_f - angle of sliding friction

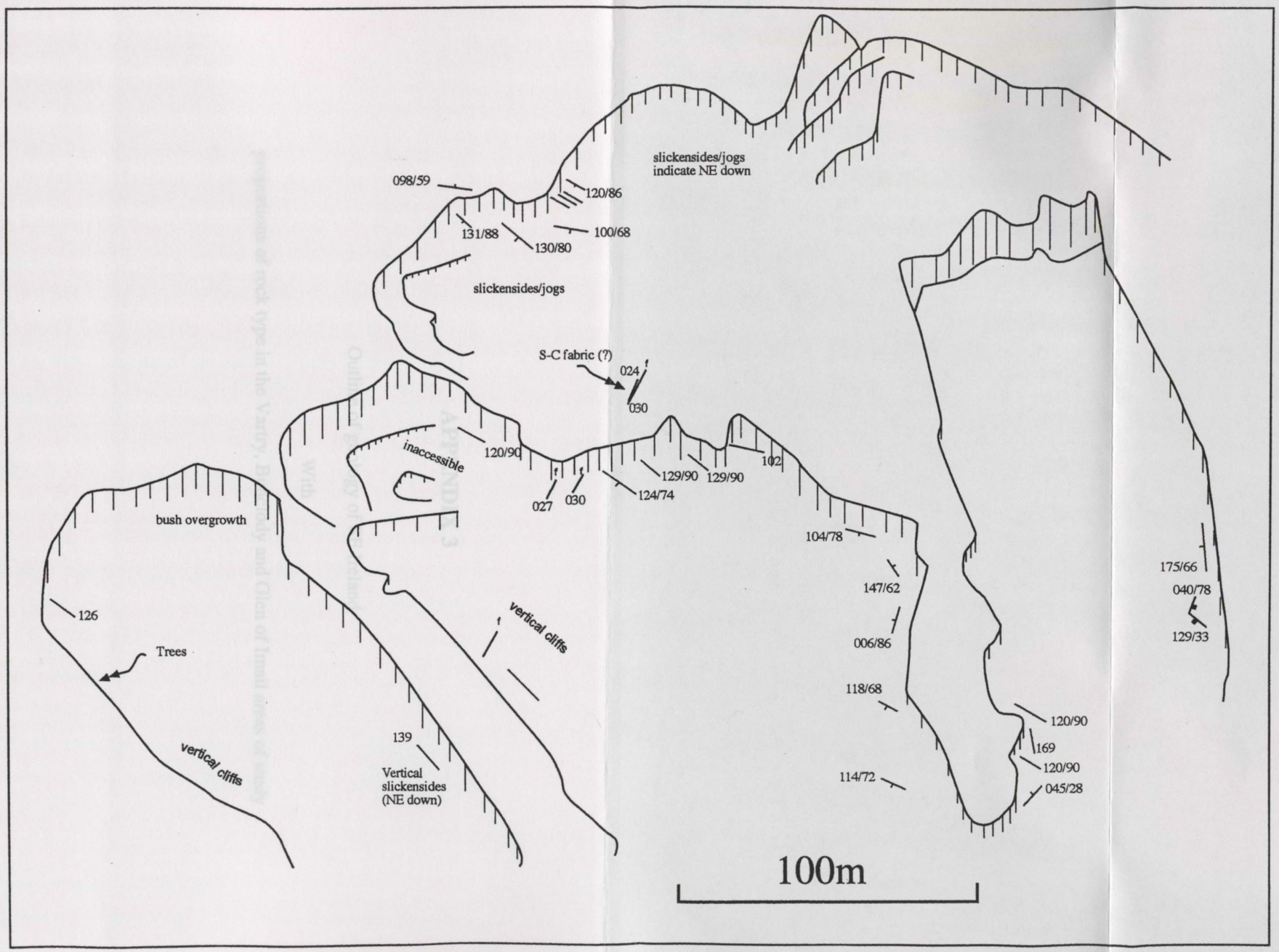
The tangent of ϕ_f is known as the coefficient of sliding friction $\left(\psi_f = \tan\phi_f\right)$ which expresses the ratio of shear stress to normal stress. Hence, this simply states that "the critical shear stress necessary to cause reactivation of an existing fracture is equal to the coefficient of sliding friction of the rock divided by the normal stress acting on the fracture surface" (Byerlee, 1967, 1978).

The maximum coefficient of sliding friction is the same for almost all rocks under conditions of moderate to high normal stress (Byerlee 1978). Where σ_N ranges from 0 to 200MPa then; $\sigma_S = 0.85\sigma_N$ with an angle of sliding fracture (ϕ_f) of 40°. Where σ_N is greater than 200MPa then; $\sigma_S = 0.5 + 0.6\sigma_N$ with ϕ_f of 31°.

APPENDIX 2

Structural Observations

Dalkey Quarry (Co. Dublin)



Appendix 2:- Summary of structural observations at Dalkey Quarry (plate 3.1).

APPENDIX 3

Outline of geology of SE Ireland

With

proportions of rock type in the Vartry, Bunclody and Glen of Imail areas of study

APPENDIX 3:- GEOLOGY OF PLUTONS

(refers to chapter 5)

1. Northern and Upper Liffey Valley Plutons

The Northern and Upper Liffey Valley plutons cover an area of ~460km^2 and is the second largest, accounting for 30% of the total outcrop area (figure 5.6). The pluton forms rounded bodies that exhibit broadly concentric internal zonation of various granite types. The pluton has been categorised into 5 types of granite, based on texture and composition. All these types are represented in the Vartry area (plates 5.1 & 5.12), and 3 occur in the Glen of Imail area (plates 5.1 & 5.12). The Northern pluton occupies 46% (72km^2) and 10% (35km^2 area) of the solid geology of the Vartry (figure 5.16) and Glen of Imail (figure 5.40) areas respectively.

1.1Type 2 (Nt2p & Nt2e) Granite

As figure 5.6 shows, Type2p forms over 50% (~232km^2) of the two plutons, and occurs as two concentrically elongated masses located in the south and north. The granite type is a coarse-grained adamellite with phenocrysts of microcline. Type2p occupies 34% (9km^2) and 7% (26km^2) of the solid geology of the Vartry and Glen of Imail areas (figures 5.16 & 5.66 and plate 5.12 respectively).

Type Nt2e accounts for 34% of the Northern and Upper Liffey Valley plutons and occupies an area of over 158km^2. The rock is similar to Type2p but non-porphyritic, and can best be described as a pale grey, fine to coarse-grained equigranular adamellite. This type mostly forms the contact with the country rock and displays a magmatic foliation that is sub-parallel with the plutonic margins, which decreases in intensity with distance from the margin. The foliation is also concordant with the schistosity in the country rock. Type2e occupies 6% (22km^2) and 2% (9km^2) of the solid geology of the Vartry and Glen of Imail areas (figures 5.16 & 5.66) respectively.

1.2 Type 3 (Nt3) Granite

Type3 granite is concentrically nested within both the Upper Liffey Valley and Northern plutons. This type forms 12% (53km^2) of the pluton (figure 5.5). Type3 granite only occurs in the Vartry area (plate 5.12), and represents 2 % of plutonic rocks (figure 5.16). The granite type can best be described as a muscovite porphyritic adamellite, i.e. similar to Type2e and Type2p but with additional phenocrysts of muscovite.

1.3 Type 1 (Nt1) Granodiorite

The most melanocratic type of granite is of Type1. Within the Vartry and Glen of Imail areas, Type1 granodiorite comprises 1% (4km^2) and 2% (9km^2) of the solid geology (figures 5.16 & 5.66) respectively. The rocks occur as discontinuous, elongated masses, mainly on the margins of the pluton. Small isolated lenses also occur sporadically within most of the other varieties.

1.4 Type 4 (Nt4) Granite

The most leucocratic type of granite is of Type4 variety, which also accounts for the smallest of plutonic rock (7% of the pluton), forming a circular mass nested within Type3 (figure 5.6). Type4 represents a muscovite-microcline porphyry and accounts for <1% of the solid geology within the Vartry area (figure 5.16 & plate 5.12).

2. Lugnaquillia Pluton

The Lugnaquillia pluton is more irregular in shape and internal zonation in comparison with the other 5 plutons. The pluton contains 5 granitic varieties and is the second smallest (figure 5.5), representing 10% (167km^2) of the batholith. Part of the Lugnaquillia pluton contact occurs within the Glen of Imail area (figure 5.7), accounting for 27% (97km^2) of the solid geology (figure 5.66). Exposure of the pluton is variable as

much of the area is overlain by several metres of blanket bog. Where exposed, however, the pluton is concordant with the country rock schistosity.

The pluton is flanked to the north and south by the Northern and Tullow plutons respectively. The pluton is separated from the Northern pluton by a thin schist septum (ranging in width from ~50m to 250m). A branch of septum also separates different granitic types within the Lugnaquillia pluton. The schist septum is ~10km in length and extends from the Wicklow Gap to Glen of Imail. The pluton produces the most mountainous topography of the Leinster Mountain chain. This is believed to be partly due to the resistance of schist bodies to weathering, and hence providing a protective cap for the underlying granite, but this is not consistent with the evidence presented in this thesis (section 5.6).

2.1 Carrawaystick Aplite (LqCw)

The Carrawaystick Aplite (CA) forms the SE part of the pluton, from Glenmalure to Ow River, and a large tongue runs west to Baltinglass, where it is in sharp contact with the Tullow pluton (figure 5.66). This granite type is poorly exposed and can best be seen on the northern flanks of the Carrawaystick Mountain. The CA represents 29% (48km^2) of the pluton (figure 5.5) and comprises 26% (26km^2) of plutonic rock and 7% of solid geology (plate 5.2). The rock has a white saccharoidal appearance with abundant sub-mm almandine-spessartine garnets. This granite type is cut with abundant pegmatite dykes and has a gradational contact with the Barravore Aplogranite.

2.2 Barravore Aplogranite (LqBv)

The Barravore Aplogranite (BA) is the smallest of the granite types and represents 5% (8km^2) of the pluton (plate 5.3). This accounts for 3.86% of the Lugnaquillia plutonic rocks and 3.76% of solid geology within the Glen of Imail area respectively (figure 5.66). The BA is an irregular shaped body and is exposed in several large crags on the SW side of Glenmalus (figure 5.66). The granite interdigitates with rafts of schist (up to 700m in

length). The rock forms a pale, medium to coarse-grained equigranular granite, with conspicuous muscovite content.

2.3 Percy's Table Granodiorite (LqPt)

The Percy's Table Granodiorite forms the second largest granitic type of the pluton and has a total outcrop of 47km^2, which equates to 28% of the unit. This granite type represents 42% (41km^2) of the Lugnaquillia pluton (plate 5.3) and 12% of solid geology within the Glen of Imail area (figure 5.66). It forms the central part of the pluton and is partially capped with schist roof pendants are probably remnants of original roof rock.

2.4 Glendalough Adamellite (LqGd)

The Glendalough Adamellite represents 23% of the pluton or 39km^2 (figure 5.7) and 2% (8km^2) of the solid geology (figure 5.66) within the Glen of Imail area. The GA forms the NE part of the pluton between Glenmalure and Glenmacnass. The best exposure of this granite type is seen along the ridge between Three Lakes and Lough Forrib. The rock is a coarse, 2-mica adamellite with microcline phenocrysts. The feldspars are distinctly reddened and the granite contains secondary calcite. This is probably due to hydrothermal alteration along the Glendasan fracture, near Lough Nahanagan.

2.5 Glen of Imail Quartz-diorite (LqGi)

The Glen of Imail (GI) Quartz-diorite forms a NE trending body (~11km in length) on the western side of the pluton (figure 5.66) and is best exposed in large crags, and in mountain streams between Corrig and Wicklow Gap. The GI forms 16% (26km^2) of the pluton (plate 5.3) and 6% (20km^2) of the solid geology within the Glen of Imail area. It is the most melanocratic type and is an aphyric granite, although medium grained in places. The contact with Percy's Table granodiorite is not seen, and is inferred from the occurrence of rare boulders of both granite types (Brück & Reeves, 1983).

3. Tullow Pluton

The Tullow pluton is the largest of the Leinster batholith (figure 5.5) and covers an area of 816km^2, which equates to 51% of the batholith (figure 5.8). It is also the least well exposed. The pluton forms a NNE-SSW trending body and underlies the Tullow Lowland. The granite varieties are similar to the Blackstairs pluton with both porphyritic and non-porphyritic types present, albeit it, with less distinct zonation than the Northern pluton.

The four granite types occur in the Bunclody area (figure 5.40) and comprises 28% (28km^2) of the solid geology. Three of the four types also occur within the Glen of Imail area (plates 5.3 & 5.15) and comprise 13% (45km^2) of the solid geology of this area.

3.1 Type2e (Tw2e) – Tullow Adamellite

The Tullow Adamellite forms the largest part of the pluton, comprising over 55% (453km^2) of the body (figure 5.8). The granite type is a coarse or sometimes medium-grained adamellite. Within the Bunclody area, this type comprises 7% (25km^2) of the solid geology (figure 5.40) and 21% of batholith rocks (plate 5.4). This variety occupies the ground toward the north of the Bunclody area, and a small part also occurs on the SW margin of the area of study. At the Glen of Imail area, the Tullow Adamellite comprises 10% (35km^2) of the solid geology (figure 5.66) and 77% of the pluton (plate 5.5). These rocks occupy the southern part of the area and form a poorly exposed contact with the Carrawaystick Aplite of the Lugnaquillia pluton. Although, in places, Type2e occurs as rafts within the Carrawaystick Aplite.

3.2 Type2m (Tw2m) – Porphyritic Microcline Adamellite

This type is similar to the Porphyritic Microcline Type2 adamellite of the Northern pluton. Abundant elongate megacrysts of perthitic microcline are set in a medium grained ground-mass. This variety forms the second largest type in the Tullow pluton

(figure 5.8), at 28% (228km^2). At the Glen of Imail area, it comprises 2% (8km^2) of the solid geology (figure 5.66) and is mostly surrounded by Type2e adamellite. At the Bunclody area, these rocks form the largest proportion of Tullow plutonic rocks (plate 5.5). It comprises 18% (61 km^2 area) of the solid geology and >50% of batholith rocks (figure 5.40). The body forms a NE-SW trending mass, which pinches out towards the NE (where it exhibits a sheeted margin), and abuts against Type2e to the SW (just west of the Bunclody area).

3.3 Type2i (Tw2i) – Sparsely Microcline Porphyritic Adamellite

This granite type occupies 14% (116km^2) of the Tullow pluton (figure 5.8). It forms truncated masses with Type2e, and exhibits a gradational contact with Type2m. This variety occurs in the Bunclody area only (plate 5.12) and comprises 3% (11km^2) of solid geology and 18% of the Tullow plutonic rock. It occurs in the NW part of the area (figure 5.40), just south of the town of Tullow, sandwiched between Tw2e to the north and Tw2m to the south. A smaller mass, enclosed by Tw2m, occurs ~6km east of the town of Ballon. The rock is similar to Type2m but with less abundant microcline phenocrysts.

3.4 Type 1 (Tw1) – Granite to Granodiorite

This variety is the smallest type and represents 2% (18km^2) of the pluton (figure 5.8). The body mainly occurs towards the northern part of the pluton, where it is restricted to the margins. Although, at the Glen of Imail area, a circular mass of Tw1 is encircled by Tw2e, and is capped by schist. At the Bunclody area, two small masses occur in the NE of the area of study. A major NE-SW trending shear zone (section 5.5) has deformed these.

4. Blackstairs Pluton

To the SE, a major NE-SW trending shear zone, the East Carlow Deformation Zone, separates the Blackstairs pluton from the Tullow pluton (figure 5.40). Hence, the margin of the pluton has a highly sheared and sheeted relationship with the surrounding schist. The Blackstairs pluton is the smallest of the batholith (figures 5.5 & 5.9), covering an area of 147km^2 (or 9% of the batholith). The pluton forms an elongate body, of ~28km length, and is aligned ~NNE-SSW. The rocks are normally grey, even-textured, though in places porphyritic with large microcline feldspars also occur. The granite is made up of a number of thick sheets around the margins, which are separated by bands of schist.

Four granite types of this pluton are recognised (figure 5.9). Only Type1 (Bs1) and Type2 (Bs2e) occur in the Bunclody area (plate 5.12). The other 2 types, the Graiguenamanagh Granite (BsGg) and the Porphyritic Microcline Granite (Bs2m) account for a small percentage of plutonic rock (i.e. 4%) and will not be considered further (see Sweetman (1987), for further details).

4.1 Bs2e Equigranular Granite

The Bs2e equigranular granite forms a major part of the pluton and has a total outcrop area of ~160km^2, which equates to 93% of the pluton (figure 5.9). This granite type comprises 5% (17km^2) of the solid geology within the Bunclody area (figure 5.40). The rocks are fine to coarse grained and pale in colour and largely equates with the Equigranular Type 2 of the Northern pluton, based on mineralogy and chemistry.

4.2 Bs1 Granodiorite

Type Bs1 equates with the Type 1 granodiorite of the Northern pluton. The rocks are fine-grained granodiorite to granite. Although, Sweetman (1987) describes this variety as homogenous. The mineralogical and chemical characteristics also resemble the undifferentiated granite to the east of Bs1 at Bunclody (Brindley & Connor, 1972). This

variety comprises 2% (3km^2) of Baltinglass plutonic rock (plate 5.9) in the area and forms a NE elongate body that is ~25km length and ~7km in width. The granite pinches out to the SW, where a thin, narrow neck (~100m in width) forms the contact with Bs2e (figure 5.9).

5. Other Igneous Rocks

Small bodies of igneous rock, other than those members assigned to the Maulin Formation, occur in all 3 localities (plate 5.12). Acid and intermediate volcanics occur within both Glen of Imail (figure 5.66) and Bunclody areas (figure 5.40) and mafic and intermediate volcanics occur within the Vartry area (figure 5.16). Aplite occurs in the Vartry and Glen of Imail areas (plate 5.12), and an elongated body of appanite occurs in the latter area. These rocks make up <1% of the solid geology at The Glen of Imail area, and <3% at both the Bunclody and Vartry areas. However, the contrast between these igneous rocks and the surrounding country rock produce local mesoscopic topographical effects.

6. Ribband Group

The Ribband Group represents a thick succession of finely laminated slaty mudstone representing a deep marine setting. The rocks have scarce fossils of Tremadoc-Llanvirn age (Brenchley *et al.*, 1967). This group occurs in all three areas (plate 5.12). In the Vartry area (figure 5.16), the Ribband Group comprises an area of 200km^2 (40% of solid geology). At the Bunclody area (figure 5.40), the surface outcrop is ~ 265km^2, (~53% of solid geology). And, at the Glen of Imail area (figure 5.66), the Ribband Group has a surface outcrop of ~115km^2 (25% of solid geology).

The Glencullen River and Wicklow Head Formations are geographically restricted to the Vartry area (plate 5.12). Likewise, the Oaklands Formation, which overlies the Ballylane Formation is restricted to the Bunclody area, and the Butter Mountain Formation is restricted to the Glen of Imail area (plate 5.12).

6.1 Oaklands and Ballylane Formation

The Oaklands and Ballylane Formations occur as small horst blocks south of the Glenealy fault. The Oaklands Formation makes up 7% (~17km^2) of the Ribband Group within the Bunclody area (plate 5.7). The Ballylane Formation is present in both the Vartry and Bunclody areas (plate 5.12) and represents 2% (~5km^2) and 23% (~60km^2) of the solid geology (plates 5.7 & 5.8) respectively. The rocks are green-grey and grey shales and siltstones, overlain by interbedded reddish purple, buff and green-grey mudstone and siltstones of the Oaklands Formation. The formation has yielded Upper Arenig to Lower Llanvirn graptolites (Brenchley *et al.,* 1967).

6.2 Glencullen River Formation

The Glencullen River Formation makes up a mere ~0.4% (~2km^2) of the solid geology within the Vartry area (figure 5.16), and represents ~1% of the Ribband Group (plate 5.12). These rocks are exposed between Enniskerry and the junction with the Dargle. To the south, the rocks are in thrust contact with the Bray Group and consist of massive, buff-coloured finely-graded tuffs, interbedded with phyllites and tuffaceous greywacke siltstones (Brück *et al.,* 1974). The formation is considered to be the youngest of the group. Poorly preserved palynomorphs suggest an Upper Arenig age (Brück, *et al.,* 1974).

6.3 Maulin Formation

The rocks of the Maulin Formation are predominantly dark to mid-grey laminated siltstones and shales. The metamorphism of these rocks range from low-grade regional zeolite facies to andalusite and staurolite hornfels. The outer contact aureole is phyllitic (~1km to 3km in width) accompanied with increasing amounts of muscovite, biotite and garnet, relative to those beds which have only experienced regional metamorphism. The outer aureole grades into an inner aureole (~0.5km in width) of schist with staurolite and andalusite present. Hence, the Maulin Formation has experienced contact metamorphism

due to the intrusion of the Leinster batholith. The metamorphosed rocks are predominantly dark blue-grey slate, phyllites and schist, representing high-temperature low-pressure metamorphic assemblages. The width of the aureole within the Vartry area is between ~2km and 4km (figure 5.16). Thin beds of grey quartzite are interbedded with pelitic schists and phyllites of the Maulin Formation, near the eastern margin of the granite. Subordinate beds of coticules interdigitate within pelitic schists. These coticule beds can be traced from east to west, across the Leinster Mountain chain, into the Butter Mountain Formation.

The Maulin Formation has a surface outcrop of 181km^2, which equates to 92% of the Ribband Group in the Vartry area (plate 5.8). At the Bunclody area, the formation has a surface outcrop of 77km^2, which equates to 29% of the Ribband Group (plate 5.7). At the Glen of Imail area, the surface outcrop is significantly less, at 0.36 km^2, which equates to ~2% of the Ribband Group (plate 5.9). The Butter Mountain Formation makes up the largest proportion of the Ribband Group at this latter area (figure 5.66).

6.3.1 Knockree & Roundwood Members

The Knockree and Roundwood Members of the Maulin Formation occur in the Vartry area. These rocks form <0.05% (192500m^2) of the solid geology of the area (figure 5.16). The Knockree Member of the Maulin Formation consists of white quartzite, and occurs at Knockree in Glencree and also around the Lough Dan area. These rock units have relatively large thicknesses to length ratios, suggesting they may be Olistoliths. The Ballybeg Member forms a thick unit of interbedded psammites and semi-pelites. Highly deformed and altered basalt, the Roundwood Member, outcrop beside the Laragh road, 1km south of Roundwood. The basalts have a variolitic texture with small, sparse chlorite filled vesicles.

6.3.2 Monaughrim, Kilcarry & Ballybeg Members

The Monaughrim, Kilcarry and Ballybeg Members of the Maulin Formation occur in the Bunclody area (plate 5.12). These rocks form 22% (109km^2) of the solid geology (figure 5.7) of this area. The Monaughrim Member represents dark-grey psammitic schist and the Kilcarry Member consists of andesitic lavas and tuffs interbedded with amphibolites and chloritic schist. The Ballybeg member consists of thick units of psammites and semi-pelites. The Kilcarry Member lies adjacent to the eastern margin of the Tullow Pluton (McArdle, 1981), and interdigitates with the sheared margins.

6.4 Wicklow Head Formation

The Wicklow Head Formation makes up just over 2% (~10km^2) of the solid geology (figure 5.16) and ~5% of the Ribband Group within the Vartry area (figure 5.8). These rocks consist of silvery-grey mica chlorite and garnet schists and are thought to be the highly metamorphosed and deformed equivalent of the Maulin Formation. The increase in metamorphic grade and deformation may also be due to greater depth of burial, due to sinistral shearing and WNW thrusting of the Bray Group (Max *et al.,* 1990).

6.5 Butter Mountain Formation & Donard Andesite Member

The Butter Mountain Formation comprises 4% (~20km^2) of the solid geology and 82% of the Ribband Group within the Glen of Imail area (plates 5.9) respectively. The rocks are dominated by dark blue-grey slates that become schistose towards the granite margin. A stream section adjacent to St Brigets Chair shows 200mm thick interbedded quartzite with purple, tourmaline bearing pelites. The Donard Andesite Member consists of thick andesites and interbedded acidic tuffs.

7. Bray Group

The Lower-Middle Cambrian Bray Group is located in the Vartry area (plate 5.2), and outcrops over an area of 210km^2, equivalent to 43% of the solid geology (figure 5.16). The group consists of the Bray Head and Devil's Glen Formations, which are ~2,500m (minimum) and 2,000m thick respectively (Brück & Reeves, 1976). The type exposure occurs at Bray Head and Greystones. Outcrop also occurs in Rocky Valley and in a section of a tributary of the Dargle River, near Powerscourt. The Bray Group within the Vartry area stretches from the Dargle River in the north and is bounded to the south by the Southeastern Boundary fault (a northward dipping reverse fault). On the west, the contact between the Bray and Ribband Groups is only exposed within parts of the Dargle and Powerscourt river sections, and is interpreted as a thrust contact. To the east, the Bray Group forms the coastline from Bray Head to Wicklow Town. Jenner (1981) suggested that the light green chloritic slates in well 33/22-1 (30km east of Bray Head; see chapter 4) may correlate with the Bray Group.

7.1 Bray Head Formation

The Bray Head Formation comprises over 75% (160km^2) of the Bray Group (plate 5.12). The rocks consist of greywackes and quartzite units, ranging in thickness from 10 to >100m. The intercalated quartzites show both transitional and sharp contacts with the greywacke. The rocks range from feldspathic to lithic to quartz greywackes to ortho-quartzite. Lateral correlation of the greywackes is hampered by a lack of distinctive marker horizons. The quartzites are usually yellowish-white in colour, but pink, red or browns also occur. Individual quartzites are difficult to distinguish due to scattered outcrop and the similarity of lithological characteristics. Discontinuous beds of ortho-quartzite represent over 8km^2 of outcrop area, and equates to 4% of the Bray Group (plate 5.12).

Slump deformation is widespread in the Bray Head Formation with zones from 10 to 200m thick alternating with relatively undisturbed sediments, e.g. the Great Sugar Loaf

Mountain (figure 5.16), which Brück & Reeves (1976) believed represented the core of a megascopic isoclinal slump-fold.

7.2 Devil's Glen Formation

The Devil's Glen Formation underlies the Bray Head Formation and covers an outcrop area of 44km^2 and represents ~9% of the Bray Group (plate 5.12), and is located towards the SW where the type area is the Devil's Glen. The rocks consist of thick-bedded greywackes and shales. The thickest units and the highest sandstone to shale ratios are located in the SE of the area (Brück & Reeves, 1976). The western boundary is dominated by red and green shale, and medium to thick-bedded sandstones. A 20m to 30m thick ortho-quartzite unit is interbedded with greywackes, and has a characteristic fine, sugary texture. The contact between the Devil's Glen and Bray Head Formations outcrop in the Powerscourt and Bray Head sections. The transition between the two is taken to be a thick red shale unit. The red unit is a hemipelagic mudstone drape over turbidite successions. The unit probably formed during a lull in sedimentation, before the onset of clastic sedimentation that formed the Bray Head Formation.

8. Kilcullen Group

At the Glen of Imail area (figure 5.165), the Kilcullen Group forms the relatively low ground to the west, and has an outcrop area of ~123km^2 or 25% of the solid geology (plate 5.11). The rocks are separated to the east by the Hollywood Shear zone, which separates the Butter Mountain Formation (Ribband Group) from the Glen Ding Formation. The rocks are transected by a NE trending fault, the Athgarret fault. To the east of this fault, the Pollaphuca, Slate Quarries and Glen Ding Formation comprise ~78% (area 75km^2) of the Kilcullen Group within the Glen of Imail area. The Tipperkevin and Carrighill Formations are located to the west of the fault, and represent 35% (a surface outcrop area of 48km^2) of the Kilcullen Group.

The Kilcullen Group consist of greywackes and shales (Brück *et al.*, 1979). These rocks represent turbidite successions which fine upwards from the Pollaphuca to Carrighill Formation, coupled with an increase in complexity in the internal organisation of the turbidite beds. Brück (1972) suggested that the turbidites represent proximal to distal upward transitional facies. The age of the group was suggested to be Llandovery-Ludlow to Silurian based on poorly preserved palynomorphs and non-diagnostic fossils.

8.1 Pollaphuca & Slate Quarries Formations

The Pollaphuca and Slate Quarries Formations represent 35% (24km^2) of the Kilcullen Group (plate 5.11), with the Pollaphuca Formation being the largest (23km^2 in area) by an order of magnitude. The Pollaphuca Formation consist of coarse, graded medium-grey greywackes and dark grey shales. The Slate Quarries Formation consists of dark grey slate with minor interbedded greywackes. These units correspond with a bouma "ae" turbidite sequence, although the "a" units are generally finer-grained than those of the Pollaphuca Formation.

8.2 Glen Ding & Tipperkevin Formations

The Glen Ding and Tipperkevin Formations represent 49% (34km^2) of the Kilcullen Group within the Glen of Imail area (plate 5.11). The rocks are medium to fine-grained greywackes. The greywackes of the Glen Ding Formation are the most chloritic and feldspathic of the Kilcullen Group. All bouma successions are present in various combinations, although, "ae" are the most dominant. Rare load structures and tool marks have been observed at the base of "a" units in the Tipperkevin Formation. The base of the Tipperkevin Formation is not seen and the top of the Glen Ding Formation is faulted out by the Athgarrett fault.

8.3 Carrighill Formation

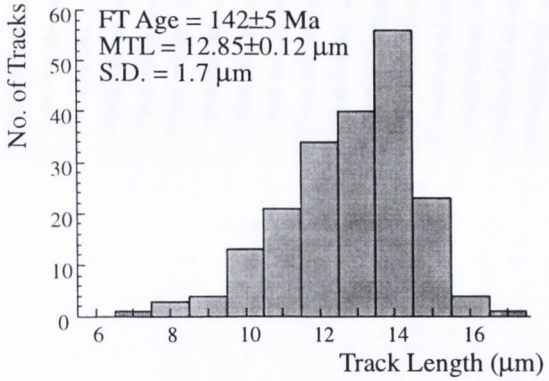
The Carrighill Formation is the youngest of the group and also contains the finest-grained rocks. This formation represents 16% (3km^2) of the Kilcullen Group (plate 5.11) within the Glen of Imail area. The rocks consist of greywackes, siltstones and shales. The greywackes have a distinctive calcareous matrix, which is primarily iron-rich dolomite.

APPENDIX 4

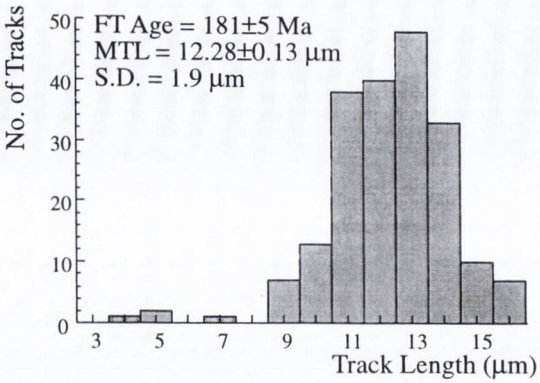
Track-Length Distribution Histograms.

1μm bins for track lengths

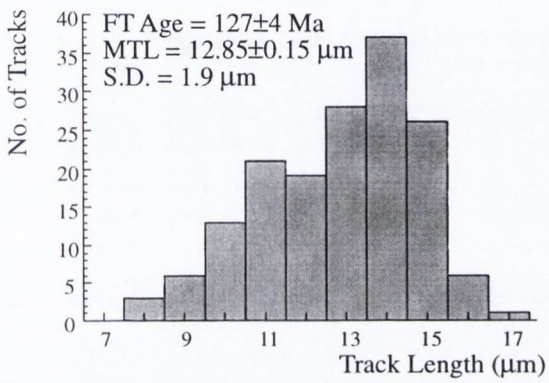
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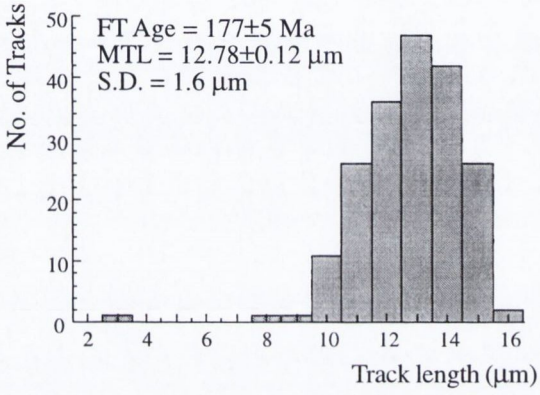
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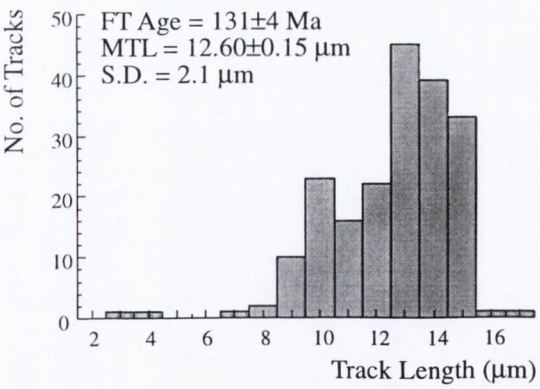
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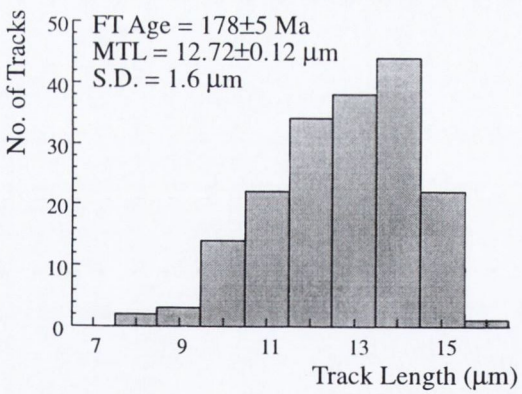
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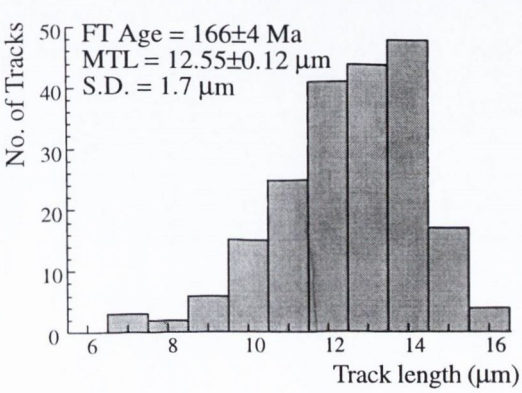
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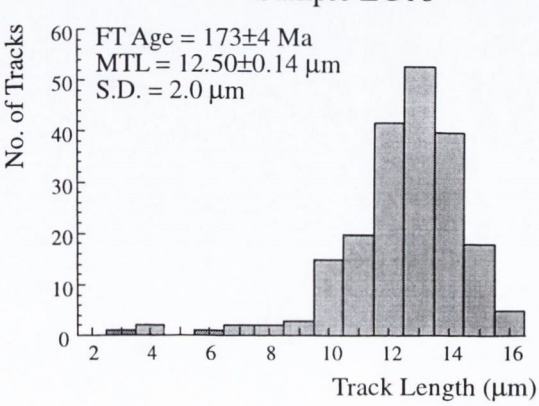
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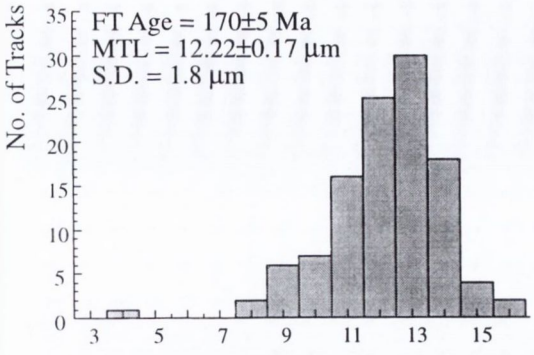
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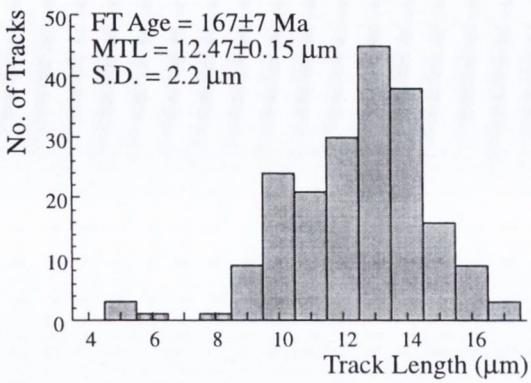
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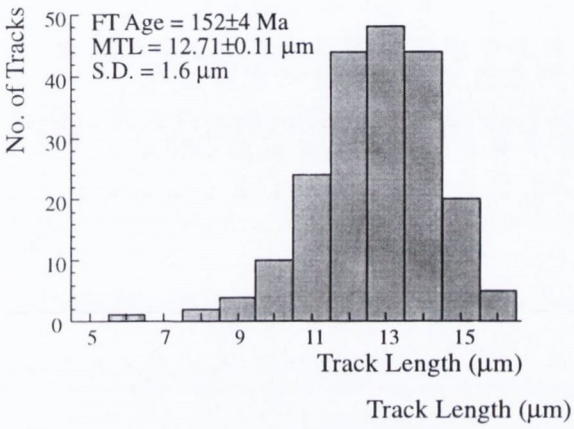
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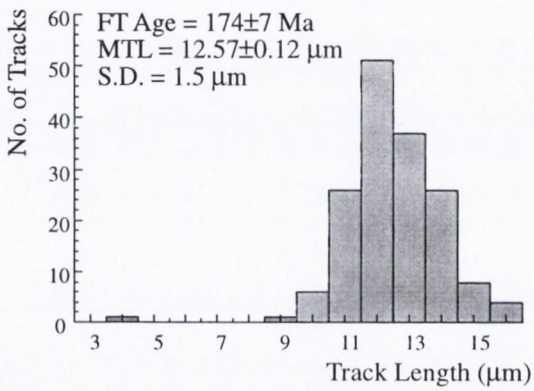
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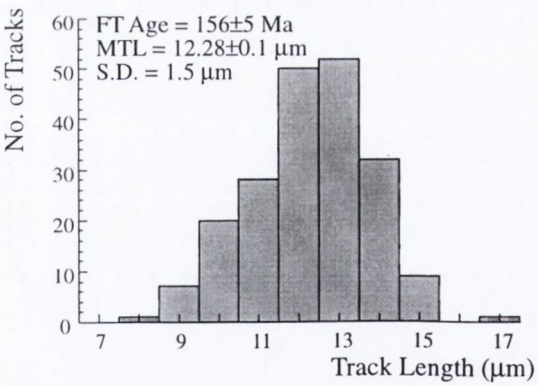
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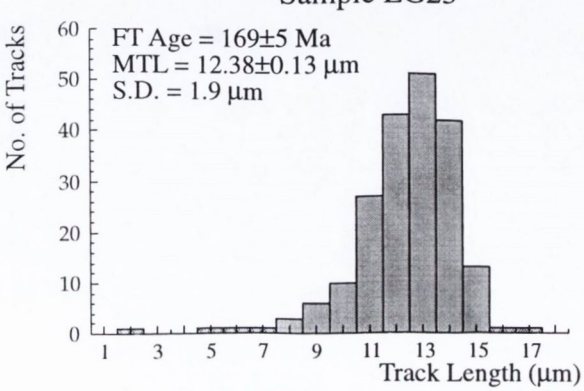
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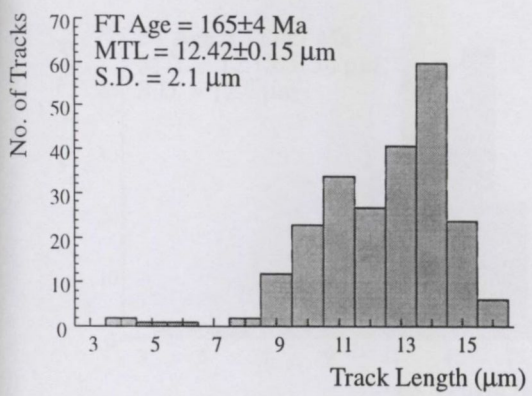
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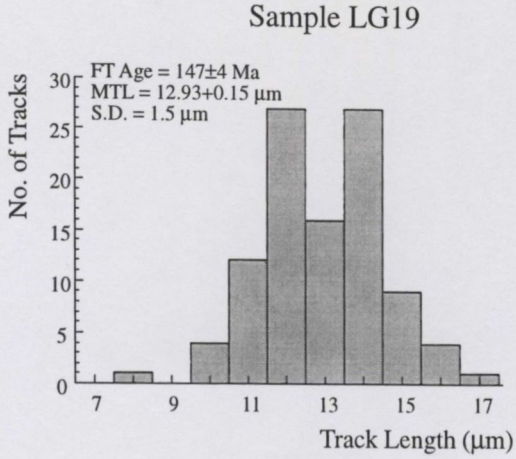
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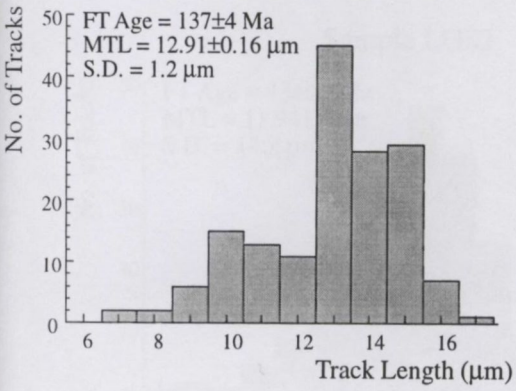
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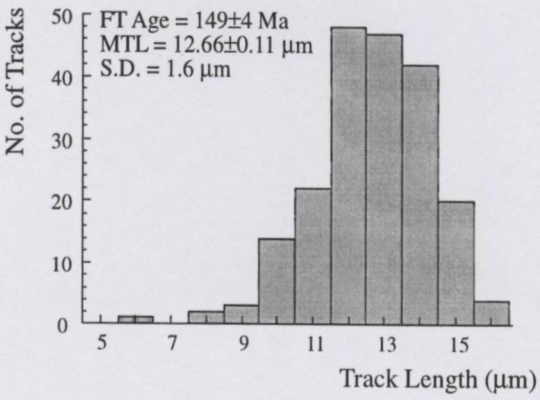
Sample LG19



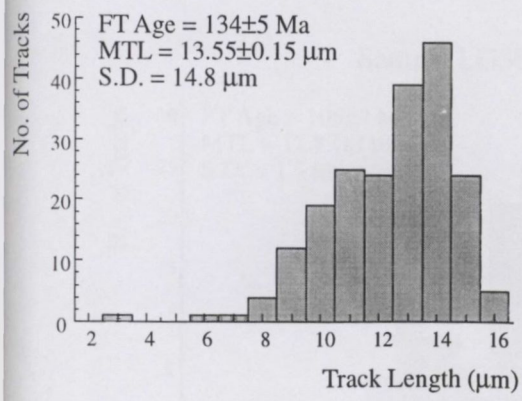
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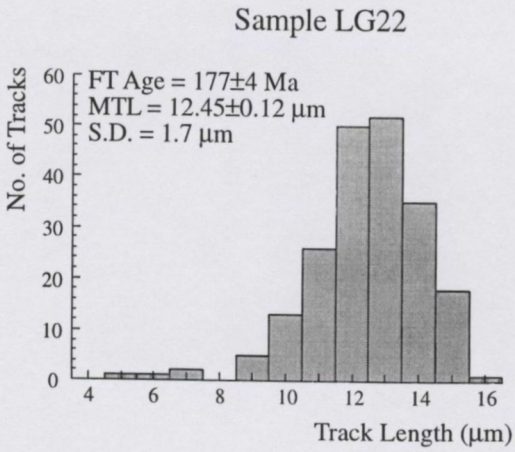
Sample LG20



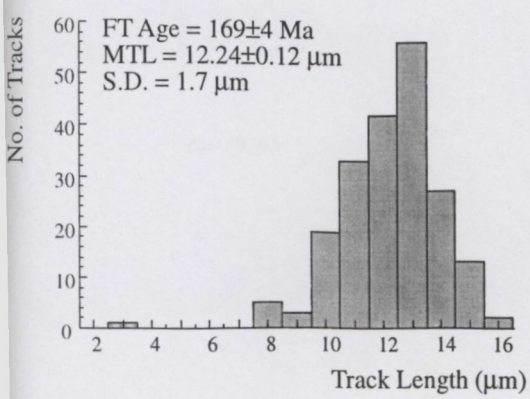
Sample LG6



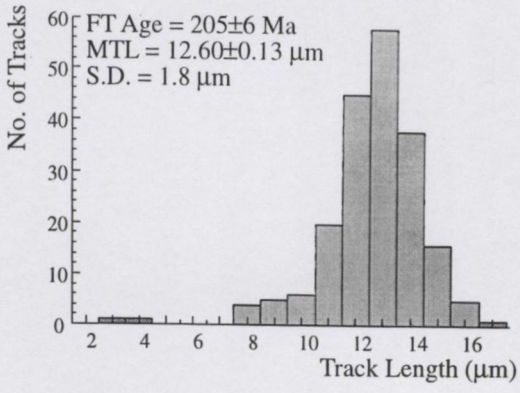
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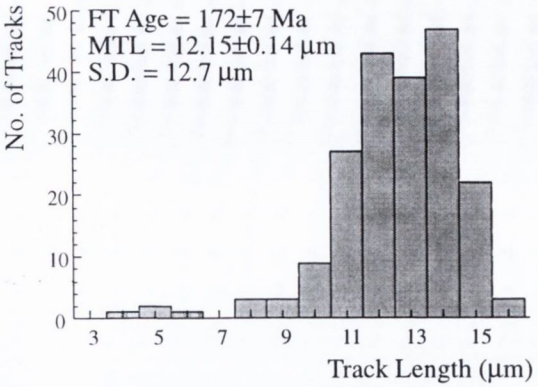
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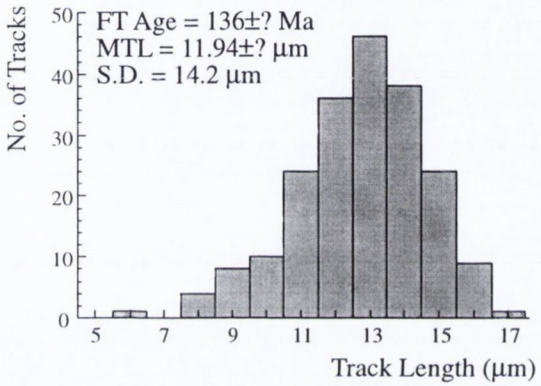
Sample LG28



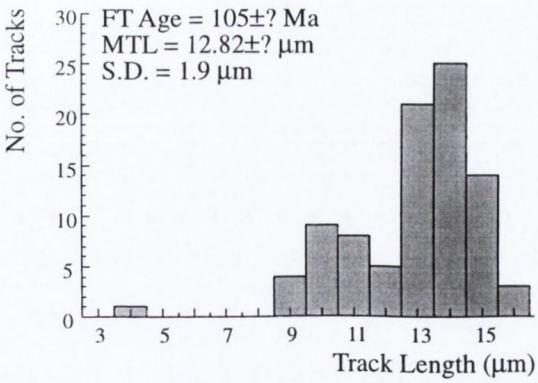
Sample LG30



Sample LG32



Sample LG38

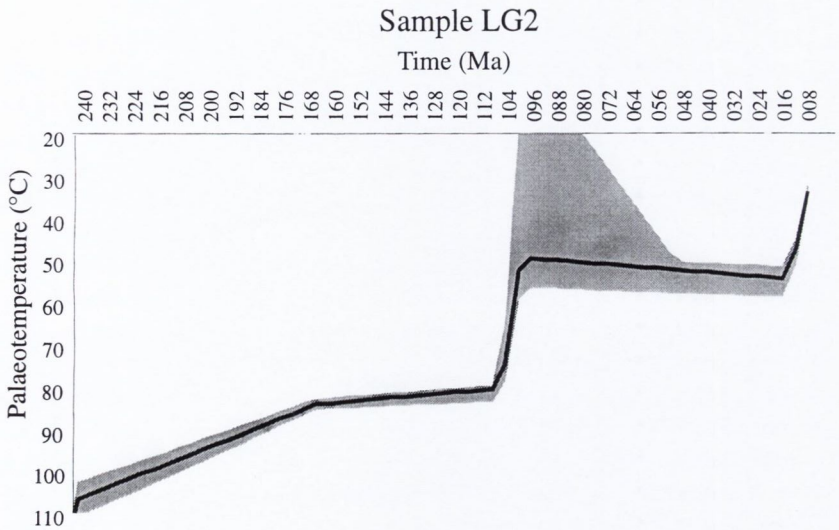


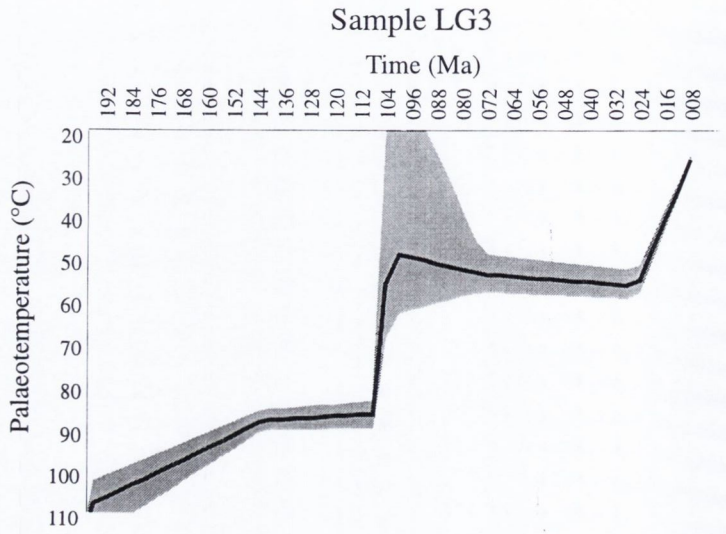
Non Profile

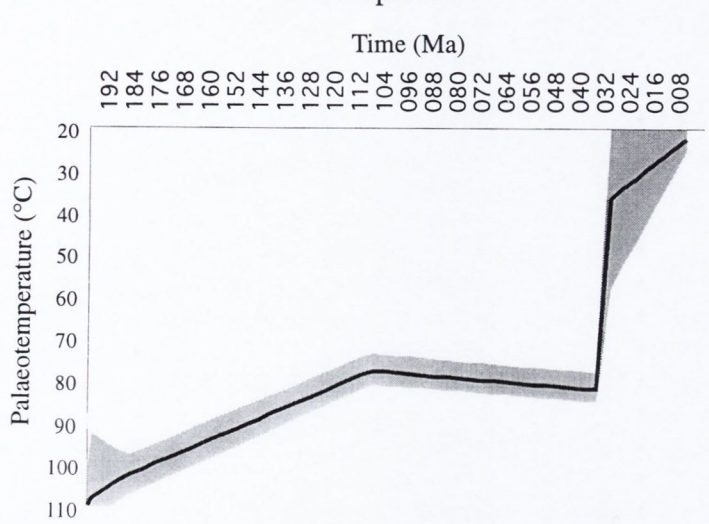
APPENDIX 5

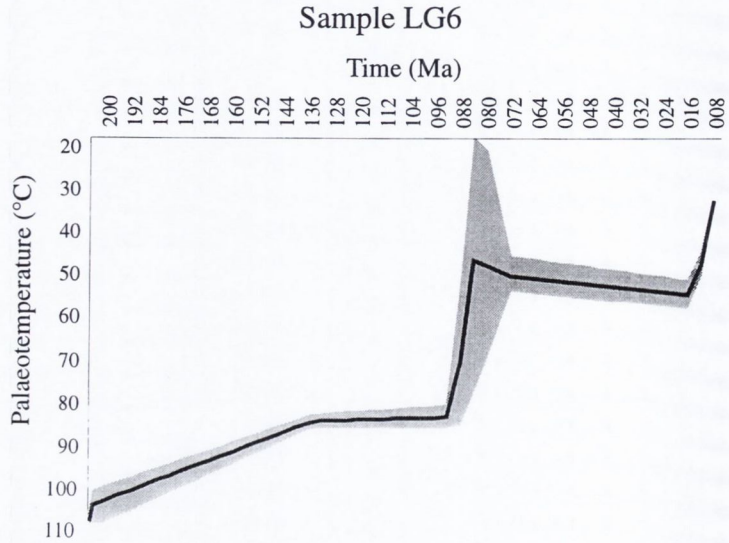
Thermal History of TULIP AFT Samples

SE Ireland

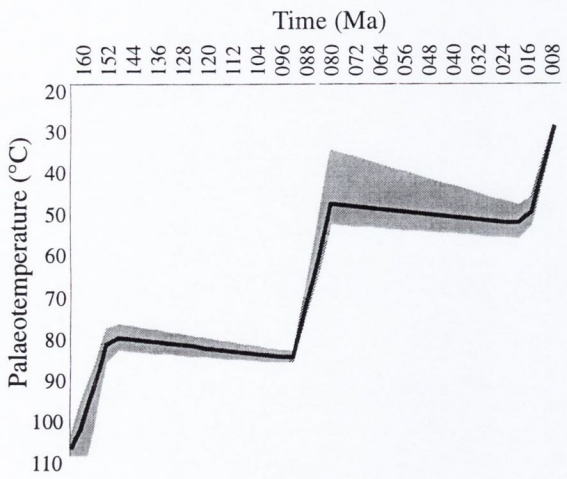

Sample LG2
Time (Ma)
240 232 224 216 208 200 192 184 176 168 160 152 144 136 128 120 112 104 096 088 080 072 064 056 048 040 032 024 016 008
Palaeotemperature (°C)
20 30 40 50 60 70 80 90 100 110


Sample LG3
Time (Ma)
192 184 176 168 160 152 144 136 128 120 112 104 096 088 080 072 064 056 048 040 032 024 016 008
Palaeotemperature (°C)
20 30 40 50 60 70 80 90 100 110

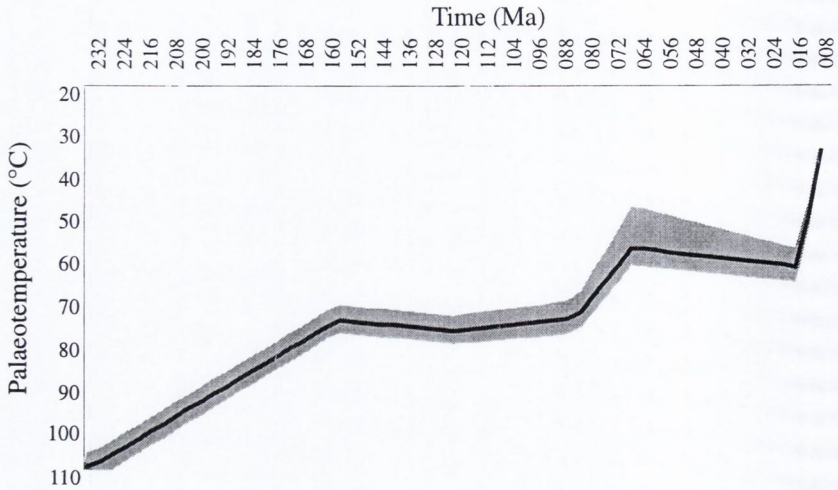

Sample LG4
Time (Ma)
192 184 176 168 160 152 144 136 128 120 112 104 096 088 080 072 064 056 048 040 032 024 016 008
Palaeotemperature (°C)
20 30 40 50 60 70 80 90 100 110


Sample LG6
Time (Ma)
200 192 184 176 168 160 152 144 136 128 120 112 104 096 088 080 072 064 056 048 040 032 024 016 008
Palaeotemperature (°C)
20 30 40 50 60 70 80 90 100 110

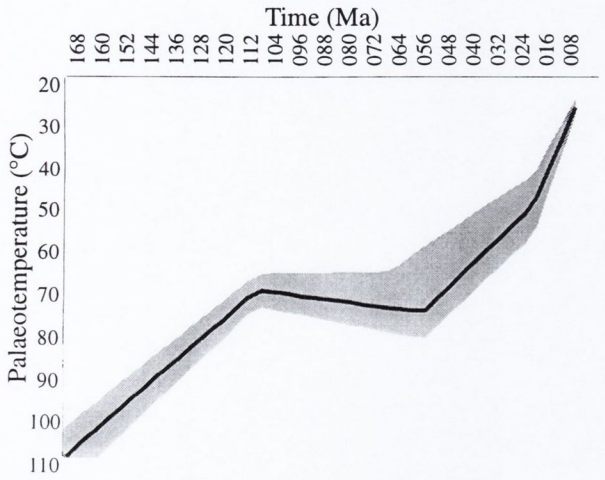
Sample LG7



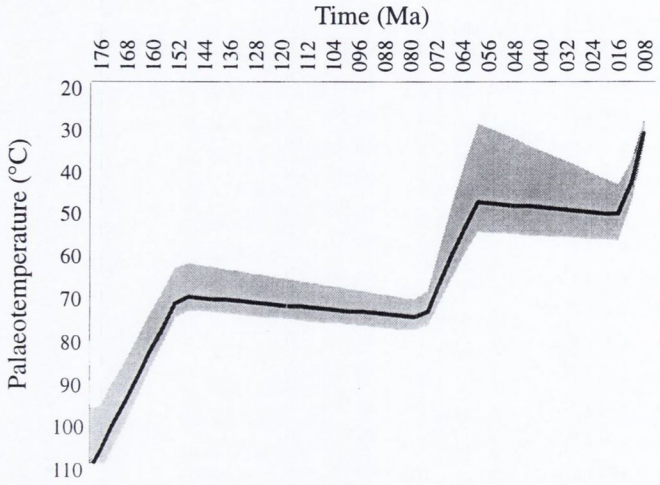
Sample LG12



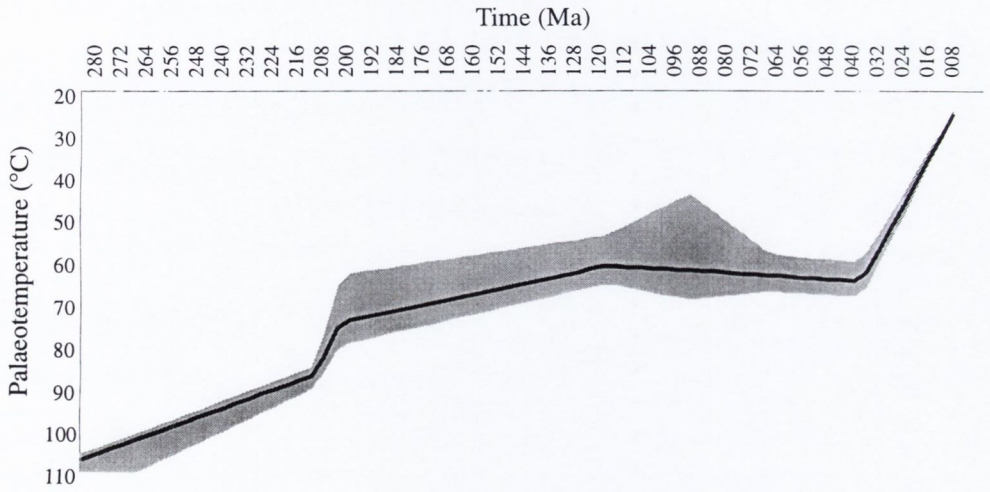
Sample LG19



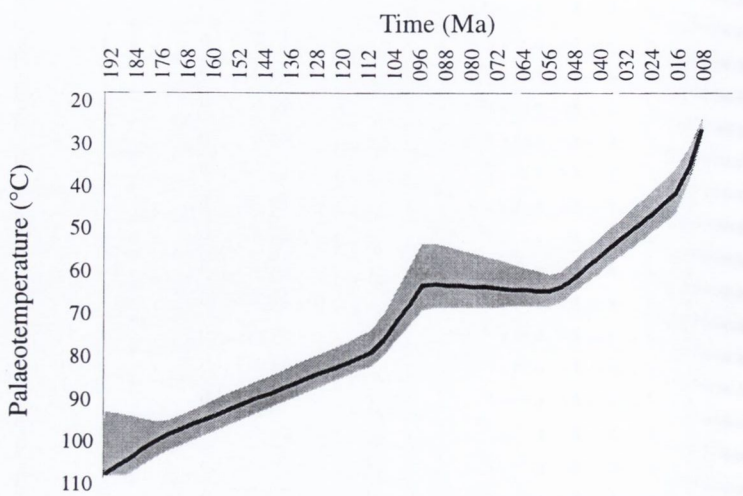
Sample LG24



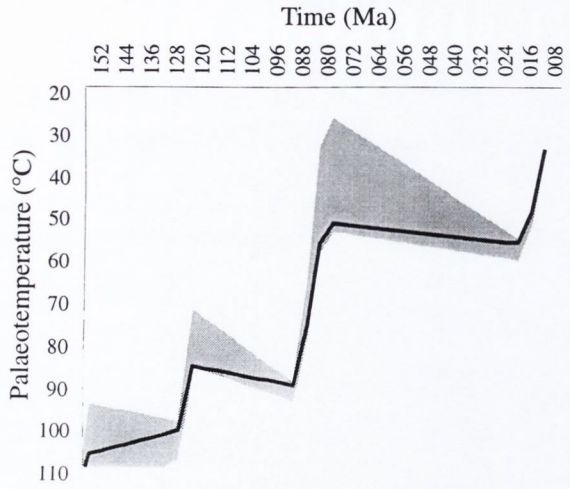
Bunclody - Sample LG28



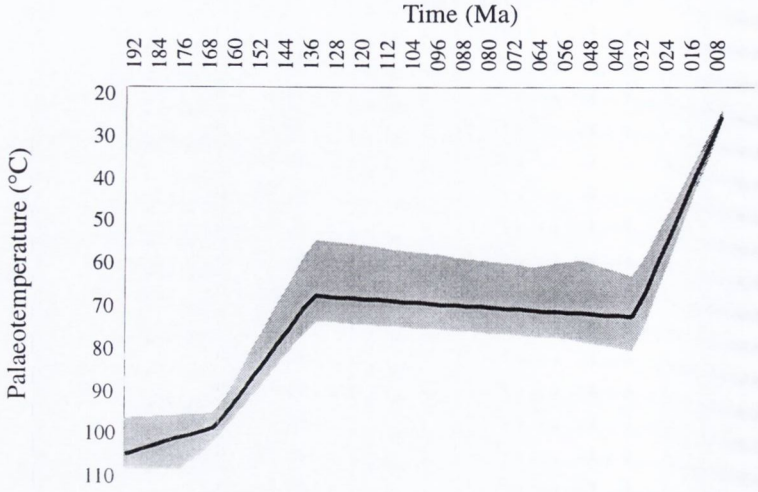
Bunclody - Sample LG32



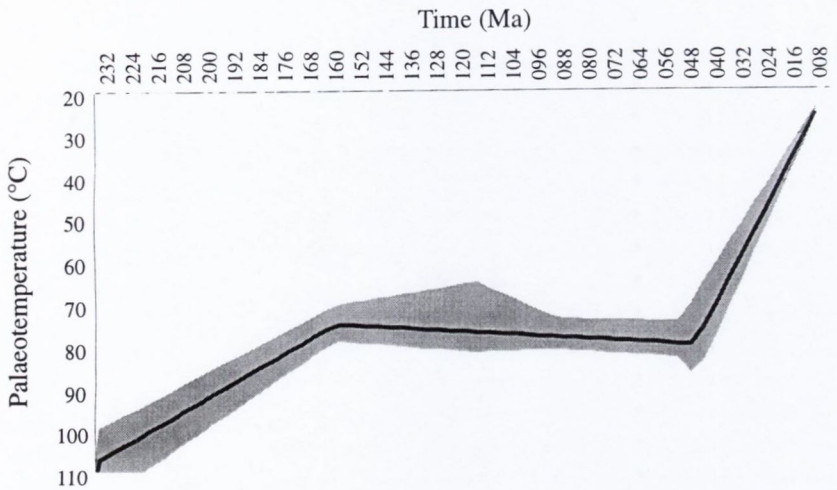
Sample LG38



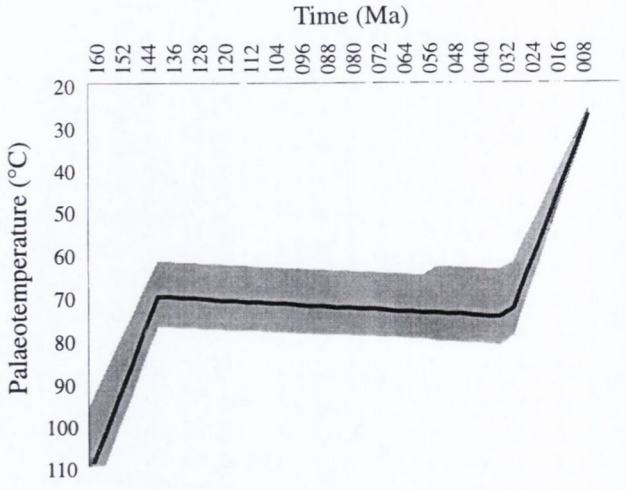
Vartry - Sample O160086



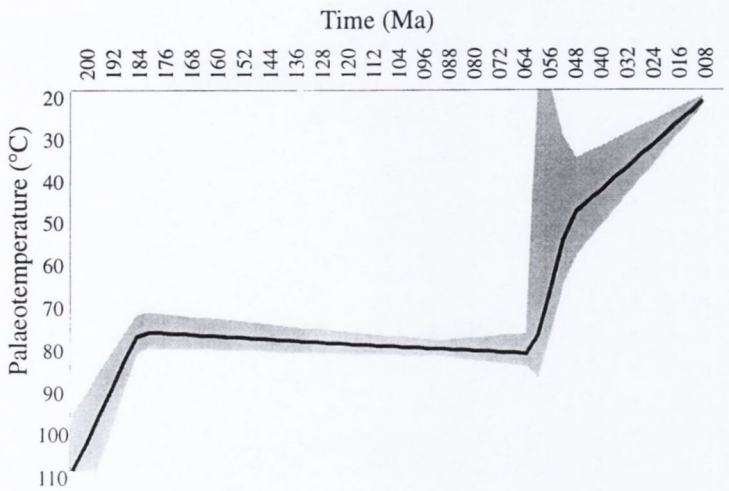
Sample O178232



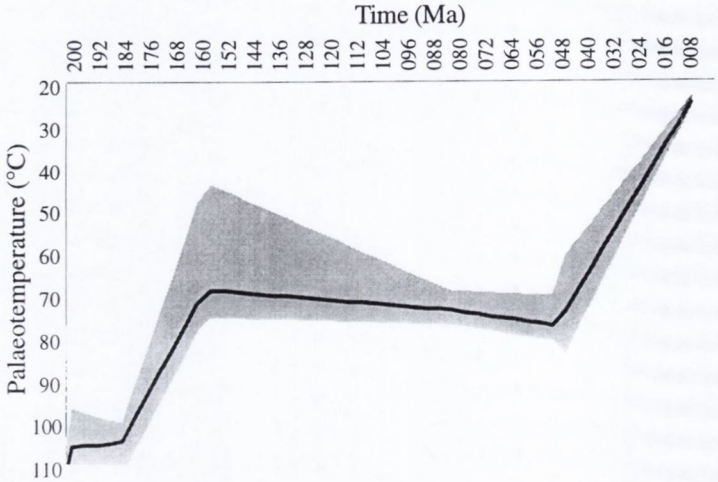
Vartry - Sample O192193



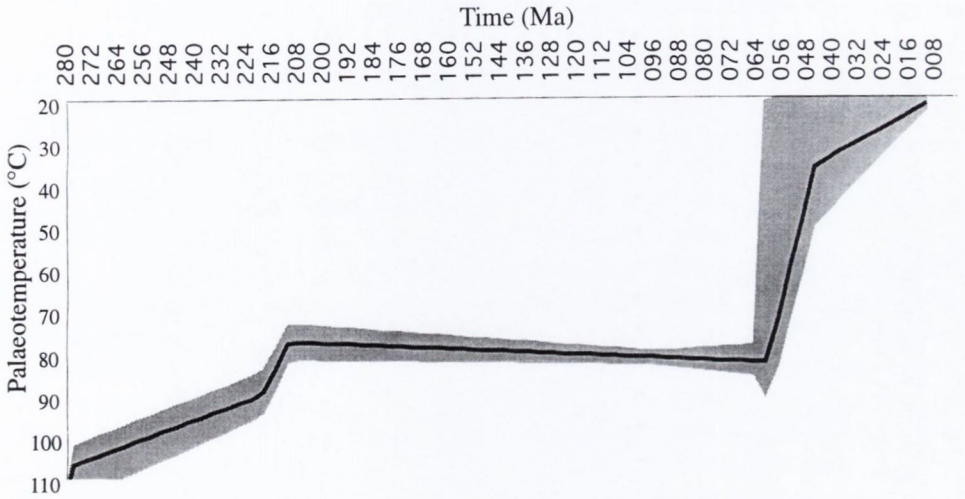
Sample S662767



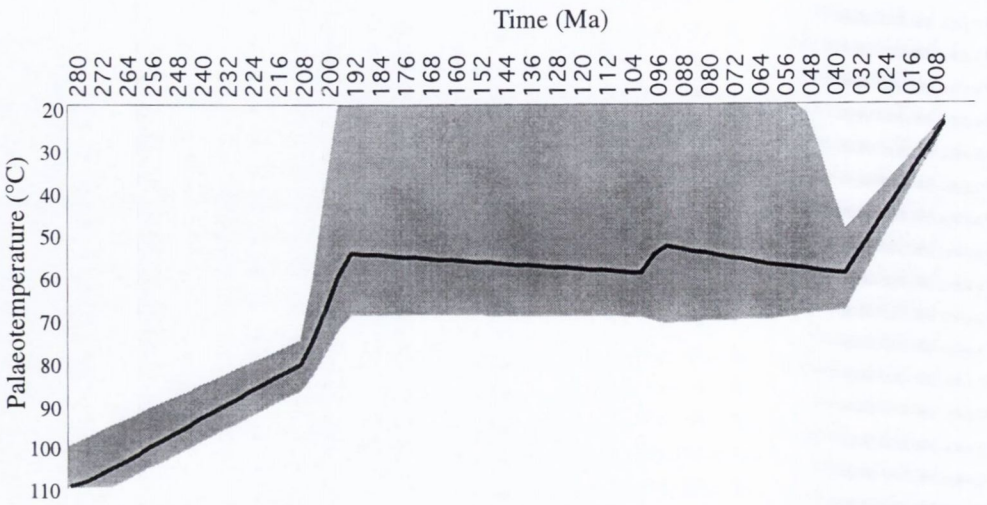
Sample S708434



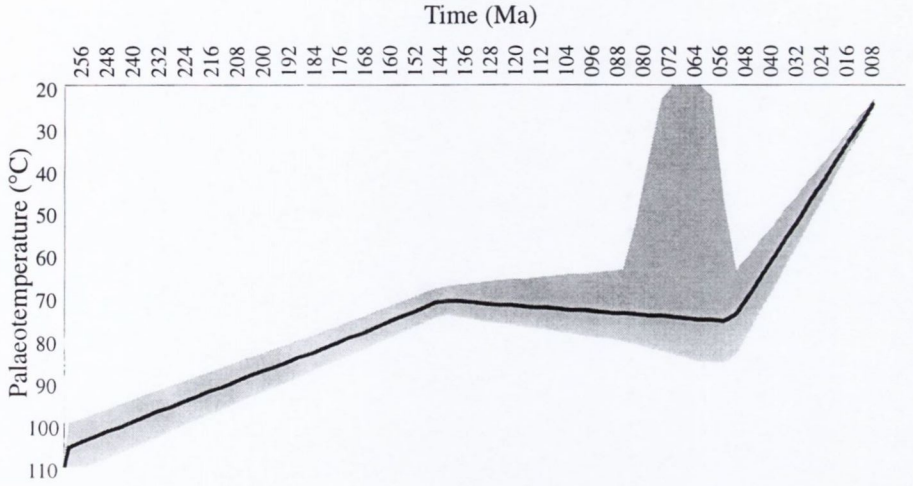
Sample T131797



Sample T251889

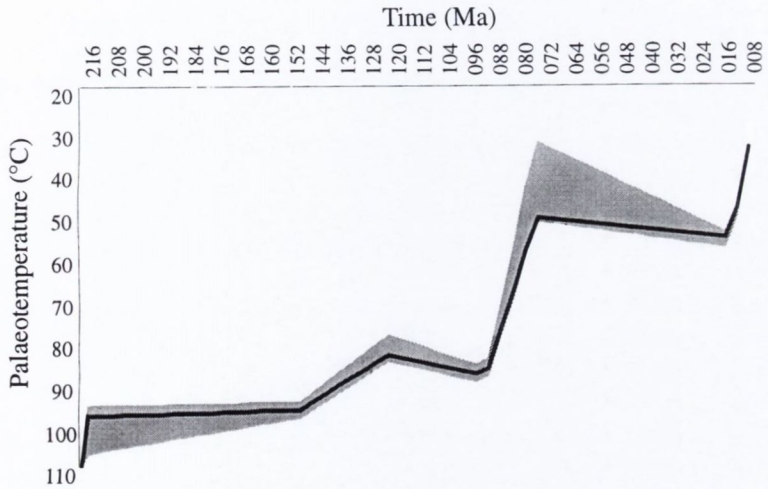


Sample T183855



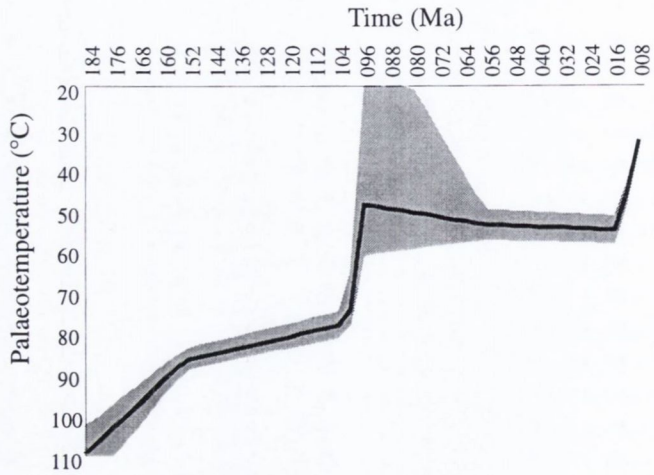
ENE

Sample LG8



WSW

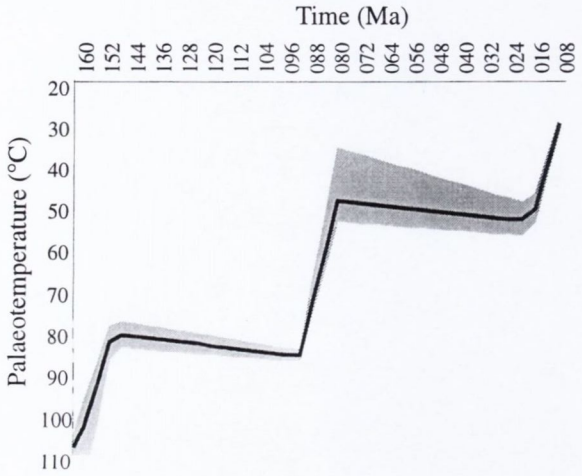
Sample LG5



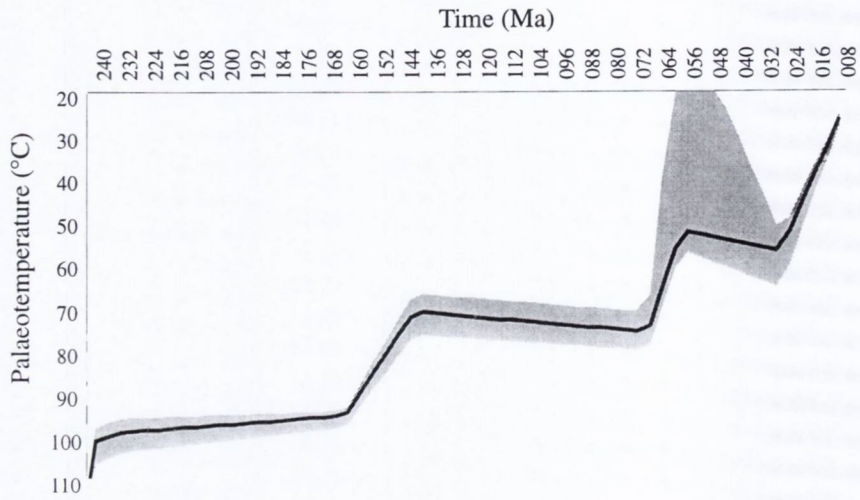
SSW

NNE

Sample LG7

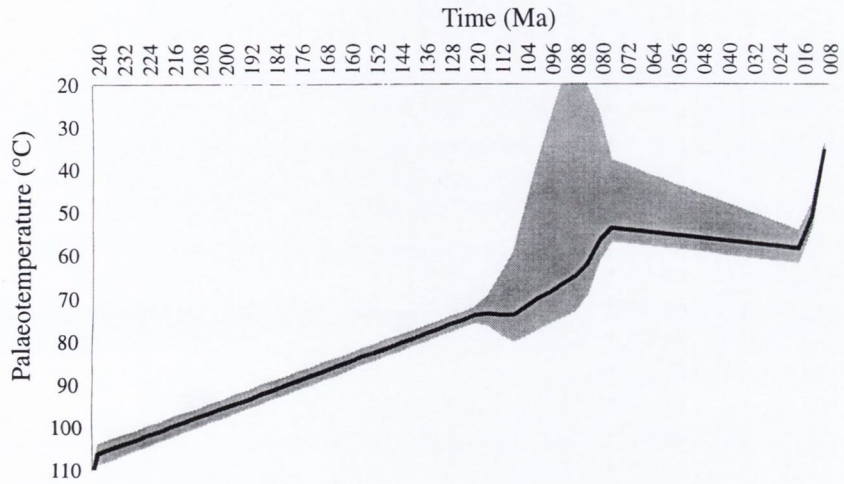


Sample LG10

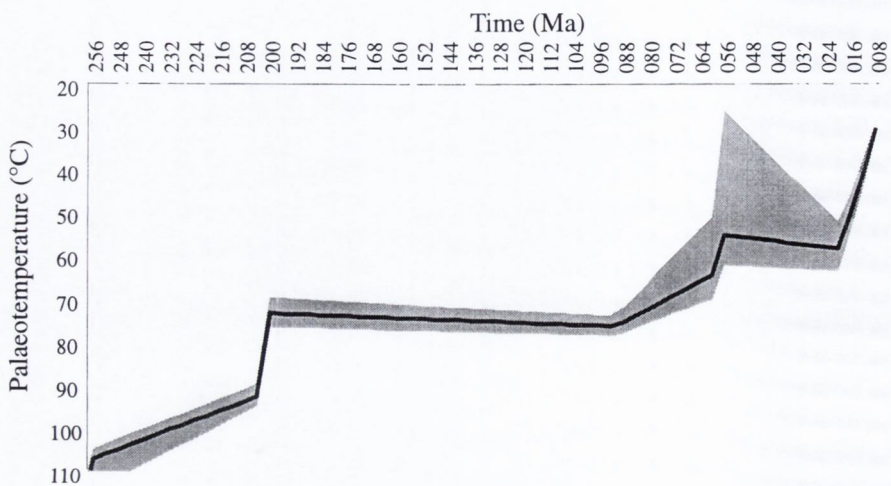


Sample LG11

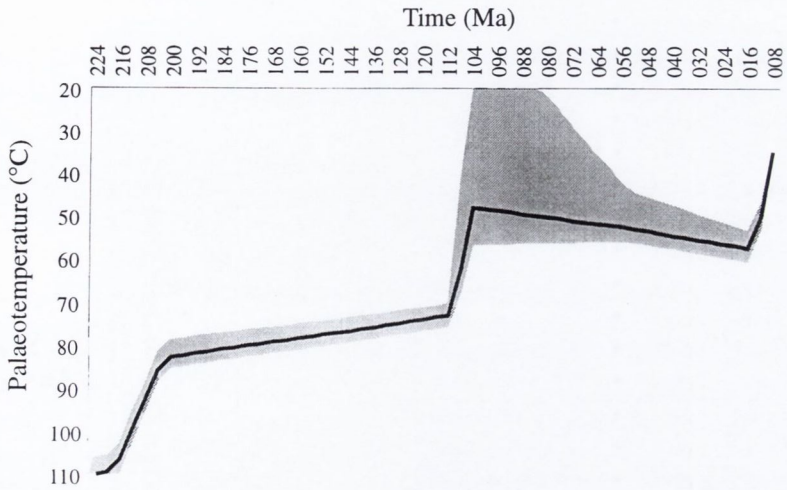
NNE



Sample LG13

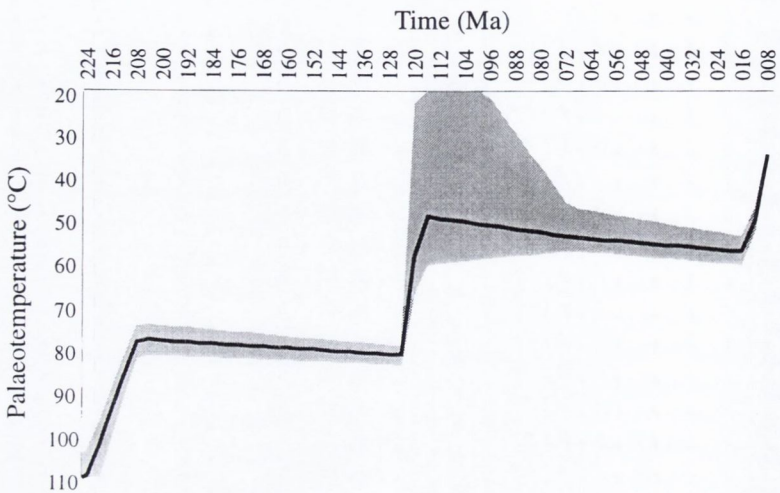


Vartry - Sample LG14



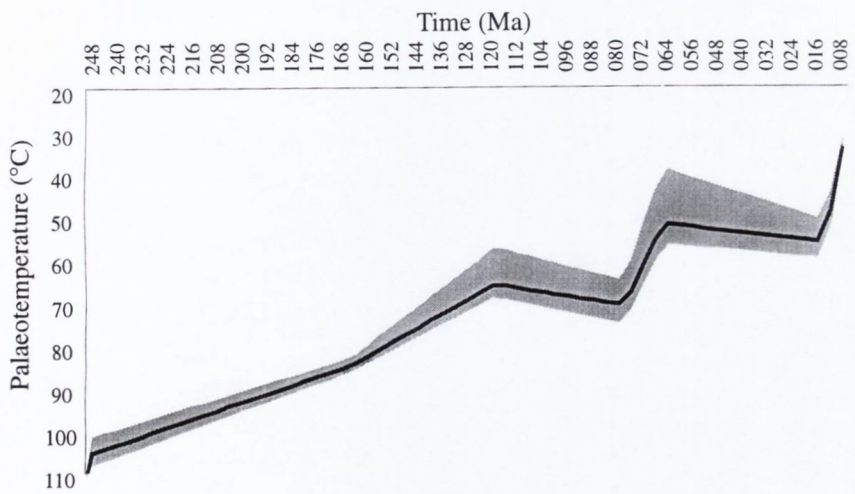
Vartry - Sample LG15

SSW

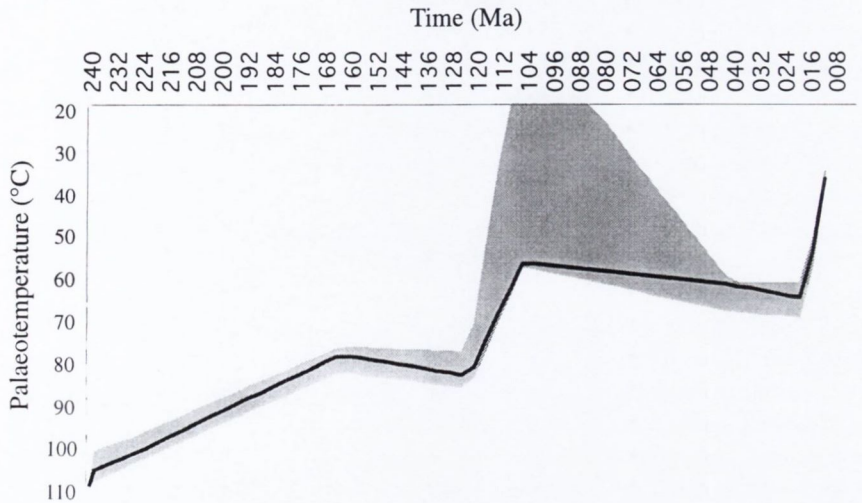


NNE

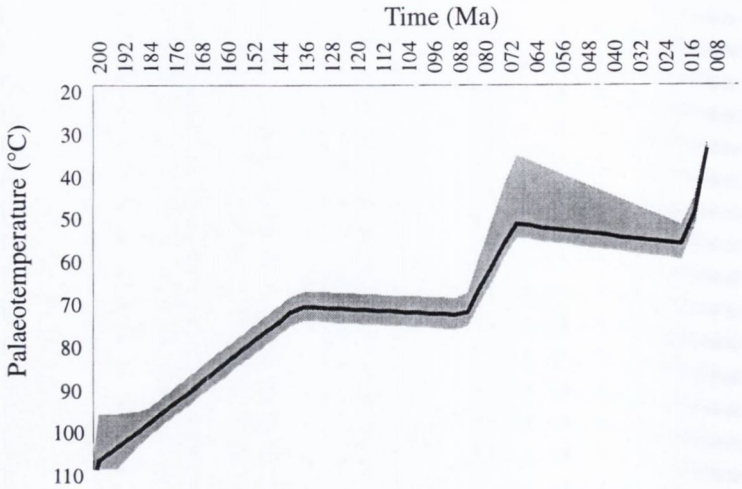
Sample LG16



Sample LG17

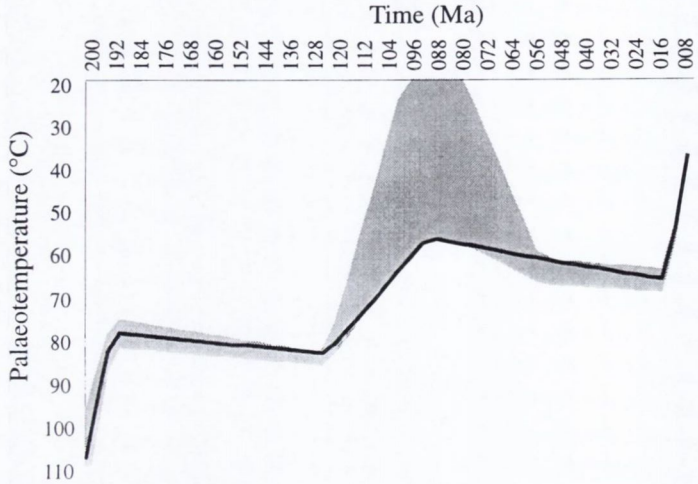


Sample LG18



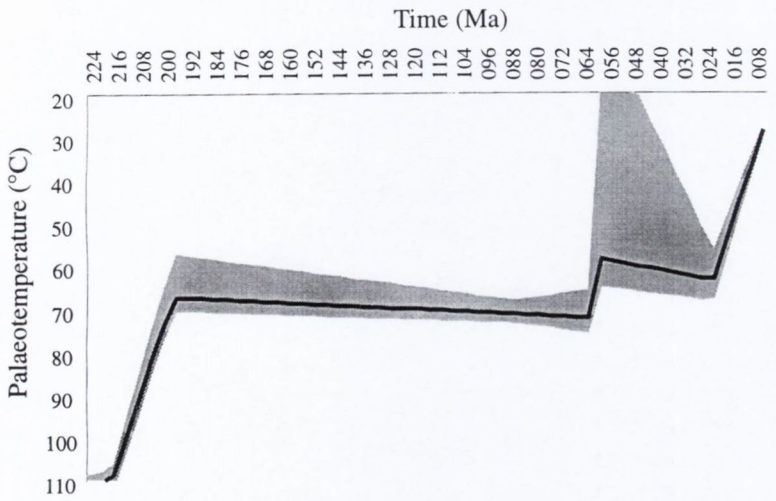
SSW

Sample LG21

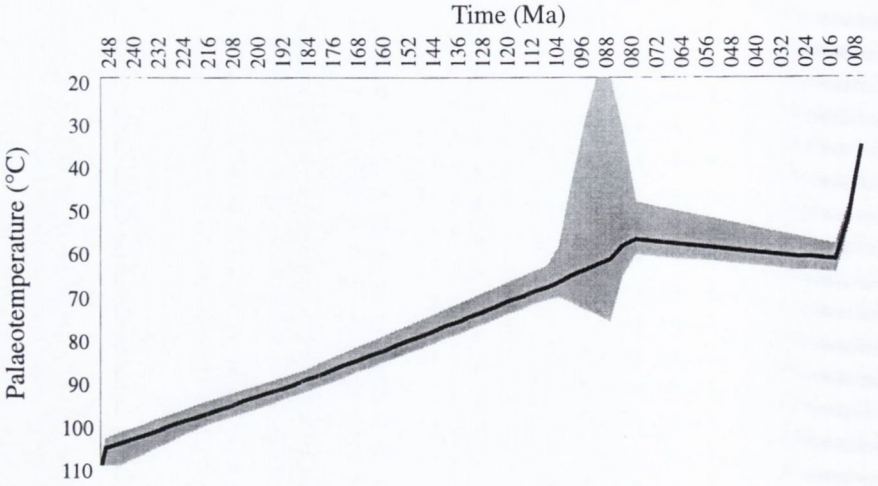


ENE

Baltinglass - Sample LG36

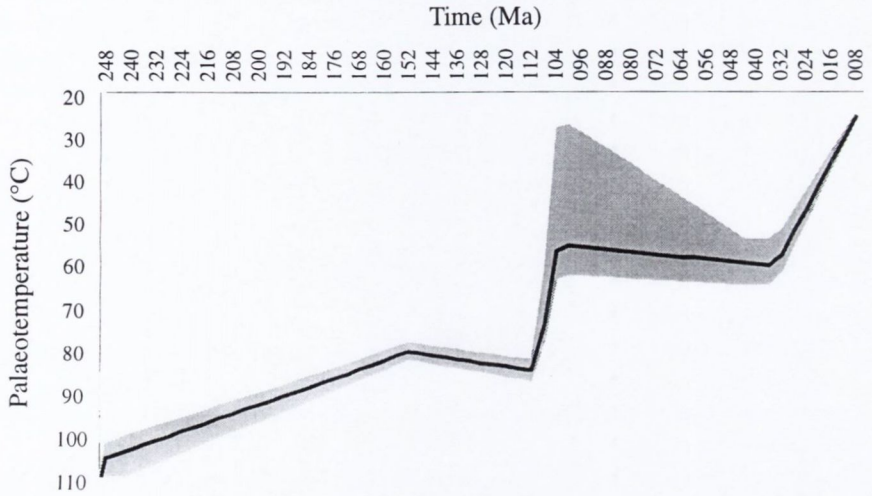


Baltinglass - Sample LG23



WSW

Baltinglass - Sample LG26



Profile

APPENDIX 6

TULIP AFT Database

Sample Localities

Appendix 6:- Details of AFT samples

Sample	Locality	County	Easting	Northing	Stratigraphy	Lithology	FT Age (Ma)	Age (1σ)	MTL (μm)	MTL (1σ)	SD (μm)	Origin
BS1	Barnesmore Gap	Donegal	185098	374943	Carboniferous	Granite	143		13.00		1.47	Tulip
C062277	Main Donegal Granite	Donegal	206198	427751	Devonian	Granite	159	±11	12.41	±0.21	1.65	McCulloch (unpublished)
C380251	Dalradian Basement	Donegal	237998	425126	Devonian	Sandstone	301	±25	12.85	±0.28	2.37	McCulloch (1993)
CL1	Omey Granite (Connemara)	Galway	56890	257770	Devonian	Granite	145	±8	12.84	±0.13	1.63	Tulip
CG1	Crest of Laghtaeighter	Mayo	85170	274020	Devonian	Granite	172	±5	12.74	±0.11		Tulip
D243261	Northern Red Bay	Antrim	324298	426138	Devonian	Sandstone	394	±48	12.37	±0.2	1.59	McCulloch (unpublished)
D244276	Cushendal	Antrim	324398	427589	Devonian	Andesite	267	±13	12.71	±0.16	1.61	McCulloch (1993)
DQ1	Doonan Quarry (NI)	Fermanagh	219500	356600	Devonian	Sandstone	73		14.54			Tulip
F1	Barnesmore Granite	Donegal	202500	385400	Devonian	Granite	190		12.72		1.82	Tulip
F4	Kingscourt	Meath	280594	296847	Triassic	Sandstone	166		11.93			Tulip
F9	Mourne Mountains	Down	326850	326277	Silurian	Quartzite	197		12.72		1.63	Tulip
G222329	Killala Bay	Mayo	122200	332903	Carboniferous	Sandstone	55	±3	13.74	±0.25	1.45	McCulloch (1993)
G235045	Ox Mountains	Mayo	123499	304494	Devonian	Sandstone	155	±6	12.94	±0.43	1.38	McCulloch (1993)
G402145	Ox Mountains	Sligo	140199	314490	Devonian	Sandstone	155	±9	12.55	±0.16	1.53	McCulloch (1993)
G450237	Ox Mountains	Sligo	145002	323669	Devonian	Sandstone	169	±8	12.48	±0.23	1.54	McCulloch (1993)
G710579	Mullaghmore	Sligo	171002	357937	Carboniferous	Sandstone	166	±8	12.45	±0.21	1.92	McCulloch (1993)
G725933	Ardara Granite	Donegal	172501	393324	Devonian	Granite	181	±6	12.49	±0.16	1.56	McCulloch (1993)
GA	Killary fjord	Galway	86500	262200	Ordovician	Schist	227	±23	14.85	±0.33	1.18	Tulip
GG12	Bovroughaun Peak	Galway	101740	228360	Devonian	Granite	140	±4	13.01	±0.1	1.43	Tulip
GG13	Beach (near Spiddle)	Galway	109360	222060	Devonian	Granite	128	±5	12.71	±0.13	1.81	Tulip
GG15	(near Connaught)	Galway	122590	225470	Devonian	Granite	152	±7	12.97	±0.17	2.01	Tulip
GG3	Tombeoloa Bridge	Galway	79610	242400	Devonian	Granite	196	±10	12.87	±0.11	1.55	Tulip
GG4	Quarry (near Cashel)	Galway	97320	249000	Devonian	Granite	136	±17	12.32	±0.47	1.98	Tulip
GG9	Kilkieran Bay	Galway	82860	231453	Devonian	Granite	138	±6	13.62	±0.15	1.85	Tulip
GL	Partry Mts	Mayo	105900	270800	Ordovician	Sandstone	201	±23	12.55	±0.3	2.77	Tulip
Gleadow1	Thorr Granite	Donegal	182497	417986	Devonian	Granite	187	±3.6	12.25	±2.15	2.15	Gleadow (unpublished)
Gleadow10	Inish Granite	Galway	57017	245480	Devonian	Granite	120	±6.1	12.18	±1.77	1.77	Gleadow (unpublished)
Gleadow11	(west of Kilkieran)	Galway	71001	238955	Devonian	Granite	127	±6.4	12.78	±0.21	2.16	Gleadow (unpublished)
Gleadow12	Kilkieran Bay	Galway	73001	242018	Devonian	Granite	163	±7.5	12.37	±0.2	1.94	Gleadow (unpublished)
Gleadow14	near Costelloe	Galway	78998	231952	Devonian	Granite	183	±5.3	11.91	±0.22	2.17	Gleadow (unpublished)
Gleadow16	SE of Poulaphouca Res.	Wicklow	301002	207552	Devonian	Granite	208	±4.6	12.16	±0.17	2.3	Gleadow (unpublished)
Gleadow17	Glendasan	Wicklow	307002	201003	Devonian	Granite	208	±6.4	12.20	±0.23	2.3	Gleadow (unpublished)
Gleadow2	Thorr Granite	Donegal	183002	417984	Devonian	Granite	201	±7	12.25	±1.93	2.04	Gleadow (unpublished)
Gleadow3	Rosses Granite	Donegal	179999	415992	Devonian	Granite	197	±6.8	11.92	±2.15	2.15	Gleadow (unpublished)
Gleadow4	Thorr Granite	Donegal	182501	415759	Devonian	Granite	187	±7.1	12.25	±2.04	2.15	Gleadow (unpublished)
Gleadow5	Trawenagh Granite	Donegal	178998	409875	Devonian	Granite	194	±8	12.24	±2.42	2.42	Gleadow (unpublished)
Gleadow6	Trawenagh Granite	Donegal	179999	407310	Devonian	Granite	180	±8.8	12.32	±2.27	2.27	Gleadow (unpublished)
Gleadow8	Trawenagh Granite	Donegal	173002	411361	Devonian	Granite	175	±9.3	12.36	±1.88	1.88	Gleadow (unpublished)
Gleadow9	Corvock Granite	Mayo	86002	273976	Devonian	Granite	124	±5.1	12.27	±2.36	2.36	Gleadow (unpublished)
H302411	near Eniskillen	Fermanagh	230198	341137	Silurian	Sandstone	176	±7	12.32	±0.2	2.07	McCulloch (1993)
H352007	SW of Cavan	Cavan	235203	300659	Devonian	Granite	201	±8	12.15	±0.18	1.76	McCulloch (1993)

H395090	north of Cavan	Cavan	239501	308988	Devonian	Sandstone	179	±16.4	11.20	±0.22	2.16	McCulloch (1993)
H397547	SE of Trillick	Tyrone	239698	354678	Devonian	Sandstone	177	±9	11.49	±0.2	1.67	McCulloch (1993)
H683815	NW of Kildress	Tyrone	268299	381511	Ordovician	Tuff	225	±11	12.39	±0.17	1.74	McCulloch (1993)
ID2	Slieve Bloom	Laois	239411	210321	Devonian	Sandstone	179		11.20		2.16	Tulip
ID7	Omey Granite (Connemara)	Galway	54814	260471	Devonian	Granite	201		12.54		1.81	Tulip
ID8	Just west of Coole	Westmeath	239931	272804	Carboniferous	Sandsonte	172		13.15		1.44	Tulip
IG1	Inish Granite	Galway	56490	244670	Devonian	Granite	141	±6	12.42	±0.12	1.76	Tulip
J072026	Dundalk Bay	Louth	307201	302652	Silurian	Sandstone	64	±14.2	13.39	±0.2	1.3	McCulloch (1994)
J210348	Newry Granite	Down	320998	334838	Devonian	Granite	58	±7.4	13.98	±0.19	1.2	McCulloch (1994)
J278445	Newry Granite	Down	327799	344488	Devonian	Granite	134	±12.2	11.74	±0.15	1.46	McCulloch (1994)
J409807	Belfast Lough	Antrim	340896	380738	Carboniferous	Sandstone	274	±13	10.87	±0.15	1.54	McCulloch (1993)
Keeley1	Near Hook Head	Wexford	275302	101465	Devonian	Sandstone	226	±11	12.38	±0.15	1.58	Keeley *et al* .(1993)
Keeley10	Near Dunmore East	Waterford	231242	89198	Devonian	Sandstone	192	±10	12.68	±0.16	1.51	Keeley *et al* .(1993)
Keeley2	South of Graiguenamanagh	Kilkenny	271240	139464	Devonian	Sandstone	130	±7	12.39	±0.19	1.67	Keeley *et al* .(1993)
Keeley3	near Cloyne Outlier	Cork	192550	69747	Devonian	Sandstone	187	±16	11.96	±0.64	2.46	Keeley *et al* .(1993)
Keeley4	Slieve Bloom	Laois	221097	197378	Devonian	Sandstone	154	±14	12.56	±0.31	1.55	Keeley *et al* .(1993)
Keeley5	Dunsmore East	Cork	199821	63845	Devonian	Sandstone	212	±12	12.12	±0.29	1.98	Keeley *et al* .(1993)
Keeley6	NE of Templemore	Laois	219762	176567	Devonian	Sandstone	186	±9	12.05	±0.33	1.92	Keeley *et al* .(1993)
Keeley7	Comeragh Mts	Waterford	230059	121346	Devonian	Sandstone	166	±8	12.34	±0.16	1.58	Keeley *et al* .(1993)
Keeley8	Old Head of Kinsale	Cork	162423	40733	Devonian	Sandstone	154	±6	12.66	±0.15	1.44	Keeley *et al* .(1993)
Keeley9	NE of Fermoy	Cork	184901	101696	Devonian	Sandstone	193	±8	12.67	±0.14	1.41	Keeley *et al* .(1993)
L569453	Slyne Head	Galway	56878	245262	Devonian	Sandstone	130	±6	12.68	±0.16	1.61	McCulloch (1993)
L574560	Omey Granite (Connemara)	Galway	57403	256048	Devonian	Granite	135	±8	13.06	±0.21	2.07	McCulloch (1993)
L620450	Mannin Bay	Galway	61990	244999	Devonian	Schist	154	±9	12.11	±0.34	2.18	McCulloch (unpublished)
L723403	Kilkieran Bay	Galway	72301	240256	Devonian	Granite	149	±7	12.45	±0.22	2.1	McCulloch (1993)
L728560	The Twelve Bens	Galway	72800	256054	Pre-Cambrian	Gneiss	156	±9	13.22	±0.13	1.27	McCulloch (1993)
L730629	near Renvyle	Galway	72999	262952	Silurian	Sandstone	171	±13	13.27	±0.23	2.15	McCulloch (1993)
L810743	Cregganbaun	Mayo	81003	274323	Devonian	Granite	152	±7	12.89	±0.19	1.99	McCulloch (1993)
L935657	N of Leenane	Mayo	93497	265672	Ordovician	Schist	152	±7	12.65	±0.18	1.81	McCulloch (1993)
L981498	Lough Corrib	Galway	98097	249762	Pre-Cambrian	Schist	150	±6	12.69	±0.2	1.94	McCulloch (1993)
LE	Partry Mts	Mayo	104900	267000	Ordovician	Sandstone	271	±28	12.43	±0.58	2.12	Tulip
LG10	Church View Road	Dublin	324100	225459	Devonian	Granite	151	±6	12.49	±0.27	1.93	Tulip
LG11	Ballyedmond Quarry	Dublin	318739	223458	Devonian	Granite	166	±4	12.43	±0.12	1.83	Tulip
LG12	Barnaculla quarry	Dublin	317890	224230	Devonian	Granite	169	±4	12.15	±0.12	1.68	Tulip
LG13	Three Rock Mountain	Dublin	317600	223400	Devonian	Granite	180	±5	12.24	±0.13	1.72	Tulip
LG14	Military Road/Oldboley	Wicklow	315090	218000	Devonian	Granite	175	±5	12.69	±0.12	1.56	Tulip
LG15	Lough Bray	Wicklow	314290	215140	Devonian	Granite	179	±5	12.58	±0.12	1.64	Tulip
LG16	Sally Gap	Wicklow	312940	212200	Devonian	Granite	172	±4	12.46	±0.14	1.82	Tulip
LG17	Top of Carrigshouk	Wicklow	309280	205200	Devonian	Granite	168	±5	12.11	±0.17	1.73	Tulip
LG18	Halfway up Carrigshouk	Wicklow	309794	205293	Devonian	Granite	151	±4	12.61	±0.11	1.65	Tulip
LG19	T. of Glenmacnass	Wicklow	311500	203000	Devonian	Granite	124	±4	12.46	±0.15	1.79	Tulip
LG2	Carysfort Park, Du	Dublin	321580	228571	Devonian	Granite	166	±4	12.42	±0.15	2.01	Tulip
LG20	Wicklow Gap Rd	Wicklow	310090	198140	Devonian	Granite	148	±4	12.56	±0.11	1.65	Tulip

LG21	Lough Nahanagan	Wicklow	307600	199200	Devonian	Granite	155	±5	12.22	±0.1	1.52	Tulip
LG22	Turbogh Hill	Wicklow	310090	198140	Devonian	Granite	148	±4	12.56	±0.12	1.65	Tulip
LG23	Tullow Lowlands	Wicklow	288770	185165	Devonian	Granite	169	±5	12.32	±0.13	1.76	Tulip
LG26	Kelshabeg	Wicklow	293700	188250	Devonian	Granite	168	±7	12.35	±0.15	2.09	Tulip
LG28	Mt Leinster	Wexford	282743	152564	Devonian	Granite	205	±6	12.54	±0.13	1.7	Tulip
LG3a	Dalkey	Dublin	326171	227526	Devonian	Granite	127	±4	11.80	±0.16	2.21	Tulip
LG3	Sandycove	Dublin	325700	228000	Devonian	Granite	137	±7	12.75	±0.14	2.06	Tulip
LG30	Tomduff	Carlow	278140	153114	Devonian	Granite	173	?	12.54	±0.13	1.78	Tulip
LG32	Tullow Hill	Carlow	286582	173267	Devonian	Granite	136	±7	12.59	±0.12	1.95	Tulip
LG36	Lugnaquilla Mt	Wicklow	303180	191200	Devonian	Granite	173	?	12.49	?	1.42	Tulip
LG38	Quinagh borehole	Carlow	272642	173790	Devonian	Granite	104	?	12.80	?	1.92	Tulip
LG5	Dalkey Quarry	Dublin	326450	226040	Devonian	Granite	140	±5	12.74	±0.12	1.78	Tulip
LG6	Dalkey Quarry	Dublin	326247	226304	Devonian	Granite	134	±5	12.31	±0.15	2.12	Tulip
LG7	Killiney Hill	Dublin	325990	225550	Devonian	Granite	128	±4	12.77	±0.15	1.88	Tulip
LG8	Sorrento/Dalkey Sound	Dublin	327135	226371	Devonian	Granite	130	±4	12.43	±0.15	2.15	Tulip
M117426	Oughterard (Lough Corrib)	Galway	111699	242587	Devonian	Granite	130	±7	12.36	±0.25	1.91	McCulloch (1993)
M132222	Spiddal (Connemara)	Galway	113203	222189	Devonian	Granite	116	±5	12.23	±0.2	2.13	McCulloch (1993)
M132230	Spiddal (Connemara)	Galway	113197	222969	Devonian	Granite	116	±6	12.51	±0.23	1.95	McCulloch (1993)
M234225	near Barna	Galway	123403	222460	Devonian	Granite	119	±6	12.15	±0.17	1.66	McCulloch (1993)
M547013	Slieve Aughty Mts	Galway	154696	201250	Devonian	Sandstone	192	±8	12.86	±0.18	1.71	McCulloch (1993)
M973075	near Newtown	Tipperary	197302	207491	Devonian	Sandstone	187	±8	12.09	±0.24	2.42	McCulloch (1993)
MG1	Mourne Mountains	Down	329979	325285	Eocene	Granite	36		14.00		1.7	Tulip
MG2	Mourne Mountains	Down	330663	324191	Eocene	Granite	28		14.36		1.31	Tulip
MT1	Milltown	Donegal	184980	378454	Carboniferous	Sandstone	191	±8	12.29		2.15	Tulip
N-1442	Borehole	Meath	295620	267370	Carboniferous	Sandstone	85		13.07		1.68	Tulip
N955793	N of Slane	Meath	295498	279352	Ordovician	Tuff	212	±32	12.78	±0.24	2.43	McCulloch (1994)
O114027	Wicklow Mountains	Wicklow	311398	202661	Devonian	Granite	124	±13.2	12.43	±0.18	1.79	McCulloch (1994)
O115935	S Dundalk Bay	Louth	311497	293512	Silurian	Sandstone	45	±15.6	13.85	±0.16	1.17	McCulloch (1994)
O160086	NW of Roundwood	Wicklow	316003	208559	Devonian	Granite	137	±13	12.26	±0.17	1.71	McCulloch (1994)
O171846	Clogher Head	Louth	317101	284630	Silurian	Sandstone	51	±6.4	13.12	±0.25	1.95	McCulloch (1994)
O178232	S of Dublin (foothills)	Dublin	317799	223188	Devonian	Granite	162	±33	11.71	±0.21	1.96	McCulloch (1994)
O192193	near Kippure	Wicklow	319198	219326	Devonian	Granite	127	±6	12.27	±0.16	1.61	McCulloch (1994)
O203644	Balbriggan	Dublin	320300	264446	Ordovician	Tuff	128	±22.8	13.54	±0.38	2.4	McCulloch (1994)
O253606	E of Skerries	Dublin	325303	260568	Silurian	Sandstone	73	±10	12.20	±0.5	2.45	McCulloch (1994)
O263262	Killiney Hill	Dublin	326302	226189	Devonian	Granite	127	±12	11.76	±0.29	2.21	McCulloch (1994)
O270577	Loughshinny	Dublin	327003	257718	Carboniferous	Sandstone	70	±30.4	12.54	±0.52	2.52	McCulloch (1994)
OM1	Ox Mountains	Sligo	164223	327635	Pre-Cambrian	Granite	154		13.02		1.5	Tulip
OM2	Pontoon Bridge	Mayo	123383	304852	Pre-Cambrian	Granite	155		12.94		1.38	Tulip
Q690321	Kerry Head	Kerry	69001	132124	Devonian	Sandstone	154	±13	11.57	±0.24	2.43	McCulloch (1993)
Q848524	Carrigaholt	Clare	84798	152433	Carboniferous	Sandstone	133	±15	11.78	±0.26	2.58	McCulloch (1993)
Q876449	Mouth of Shannon	Kerry	87600	144910	Carboniferous	Sandstone	134	±14	12.31	±0.19	1.85	McCulloch (1993)
Q884598	Kilkee	Clare	88403	159808	Carboniferous	Sandstone	139	±10	12.53	±0.23	1.36	McCulloch (1993)
Q957675	White Strand	Clare	95699	167549	Carboniferous	Sandstone	113	±9	13.22	±0.26	1.45	McCulloch (1993)

R085948	near Cliffs of Moher	Clare	108501	194783	Carboniferous	Sandstone	150	±24	12.16	±0.43	2.31	McCulloch (1993)
R247521	near Foyne	Limerick	124569	153212	Carboniferous	Sandstone	144	±15	12.43	±0.21	2.24	McCulloch (1993)
R481616	South of Sixmilebridge	Clare	148098	161588	Devonian	Sandstone	205	±27	12.54	±0.18	1.7	McCulloch (1993)
RB1	Western Red Bay	Antrim	324300	425500	Triassic	Sandstone	369		12.72			Tulip
S287542	Slieveardagh Hills	Tipperary	228701	154163	Carboniferous	Sandstone	147	±7	12.05	±0.26	1.92	McCulloch (1993)
S662767	W of Carlow	Laois	266200	176700	Carboniferous	Sandstone	154	±18	12.15	±0.34	2.18	McCulloch (1993)
S708434	Graiguenamanagh	Carlow	270804	143352	Devonian	Granite	149	±6	12.31	±0.13	1.76	McCulloch (1993)
SB1	Silver river, Slieve Bloom	Galway	173517	209806	Carboniferous	Sandstone	239	±9	12.42		1.64	Tulip
SB2	The Cut, Slieve Bloom	Laois	229600	204700	Devonian	Sandstone	204		12.65		1.48	Tulip
SB3	Knockshigowna, Slieve Bloom	Tipperary	200163	209636	Carboniferous	Sandstone	223	±13	12.72	±0.15	1.55	Tulip
T103114	Wexford	Wexford	310299	111358	Ordovician	Tuff	220	±10	12.30	±0.19	1.85	McCulloch (1993)
T131797	near Aughrum	Wicklow	313103	179657	Devonian	Granite	182	±8	11.81	±0.45	2.36	McCulloch (1993)
T183855	near Rathdrum	Wicklow	318298	185459	Devonian	Granite	184	±12	12.04	±0.21	1.91	McCulloch (1993)
T251889	S of Glenealy	Wicklow	325102	188859	Devonian	Granite	217	±10	13.00	±0.16	1.61	McCulloch (1993)
V316967	Slea Head	Kerry	31583	96736	Devonian	Sandstone	168	±8	11.78	±0.24	2.07	McCulloch (1993)
V898730	near Blackwaterbridge	Kerry	89797	72956	Devonian	Sandstone	156	±12	12.62	±0.19	1.45	McCulloch (1993)
V930583	Caha Mountains	Cork	92997	58307	Devonian	Sandstone	165	±11	12.63	±0.26	1.88	McCulloch (1993)
X336948	near Stradbally	Waterford	233598	94777	Carboniferous	Sandstone	196	±6	12.94	±0.17	1.67	McCulloch (1993)

APPENDIX 7

Well-logs

Porcupine Basin (Ireland)

Appendix 7:- Key to Abbreviations

Terrestrial (T)

TD	Desert
TG	Glacial
TA	Aqueous (alluvial plain)
TR	River current-related
TF	Fan
TD	Dune

Coastal-Tranistional Marine (C)

CT	Supratidal/storm beach/sabkha/coastal plain
CA	Mainly flooded: intertidal, coastal marine
CR	Proximal deltaic, delta front
CL	Coastal lagoonal

Marine (M)

MS	Shallow marine (above storm base)
MD	Deep marine (below storm base)

Marine Shelf (S)

SS	Above storm base; euphotic zone inner shelf
SM	Mid-shelf

SD	Below storm base & euphotic zone outer shelf
SB	Bar, barrier

Marine Off-Shelf (O)

DB	Abyssal plain/misc
OS(U)	Slope (upper)
OS(L)	Slope (lower)

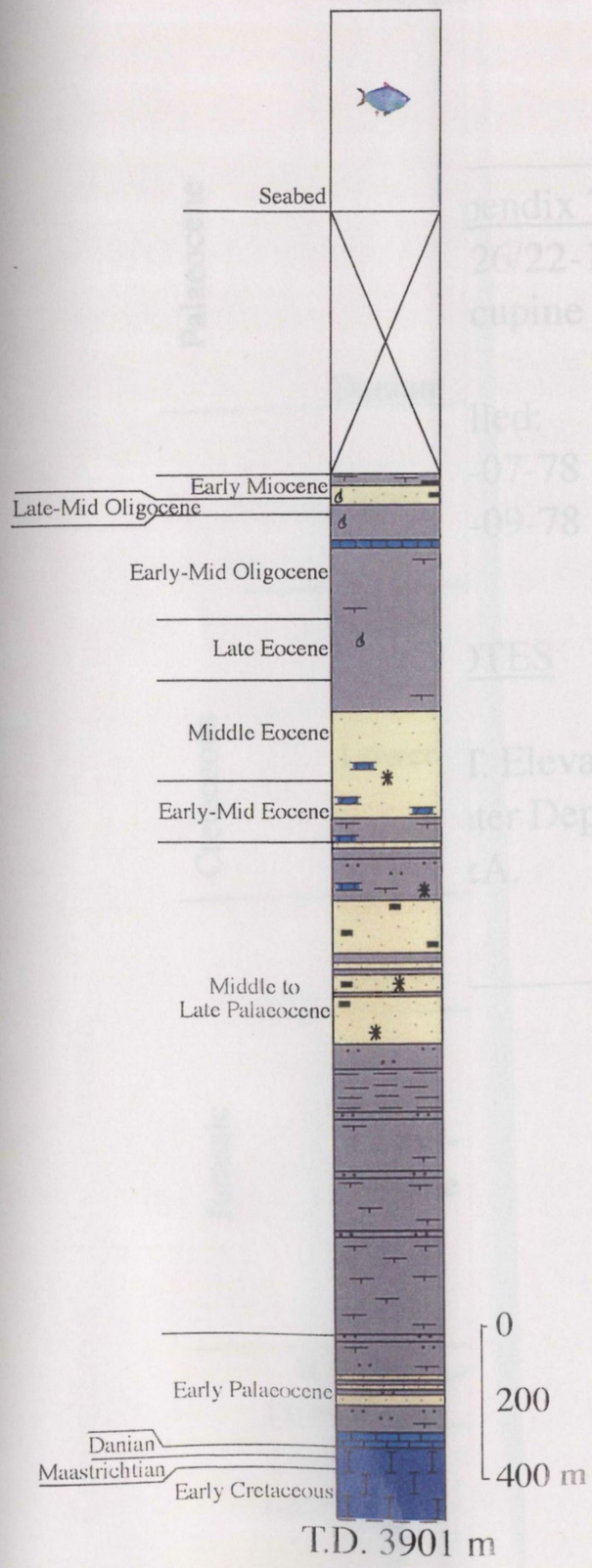
Other

MR	Bioherm/reef
MT	Turbidite sequence
MV	Proximal
MW	Distal
B	Brackish
E	Euxine
H	Hypersaline
S	Supersaline

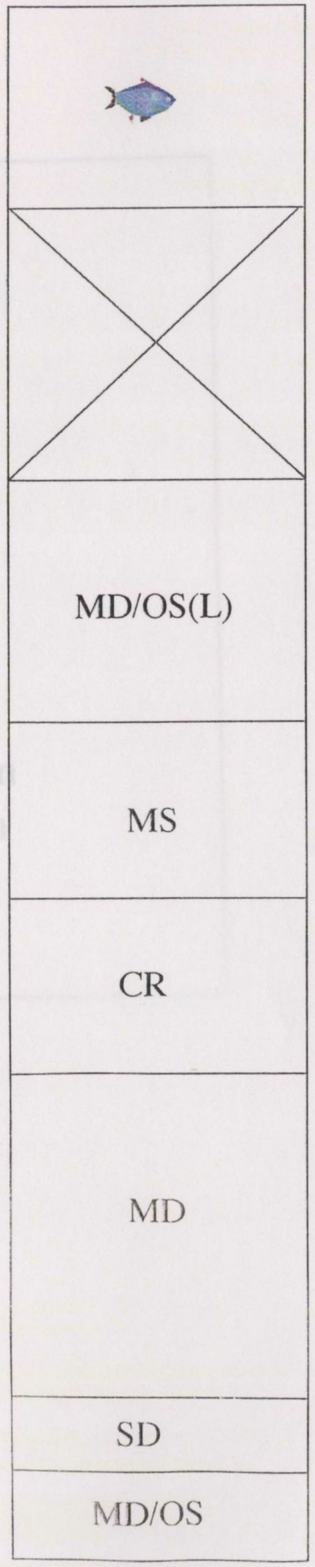
Appendix 7 - LEGEND



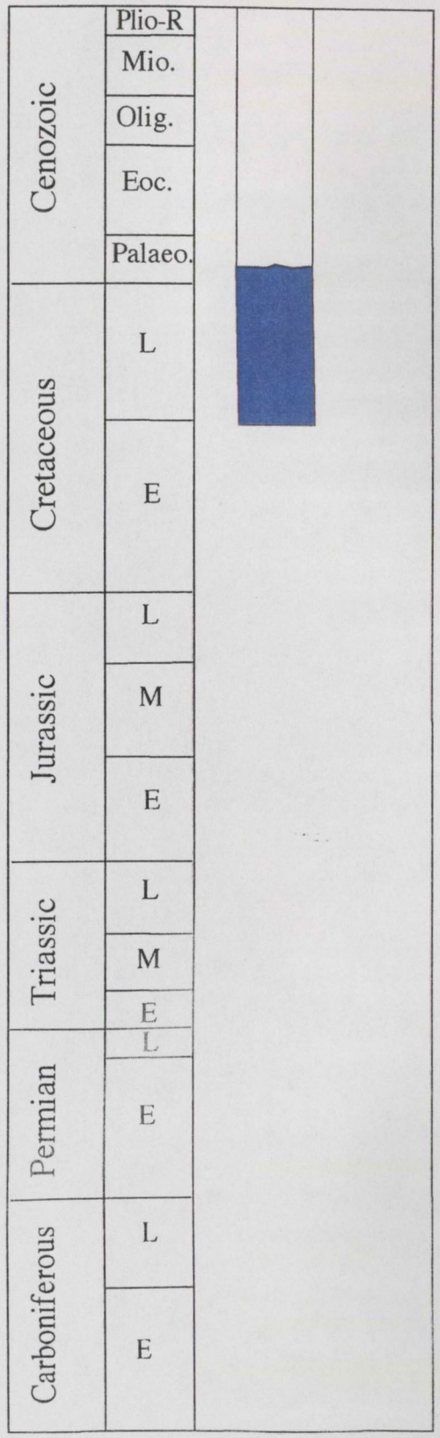
TOTAL SECTION



ENVIRONMENT



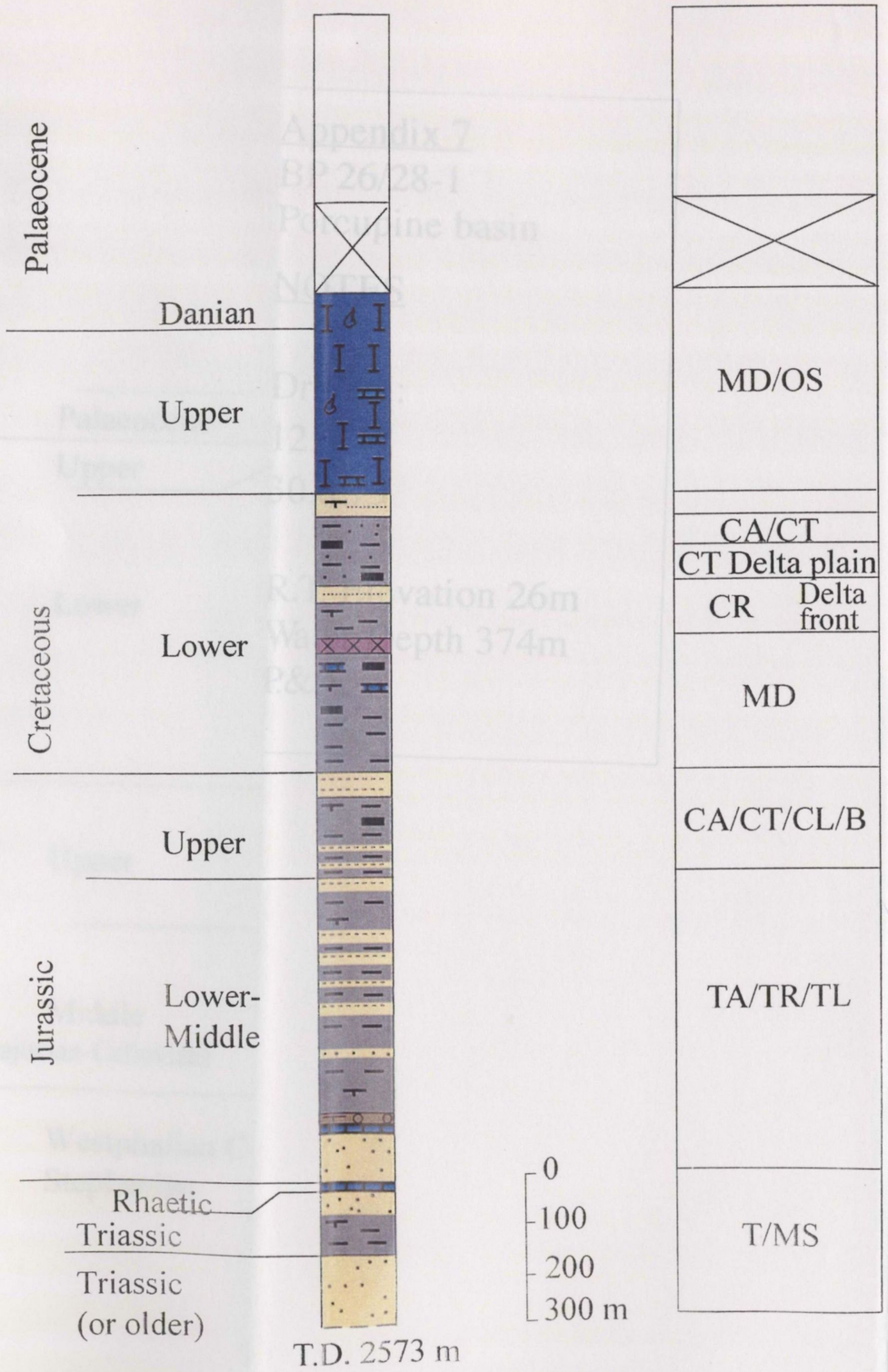
CHRONOSTRATIGRAPHY



Appendix 7
AMOCO 35/18-1
Porcupine basin
NOTES

Drilled :
7.6.88
18.7.88

R.T. Elevation 22m
Water Depth 566m
P.&A.

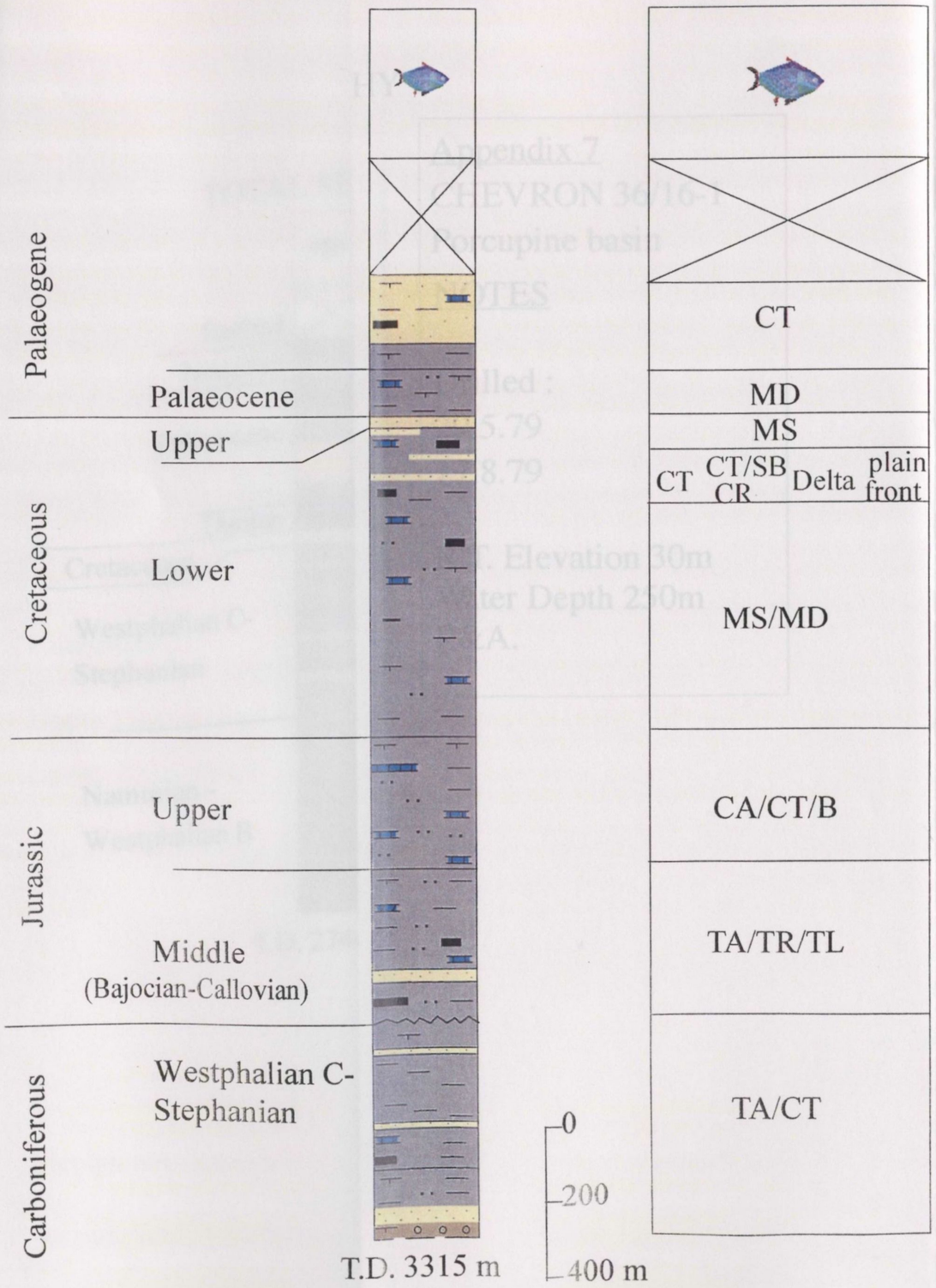


Appendix 7
BP 26/22-1A
Porcupine basin

Drilled:
26-07-78
28-09-78

NOTES

R.T. Elevation:26m
Water Depth:346m
P.&A.

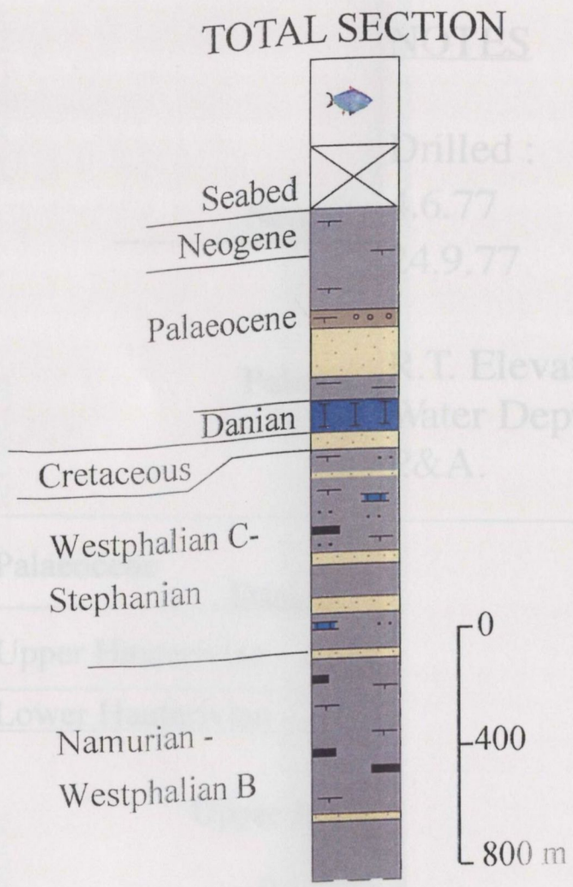


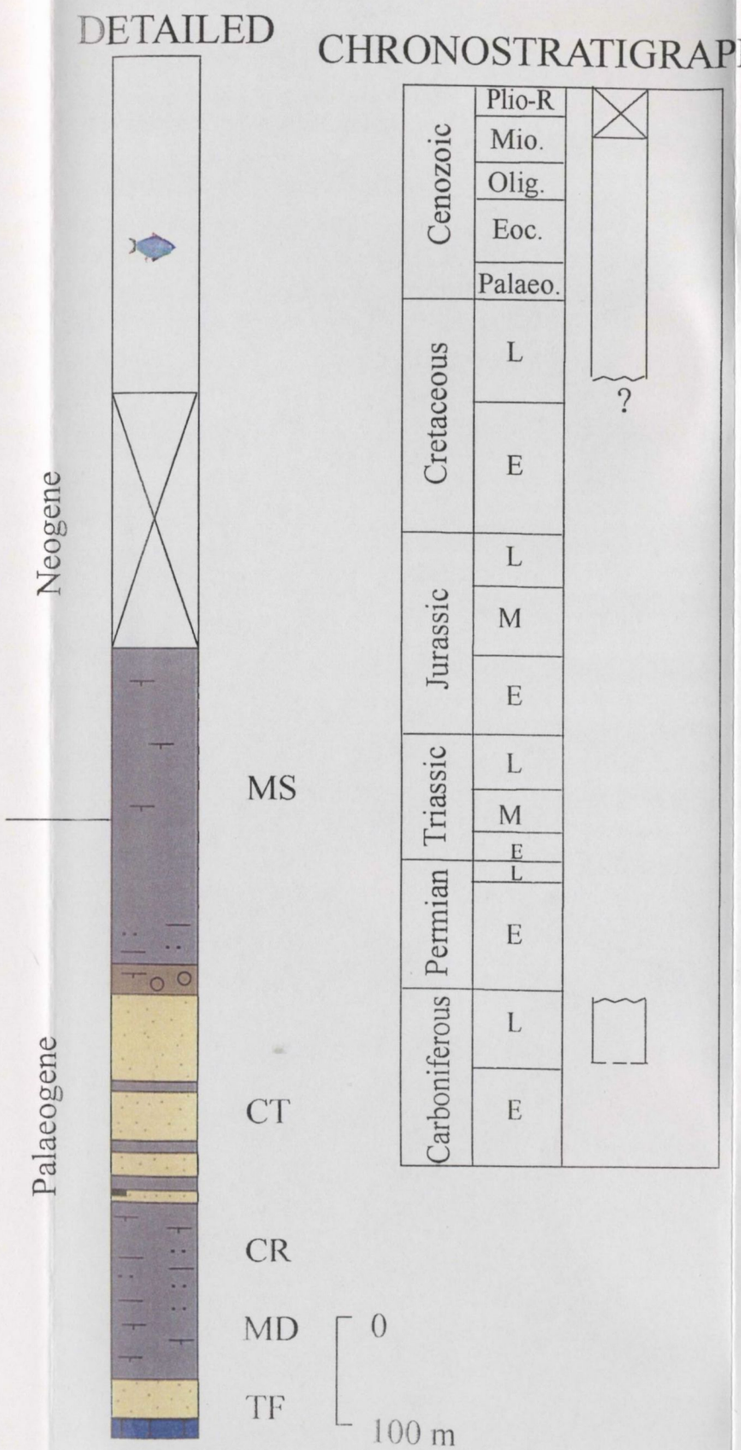
Appendix 7
BP 26/28-1
Porcupine basin

NOTES

Drilled :
12.6.79
30.8.79

R.T. Elevation 26m
Water Depth 374m
P.&A.



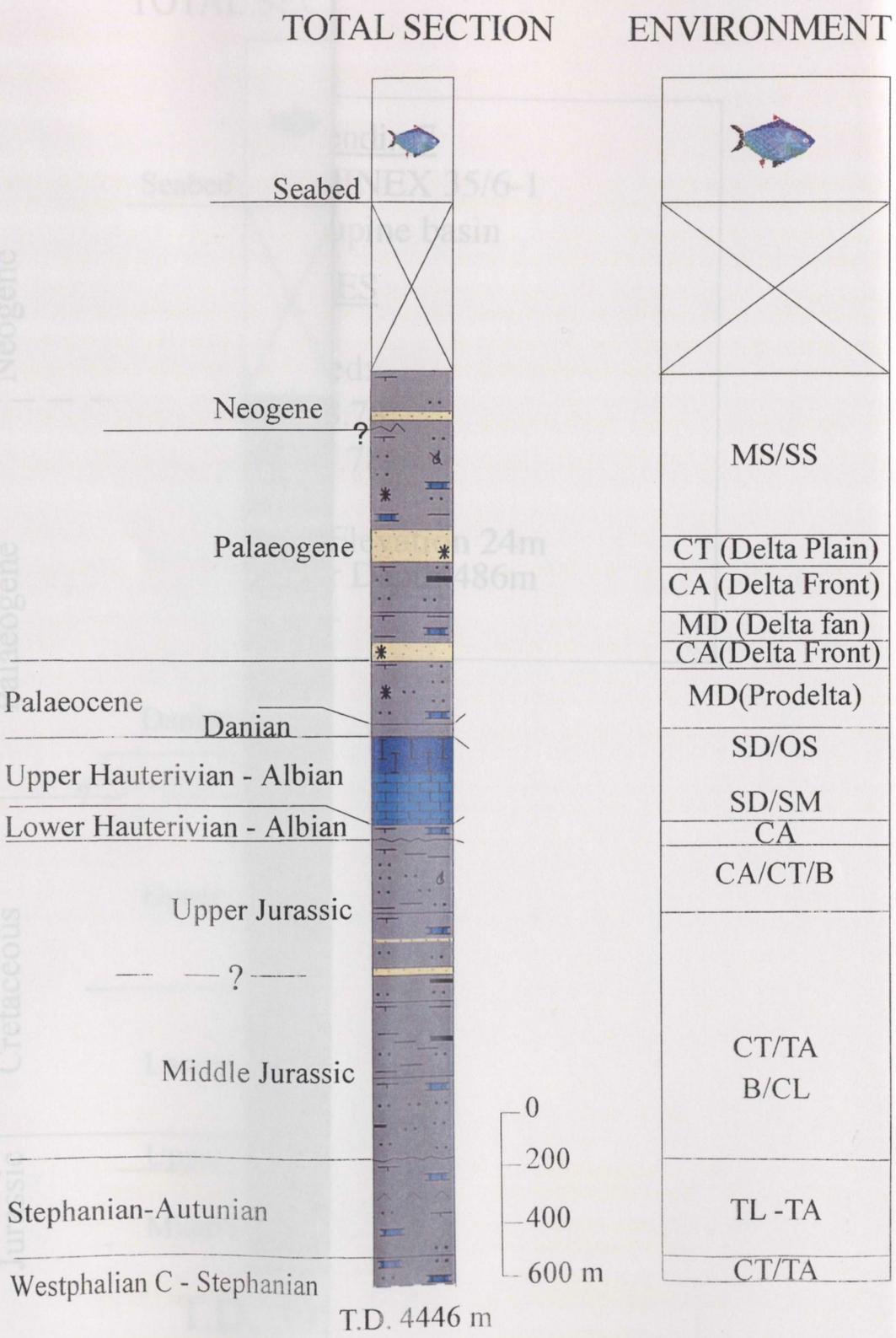


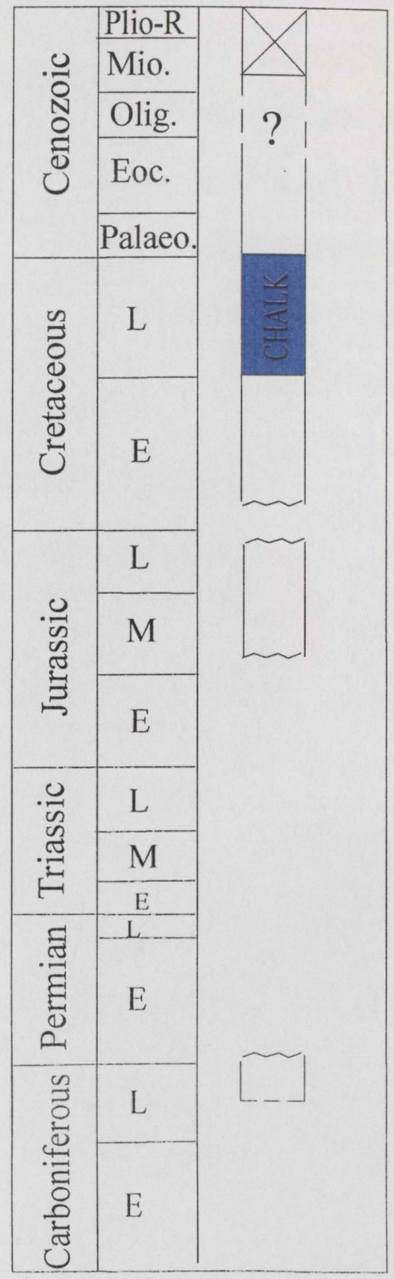
Appendix 7
CHEVRON 36/16-1
Porcupine basin

NOTES

Drilled :
29.5.79
17.8.79

R.T. Elevation 30m
Water Depth 250m
P.&A.





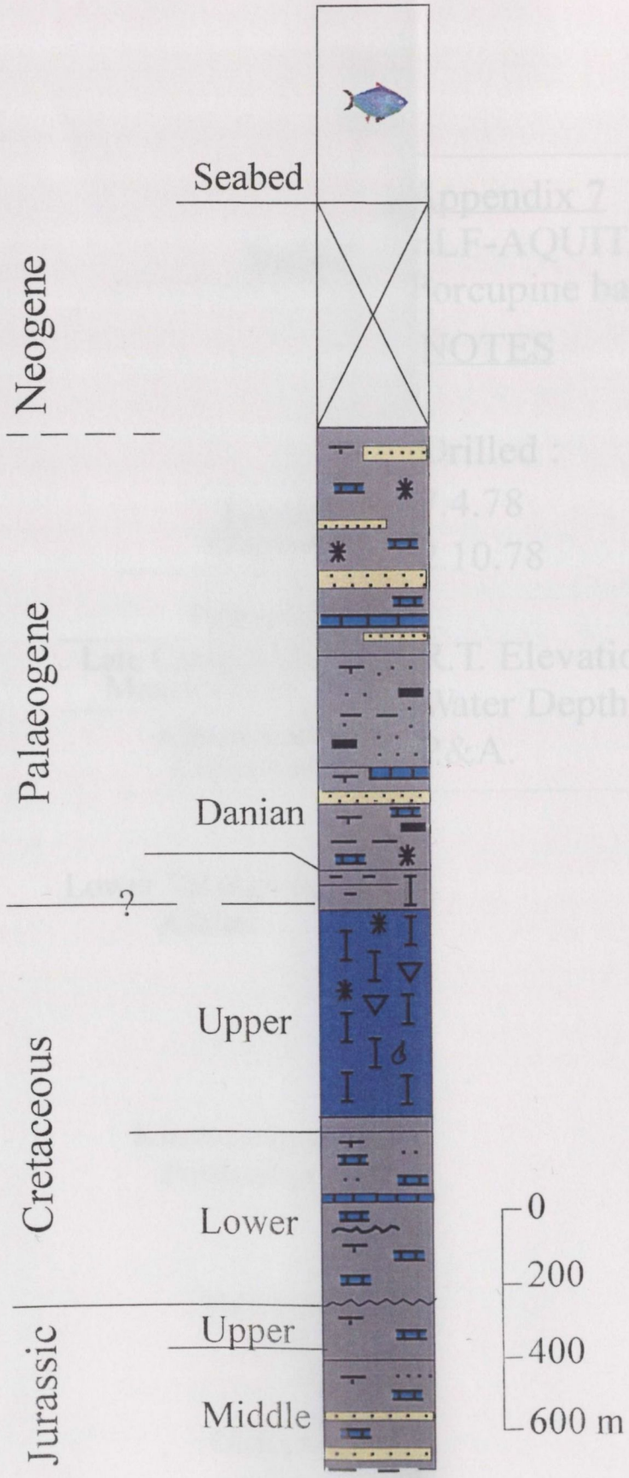
Appendix 7
DEMINEX 34/15-1
Porcupine basin

NOTES

Drilled :
4.6.77
24.9.77

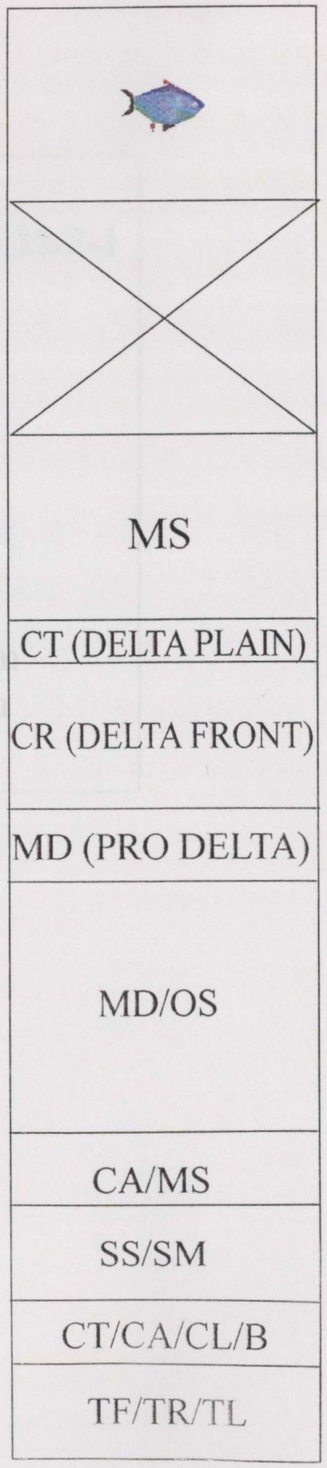
R.T. Elevation 23m
Water Depth 482m
P.&A.

TOTAL SECTION

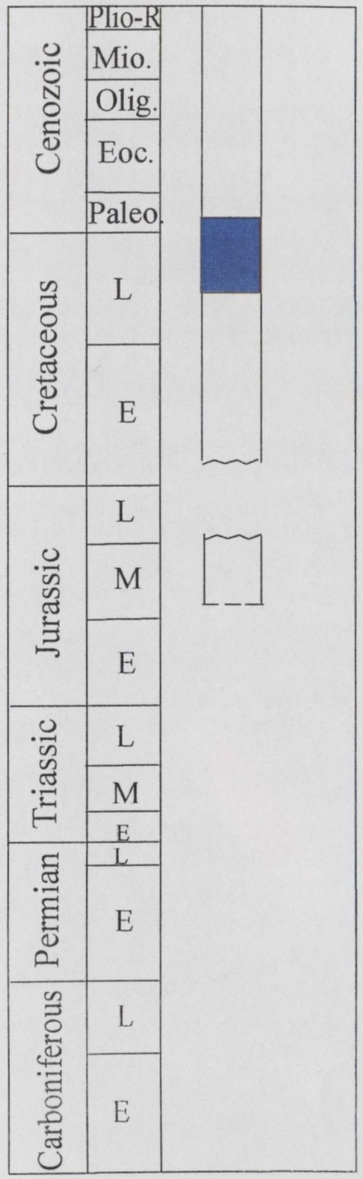


T.D. 3959 m

ENVIRONMENT



CHRONOSTRATIGRAPHY



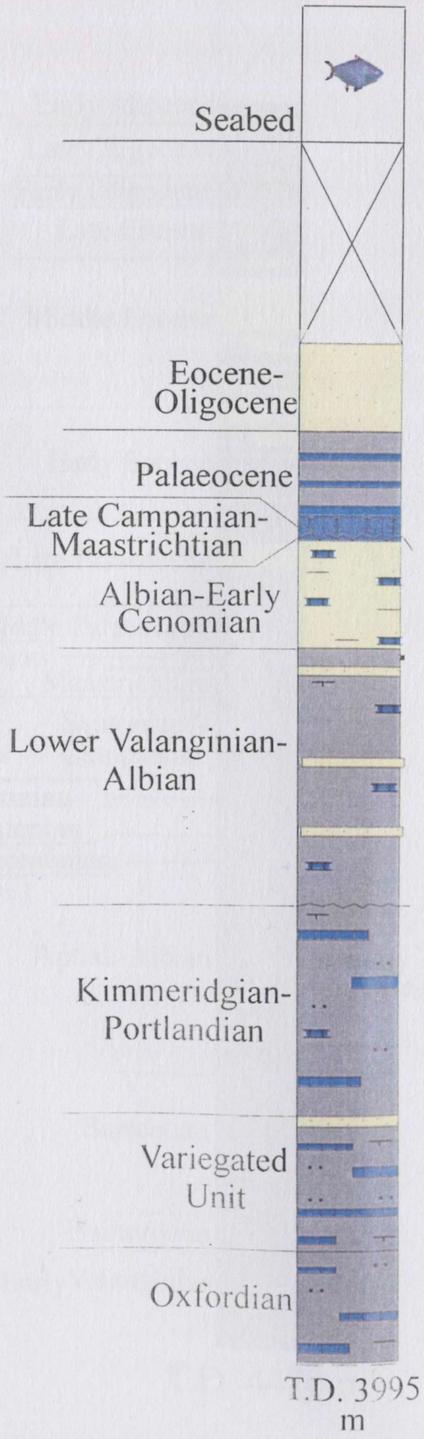
Appendix 7
DEMINEX 35/6-1
Porcupine basin

NOTES

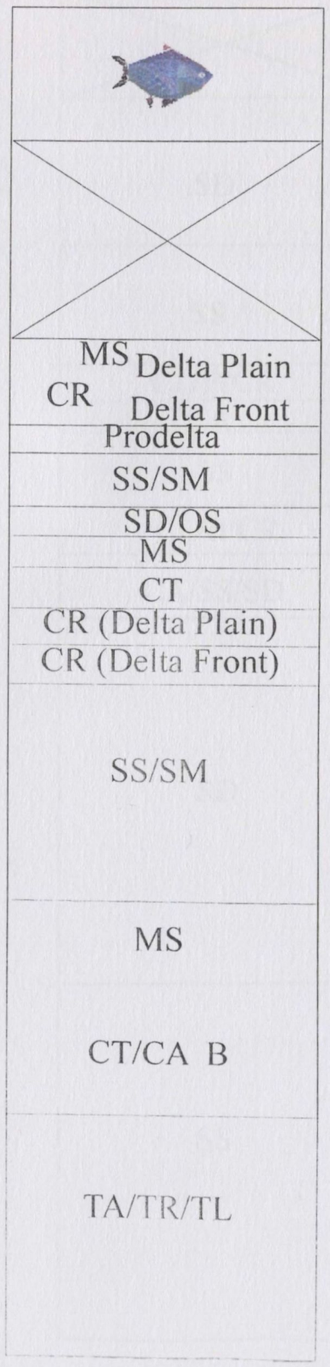
Drilled:
13.08.78
19.11.78

R.T. Elevation 24m
Water Depth 486m
P.&A.

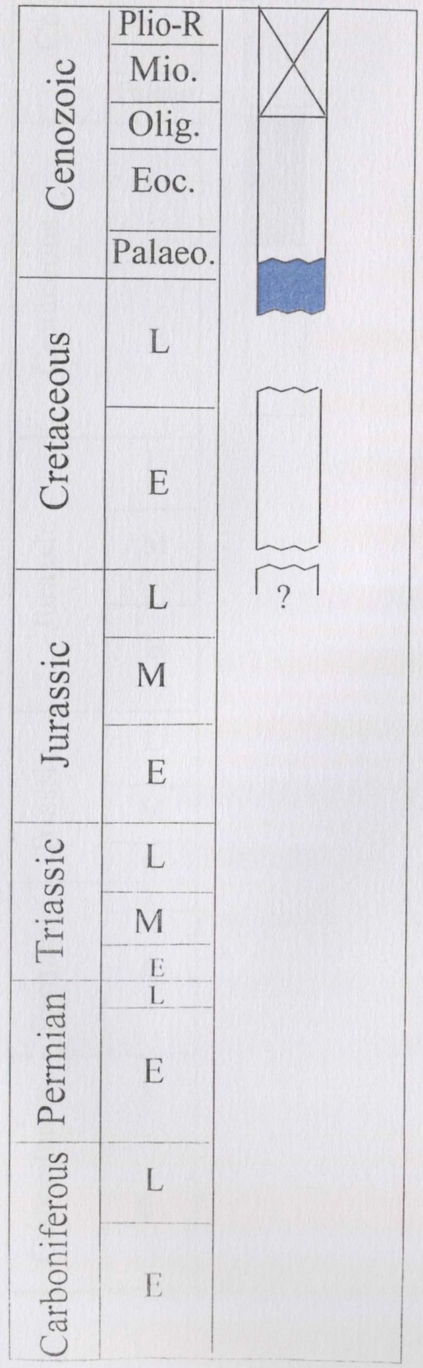
TOTAL SECTION



ENVIRONMENT



CHRONOSTRATIGRAPHY



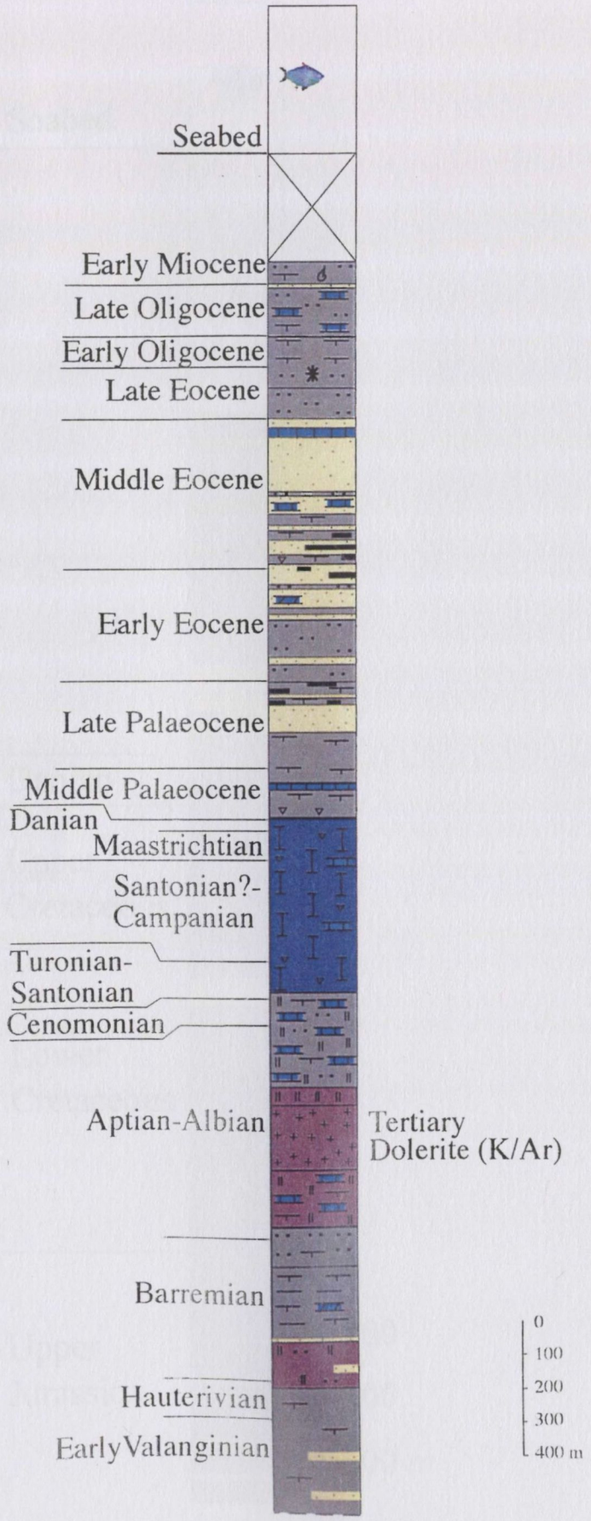
Appendix 7
ELF-AQUITAINE 35/2-1
Porcupine basin

NOTES

Drilled :
7.4.78
2.10.78

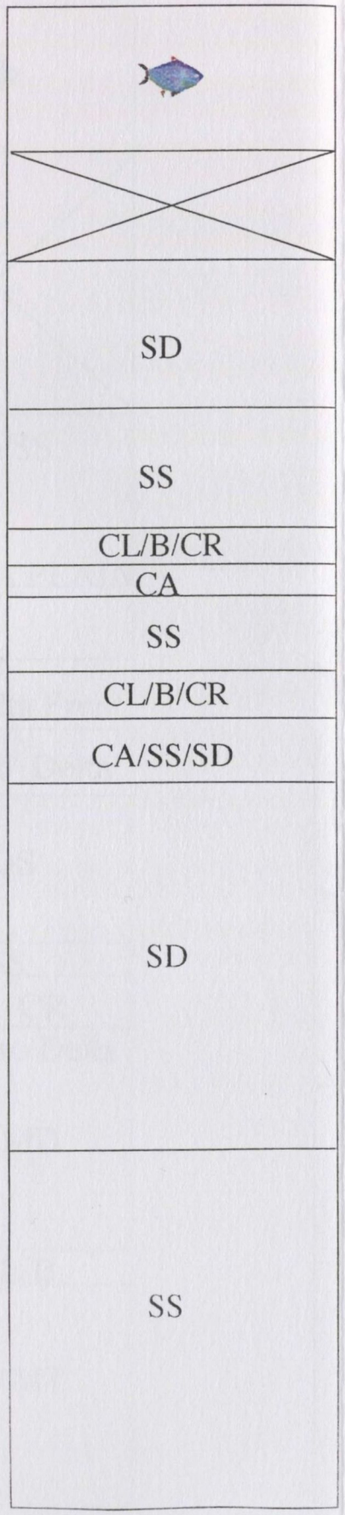
R.T. Elevation 13m
Water Depth 391m
P.&A.

TOTAL SECTION

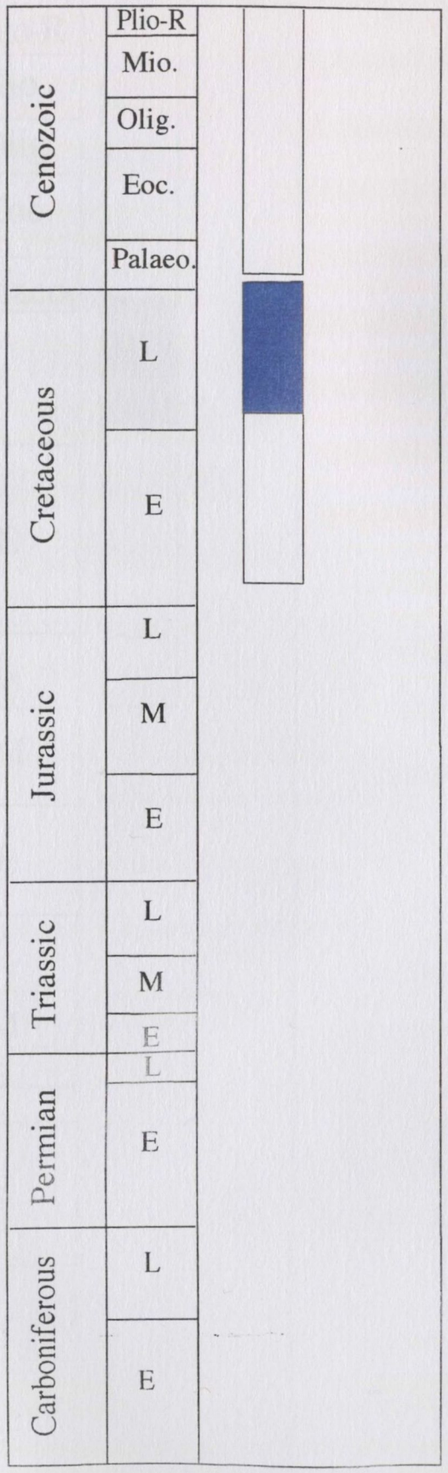


T.D. 4420 m

ENVIRONMENT



CHRONOSTRATIGRAPHY



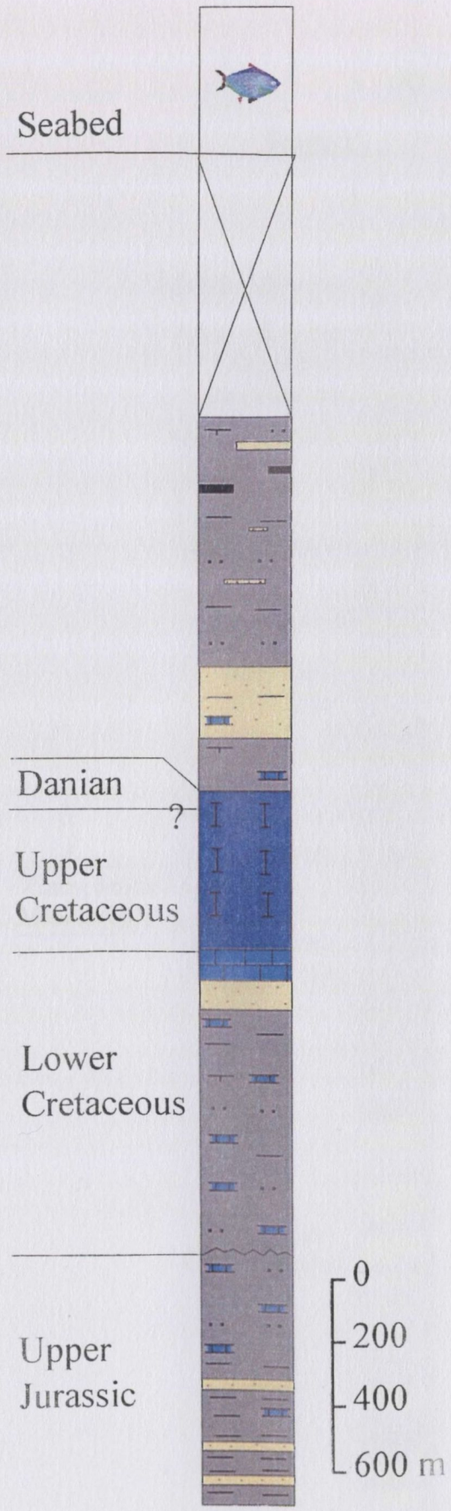
Appendix 7
PHILLIPS 35/8-1
Porcupine basin

NOTES

Drilled :
5.5.78
6.10.78

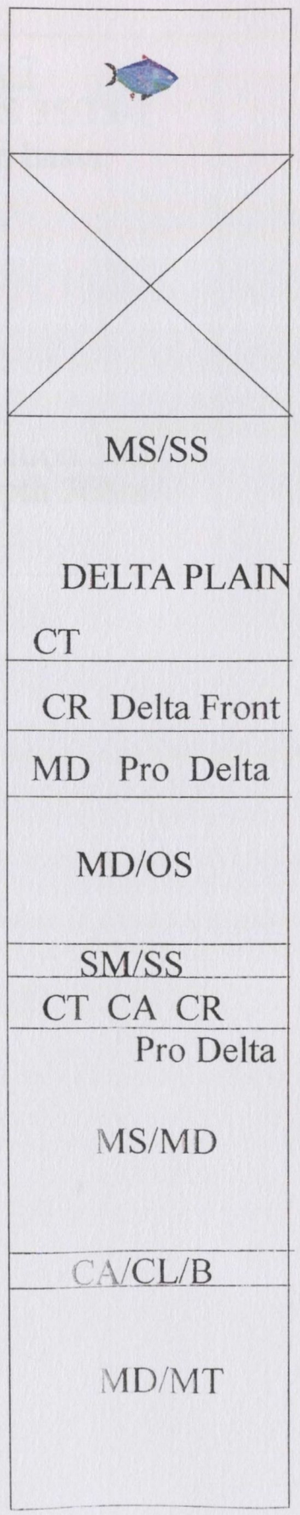
R.T. Elevation 26m
Water Depth 430m
P&A. with oil shows

TOTAL SECTION

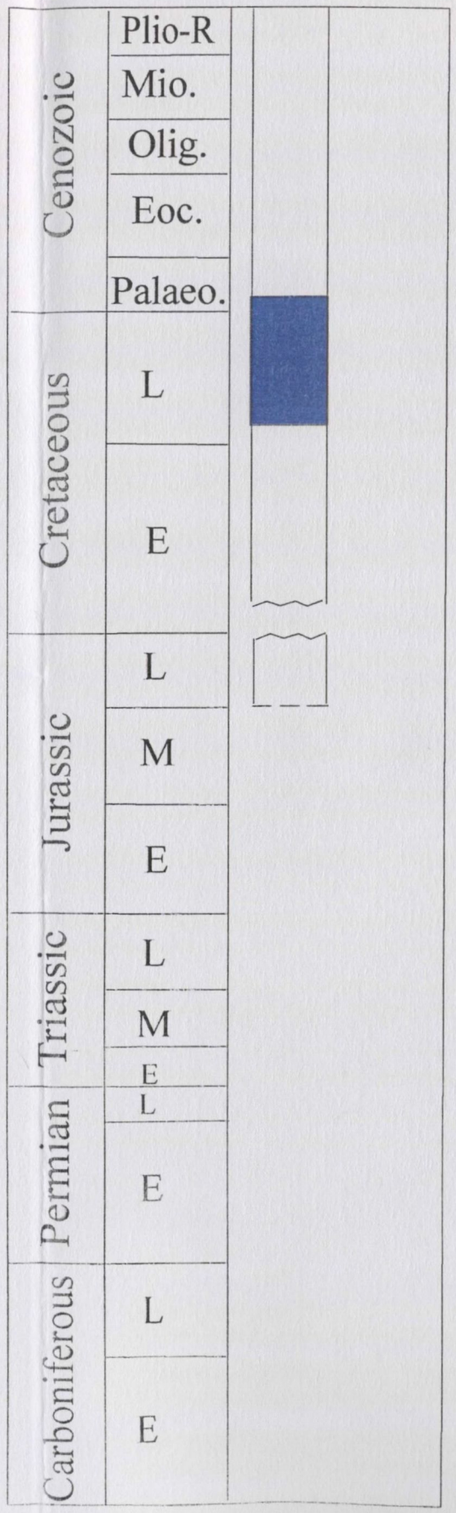


T.D. 4633 m

ENVIRONMENT



CHRONOSTRATIGRAPHY



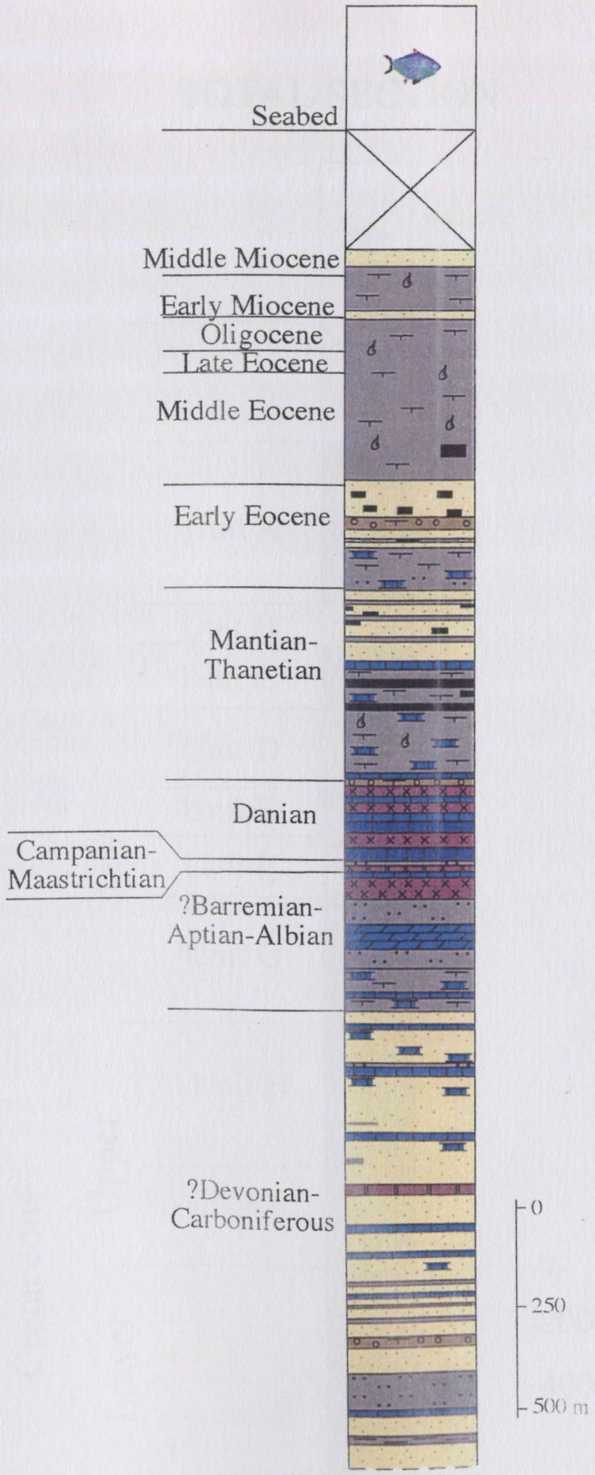
Appendix 7
PHILLIPS 35/8-2
Porcupine basin

NOTES

Drilled :
19.4.81
23.10.81

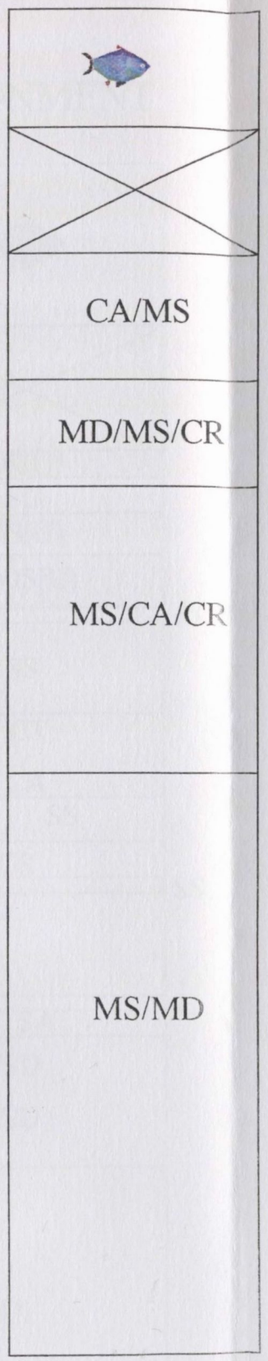
R.T. Elevation 26m
Water Depth 422m
P.&A.

TOTAL SECTION

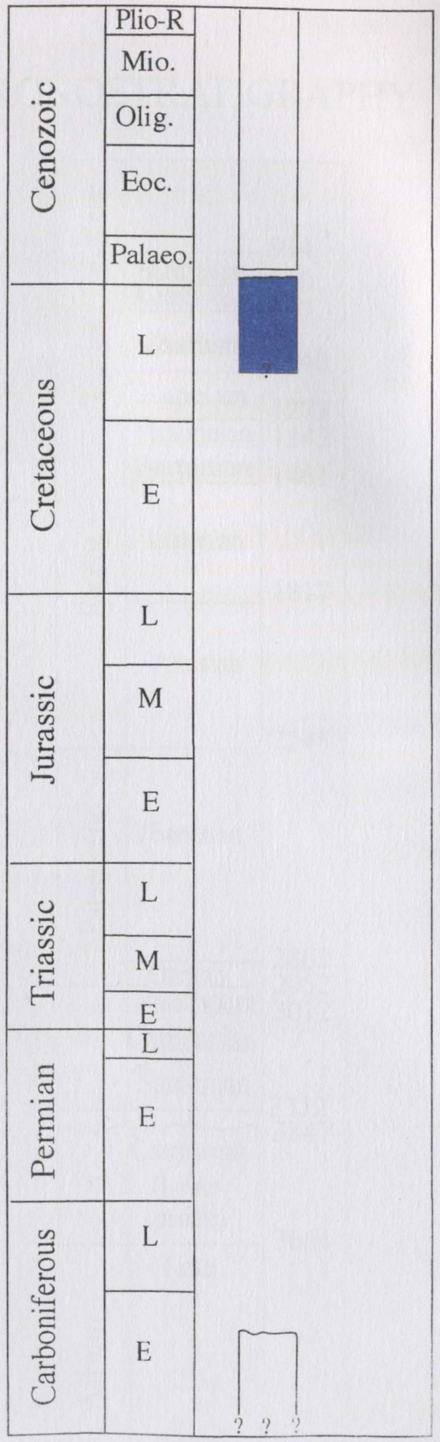


T.D. 3687 m

ENVIRONMENT



CHRONOSTRATIGRAPHY



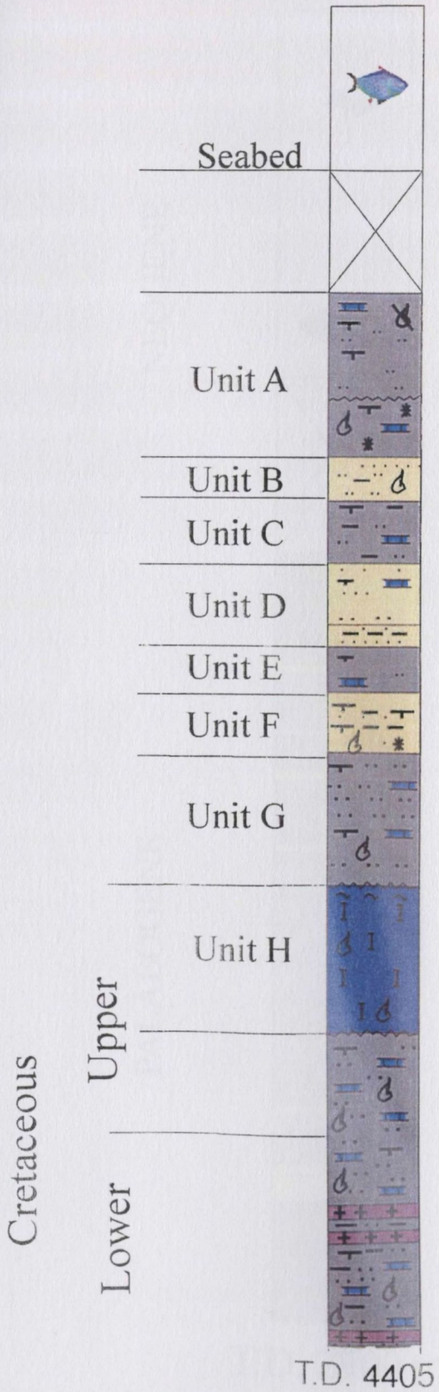
Appendix 7
PHILLIPS 35/15-1
Porcupine basin

NOTES

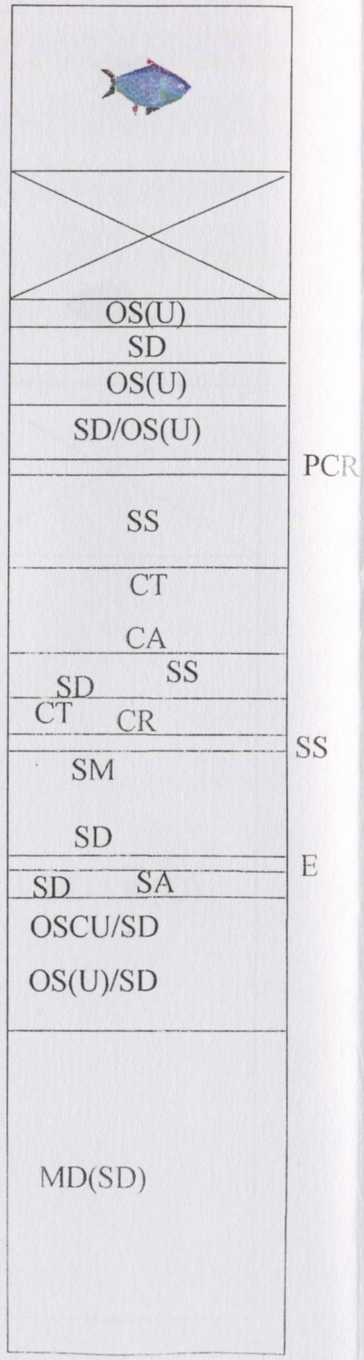
Drilled :
28.6.80
15.10.80

R.T. Elevation 30m
Water Depth 308m
P.&A.

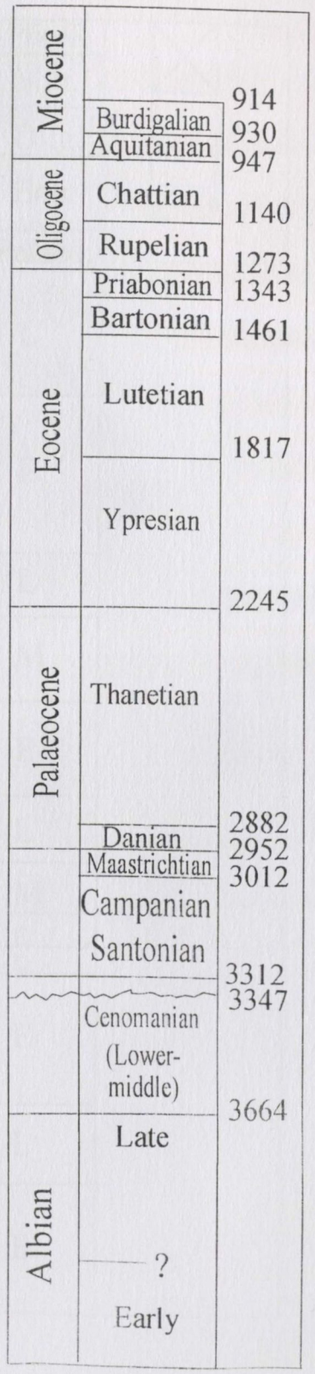
TOTAL SECTION



ENVIRONMENT



CHRONOSTRATIGRAPHY



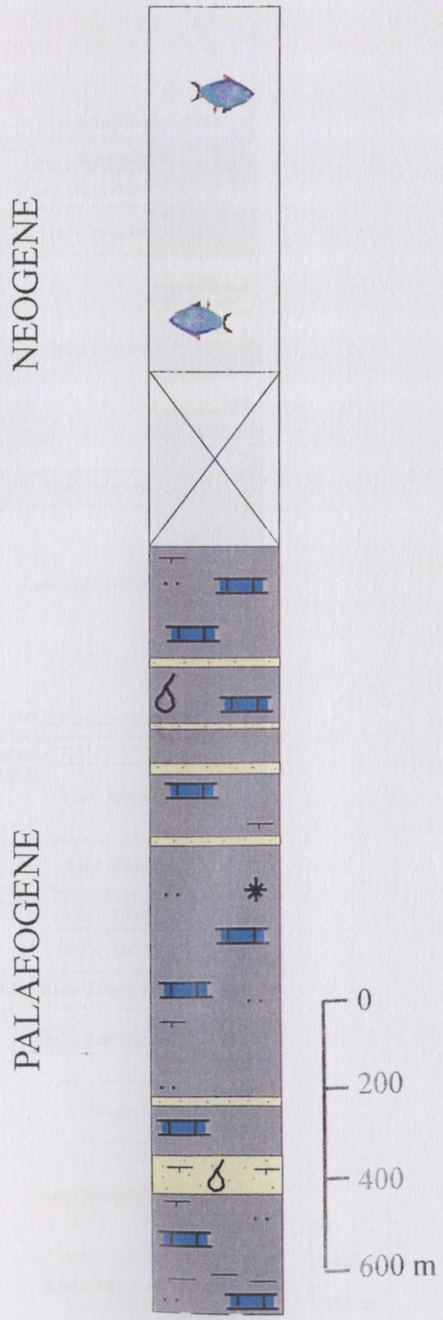
Appendix 7
SHELL 35/13-1
Porcupine basin

NOTES

Drilled :
7.4.77
2.11.77

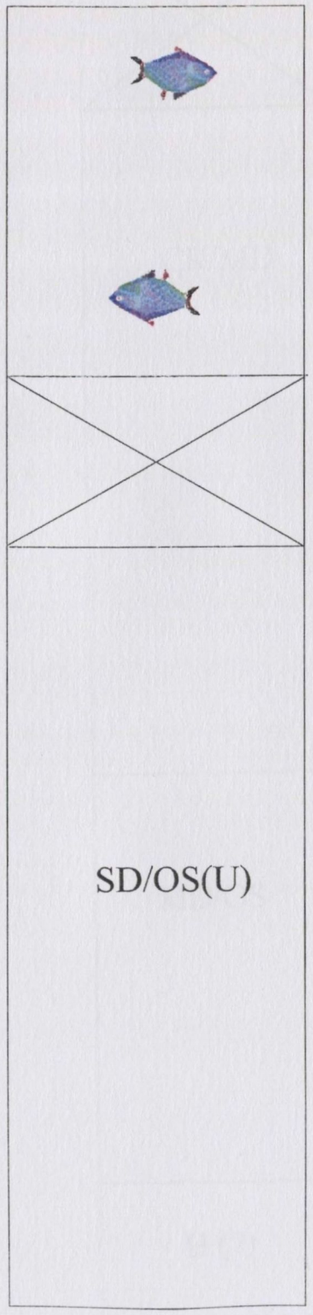
R.T. Elevation 24 m
Water Depth 482 m
P.&A.

TOTAL SECTION

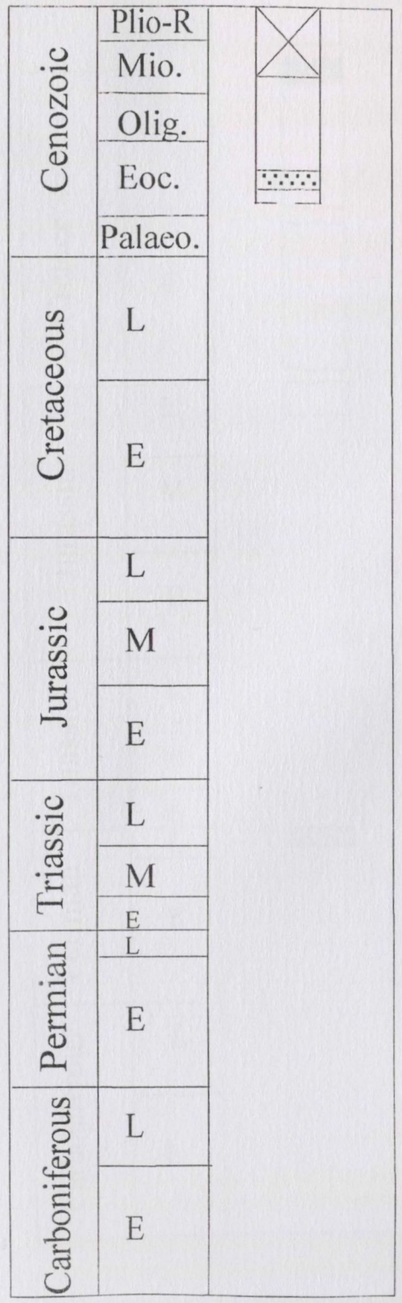


T.D. 2900 m

ENVIRONMENT



CHRONOSTRATIGRAPHY



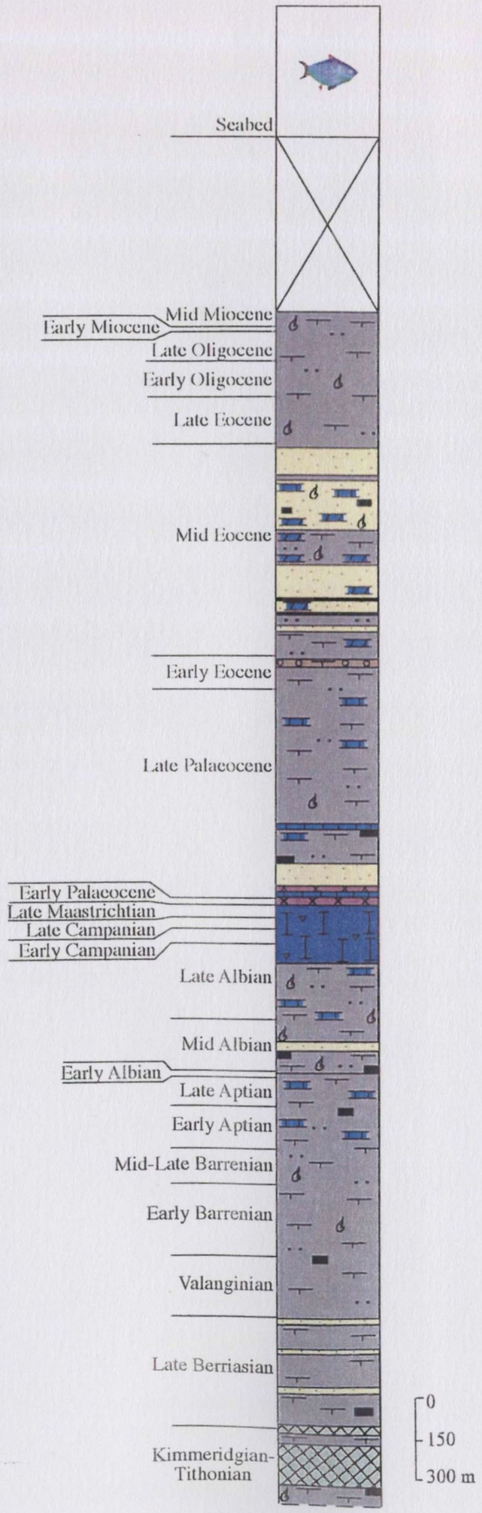
Appendix 7
SHELL-AGIP 35/29-1
Porcupine basin

NOTES

Drilled :
3.4.78
29.5.78

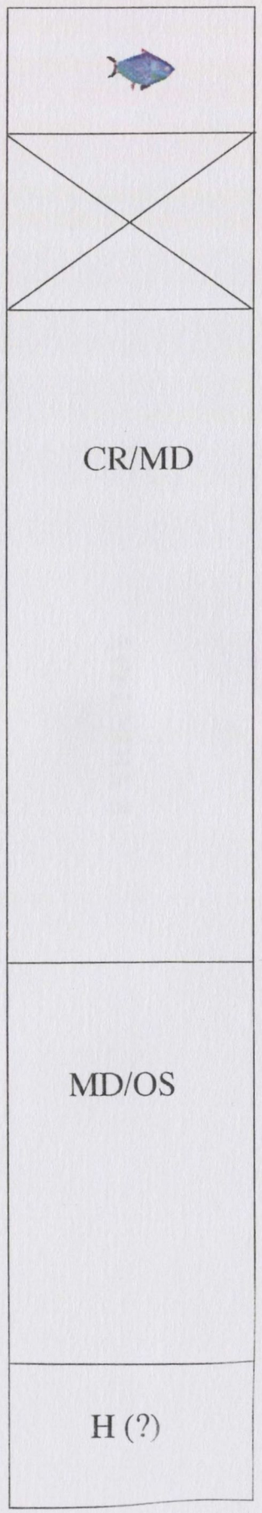
R.T. Elevation 24m
Water Depth 804m
P.&A.

TOTAL SECTION

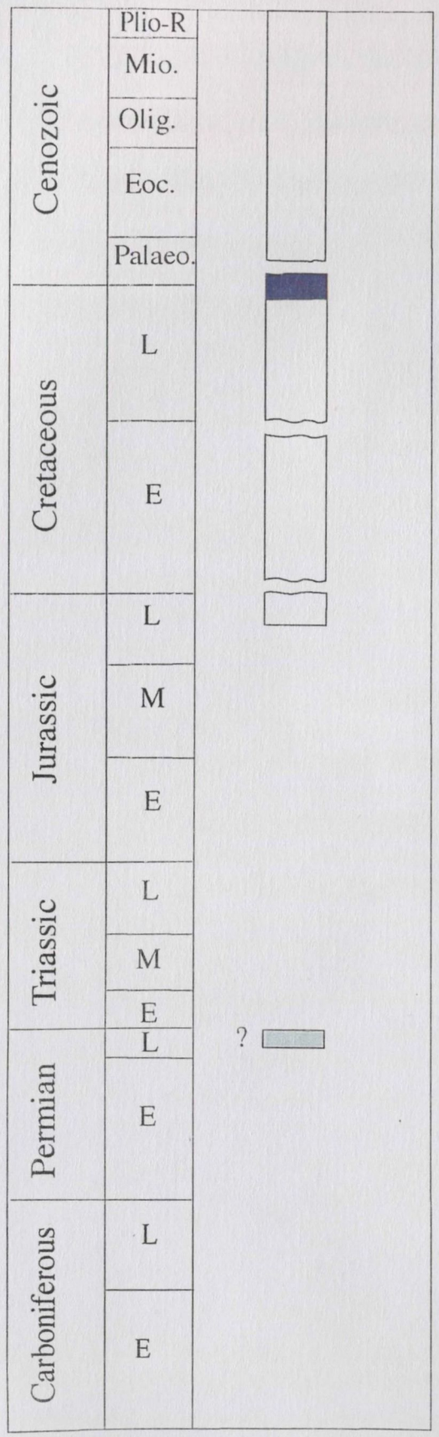


T.D. 5547 m

ENVIRONMENT



CHRONOSTRATIGRAPHY



Appendix 7

STATOIL 35/19-1

Porcupine basin

NOTES

Drilled :
8.4.85
11.9.85

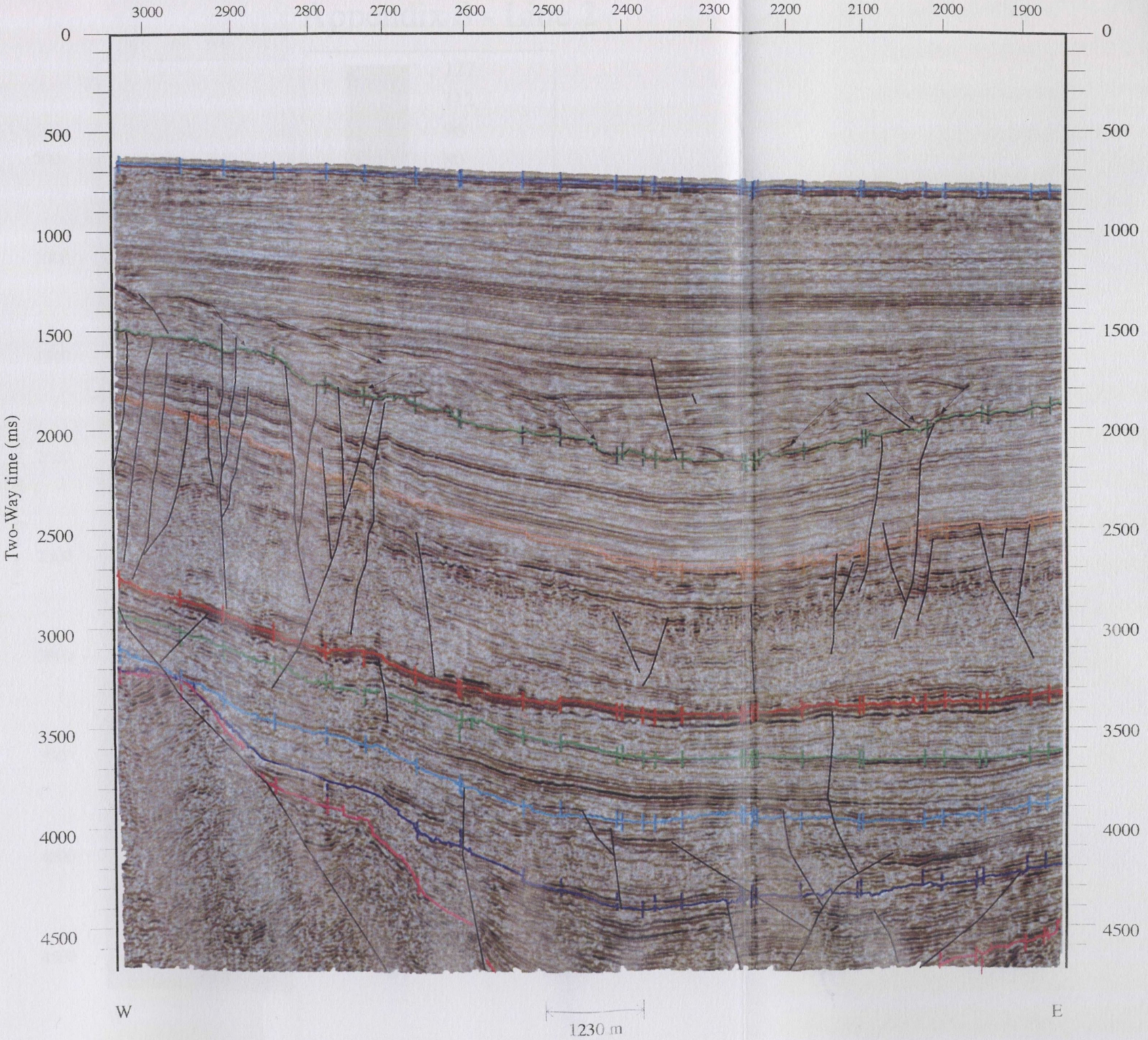
R.T. Elevation 26m
Water Depth 479m
P.&A.

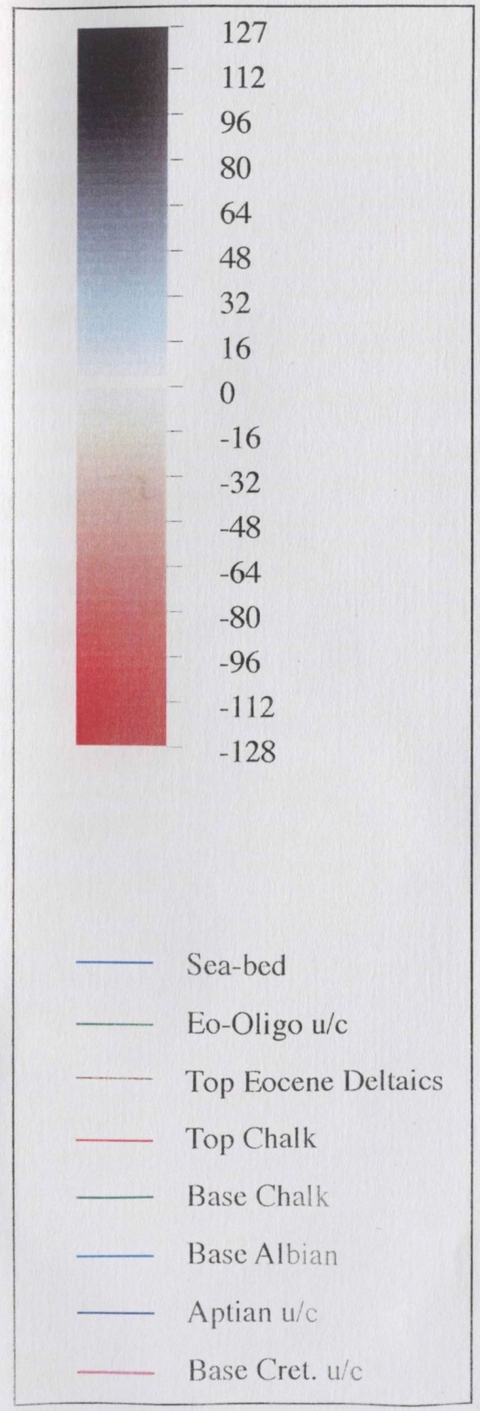
APPENDIX 8

Regional Seismic Lines

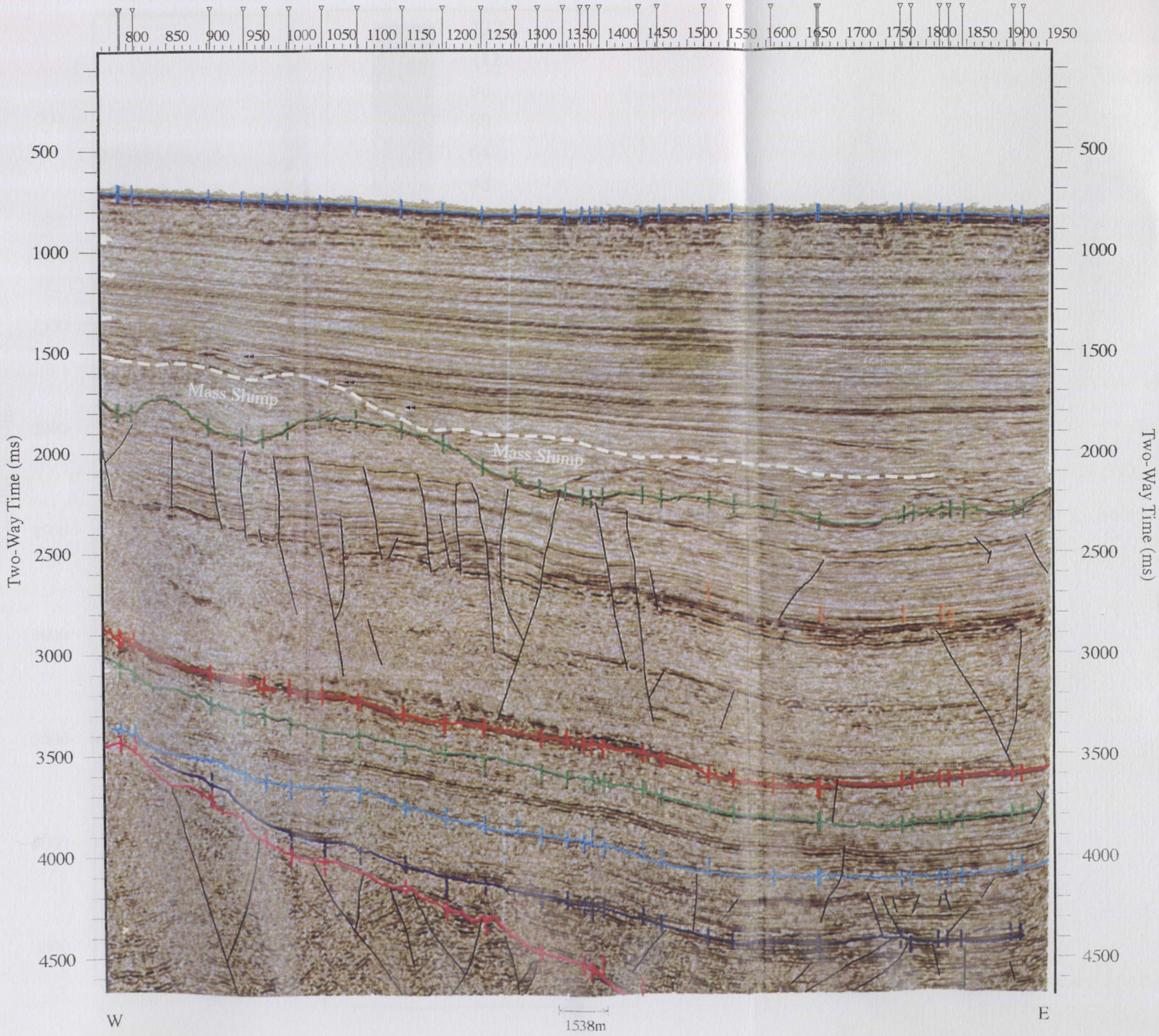
Porcupine Basin (Ireland)

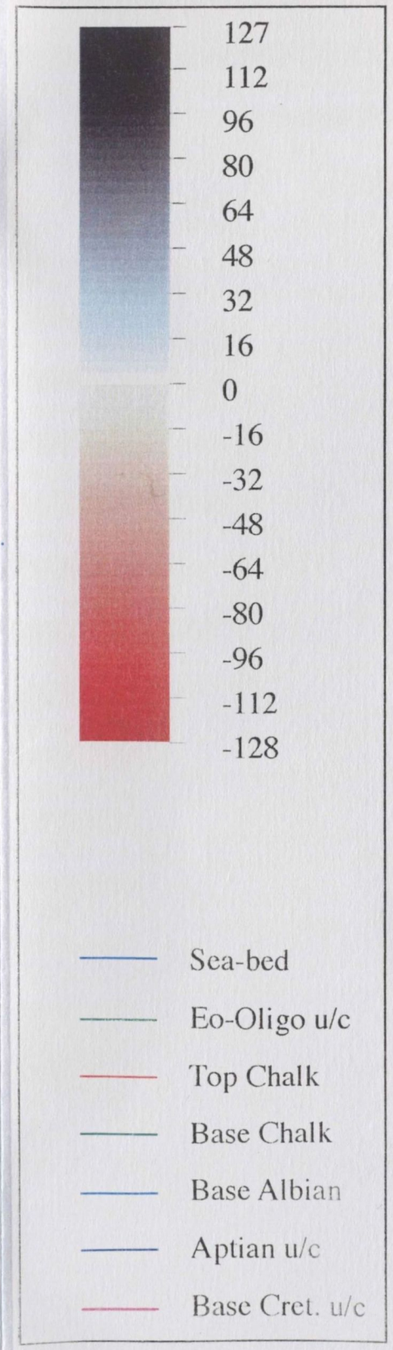
Appendix 8 - Line 1



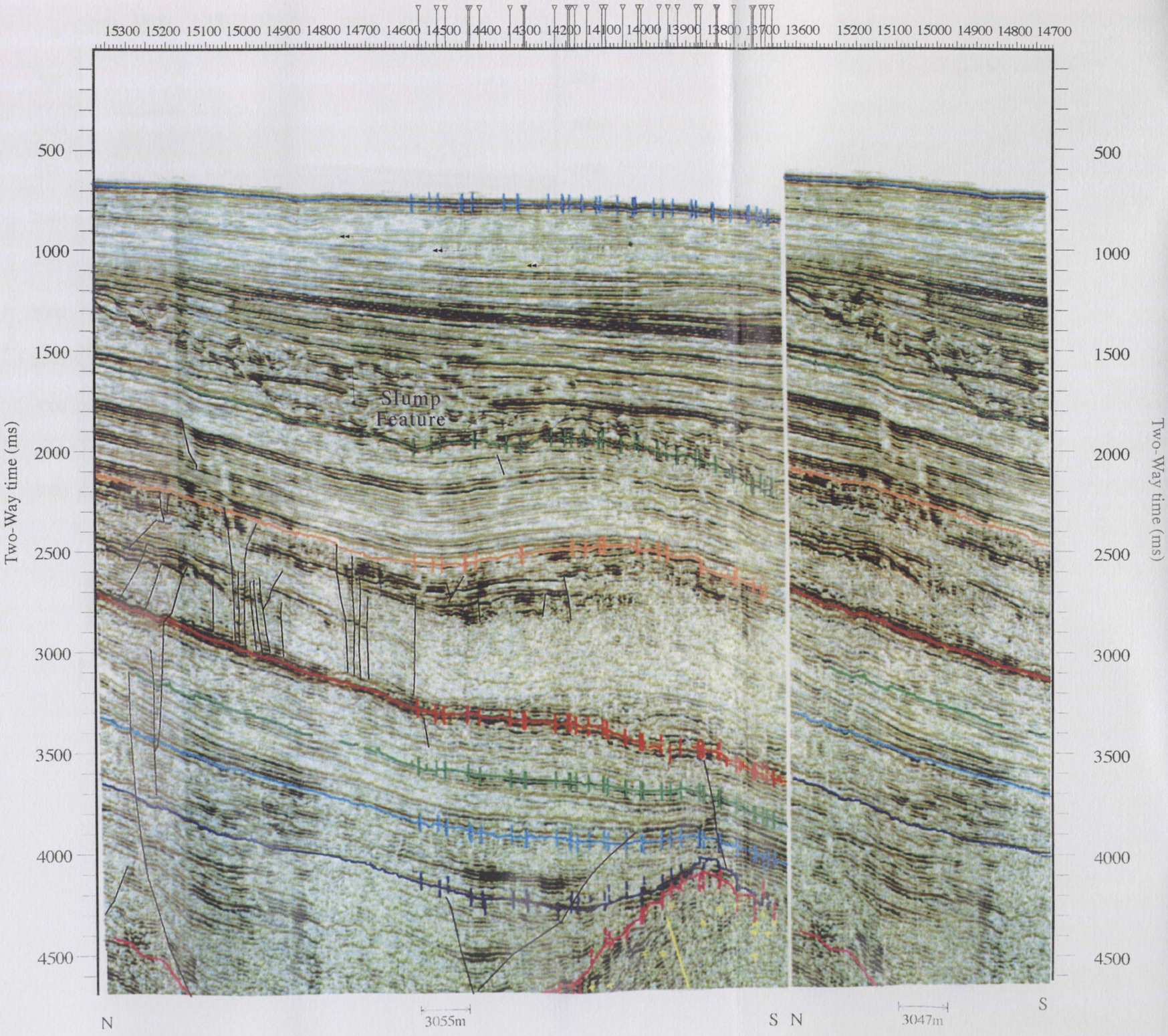


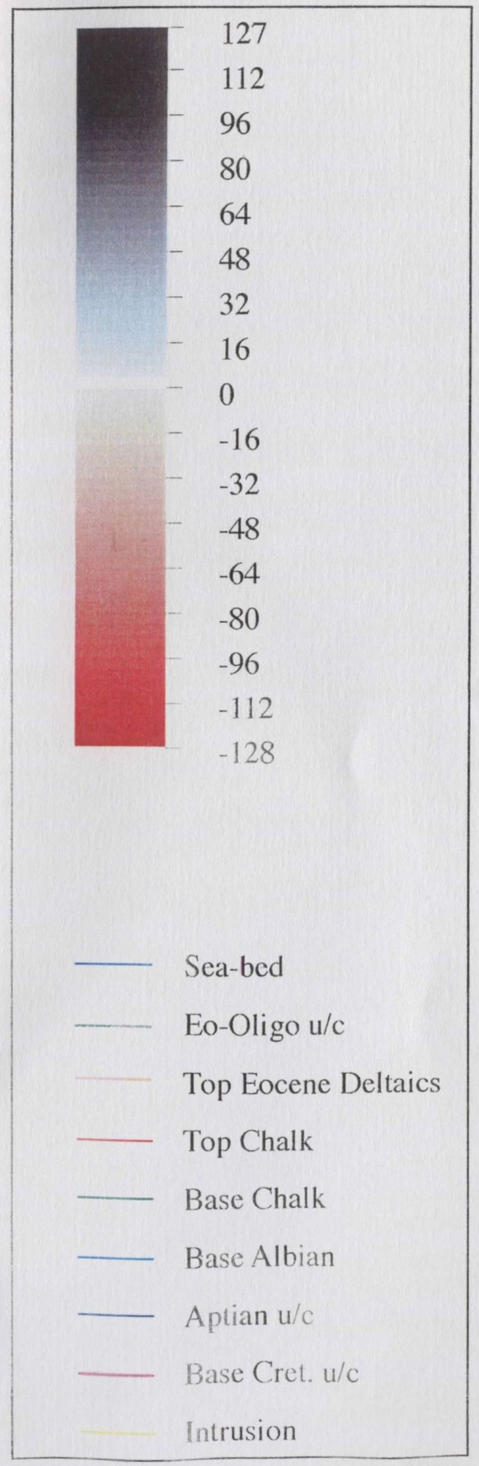
Appendix 8 - Line 2



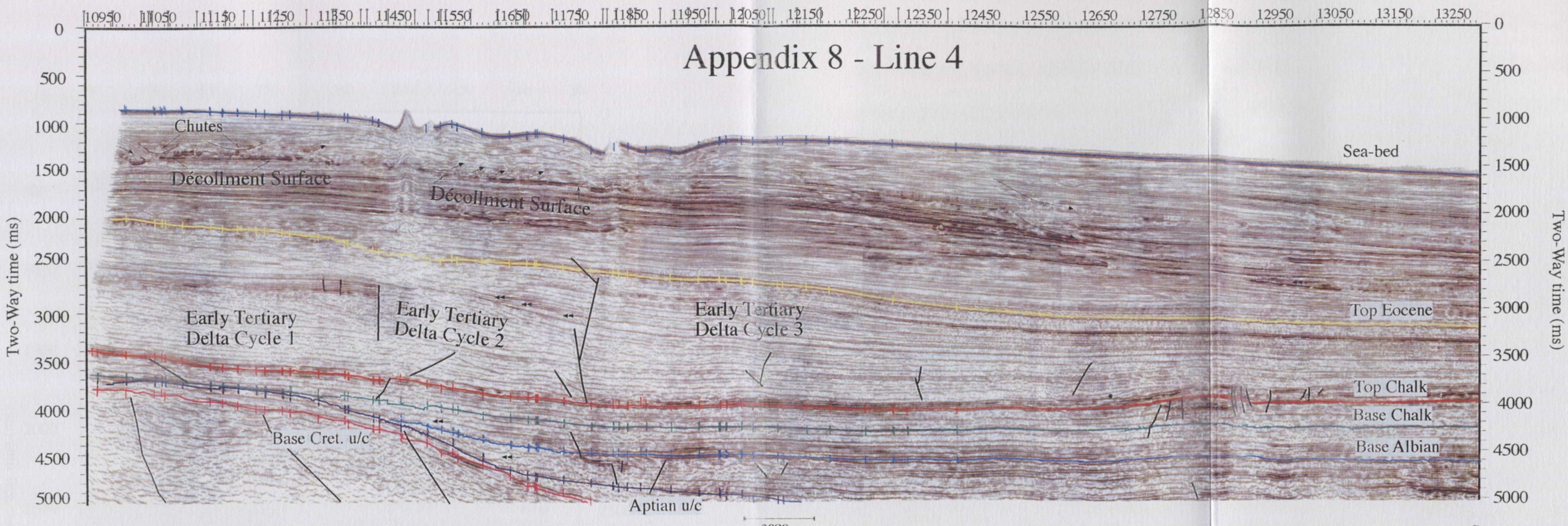


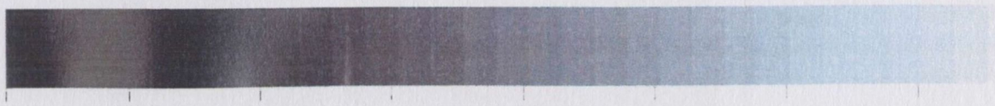
Appendix 8 - Line 3



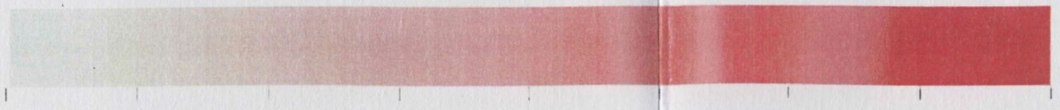


Appendix 8 - Line 4





127



0

-128

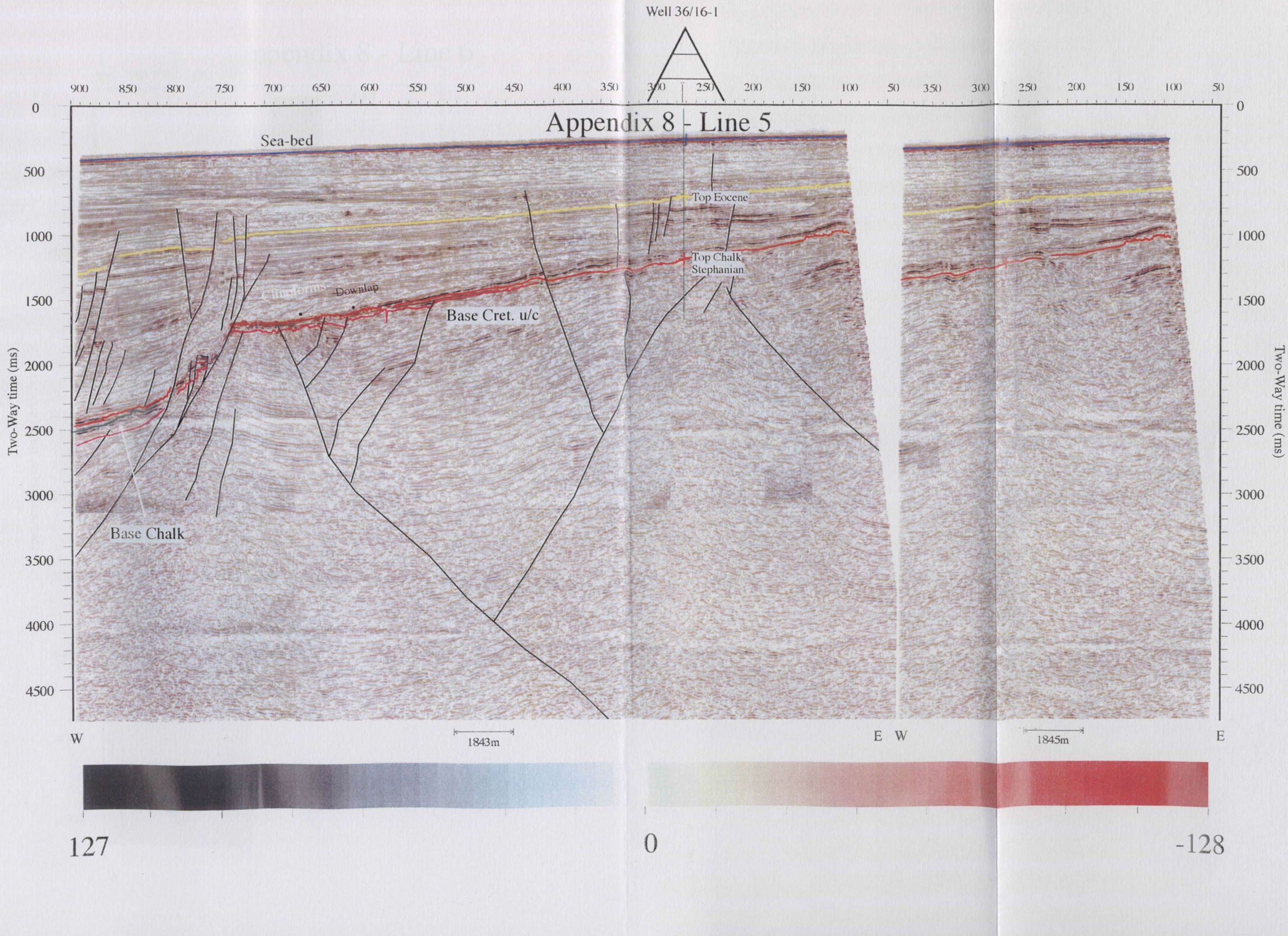
Onlap

Slump (toe)

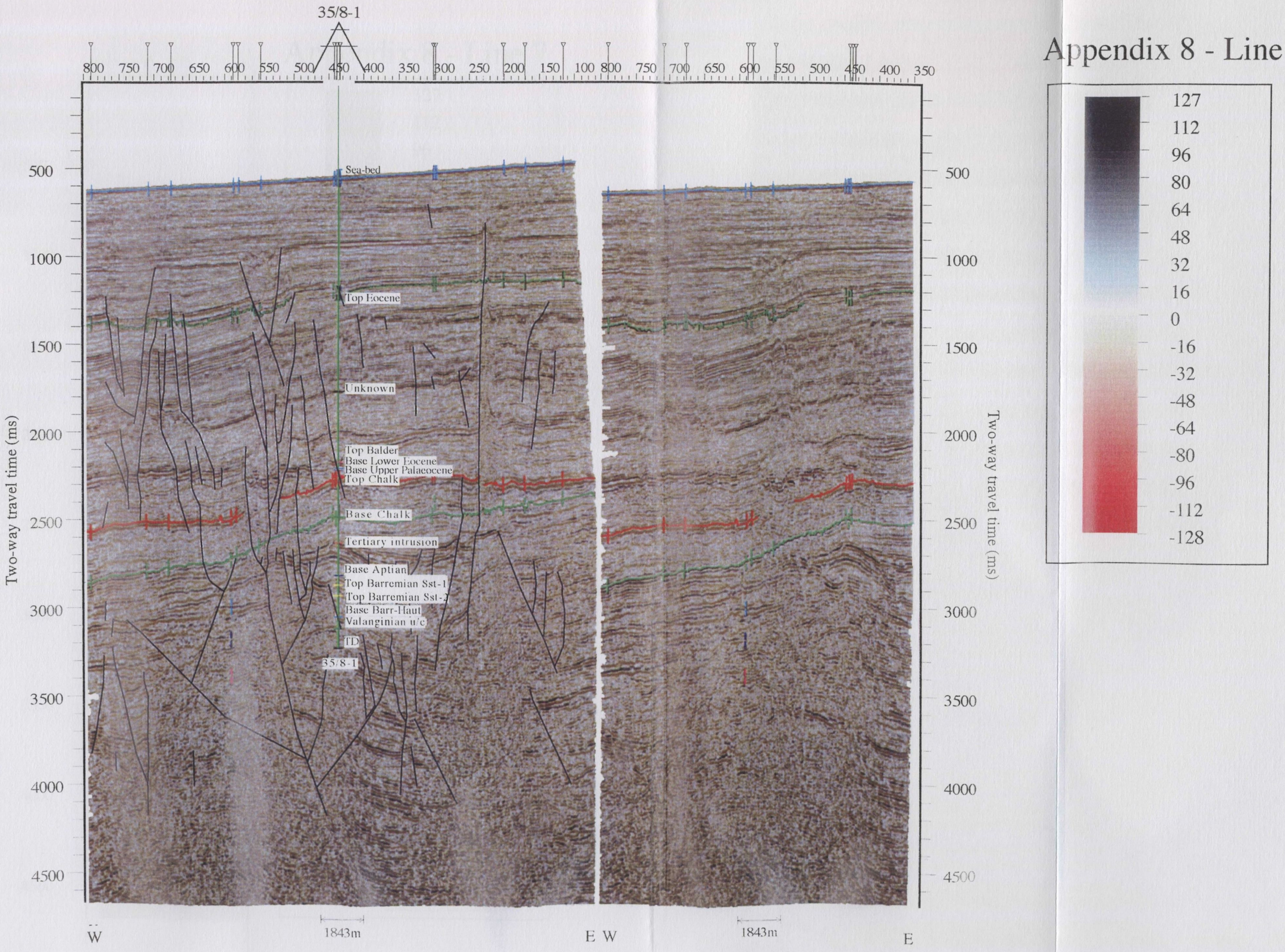
Slump (head)

Downlap

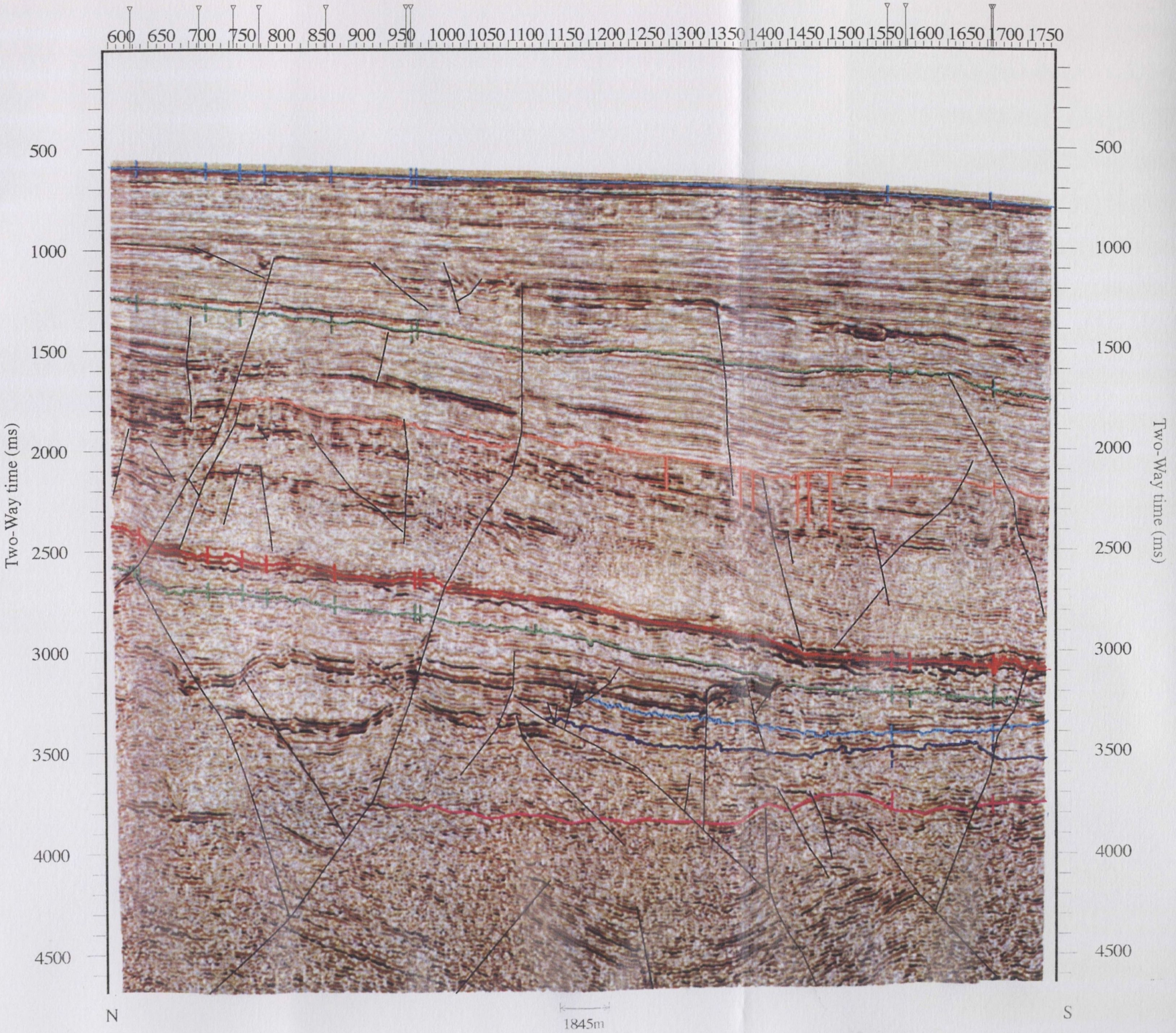
Appendix 8 - Line 5

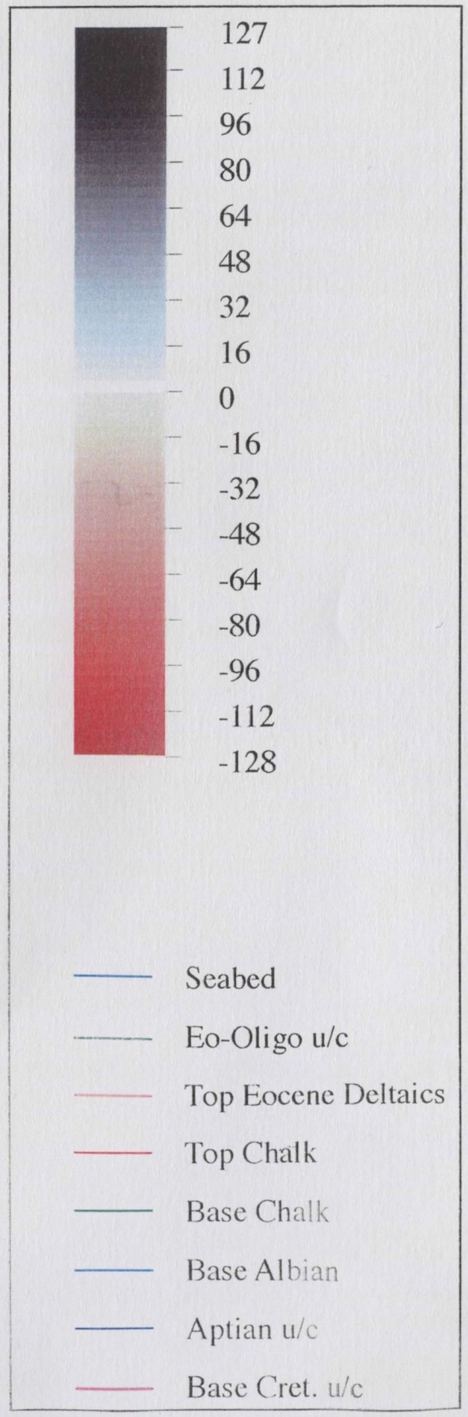


Appendix 8 - Line 6



Appendix 8 - Line 7

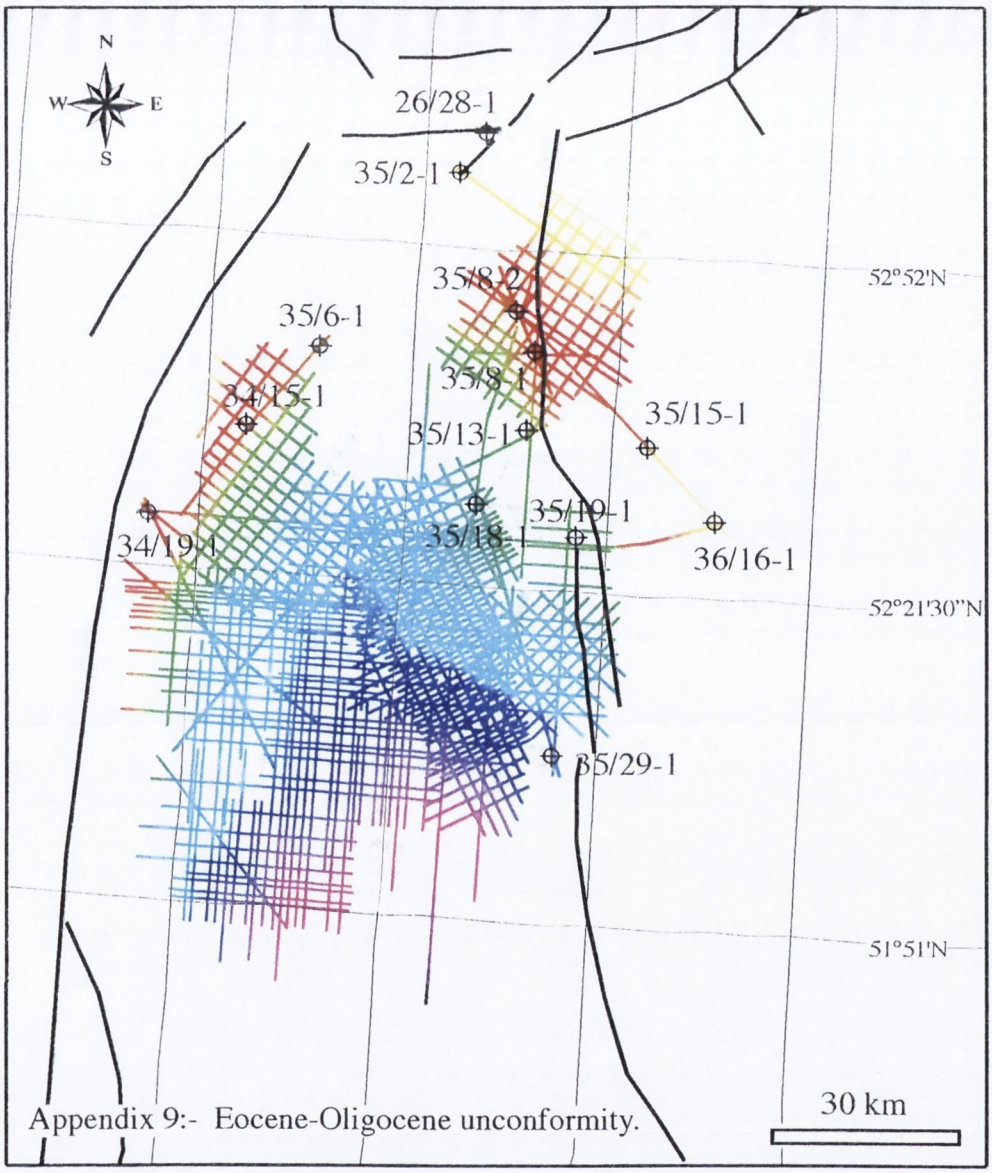




APPENDIX 9

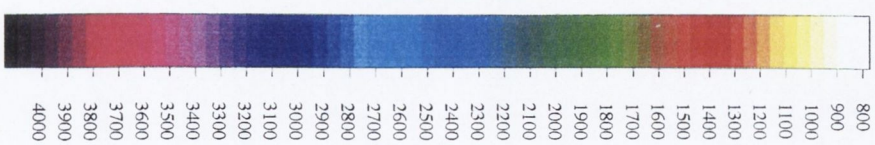
Two-way Time Maps

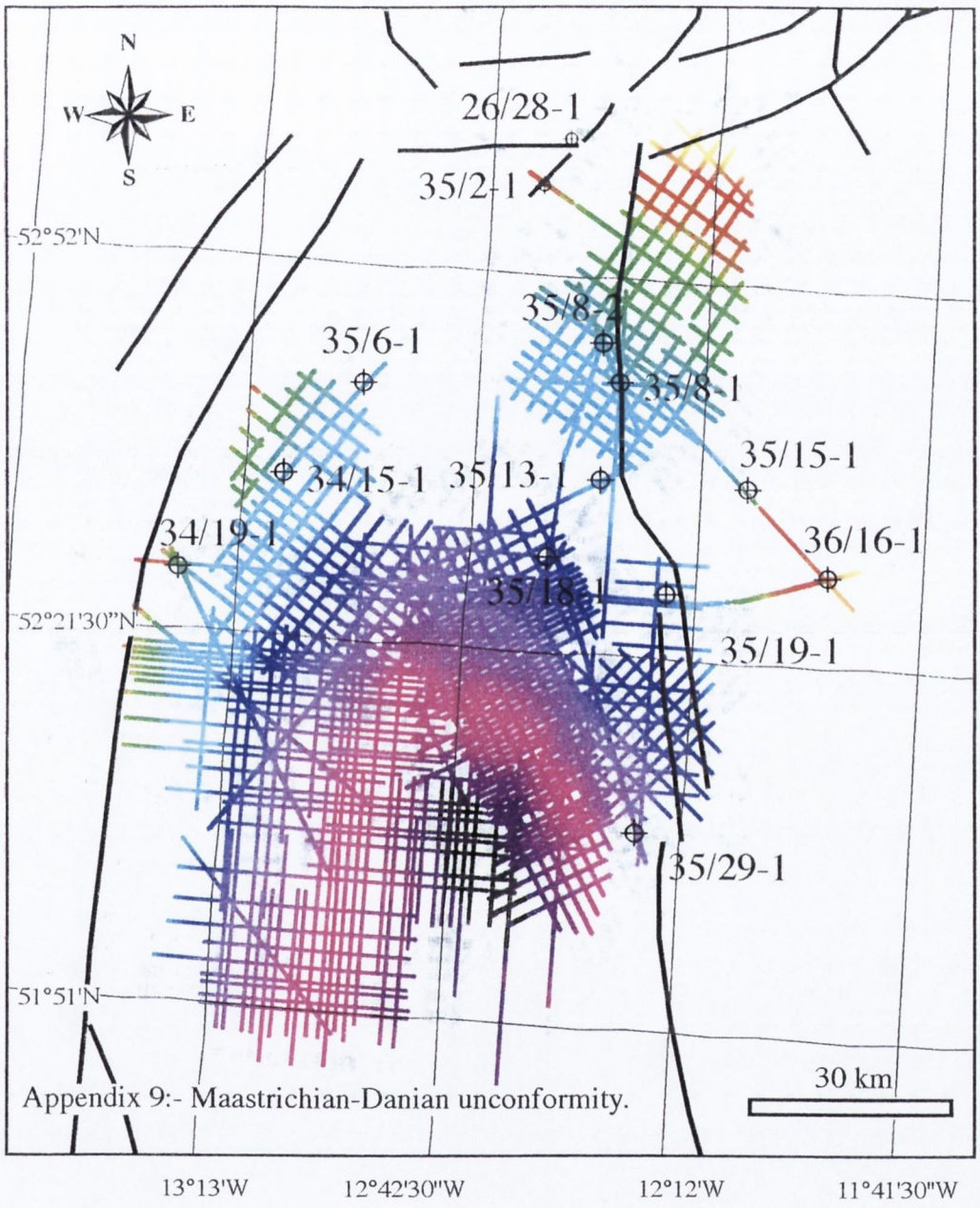
Porcupine Basin (Ireland)



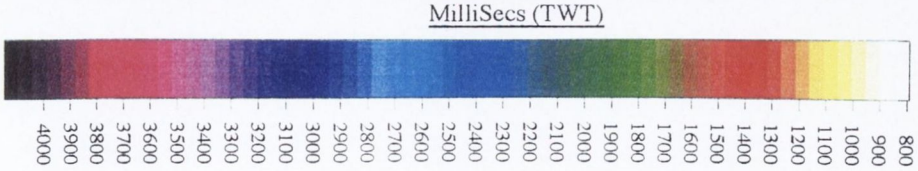
Appendix 9:- Eocene-Oligocene unconformity.

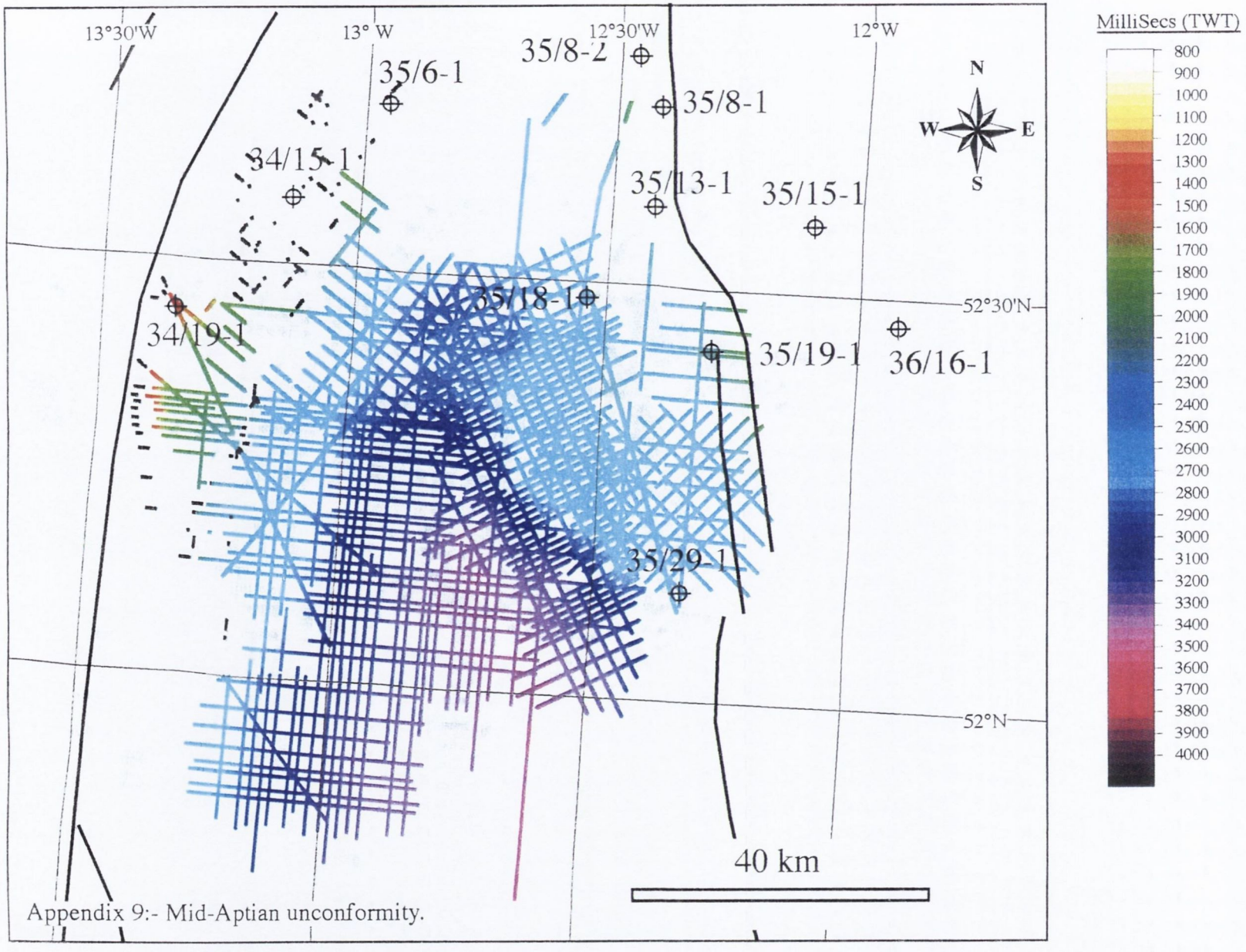
MilliSecs (TWT)



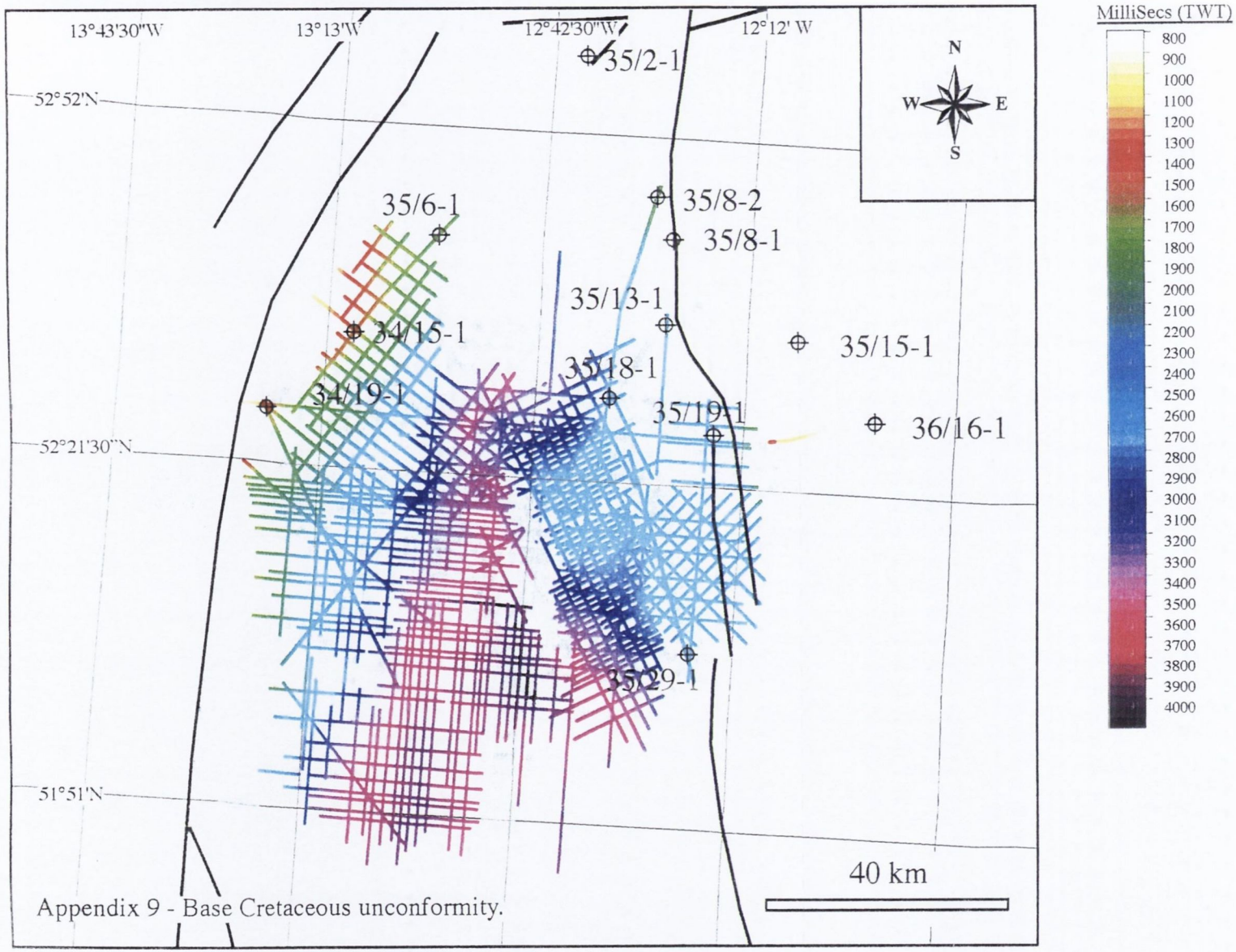


Appendix 9:- Maastrichian-Danian unconformity.





Appendix 9:- Mid-Aptian unconformity.



Appendix 9 - Base Cretaceous unconformity.