Mechanisms of failure of jointed rock masses and the behaviour of steep slopes

Owen Graham Kimber

Contents of Volume 2

List of Figures

The figures in this thesis include output from the UDEC computer simulation software. Most of the UDEC output is in the form of two-dimensional model block plots. The units of the horizontal and vertical axes are metres. The labelled notation (*10^1) indicates that the axis values need to be multiplied by 10. The legend includes an indication of the type of output plot, model cycle count and the model time, which is unrelated to real time. Where block velocity vectors are plotted, the scale is presented with units of m s^{-1}. The notation 1E 1 on the scale means that the scale is 1*10 m s^{-1} long. Again, the values of velocity do not relate to real velocity. Where UDEC plots of the history of total unbalanced forces for a model run are presented, the x-axis is model time (s), and the y-axis is force (kg m s^{-2}).

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

List of Plates

Chapter 5

Chapter 6

Chapter 7

List of Appendices

All appendices are to be found on the disk which is attached to the back cover of this volume. The file name corresponds with the appendix number. For the UDEC input files, where the letter 'v' is used, values are varied for different model runs.

Chapter 3

3.1: Program for calculating the angle of intersection between a joint plane and a UDEC mesh.

Chapter 4

4.1: UDEC input command file used to simulate four single blocks standing on inclined planes.

4.2: UDEC input command file used to simulate sliding, toppling and stable rock masses.

4.3: UDEC input command file used to simulate sliding, toppling and stable rock masses which contain joints with a friction angle of 20°.

4.4: UDEC input command file used to simulate sliding, toppling and stable rock masses which contain joints with a friction angle of 60°.

4.5: UDEC input command file used to simulate sliding, toppling and stable sandstone rock masses.

4.6: UDEC input command file used to simulate sliding, toppling and stable granite rock masses.

4.7: UDEC input command file used to simulate sliding, toppling and stable sandstone rock masses which contain deformable blocks.

4.8: UDEC input command file used to simulate sliding, toppling and stable granite rock masses which contain deformable blocks.

4.9: UDEC input command file used to simulate sliding, toppling and stable rock masses which contain variable joint dip values.

4.10: UDEC input command file used to simulate sliding, toppling and stable rock masses which contain variable joint spacing values.

Figures

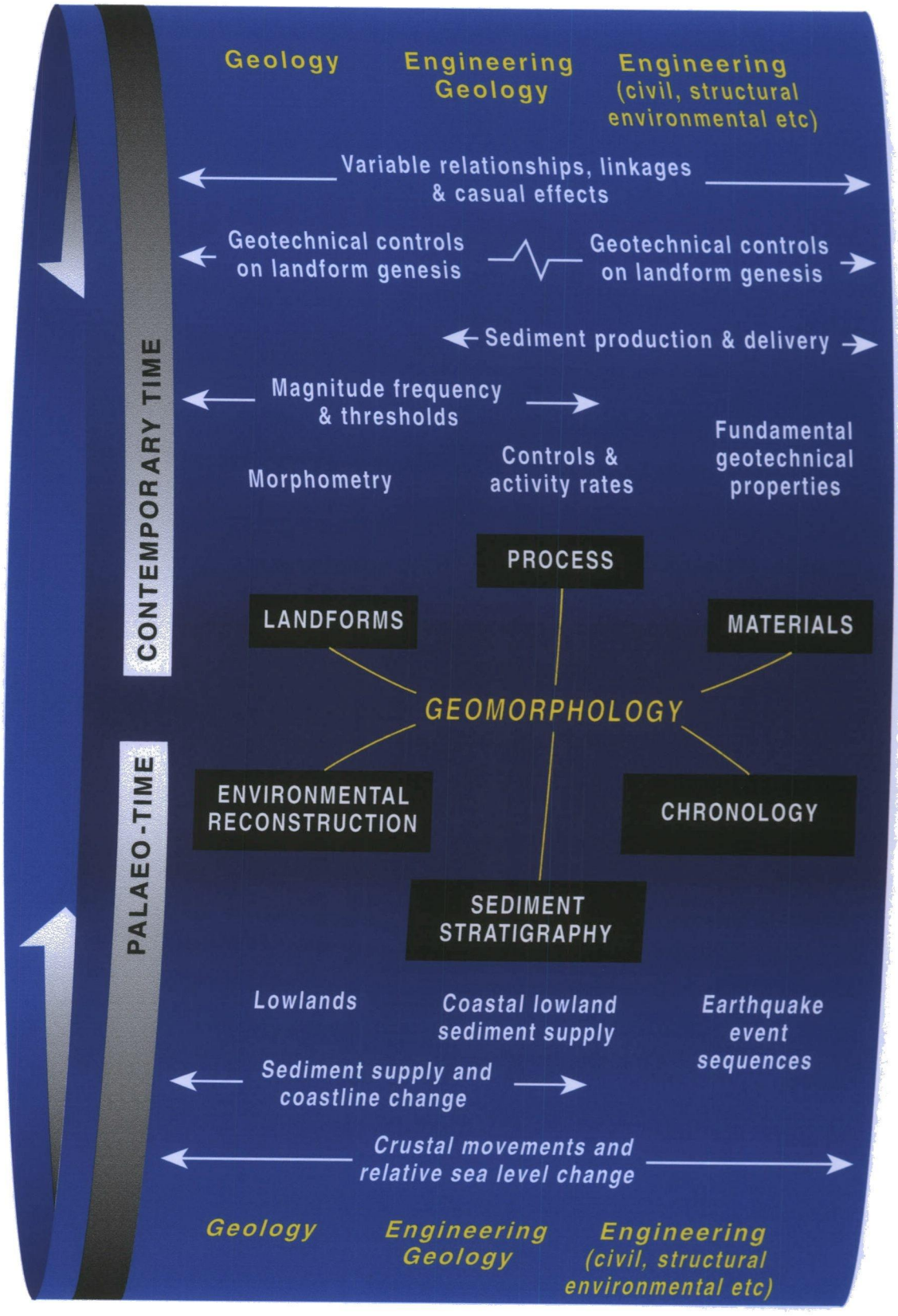


Figure 2.1: Links between engineering and geomorphology (from Allison, 1997)

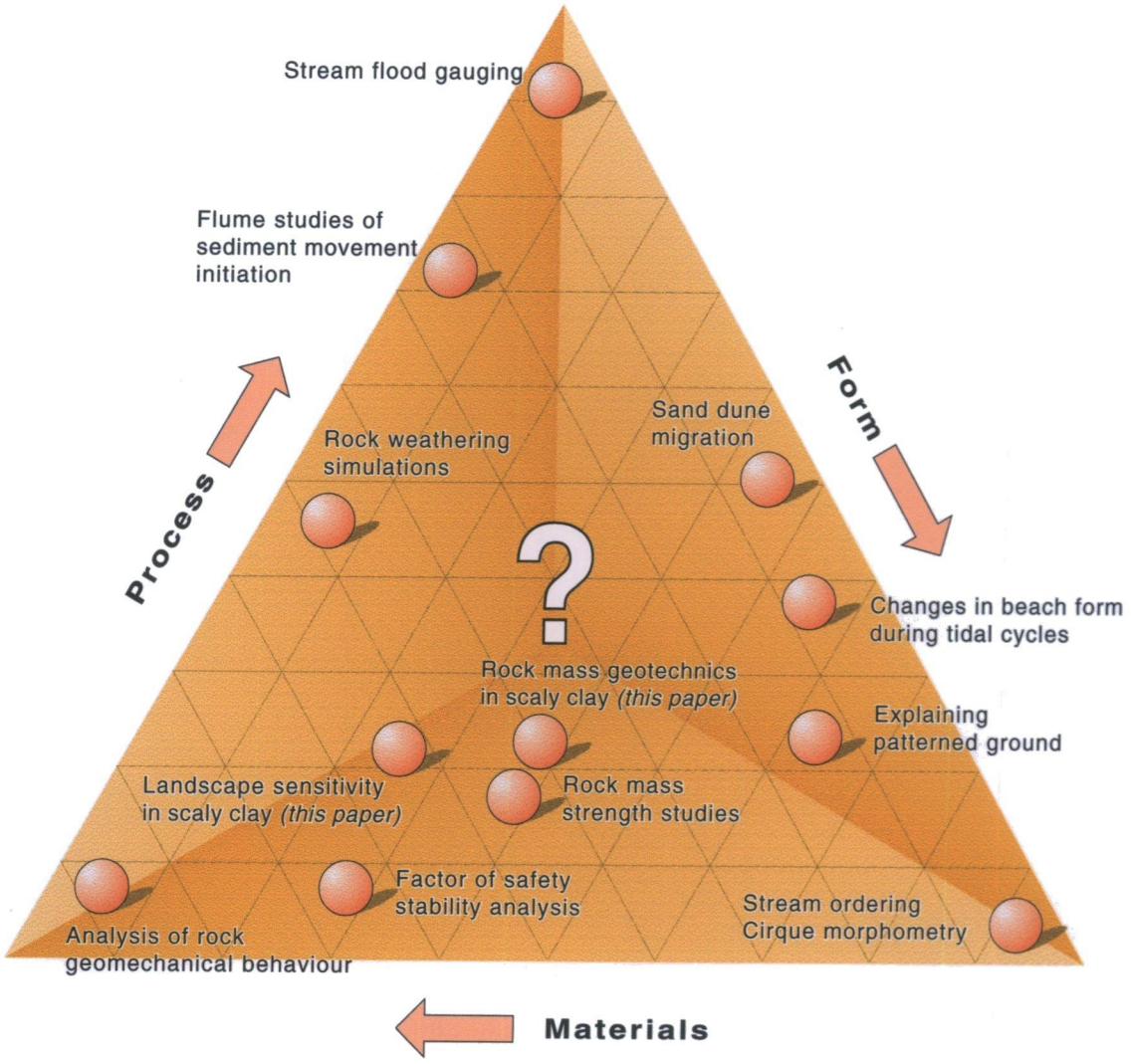


Figure 2.2: Geomorphological interactions between processes, landforms and materials (from Allison, 1996a)

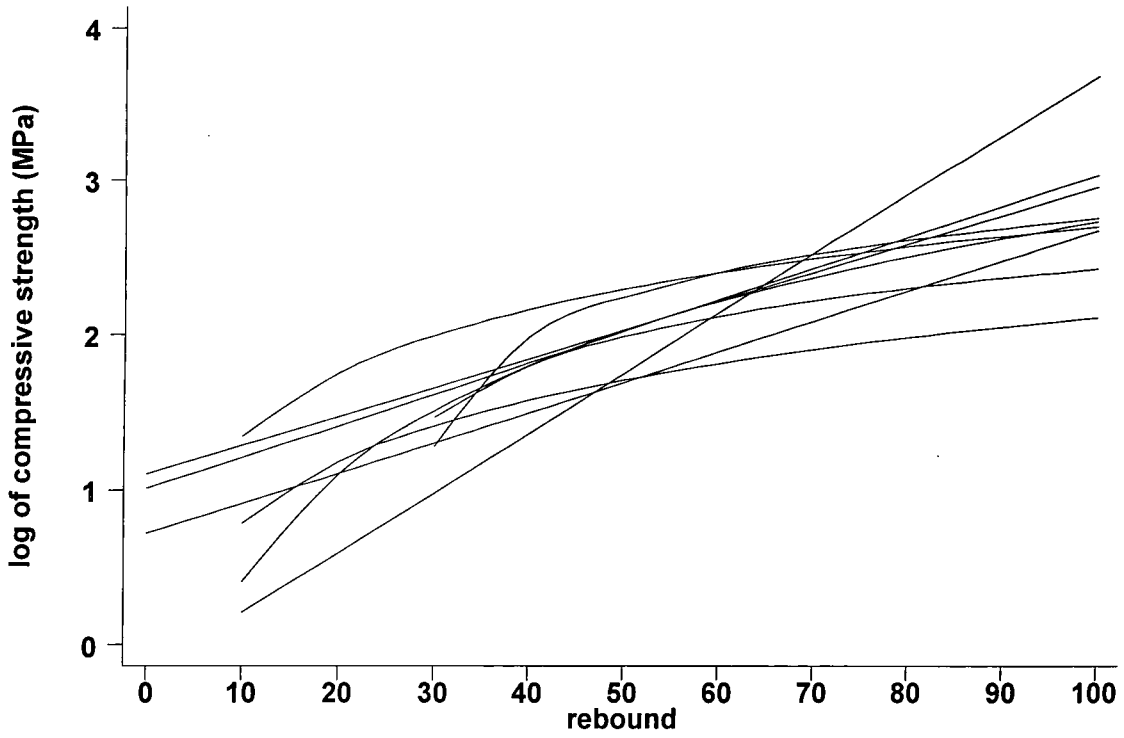


Figure 2.3: Graphs of published relationships for the conversion of Schmidt hammer rebound values (R) into uniaxial compressive strength.

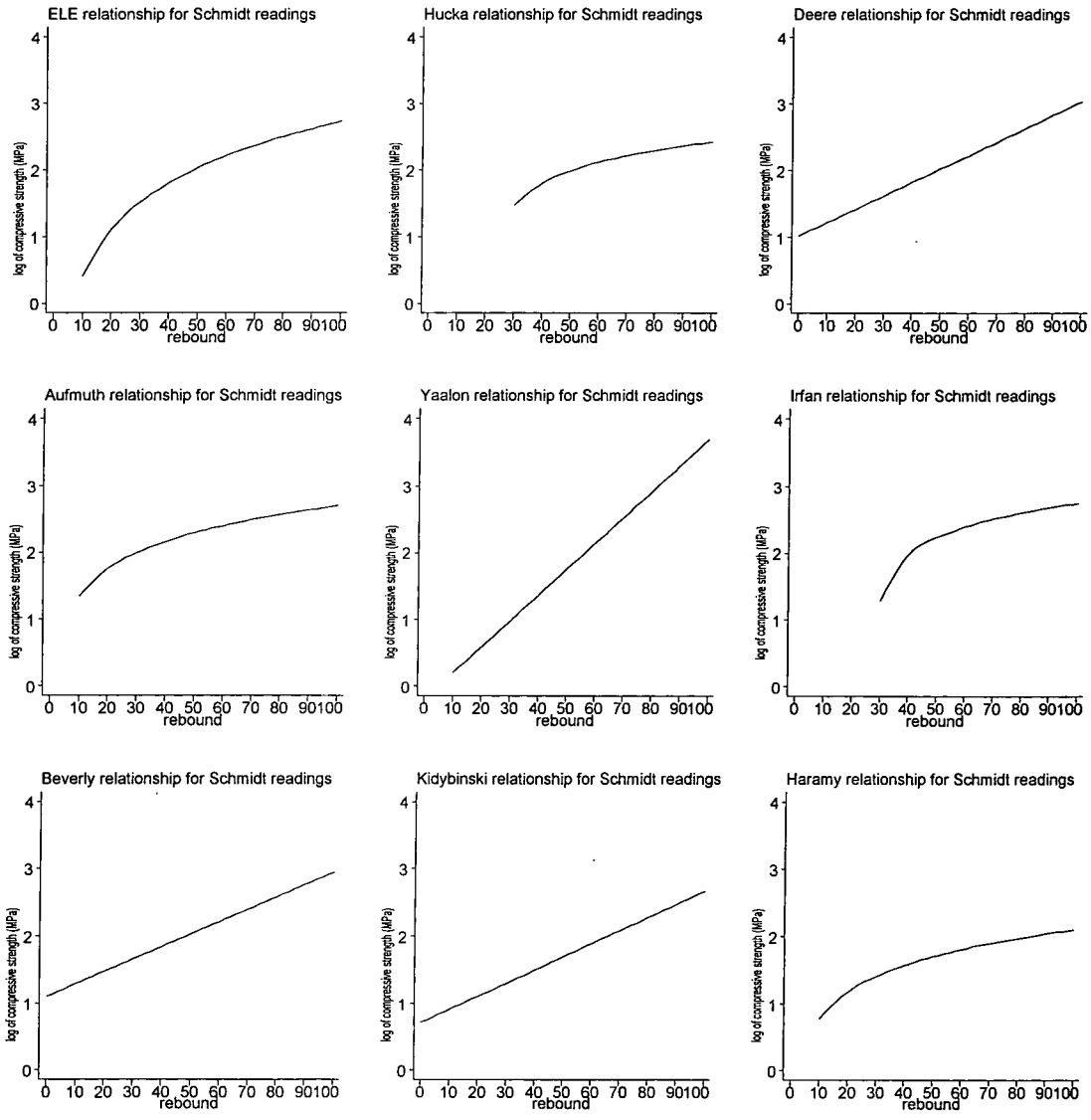


Figure 2.4: Separate graphs of published relationships for the conversion of Schmidt hammer rebound values (R) into uniaxial compressive strength.

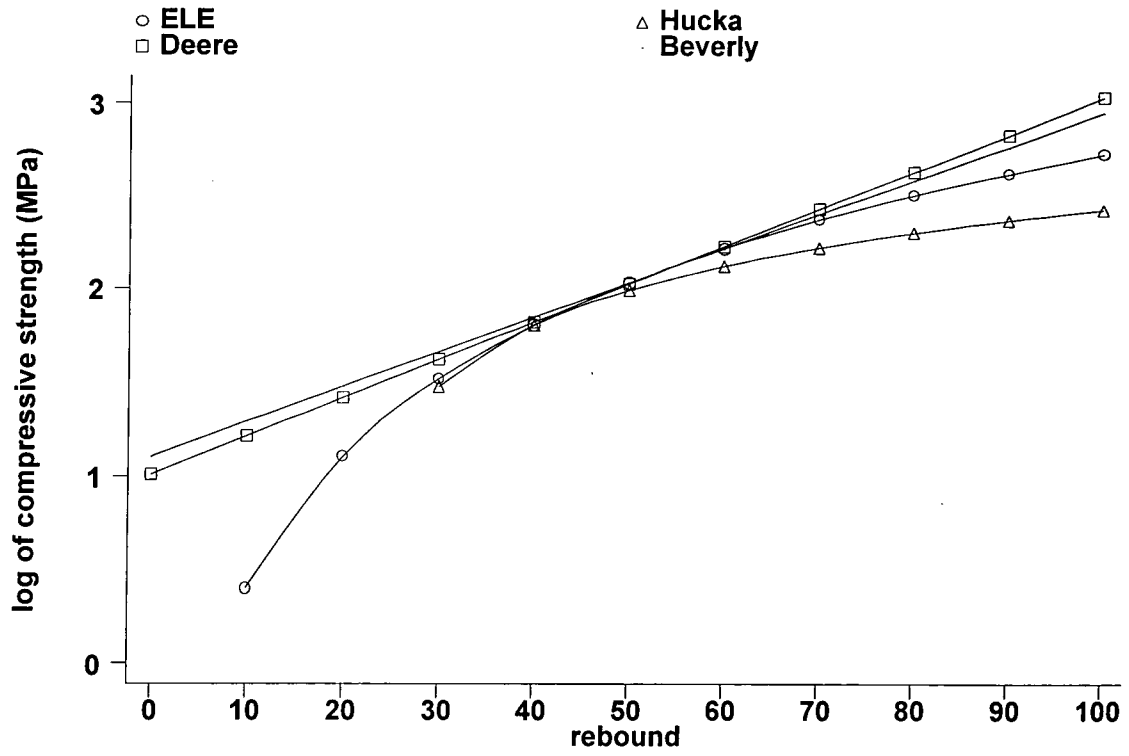


Figure 2.5: Four similar relationships for the conversion of Schmidt hammer rebound values (R) into uniaxial compressive strength.

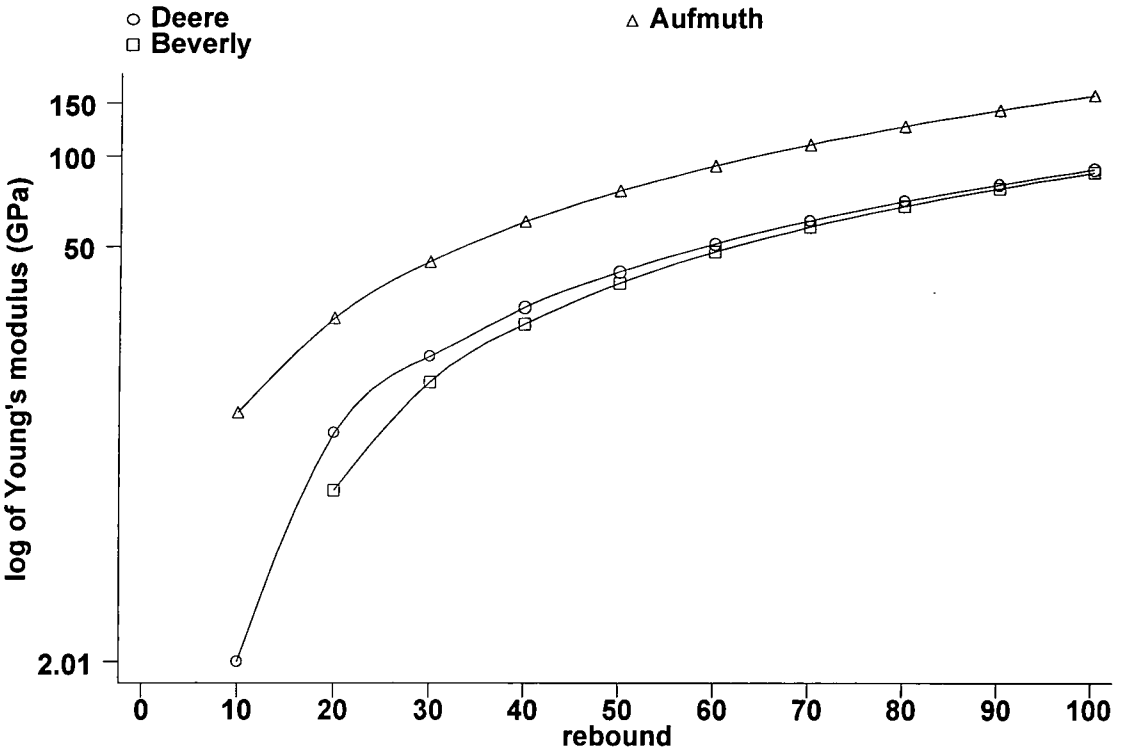


Figure 2.6: Three similar relationships for the conversion of Schmidt hammer rebound values (R) into Young's modulus.

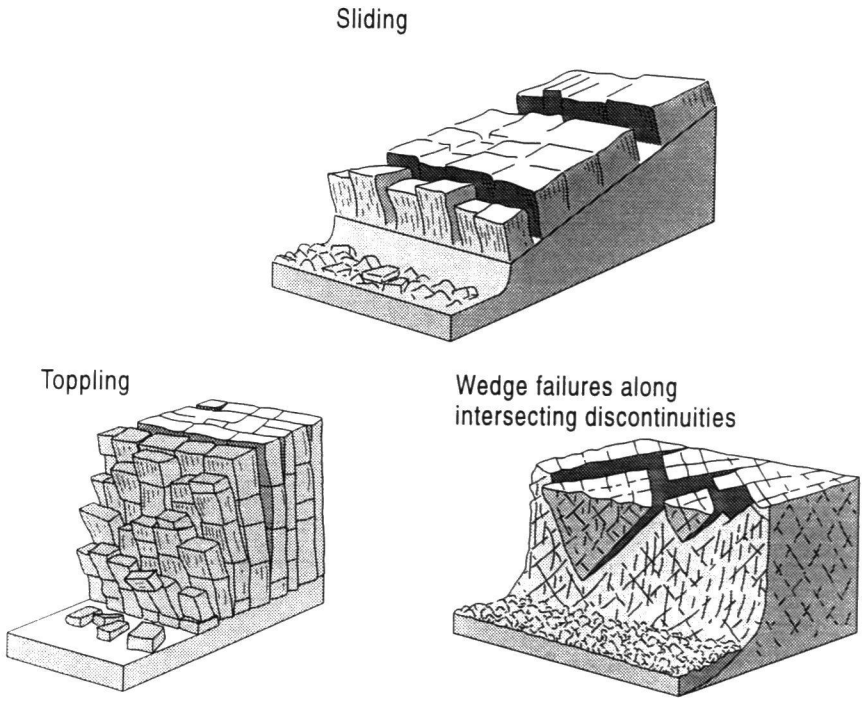


Figure 2.7: Three basic failure mechanisms of rock masses under gravitational forces.

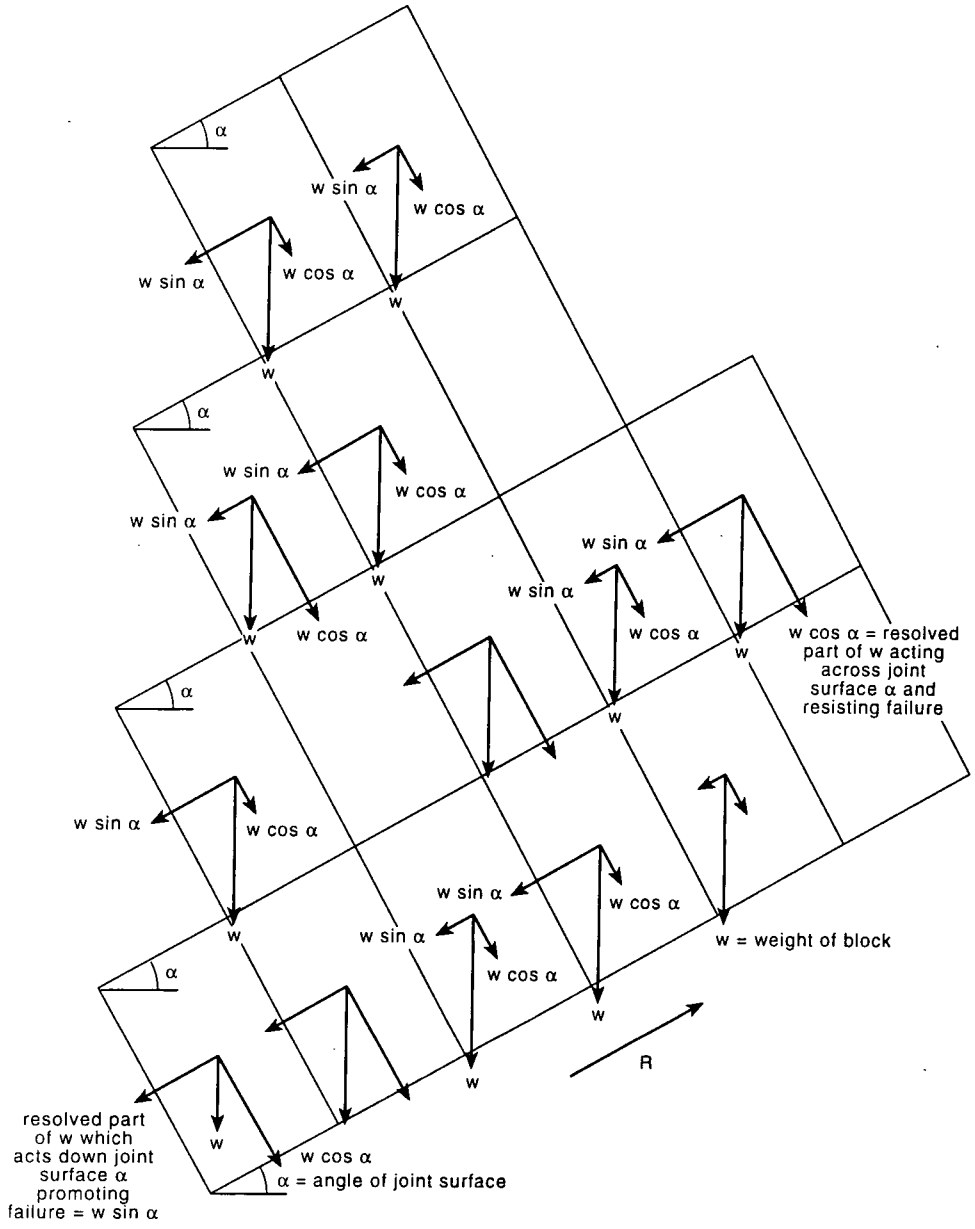


Figure 2.8: Basic conditions controlling rock mass block toppling.

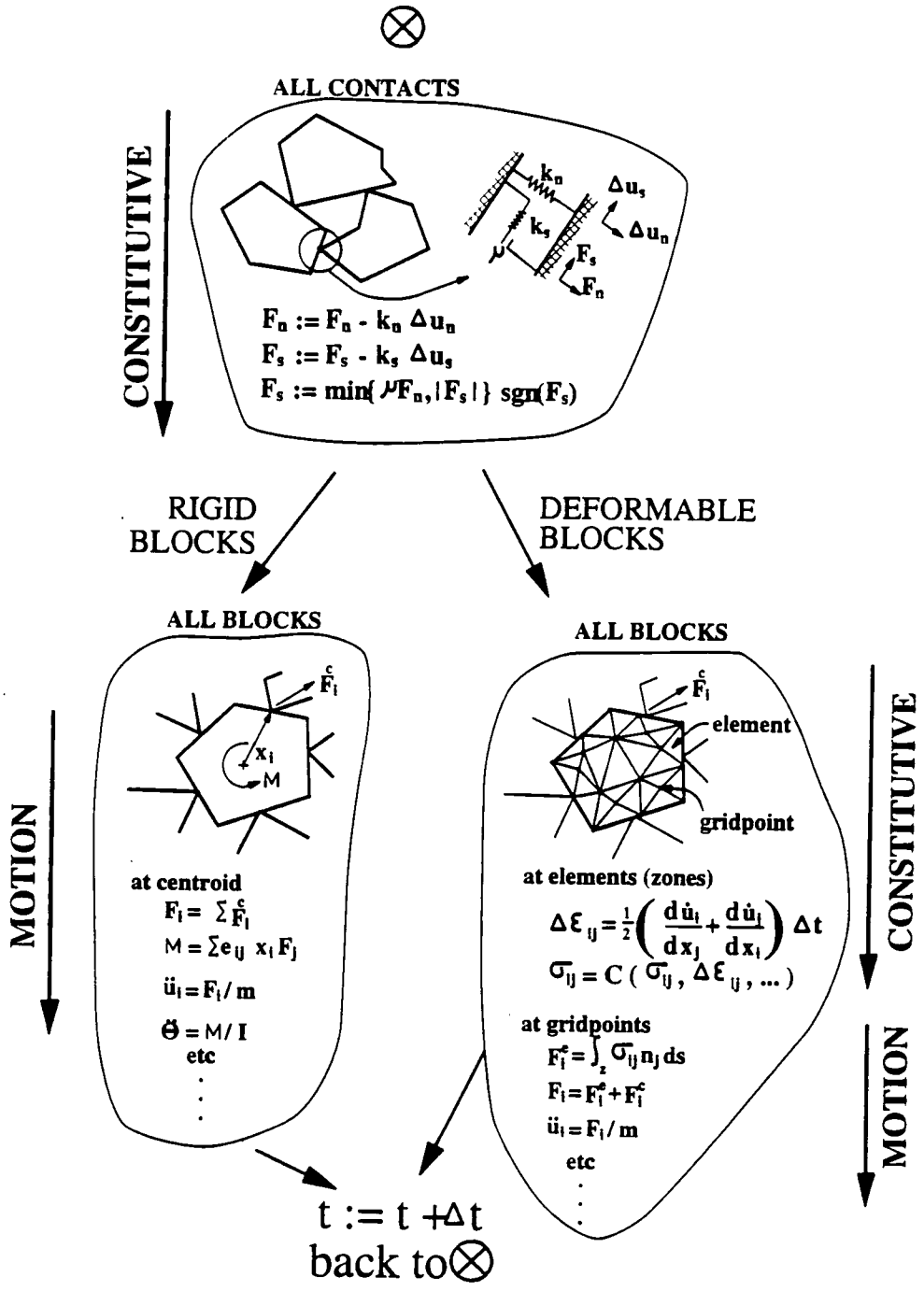
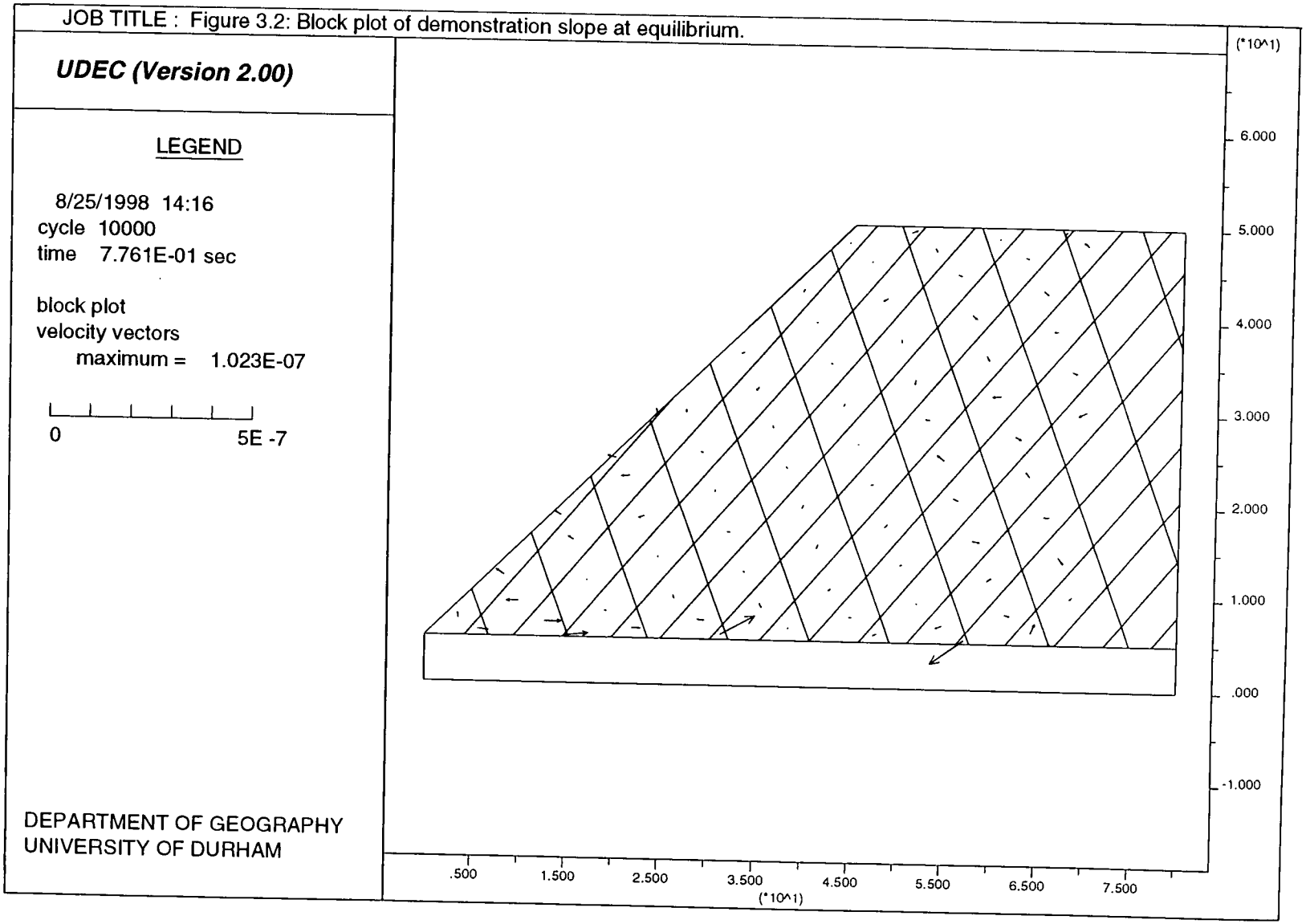


Figure 3.1: Calculation cycle for the distinct element method.


JOB TITLE : Figure 3.2: Block plot of demonstration slope at equilibrium.
UDEC (Version 2.00)
LEGEND
8/25/1998 14:16
cycle 10000
time 7.761E-01 sec
block plot
velocity vectors
maximum = 1.023E-07
0
5E -7
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

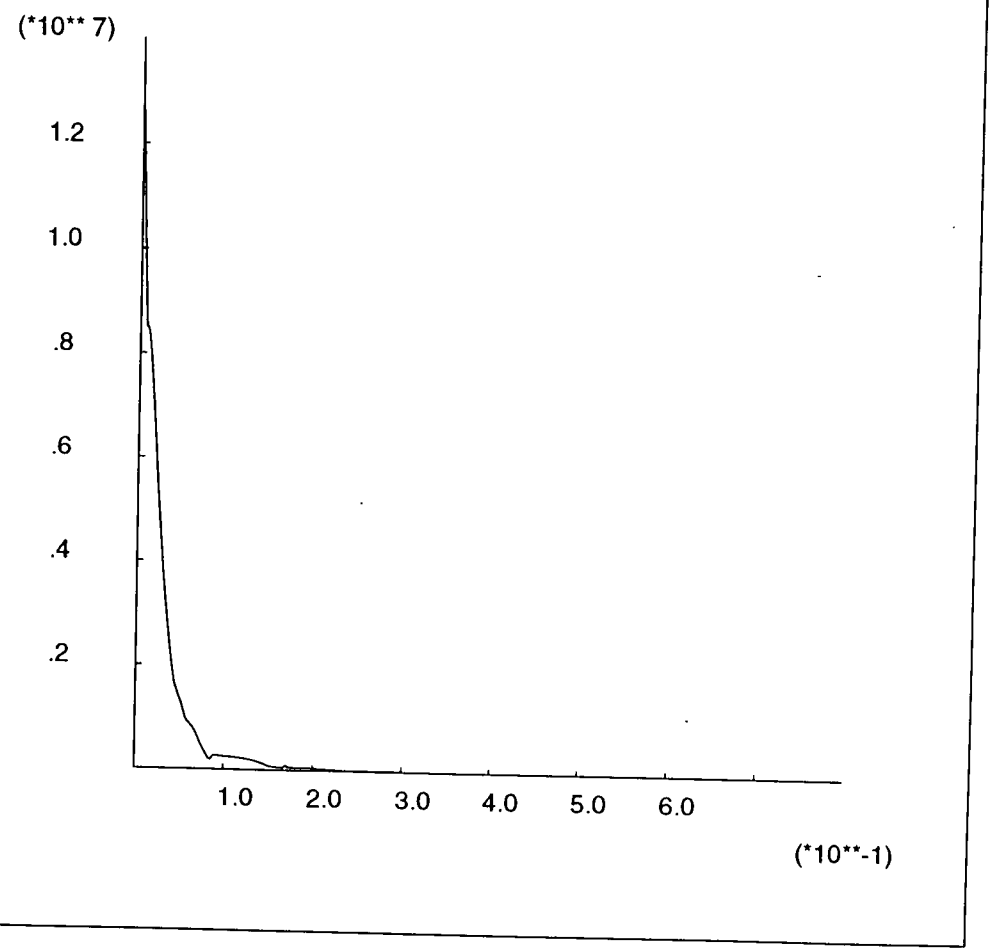
JOB TITLE : Figure 3.3: Total forces for demonstration slope at equilibrium.

UDEC (Version 2.00)

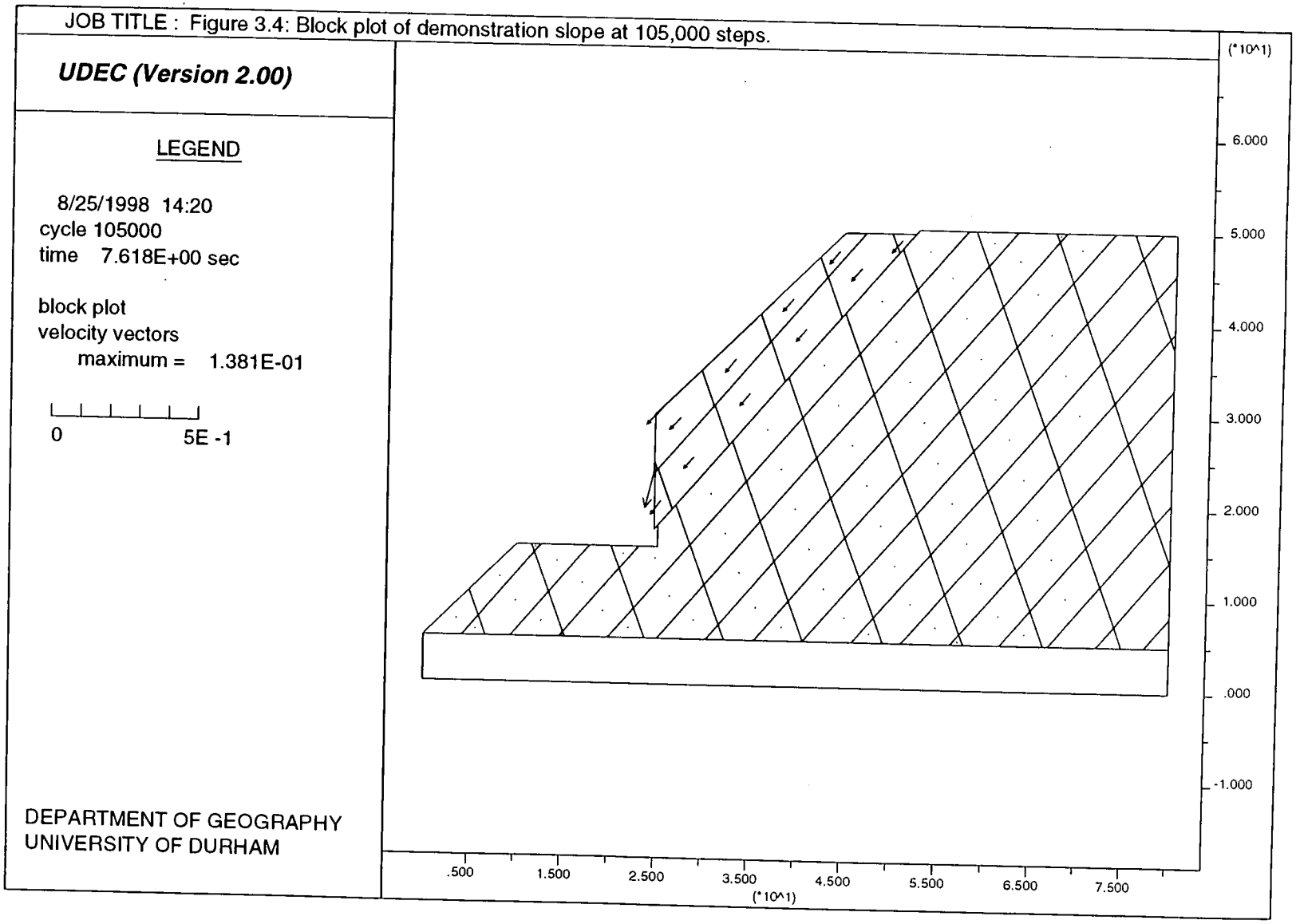
LEGEND

9/06/1998 17:10
cycle 10000
time 7.761E-01 sec

1.12E+00 <hist 2> 1.26E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 3.4: Block plot of demonstration slope at 105,000 steps.
UDEC (Version 2.00)
LEGEND
8/25/1998 14:20
cycle 105000
time 7.618E+00 sec
block plot
velocity vectors
maximum = 1.381E-01
0
5E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

JOB TITLE : Figure 3.5: Block plot of demonstration slope at 955,000 steps.

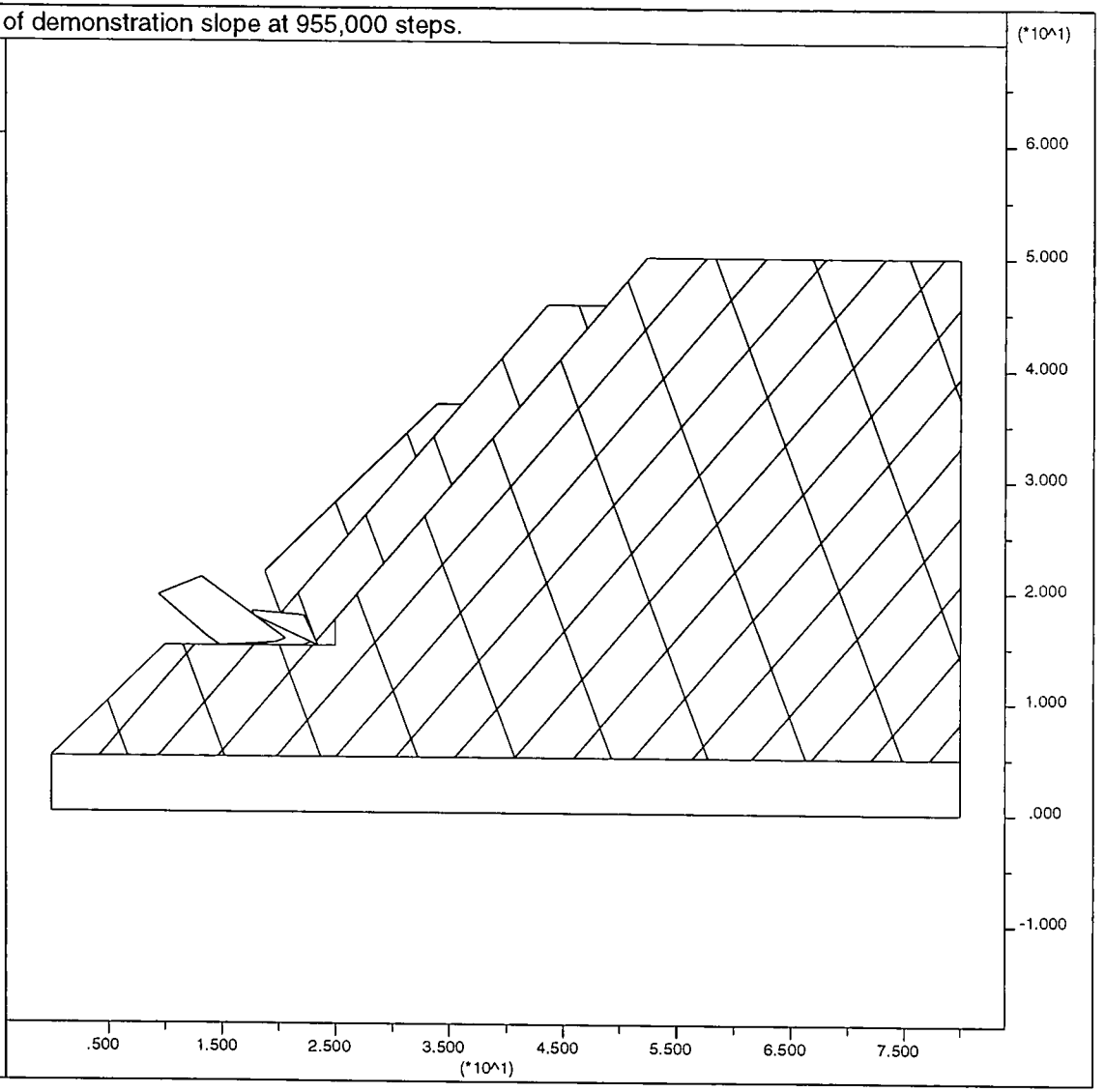
UDEC (Version 2.00)

LEGEND

11/23/1998 17:39
cycle 955000
time 6.954E+01 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



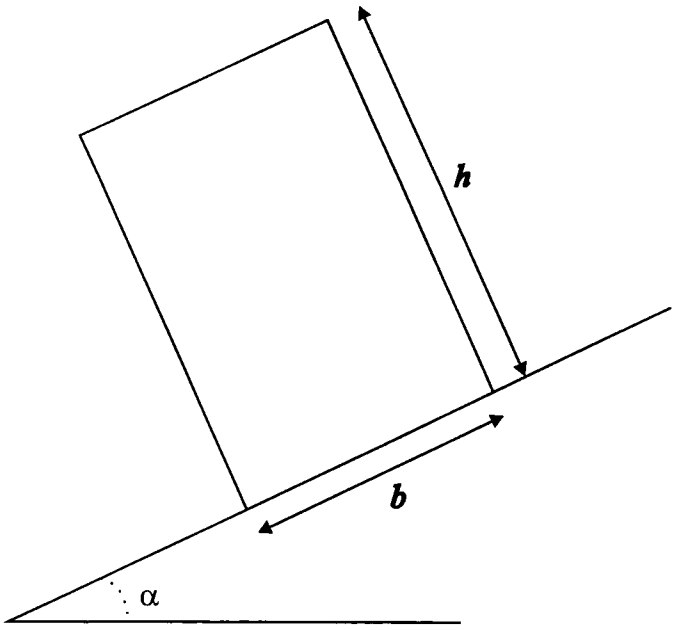


Figure 4.1: Single block geometrical parameters.

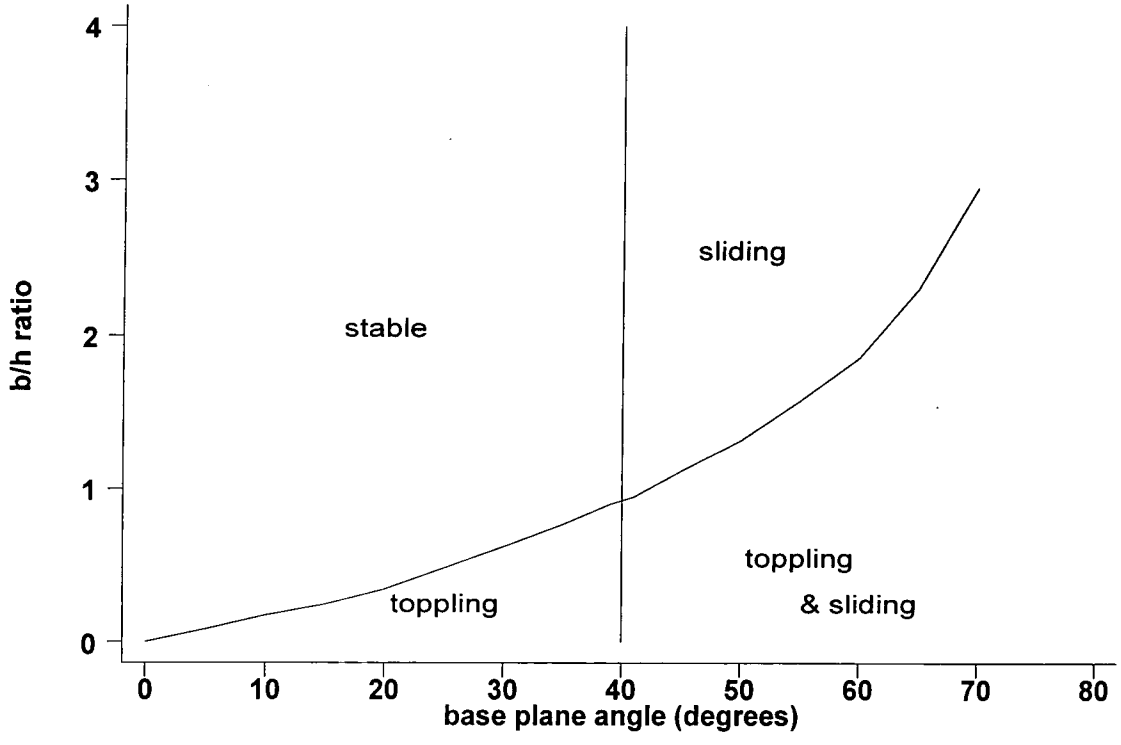
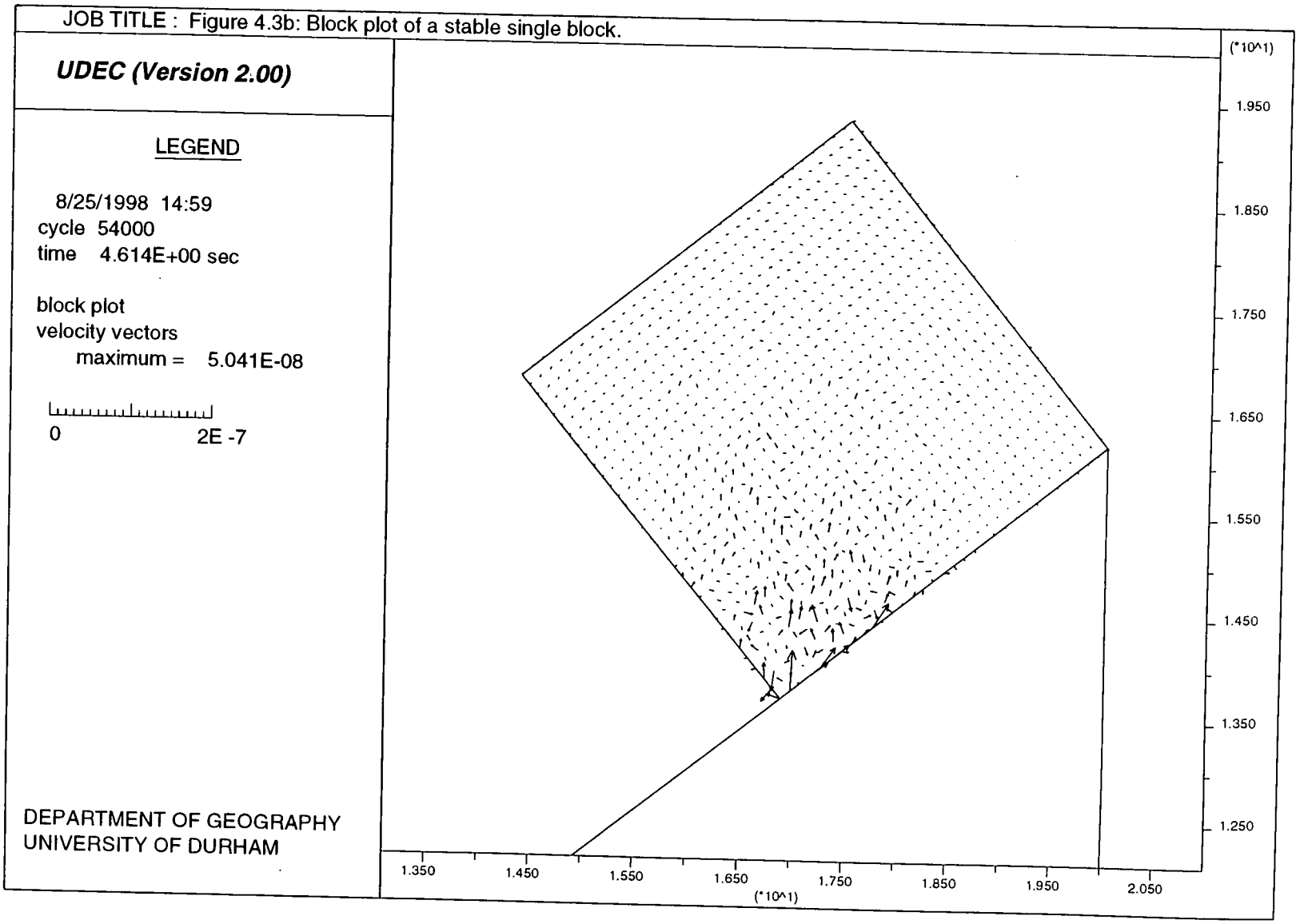
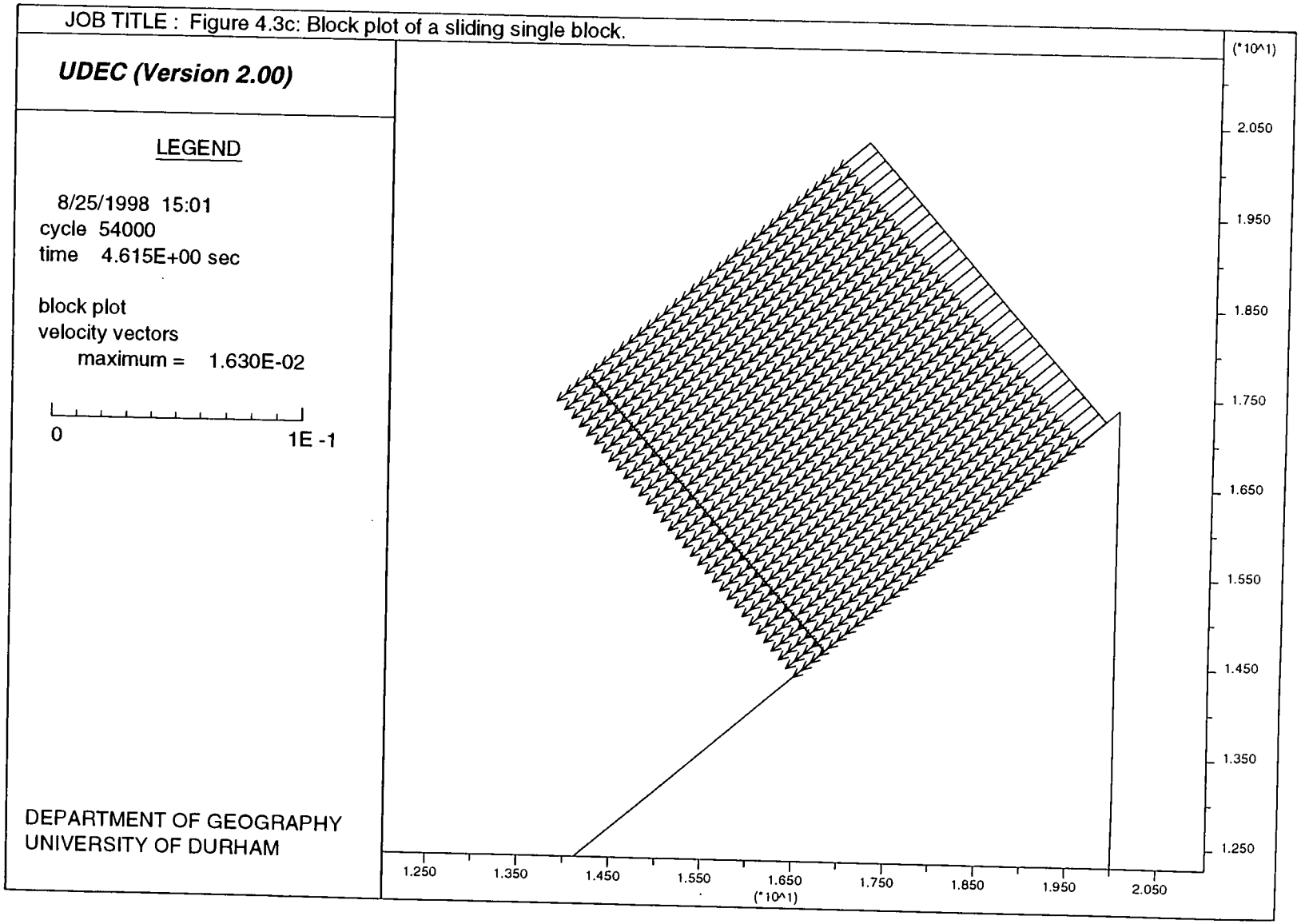
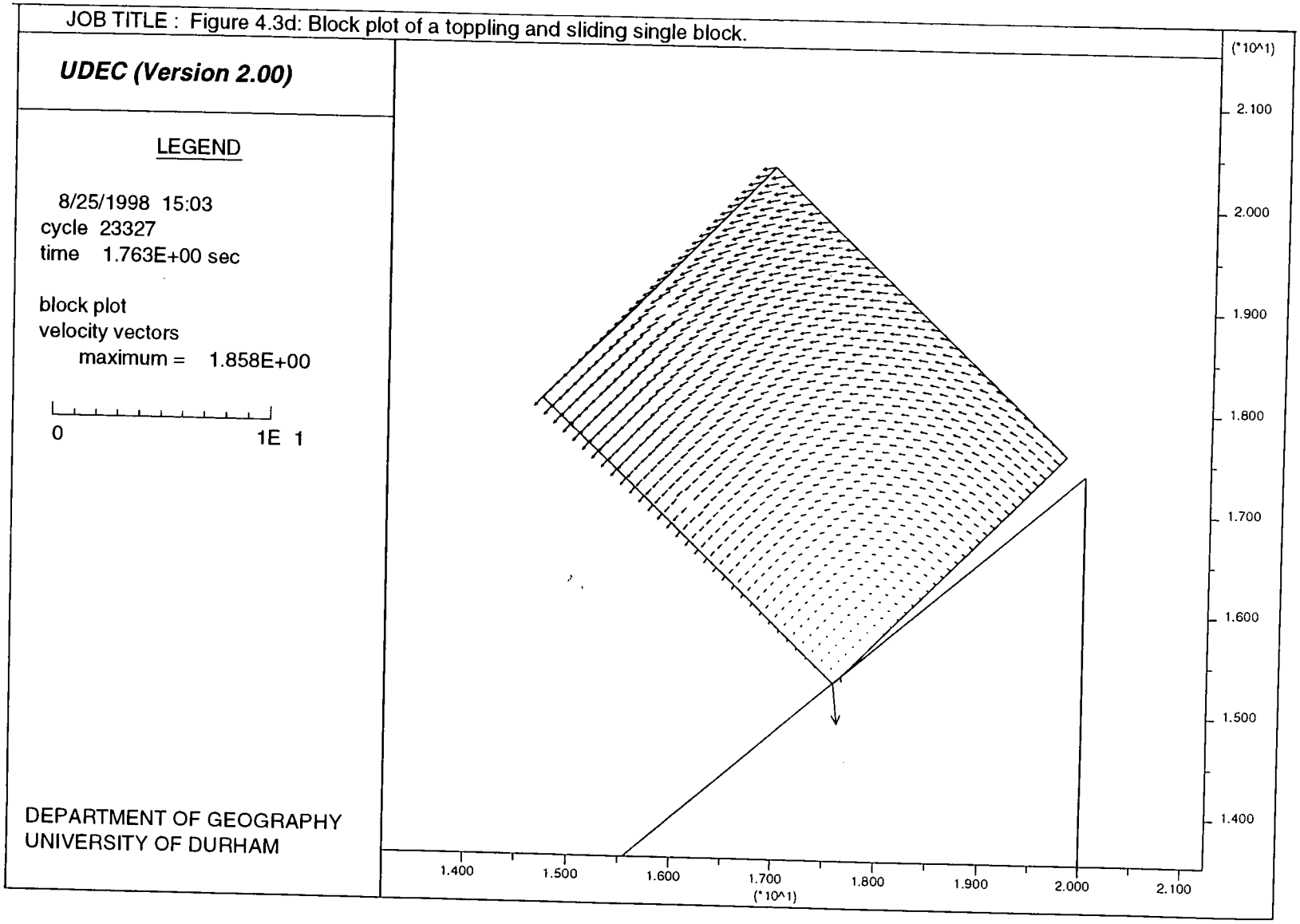


Figure 4.2: Limiting conditions for sliding, toppling and stable rock blocks (from DeFreitas and Watters, 1973).


JOB TITLE : Figure 4.3b: Block plot of a stable single block.
UDEC (Version 2.00)
LEGEND
8/25/1998 14:59
cycle 54000
time 4.614E+00 sec
block plot
velocity vectors
maximum = 5.041E-08
0
2E -7
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
1.950
1.850
1.750
1.650
1.550
1.450
1.350
1.250
1.350
1.450
1.550
1.650
1.750
1.850
1.950
2.050
(*10^1)


JOB TITLE : Figure 4.3c: Block plot of a sliding single block.
UDEC (Version 2.00)
LEGEND
8/25/1998 15:01
cycle 54000
time 4.615E+00 sec
block plot
velocity vectors
maximum = 1.630E-02
0
1E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
2.050
1.950
1.850
1.750
1.650
1.550
1.450
1.350
1.250
1.250
1.350
1.450
1.550
1.650
1.750
1.850
1.950
2.050
(*10^1)


JOB TITLE : Figure 4.3d: Block plot of a toppling and sliding single block.
UDEC (Version 2.00)
LEGEND
8/25/1998 15:03
cycle 23327
time 1.763E+00 sec
block plot
velocity vectors
maximum = 1.858E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
2.100
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.400
1.500
1.600
1.700
1.800
1.900
2.000
2.100
(*10^1)

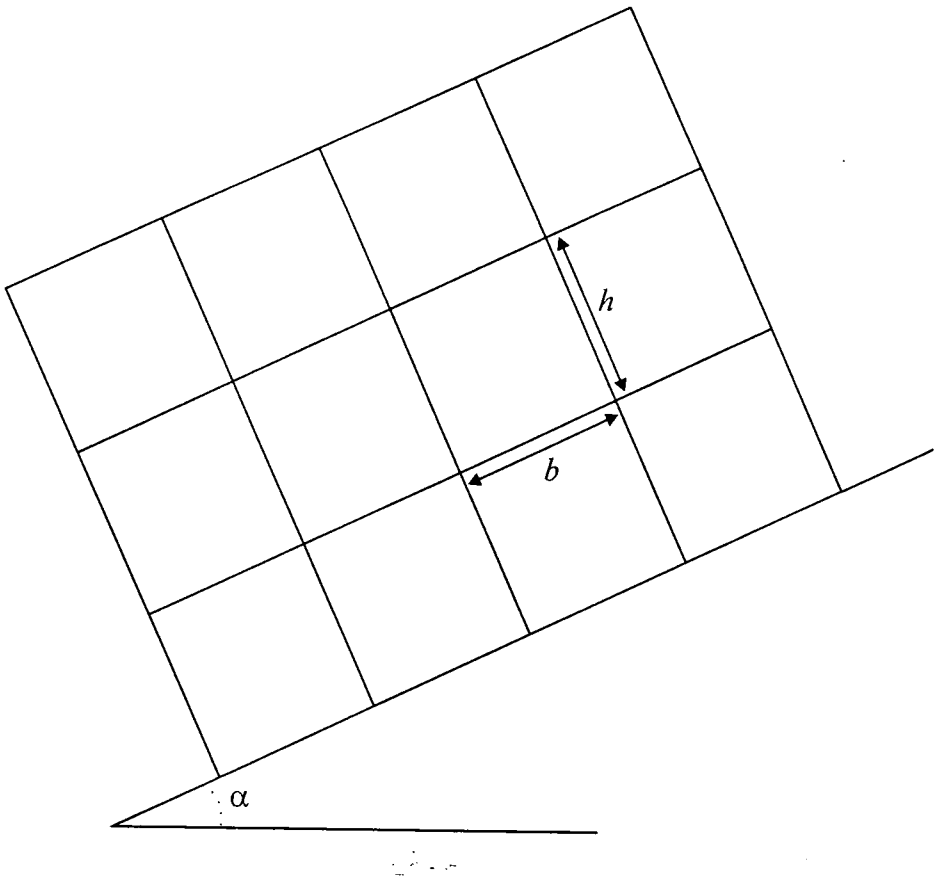


Figure 4.4: Rock mass block geometrical parameters.

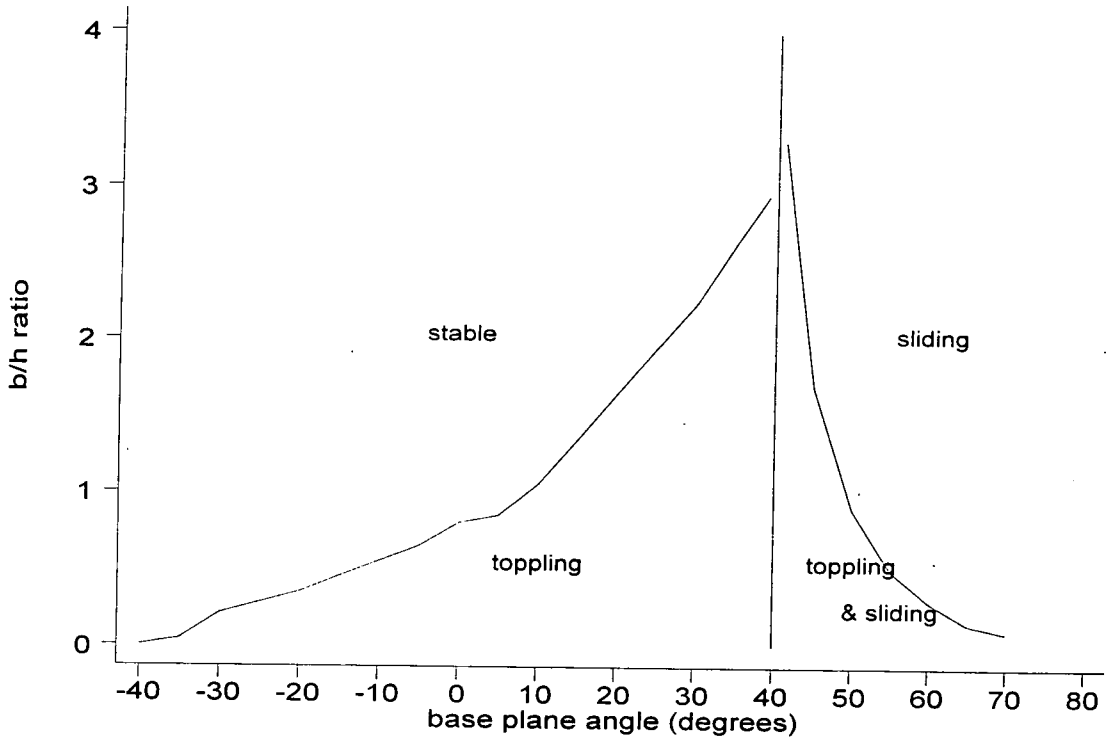


Figure 4.5: Limiting conditions for sliding, toppling and stable rock masses.

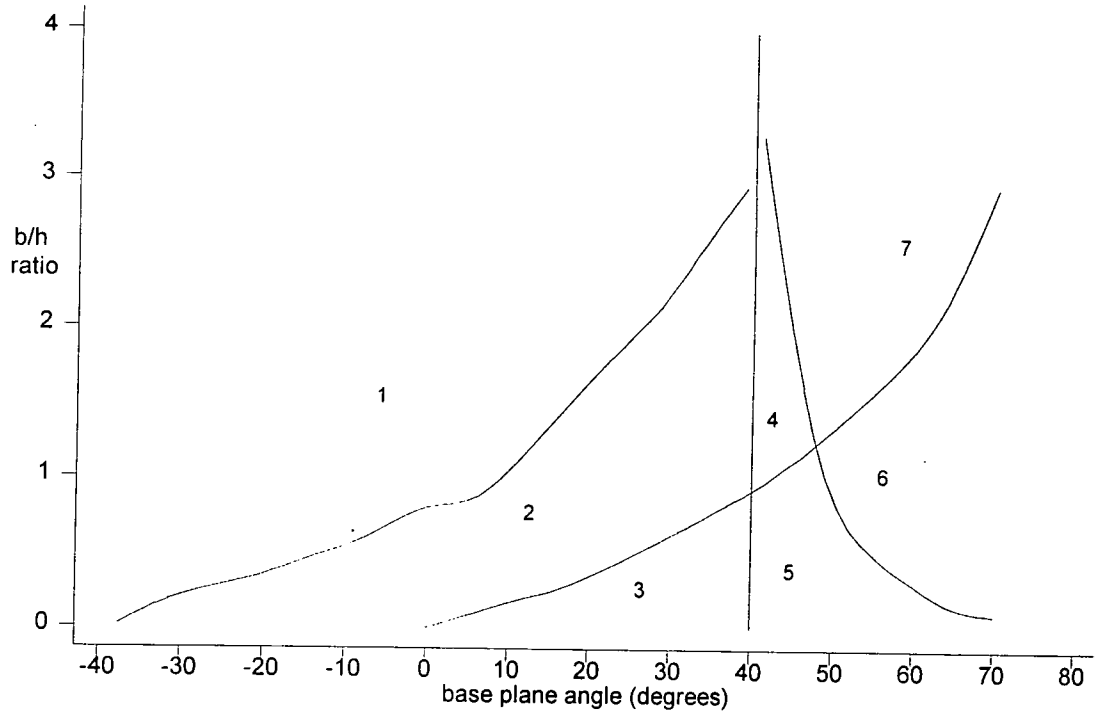
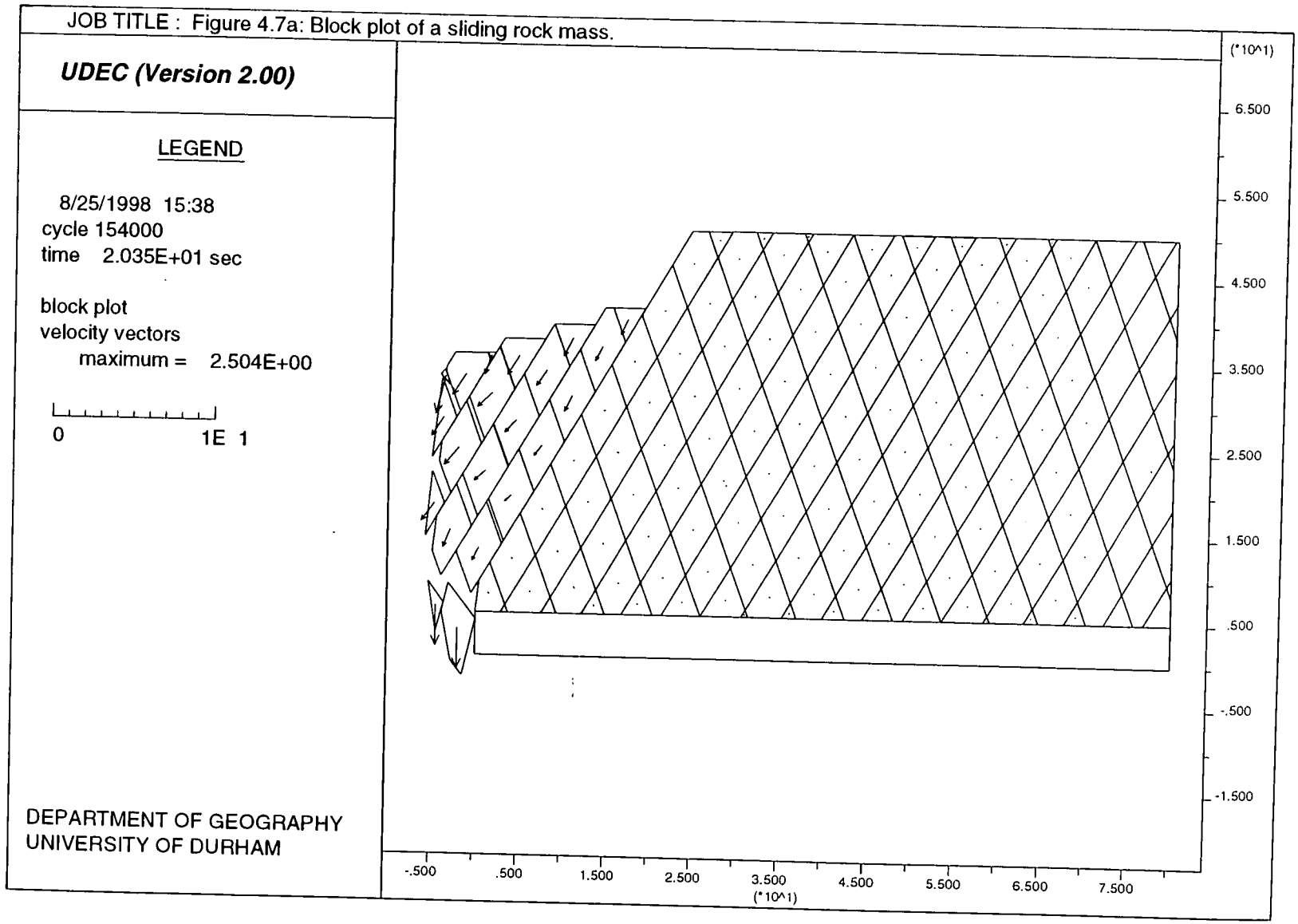
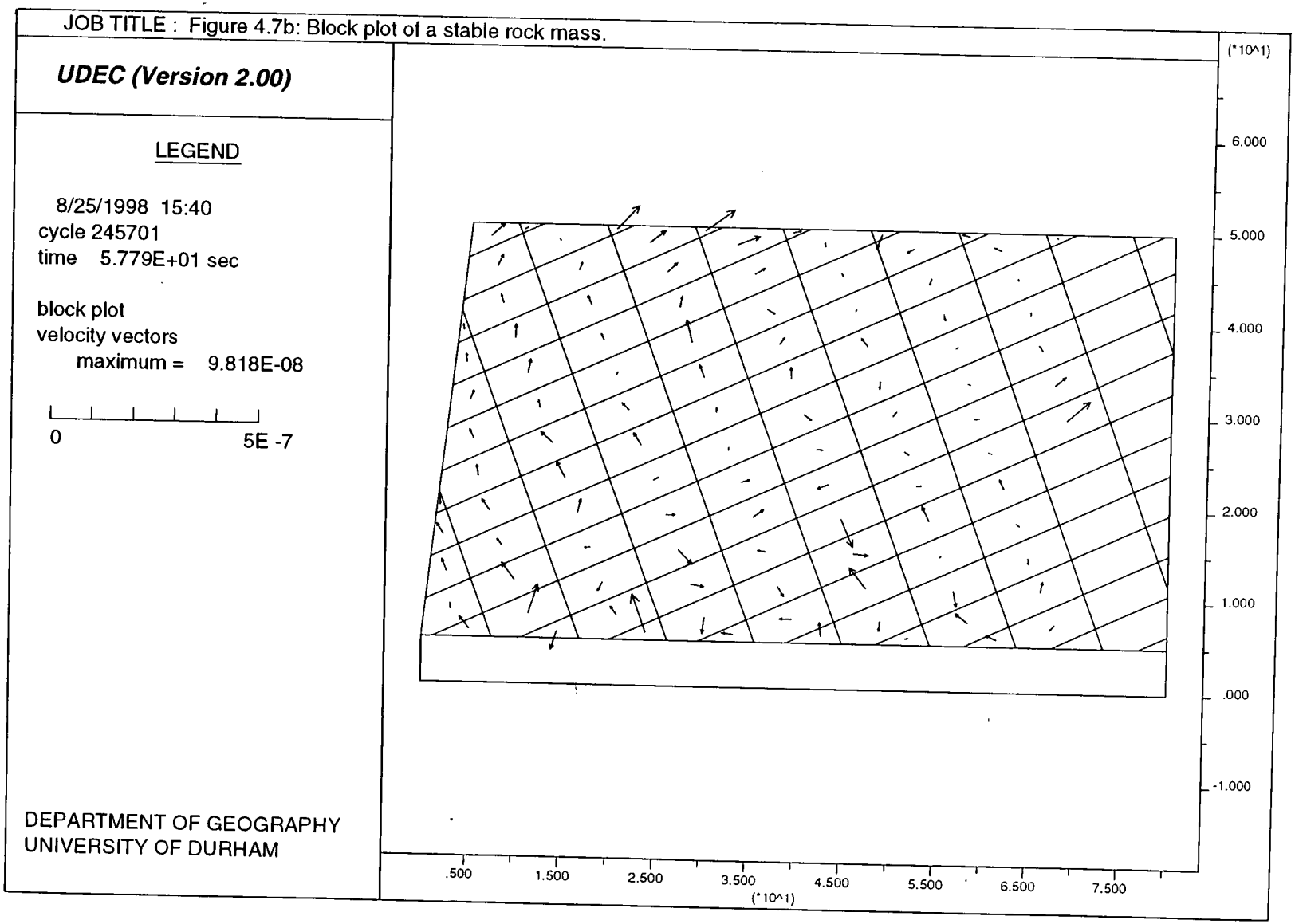


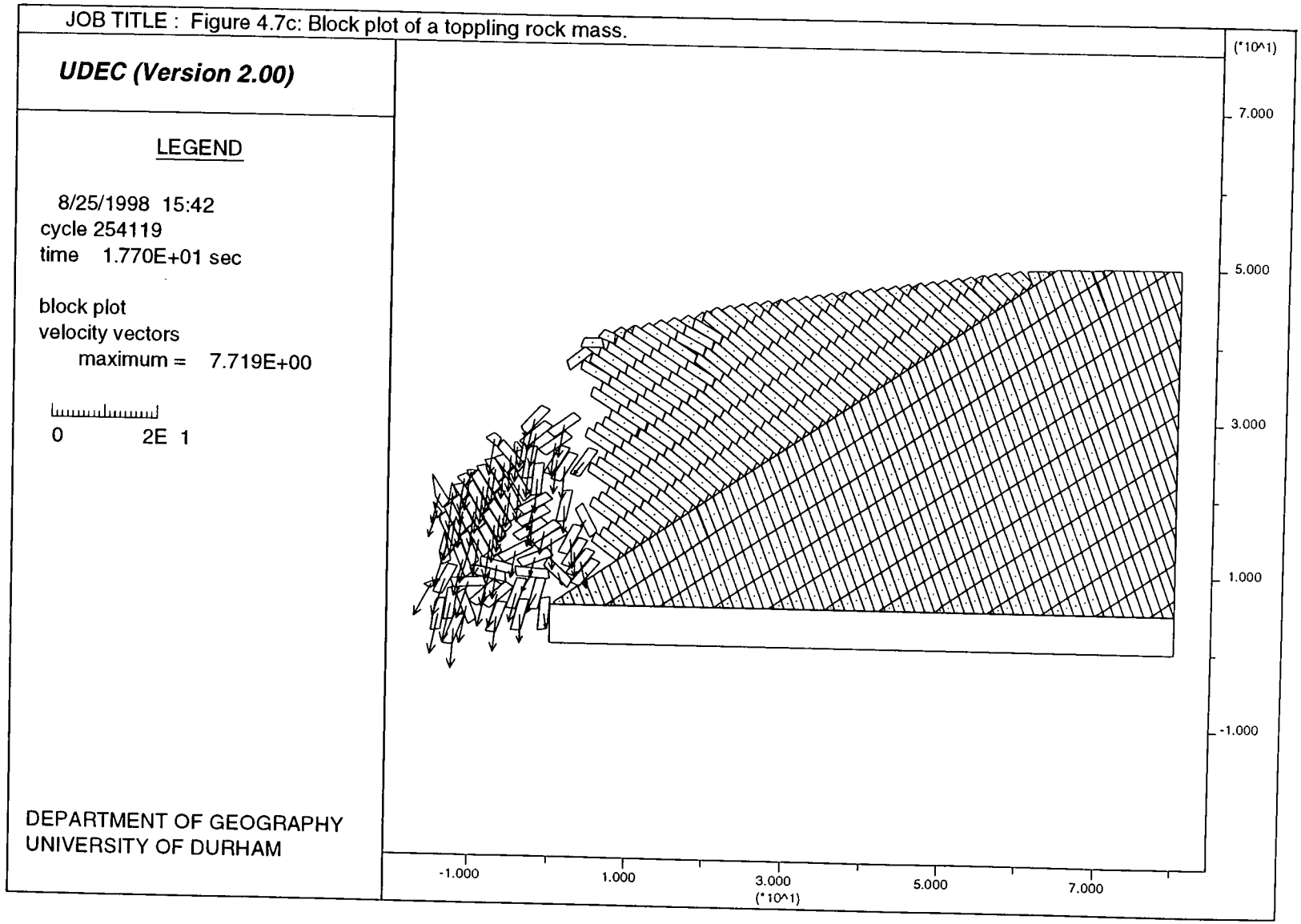
Figure 4.6: Limiting conditions for the failure of a rock mass compared with the limiting conditions for the failure of a single block.

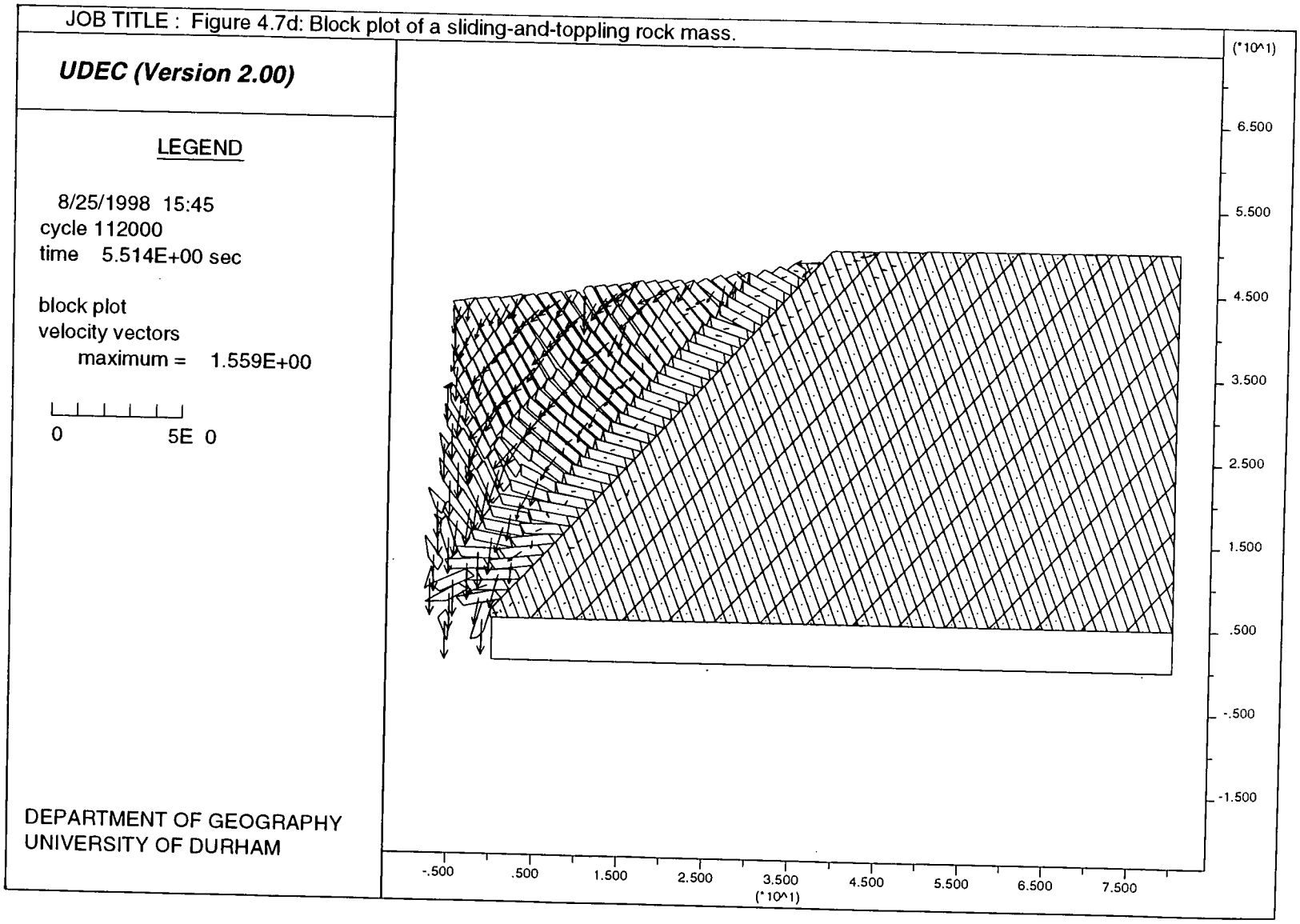
The boundaries between the mechanisms of failure are taken from Figures 4.2 and 4.5. Zones on the graph are delimited by the boundary lines:

Zone	Rock mass	Single block
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Toppling-and-sliding	Sliding
5	Toppling-and-sliding	Toppling-and-sliding
6	Sliding	Toppling-and-sliding
7	Sliding	Sliding


JOB TITLE : Figure 4.7a: Block plot of a sliding rock mass.
UDEC (Version 2.00)
LEGEND
8/25/1998 15:38
cycle 154000
time 2.035E+01 sec
block plot
velocity vectors
maximum = 2.504E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.7b: Block plot of a stable rock mass.
UDEC (Version 2.00)
LEGEND
8/25/1998 15:40
cycle 245701
time 5.779E+01 sec
block plot
velocity vectors
maximum = 9.818E-08
0
5E -7
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.7c: Block plot of a toppling rock mass.
UDEC (Version 2.00)
LEGEND
8/25/1998 15:42
cycle 254119
time 1.770E+01 sec
block plot
velocity vectors
maximum = 7.719E+00
0 2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
7.000
5.000
3.000
1.000
-1.000
-1.000
1.000
3.000
5.000
7.000
(*10^1)


JOB TITLE : Figure 4.7d: Block plot of a sliding-and-toppling rock mass.
UDEC (Version 2.00)
LEGEND
8/25/1998 15:45
cycle 112000
time 5.514E+00 sec
block plot
velocity vectors
maximum = 1.559E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

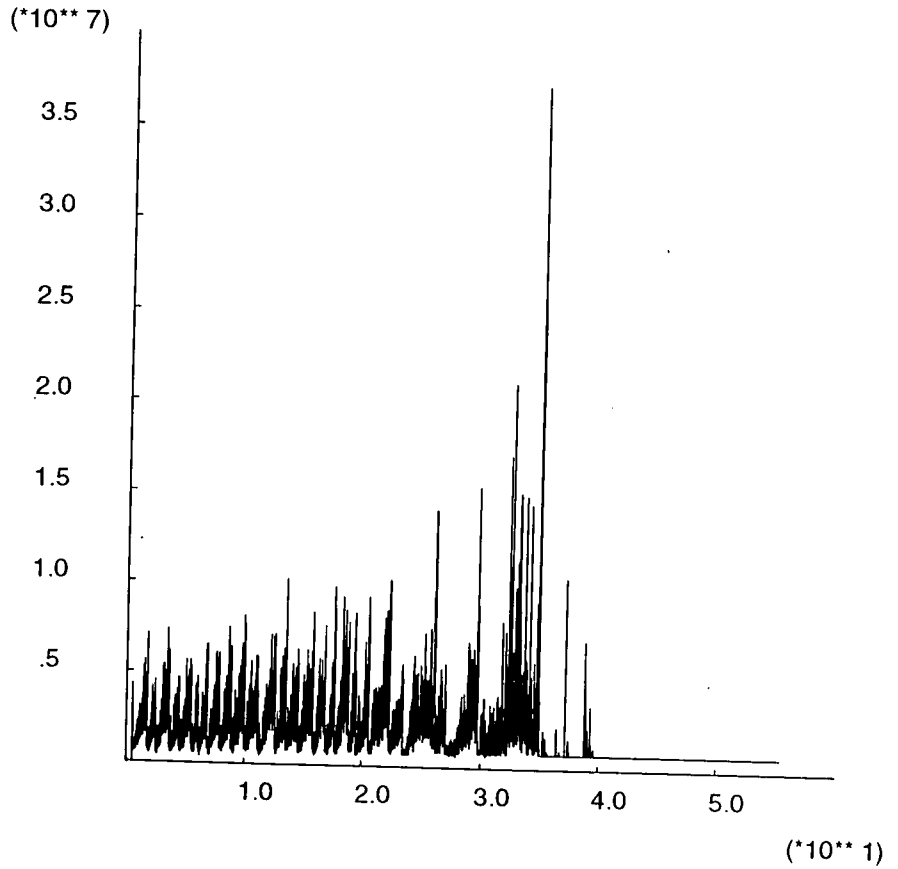
JOB TITLE : Figure 4.8a: History plot of forces for a sliding rock mass.

UDEC (Version 2.00)

LEGEND

8/25/1998 15:57
cycle 421840
time 5.539E+01 sec

6.44E+00 <hist 2> 3.73E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

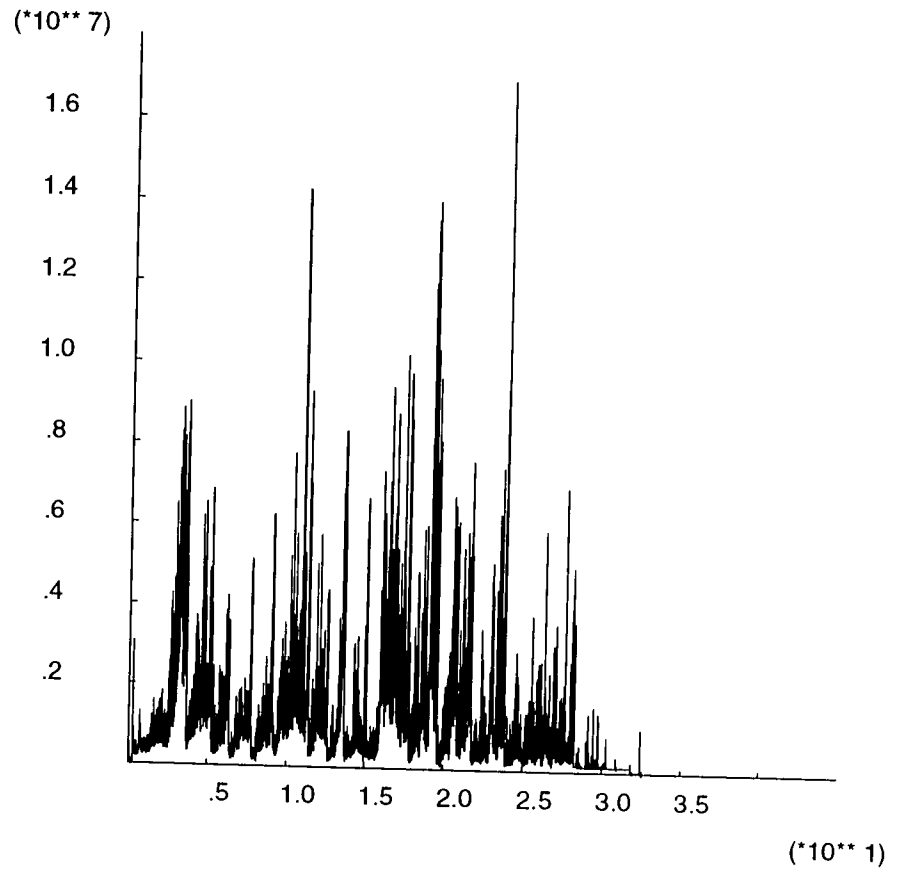
JOB TITLE : Figure 4.8b: History plot of unbalanced forces for a toppling rock mass.

UDEC (Version 2.00)

LEGEND

8/25/1998 16:00
cycle 606241
time 4.219E+01 sec

1.00E+00 <hist 2> 1.70E+07———



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

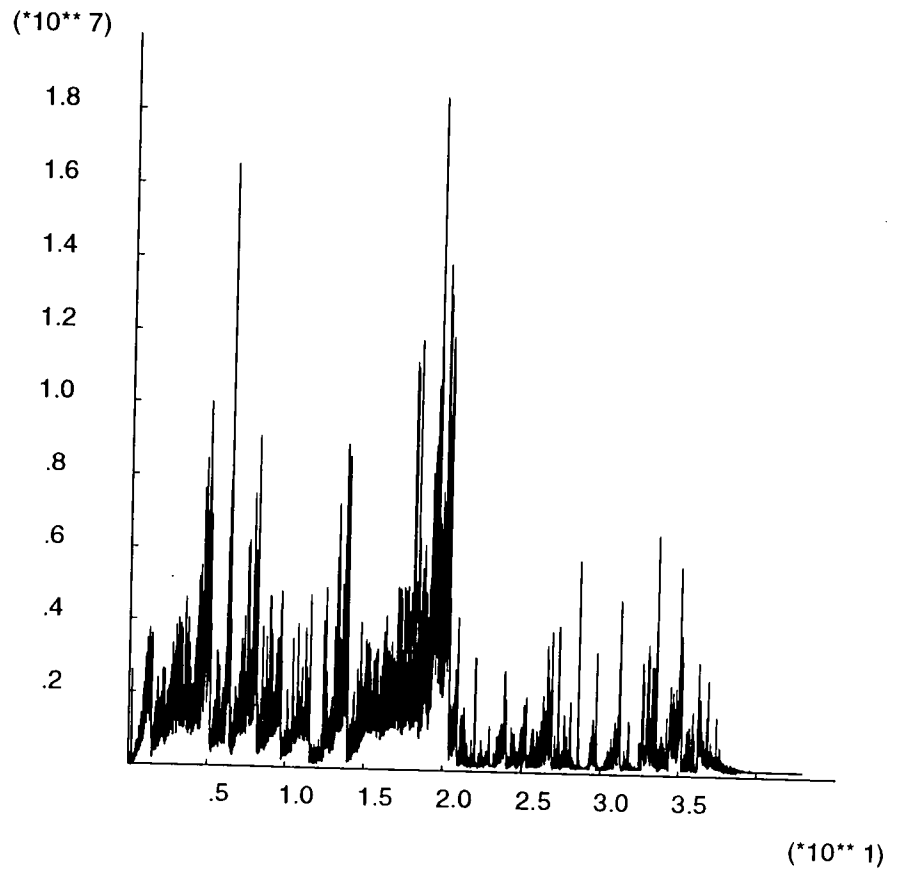
JOB TITLE : Figure 4.8c: History plot of forces for a toppling-and-sliding rock mass

UDEC (Version 2.00)

LEGEND

8/25/1998 16:02
cycle 855317
time 4.292E+01 sec

1.37E+04 <hist 2> 1.84E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

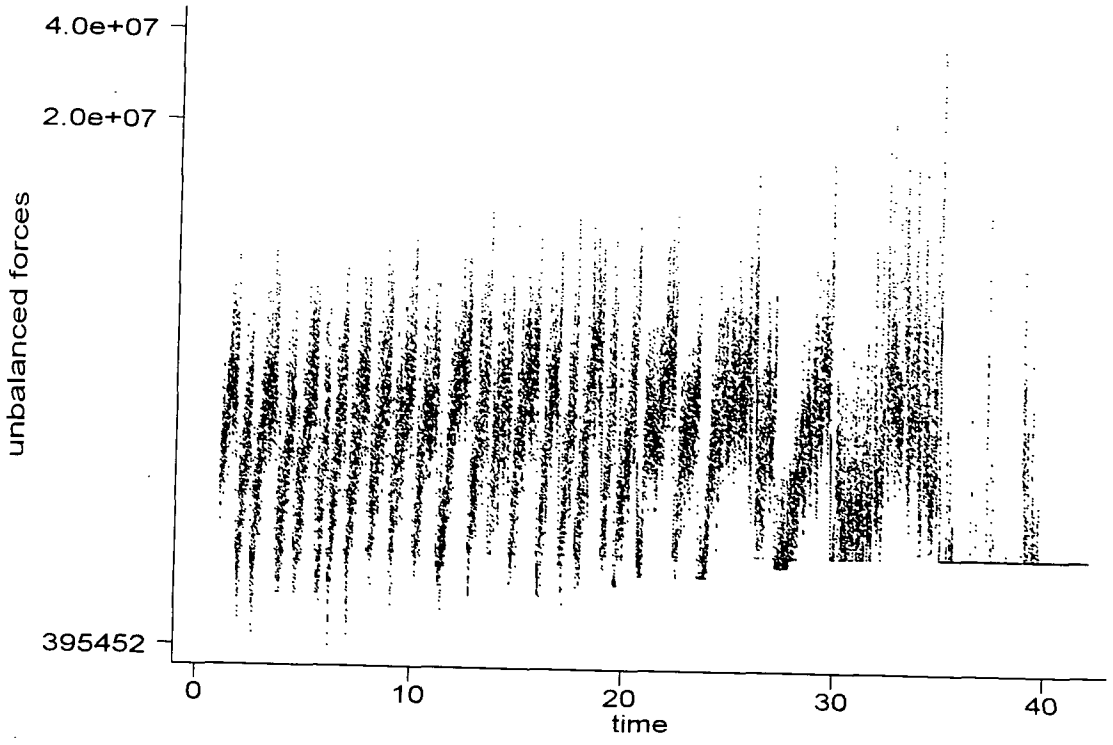


Figure 4.9: UDEC history plot of the log of total unbalanced forces for a sliding rock mass.

A log scale is used for the y-axis.

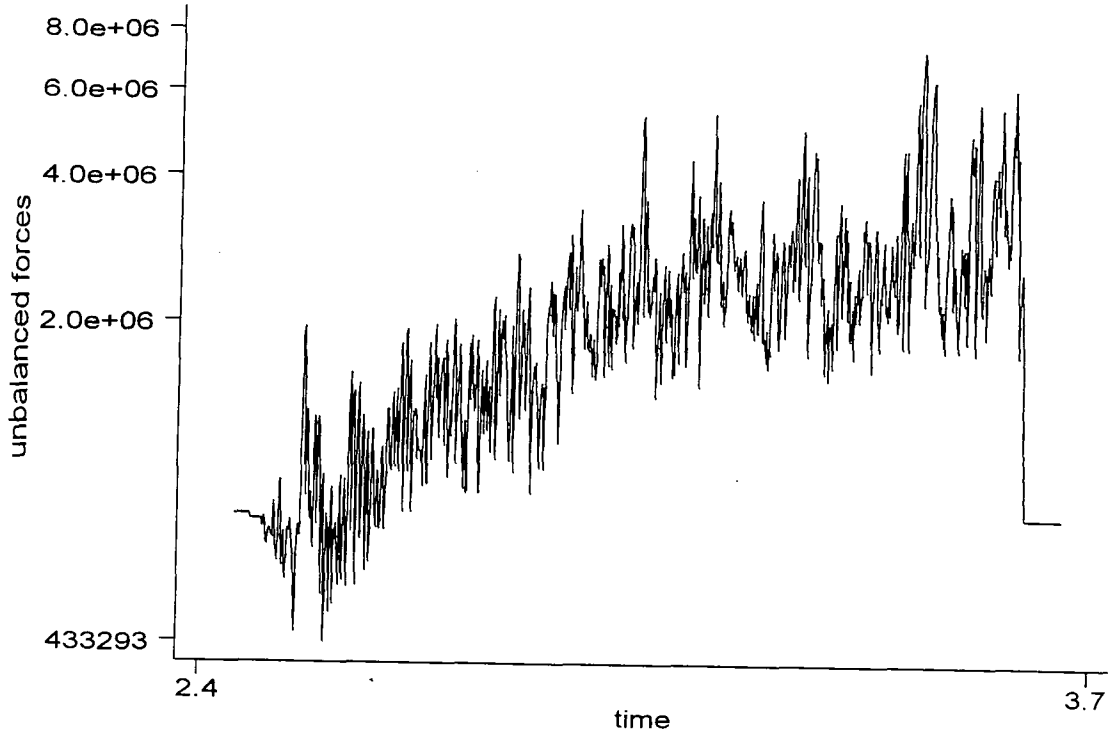


Figure 4.10: UDEC history plot of the log of an individual total unbalanced force peak for a sliding rock mass.

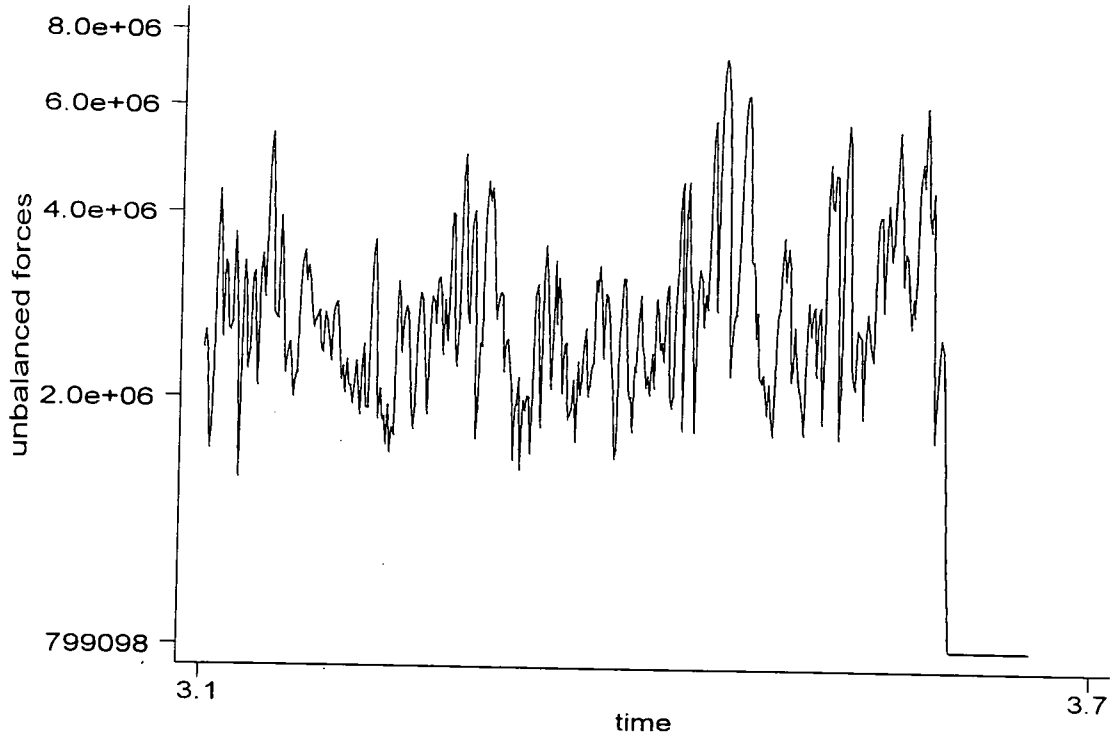
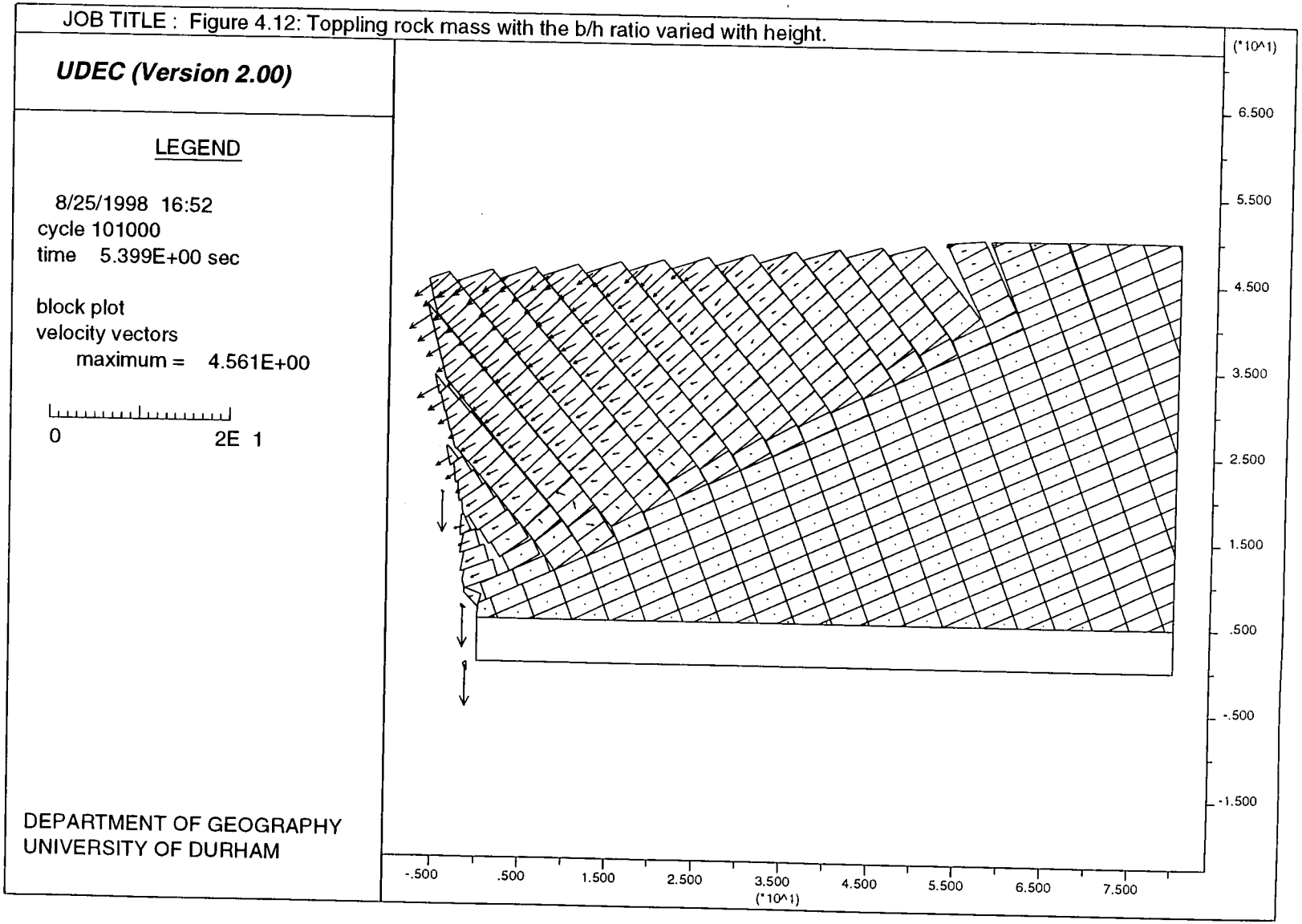


Figure 4.11: UDEC history plot of the log of an individual total unbalanced force peak for a sliding rock mass.


JOB TITLE : Figure 4.12: Toppling rock mass with the b/h ratio varied with height.
UDEC (Version 2.00)
LEGEND
8/25/1998 16:52
cycle 101000
time 5.399E+00 sec
block plot
velocity vectors
maximum = 4.561E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

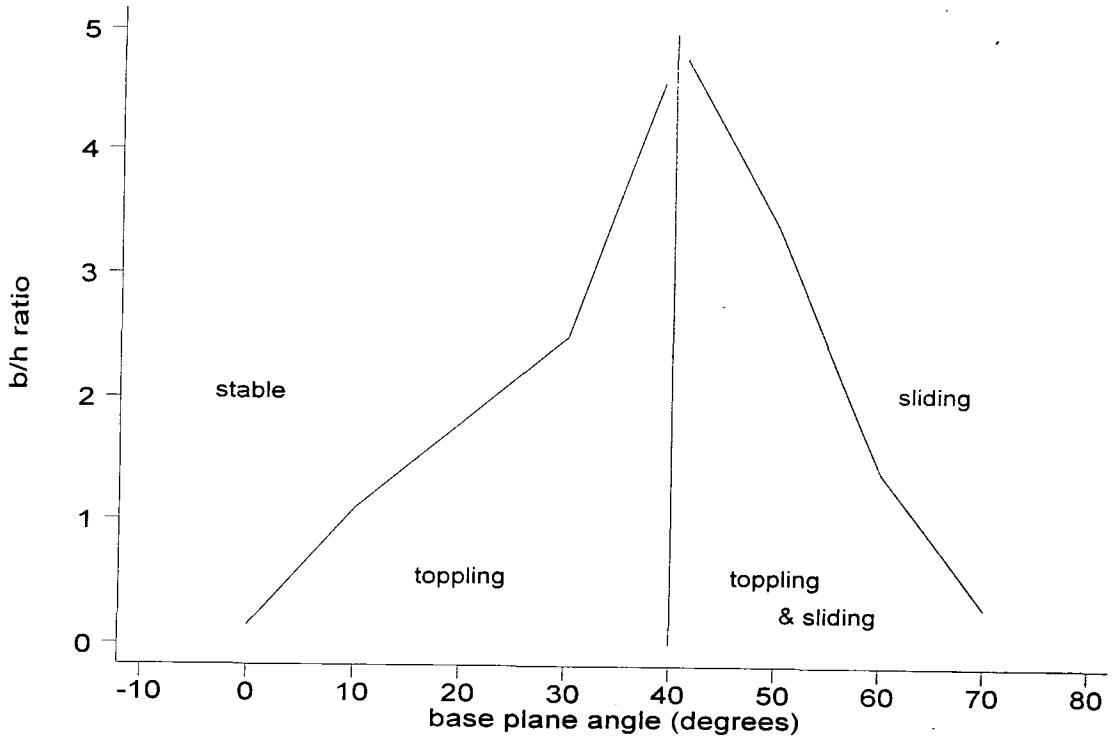


Figure 4.13: Limiting conditions for sliding, toppling and stable rock masses which contain rectangular blocks.

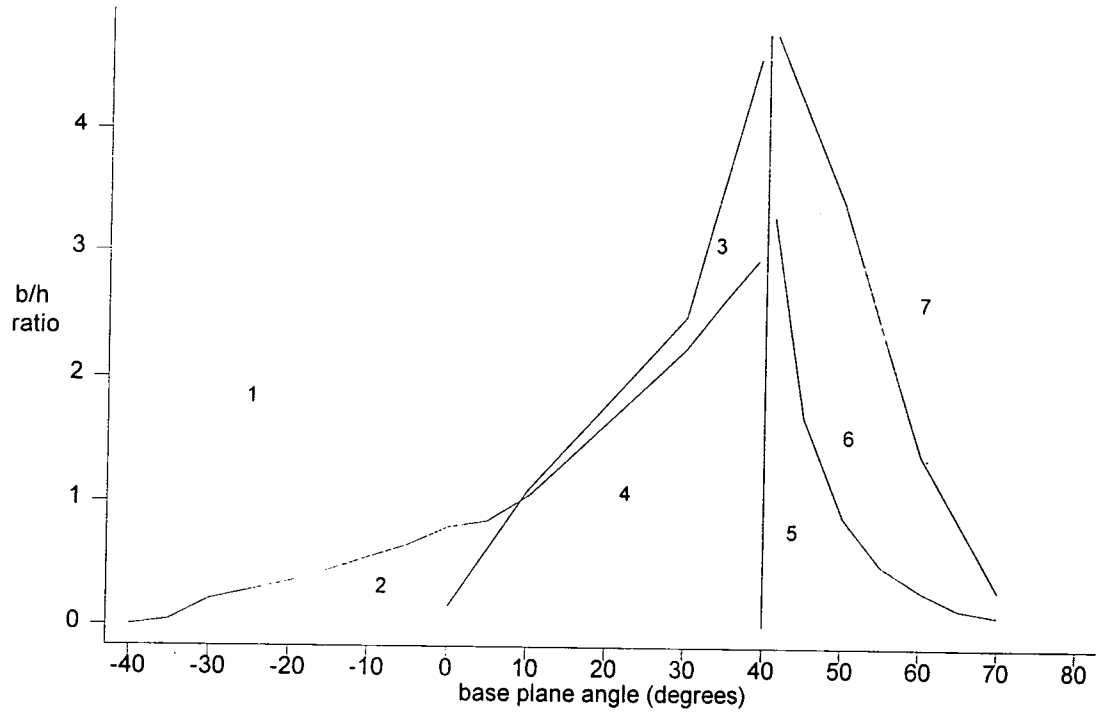
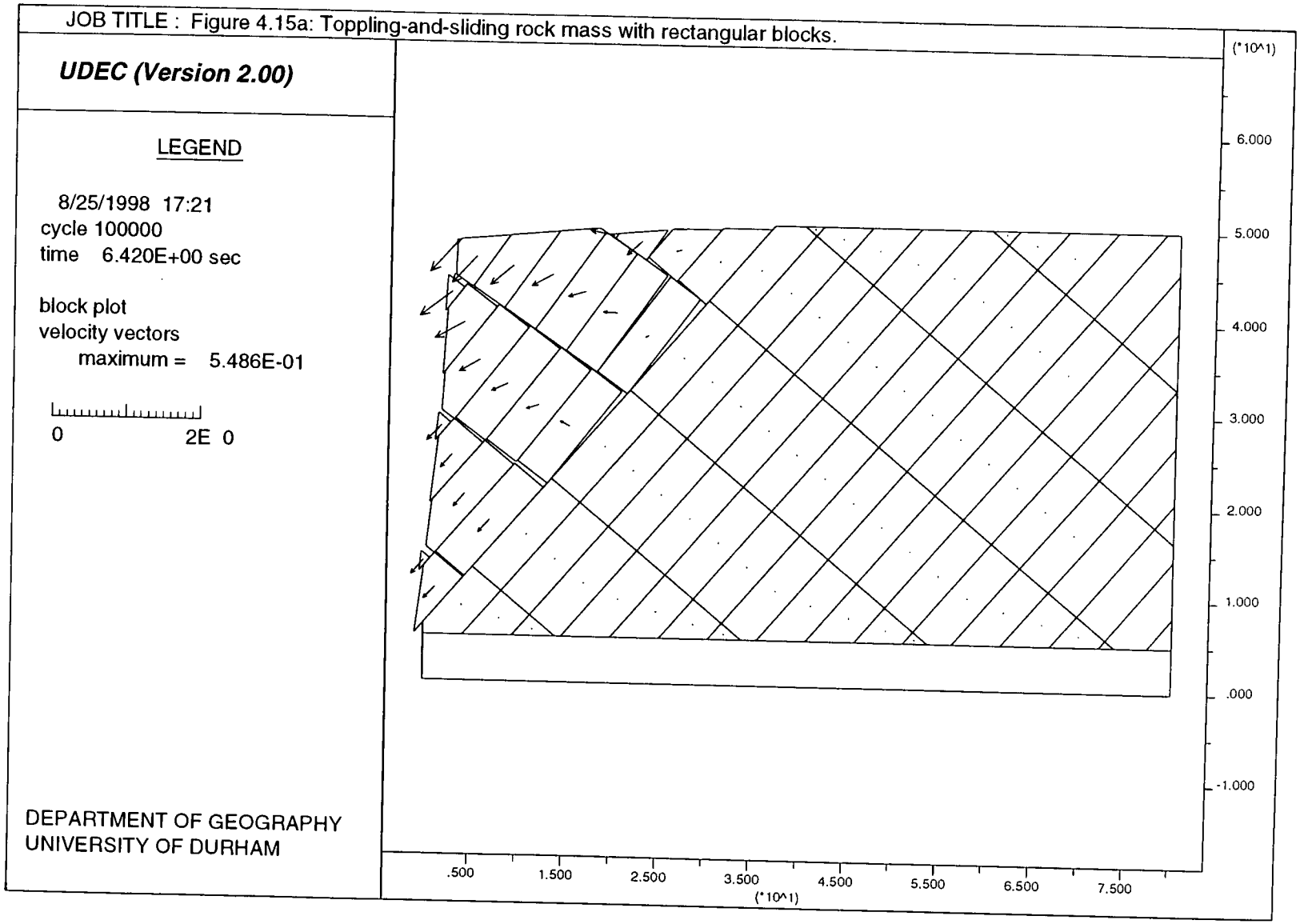
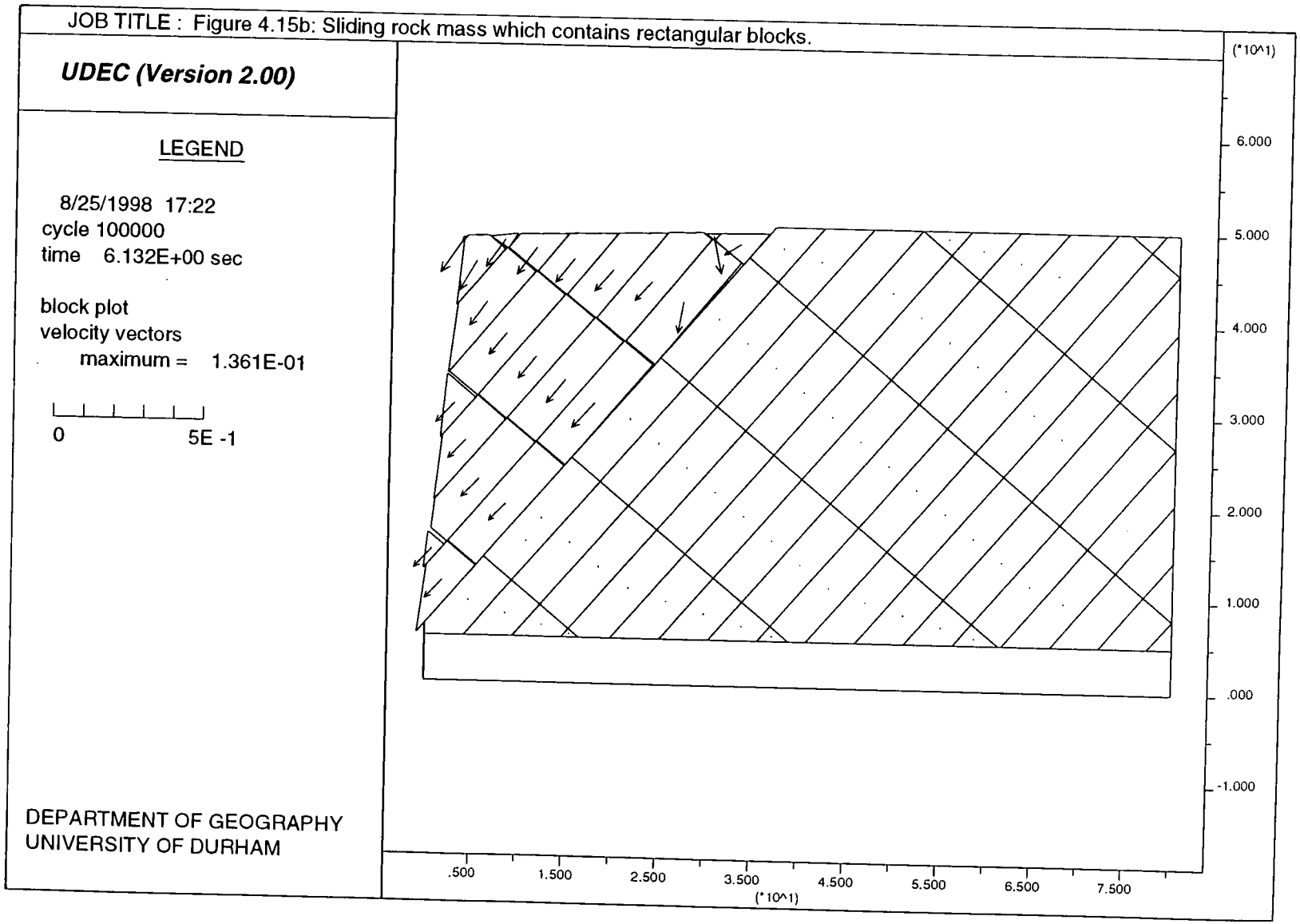


Figure 4.14: Limiting conditions for the failure of a rock mass which contains rectangular blocks compared with the limiting conditions for the failure of the limestone rock mass.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.13. Zones on the graph are delimited by the boundary lines:

Zone	Limestone rock mass	Rectangular blocks
1	Stable	Stable
2	Toppling	Stable
3	Stable	Toppling
4	Toppling	Toppling
5	Toppling-and-sliding	Toppling-and-sliding
6	Sliding	Toppling-and-sliding
7	Sliding	Sliding


JOB TITLE : Figure 4.15a: Toppling-and-sliding rock mass with rectangular blocks.
UDEC (Version 2.00)
LEGEND
8/25/1998 17:21
cycle 100000
time 6.420E+00 sec
block plot
velocity vectors
maximum = 5.486E-01
0
2E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.15b: Sliding rock mass which contains rectangular blocks.
UDEC (Version 2.00)
LEGEND
8/25/1998 17:22
cycle 100000
time 6.132E+00 sec
block plot
velocity vectors
maximum = 1.361E-01
0
5E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

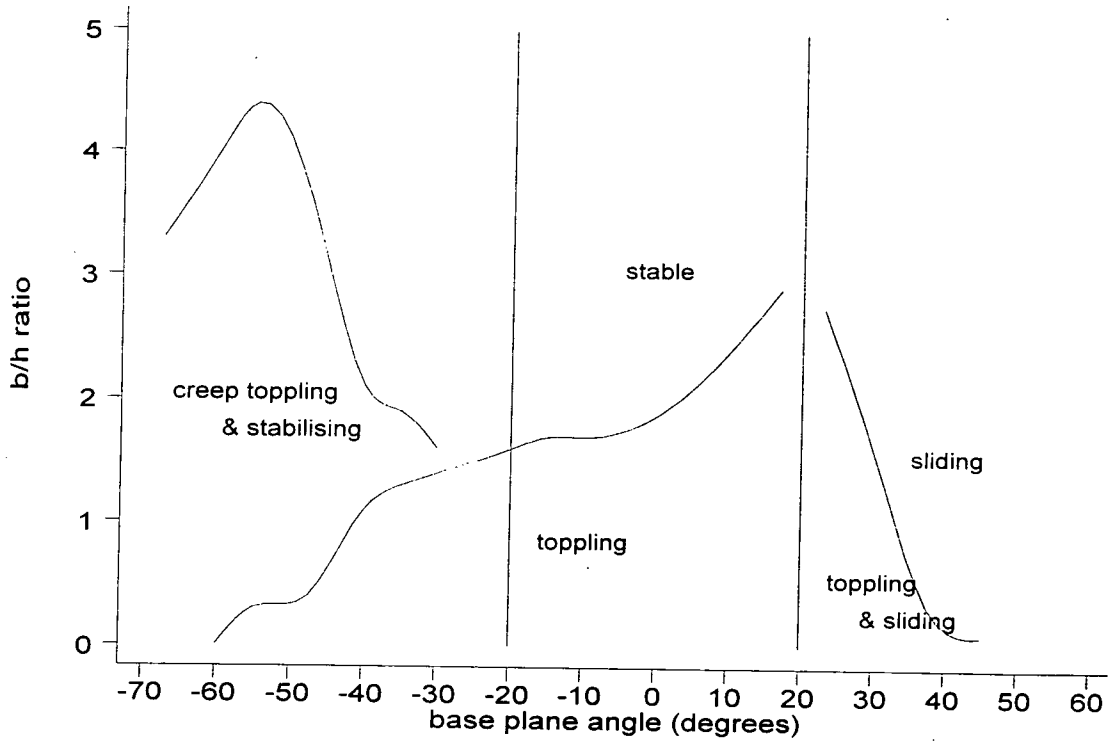
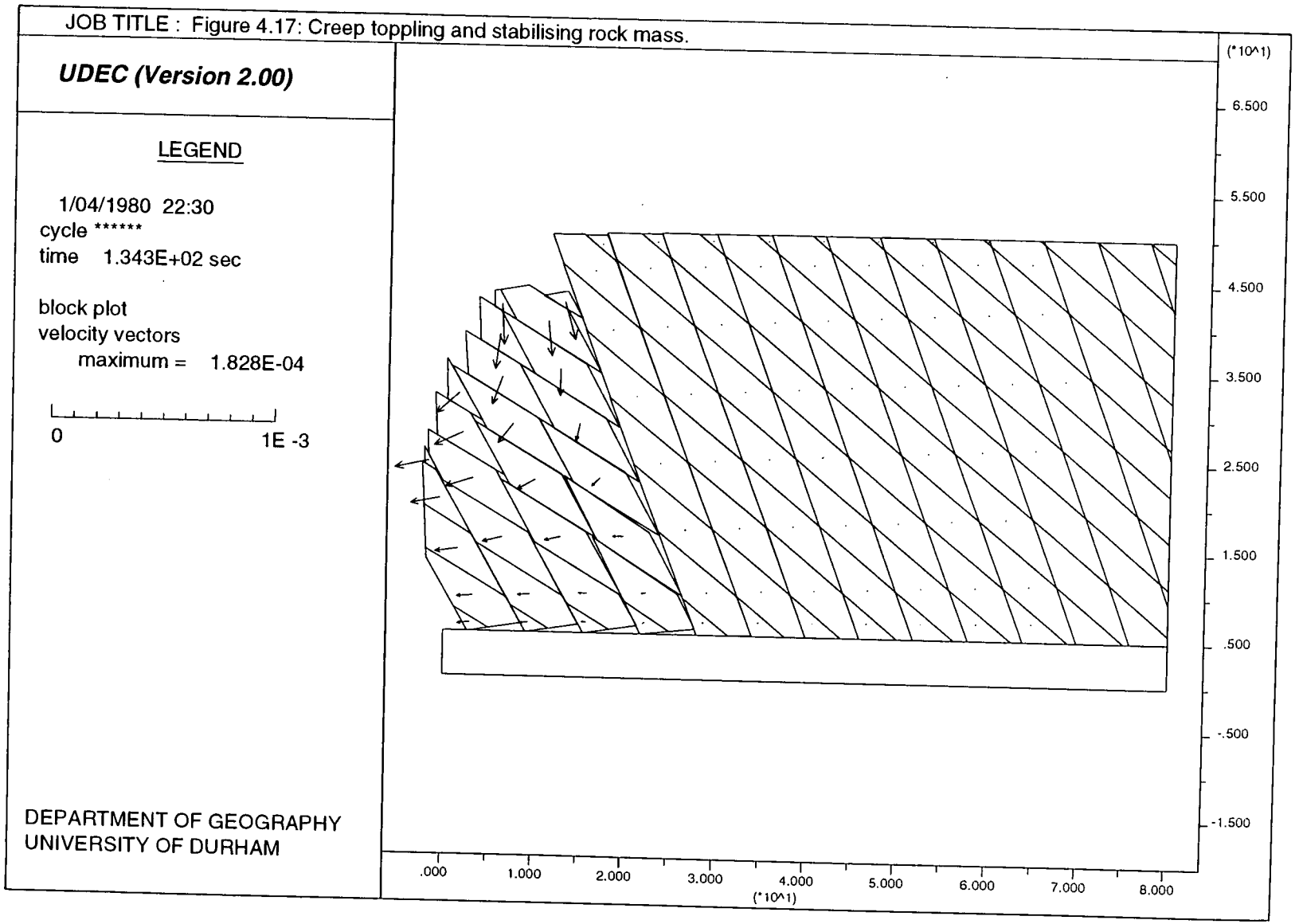


Figure 4.16: Limiting conditions for sliding, toppling and stable rock masses which have a friction angle of 20°.


JOB TITLE : Figure 4.17: Creep toppling and stabilising rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 22:30
cycle ******
time 1.343E+02 sec
block plot
velocity vectors
maximum = 1.828E-04
0
1E -3
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)

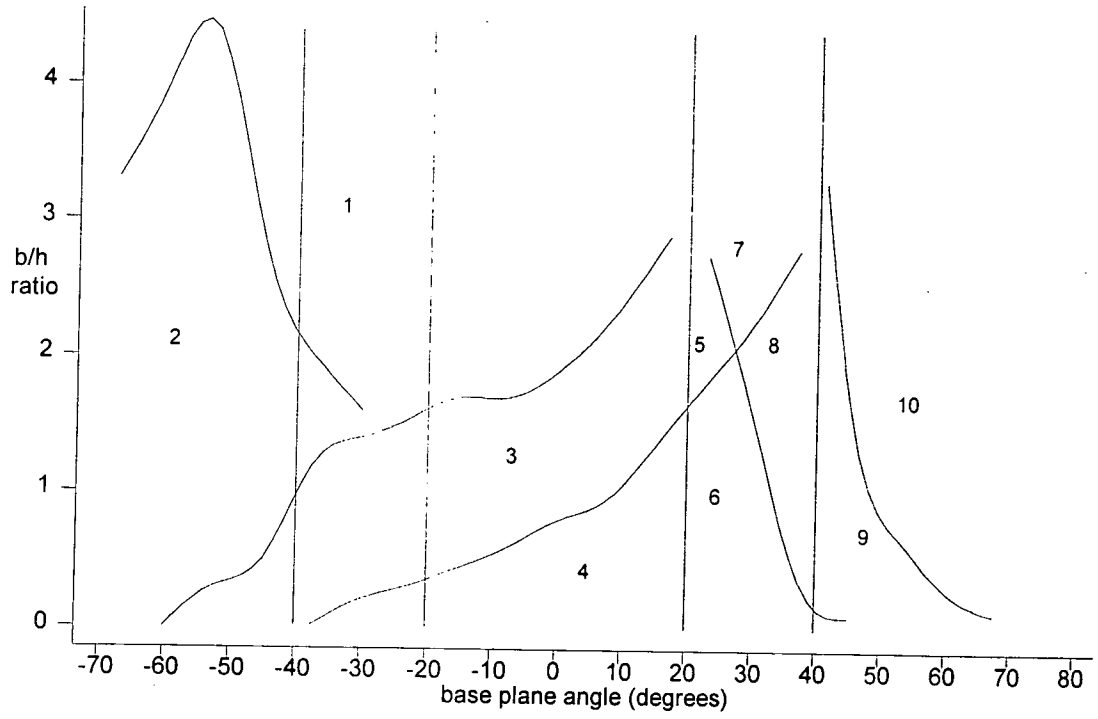


Figure 4.18: Limiting conditions for the failure of rock masses which have a friction angle of 20° compared with the limiting conditions for the failure of the limestone rock masses which have a friction angle of 40°.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.16. Zones on the graph are delimited by the boundary lines:

Zone	40° friction angle	20° friction angle
1	Stable	Stable
2	Stable	Creep toppling and stabilising
3	Stable	Toppling
4	Toppling	Toppling
5	Stable	Toppling-and-sliding
6	Toppling	Toppling-and-sliding
7	Stable	Sliding
8	Toppling	Sliding
9	Toppling-and-sliding	Sliding
10	Sliding	Sliding

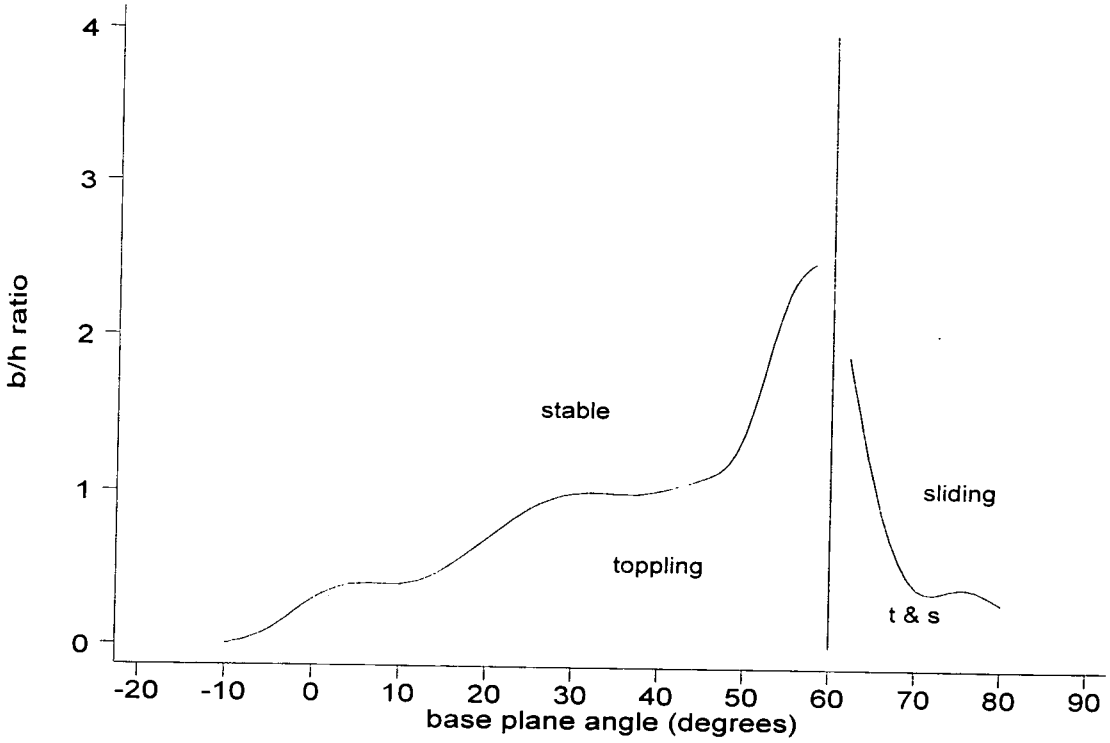


Figure 4.19: Limiting conditions for sliding, toppling and stable rock masses which have a friction angle of 60°.

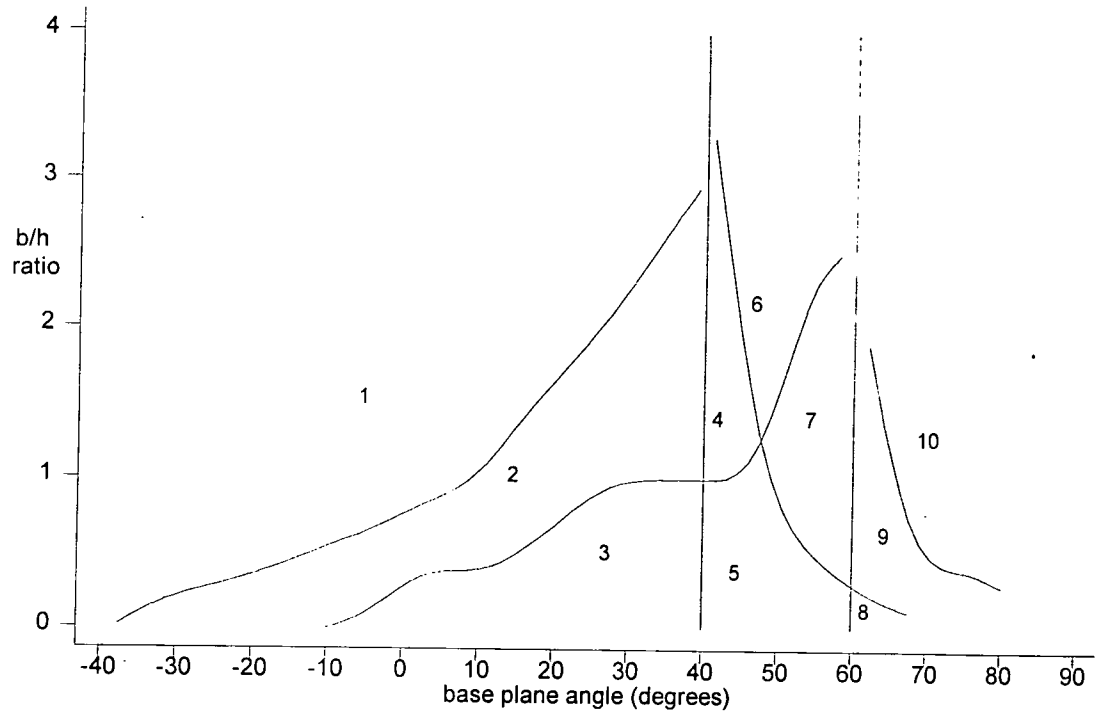


Figure 4.20: Limiting conditions for the failure of rock masses which have a friction angle of 60° compared with the limiting conditions for the failure of the limestone rock masses which have a friction angle of 40°.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.19. Zones on the graph delimited by the boundary lines:

Zone	40° friction angle	60° friction angle
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Toppling-and-sliding	Stable
5	Toppling-and-sliding	Toppling
6	Sliding	Stable
7	Sliding	Toppling
8	Toppling-and-sliding	Toppling-and-sliding
9	Sliding	Toppling-and-sliding
10	Sliding	Sliding

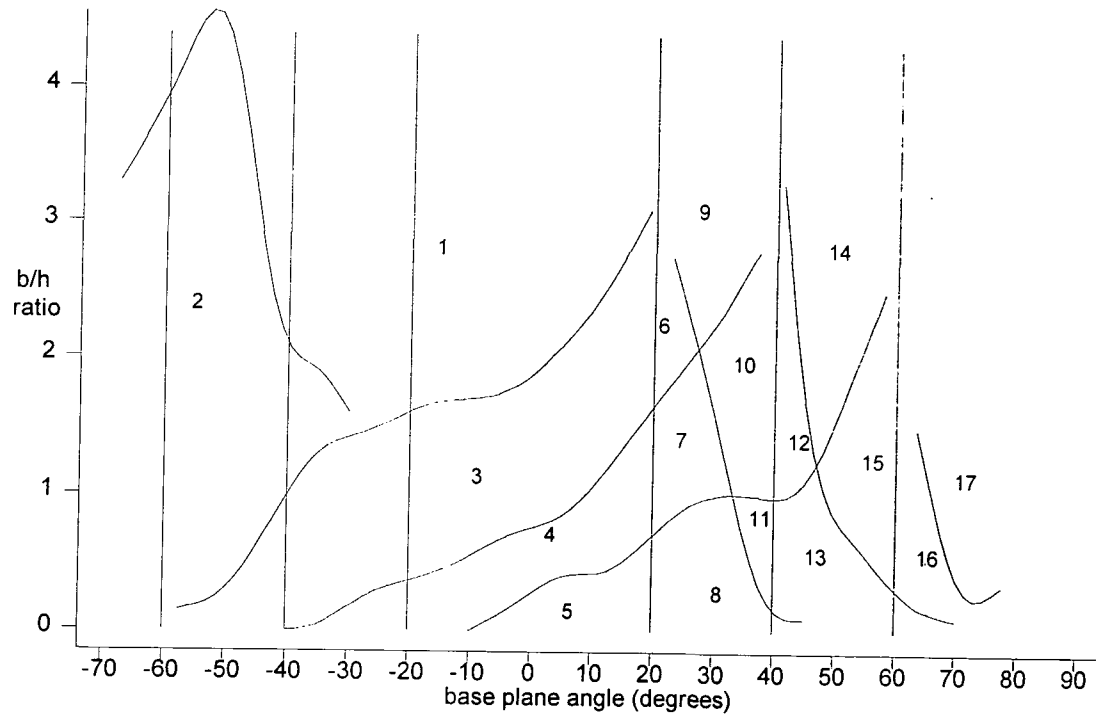


Figure 4.21: Limiting conditions for the failure of rock masses which have a friction angle of 20° and 60° compared with the limiting conditions for the failure of the original limestone rock masses which have a friction angle of 40°.

The boundaries between the mechanisms of failure are taken from Figures 4.5, 4.16 and 4.19. Zones on the graph are delimited by the boundary lines:

Zone	40° friction angle	20° friction angle	60° friction angle
1	Stable	Stable	Stable
2	Stable	Creep toppling and stabilising	Stable
3	Stable	Toppling	Stable
4	Toppling	Toppling	Stable
5	Toppling	Toppling	Toppling
6	Stable	Toppling-and-sliding	Stable
7	Toppling	Toppling-and-sliding	Stable
8	Toppling	Toppling-and-sliding	Toppling
9	Stable	Sliding	Stable
10	Toppling	Sliding	Stable
11	Toppling	Sliding	Toppling
12	Toppling-and-sliding	Sliding	Stable
13	Toppling-and-sliding	Sliding	Toppling
14	Sliding	Sliding	Stable
15	Sliding	Sliding	Toppling
16	Sliding	Sliding	Toppling-and-sliding
17	Sliding	Sliding	Sliding

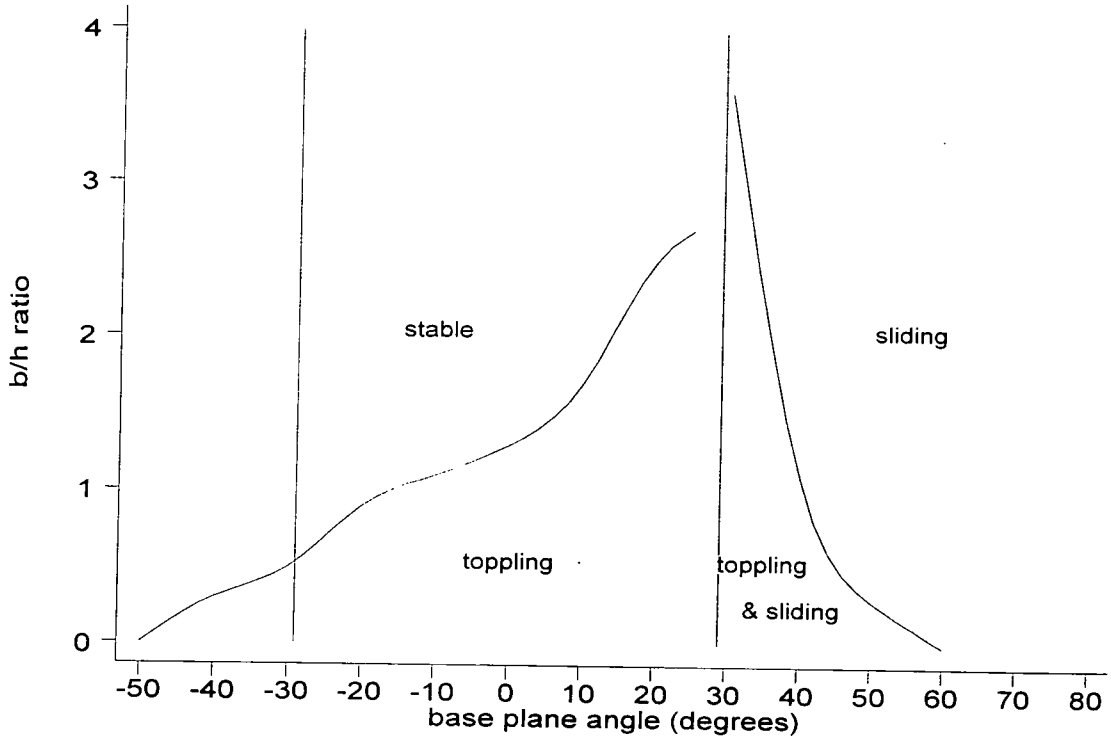


Figure 4.22: Limiting conditions for sliding, toppling and stable sandstone rock masses.

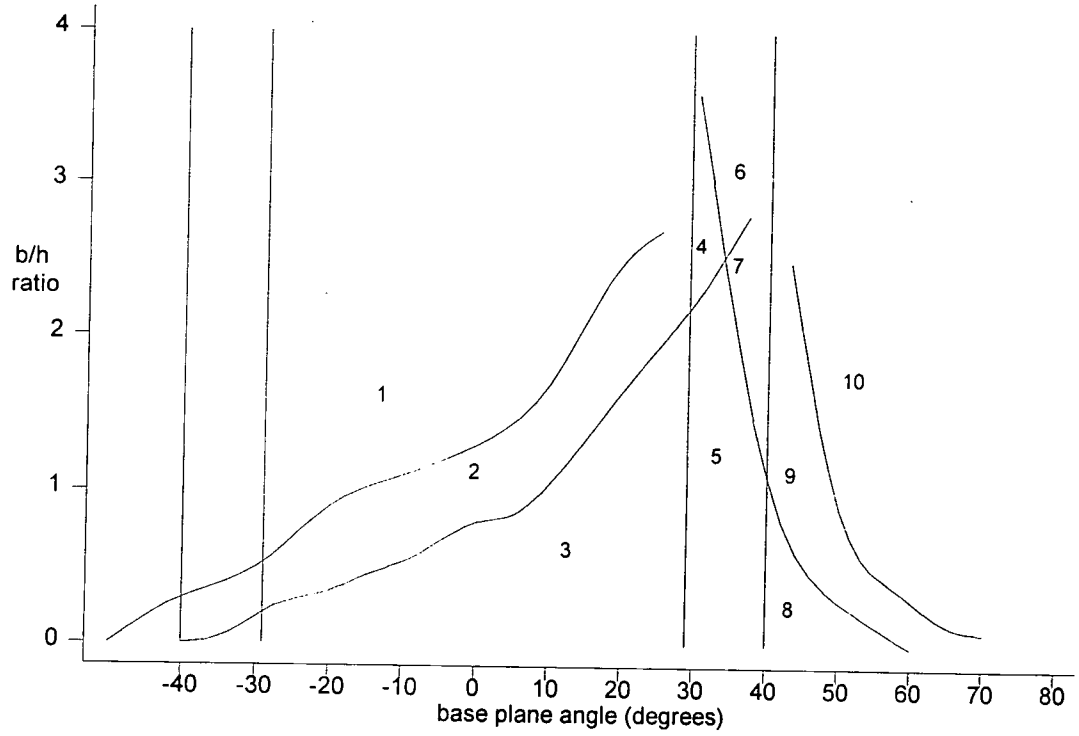
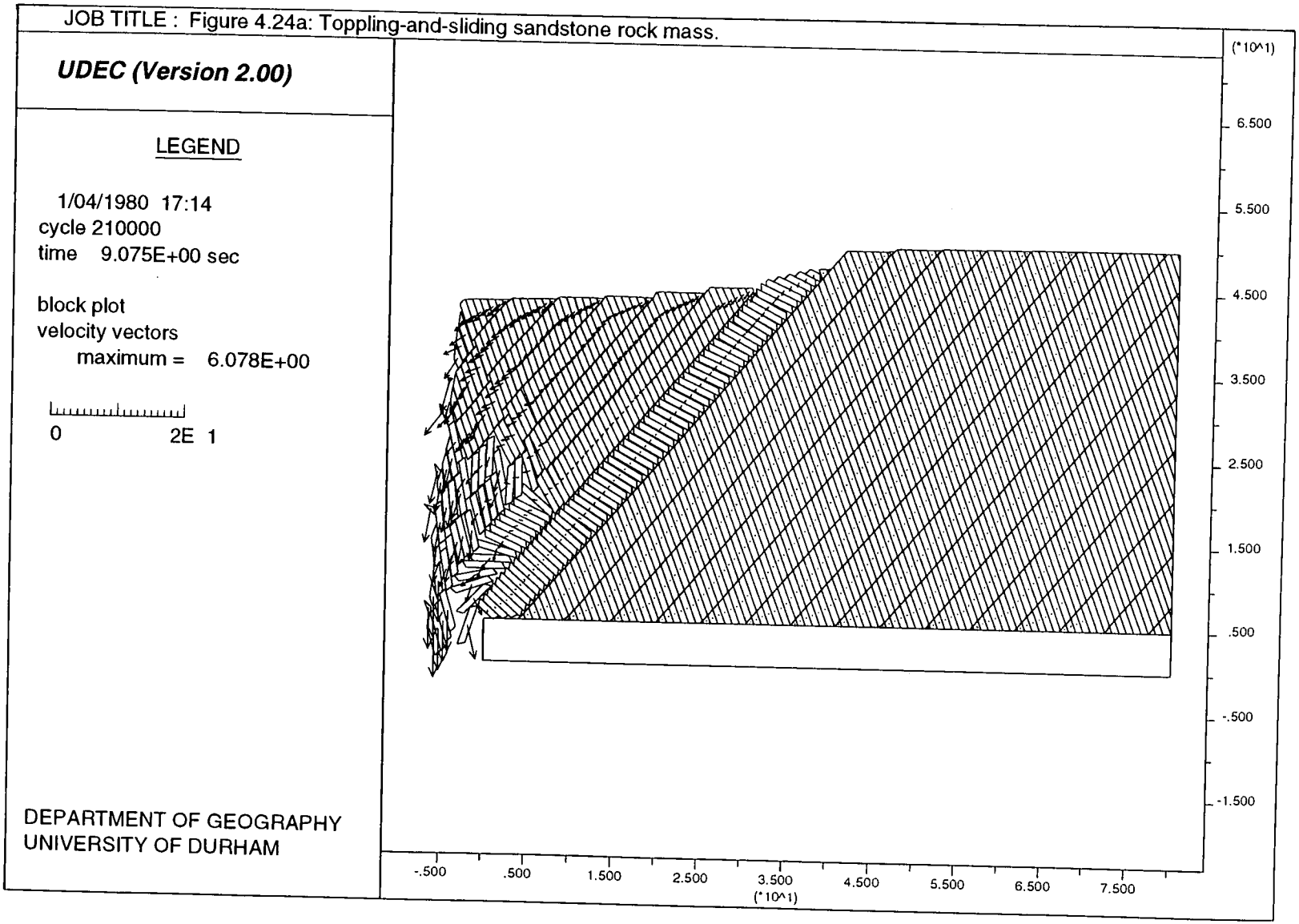
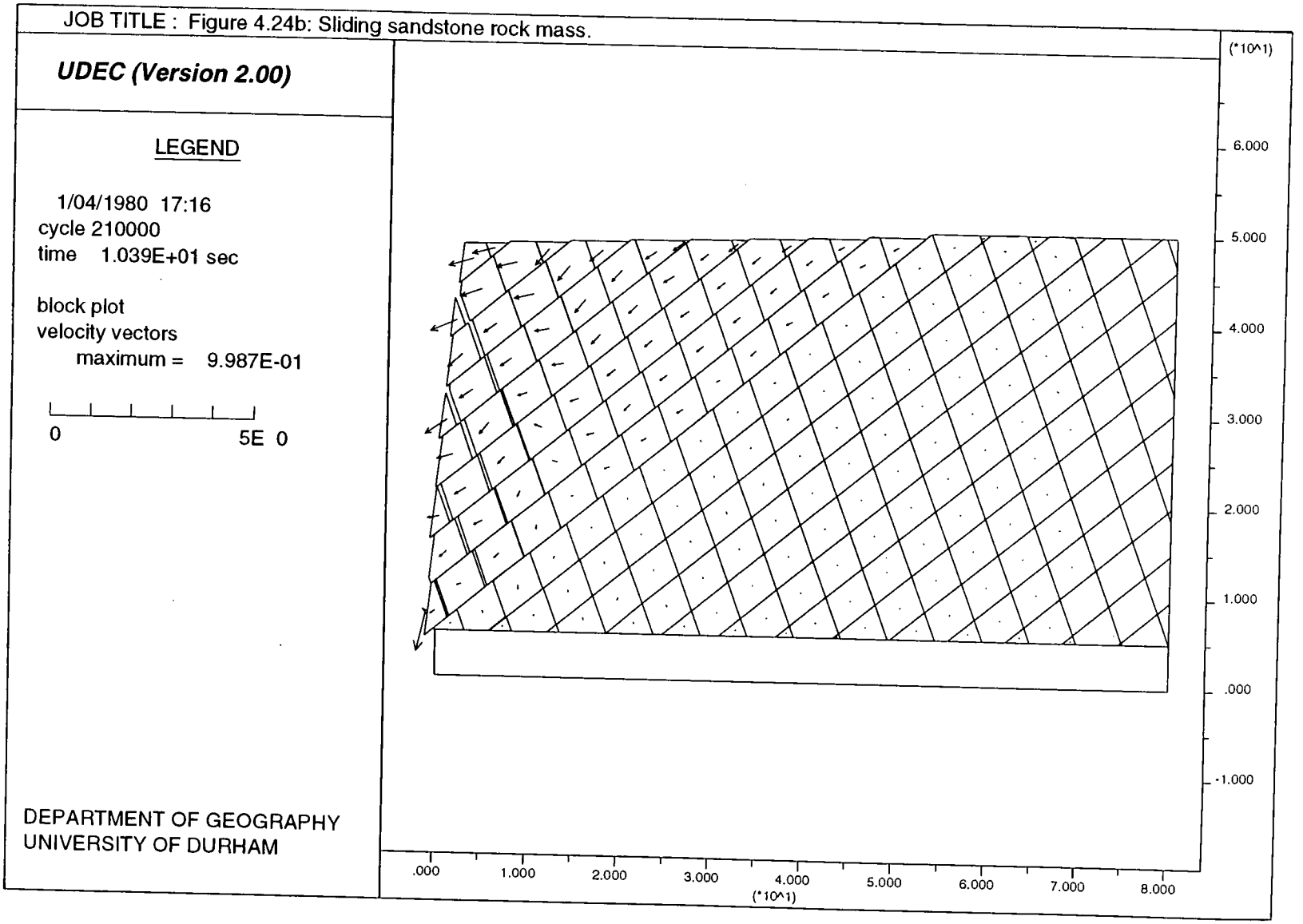


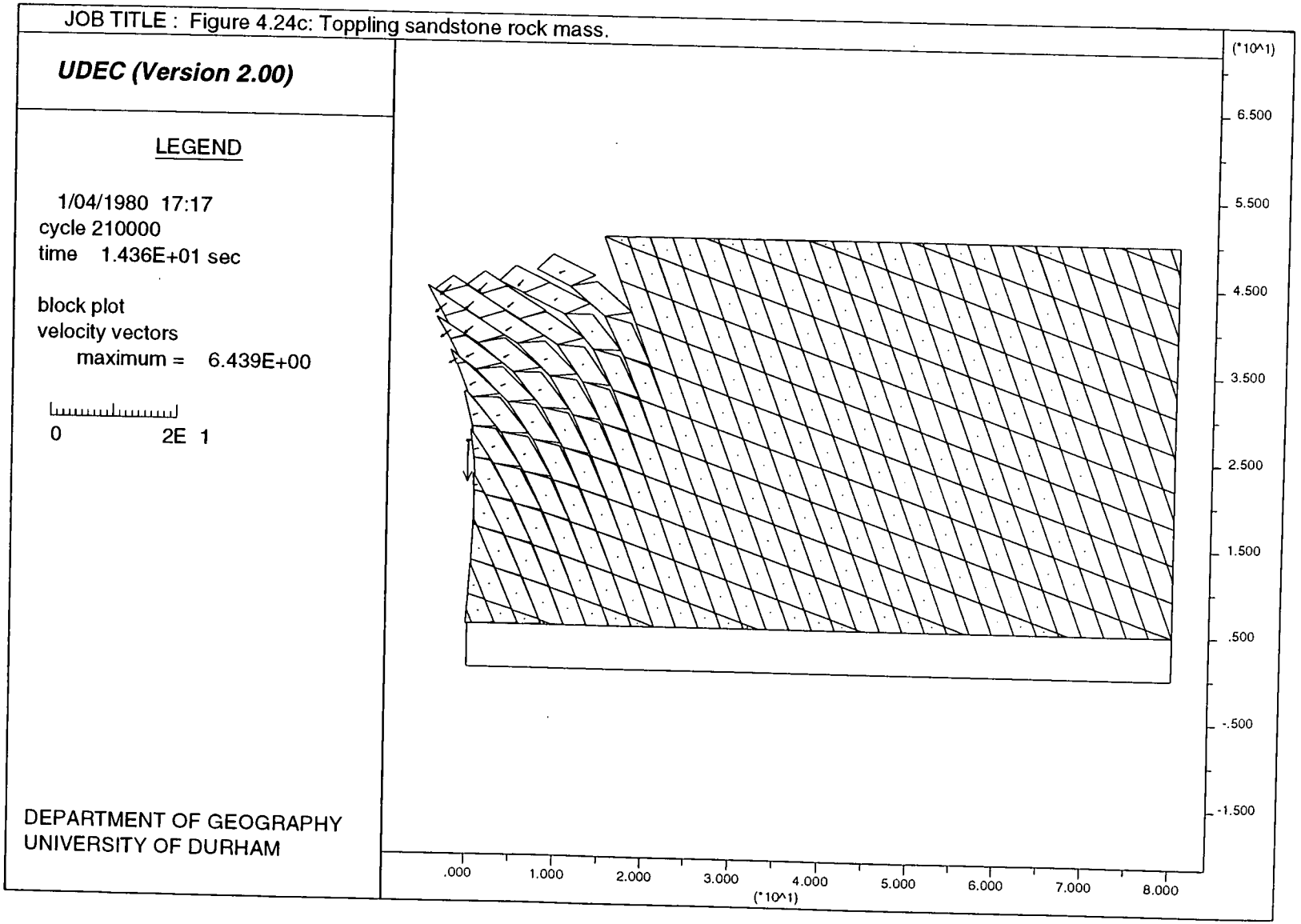
Figure 4.23: Limiting conditions for the failure of sandstone rock masses compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.22. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Sandstone
1	Stable	Stable
2	Stable	Toppling
3	Toppling	Toppling
4	Stable	Toppling-and-sliding
5	Toppling	Toppling-and-sliding
6	Stable	Sliding
7	Toppling	Sliding
8	Toppling-and-sliding	Toppling-and-sliding
9	Toppling-and-sliding	Sliding
10	Sliding	Sliding


JOB TITLE : Figure 4.24a: Toppling-and-sliding sandstone rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:14
cycle 210000
time 9.075E+00 sec
block plot
velocity vectors
maximum = 6.078E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.24b: Sliding sandstone rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:16
cycle 210000
time 1.039E+01 sec
block plot
velocity vectors
maximum = 9.987E-01
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)


JOB TITLE : Figure 4.24c: Toppling sandstone rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:17
cycle 210000
time 1.436E+01 sec
block plot
velocity vectors
maximum = 6.439E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)

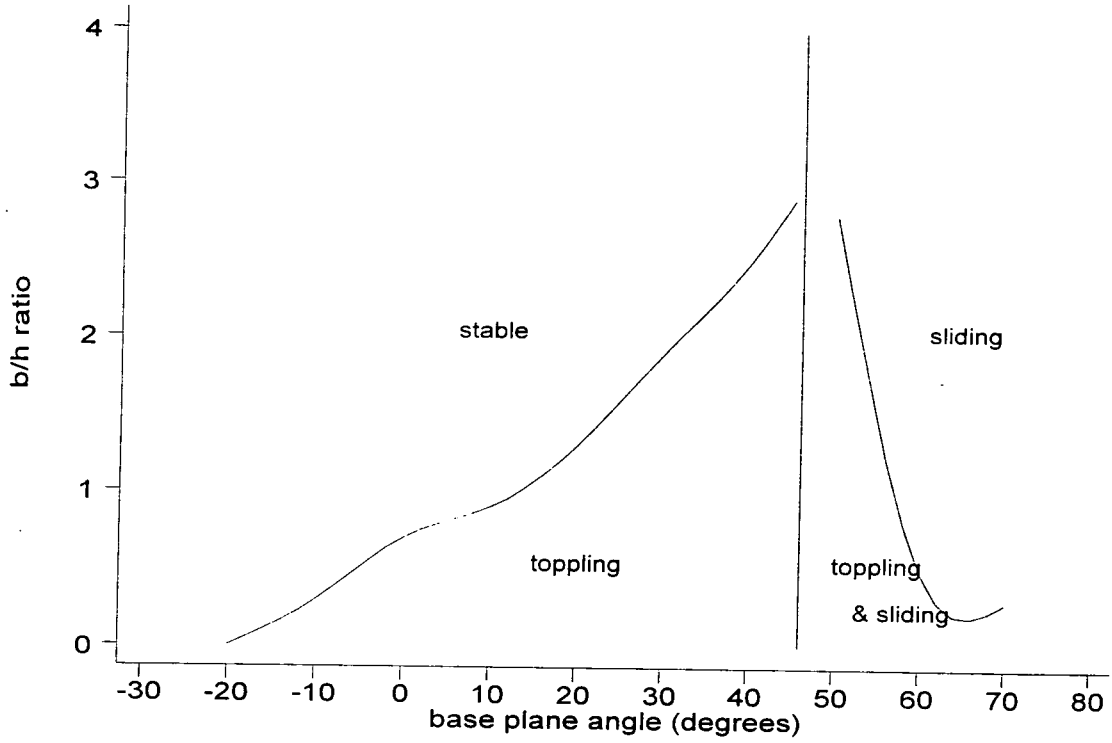


Figure 4.25: Limiting conditions for sliding, toppling and stable granite rock masses.

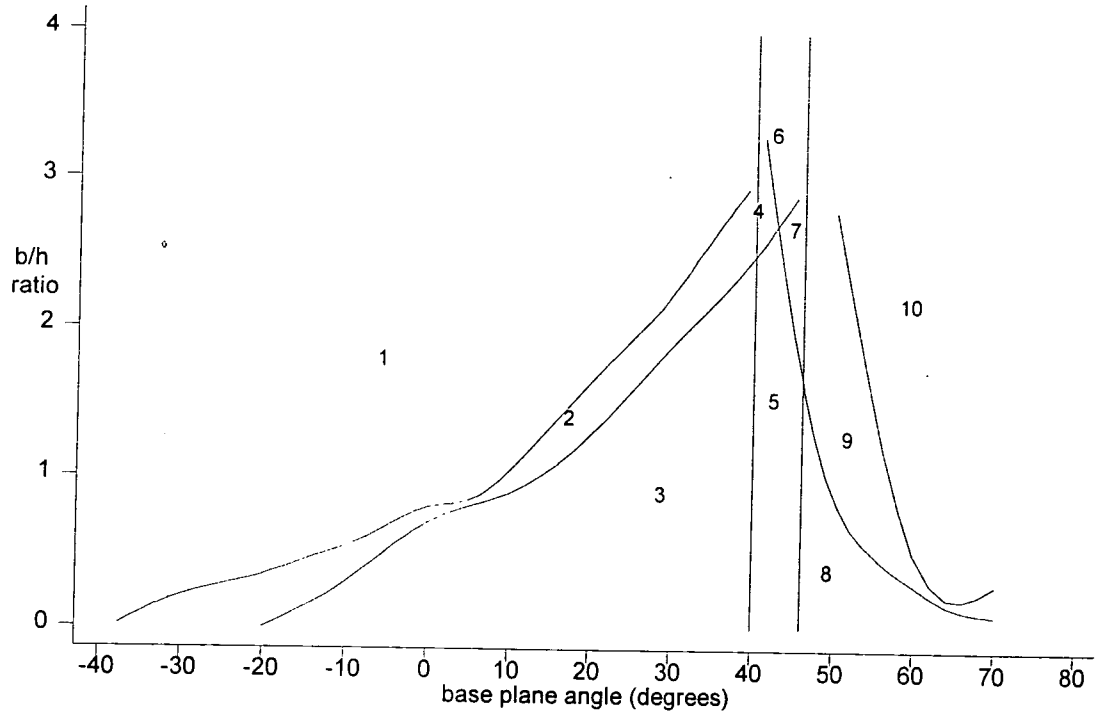


Figure 4.26: Limiting conditions for the failure of granite rock masses compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.25. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Granite
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Toppling-and-sliding	Stable
5	Toppling-and-sliding	Toppling
6	Sliding	Stable
7	Sliding	Toppling
8	Toppling-and-sliding	Toppling-and-sliding
9	Sliding	Toppling-and-sliding
10	Sliding	Sliding

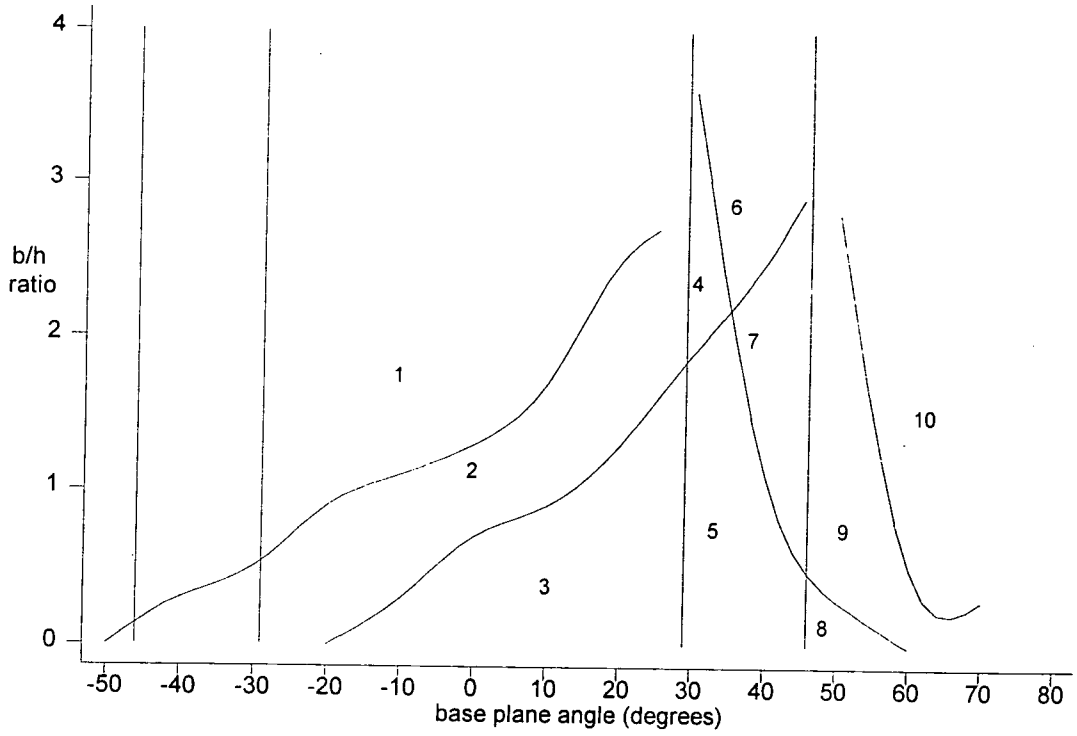


Figure 4.27: Limiting conditions for the failure of granite rock masses compared with the limiting conditions for the failure of sandstone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.22 and 4.25. Zones on the graph are delimited by the boundary lines:

Zone	Granite	Sandstone
1	Stable	Stable
2	Stable	Toppling
3	Toppling	Toppling
4	Stable	Toppling-and-sliding
5	Toppling	Toppling-and-sliding
6	Stable	Sliding
7	Toppling	Sliding
8	Toppling-and-sliding	Toppling-and-sliding
9	Toppling-and-sliding	Sliding
10	Sliding	Sliding

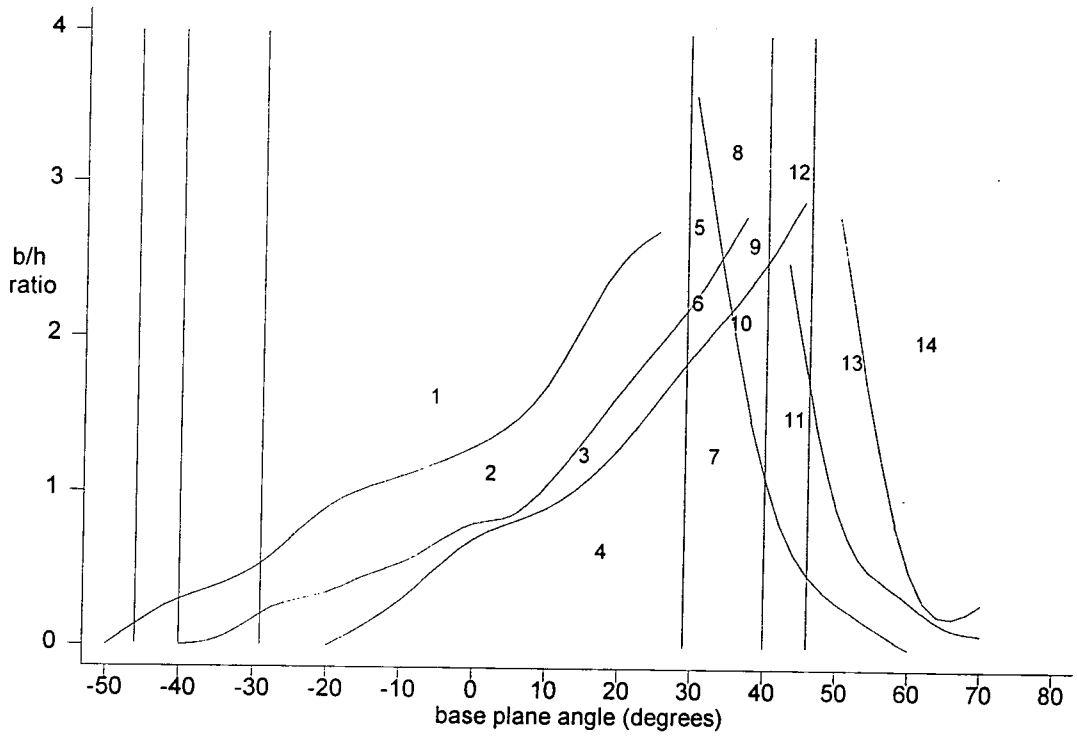
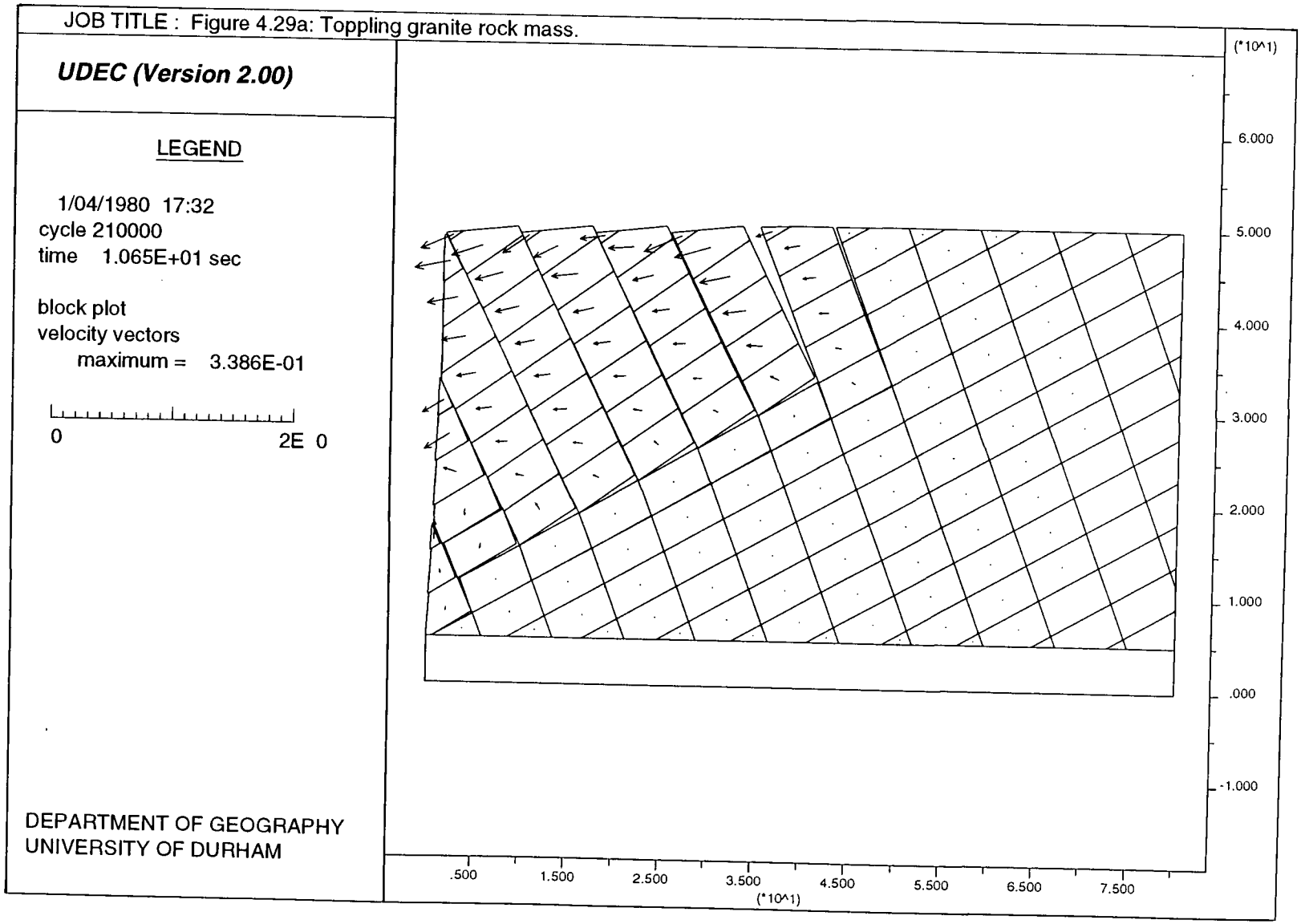


Figure 4.28: Limiting conditions for the failure of granite and sandstone rock masses compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5, 4.22 and 4.25. Zones on the graph are delimited by the boundary lines:

Zone	Sandstone	Limestone	Granite
1	Stable	Stable	Stable
2	Toppling	Stable	Stable
3	Toppling	Toppling	Stable
4	Toppling	Toppling	Toppling
5	Toppling-and-sliding	Stable	Stable
6	Toppling-and-sliding	Toppling	Stable
7	Toppling-and-sliding	Toppling	Toppling
8	Sliding	Stable	Stable
9	Sliding	Toppling	Stable
10	Sliding	Toppling	Toppling
11	Sliding	Toppling-and-sliding	Toppling
12	Sliding	Sliding	Stable
13	Sliding	Sliding	Toppling-and-sliding
14	Sliding	Sliding	Sliding


JOB TITLE : Figure 4.29a: Toppling granite rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:32
cycle 210000
time 1.065E+01 sec
block plot
velocity vectors
maximum = 3.386E-01
0
2E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

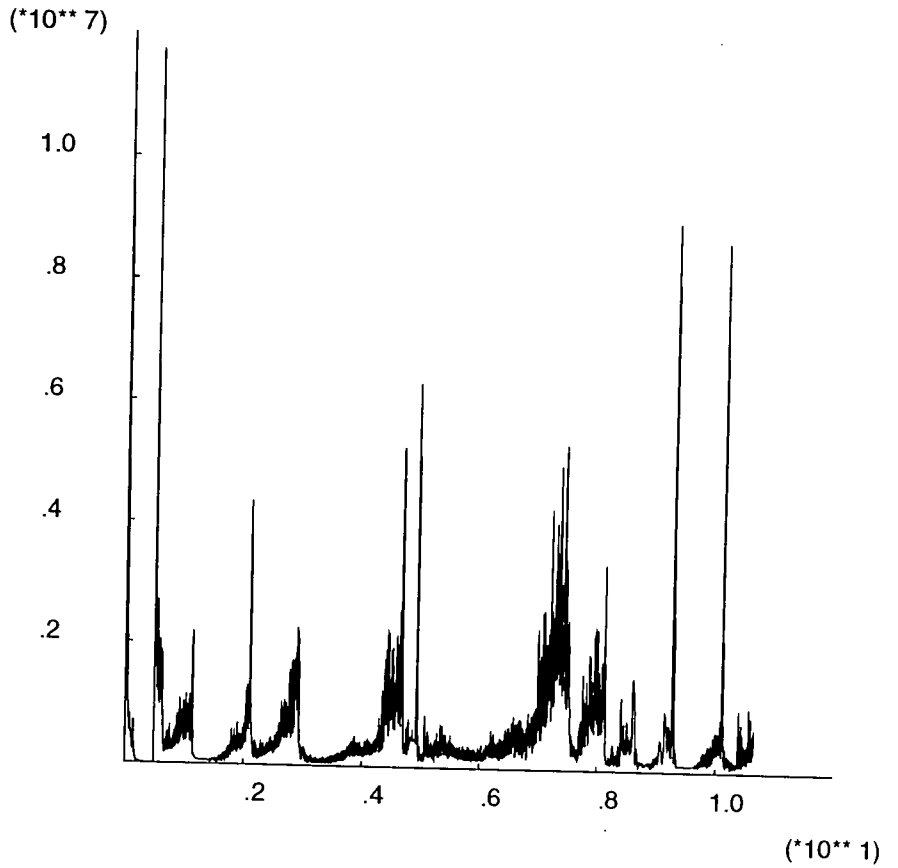
JOB TITLE : Figure 4.29b: Total unbalanced forces for a toppling granite rock mass.

UDEC (Version 2.00)

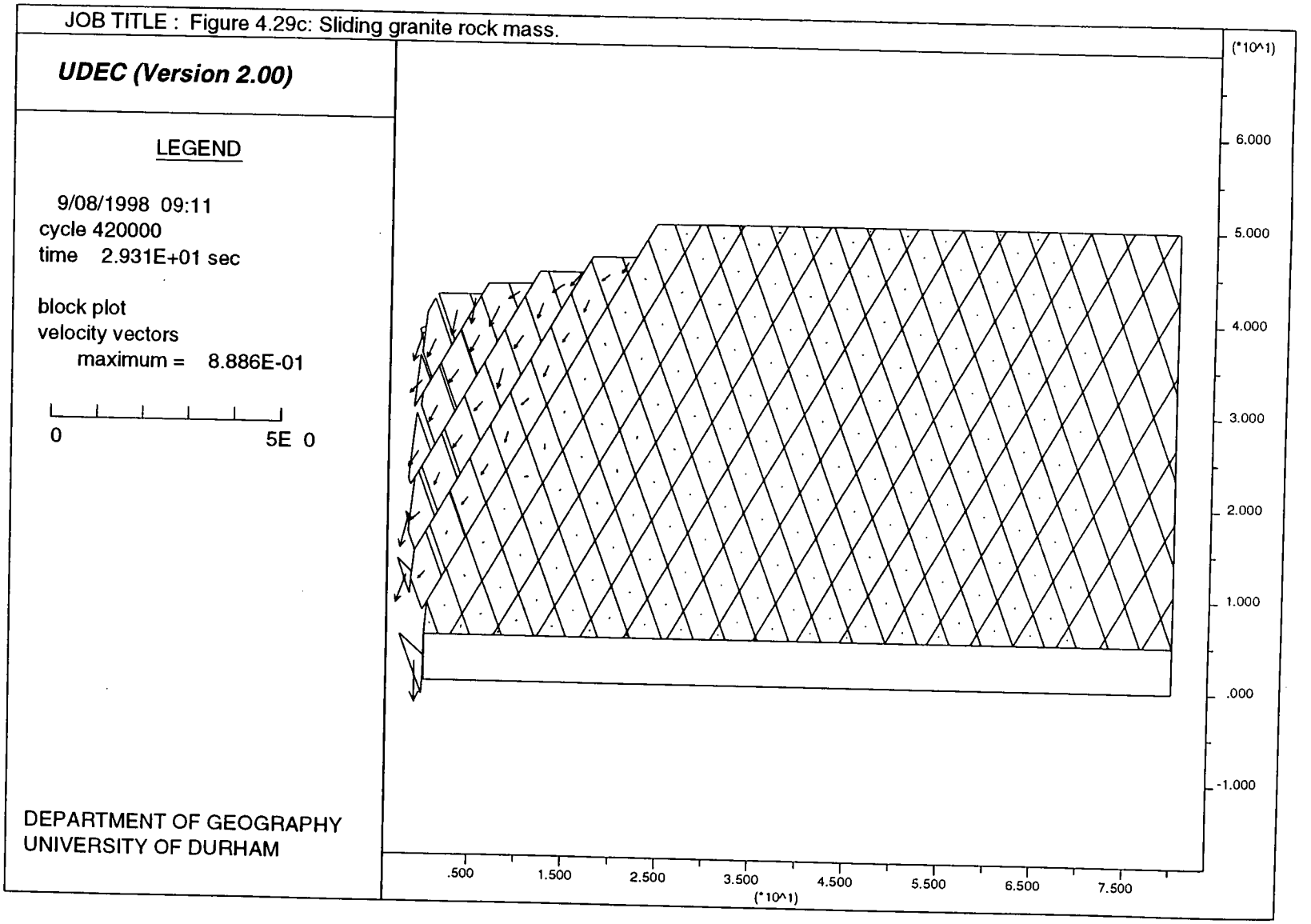
LEGEND

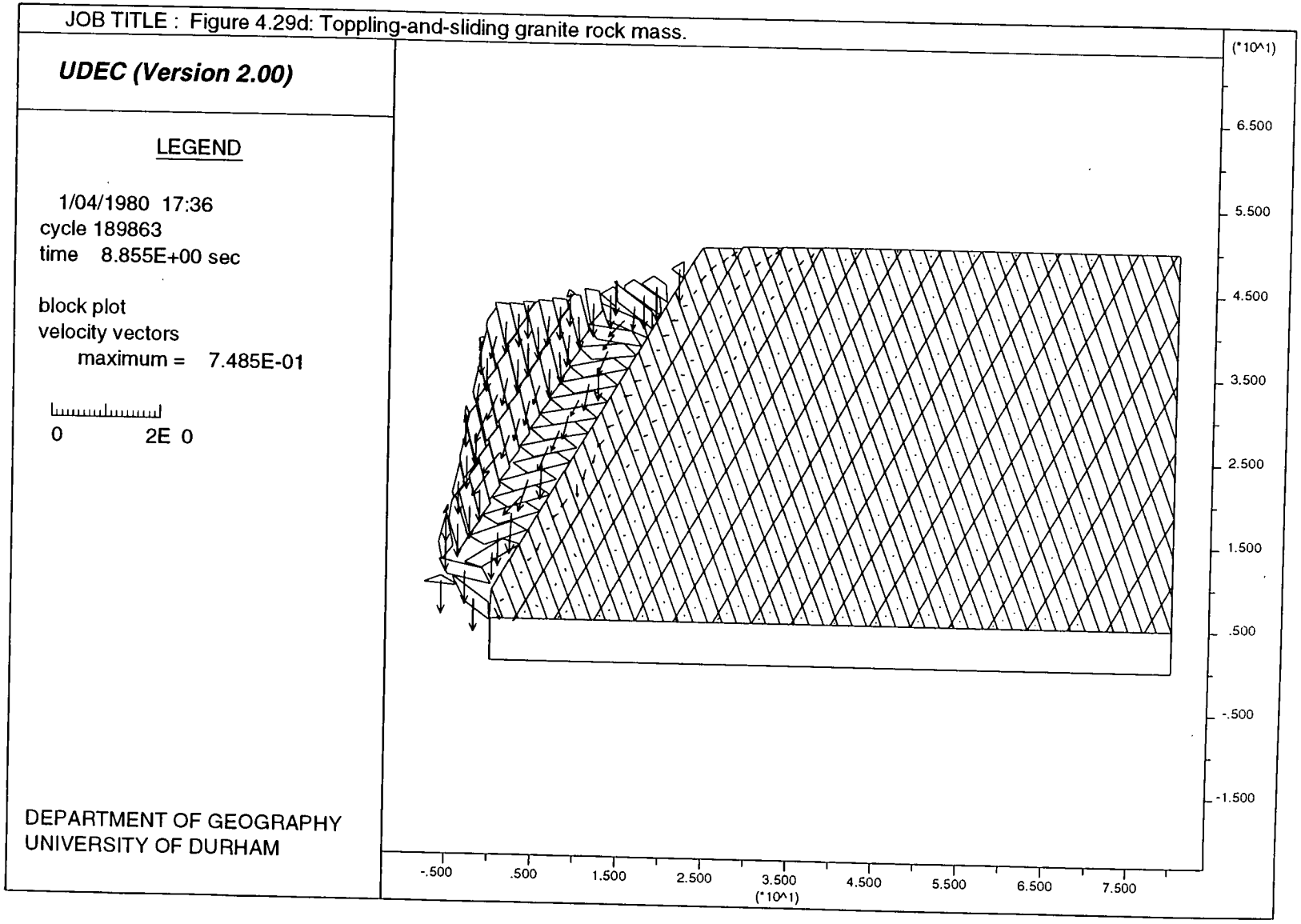
1/04/1980 17:33
cycle 210000
time 1.065E+01 sec

1.67E+01 <hist 2> 1.17E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 4.29c: Sliding granite rock mass.
UDEC (Version 2.00)
LEGEND
9/08/1998 09:11
cycle 420000
time 2.931E+01 sec
block plot
velocity vectors
maximum = 8.886E-01
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.29d: Toppling-and-sliding granite rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:36
cycle 189863
time 8.855E+00 sec
block plot
velocity vectors
maximum = 7.485E-01
0 2E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

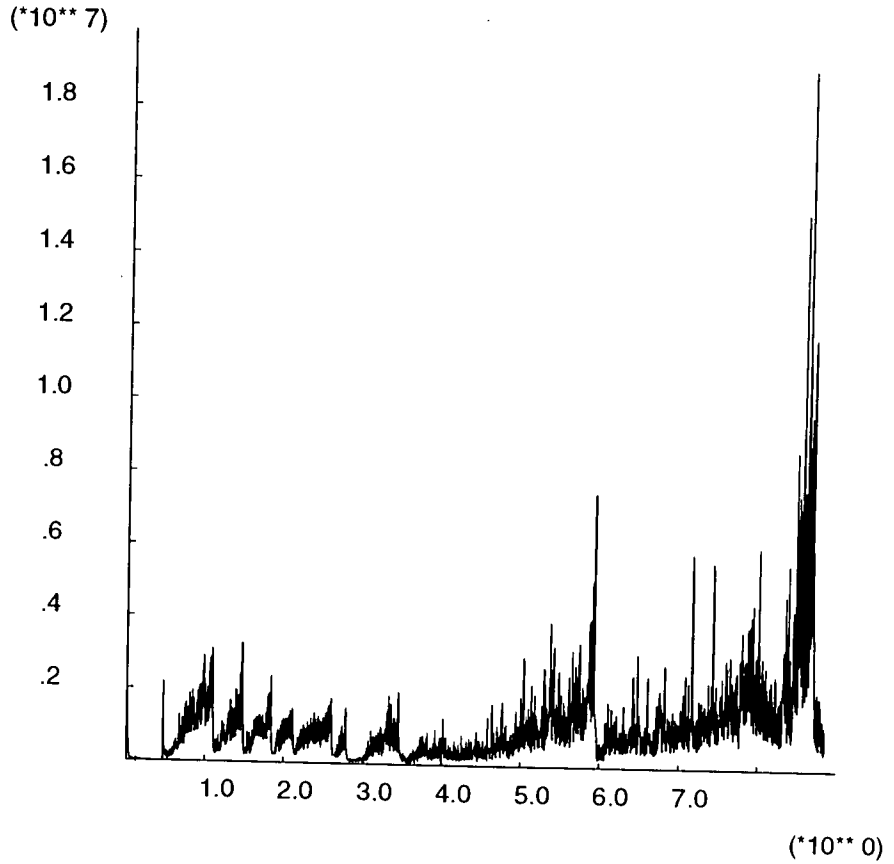
JOB TITLE : Figure 4.29e: Forces for a toppling-and-sliding granite rock mass.

UDEC (Version 2.00)

LEGEND

1/04/1980 17:38
cycle 189863
time 8.855E+00 sec

1.04E+01 <hist 2> 1.91E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

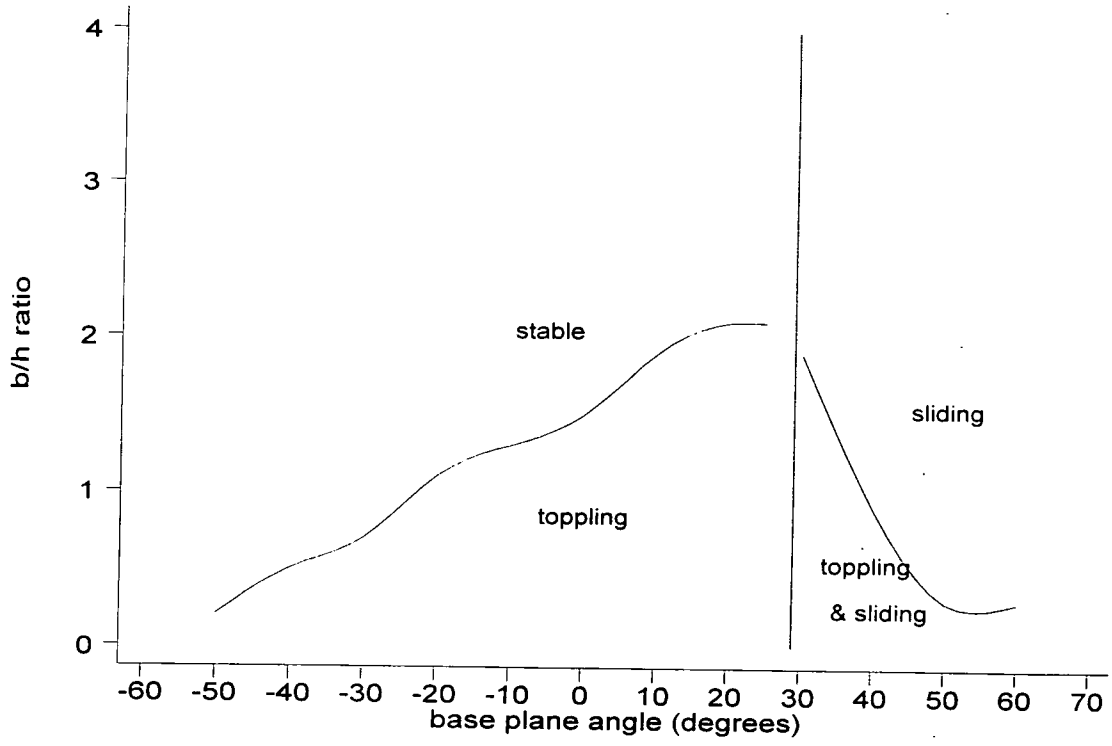


Figure 4.30: Limiting conditions for sliding, toppling and stable sandstone rock masses which contain deformable blocks.

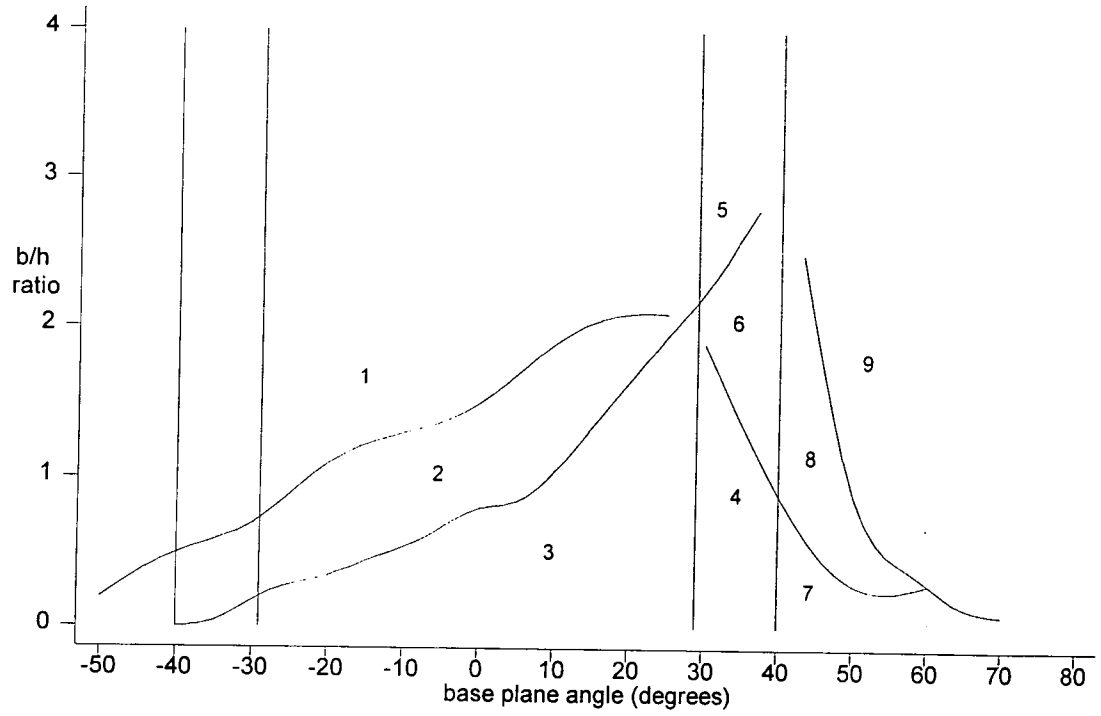


Figure 4.31: Limiting conditions for the failure of sandstone rock masses containing deformable blocks compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.30. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Deformable sandstone
1	Stable	Stable
2	Stable	Toppling
3	Toppling	Toppling
4	Toppling	Toppling-and-sliding
5	Stable	Sliding
6	Toppling	Sliding
7	Toppling-and-sliding	Toppling-and-sliding
8	Toppling-and-sliding	Sliding
9	Sliding	Sliding

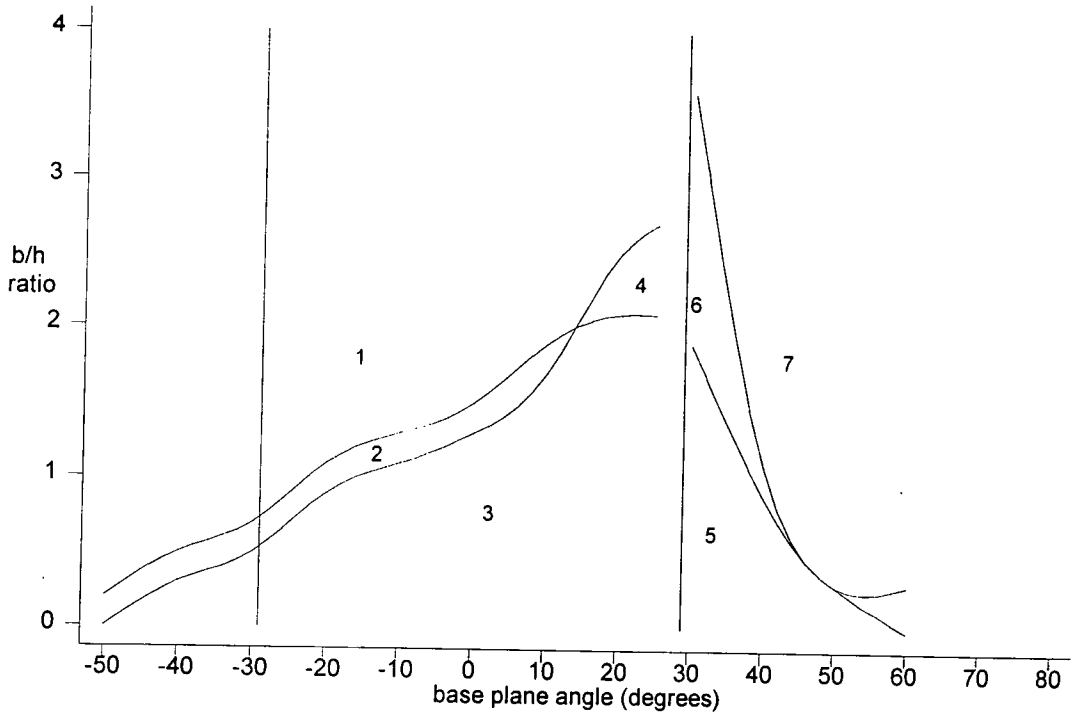
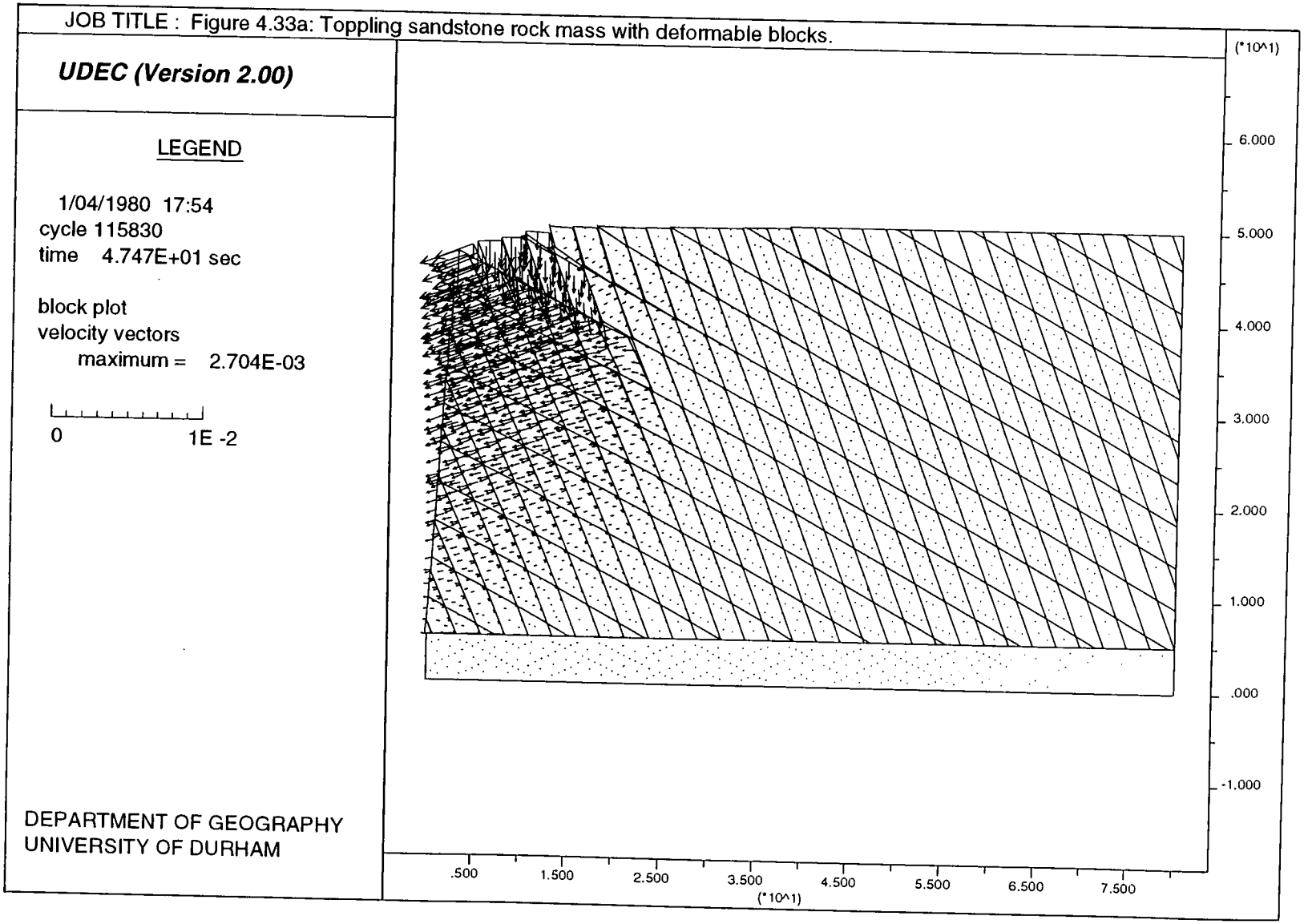
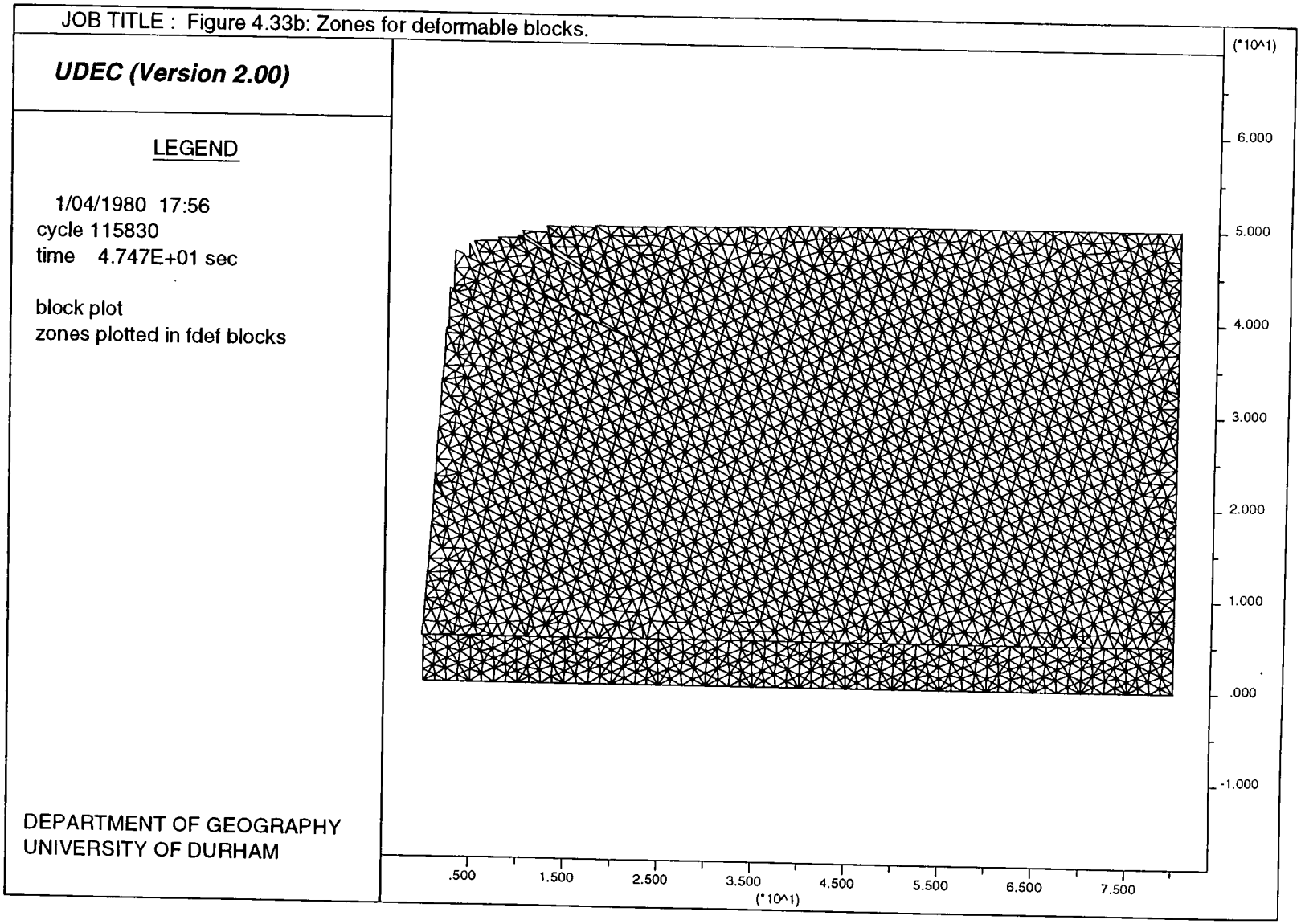


Figure 4.32: Limiting conditions for the failure of sandstone rock masses containing deformable blocks compared with the limiting conditions for the failure of the sandstone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.22 and 4.30. Zones on the graph are delimited by the boundary lines:

Zone	Deformable Sandstone	Sandstone
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Stable	Toppling
5	Toppling-and-sliding	Toppling-and-sliding
6	Sliding	Toppling-and-sliding
7	Sliding	Sliding


JOB TITLE : Figure 4.33a: Toppling sandstone rock mass with deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:54
cycle 115830
time 4.747E+01 sec
block plot
velocity vectors
maximum = 2.704E-03
0
1E -2
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.33b: Zones for deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:56
cycle 115830
time 4.747E+01 sec
block plot
zones plotted in fdef blocks
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

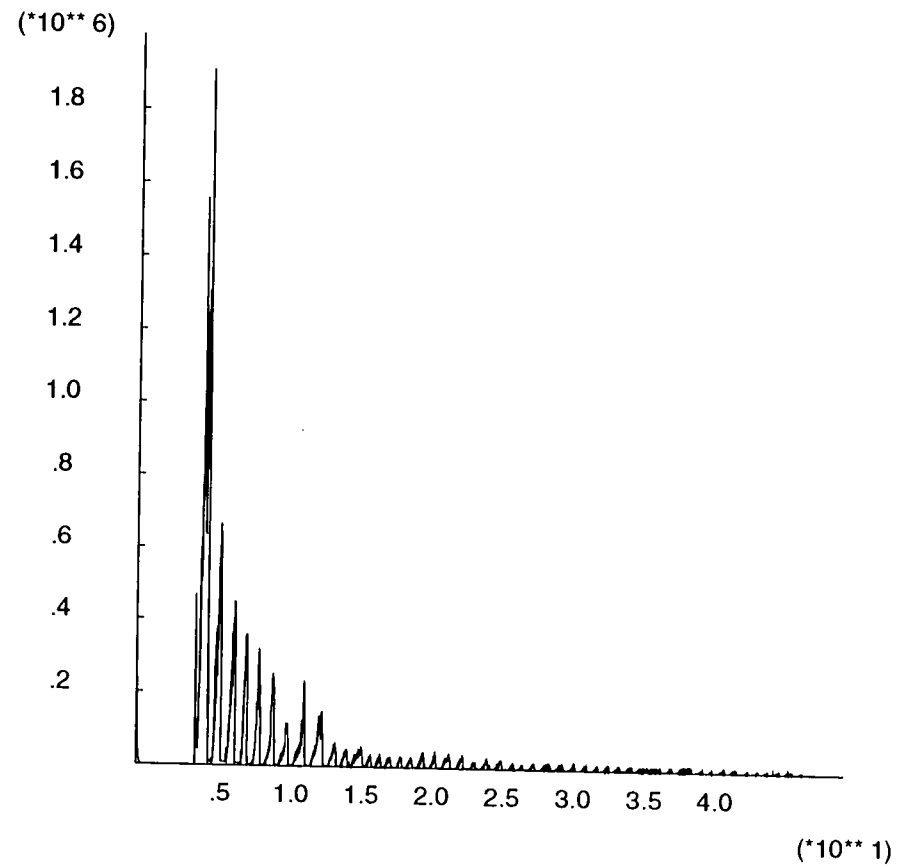
JOB TITLE : Figure 4.33c: Forces for a toppling sandstone rock mass.

UDEC (Version 2.00)

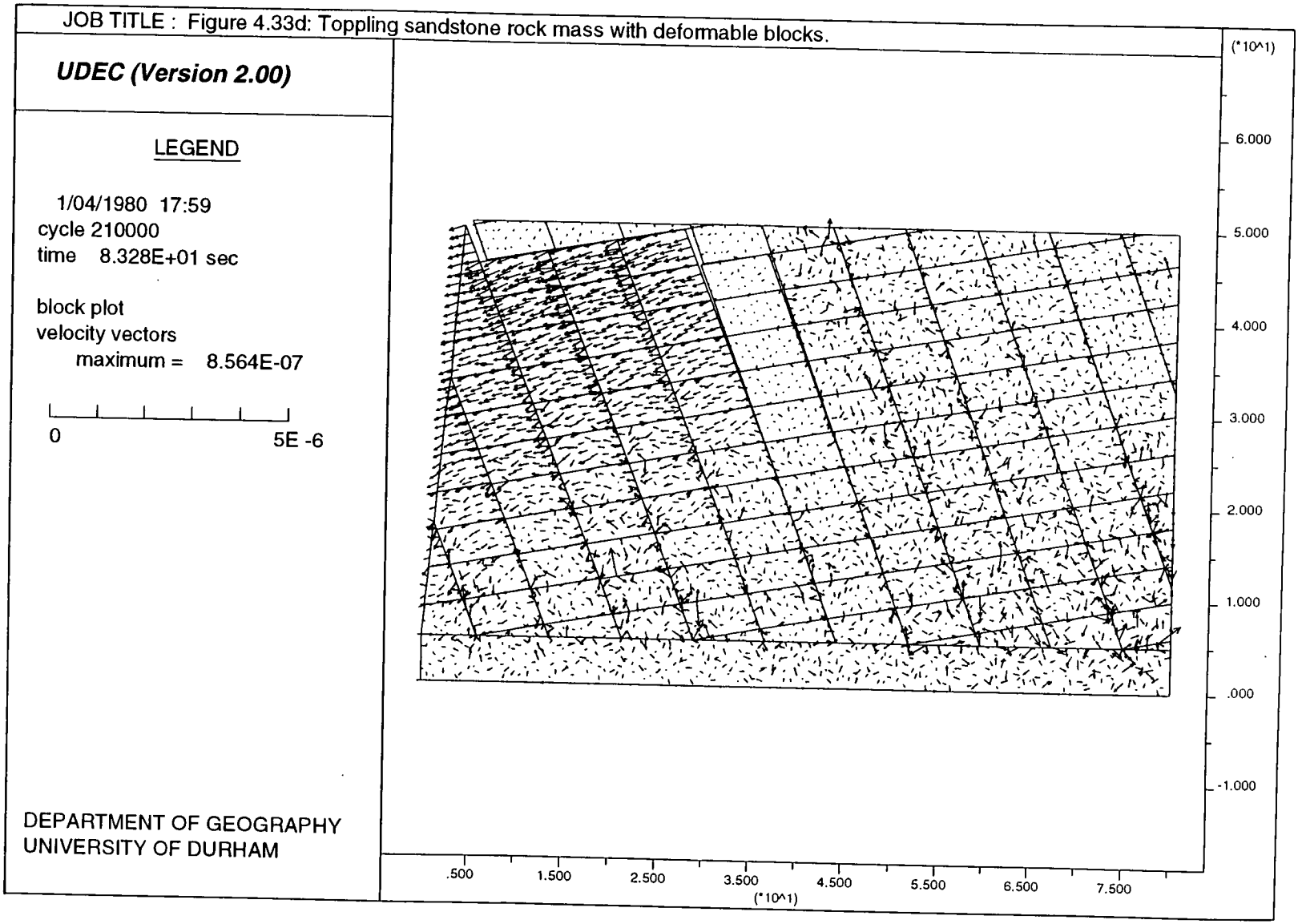
LEGEND

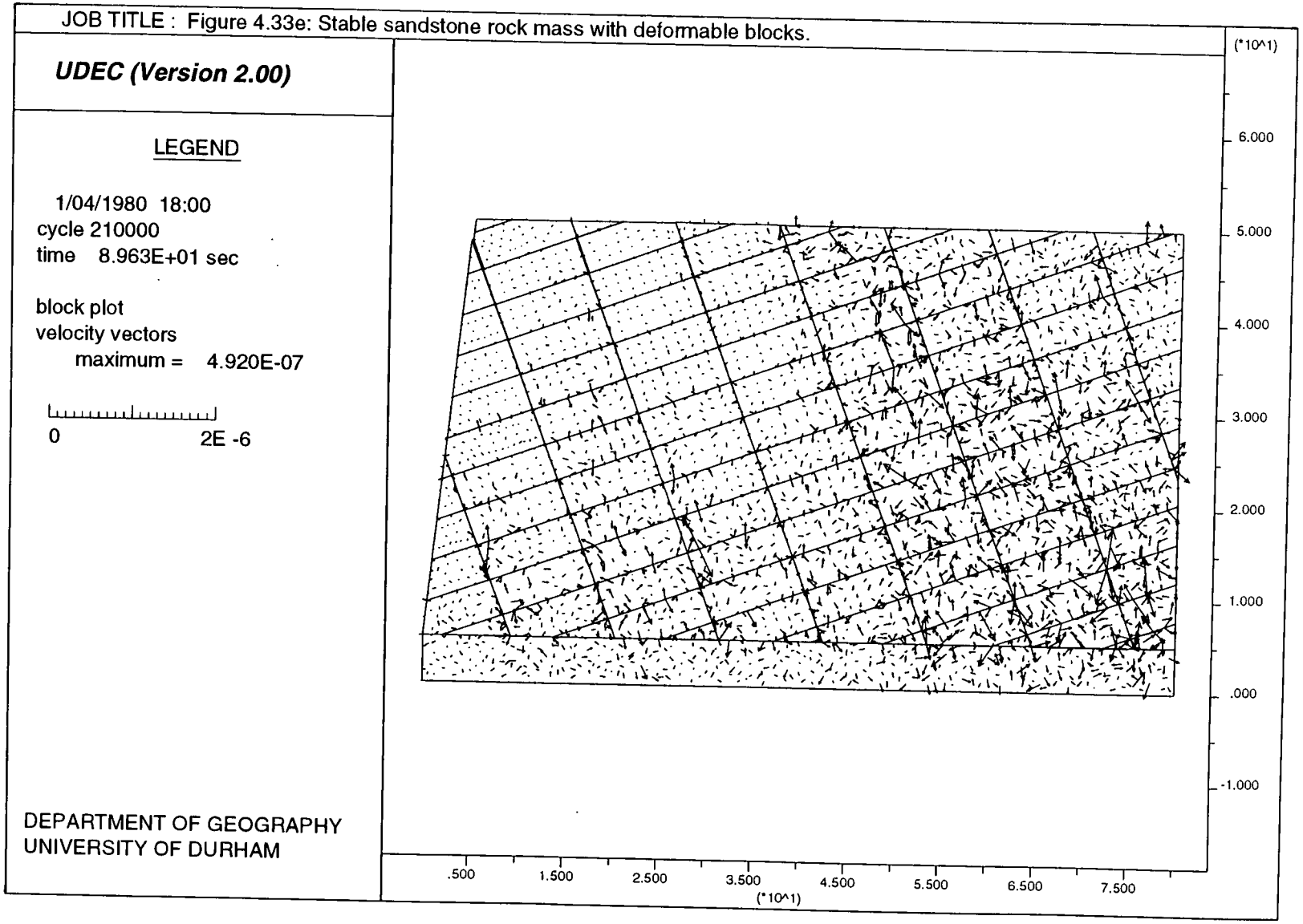
1/04/1980 17:57
cycle 115830
time 4.747E+01 sec

3.17E-01 <hist 2> 1.91E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 4.33d: Toppling sandstone rock mass with deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:59
cycle 210000
time 8.328E+01 sec
block plot
velocity vectors
maximum = 8.564E-07
0
5E -6
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.33e: Stable sandstone rock mass with deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 18:00
cycle 210000
time 8.963E+01 sec
block plot
velocity vectors
maximum = 4.920E-07
0
2E -6
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

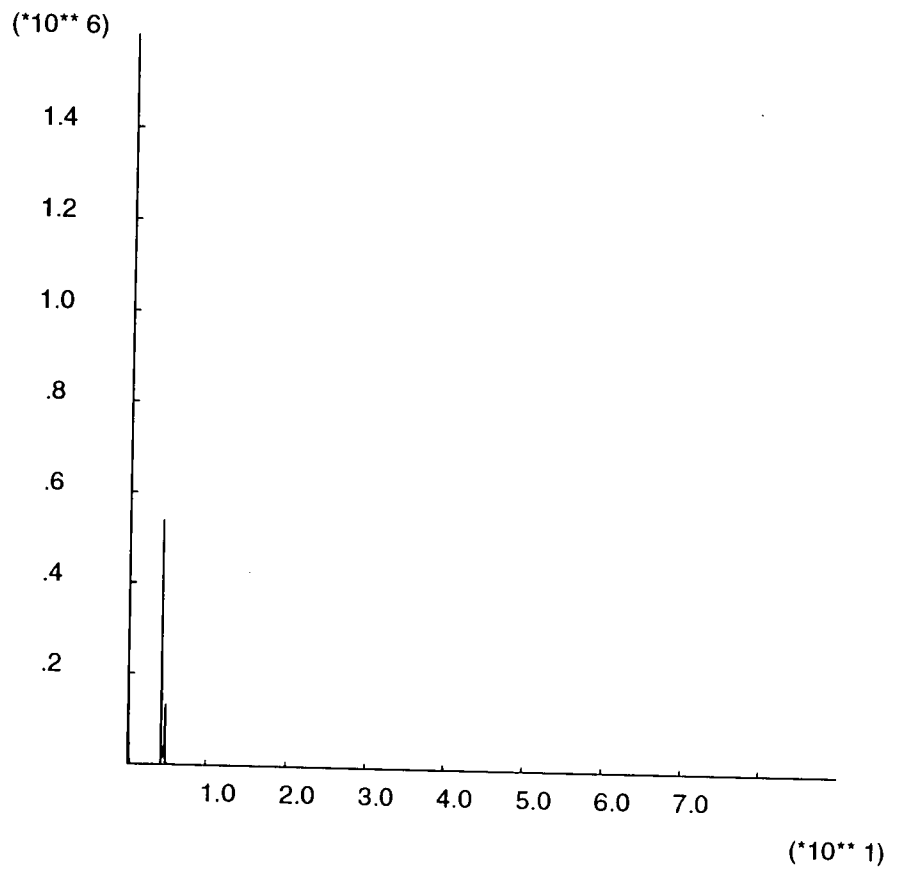
JOB TITLE : Figure 4.33f: Total unbalanced forces for a stable sandstone rock mass.

UDEC (Version 2.00)

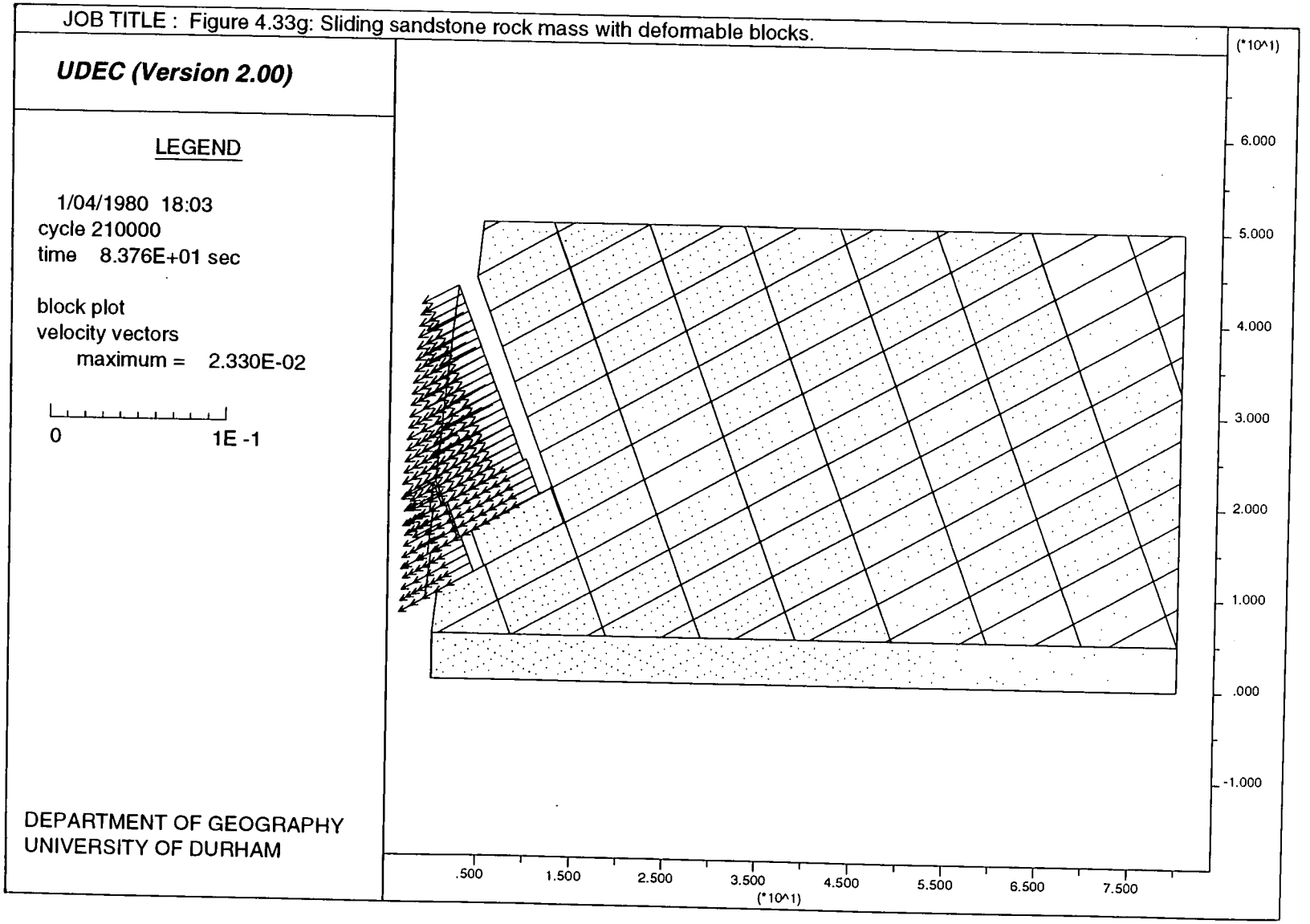
LEGEND

1/04/1980 18:01
cycle 210000
time 8.963E+01 sec

4.96E-01 <hist 2> 1.47E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 4.33g: Sliding sandstone rock mass with deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 18:03
cycle 210000
time 8.376E+01 sec
block plot
velocity vectors
maximum = 2.330E-02
0
1E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

JOB TITLE : Figure 4.33h: Sliding sandstone rock mass with deformable blocks.

UDEC (Version 2.00)

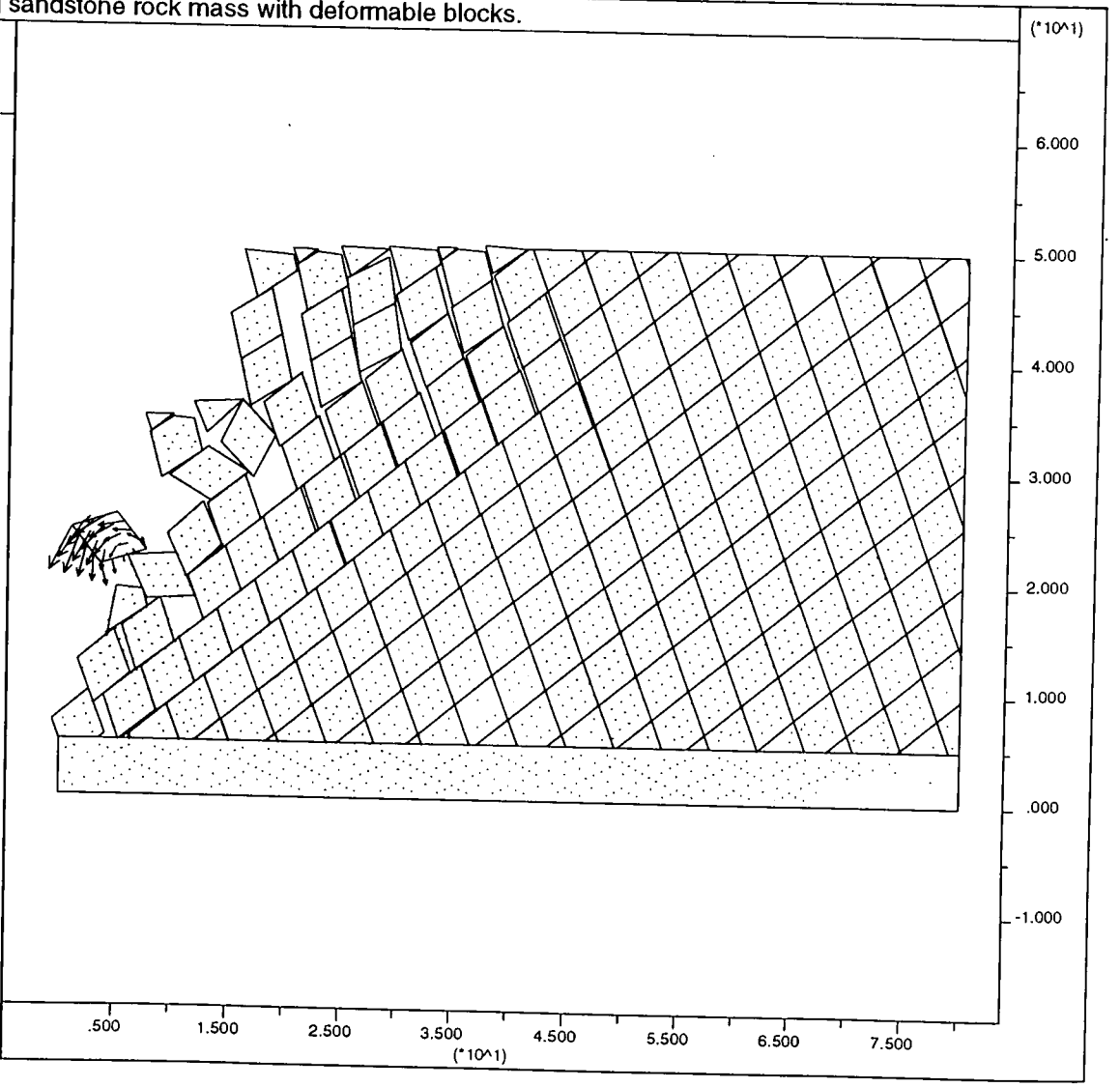
LEGEND

9/06/1998 17:15
cycle 110000
time 4.141E+01 sec

block plot
velocity vectors
maximum = 6.266E+00

0 2E 1

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



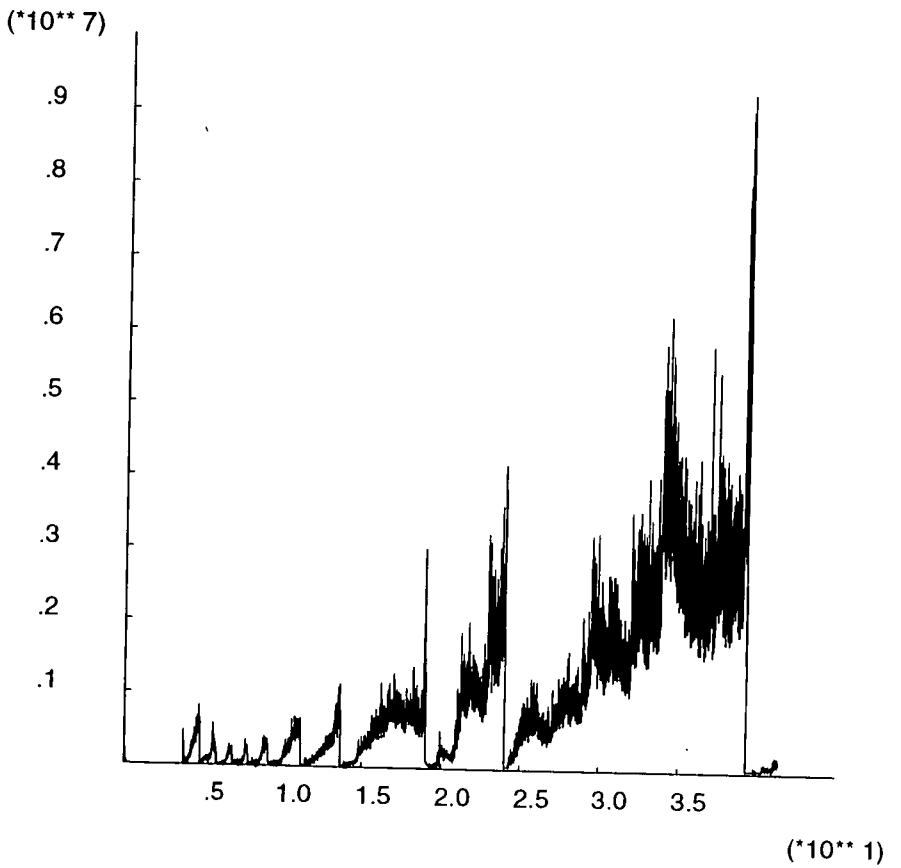
JOB TITLE : Figure 4.33i: Total unbalanced forces for a sliding sandstone rock mass.

UDEC (Version 2.00)

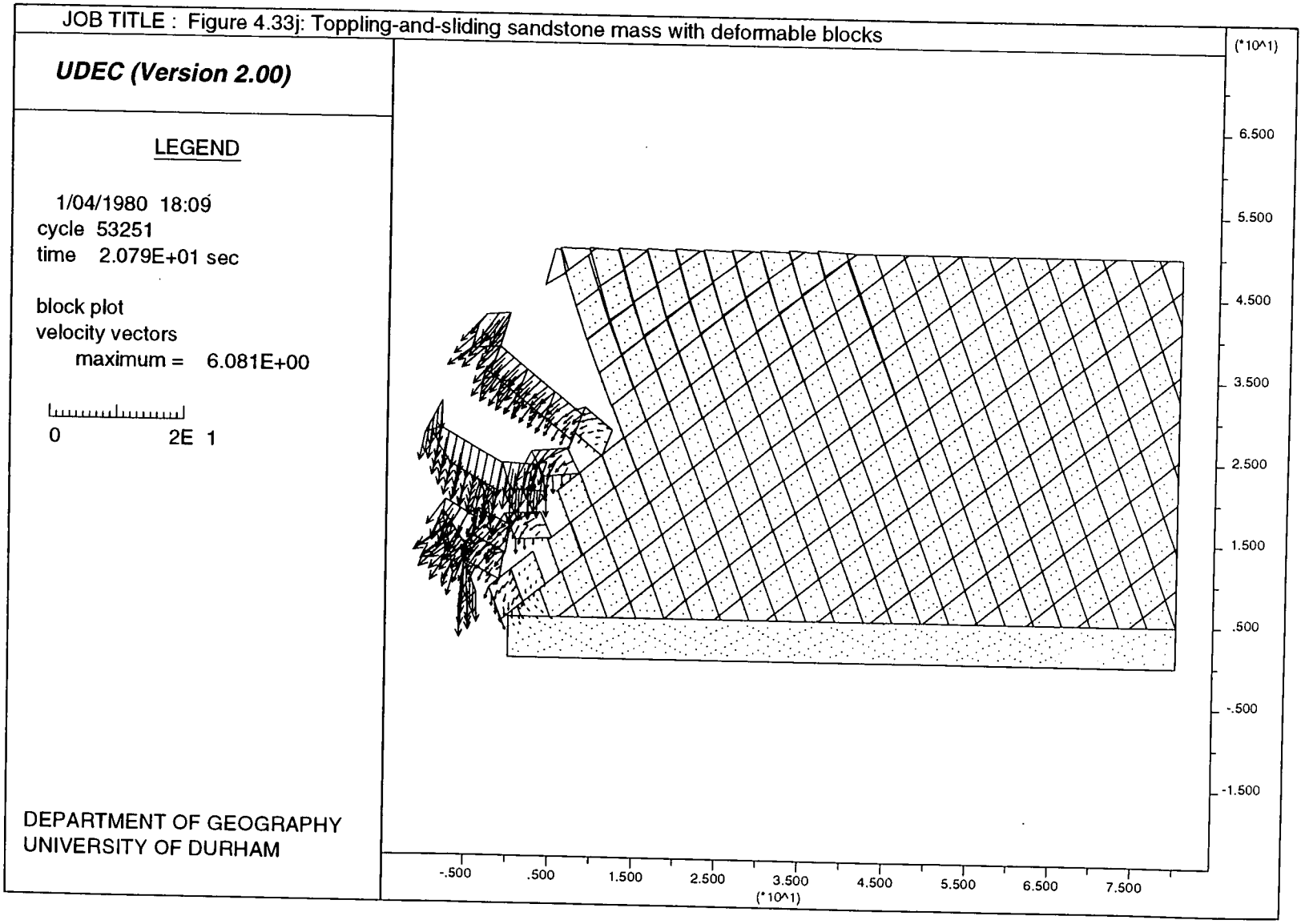
LEGEND

1/04/1980 18:07
cycle 110000
time 4.141E+01 sec

4.15E-01 <hist 2> 9.30E+06 ———



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 4.33j: Toppling-and-sliding sandstone mass with deformable blocks
UDEC (Version 2.00)
LEGEND
1/04/1980 18:09
cycle 53251
time 2.079E+01 sec
block plot
velocity vectors
maximum = 6.081E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

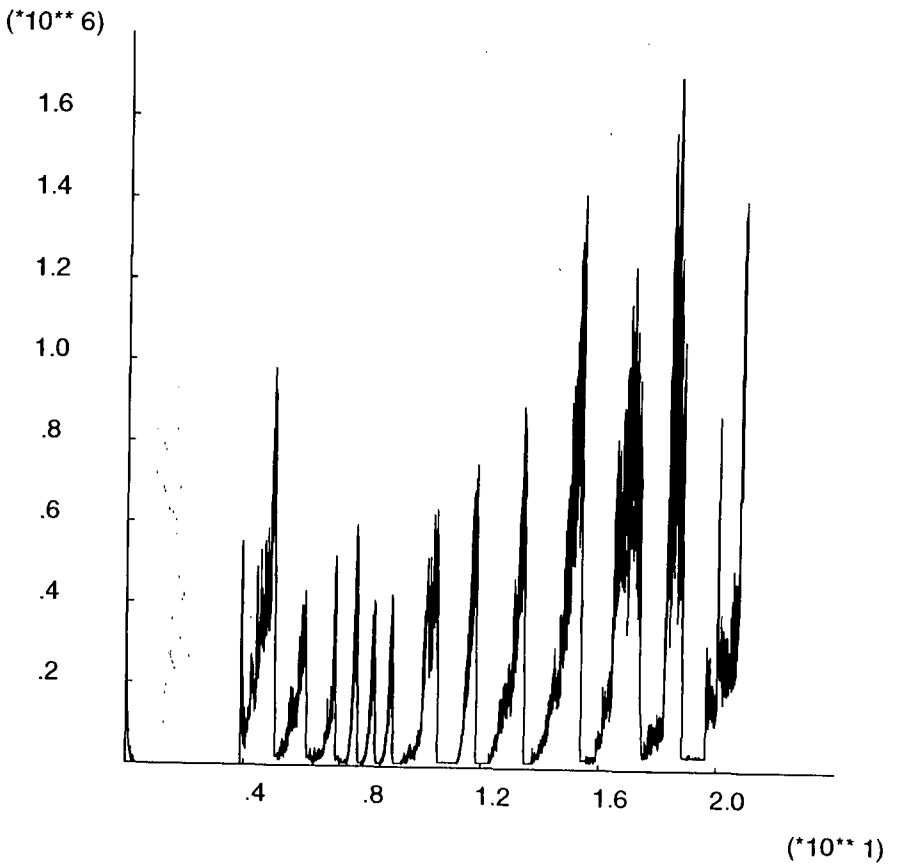
JOB TITLE : Figure 4.33k: Forces for a toppling-and-sliding sandstone rock mass.

UDEC (Version 2.00)

LEGEND

1/04/1980 18:10
cycle 53251
time 2.079E+01 sec

5.71E-01 <hist 2> 1.71E+06 ——



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

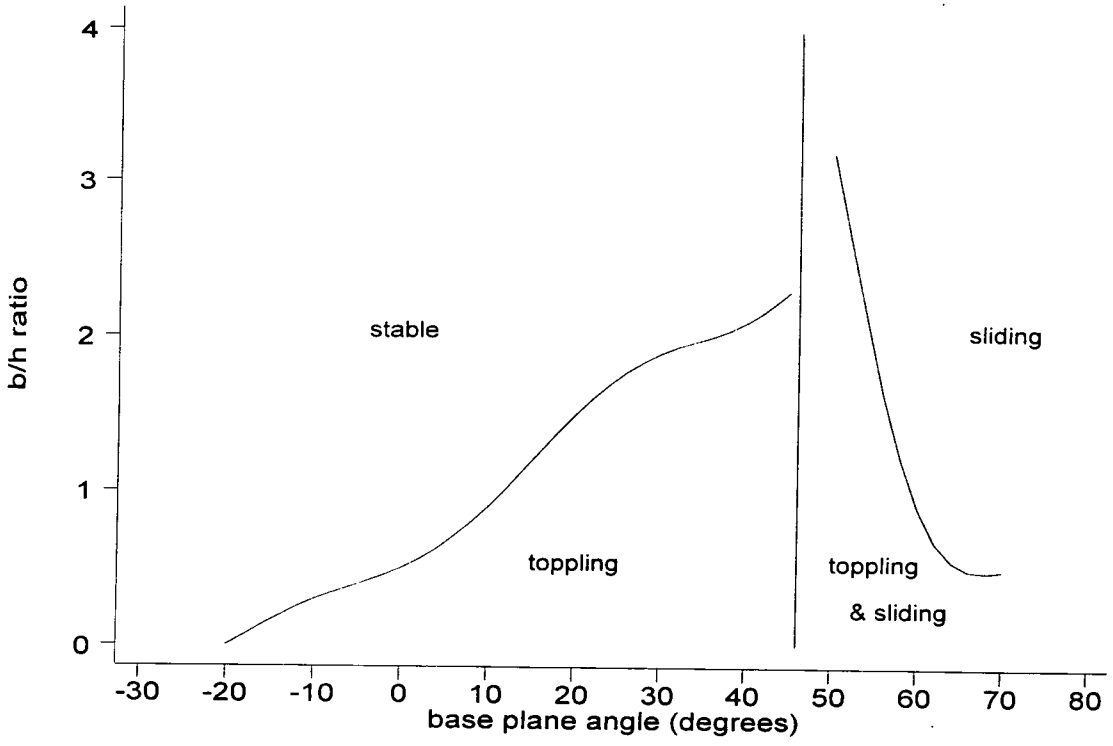


Figure 4.34: Limiting conditions for sliding, toppling and stable granite rock masses which contain deformable blocks.

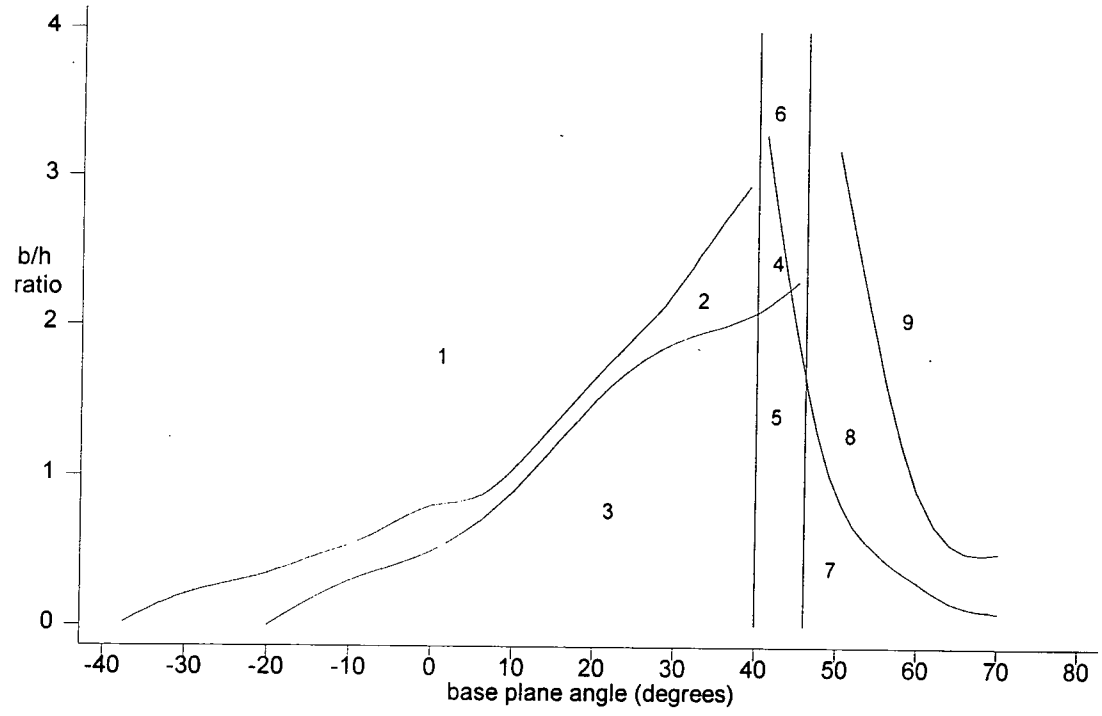


Figure 4.35: Limiting conditions for the failure of granite rock masses containing deformable blocks compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.34. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Deformable granite
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Toppling-and-sliding	Stable
5	Toppling-and-sliding	Toppling
6	Sliding	Stable
7	Toppling-and-sliding	Toppling-and-sliding
8	Sliding	Toppling-and-sliding
9	Sliding	Sliding

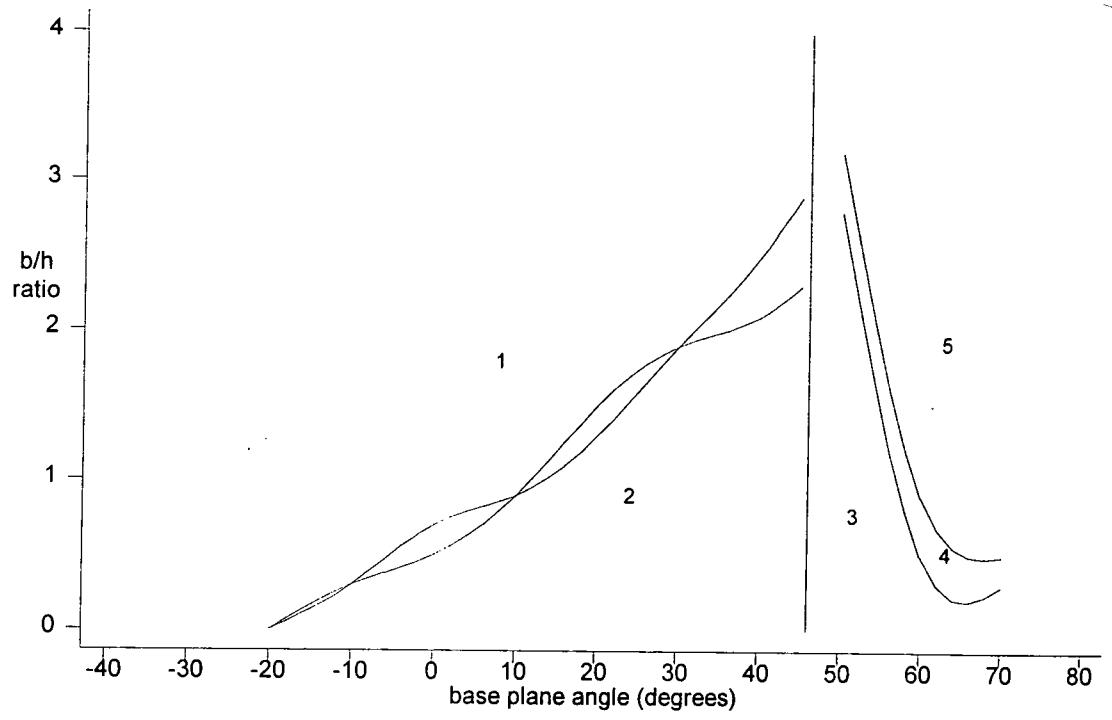
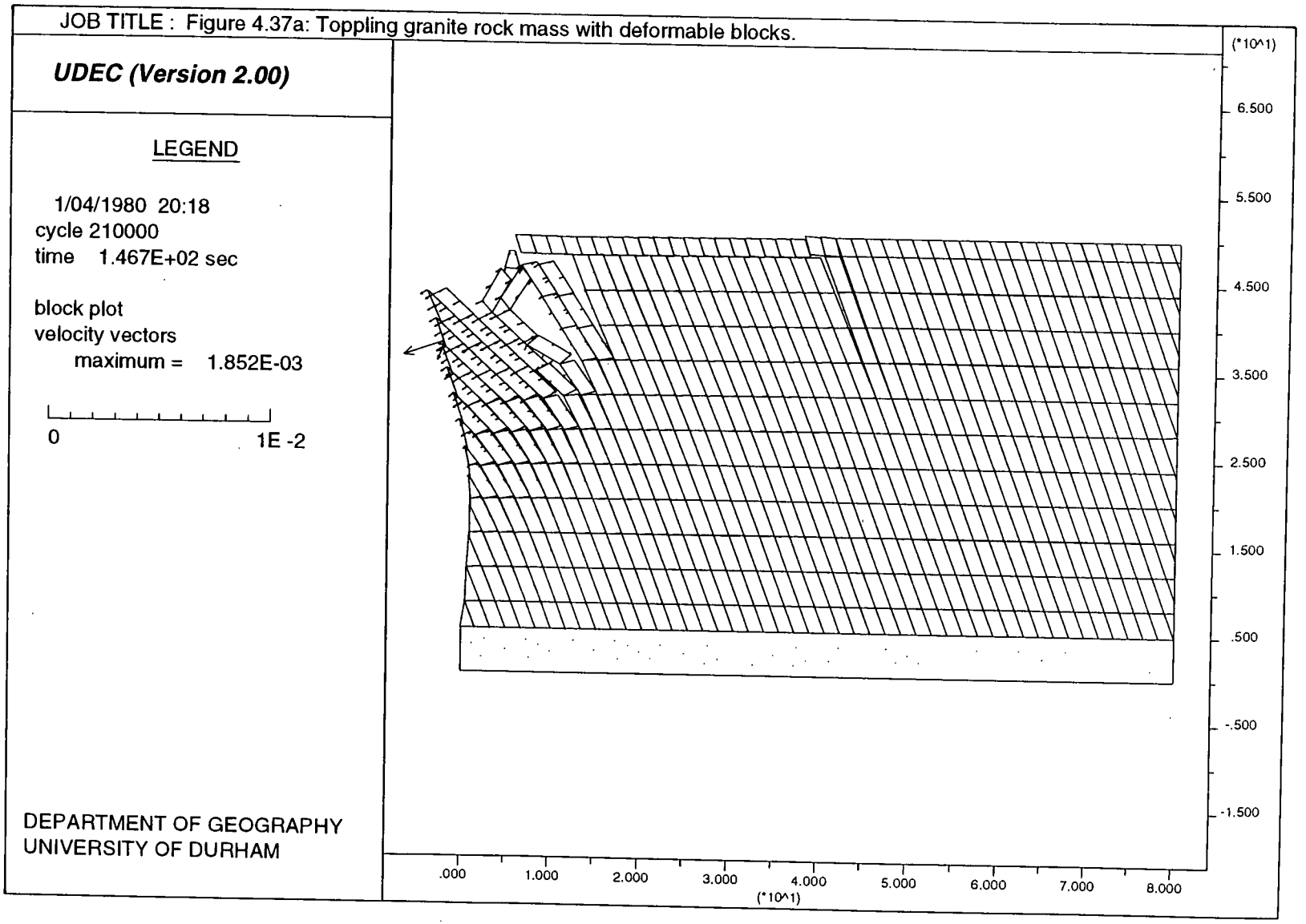
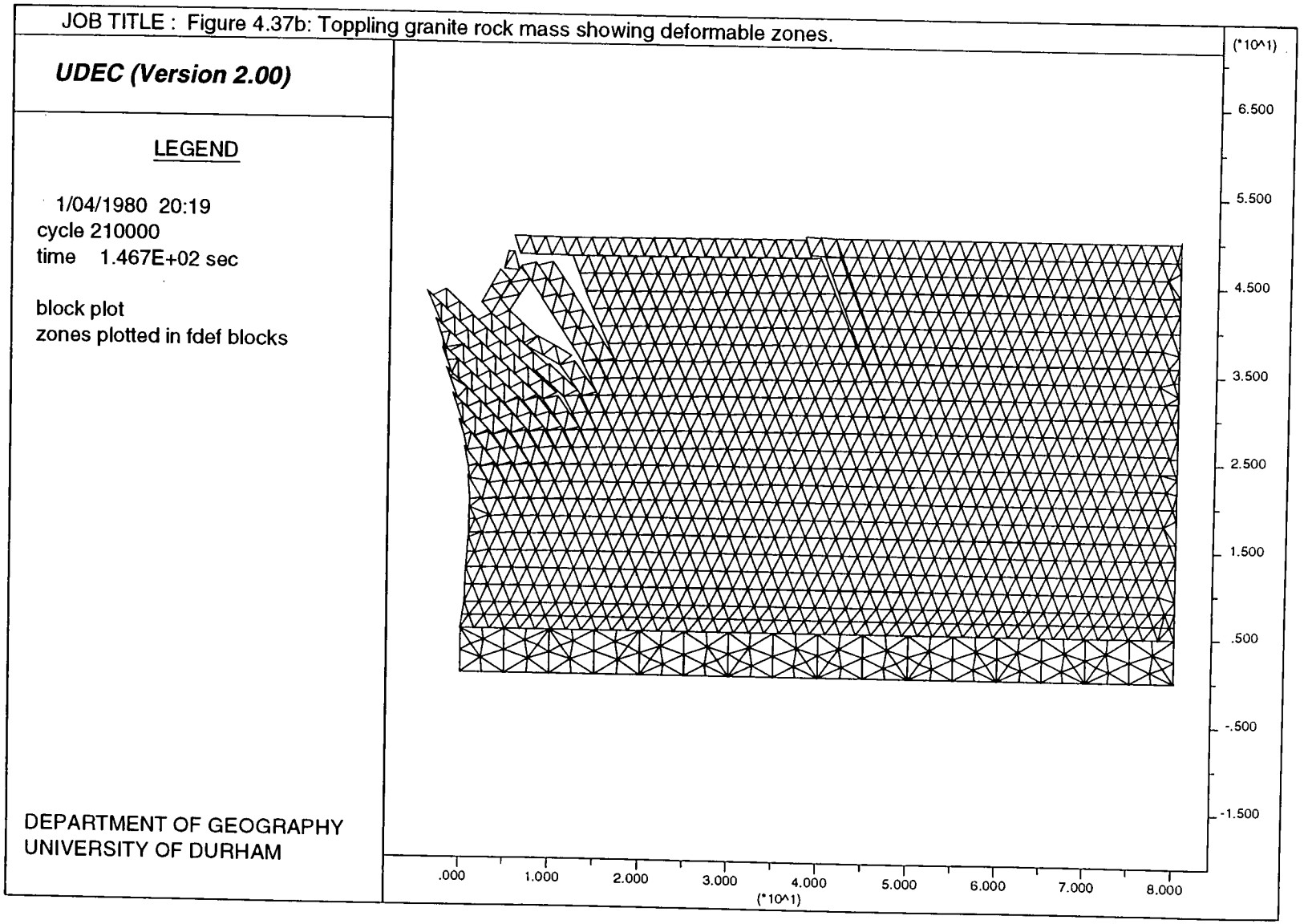


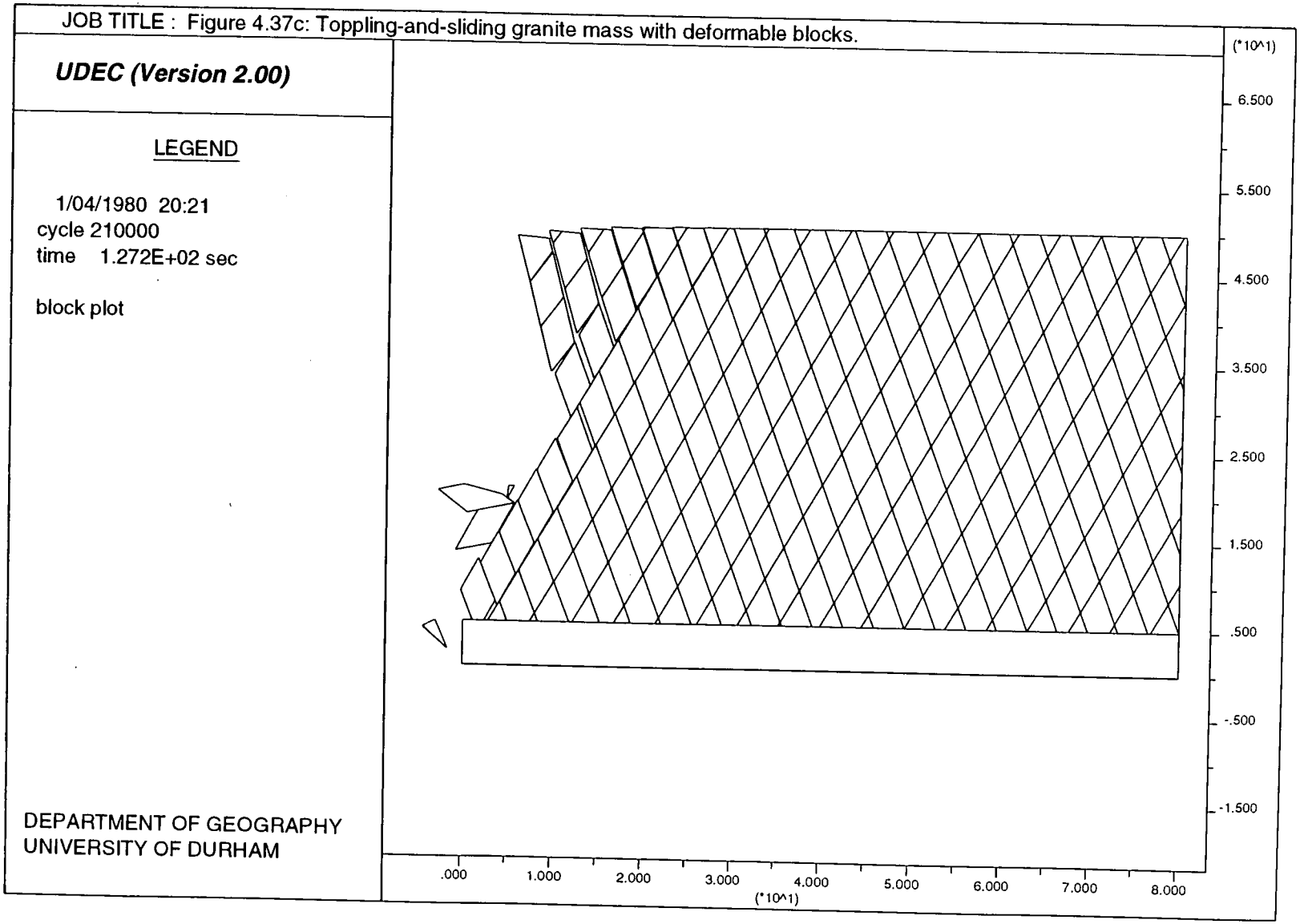
Figure 4.36: Limiting conditions for the failure of granite rock masses containing deformable blocks compared with the limiting conditions for the failure of the granite rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.25 and 4.34. Zones on the graph are delimited by the boundary lines:

Zone	Granite	Deformable granite
1	Stable	Stable
2	Toppling	Toppling
3	Toppling-and-sliding	Toppling-and-sliding
4	Sliding	Toppling-and-sliding
5	Sliding	Sliding


JOB TITLE : Figure 4.37a: Toppling granite rock mass with deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 20:18
cycle 210000
time 1.467E+02 sec
block plot
velocity vectors
maximum = 1.852E-03
0
1E -2
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)


JOB TITLE : Figure 4.37b: Toppling granite rock mass showing deformable zones.
UDEC (Version 2.00)
LEGEND
1/04/1980 20:19
cycle 210000
time 1.467E+02 sec
block plot
zones plotted in fdef blocks
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)


JOB TITLE : Figure 4.37c: Toppling-and-sliding granite mass with deformable blocks.
UDEC (Version 2.00)
LEGEND
1/04/1980 20:21
cycle 210000
time 1.272E+02 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)

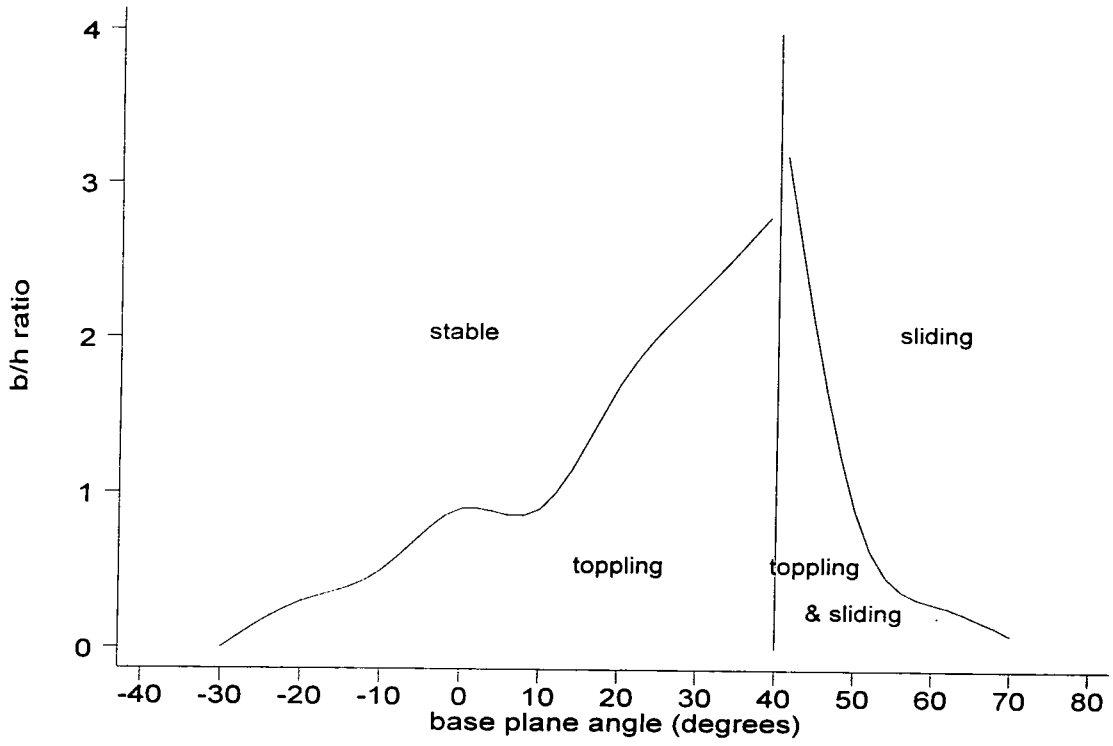


Figure 4.38: Limiting conditions for sliding, toppling and stable rock masses which contain variable discontinuity spacings.

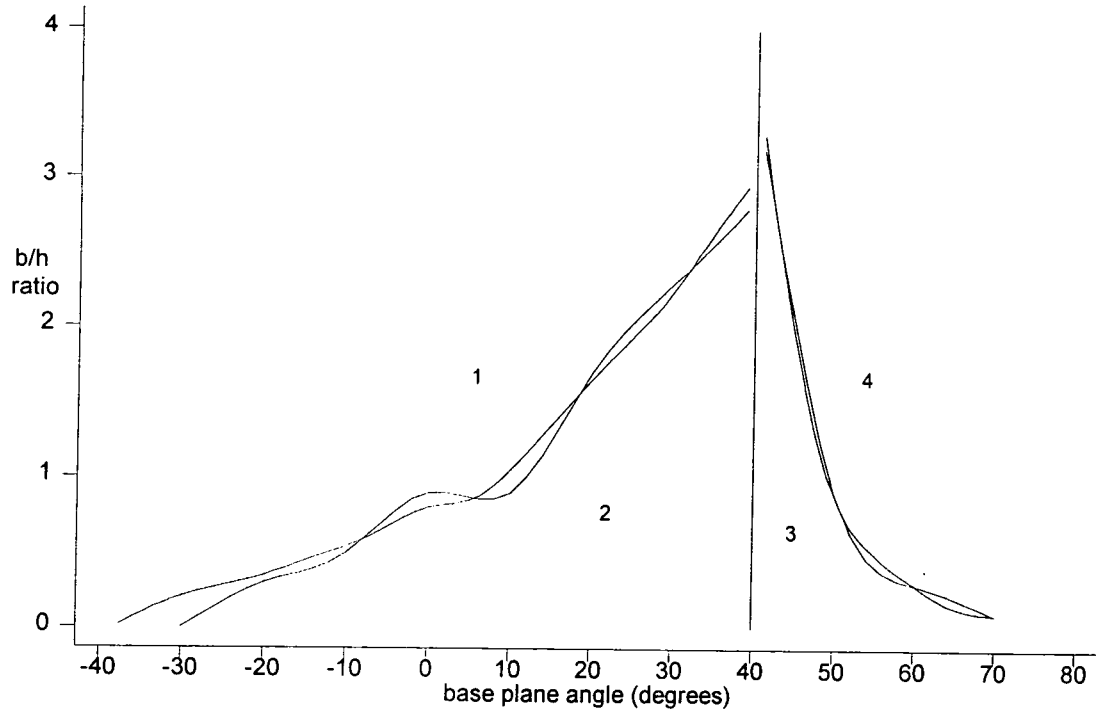


Figure 4.39: Limiting conditions for the failure of rock masses containing variable discontinuity spacings compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.38. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Variable spacings
1	Stable	Stable
2	Toppling	Toppling
3	Sliding	Sliding
4	Toppling-and-sliding	Toppling-and-sliding

JOB TITLE : Figure 4.40a: Toppling mass which contains variable joint spacings.

UDEC (Version 2.00)

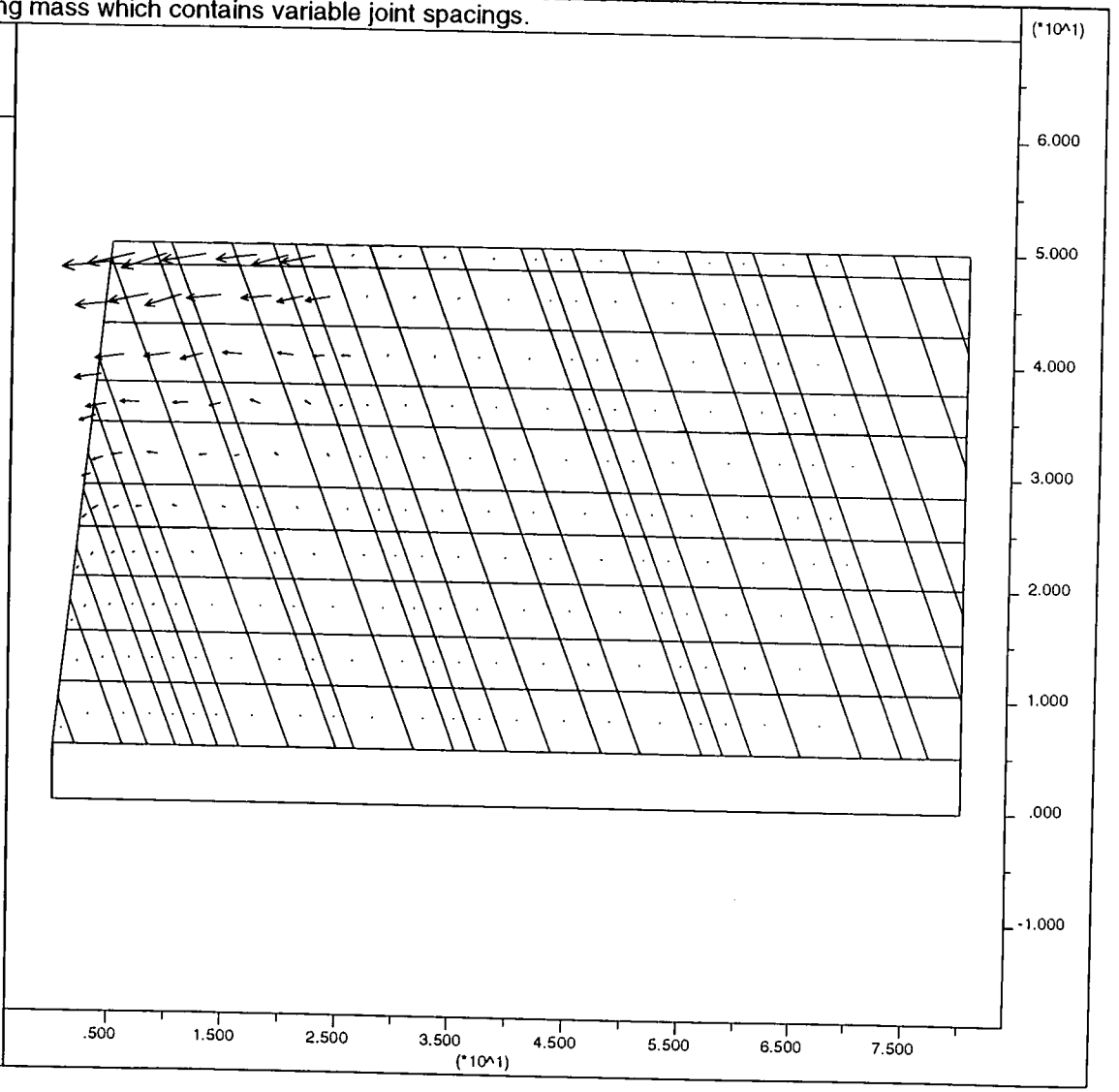
LEGEND

1/04/1980 20:33
cycle 210000
time 1.610E+01 sec

block plot
velocity vectors
maximum = 5.507E-05

0 2E -4

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 4.40b: Stable mass which contains variable joint spacings.

UDEC (Version 2.00)

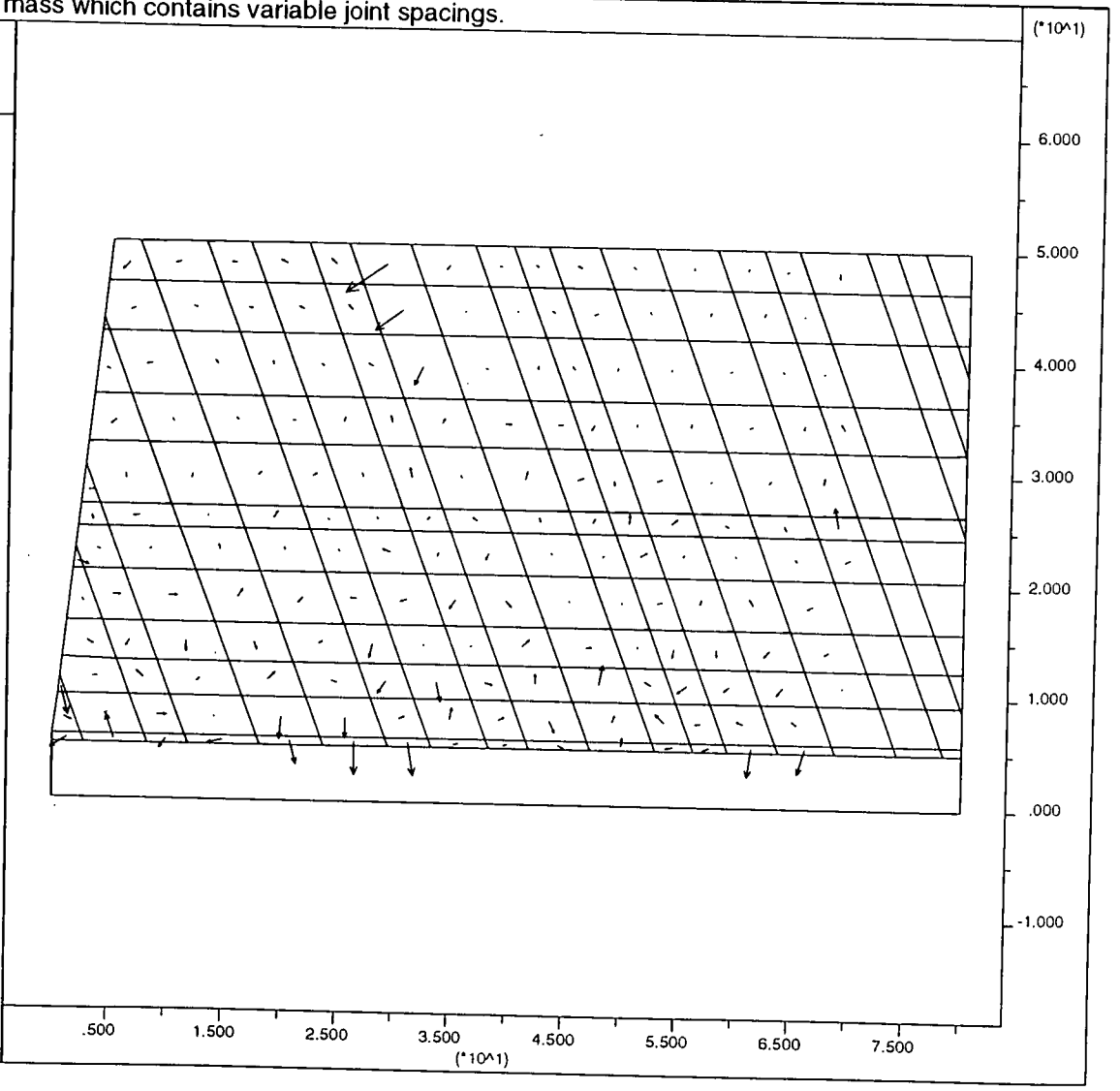
LEGEND

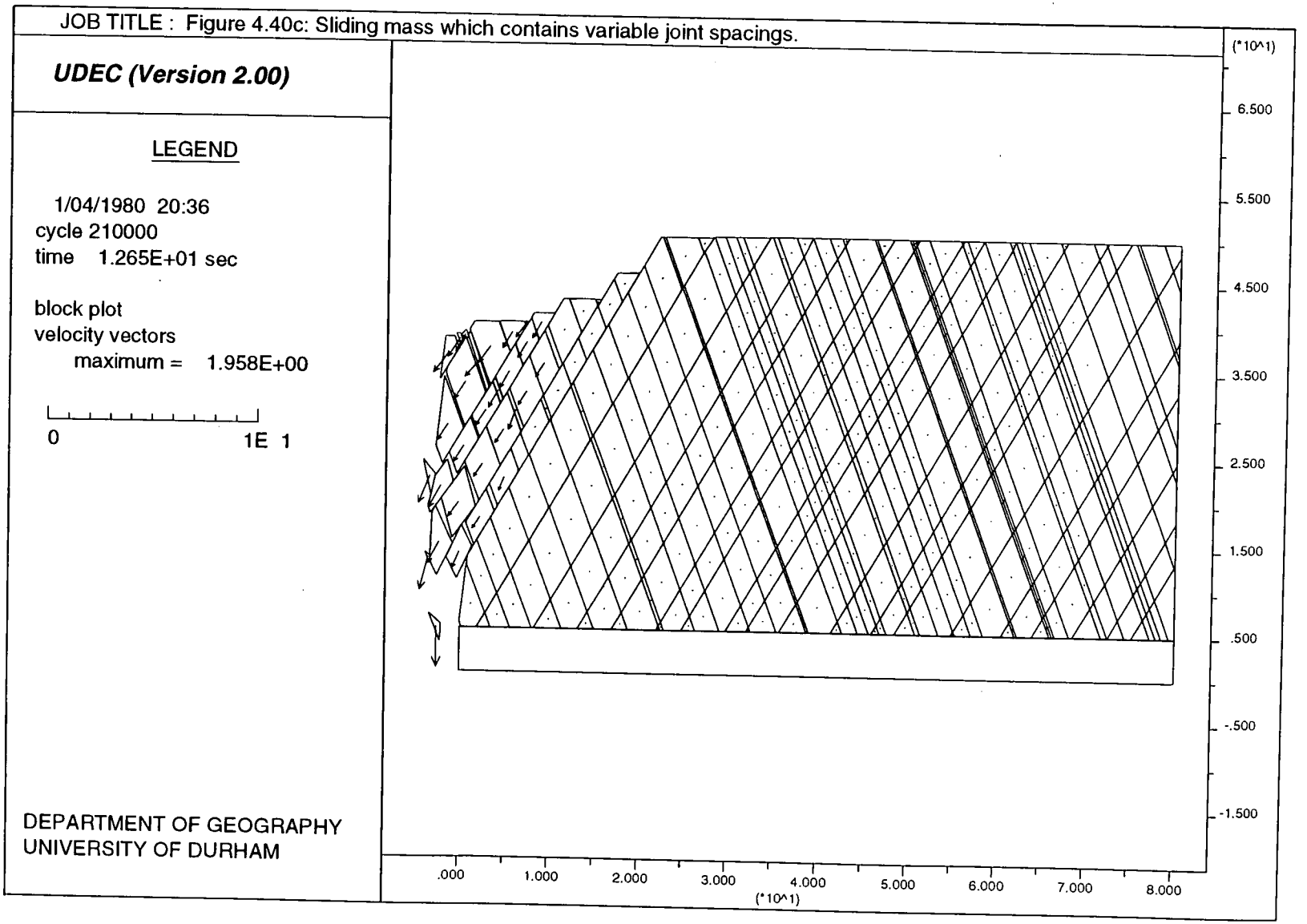
1/04/1980 20:34
cycle 210000
time 3.029E+01 sec

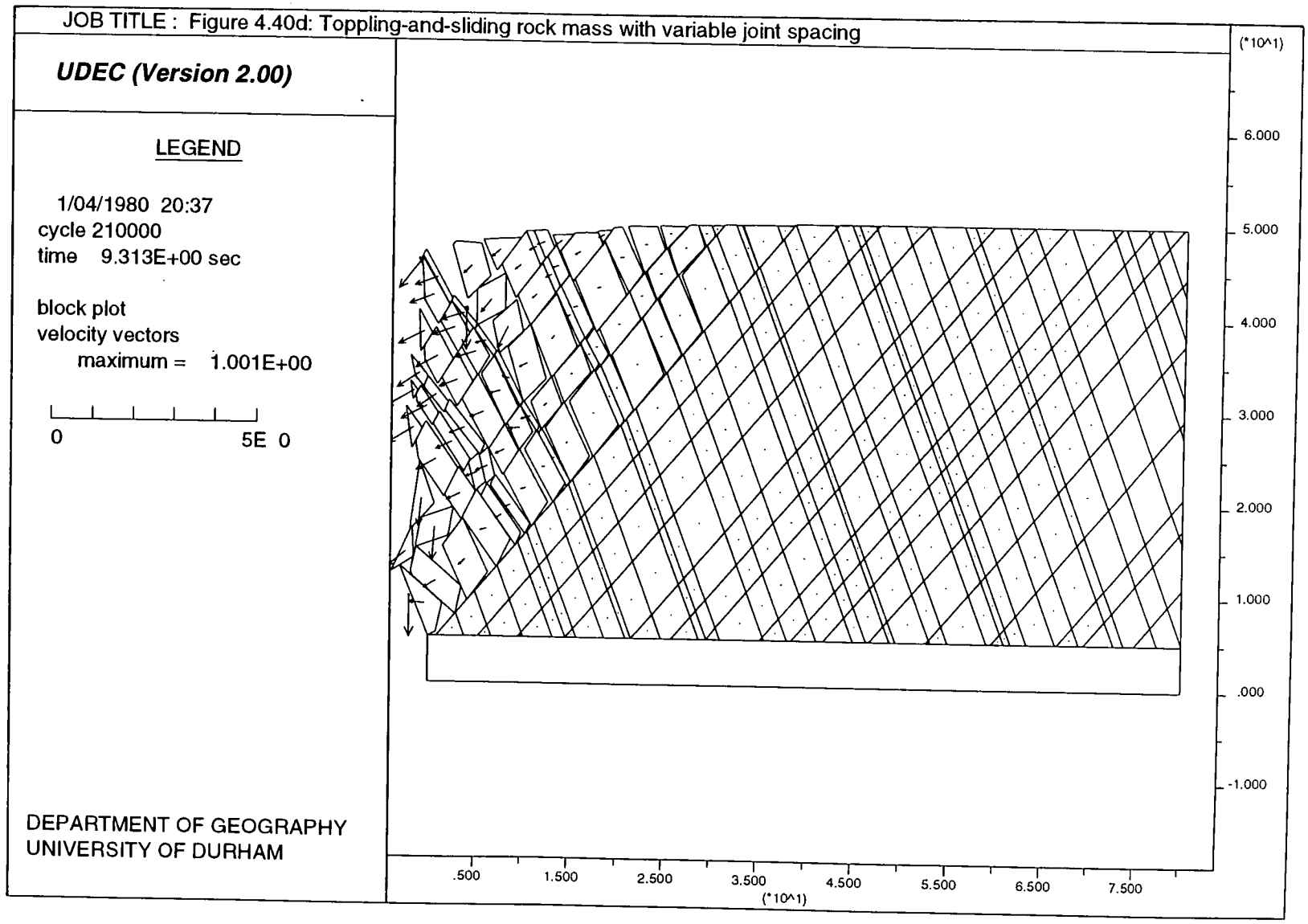
block plot
velocity vectors
maximum = 3.495E-07

0 2E -6

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 4.40c: Sliding mass which contains variable joint spacings.
UDEC (Version 2.00)
LEGEND
1/04/1980 20:36
cycle 210000
time 1.265E+01 sec
block plot
velocity vectors
maximum = 1.958E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)


JOB TITLE : Figure 4.40d: Toppling-and-sliding rock mass with variable joint spacing
UDEC (Version 2.00)
LEGEND
1/04/1980 20:37
cycle 210000
time 9.313E+00 sec
block plot
velocity vectors
maximum = 1.001E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

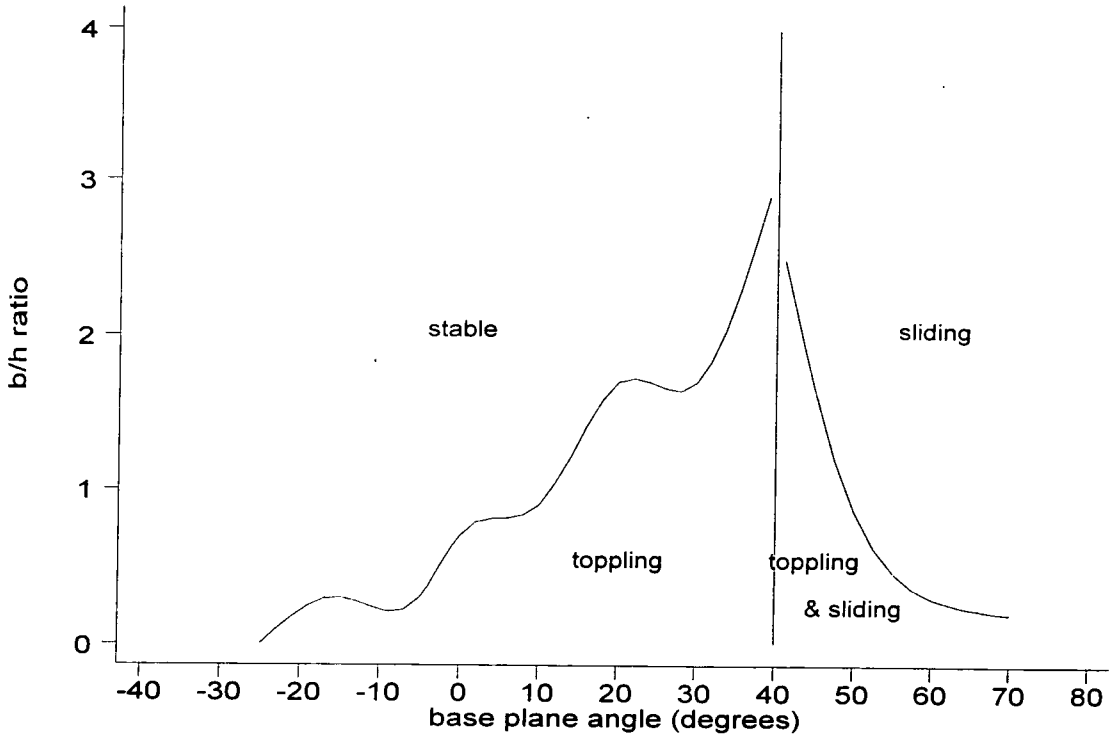


Figure 4.41: Limiting conditions for sliding, toppling and stable rock masses which contain variable discontinuity dip values.

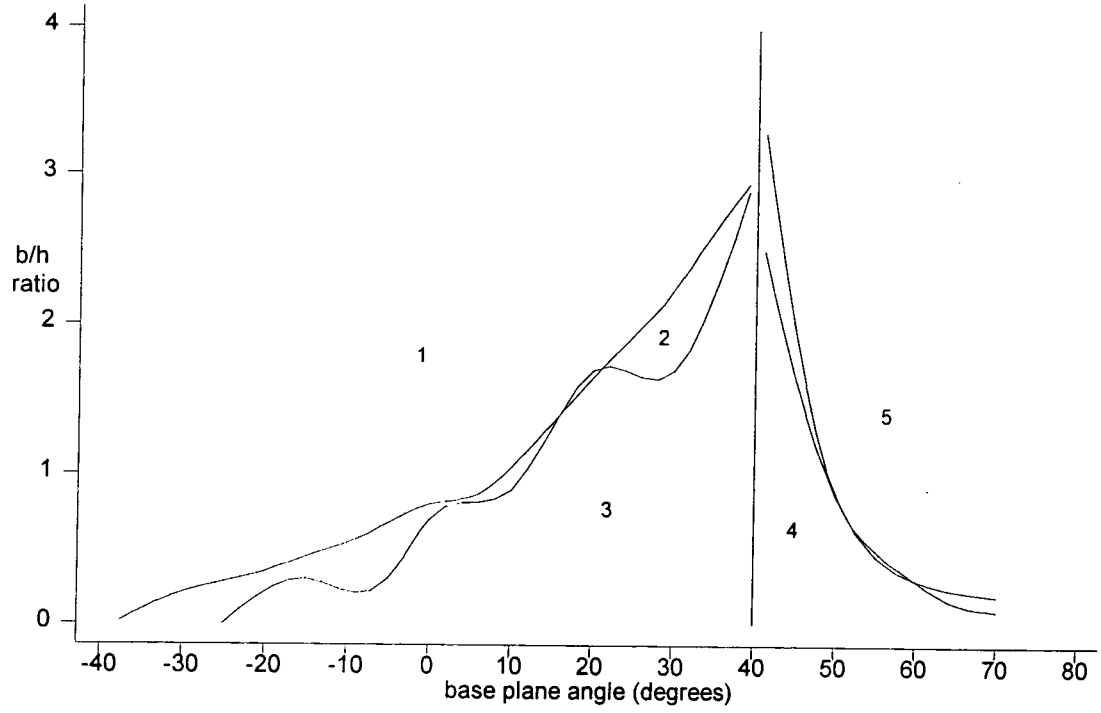
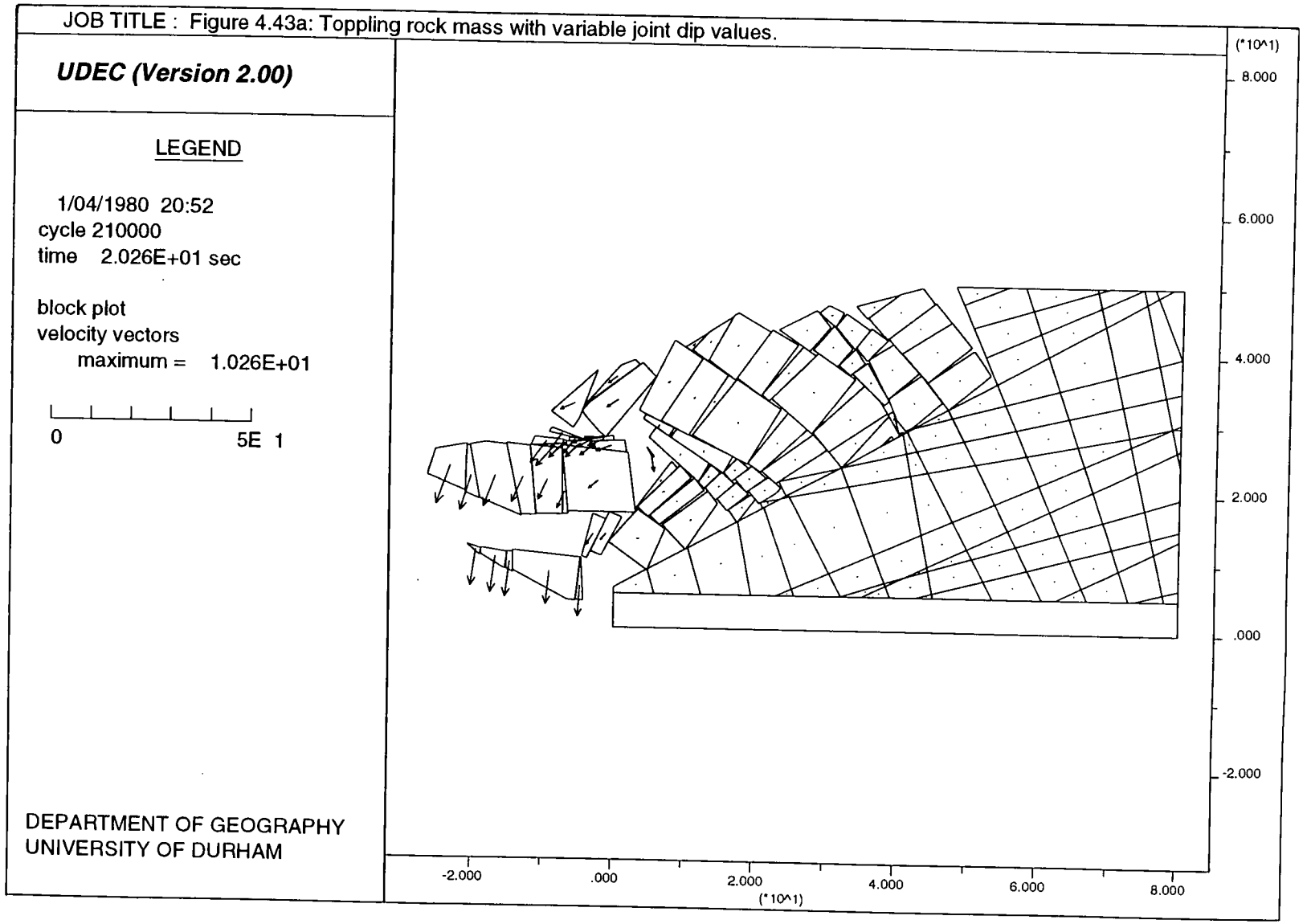


Figure 4.42: Limiting conditions for the failure of rock masses containing variable discontinuity dip values compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.41. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Variable dip
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Toppling-and-sliding	Toppling-and-sliding
5	Sliding	Sliding


JOB TITLE : Figure 4.43a: Toppling rock mass with variable joint dip values.
UDEC (Version 2.00)
LEGEND
1/04/1980 20:52
cycle 210000
time 2.026E+01 sec
block plot
velocity vectors
maximum = 1.026E+01
0
5E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
8.000
6.000
4.000
2.000
.000
-2.000
-2.000
.000
2.000
4.000
6.000
8.000
(*10^1)

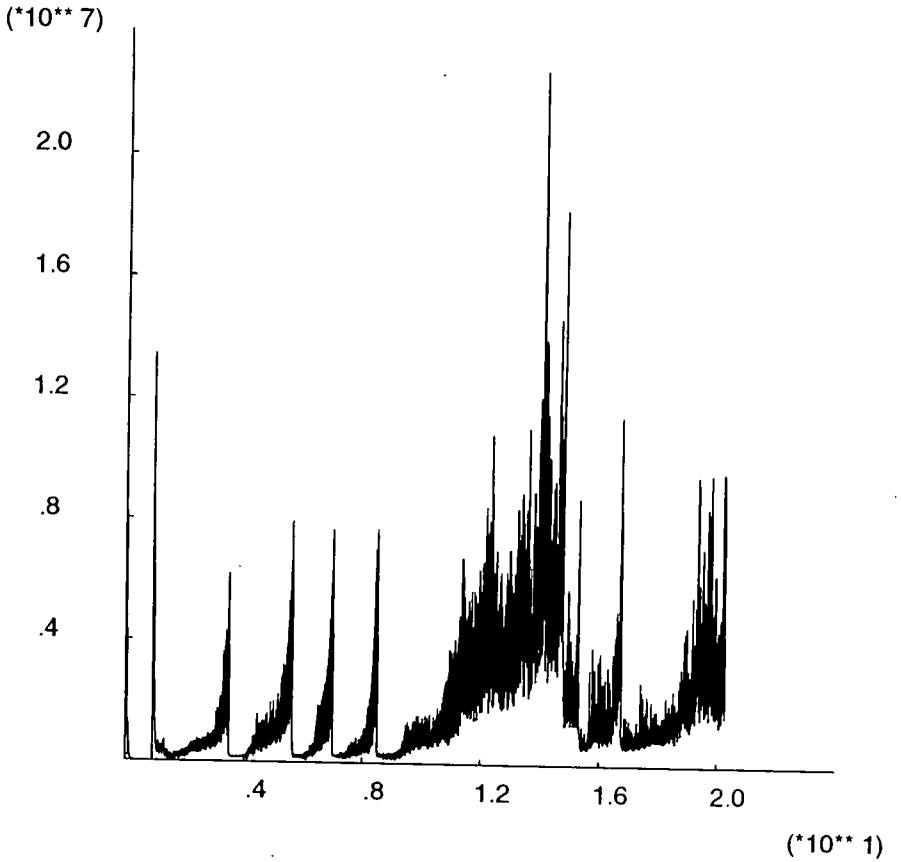
JOB TITLE : Figure 4.43b: Forces for a toppling mass with variable joint dip values.

UDEC (Version 2.00)

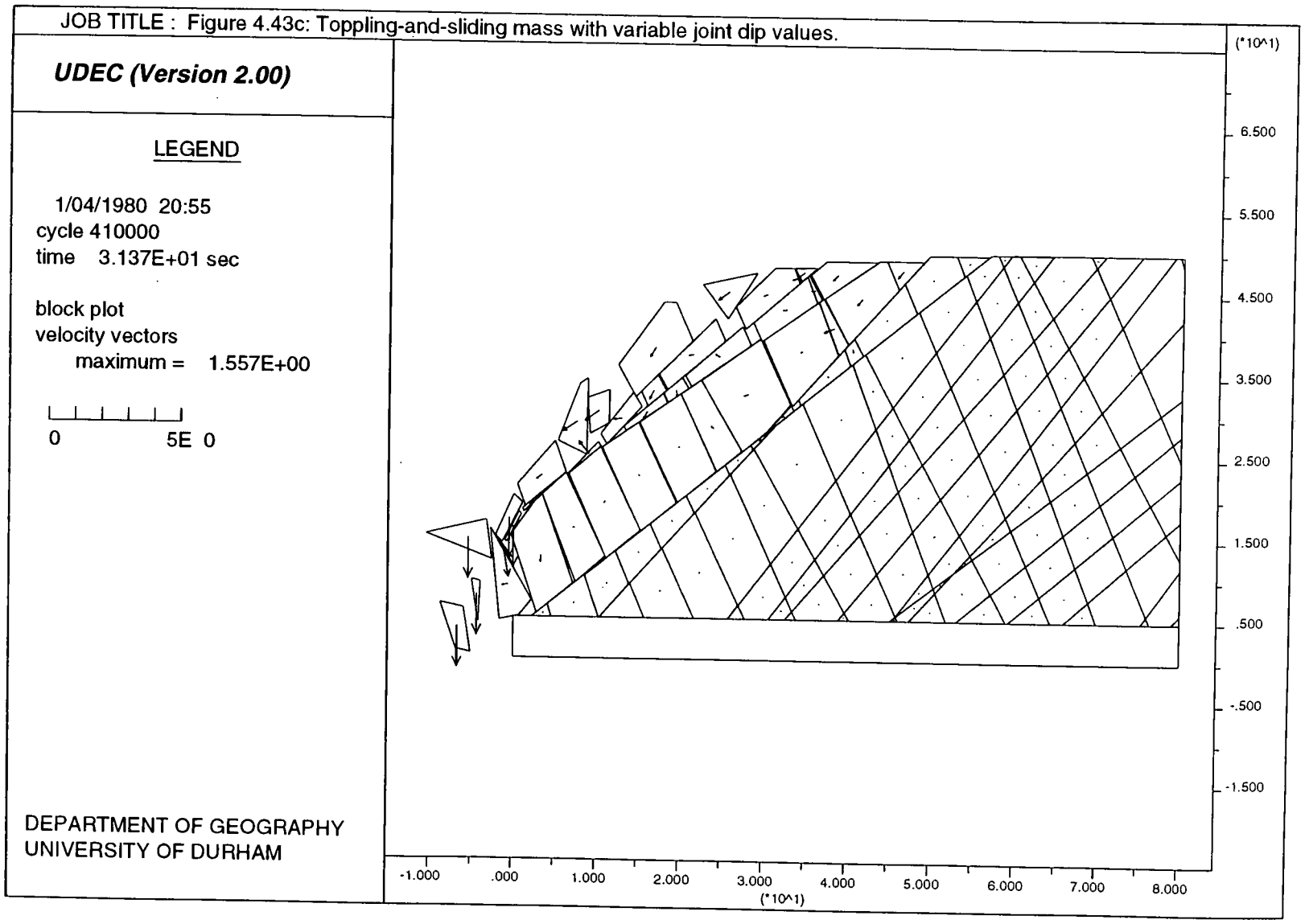
LEGEND

1/04/1980 20:54
cycle 210000
time 2.026E+01 sec

1.26E+01 <hist 2> 2.28E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 4.43c: Toppling-and-sliding mass with variable joint dip values.
UDEC (Version 2.00)
LEGEND
1/04/1980 20:55
cycle 410000
time 3.137E+01 sec
block plot
velocity vectors
maximum = 1.557E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-1.000
.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
(*10^1)

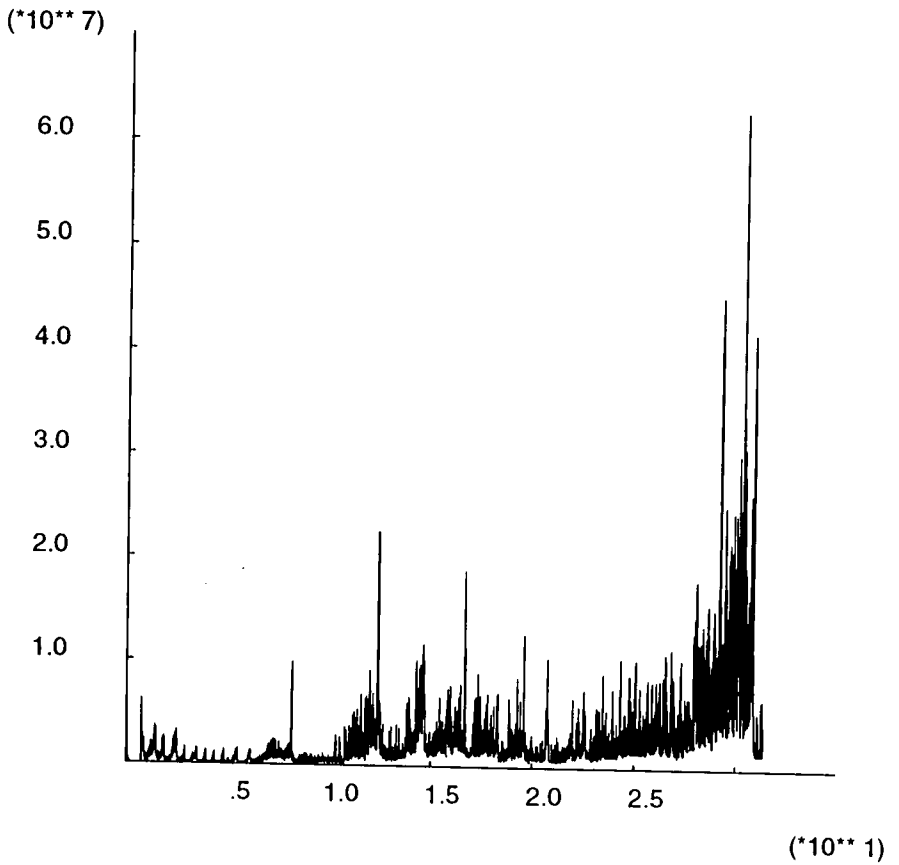
JOB TITLE : Figure 4.43d: Forces for a toppling-and-sliding mass with variable dip.

UDEC (Version 2.00)

LEGEND

1/04/1980 20:56
cycle 410000
time 3.137E+01 sec

2.95E+00 <hist 2> 6.30E+07———



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

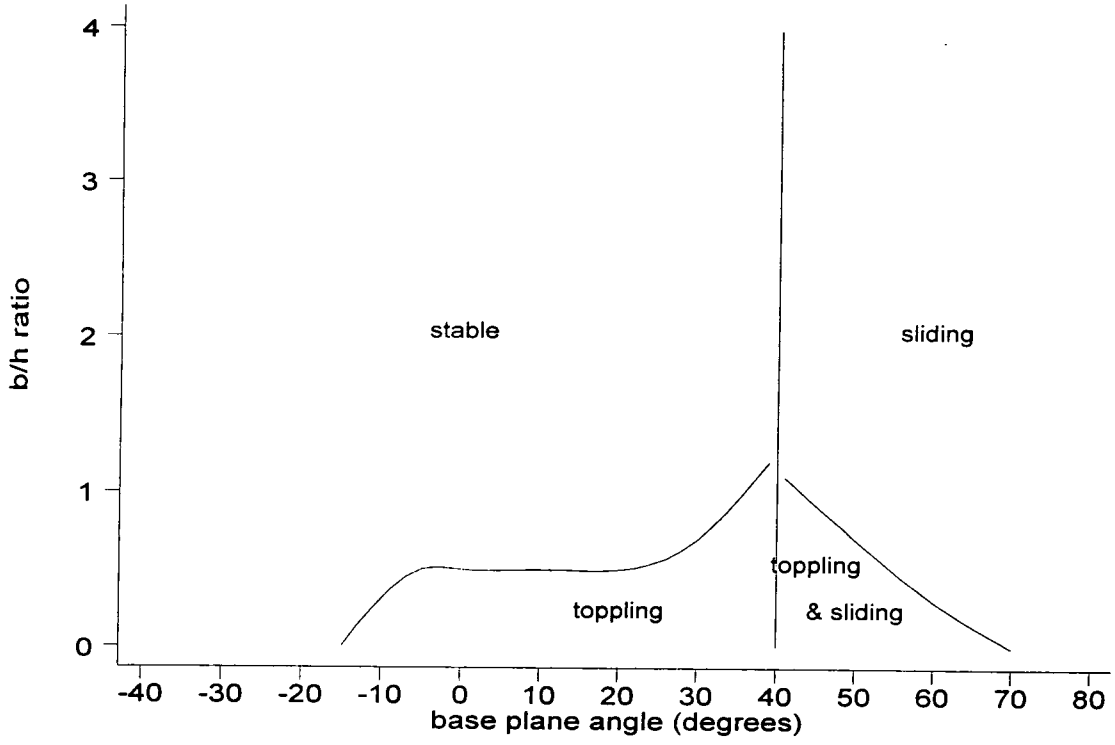


Figure 4.44: Limiting conditions for sliding, toppling and stable rock masses which contain impersistent discontinuities.

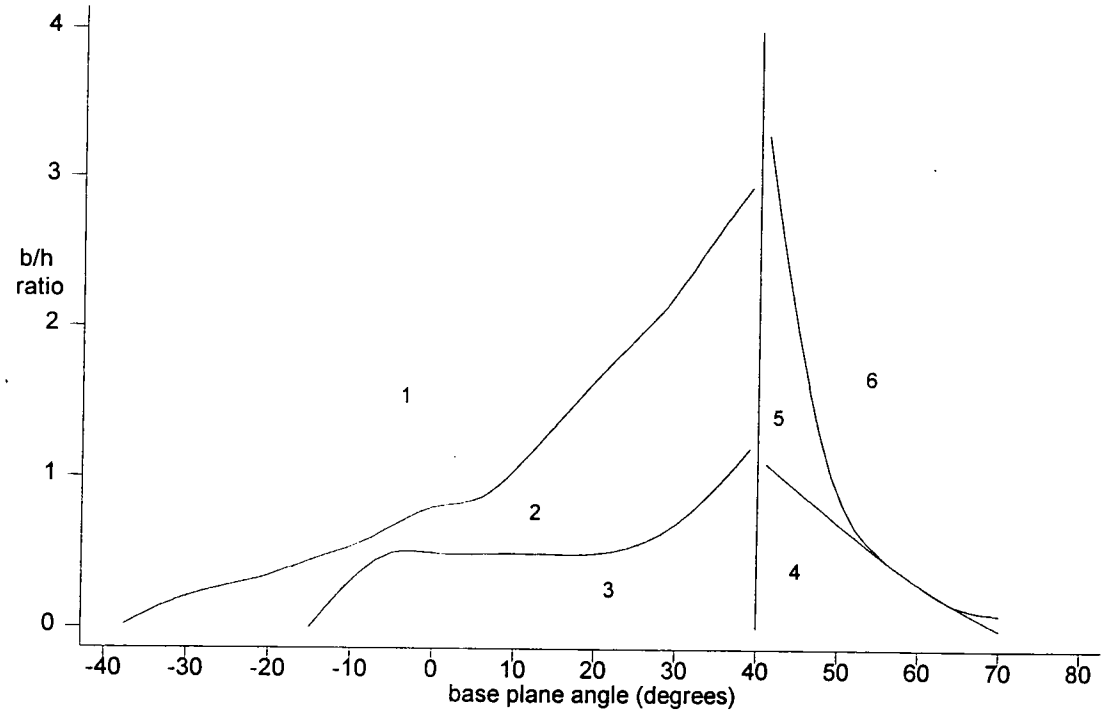


Figure 4.45: Limiting conditions for the failure of rock masses containing impersistent discontinuities compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.44. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Impersistent rock masses
1	Stable	Stable
2	Toppling	Stable
3	Toppling	Toppling
4	Toppling-and-sliding	Toppling-and-sliding
5	Toppling-and-sliding	Sliding
6	Sliding	Sliding

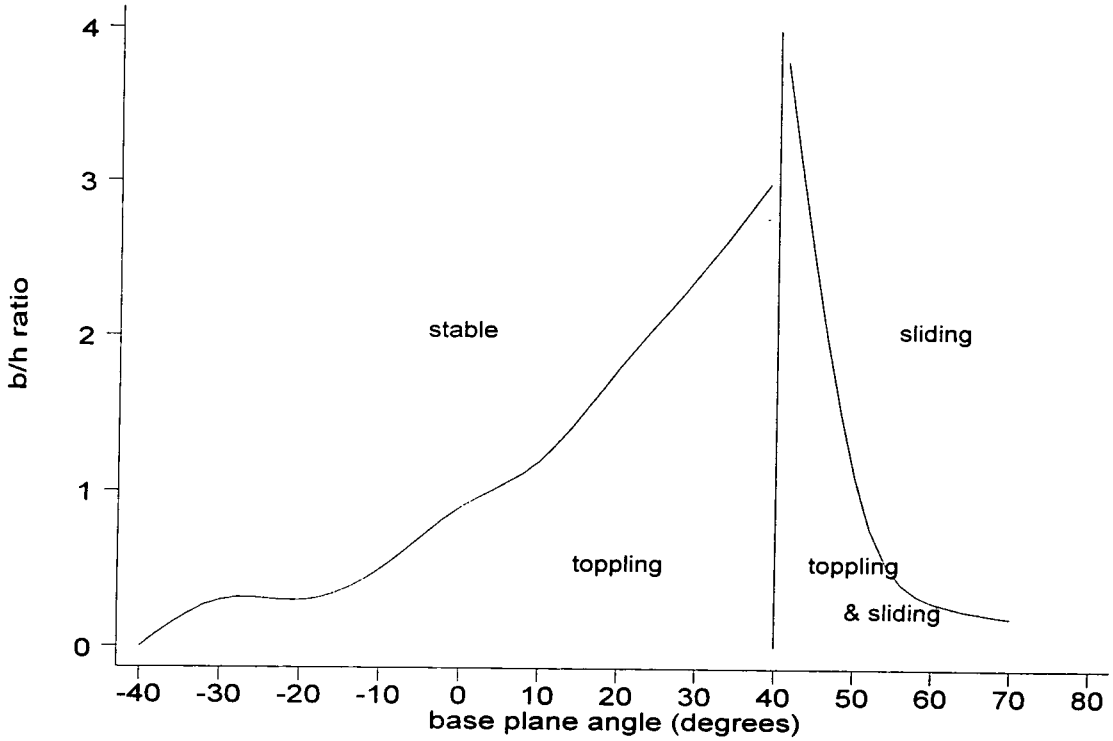


Figure 4.46: Limiting conditions for sliding, toppling and stable rock masses which contain a water table set to 35 metres.

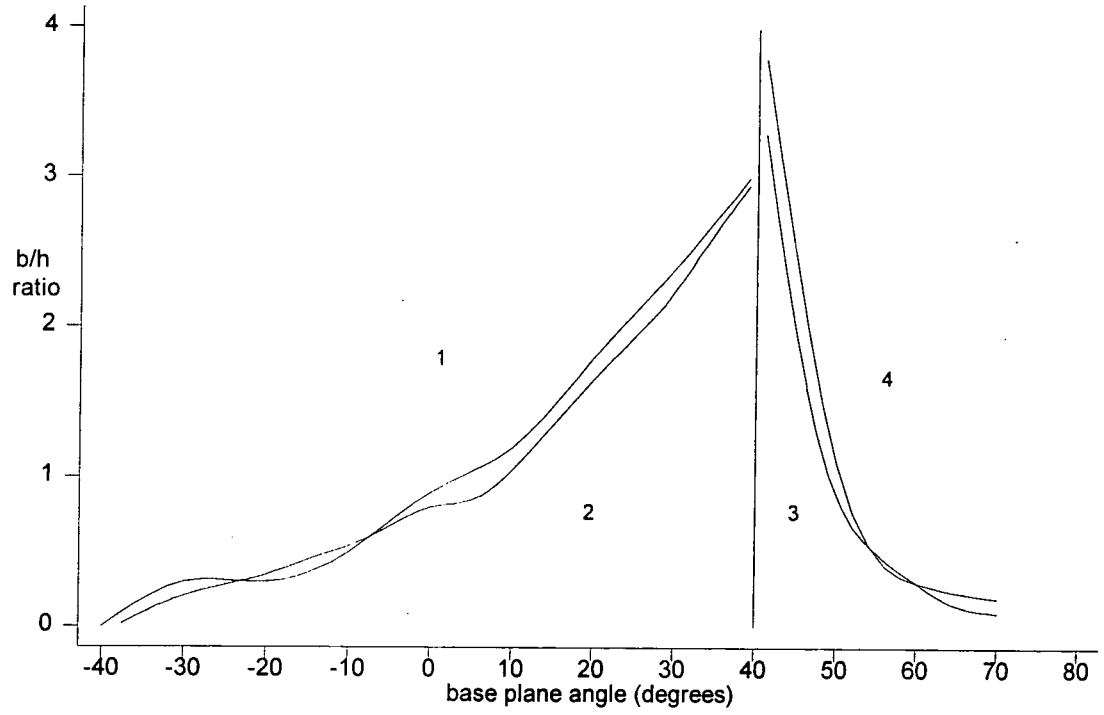
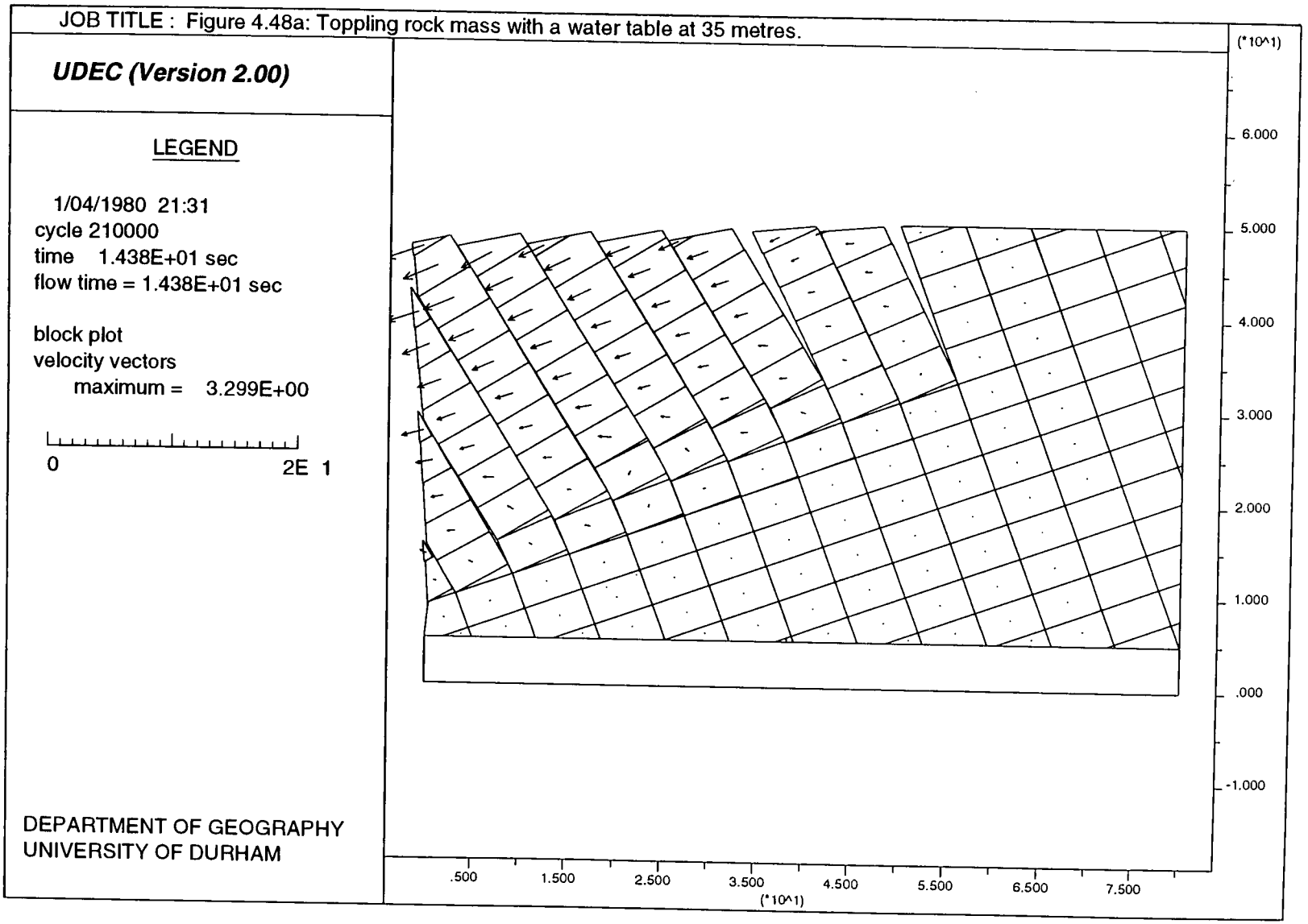


Figure 4.47: Limiting conditions for the failure of rock masses containing a water table set to 35 metres compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.46. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Rock masses with water table
1	Stable	Stable
2	Toppling	Toppling
3	Toppling-and-sliding	Toppling-and-sliding
4	Sliding	Sliding


JOB TITLE : Figure 4.48a: Toppling rock mass with a water table at 35 metres.
UDEC (Version 2.00)
LEGEND
1/04/1980 21:31
cycle 210000
time 1.438E+01 sec
flow time = 1.438E+01 sec
block plot
velocity vectors
maximum = 3.299E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

JOB TITLE : Figure 4.48b: Flow rate of water in a toppling rock mass.

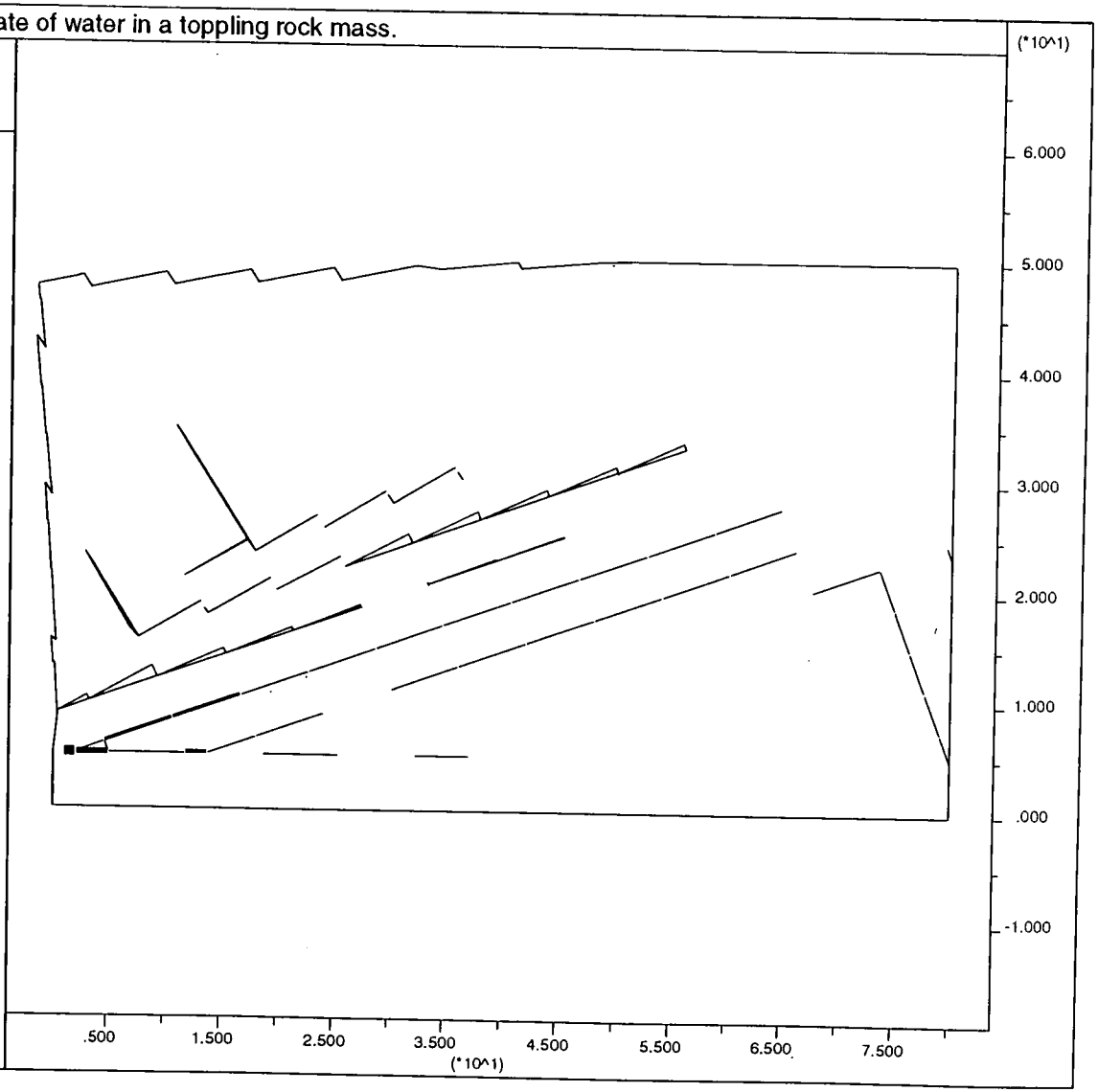
UDEC (Version 2.00)

LEGEND

1/04/1980 21:33
cycle 210000
time 1.438E+01 sec
flow time = 1.438E+01 sec

boundary plot
flow rates
max flow rate = 1.850E+01
each line thick = 3.699E+00

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 4.48c: Pore water pressure in a toppling rock mass.

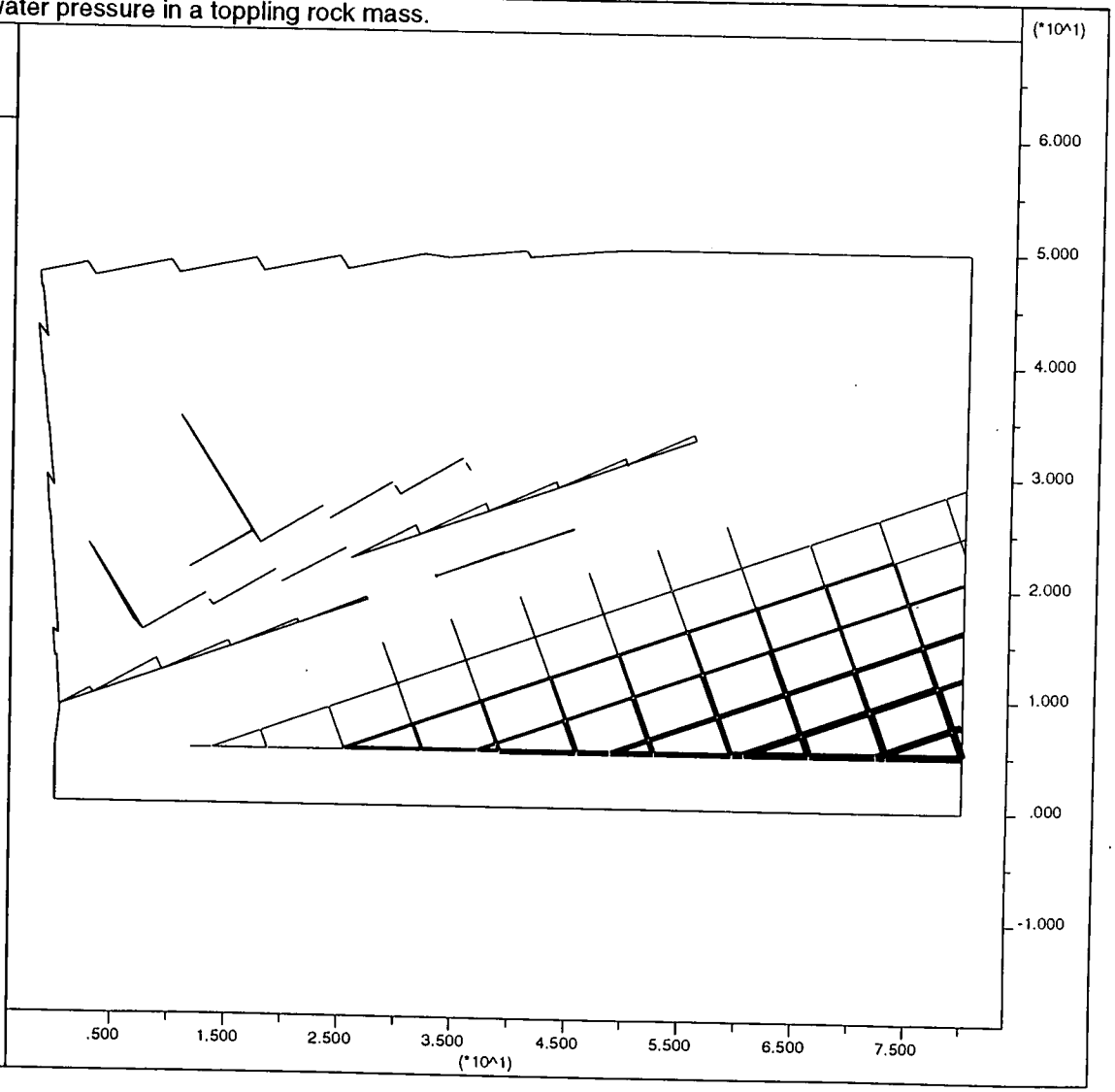
UDEC (Version 2.00)

LEGEND

1/04/1980 21:33
cycle 210000
time 1.438E+01 sec
flow time = 1.438E+01 sec

boundary plot
domain pore pressures
maximum pressure = 2.890E+05
each line thick = 5.780E+04

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 4.48d: Flow rate in a stable rock mass.

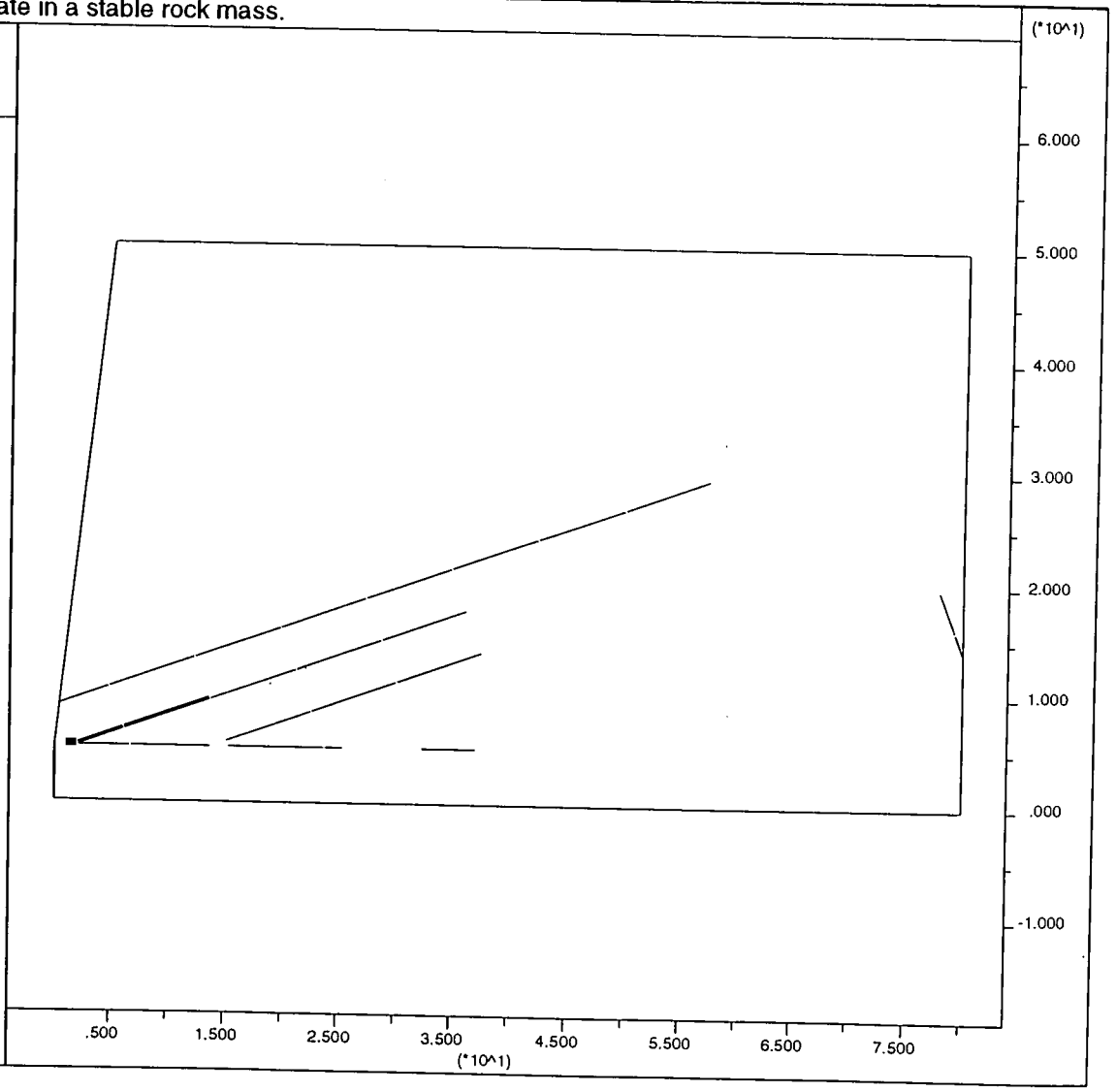
UDEC (Version 2.00)

LEGEND

1/04/1980 21:35
cycle 210000
time 2.522E+01 sec
flow time = 2.522E+01 sec

boundary plot
flow rates
max flow rate = 1.508E+01
each line thick = 3.016E+00

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 4.48e: Pore water pressure in a stable rock mass.

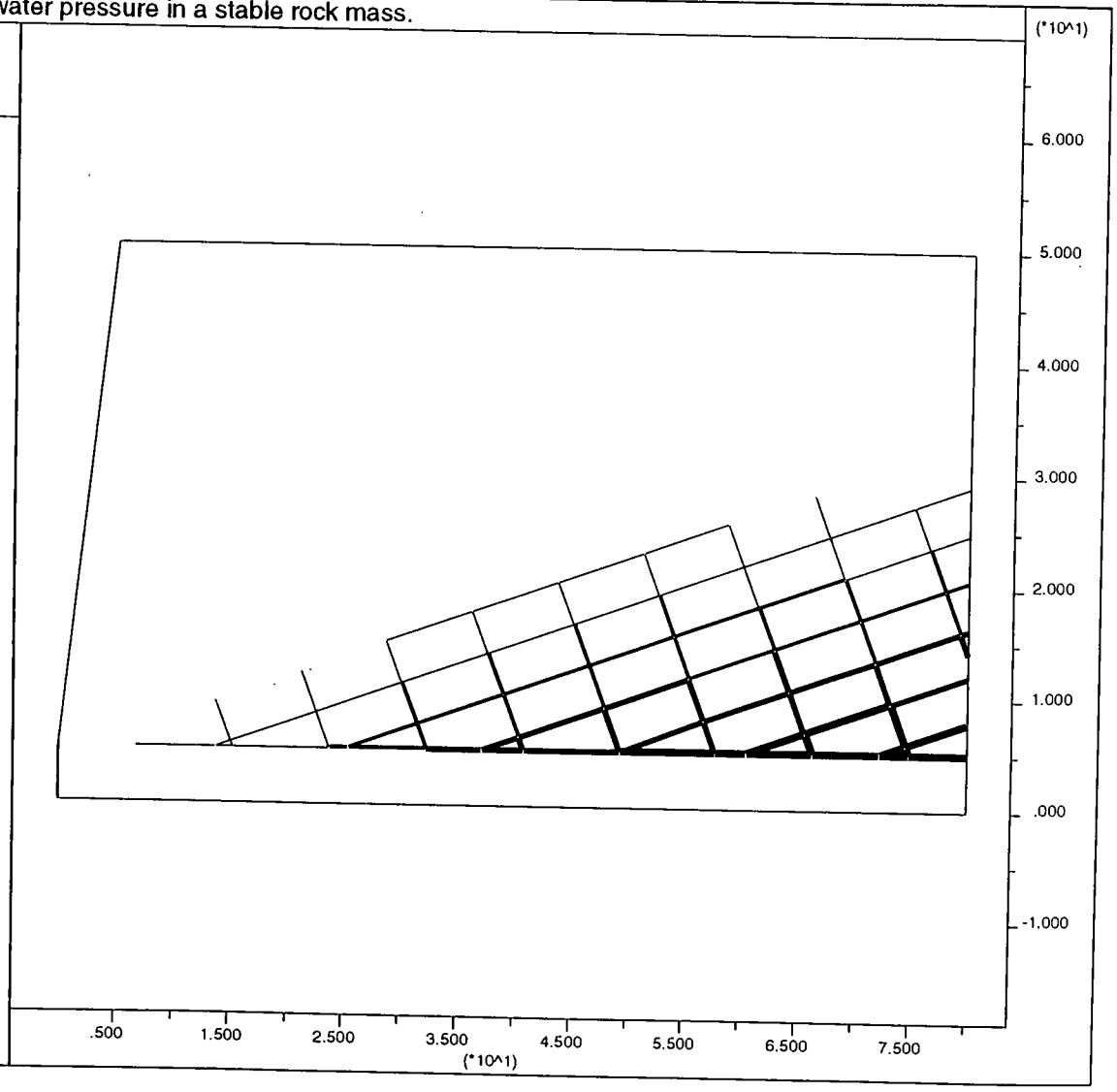
UDEC (Version 2.00)

LEGEND

1/04/1980 21:36
cycle 210000
time 2.522E+01 sec
flow time = 2.522E+01 sec

boundary plot
domain pore pressures
maximum pressure = 2.923E+05
each line thick = 5.846E+04

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



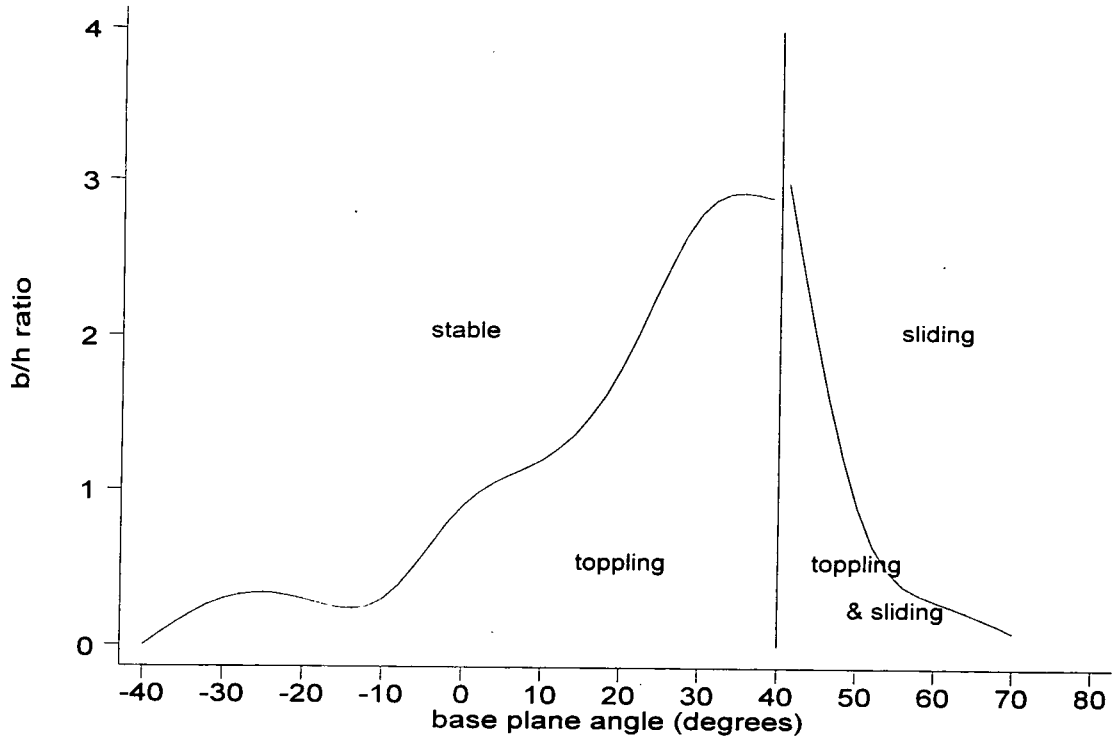


Figure 4.49: Limiting conditions for sliding, toppling and stable rock masses which contain a water table set to 50 metres.

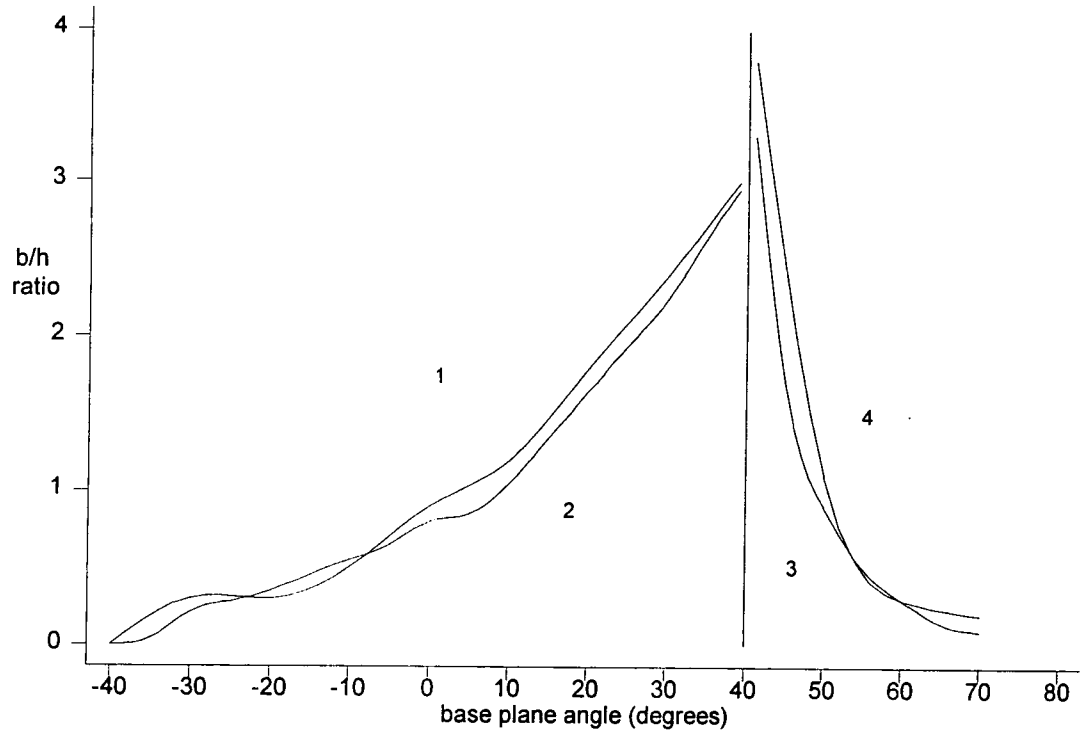


Figure 4.50: Limiting conditions for the failure of rock masses containing a water table set to 50 metres compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.49. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Rock masses with water table
1	Stable	Stable
2	Toppling	Toppling
3	Toppling-and-sliding	Toppling-and-sliding
4	Sliding	Sliding

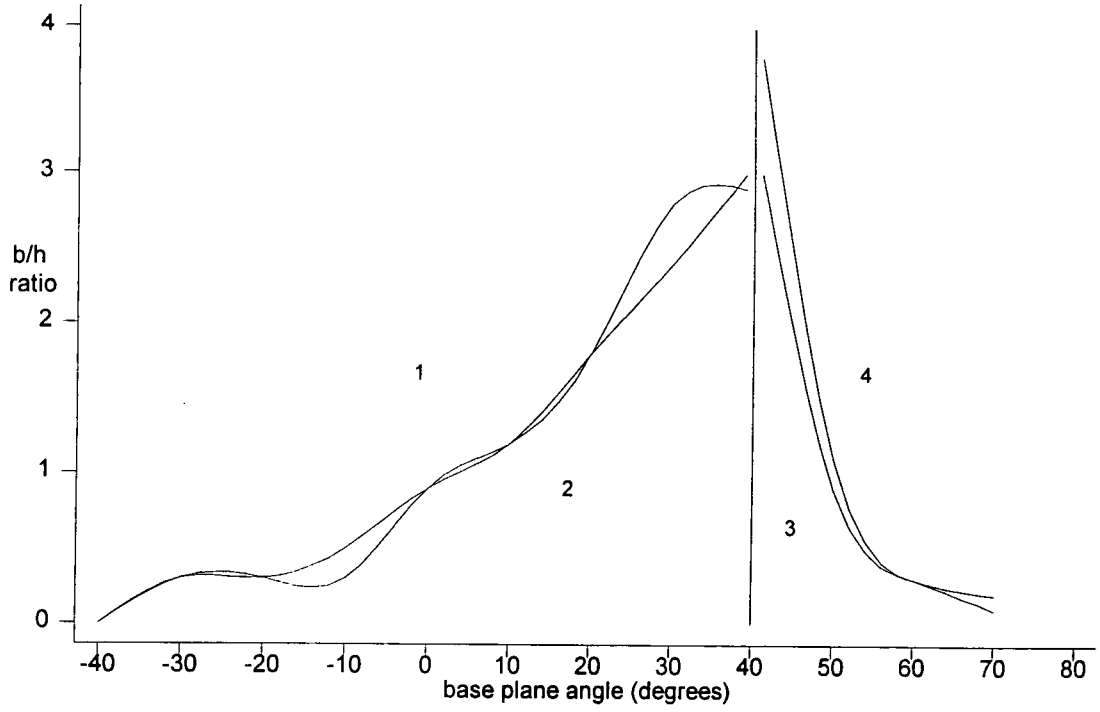


Figure 4.51: Limiting conditions for the failure of rock masses containing a water table set to 50 metres compared with the limiting conditions for the failure of rock masses containing a water table set to 35 metres.

The boundaries between the mechanisms of failure are taken from Figures 4.46 and 4.49. Zones on the graph are delimited by the boundary lines:

Zone	Water table = 50 m	Water table = 35 m
1	Stable	Stable
2	Toppling	Toppling
3	Toppling-and-sliding	Toppling-and-sliding
4	Sliding	Sliding

JOB TITLE : Figure 4.52a: Toppling-and-sliding mass with a water table at 50 metres.

UDEC (Version 2.00)

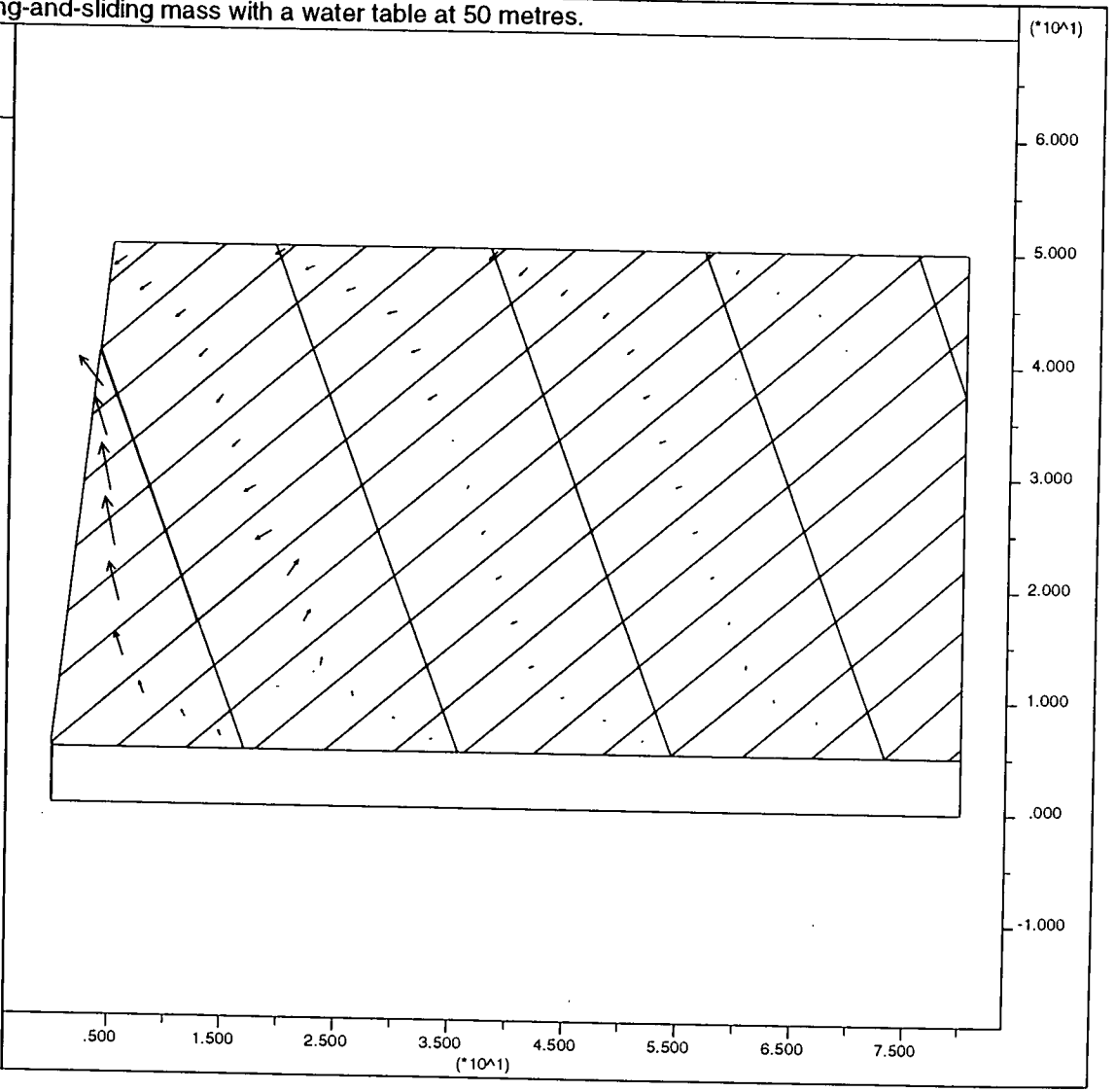
LEGEND

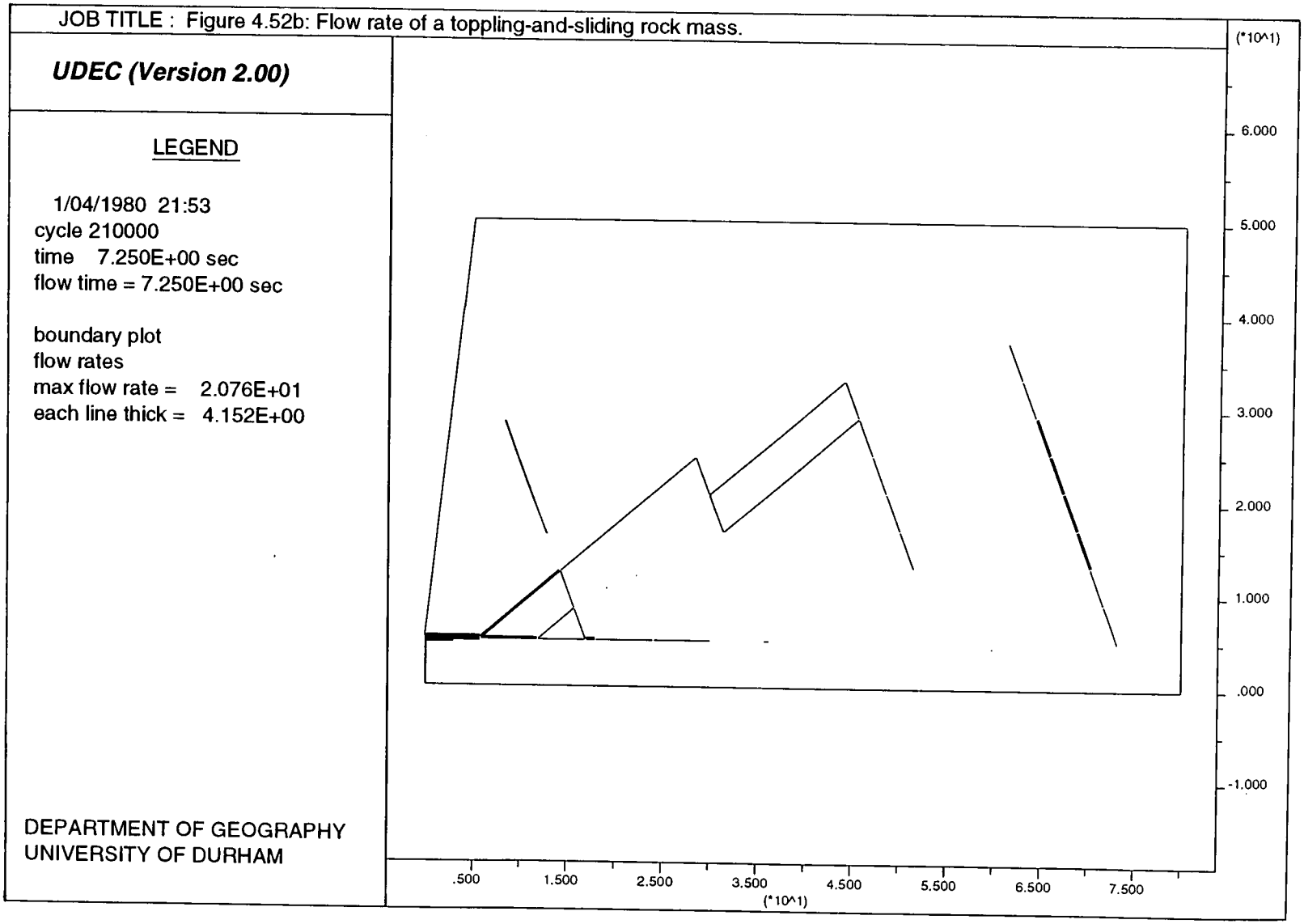
1/04/1980 21:53
cycle 210000
time 7.250E+00 sec
flow time = 7.250E+00 sec

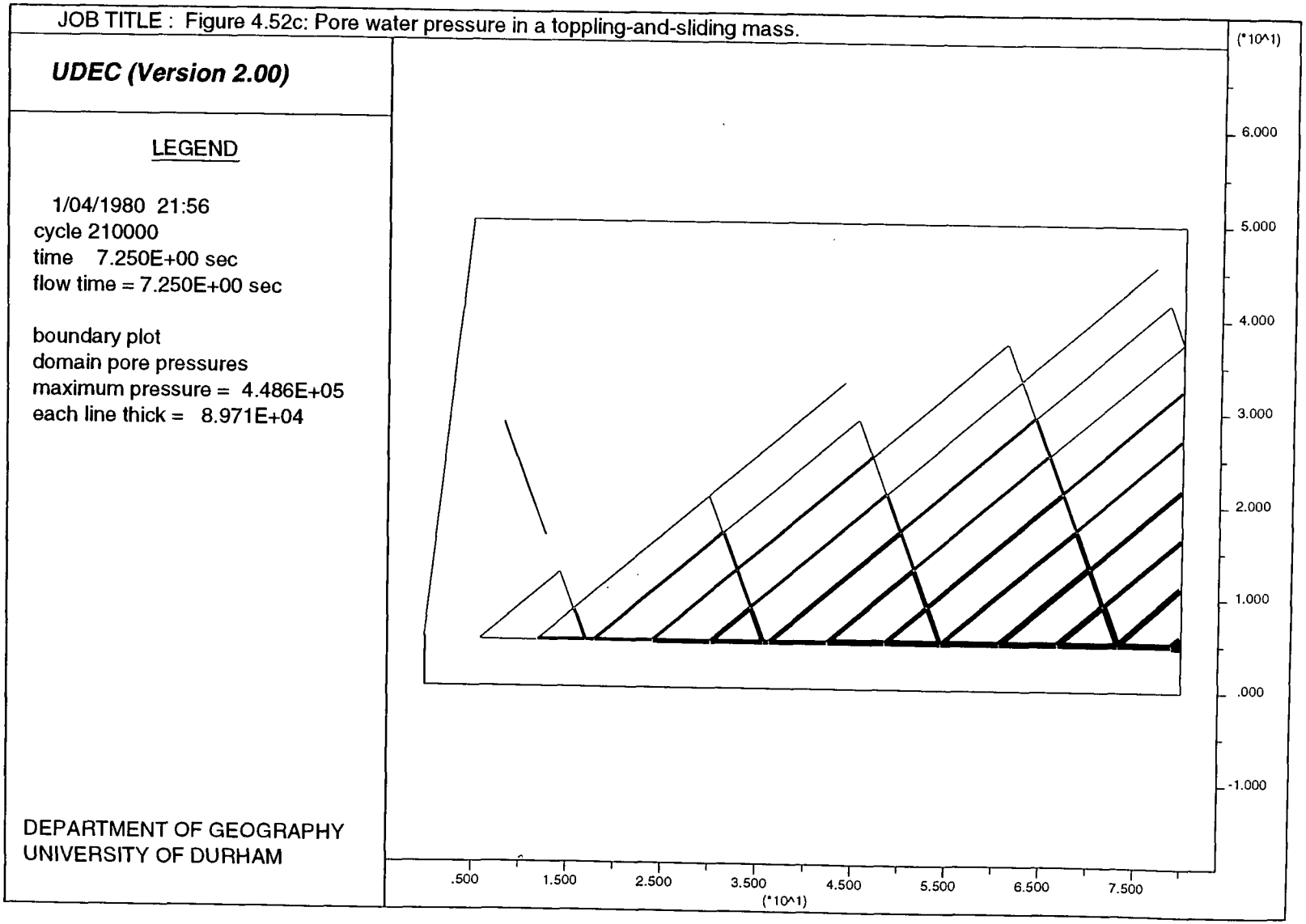
block plot
velocity vectors
maximum = 2.765E-03

0 1E -2

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 4.52b: Flow rate of a toppling-and-sliding rock mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 21:53
cycle 210000
time 7.250E+00 sec
flow time = 7.250E+00 sec
boundary plot
flow rates
max flow rate = 2.076E+01
each line thick = 4.152E+00
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 4.52c: Pore water pressure in a toppling-and-sliding mass.
UDEC (Version 2.00)
LEGEND
1/04/1980 21:56
cycle 210000
time 7.250E+00 sec
flow time = 7.250E+00 sec
boundary plot
domain pore pressures
maximum pressure = 4.486E+05
each line thick = 8.971E+04
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

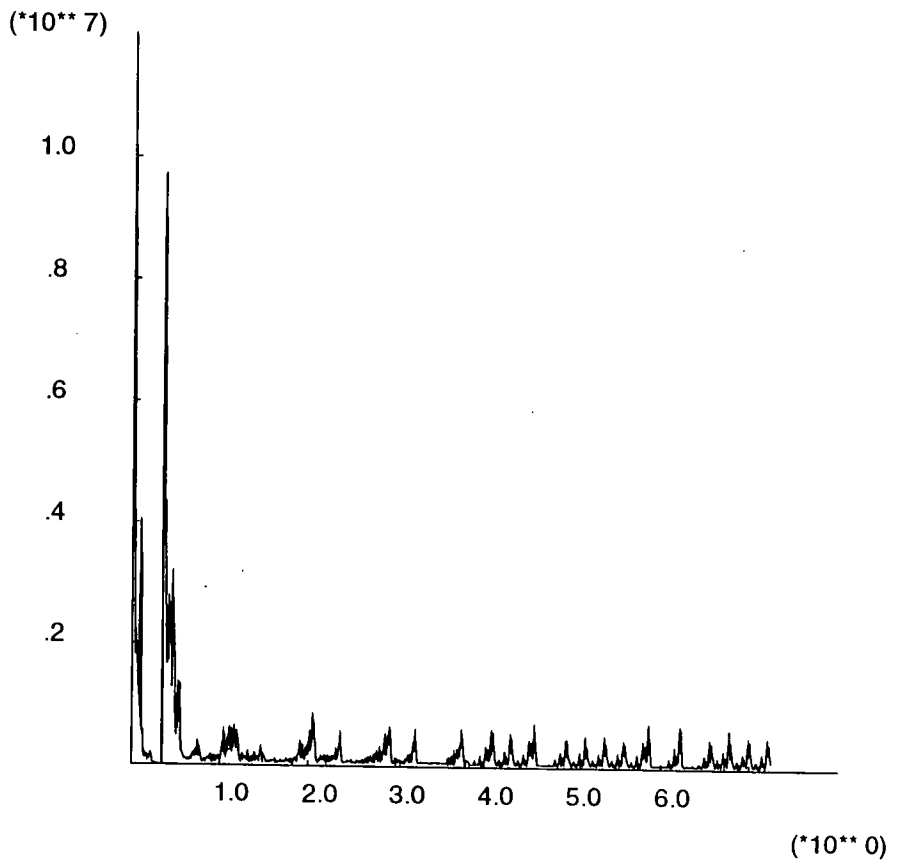
JOB TITLE : Figure 4.52d: Forces for a toppling-and-sliding mass with a water table.

UDEC (Version 2.00)

LEGEND

1/04/1980 21:57
cycle 210000
time 7.250E+00 sec
flow time = 7.250E+00 sec

1.36E+03 <hist 2> 1.19E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

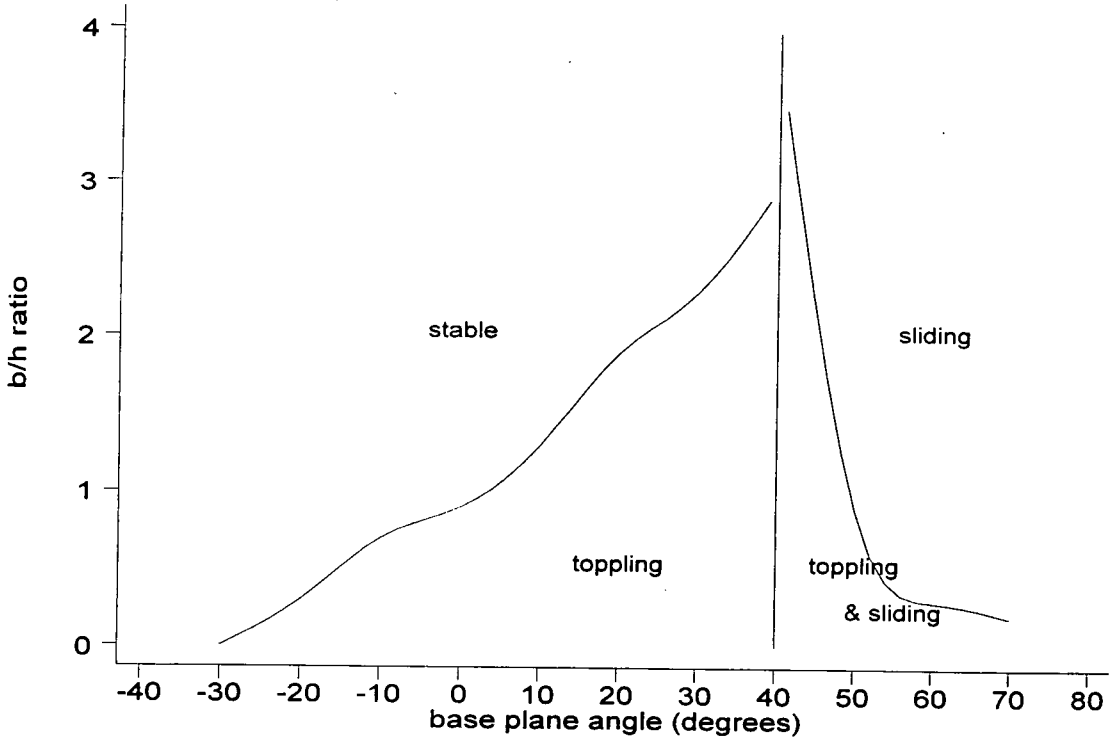


Figure 4.53: Limiting conditions for sliding, toppling and stable rock masses which have joint stiffness values set to 5 GPa.

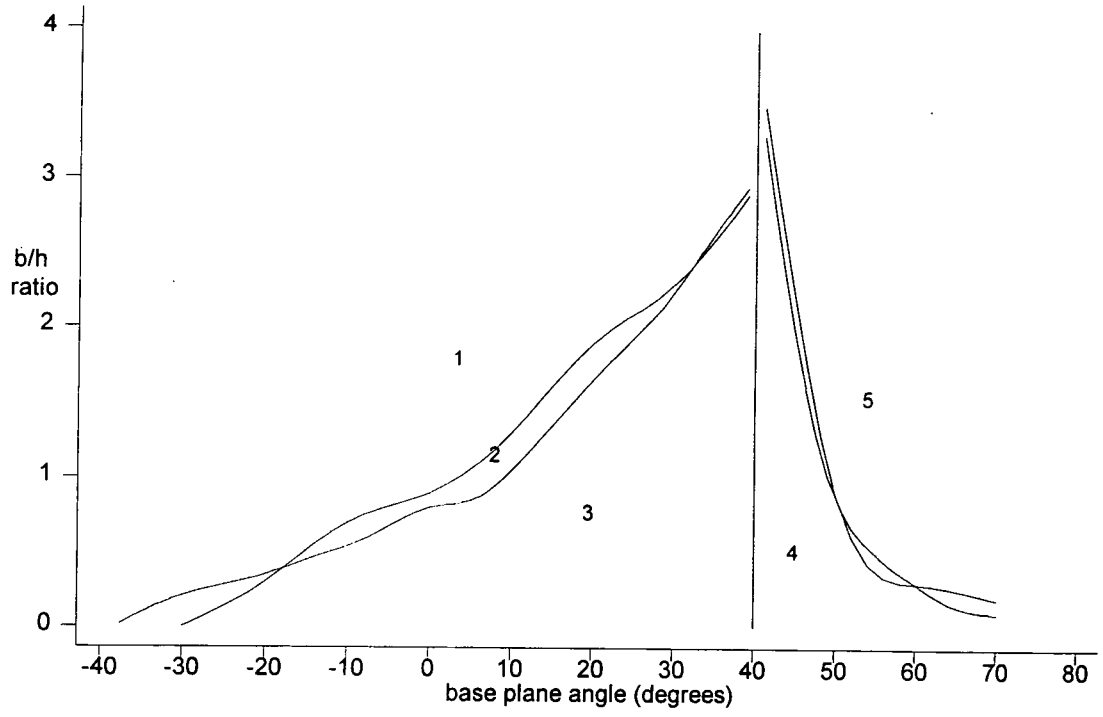


Figure 4.54: Limiting conditions for the failure of rock masses which have joint stiffness values set to 5 GPa compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.53. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Joint stiffness = 5 GPa
1	Stable	Stable
2	Stable	Toppling
3	Toppling	Toppling
4	Toppling-and-sliding	Toppling-and-sliding
5	Sliding	Sliding

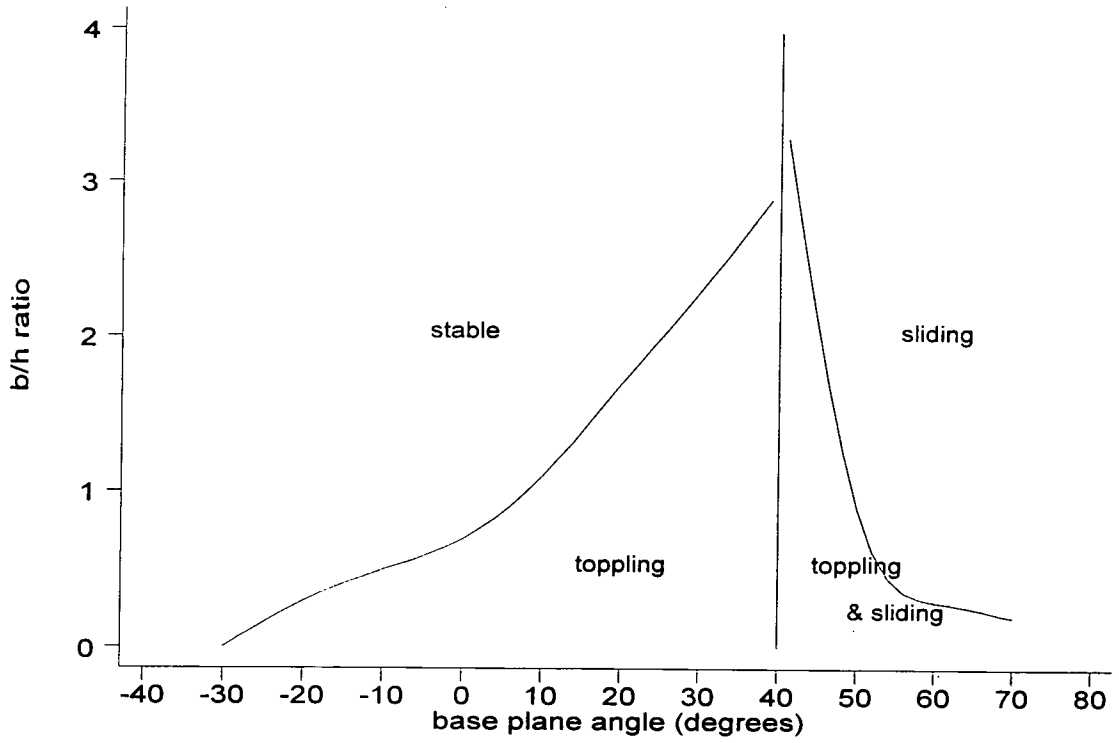


Figure 4.55: Limiting conditions for sliding, toppling and stable rock masses bounded by a wave cut platform.

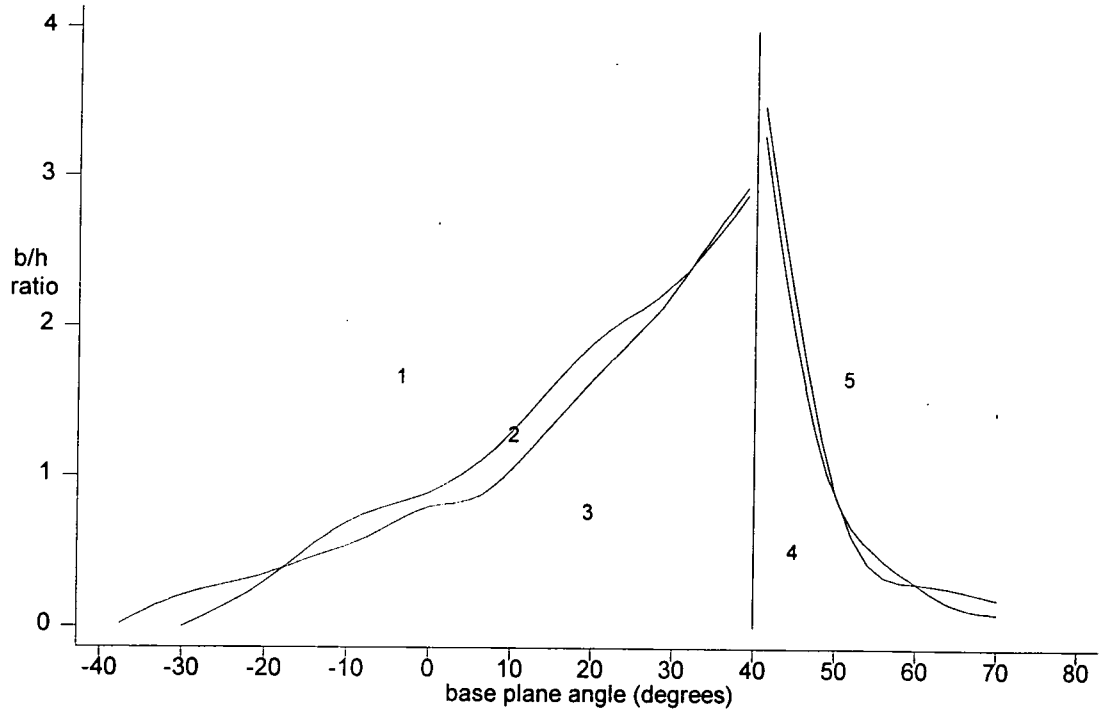


Figure 4.56: Limiting conditions for the failure of rock masses bounded by a wave cut platform compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.55. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Wave cut platform
1	Stable	Stable
2	Stable	Toppling
3	Toppling	Toppling
4	Toppling-and-sliding	Toppling-and-sliding
5	Sliding	Sliding

JOB TITLE : Figure 4.57a: Toppling rock mass bounded by a wave-cut platform.

UDEC (Version 2.00)

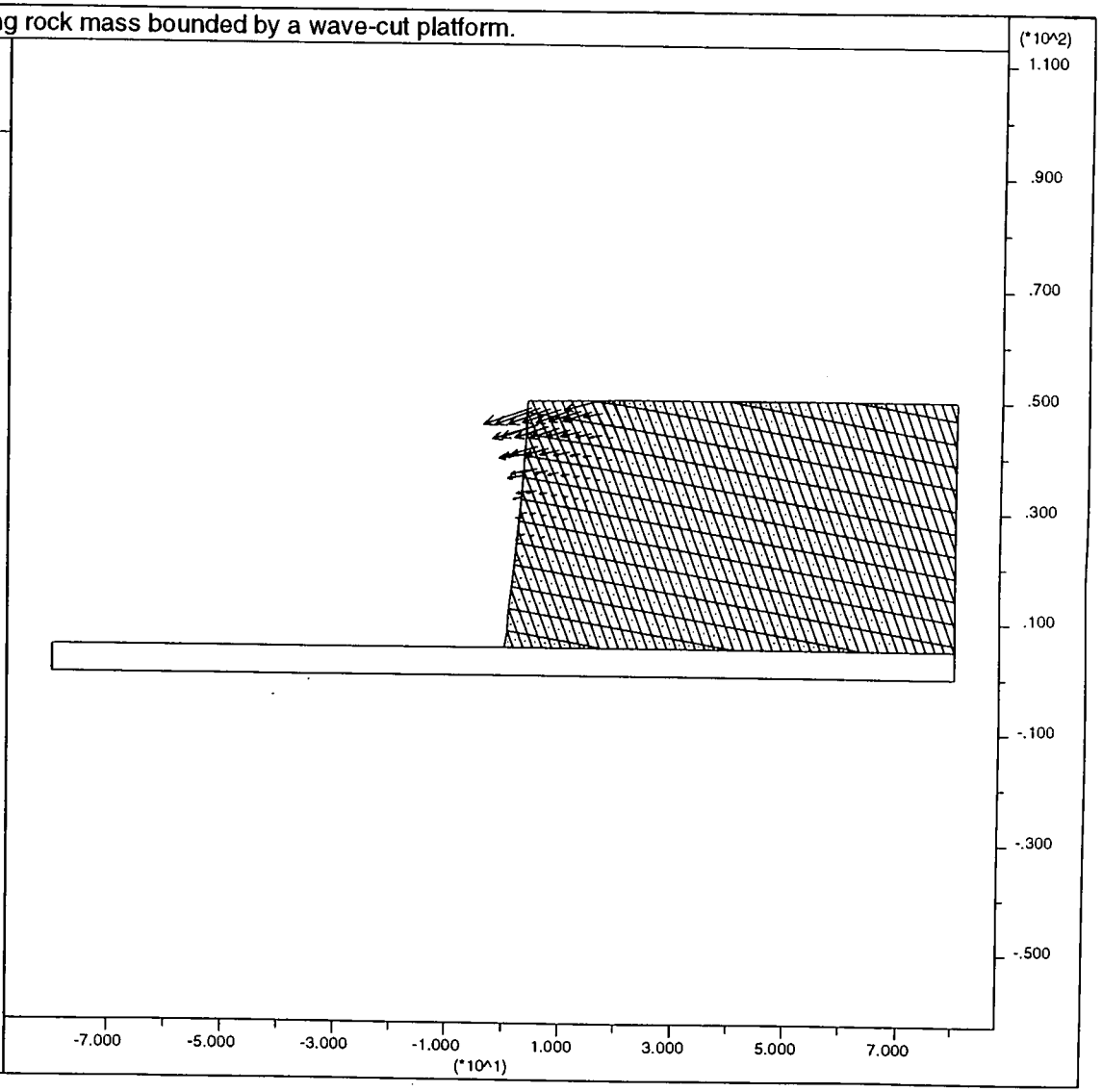
LEGEND

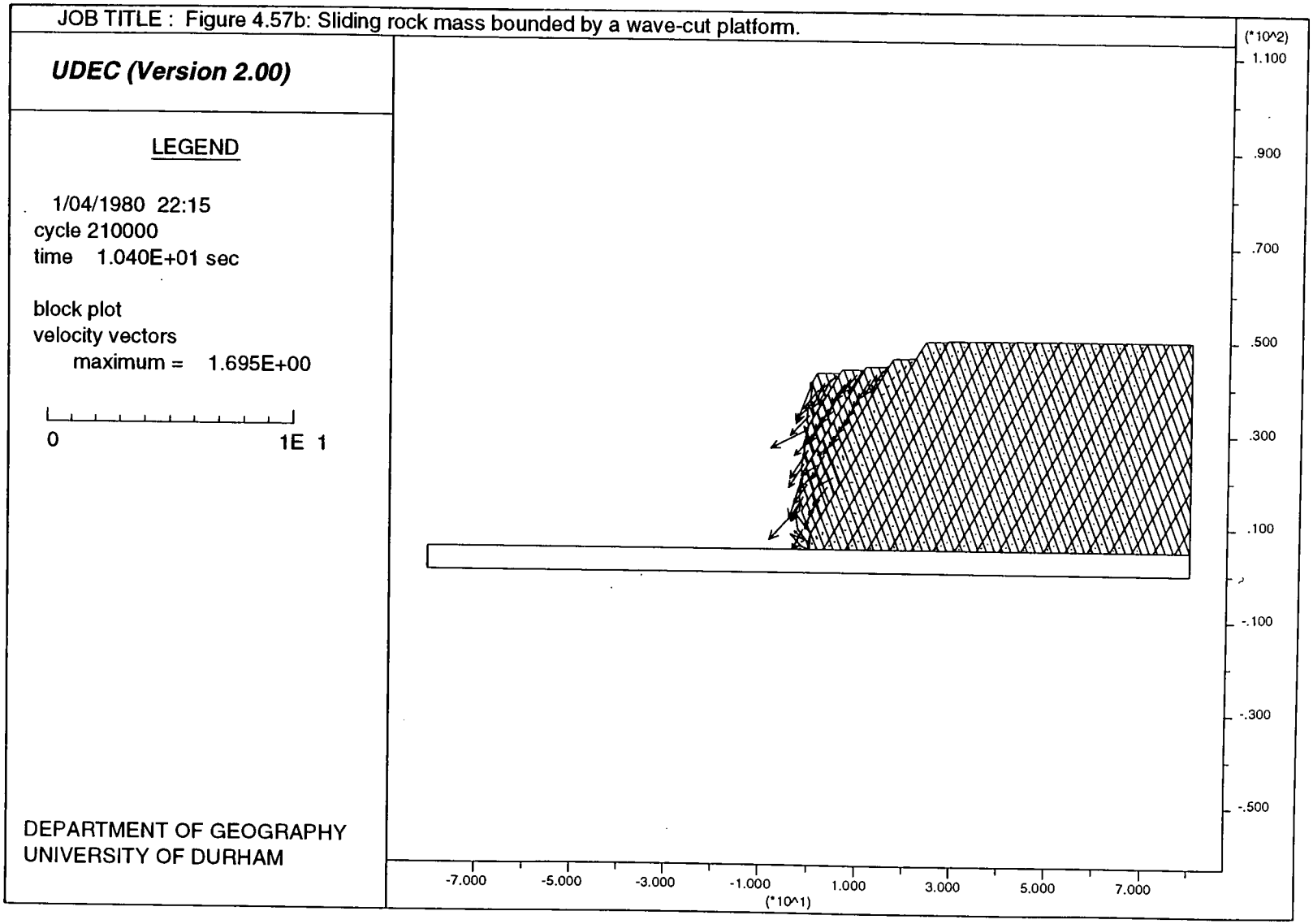
1/04/1980 22:14
cycle 210000
time 2.070E+01 sec

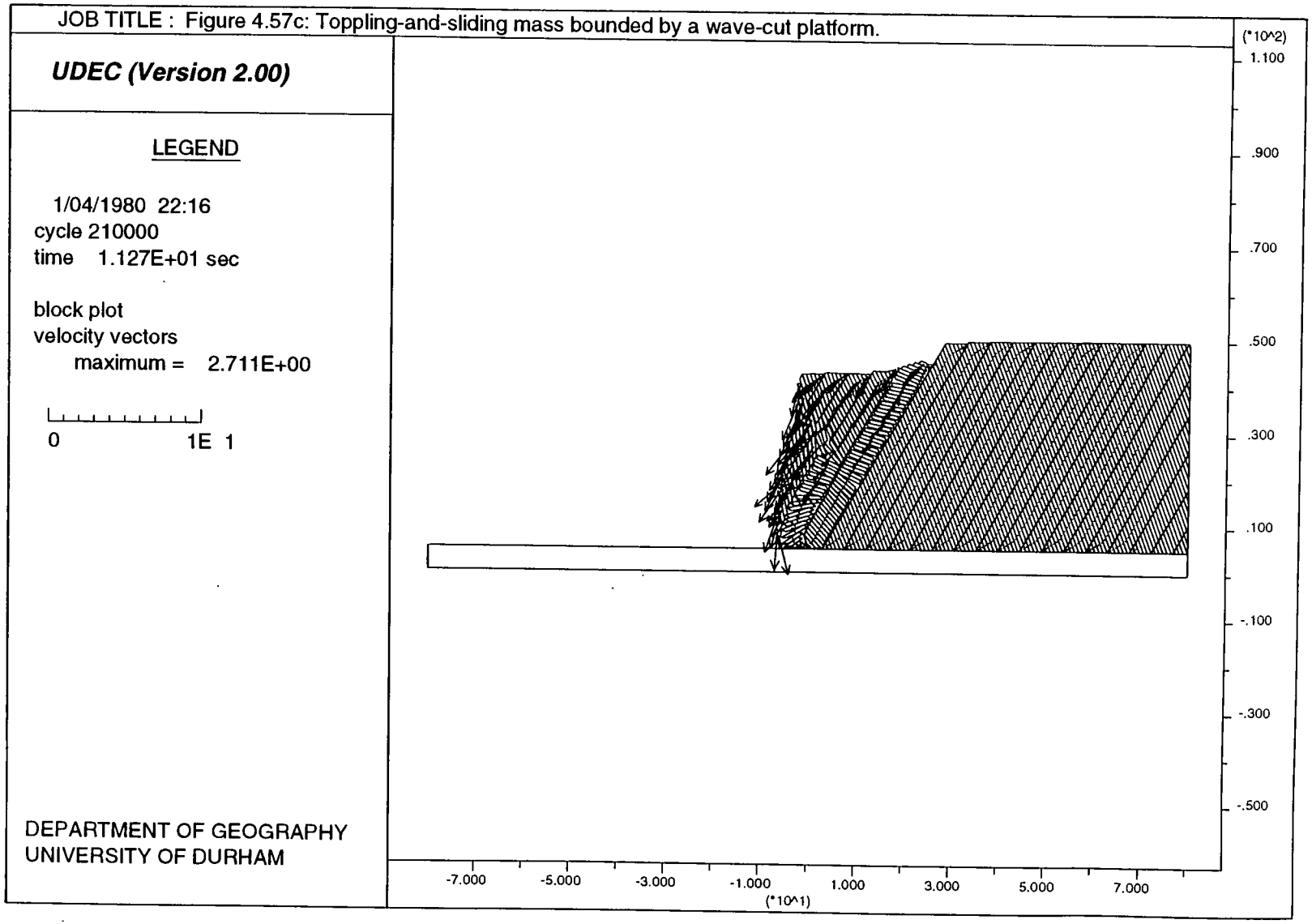
block plot
velocity vectors
maximum = 7.306E-03

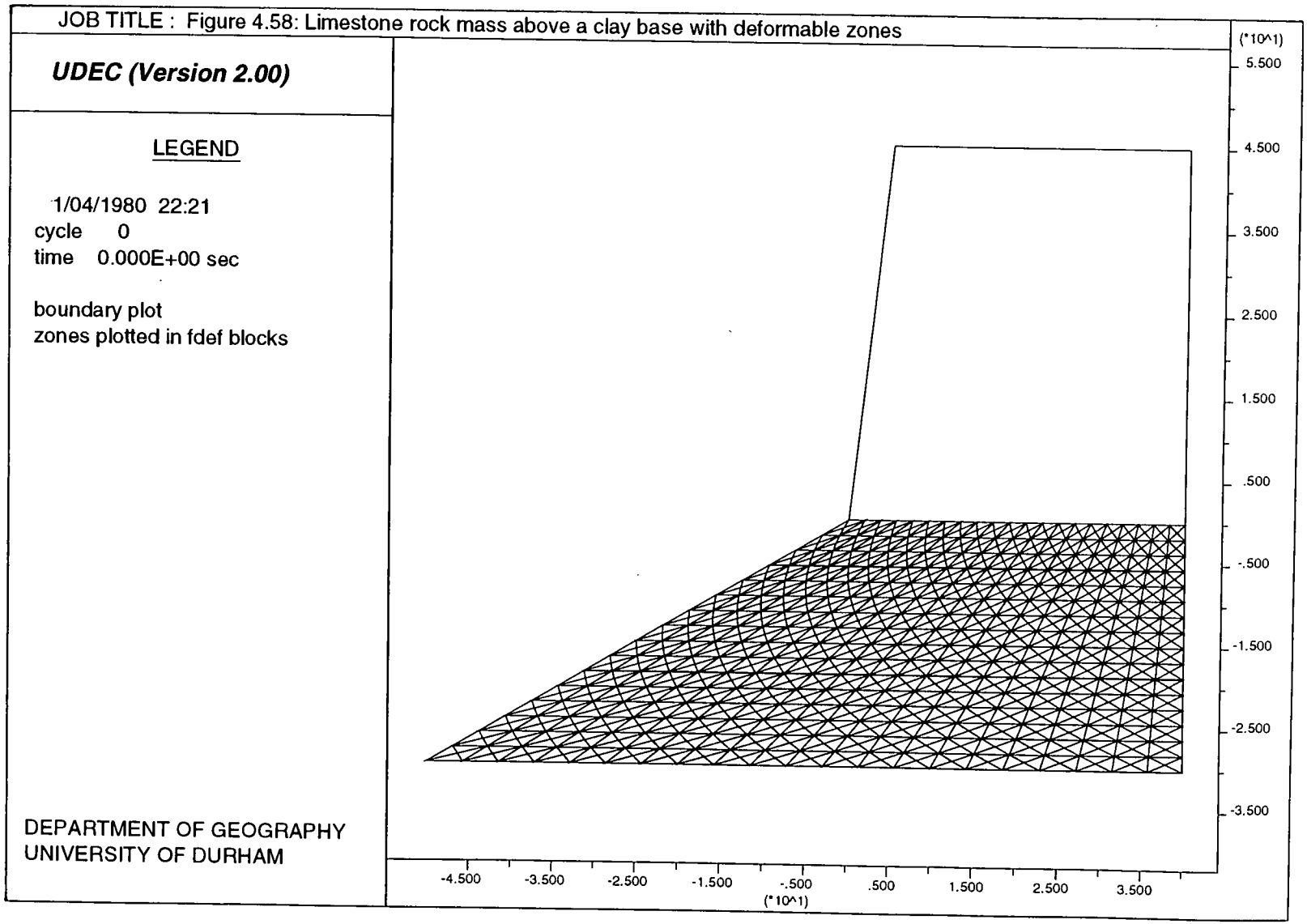
0 2E -2

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 4.57b: Sliding rock mass bounded by a wave-cut platform.
UDEC (Version 2.00)
LEGEND
1/04/1980 22:15
cycle 210000
time 1.040E+01 sec
block plot
velocity vectors
maximum = 1.695E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.100
.900
.700
.500
.300
.100
-.100
-.300
-.500
-7.000
-5.000
-3.000
-1.000
1.000
3.000
5.000
7.000
(*10^1)


JOB TITLE : Figure 4.57c: Toppling-and-sliding mass bounded by a wave-cut platform.
UDEC (Version 2.00)
LEGEND
1/04/1980 22:16
cycle 210000
time 1.127E+01 sec
block plot
velocity vectors
maximum = 2.711E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.100
.900
.700
.500
.300
.100
-.100
-.300
-.500
-7.000
-5.000
-3.000
-1.000
1.000
3.000
5.000
7.000
(*10^1)


JOB TITLE : Figure 4.58: Limestone rock mass above a clay base with deformable zones
UDEC (Version 2.00)
LEGEND
1/04/1980 22:21
cycle 0
time 0.000E+00 sec
boundary plot
zones plotted in fdef blocks
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
-2.500
-3.500
-4.500
-3.500
-2.500
-1.500
-.500
.500
1.500
2.500
3.500
(*10^1)

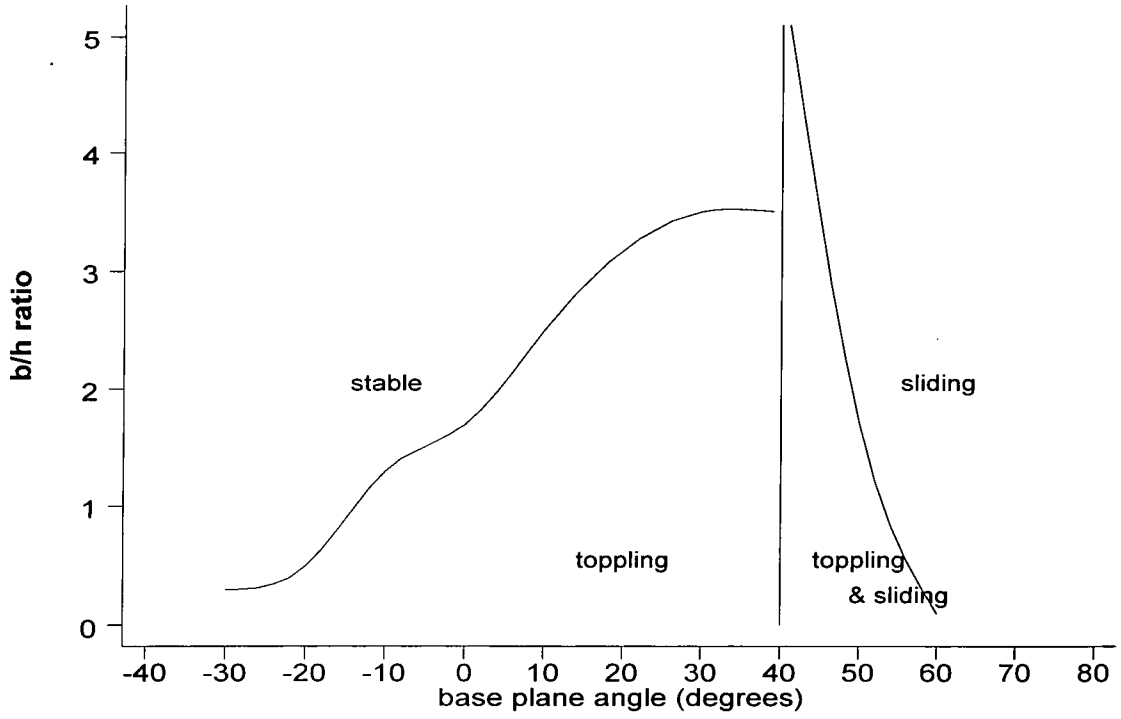


Figure 4.59: Limiting conditions for sliding, toppling and stable rock masses above a clay base.

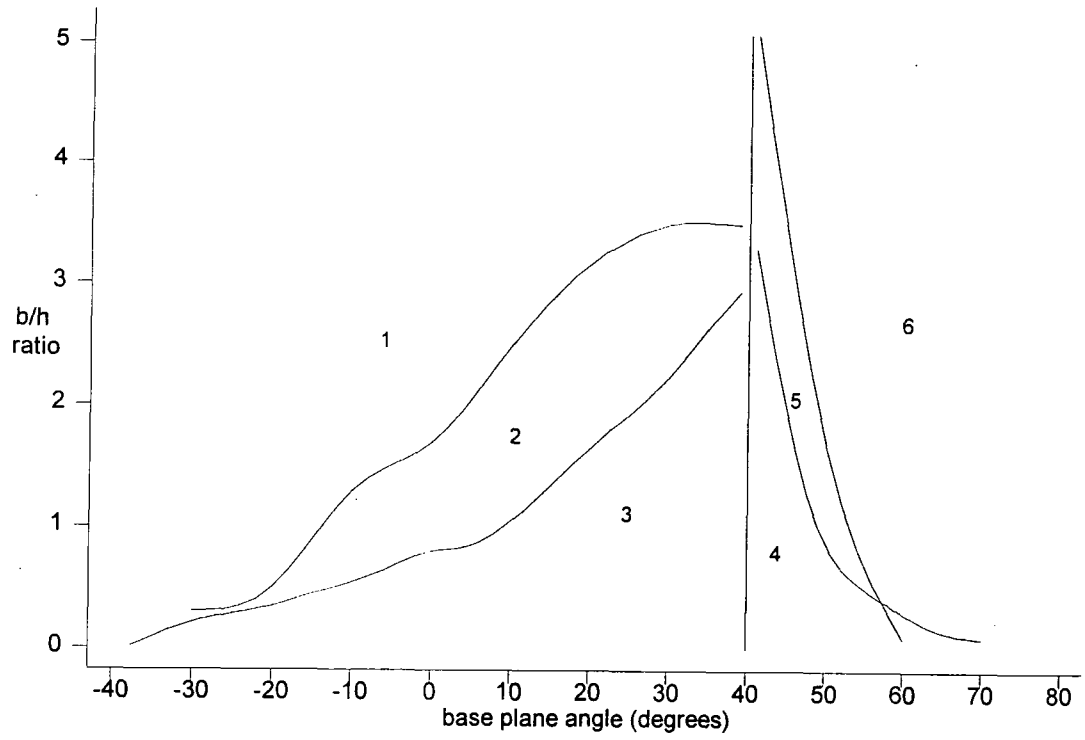
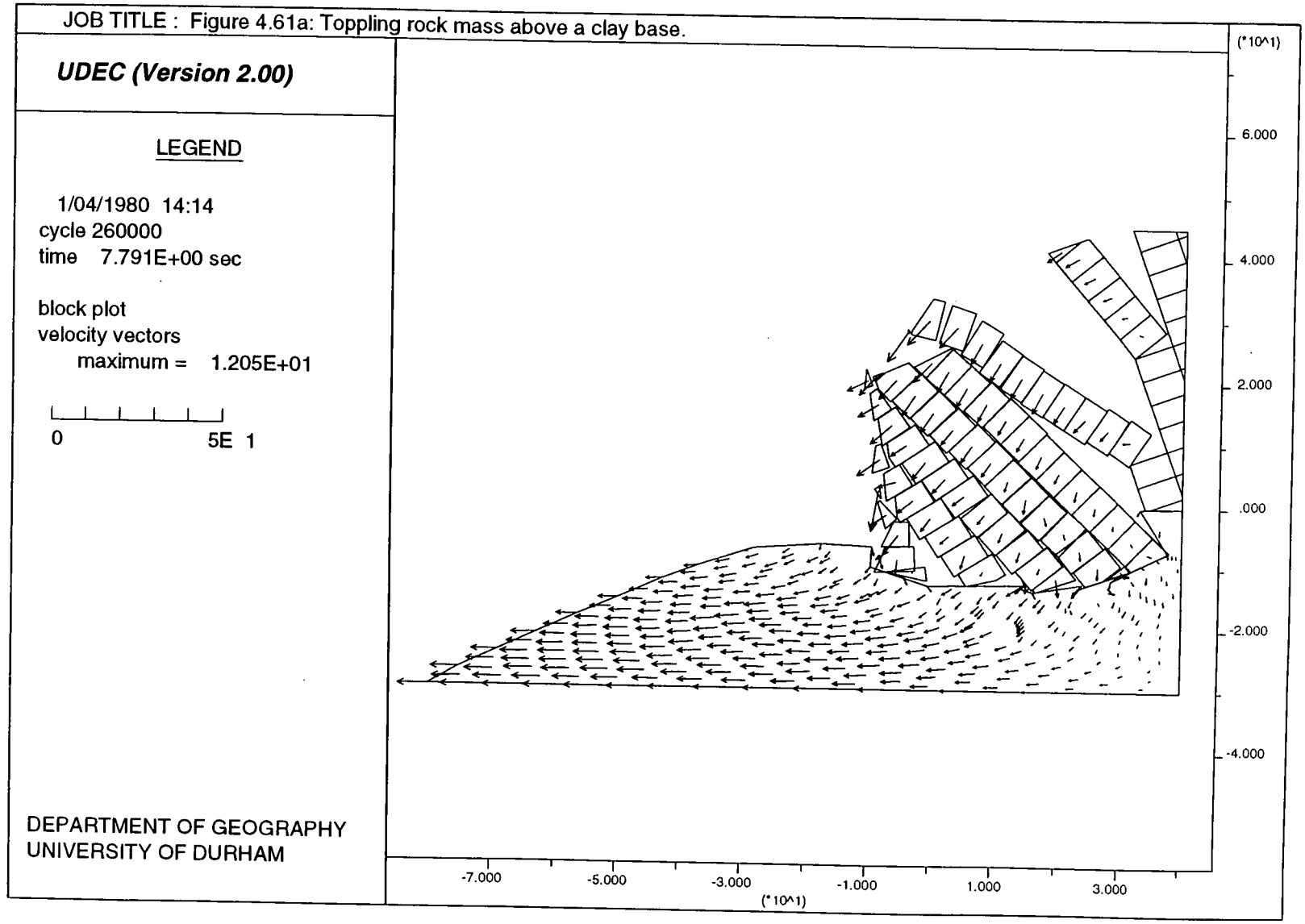


Figure 4.60: Limiting conditions for the failure of rock masses above a clay base compared with the limiting conditions for the failure of the limestone rock masses.

The boundaries between the mechanisms of failure are taken from Figures 4.5 and 4.59. Zones on the graph are delimited by the boundary lines:

Zone	Limestone	Clay base
1	Stable	Stable
2	Stable	Toppling
3	Toppling	Toppling
4	Toppling-and-sliding	Toppling-and-sliding
5	Sliding	Toppling-and-sliding
10	Sliding	Sliding


JOB TITLE : Figure 4.61a: Toppling rock mass above a clay base.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:14
cycle 260000
time 7.791E+00 sec
block plot
velocity vectors
maximum = 1.205E+01
0
5E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.000
4.000
2.000
.000
-2.000
-4.000
-7.000
-5.000
-3.000
-1.000
1.000
3.000
(*10^1)

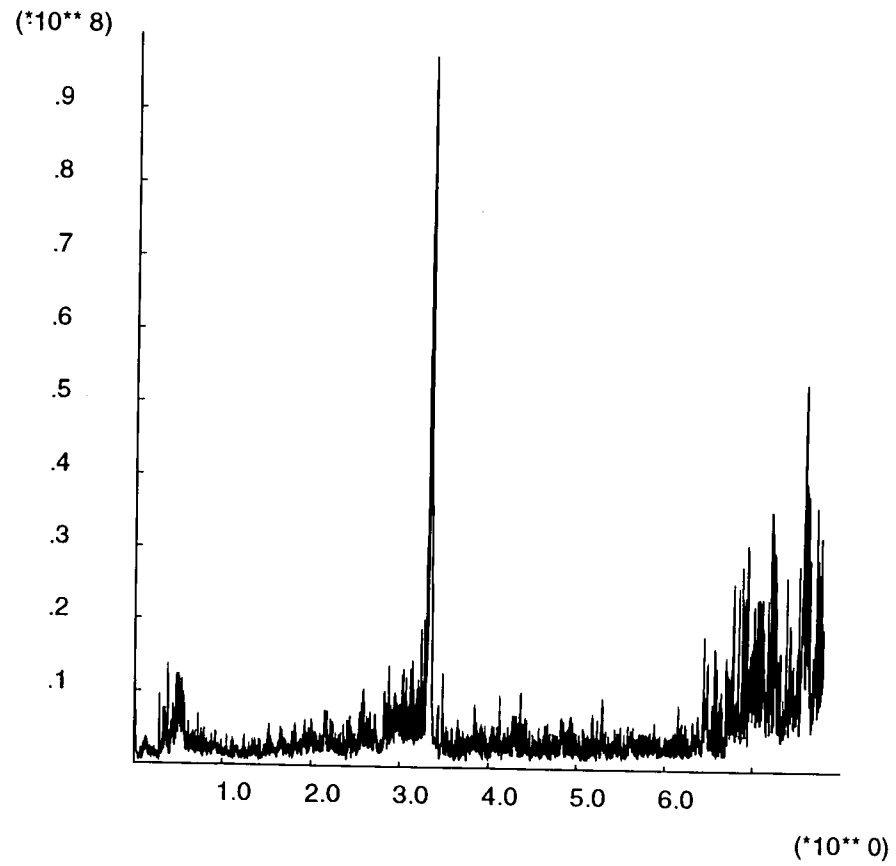
JOB TITLE : Figure 4.61b: Forces for a toppling rock mass above a clay base.

UDEC (Version 2.00)

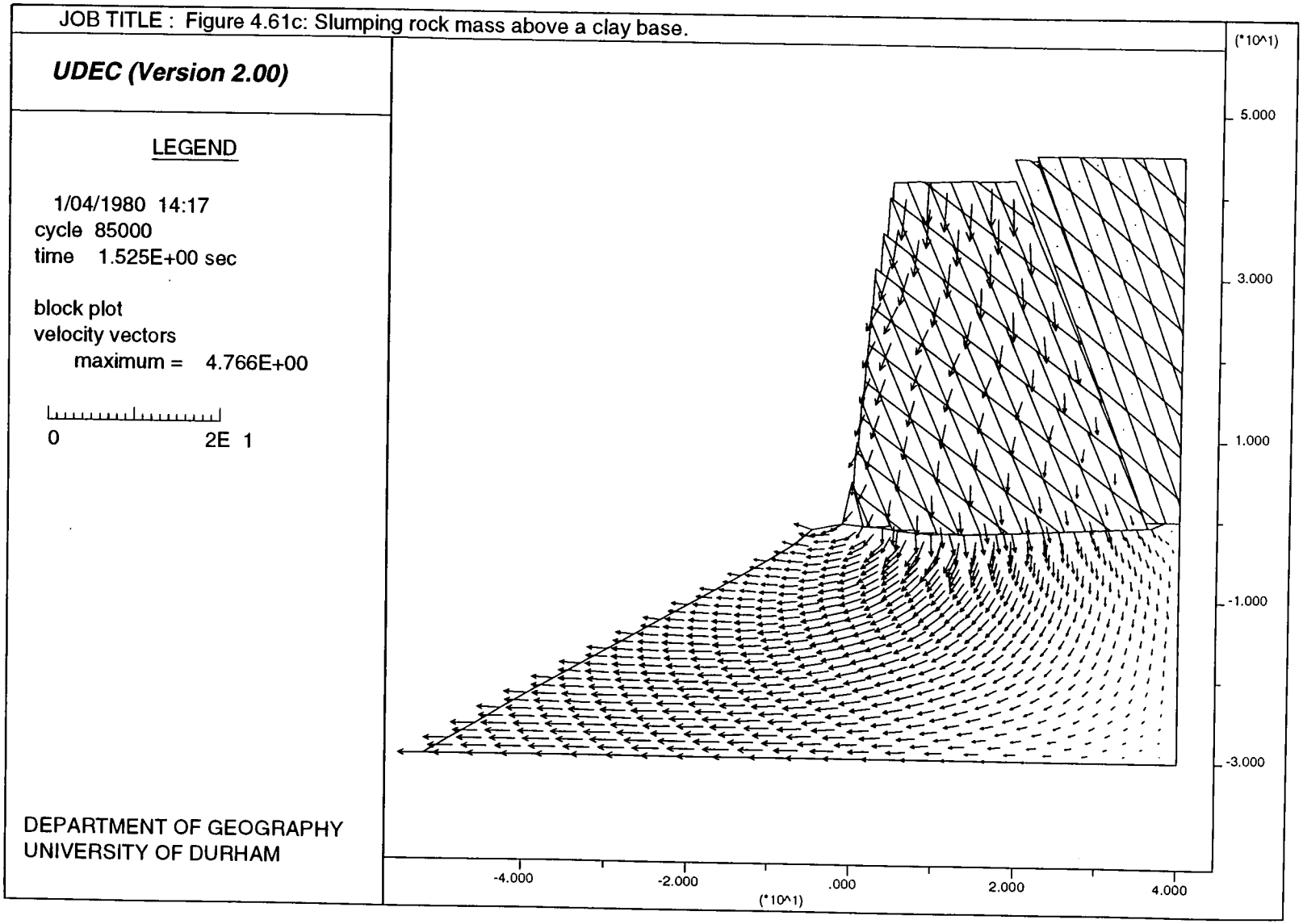
LEGEND

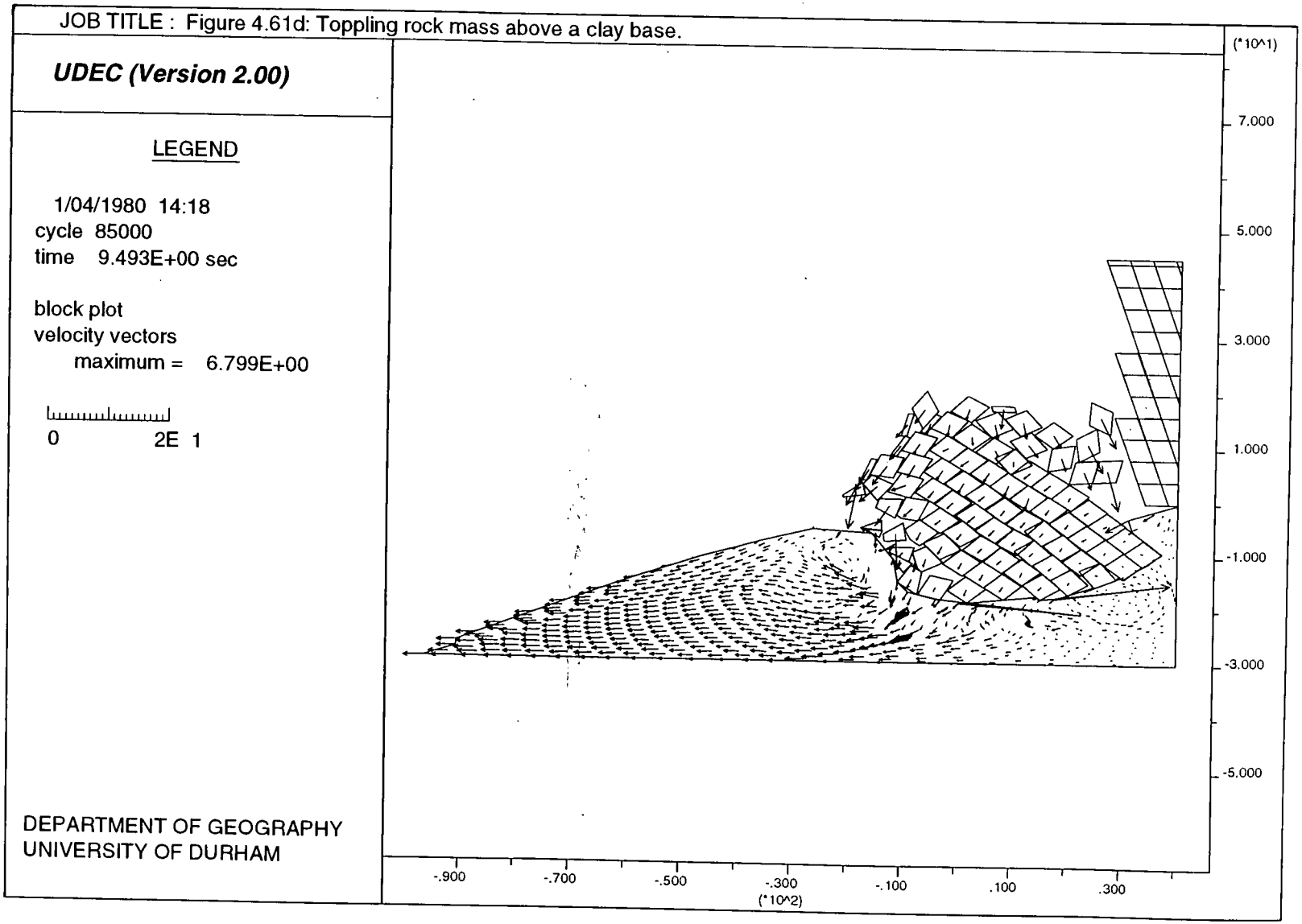
1/04/1980 14:16
cycle 260000
time 7.791E+00 sec

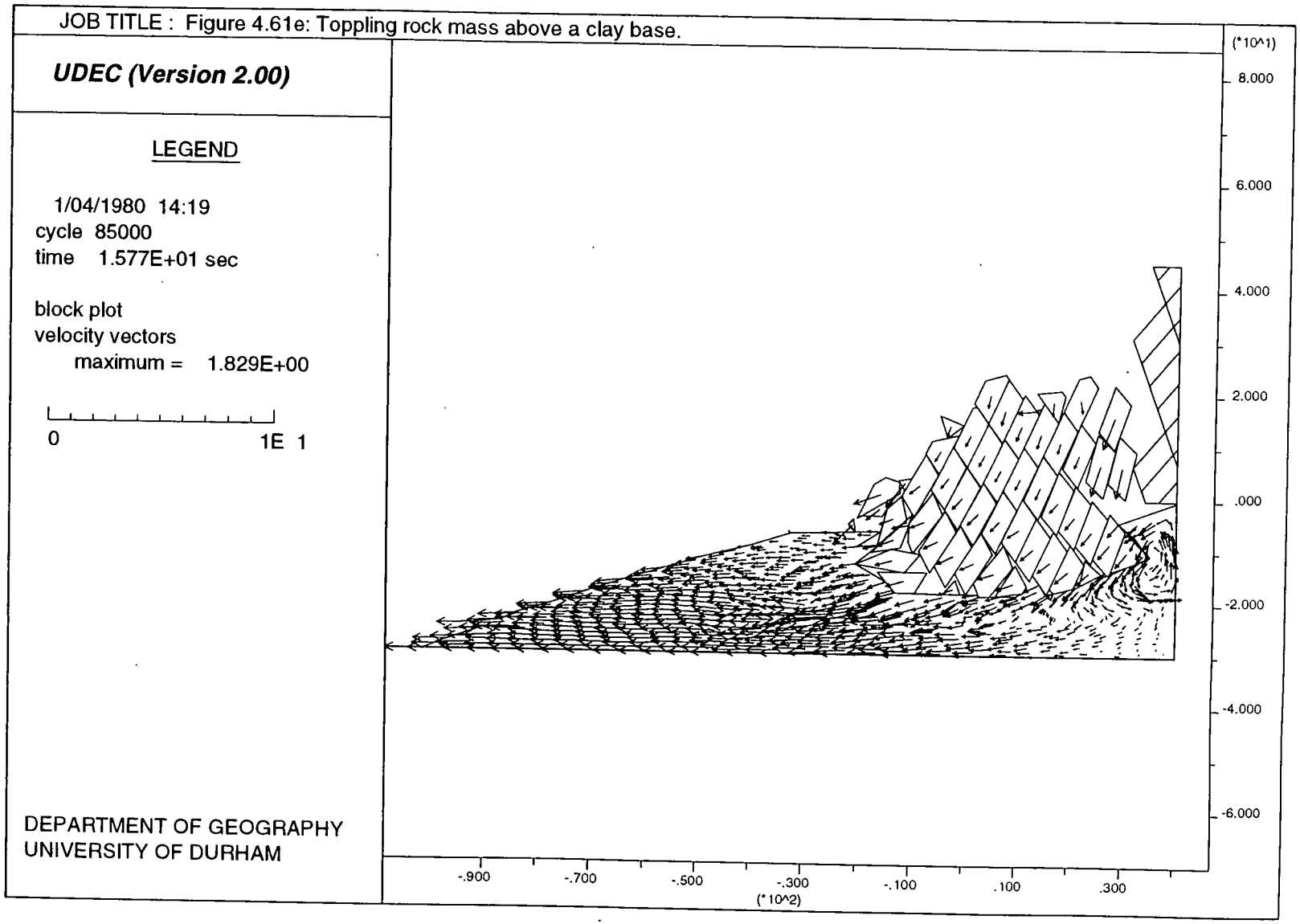
7.04E+05 <hist 2> 9.72E+07



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 4.61c: Slumping rock mass above a clay base.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:17
cycle 85000
time 1.525E+00 sec
block plot
velocity vectors
maximum = 4.766E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
3.000
1.000
-1.000
-3.000
-4.000
-2.000
.000
2.000
4.000
(*10^1)


JOB TITLE : Figure 4.61d: Toppling rock mass above a clay base.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:18
cycle 85000
time 9.493E+00 sec
block plot
velocity vectors
maximum = 6.799E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
7.000
5.000
3.000
1.000
-1.000
-3.000
-5.000
-.900
-.700
-.500
-.300
-.100
.100
.300
(*10^2)


JOB TITLE : Figure 4.61e: Toppling rock mass above a clay base.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:19
cycle 85000
time 1.577E+01 sec
block plot
velocity vectors
maximum = 1.829E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
8.000
6.000
4.000
2.000
.000
-2.000
-4.000
-6.000
-.900
-.700
-.500
-.300
-.100
.100
.300
(*10^2)

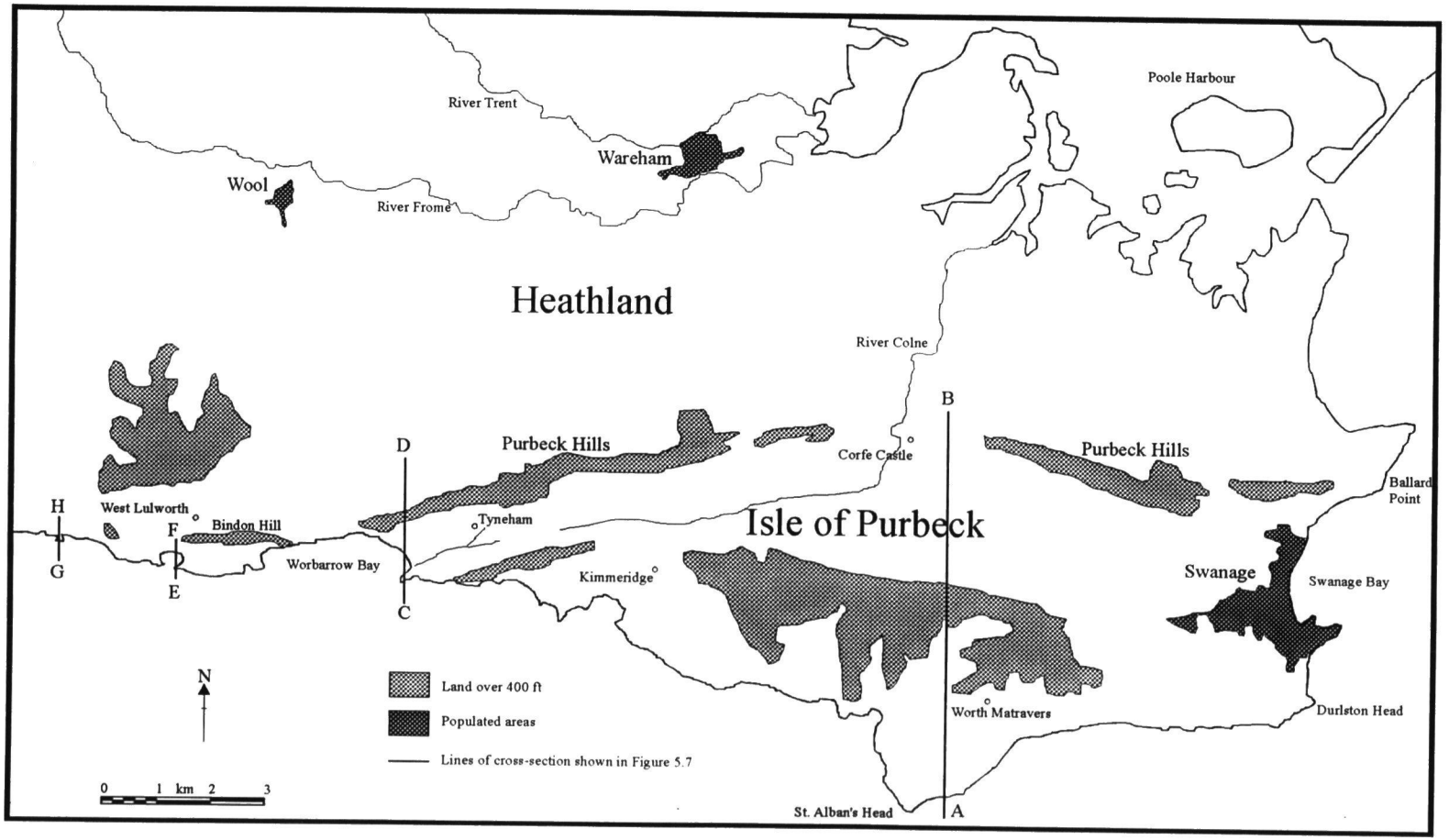


Figure 5.1: Location map of the Isle of Purbeck.

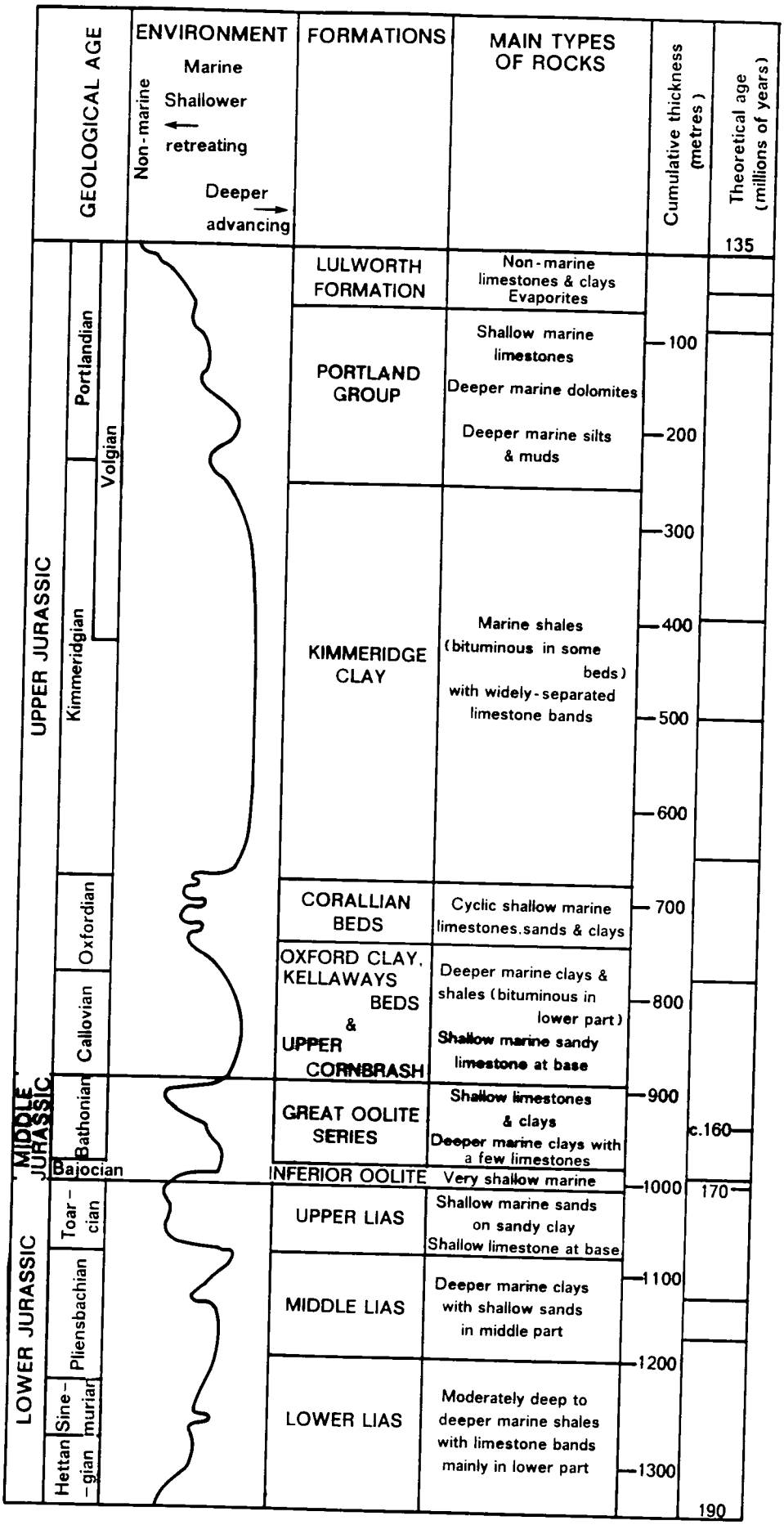


Figure 5.2a: The Jurassic stratigraphic column in Dorset.

From Allison, 1986, after Melville and Freshney, 1982.

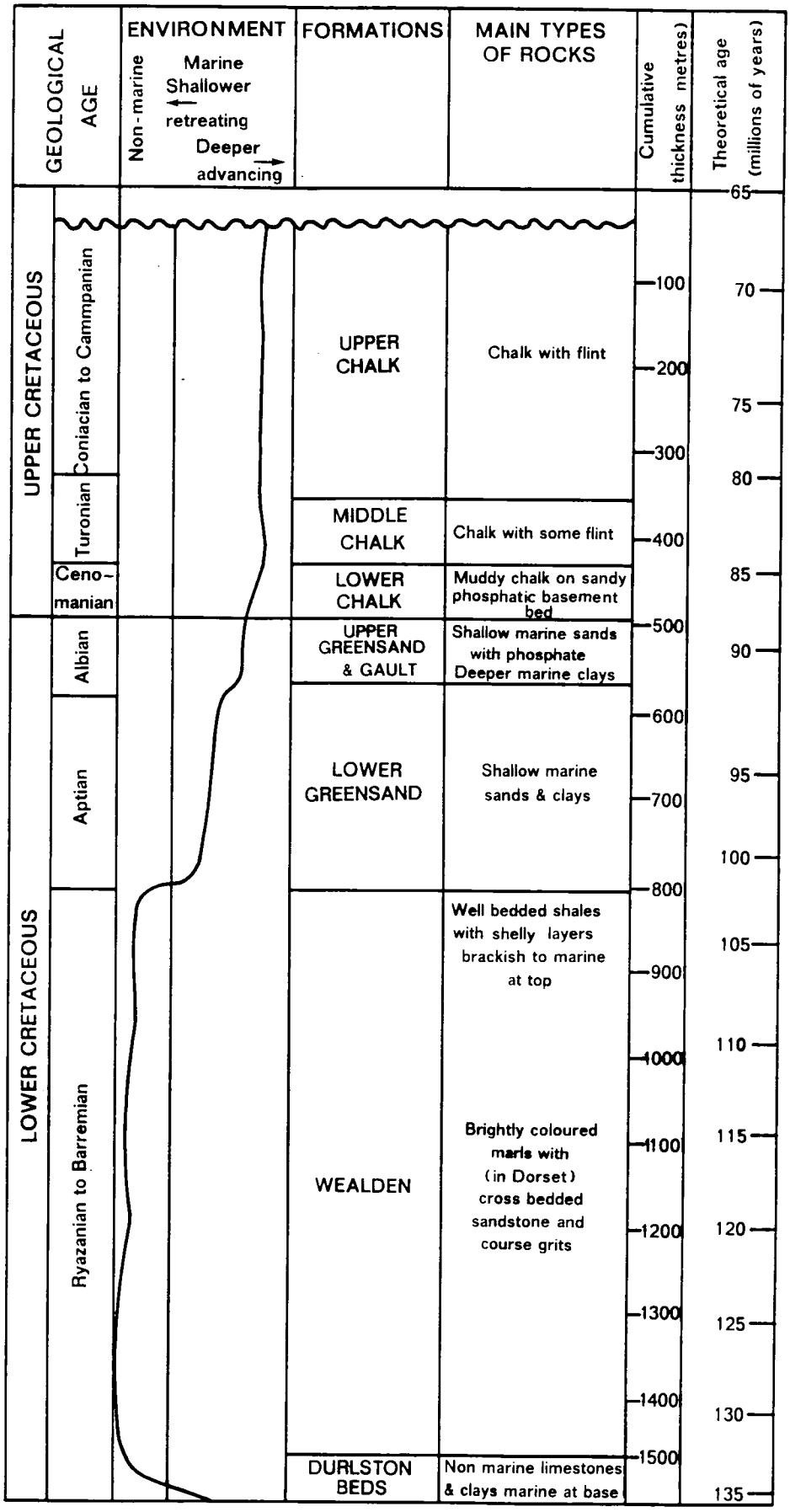


Figure 5.2b: The Cretaceous stratigraphic column in Dorset.

From Allison, 1986, after Melville and Freshney, 1982.

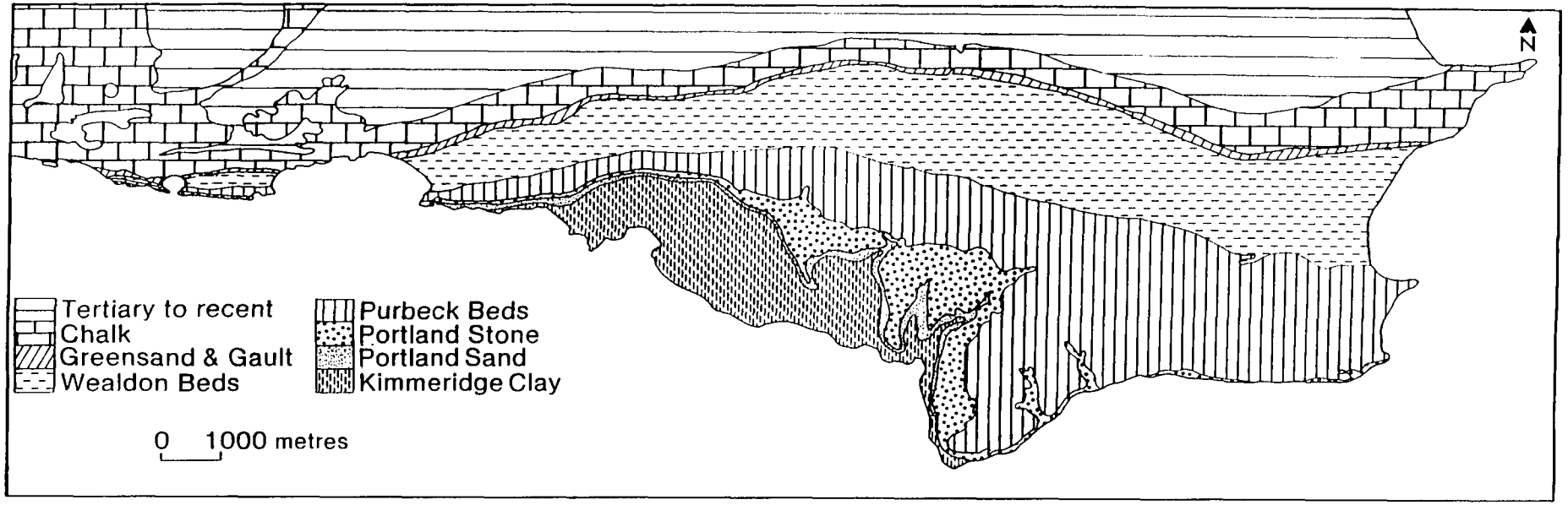


Figure 5.3: Geology of the Isle of Purbeck. From Allison, 1986.

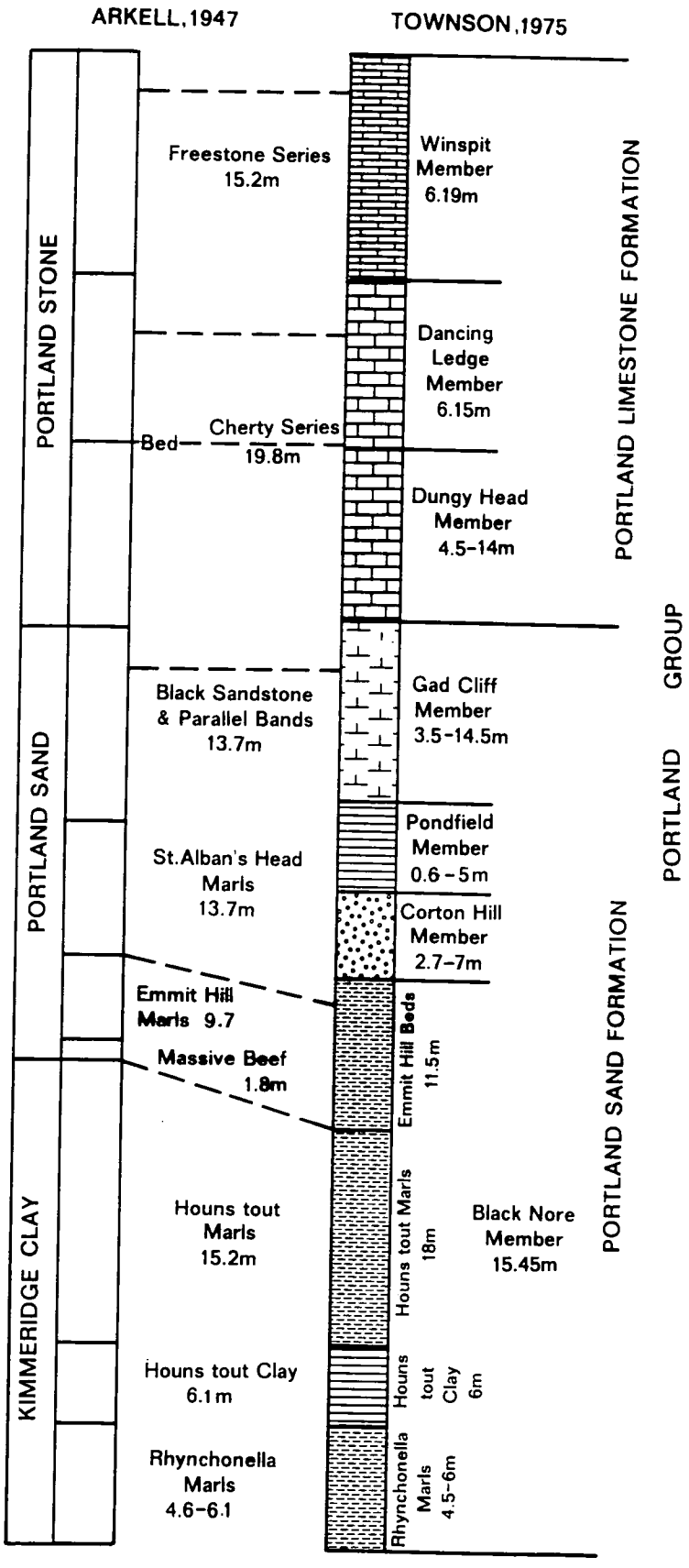


Figure 5.4: Classification of the Portland Beds. From Allison, 1986.

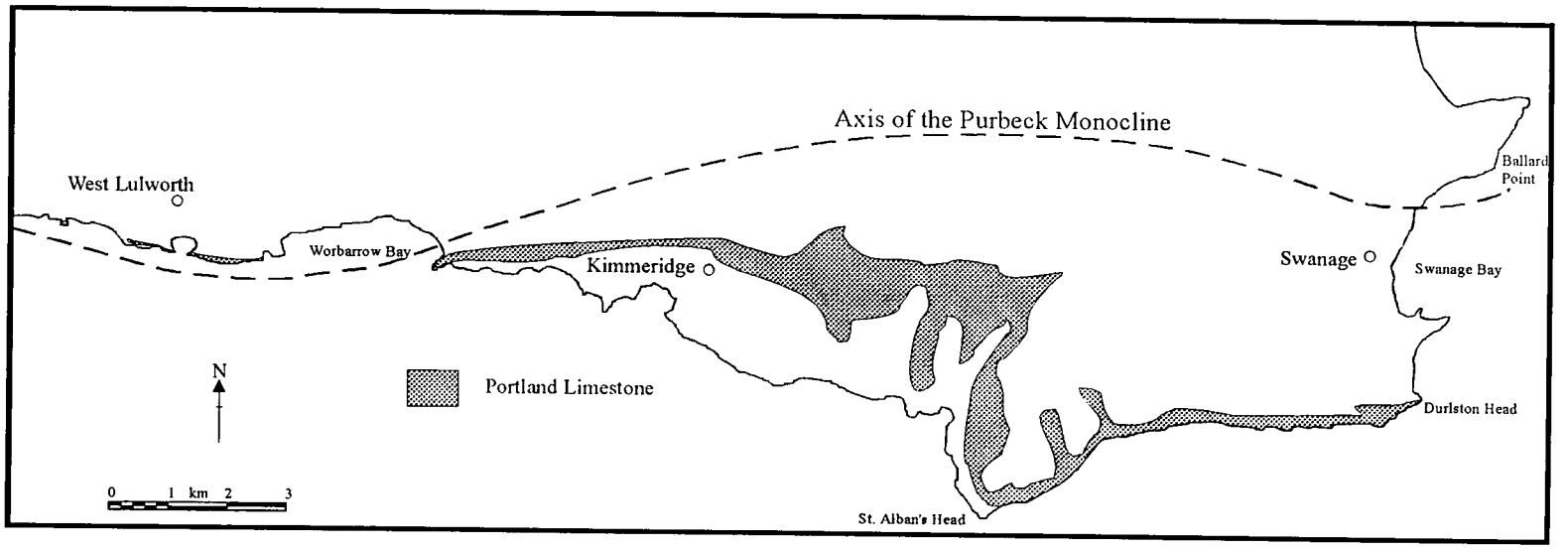


Figure 5.5: Map of the Isle of Purbeck showing the axis of the Purbeck Monocline and the distribution of the Portland Limestone. Allison, 1989.

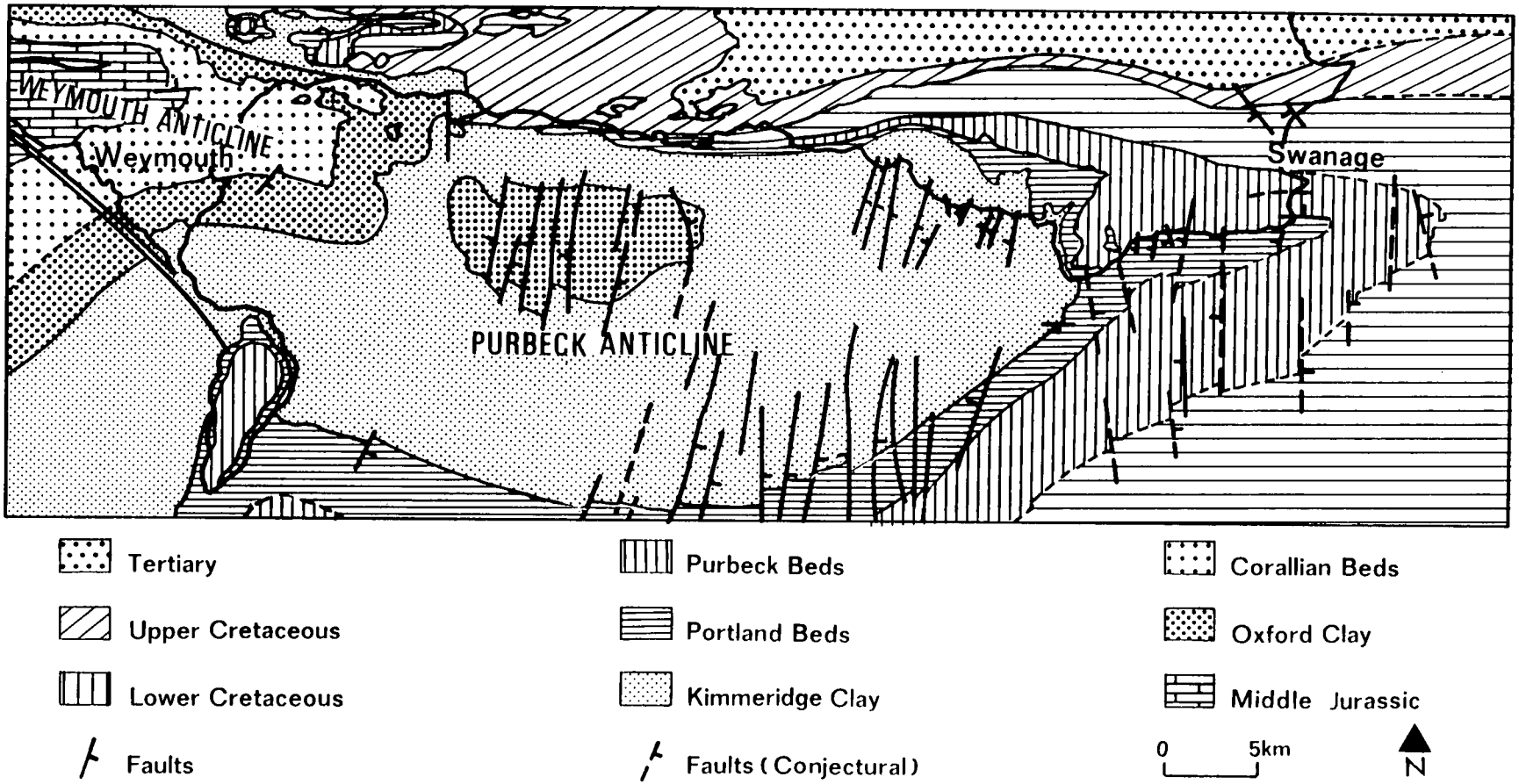


Figure 5.6: The structural setting of the east Dorset coastline. From Allison, 1986.

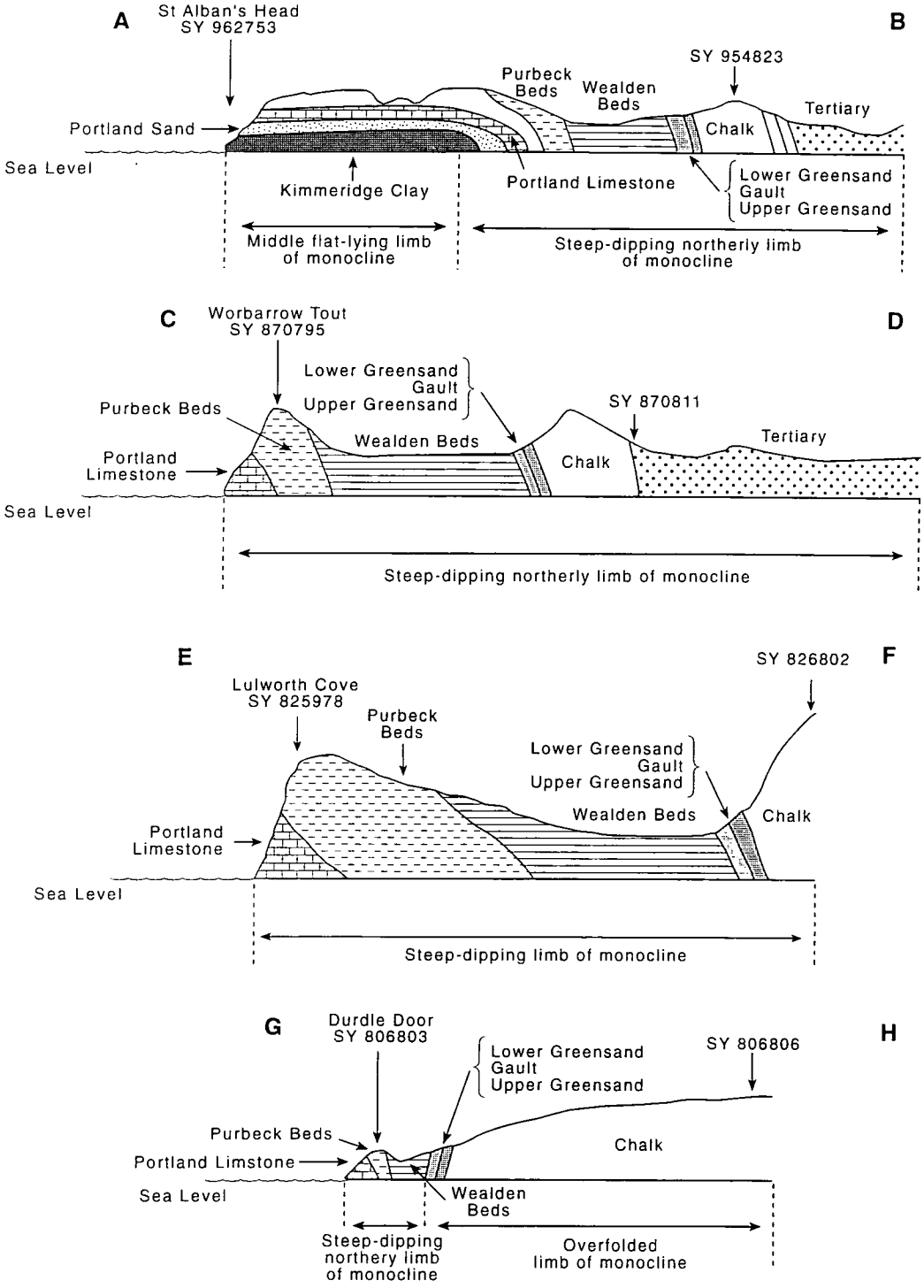


Figure 5.7: Geological cross-sections along the Purbeck coast.

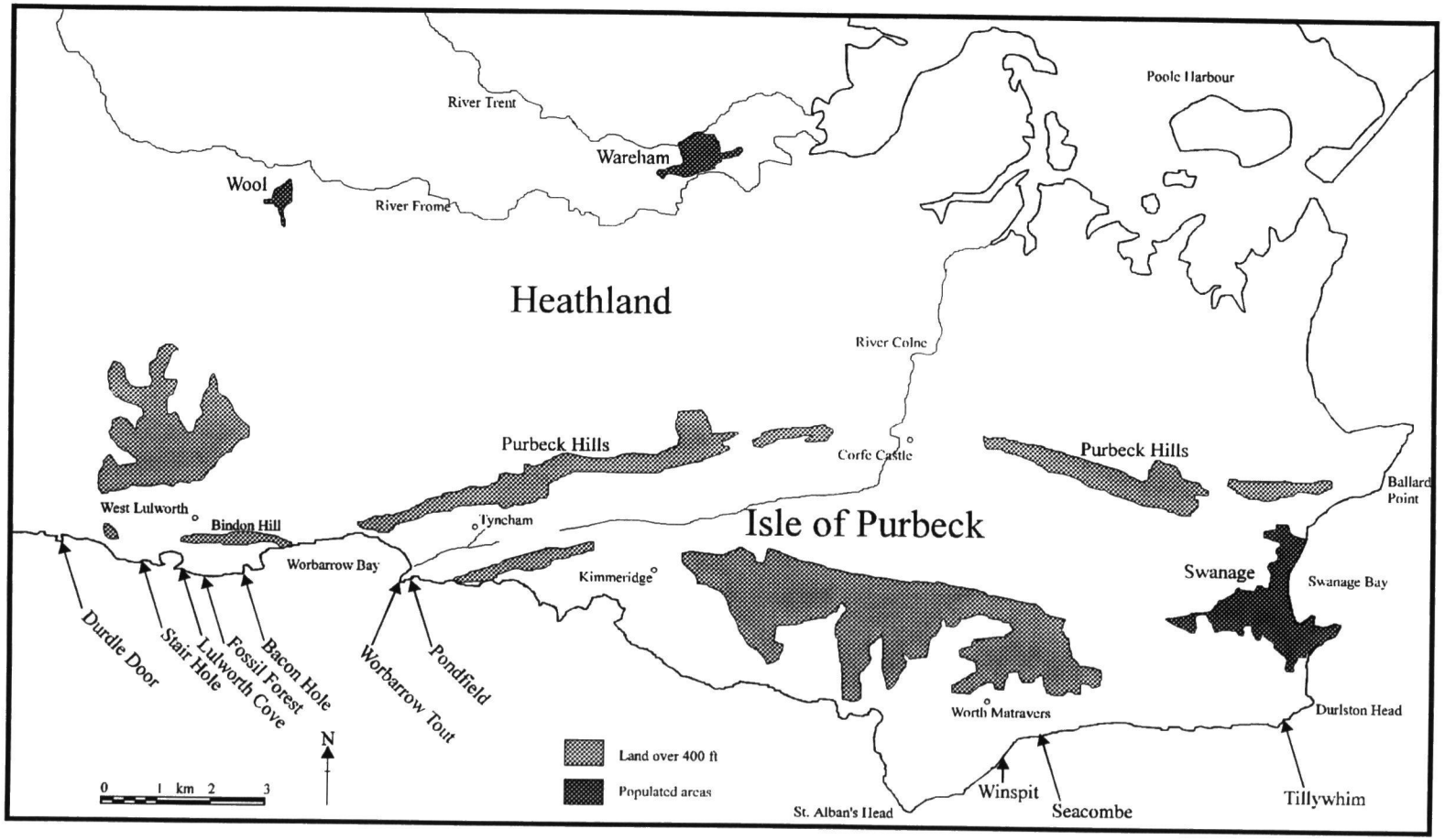


Figure 5.8: Map of the Isle of Purbeck showing the location of field sites.

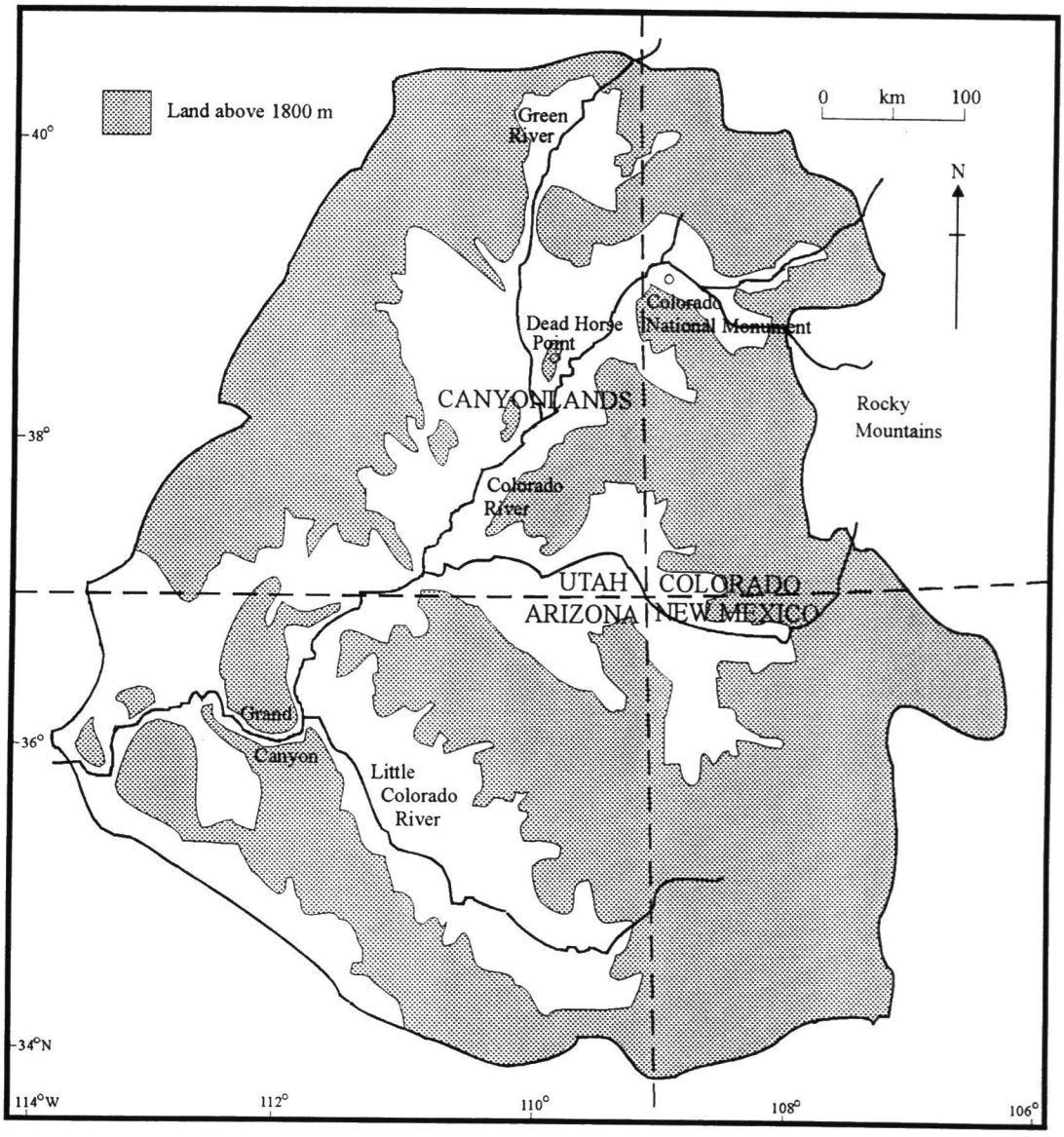


Figure 5.9: Location map of the Colorado Plateau.

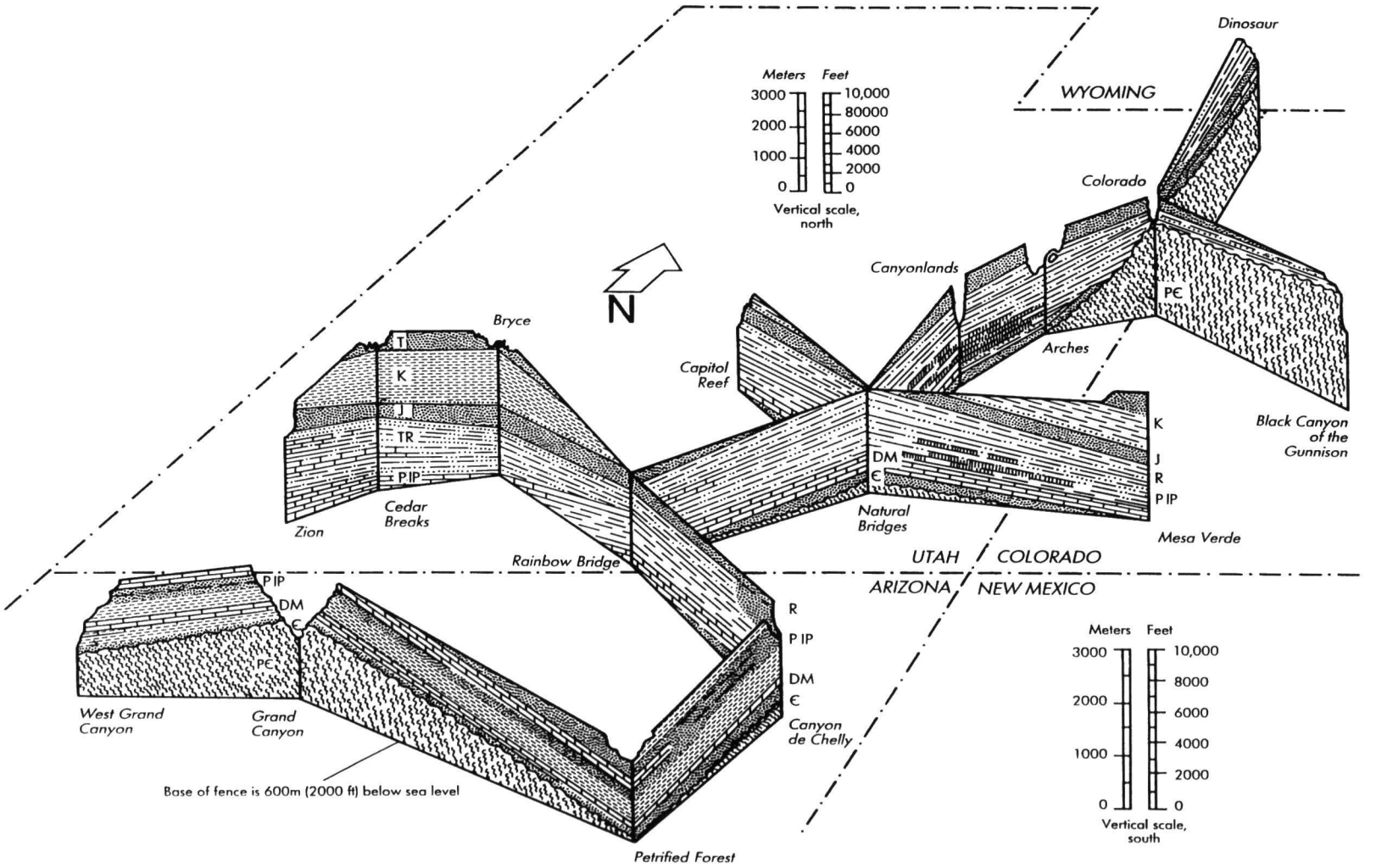


Figure 5.10: The Colorado Plateau stratigraphic column.

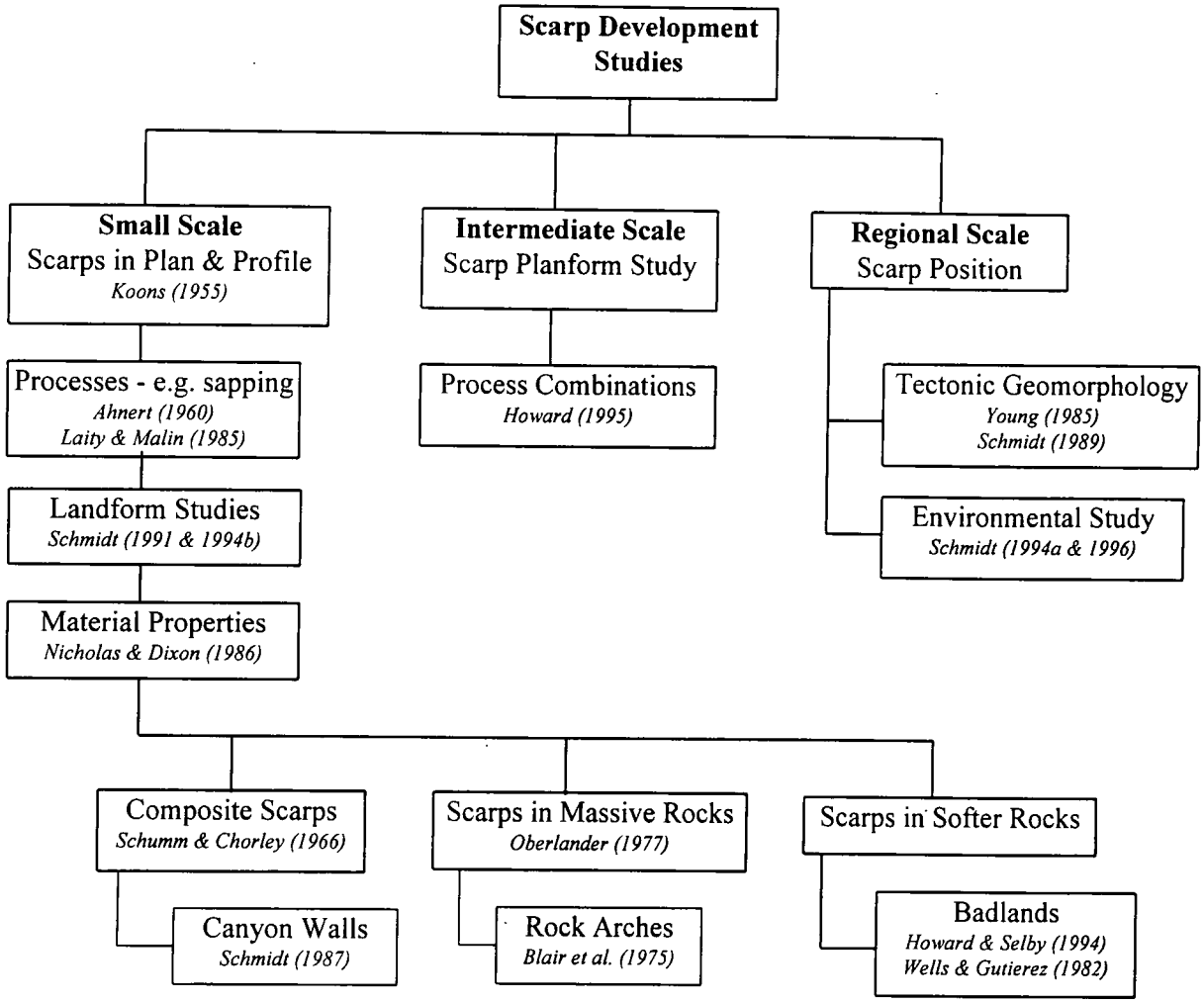


Figure 5.11: A summary of slope development studies on the Colorado Plateau.

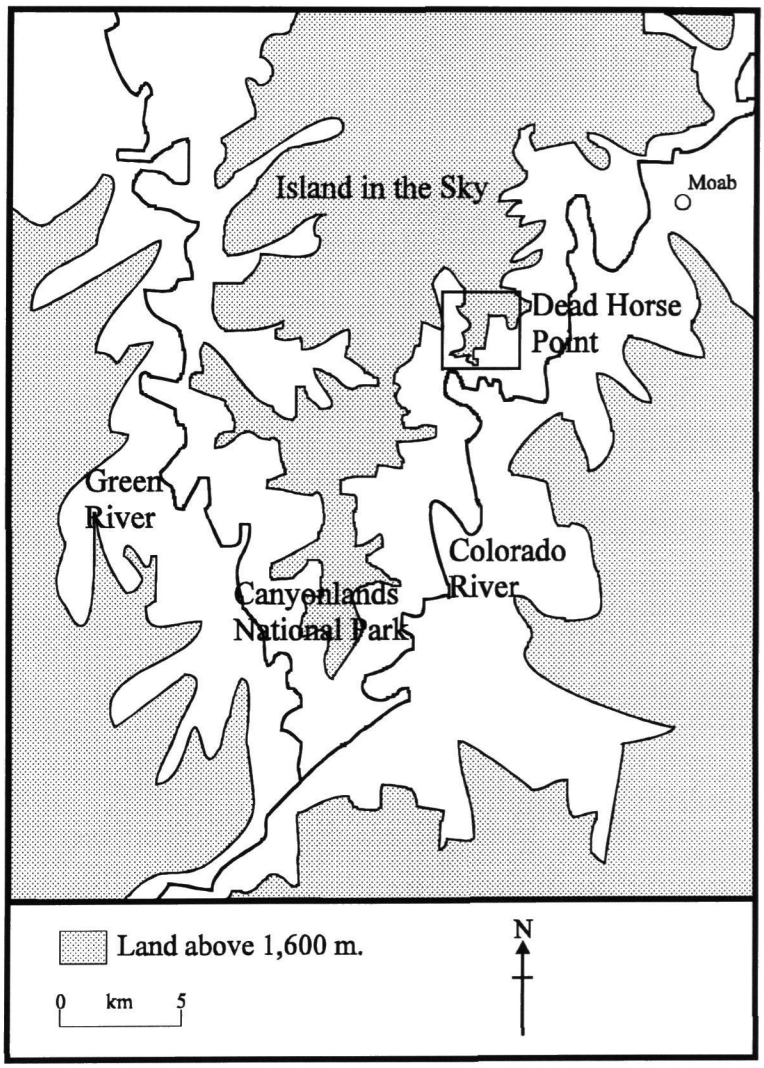


Figure 5.12: Location map of Dead Horse Point State Park and the Island in the Sky Mesa.

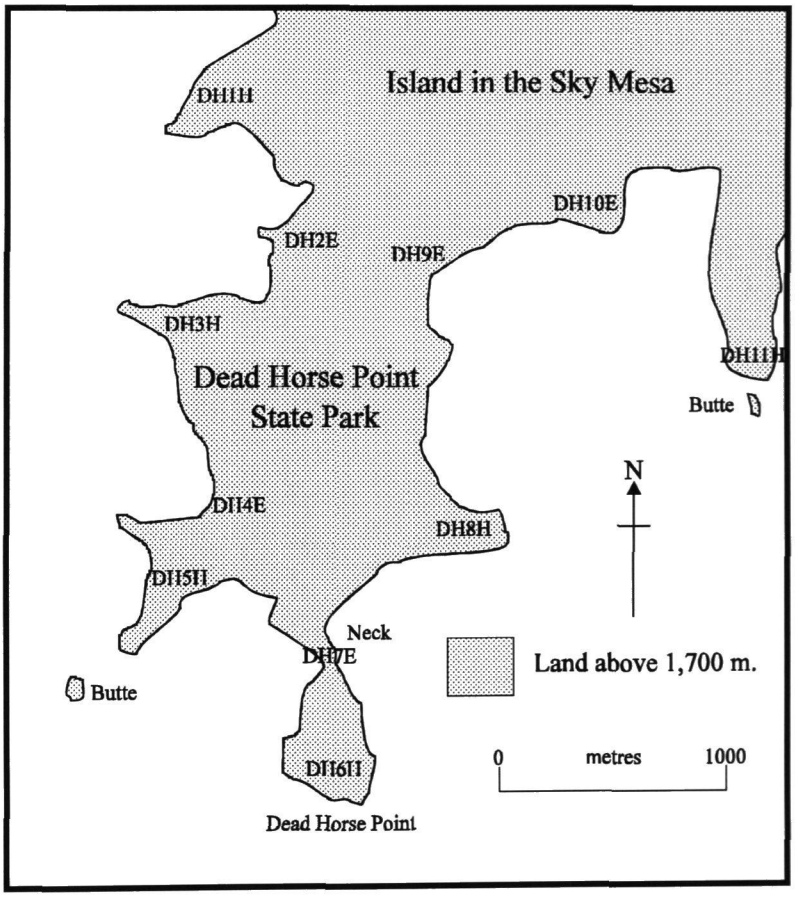


Figure 5.13: Scarp plan at Dead Horse Point State Park.

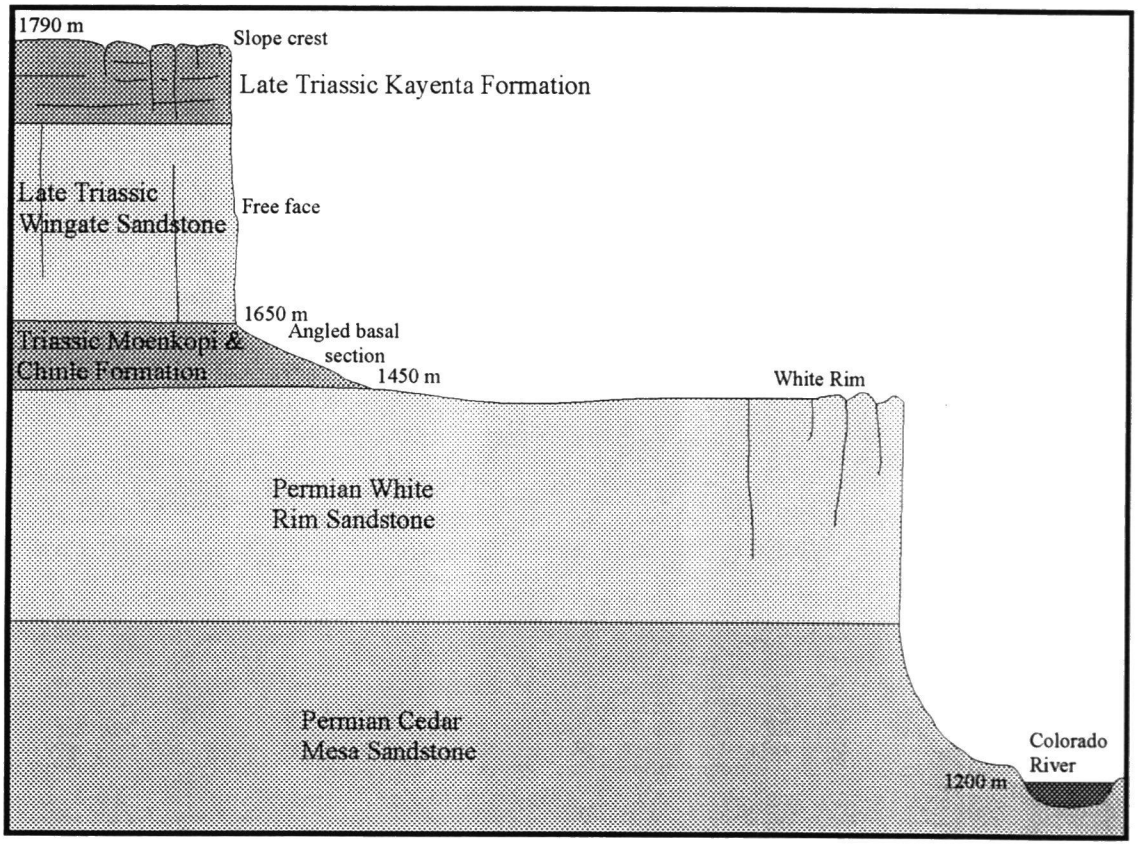


Figure 5.14: A profile of the cliffs at Dead Horse Point State Park.

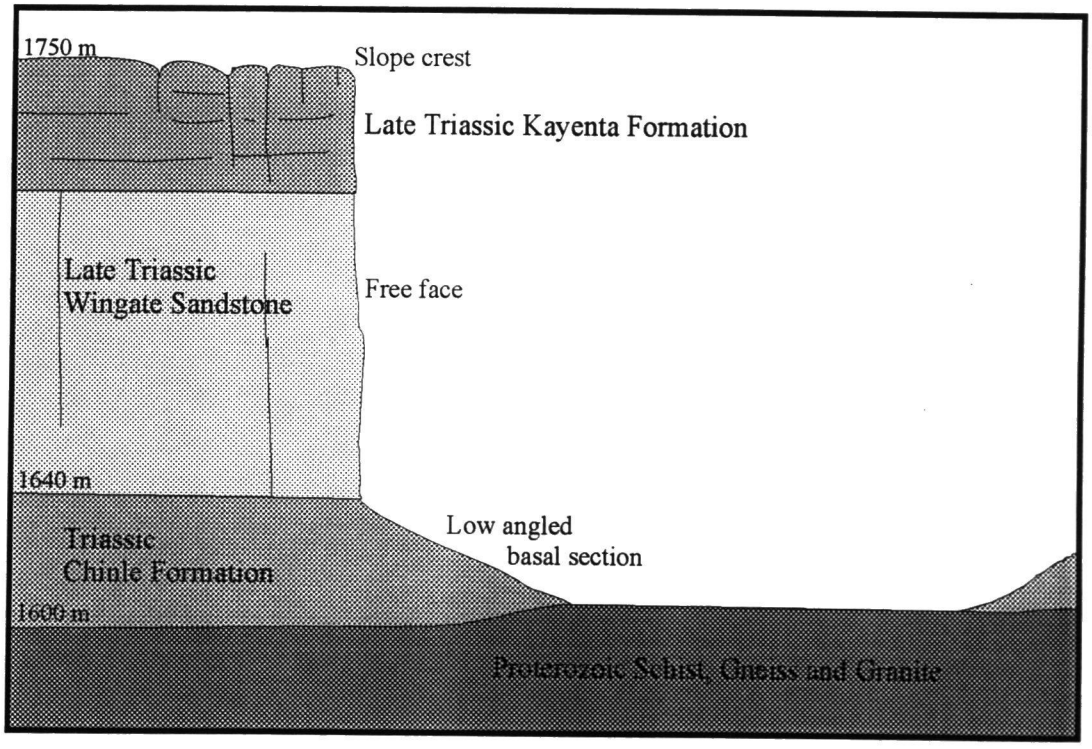


Figure 5.15: A profile of the cliffs at the Colorado National Monument.

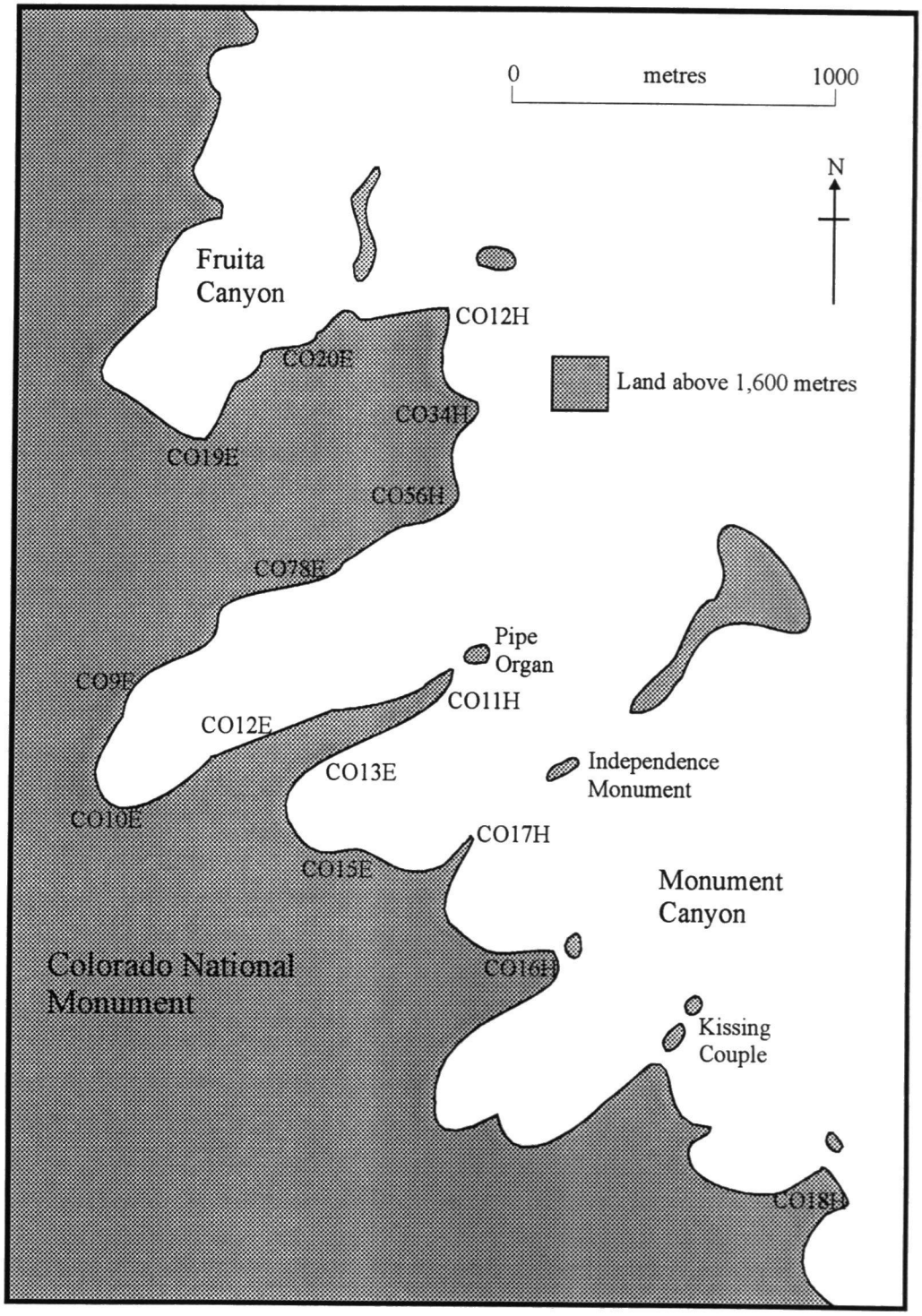


Figure 5.16: Scarp plan at the Colorado National Monument.

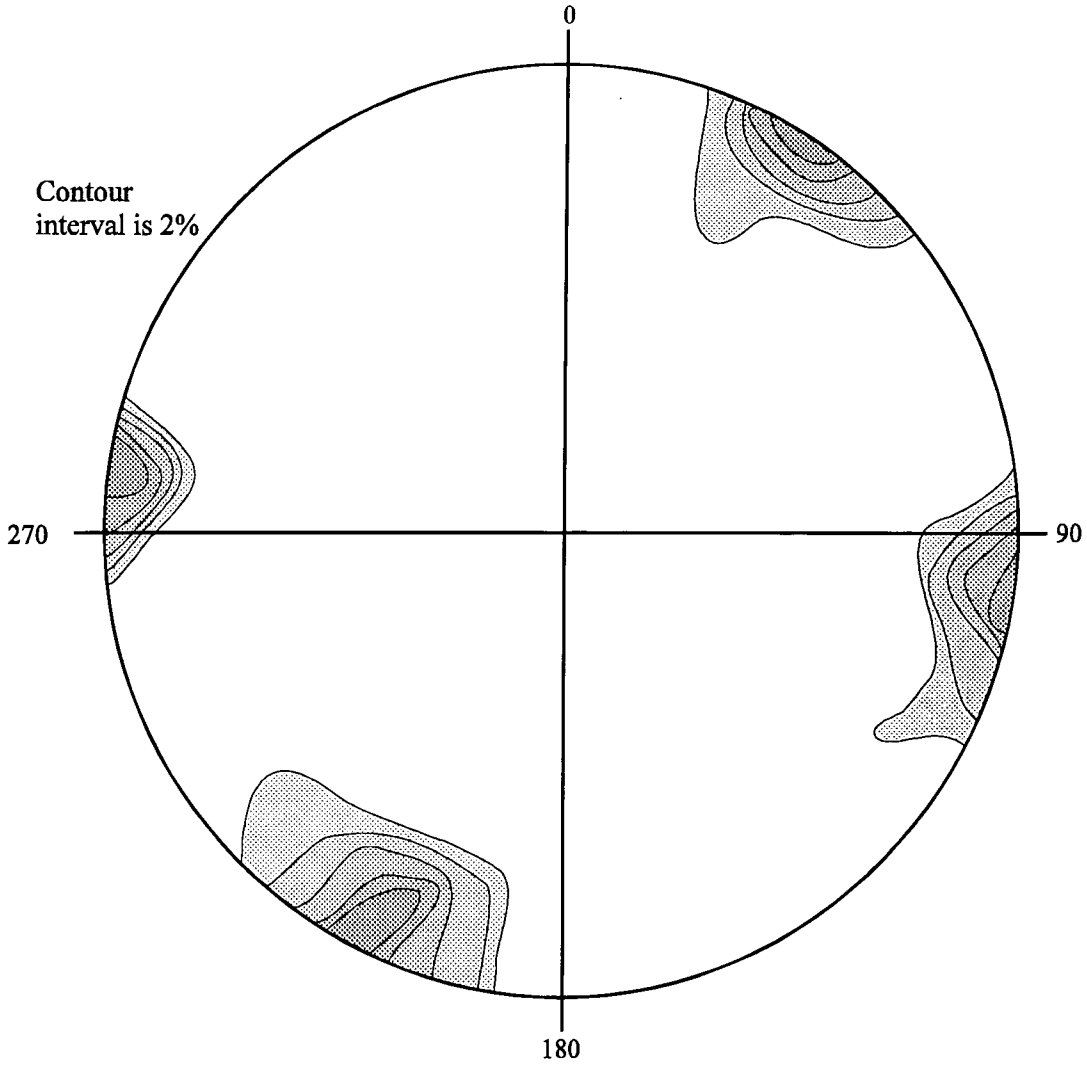


Figure 6.1: Polar projection for the discontinuities in the Portland Limestone at Winspit. From Allison, 1989.

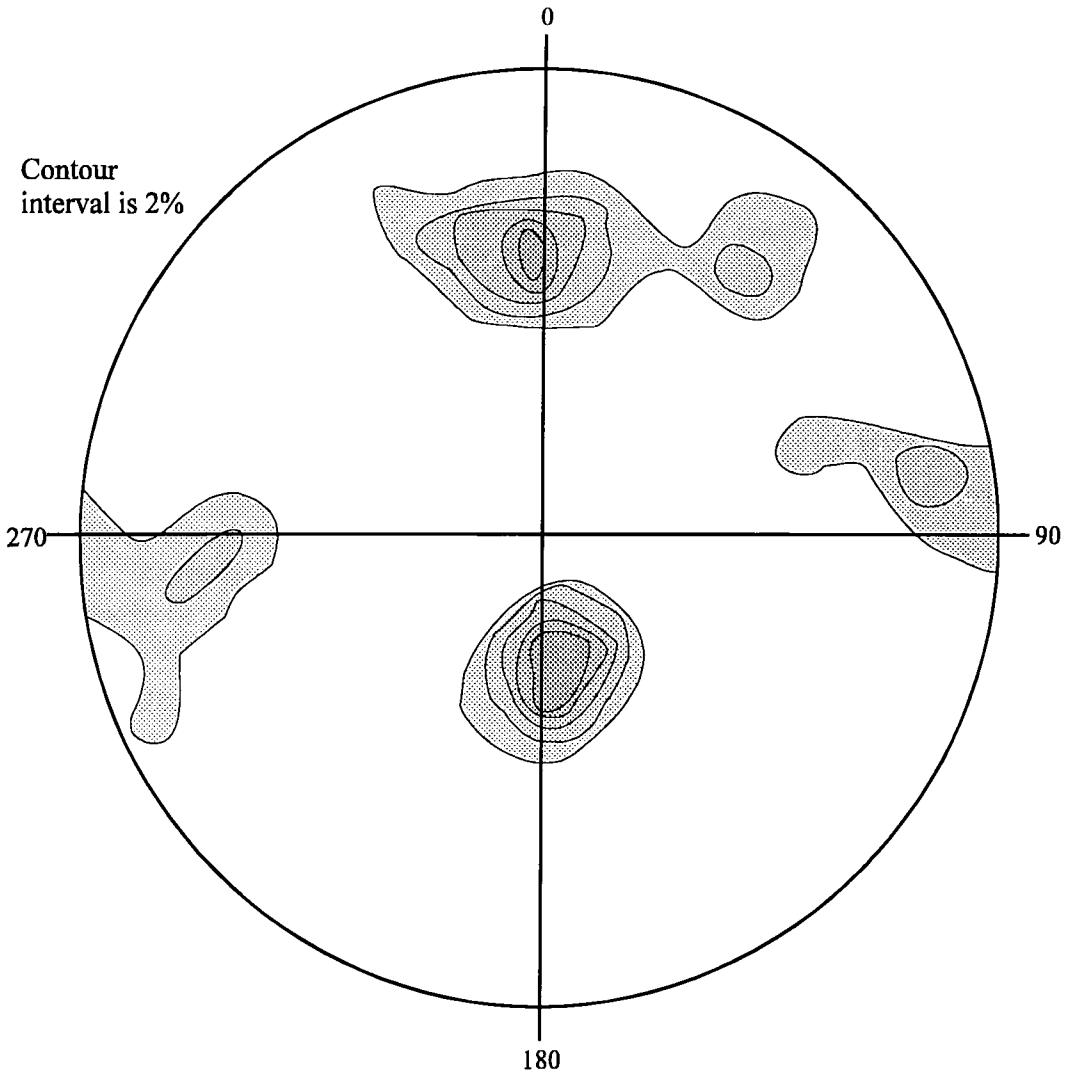


Figure 6.2: Polar projection for the discontinuities in the Portland Limestone at Fossil Forest. From Allison, 1989.

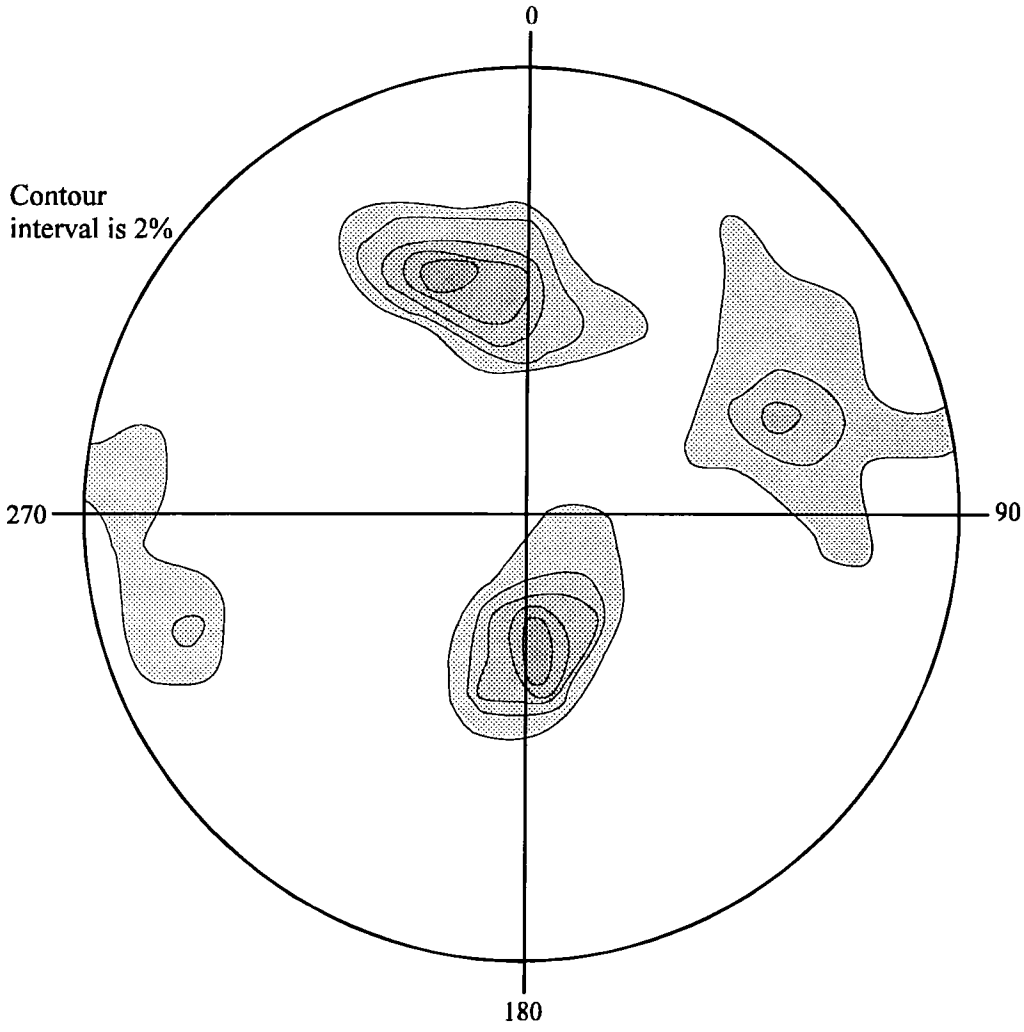


Figure 6.3: Polar projection for the discontinuities in the Portland Limestone at Lulworth Cove. From Allison, 1989.

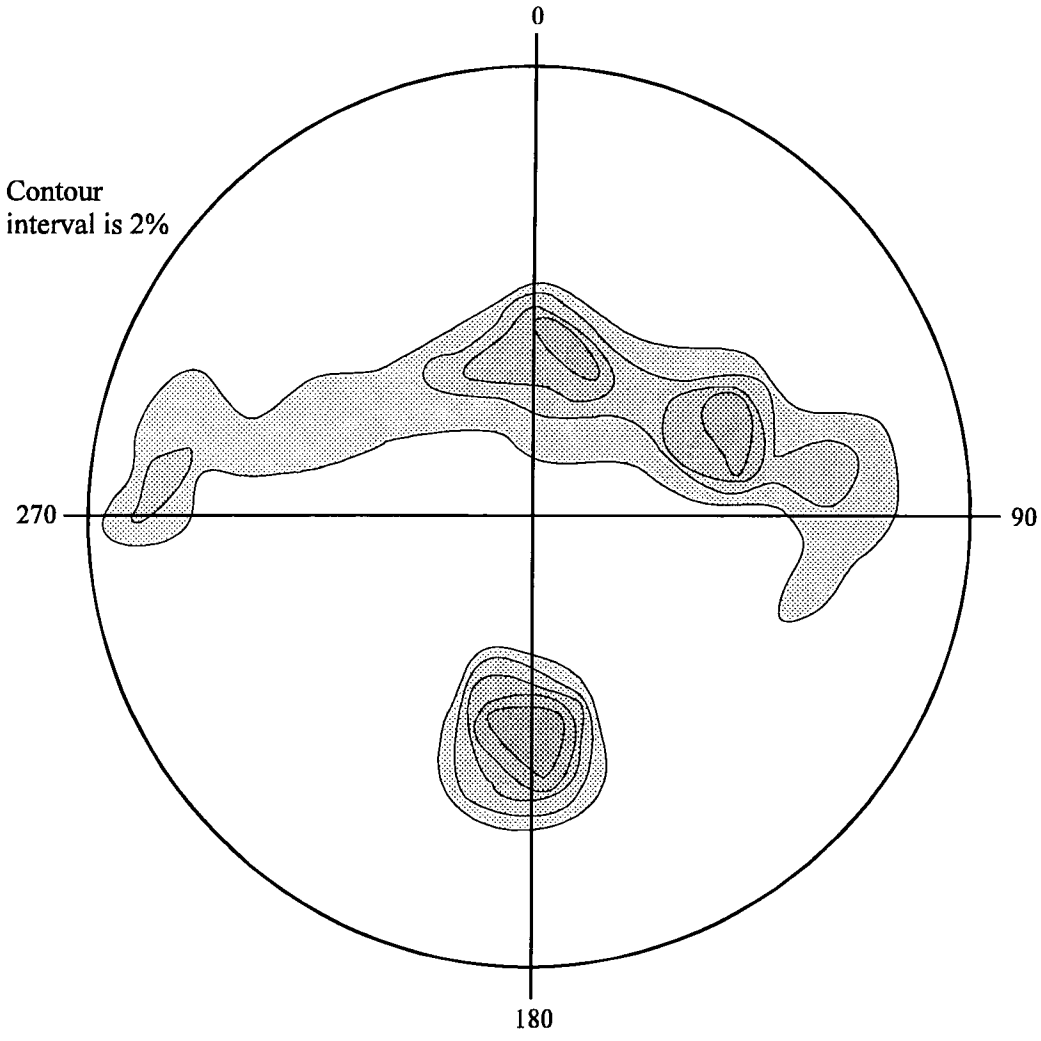


Figure 6.4: Polar projection for the discontinuities in the Portland Limestone at Durdle Door. From Allison, 1989.

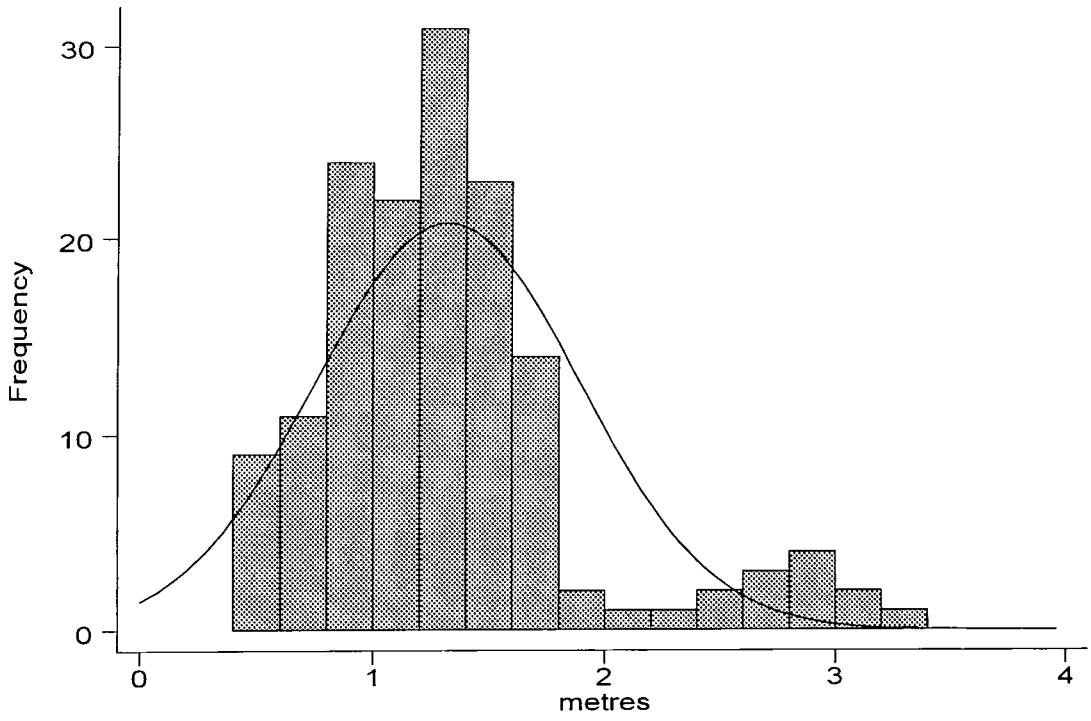


Figure 6.5: Frequency distribution of Winspit joint spacing readings.

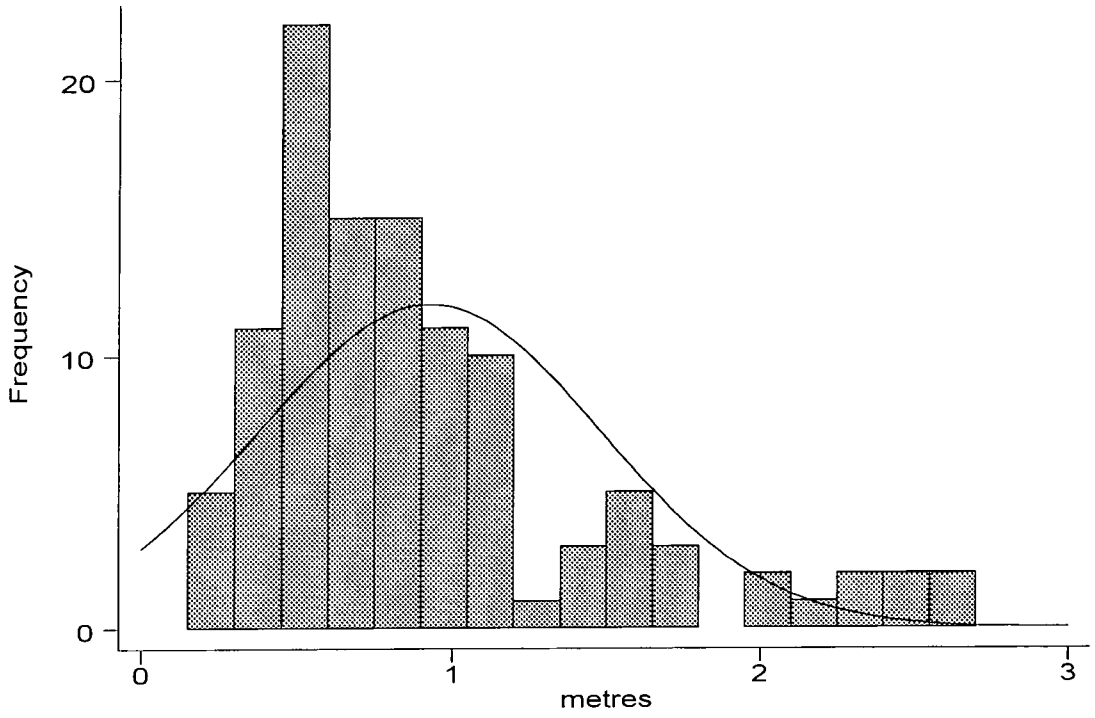


Figure 6.6: Frequency distribution of Fossil Forest joint spacing readings.

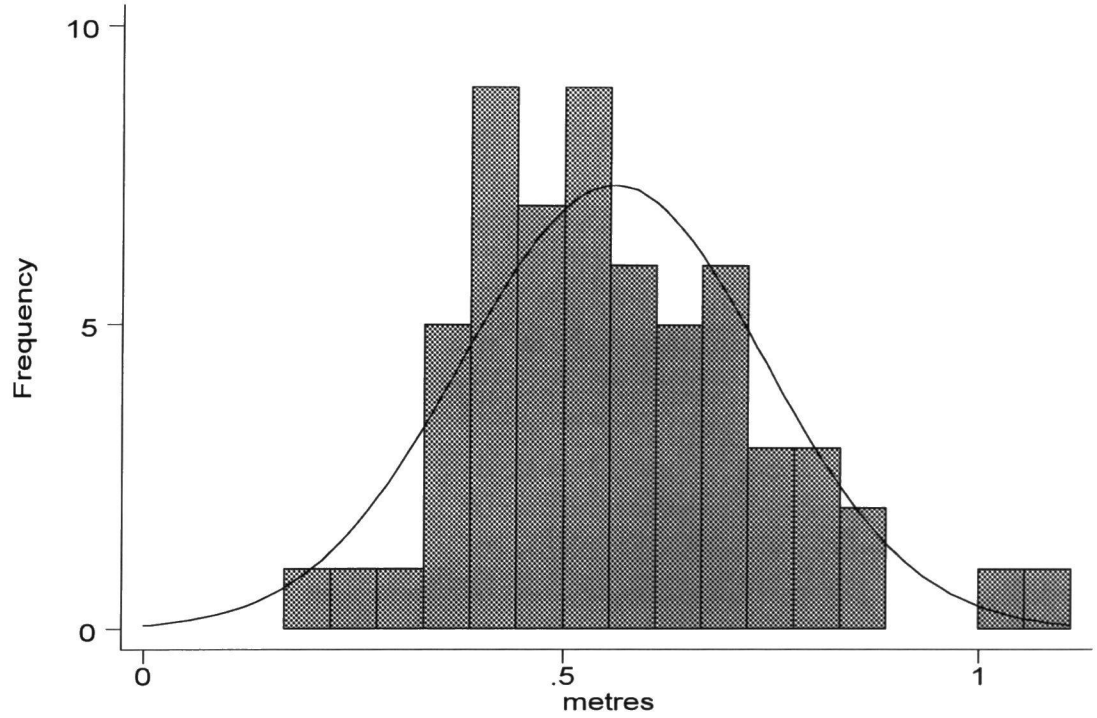


Figure 6.7: Frequency distribution of Lulworth Cove joint spacing readings.

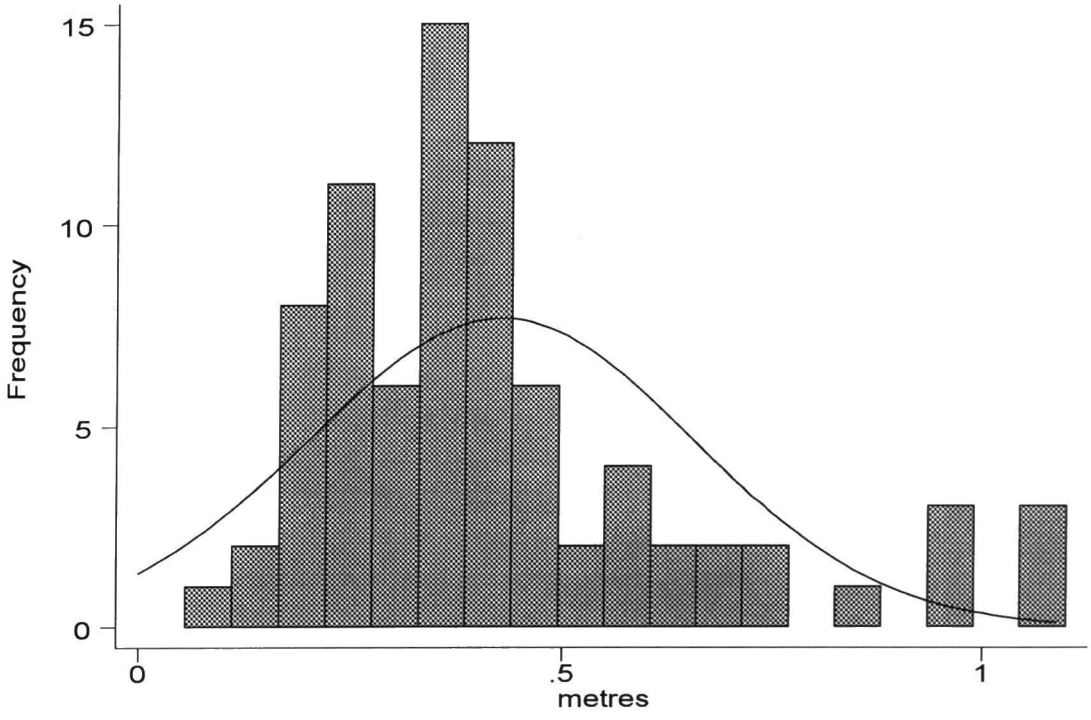


Figure 6.8: Frequency distribution of Durdle Door joint spacing readings.

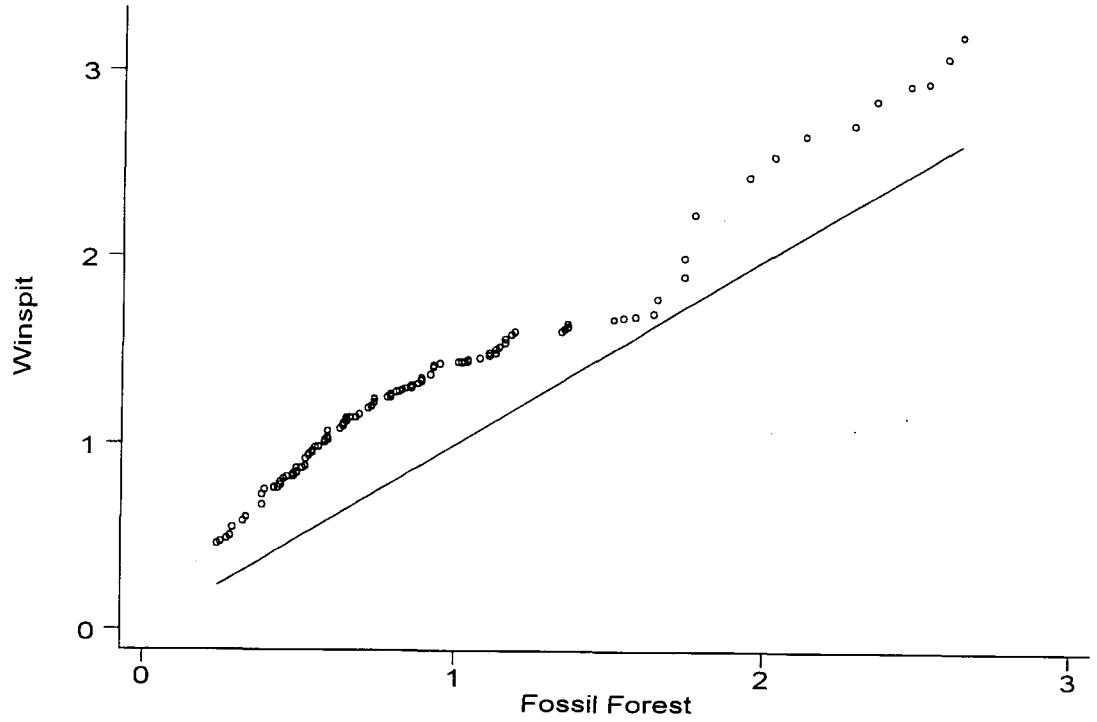


Figure 6.9: A quantile-quantile plot for joint spacing readings from Winspit and Fossil Forest.

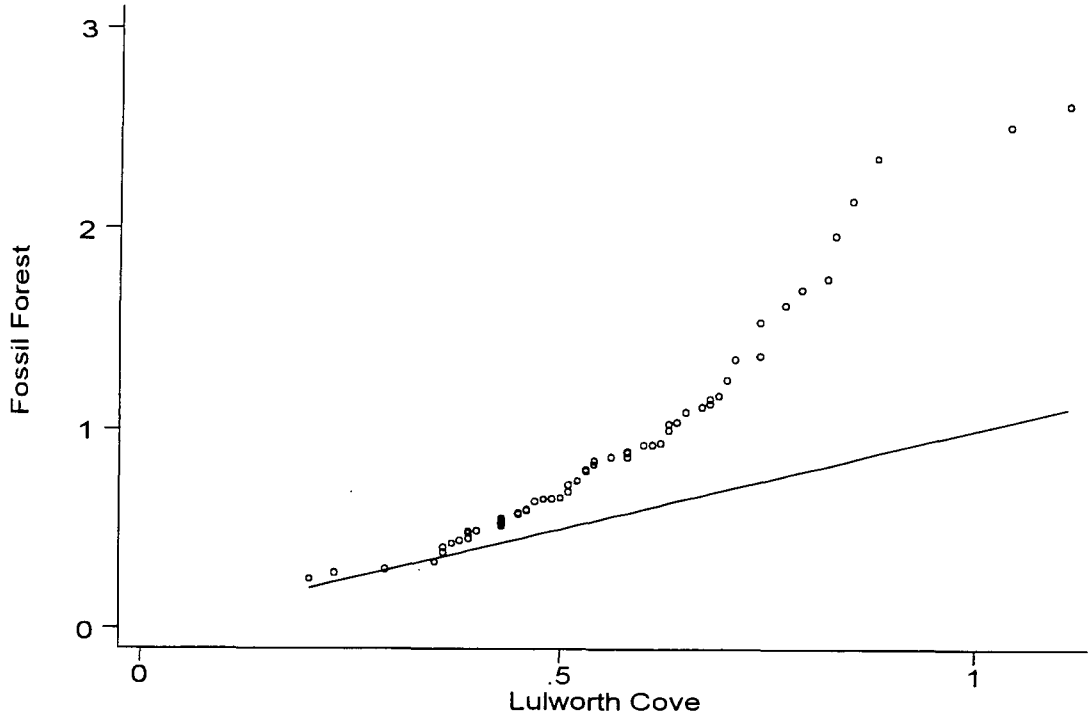


Figure 6.10: A quantile-quantile plot for joint spacing readings from Fossil Forest and Lulworth Cove.

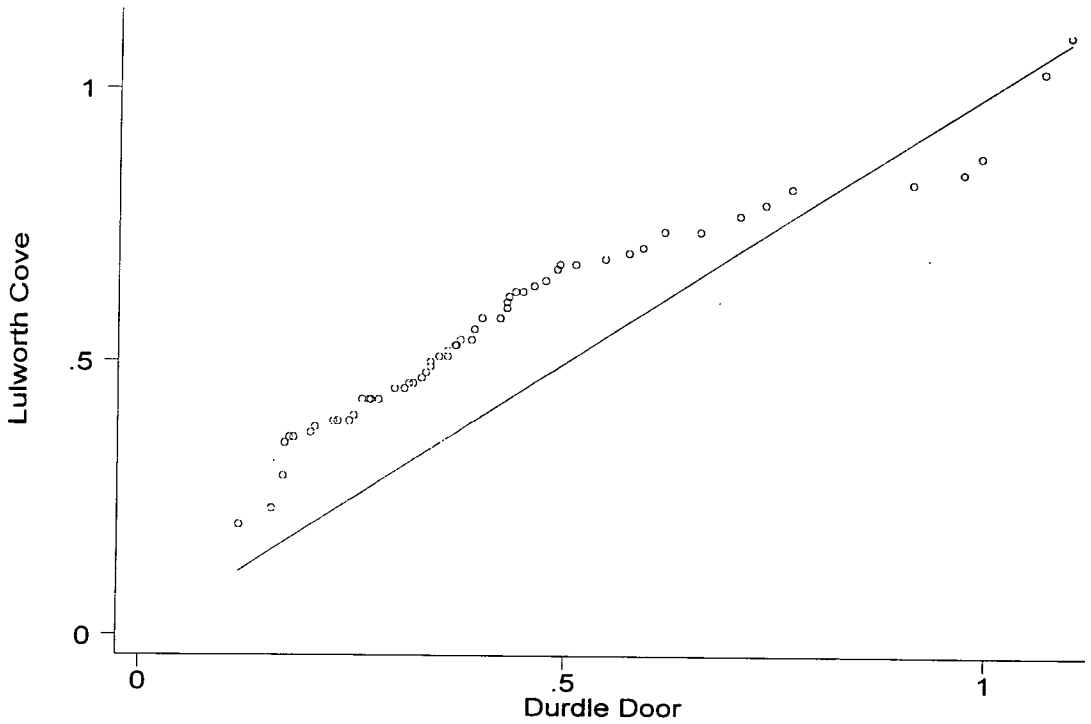


Figure 6.11: A quantile-quantile plot for joint spacing readings from Lulworth Cove and Durdle Door.

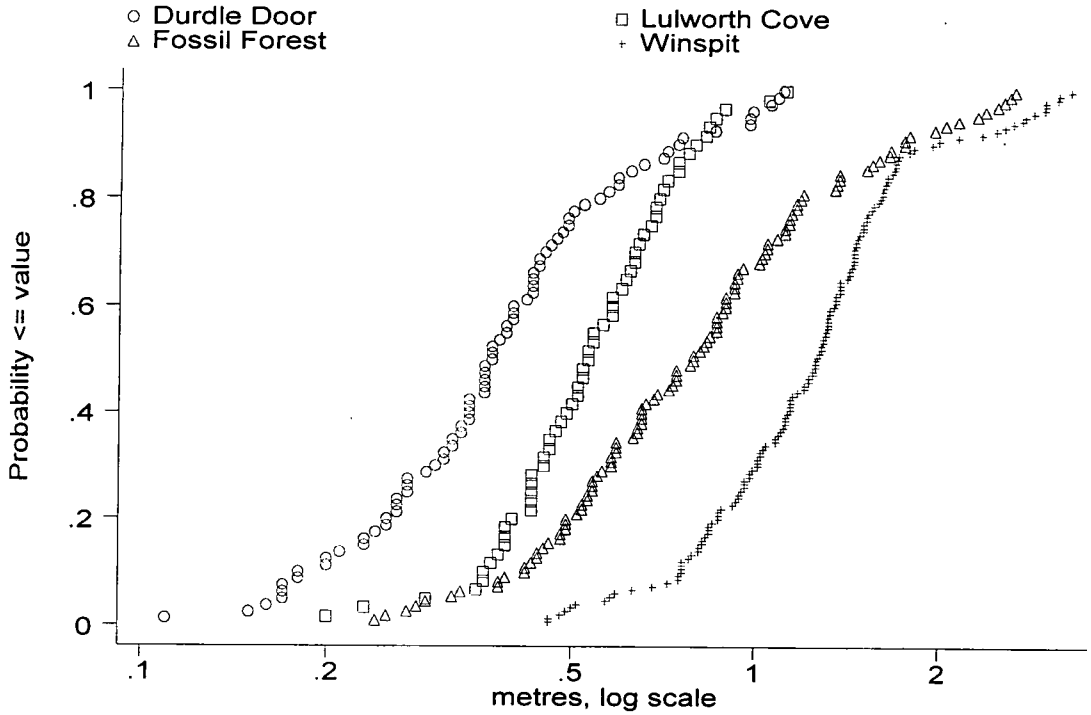


Figure 6.12: A cumulative distribution function of joint spacing readings for Winspit, Fossil Forest, Lulworth Cove and Durdle Door.

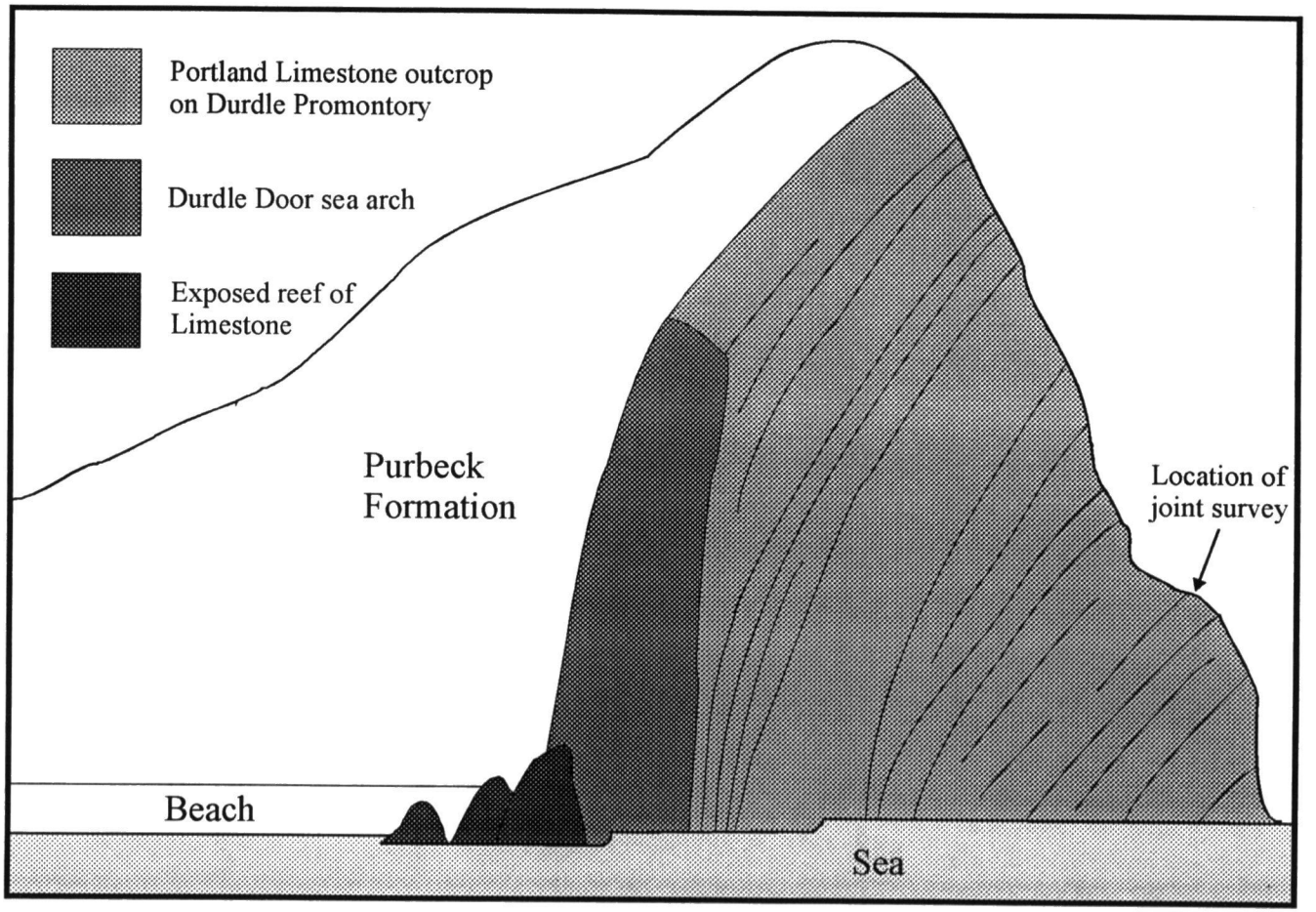


Figure 6.13: A sketch of the Durdle Promontory from the south-west, seaward side showing visible discontinuities.

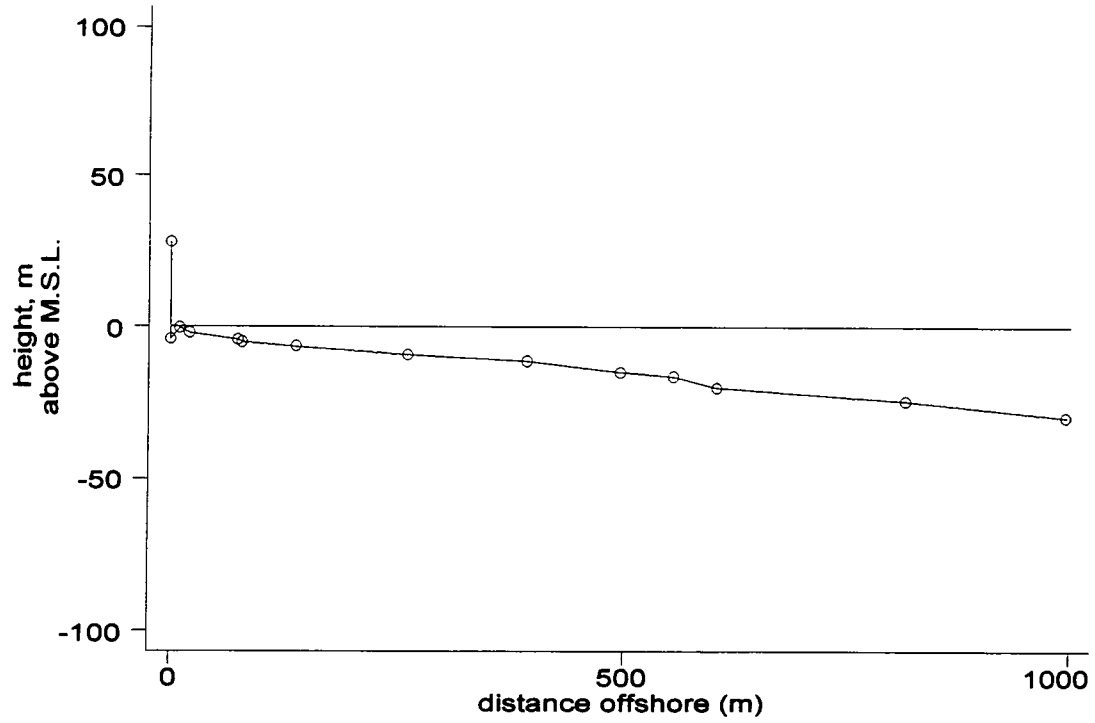


Figure 6.14: Profile of the sea floor offshore from Tillywhim.

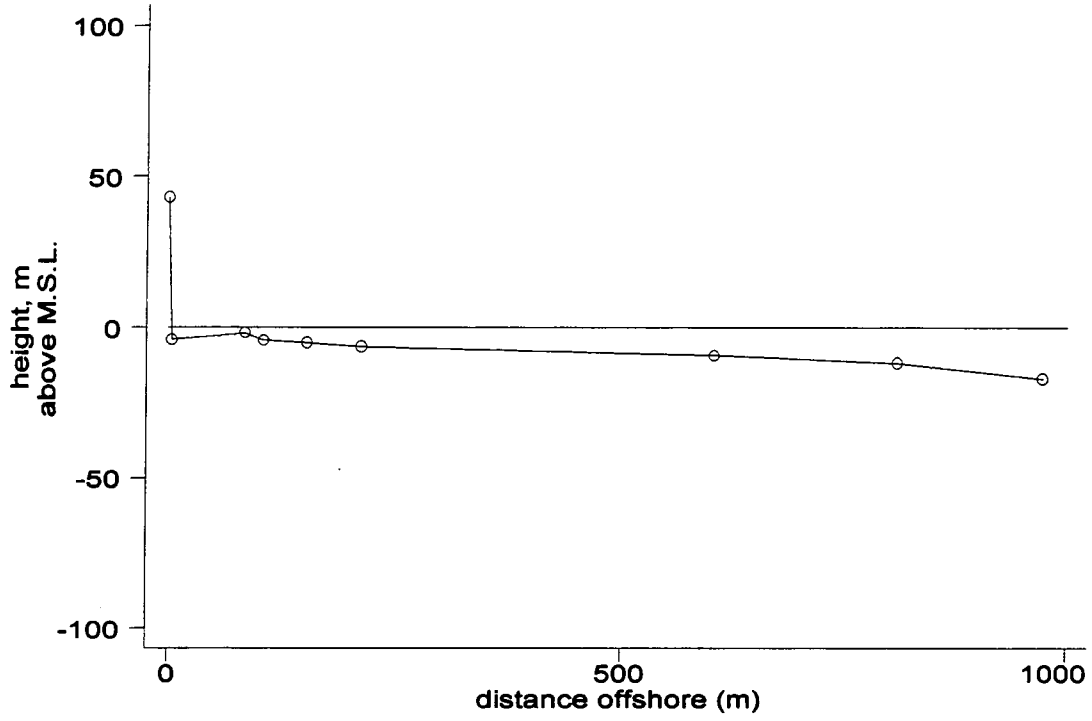


Figure 6.15: Profile of the sea floor offshore from Winspit.

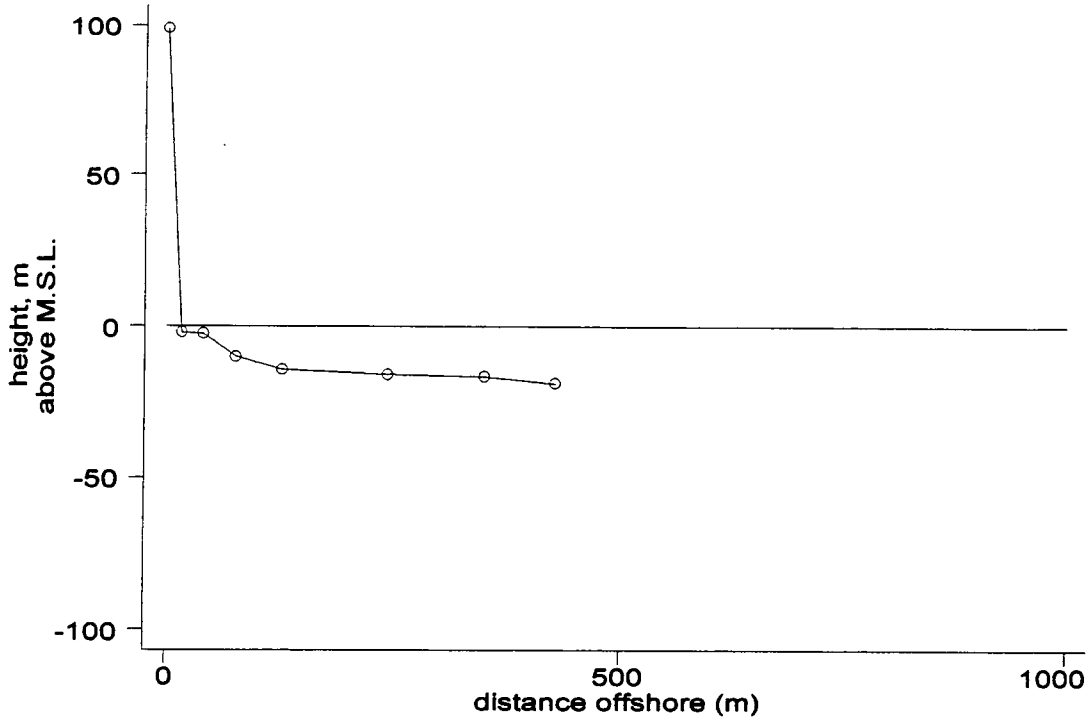


Figure 6.16: Profile of the sea floor offshore from Pondfield.

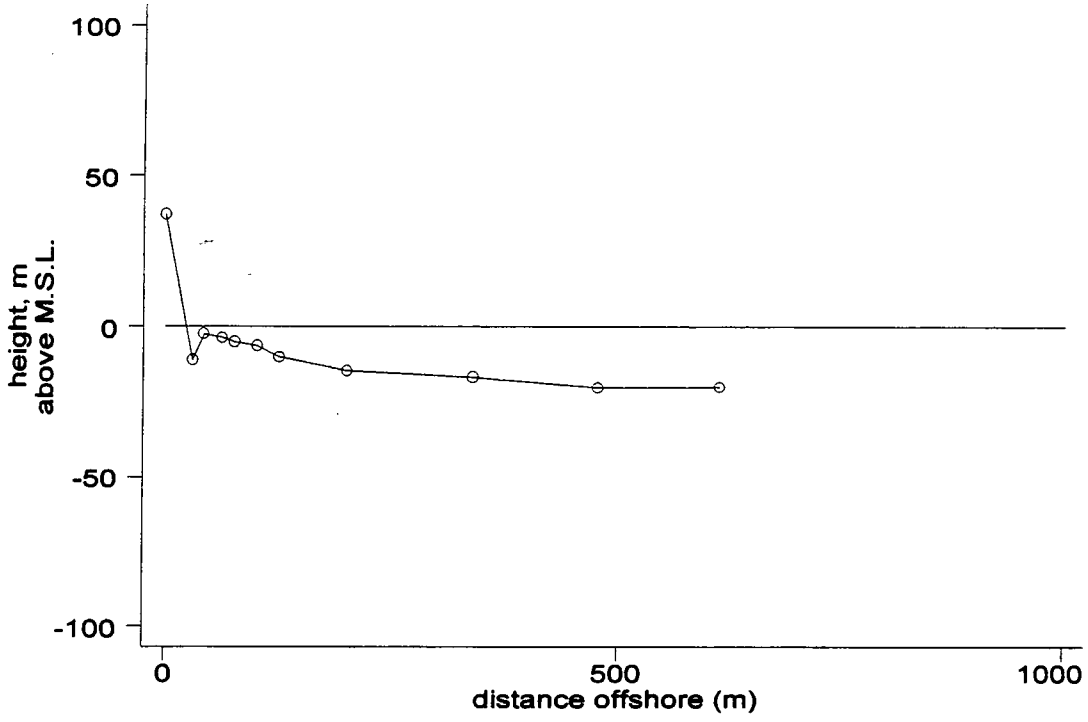


Figure 6.17: Profile of the sea floor offshore from Bacon Hole.

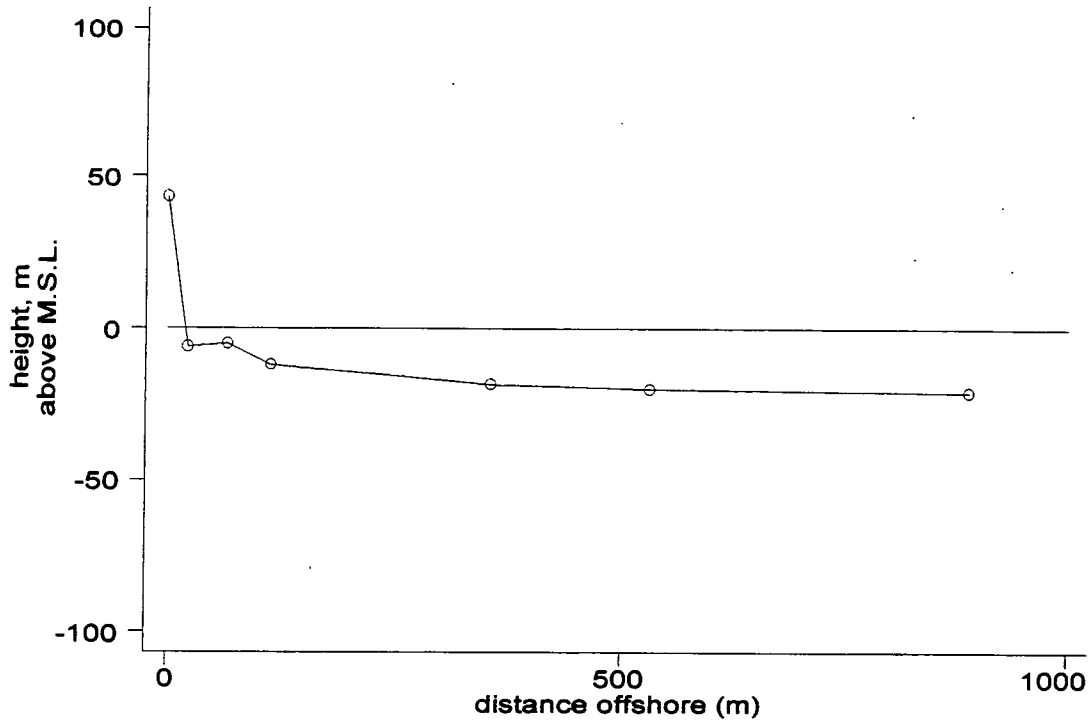


Figure 6.18: Profile of the sea floor offshore from Fossil Forest.

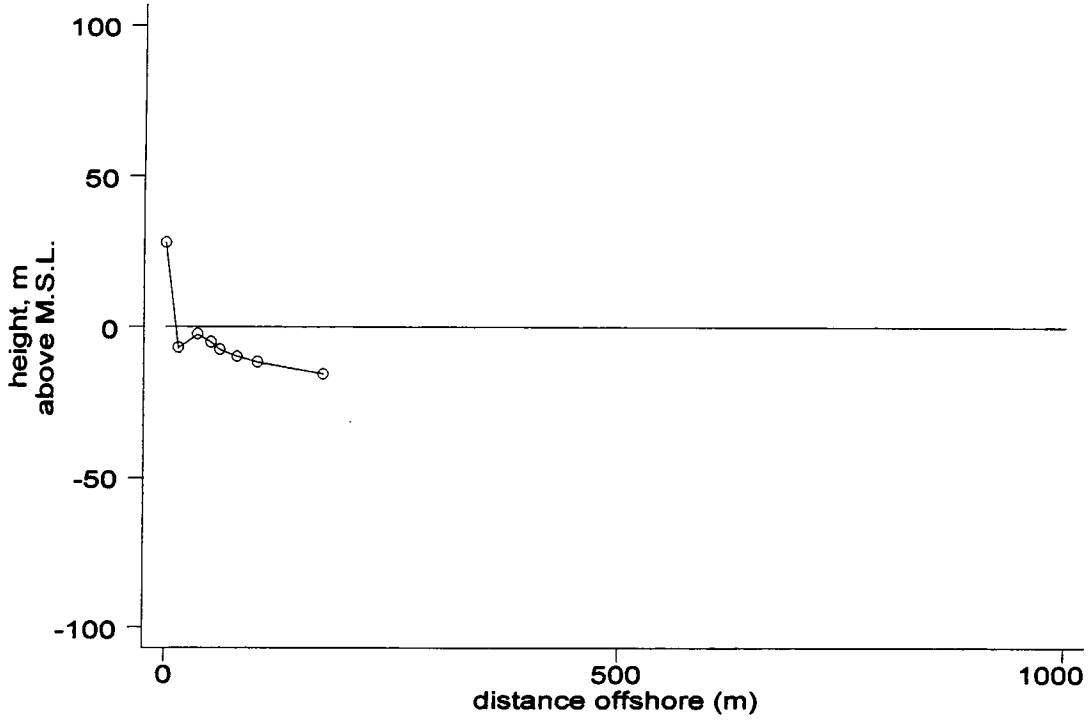


Figure 6.19: Profile of the sea floor offshore from Potter's Hole.

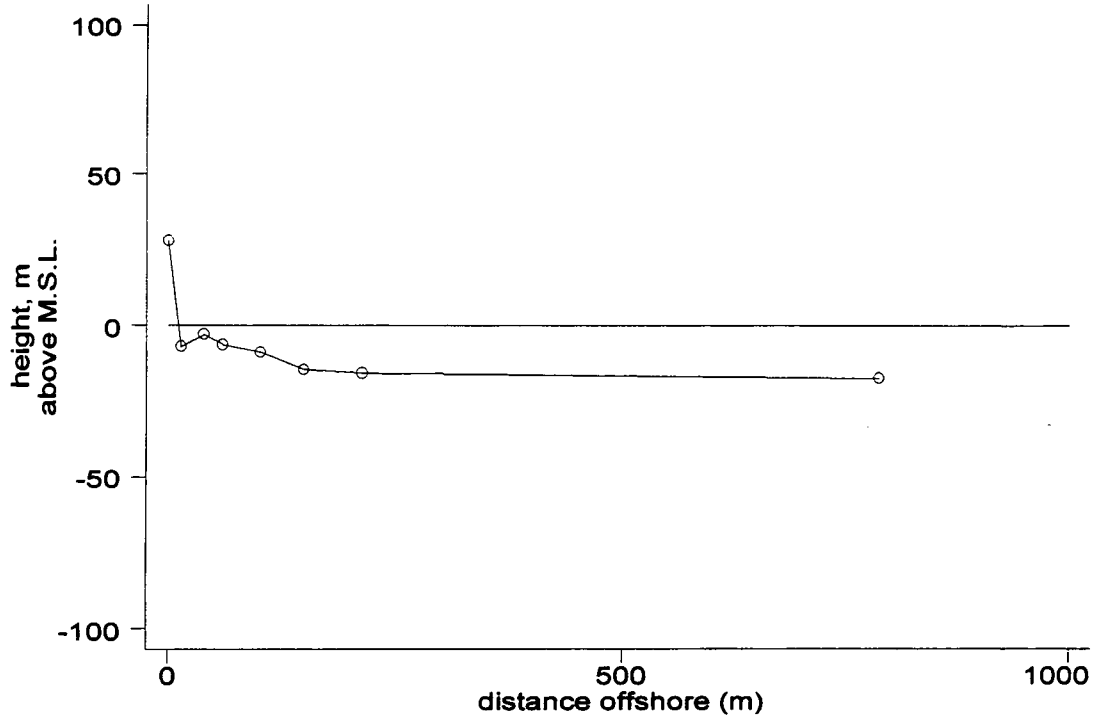


Figure 6.20: Profile of the sea floor offshore from Lulworth Cove.

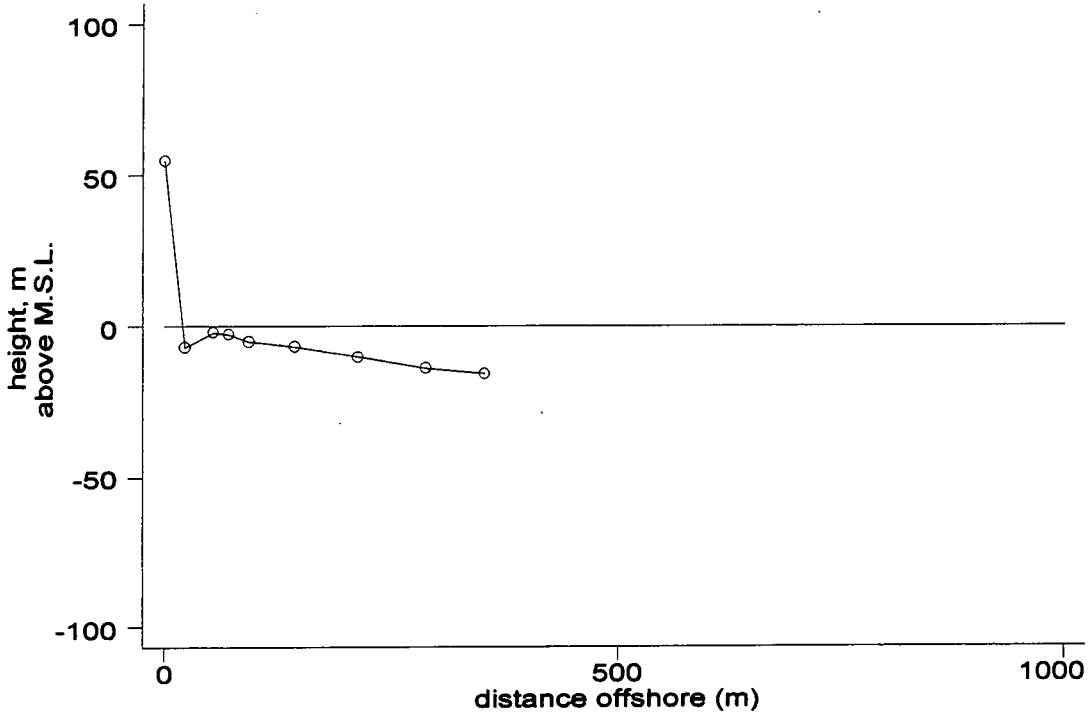


Figure 6.21: Profile of the sea floor offshore from Stair Hole.

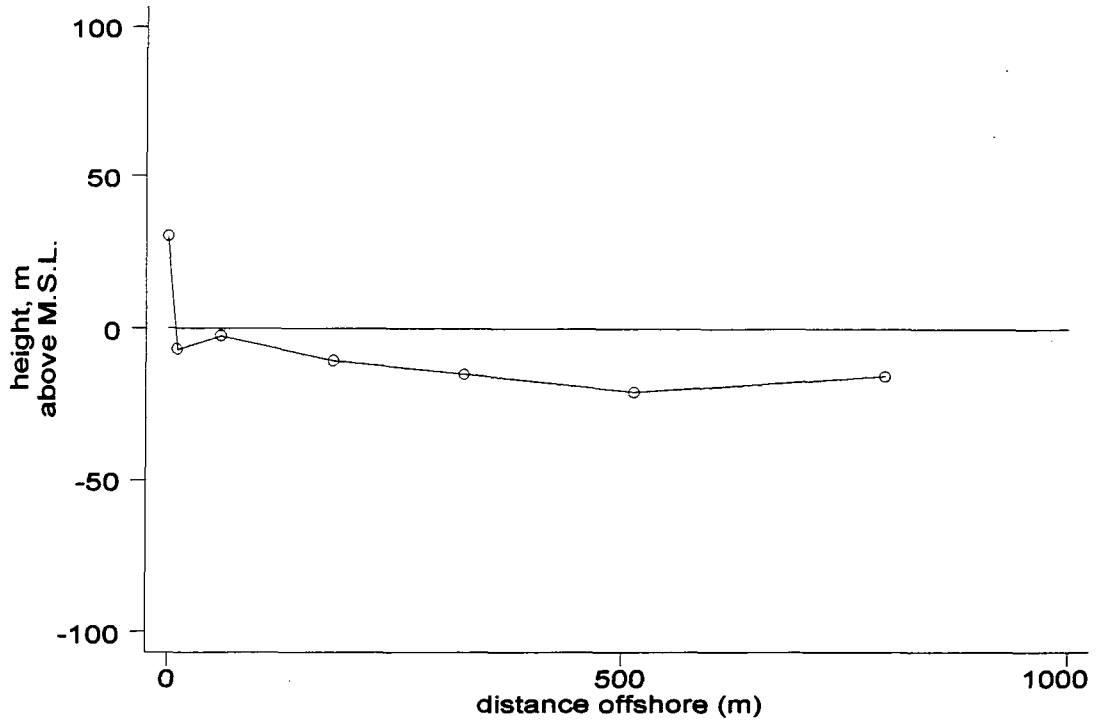


Figure 6.22: Profile of the sea floor offshore from Durdle Door.

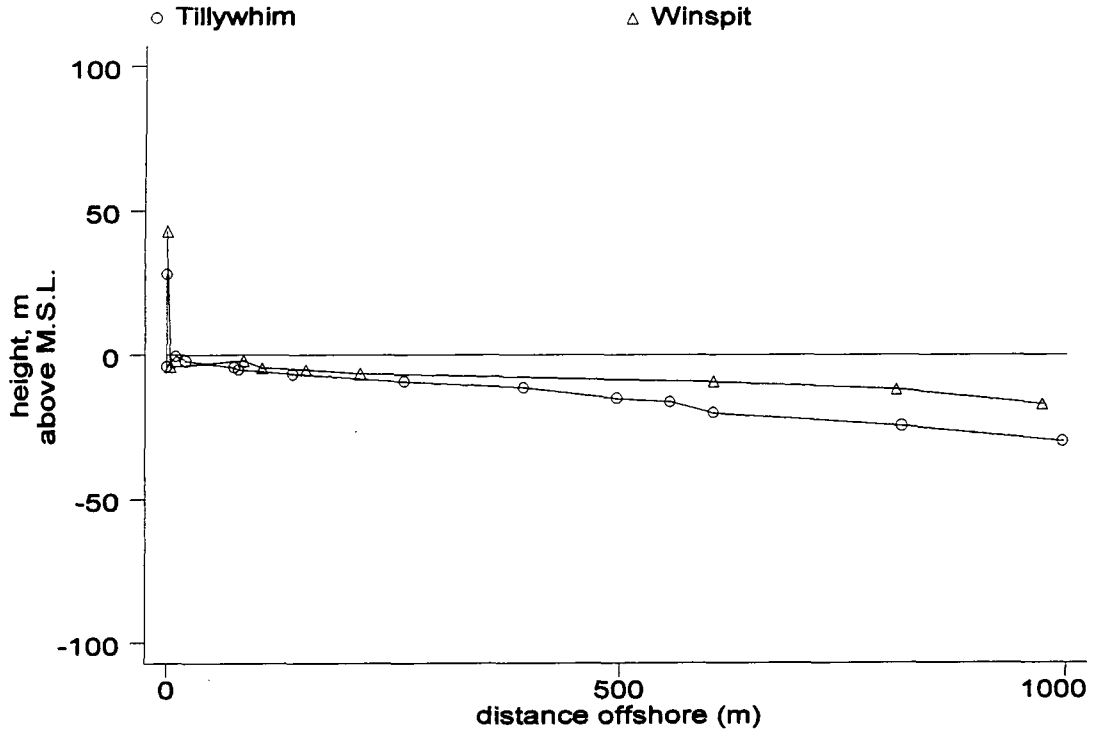


Figure 6.23: Offshore profiles for the sites at the eastern end of the Isle of Purbeck.

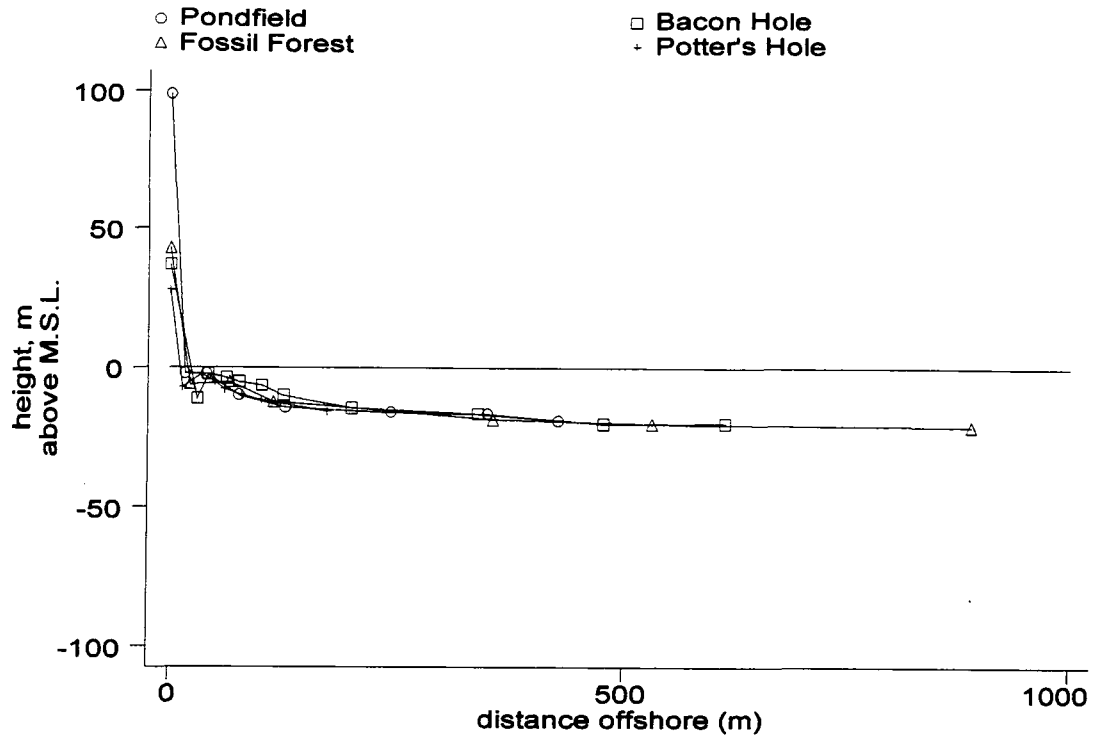


Figure 6.24: Offshore profiles for the sites in the central part of the Isle of Purbeck.

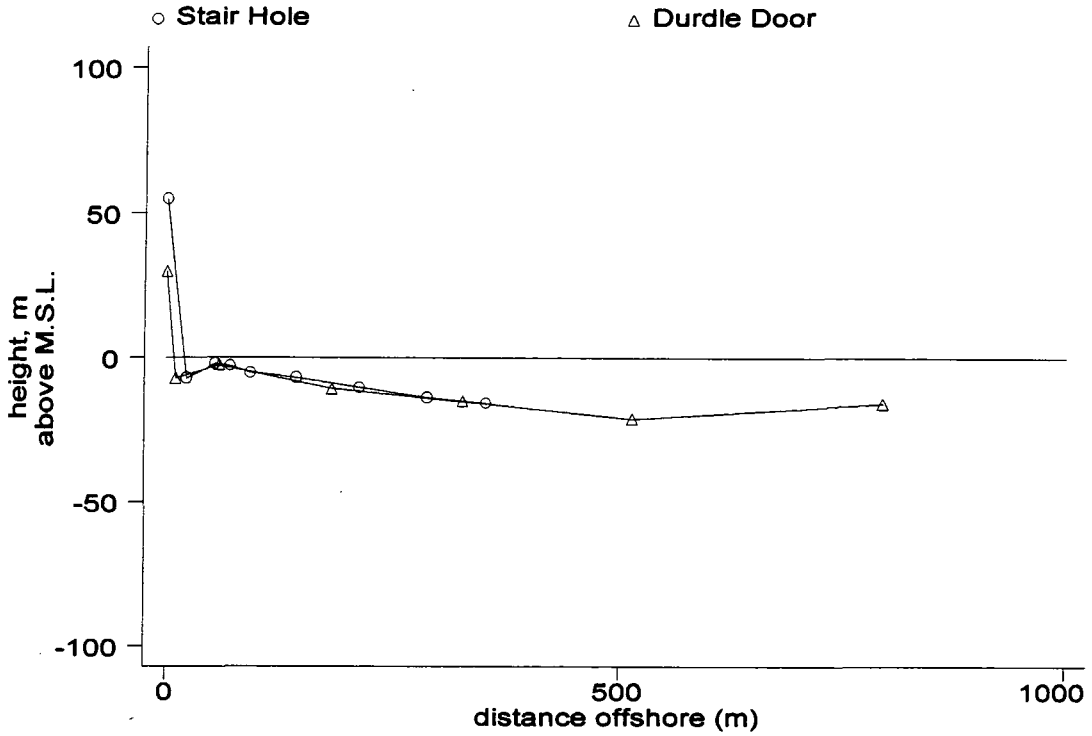


Figure 6.25: Offshore profiles for the sites at the western end of the Isle of Purbeck.

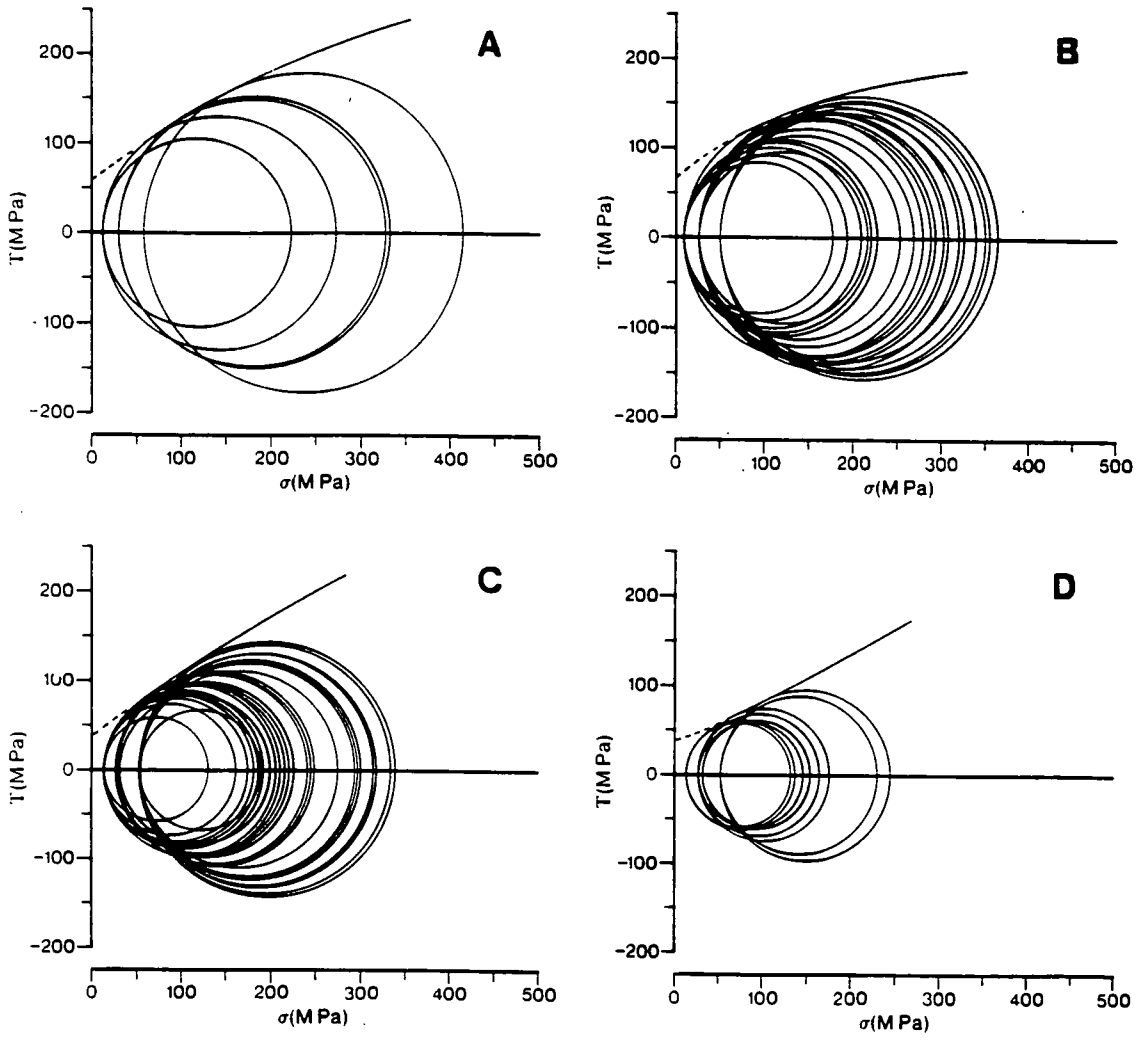


Figure 6.26: Mohr's circles of stress from tests conducted at confining pressures (σ_3) of 15 MPa, 30 MPa and 60 MPa. A: Durdle Door, B: Stair Hole, Lulworth Cove and Worbarrow Tout, C: Fossil Forest, Bacon Hole, Pondfield, Seacombe and Tillywhim, D: Winspit. From Allison, 1989.

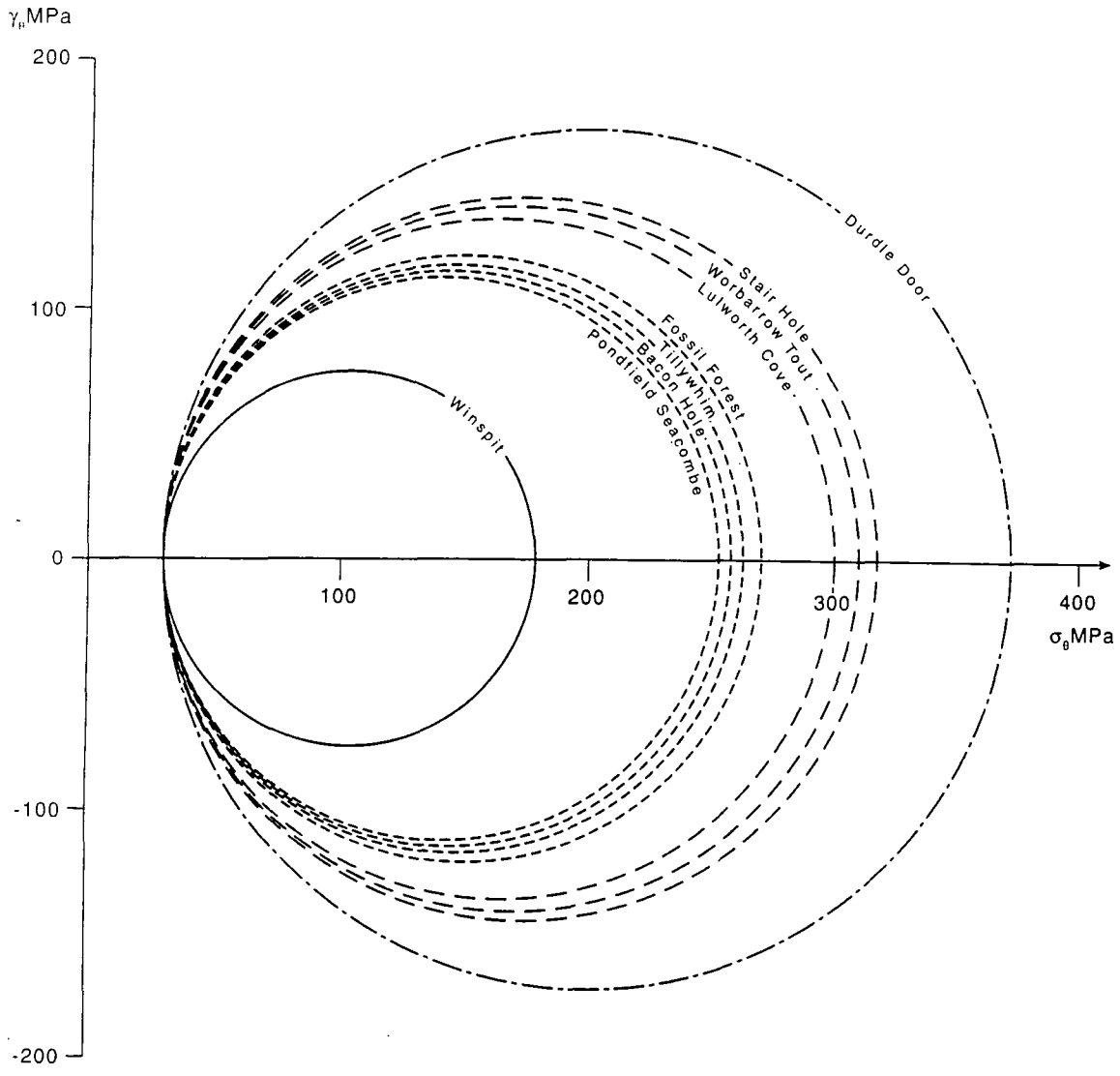


Figure 6.27: Changes in rock strength for the Portland Limestone along the Isle of Purbeck coast.

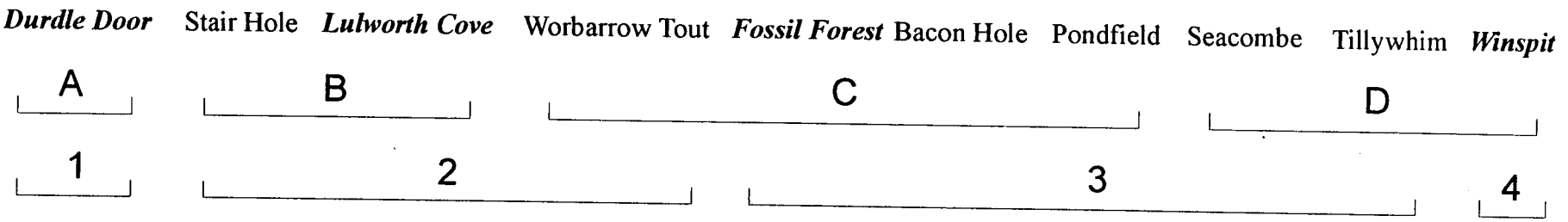
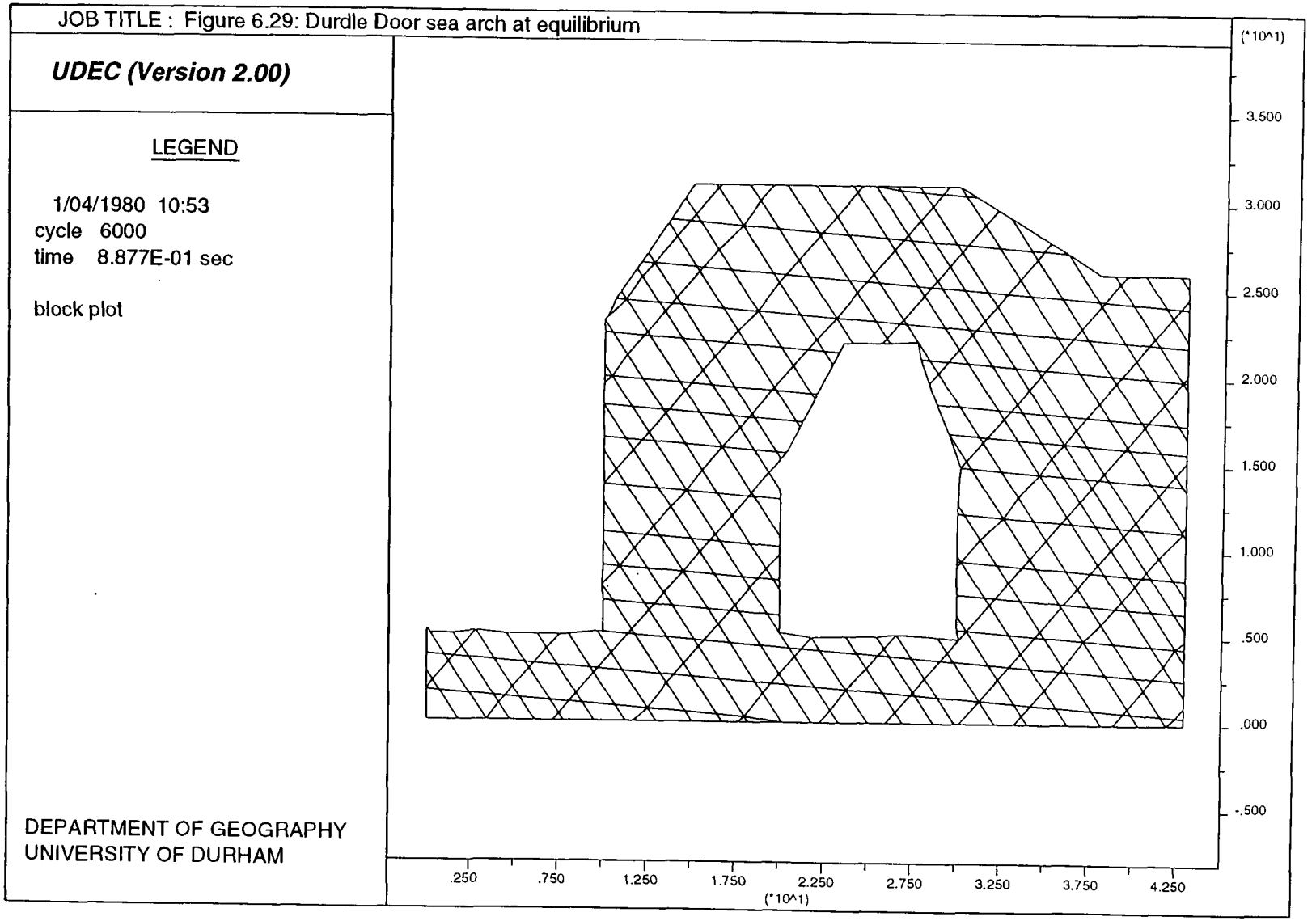
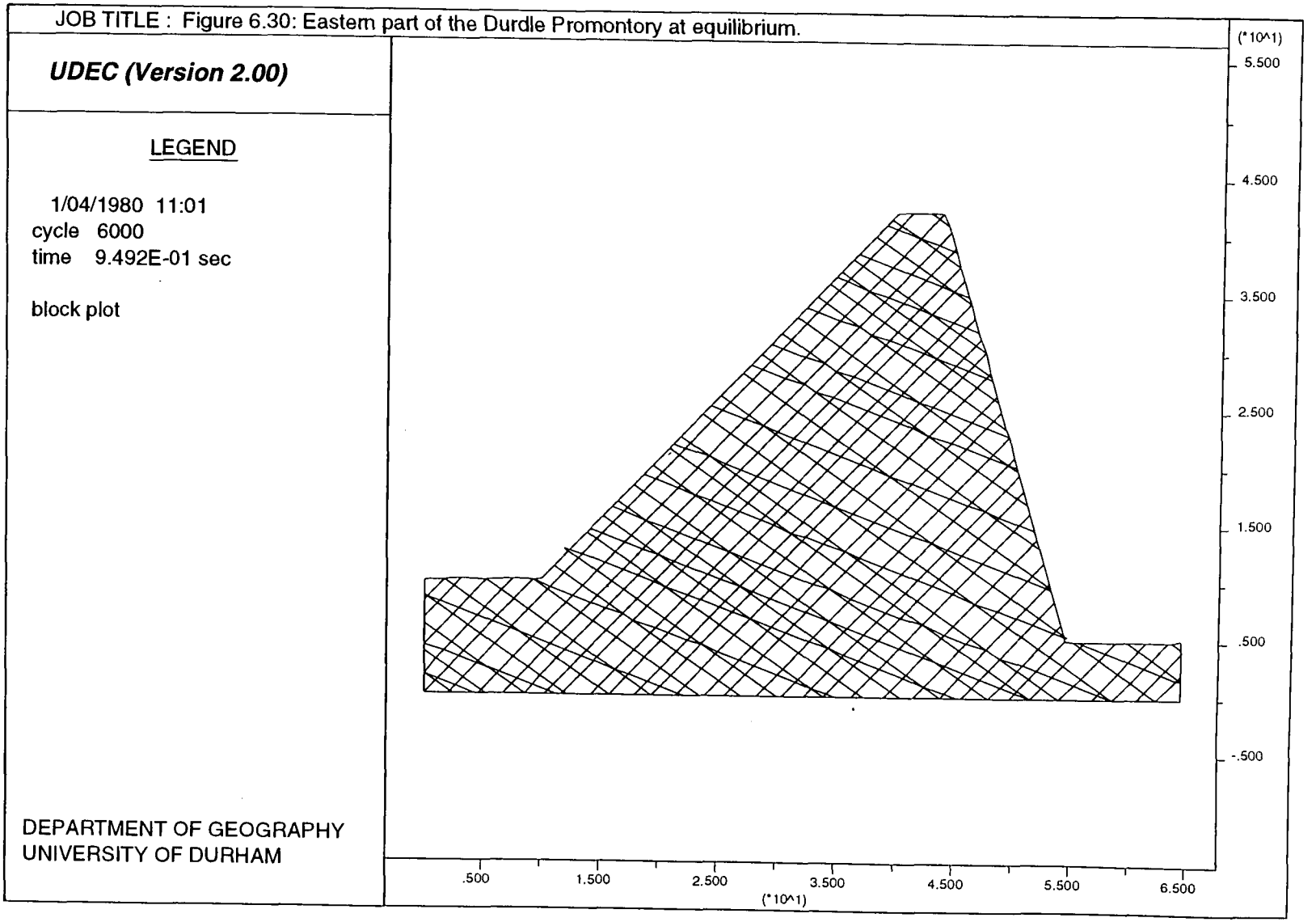
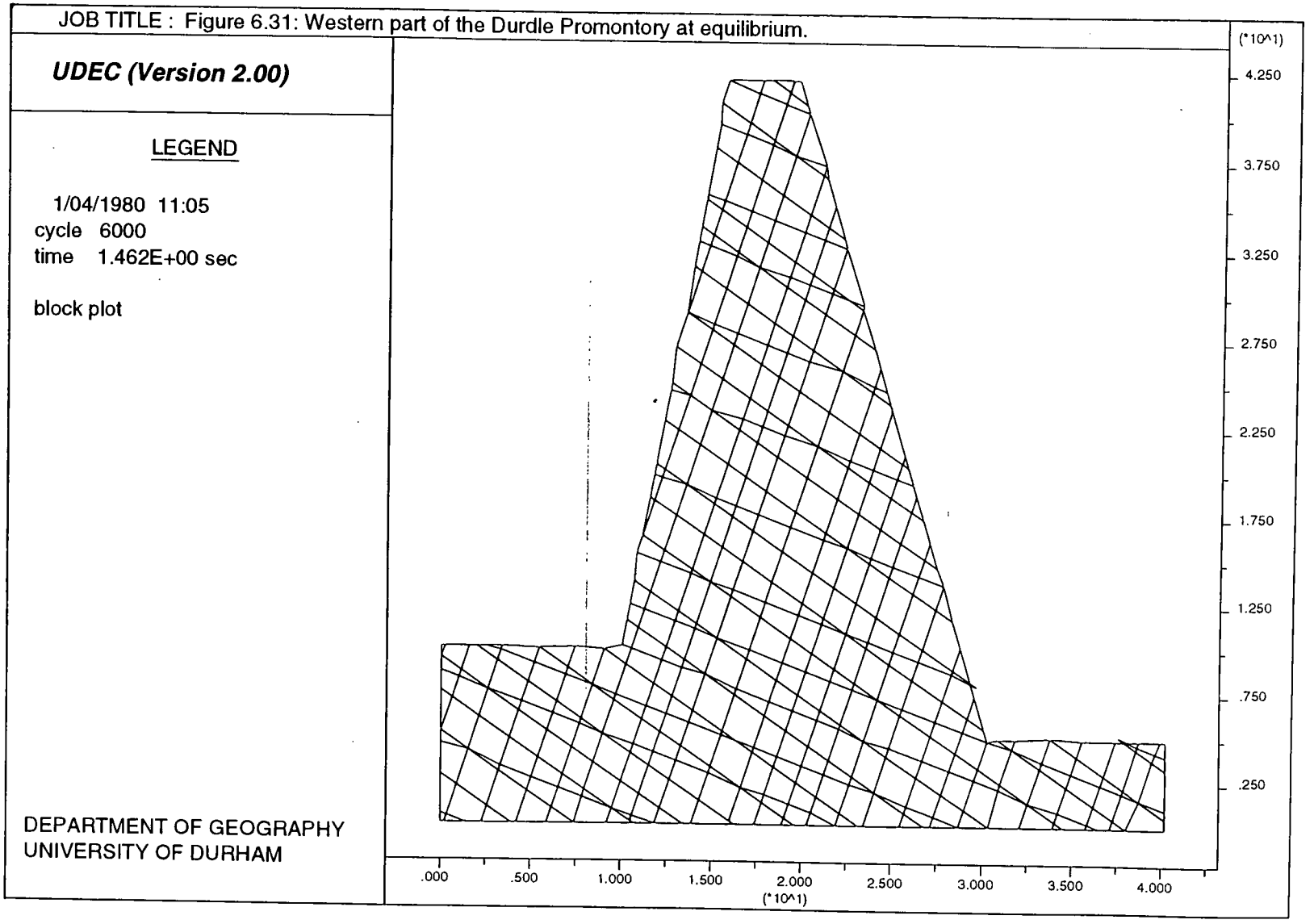
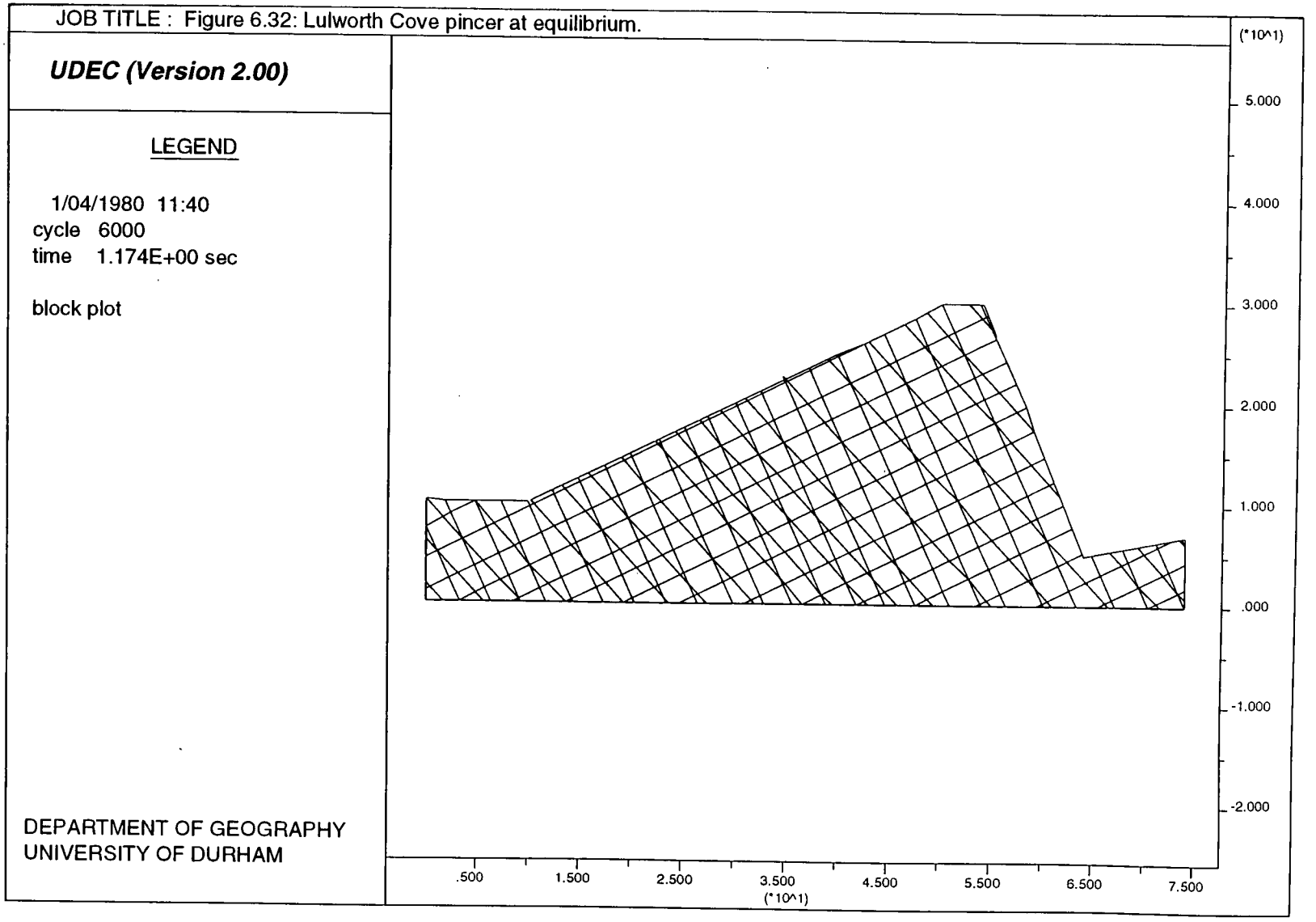


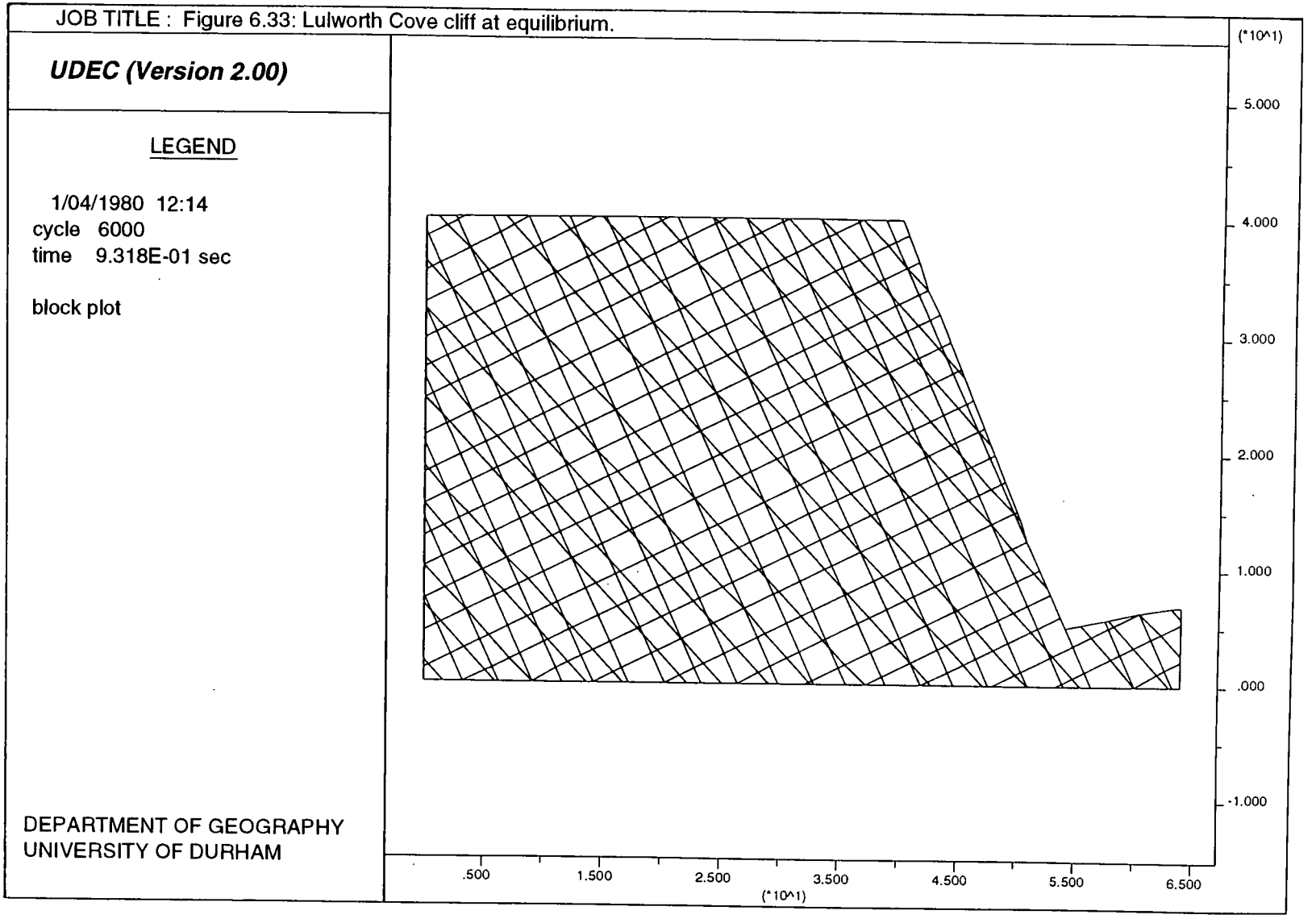
Figure 6.27: Groups of sites with similar geotechnical characteristics. The sites chosen for modelling are indicated by a bold / italic font.
Depending upon the dip of the bedding, sites are split into the groups of A, B, C and D:
Group A has bedding that dips at 50 degrees, group B at 30 degrees, Group C at 20 degrees and Group D has horizontal bedding.
Based upon an intact rock strength control, sites are split into the groups of 1, 2, 3, and 4:
Group 1 has a yield stress of 373 MPa, group 2 between 299 and 317 MPa, group 3 between 255 and 271 MPa and group 4 of 188 MPa.

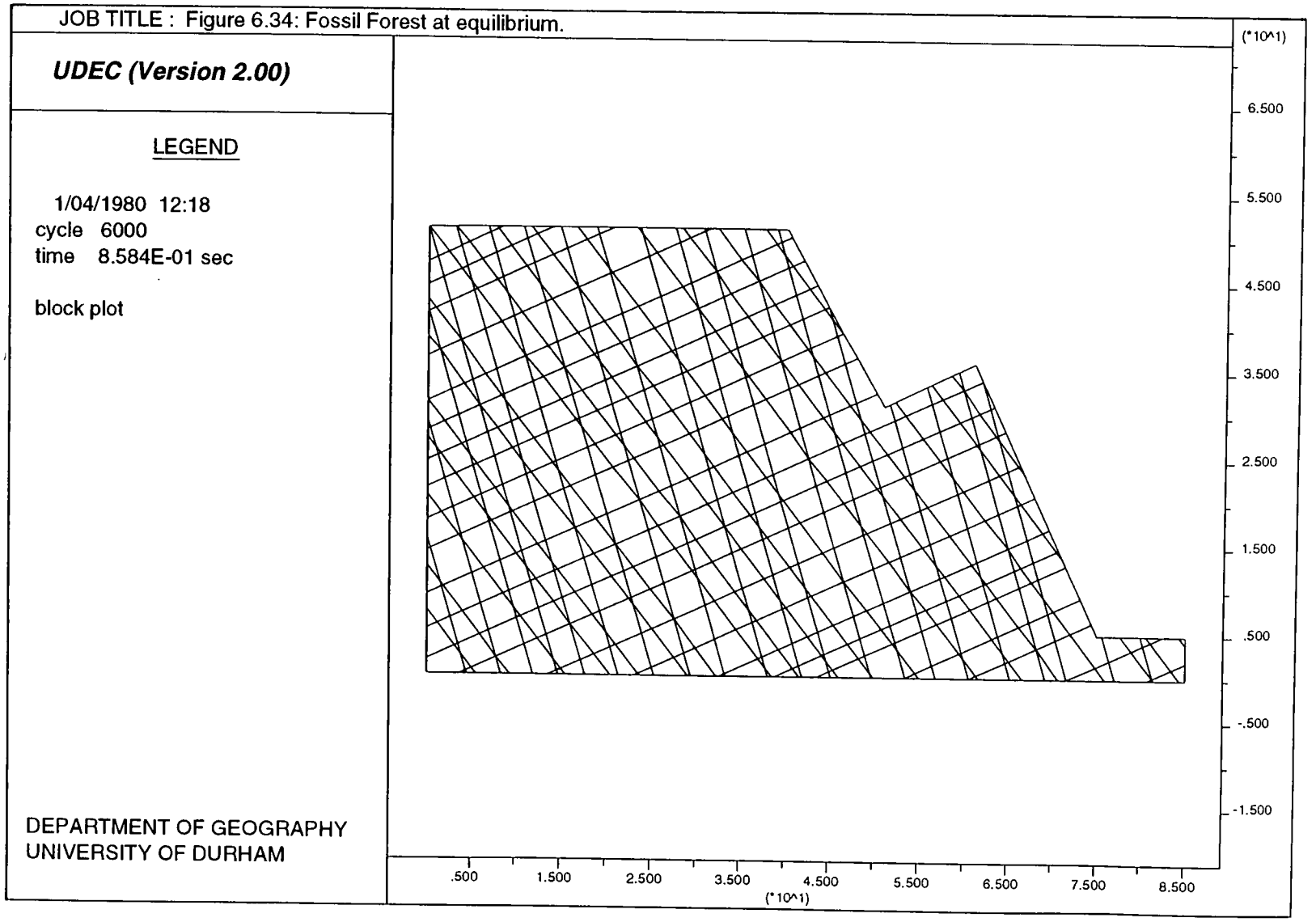

JOB TITLE : Figure 6.29: Durdle Door sea arch at equilibrium
UDEC (Version 2.00)
LEGEND
1/04/1980 10:53
cycle 6000
time 8.877E-01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
3.500
3.000
2.500
2.000
1.500
1.000
.500
.000
-.500
.250
.750
1.250
1.750
2.250
2.750
3.250
3.750
4.250
(*10^1)

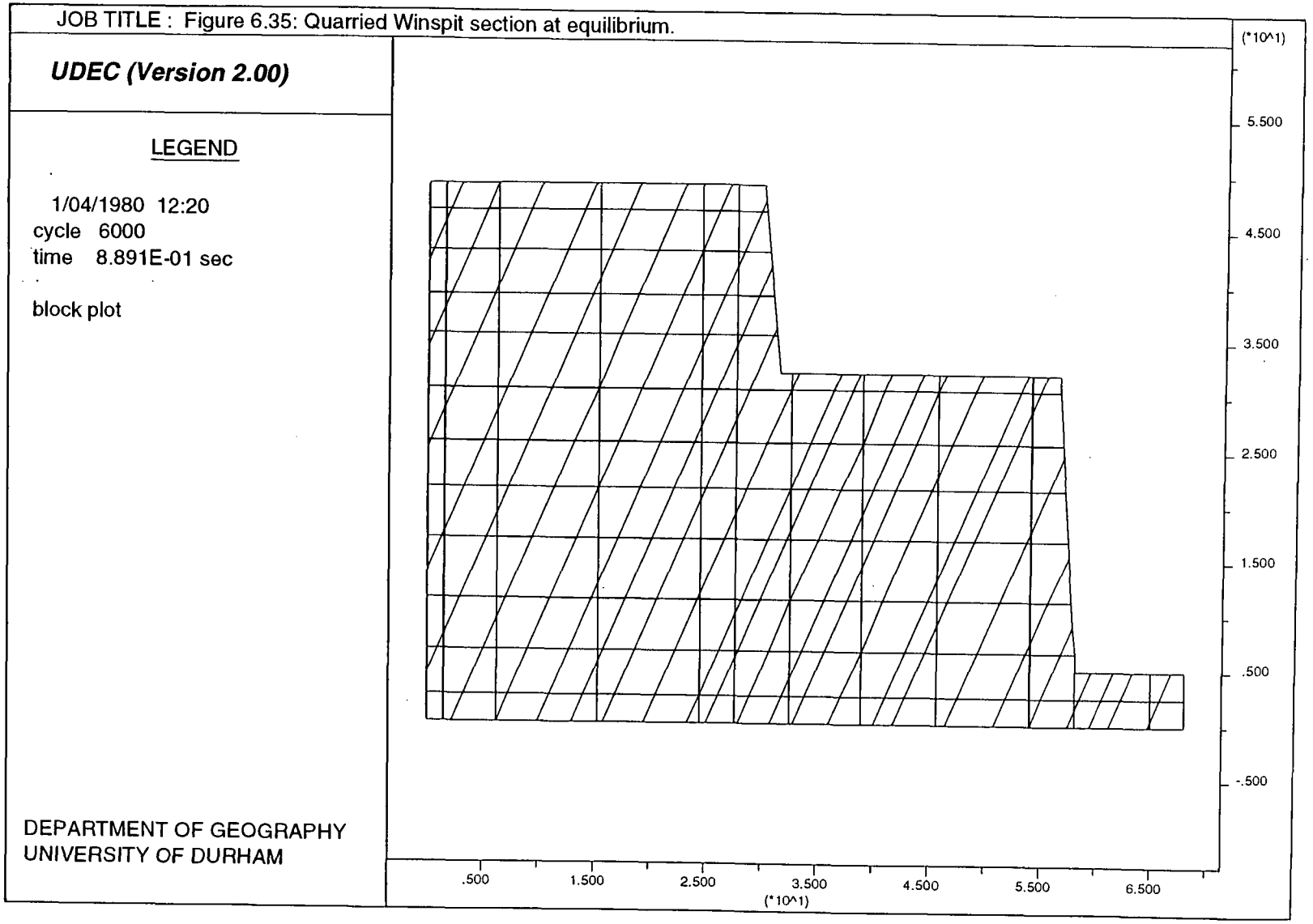

JOB TITLE : Figure 6.30: Eastern part of the Durdle Promontory at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 11:01
cycle 6000
time 9.492E-01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

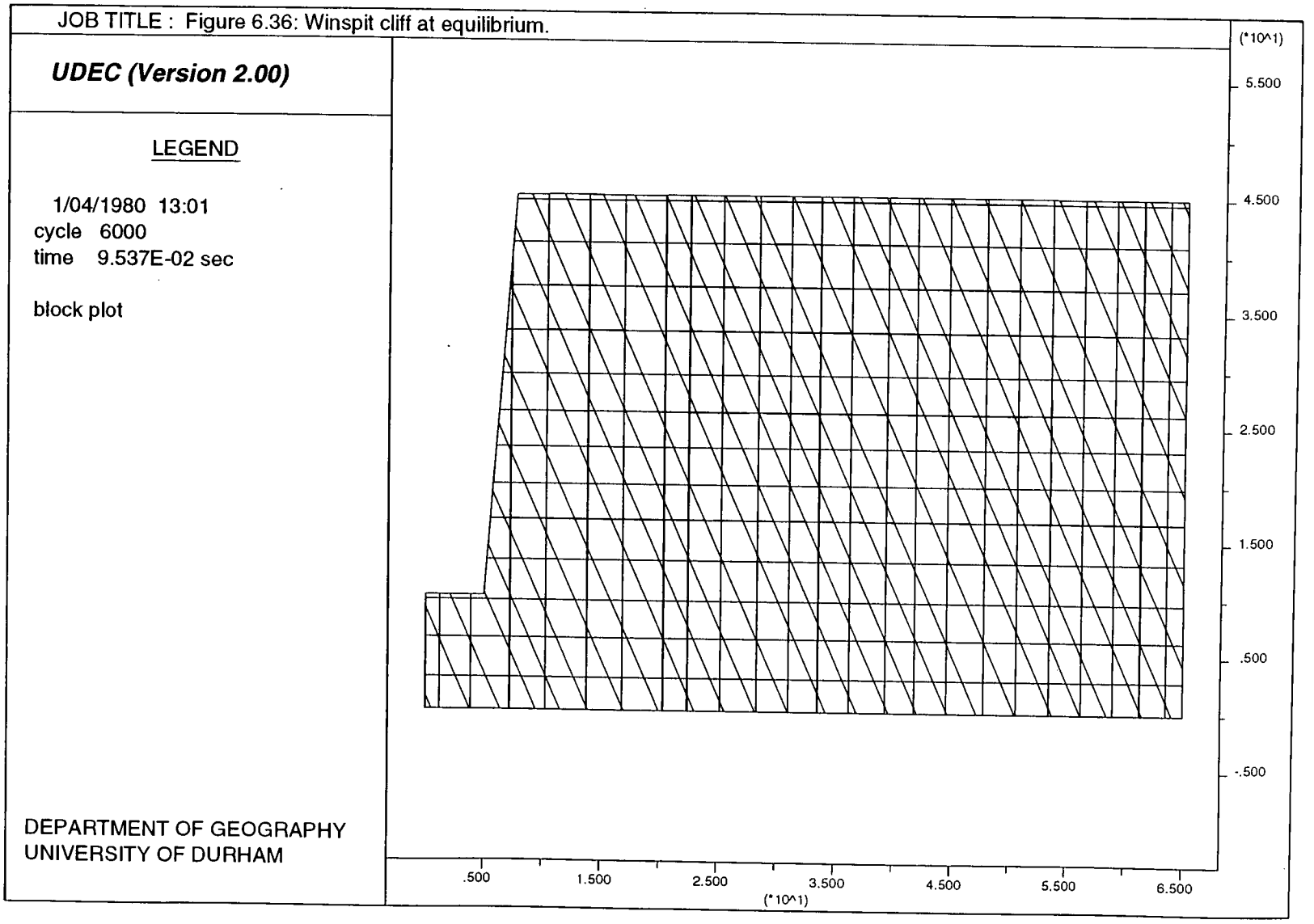

JOB TITLE : Figure 6.31: Western part of the Durdle Promontory at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 11:05
cycle 6000
time 1.462E+00 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
4.250
3.750
3.250
2.750
2.250
1.750
1.250
.750
.250
.000
.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
(*10^1)


JOB TITLE : Figure 6.32: Lulworth Cove pincer at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 11:40
cycle 6000
time 1.174E+00 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
-2.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 6.33: Lulworth Cove cliff at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 12:14
cycle 6000
time 9.318E-01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.34: Fossil Forest at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 12:18
cycle 6000
time 8.584E-01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
8.500
(*10^1)


JOB TITLE : Figure 6.35: Quarried Winspit section at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 12:20
cycle 6000
time 8.891E-01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.36: Winspit cliff at equilibrium.
UDEC (Version 2.00)
LEGEND
1/04/1980 13:01
cycle 6000
time 9.537E-02 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

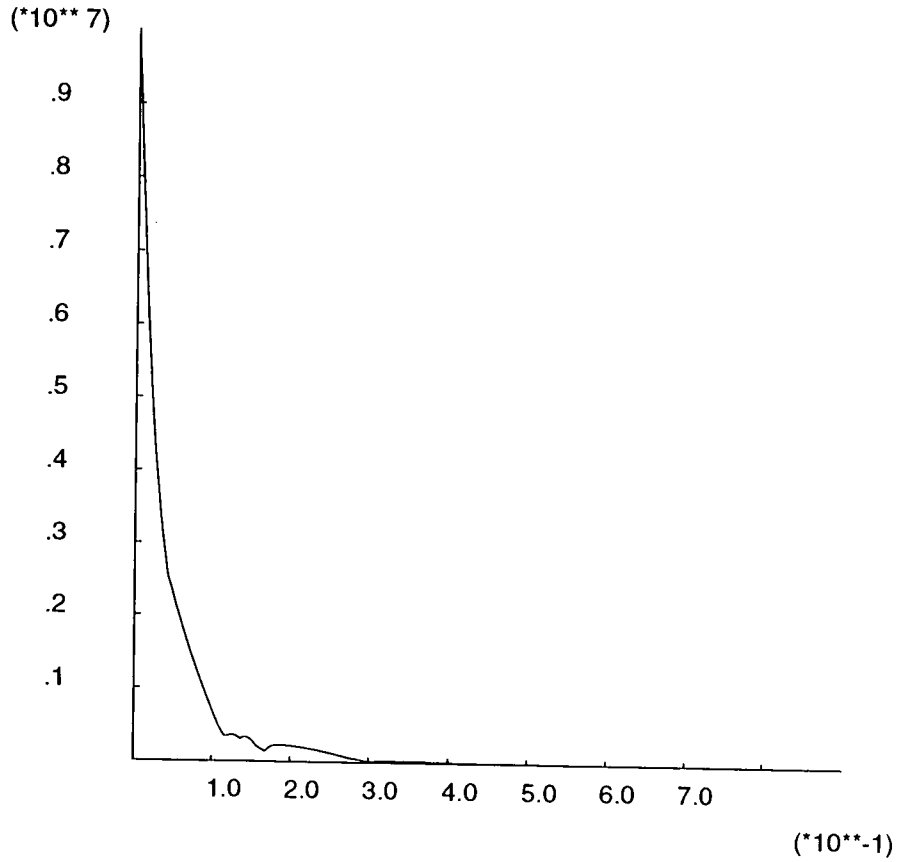
JOB TITLE : Figure 6.37: Forces for the quarried Winspit section at equilibrium.

UDEC (Version 2.00)

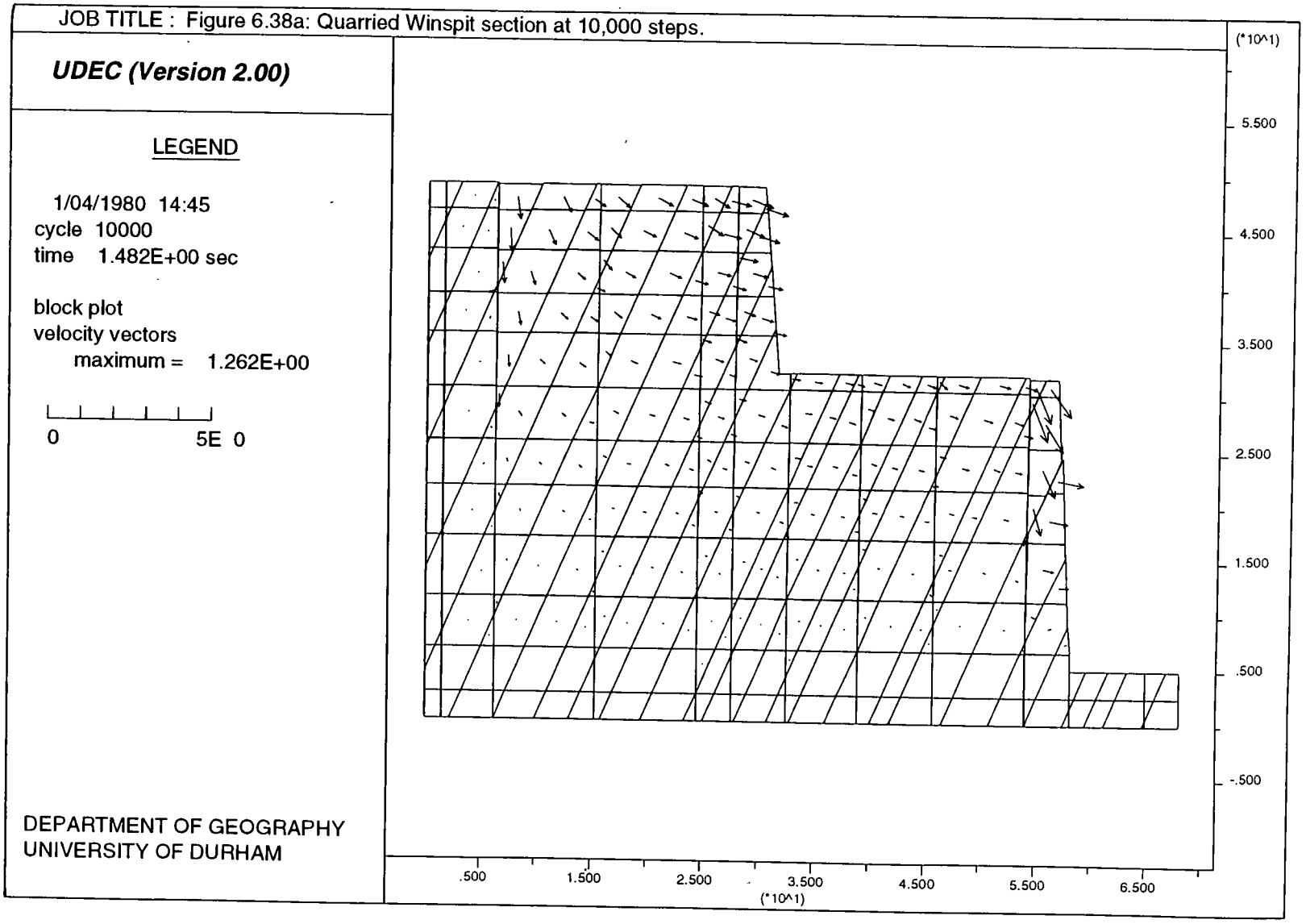
LEGEND

1/04/1980 14:44
cycle 6000
time 8.891E-01 sec

5.37E+00 <hist 3> 9.60E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 6.38a: Quarried Winspit section at 10,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:45
cycle 10000
time 1.482E+00 sec
block plot
velocity vectors
maximum = 1.262E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

JOB TITLE : Figure 6.38b: Quarried Winspit section at 30,000 steps.

UDEC (Version 2.00)

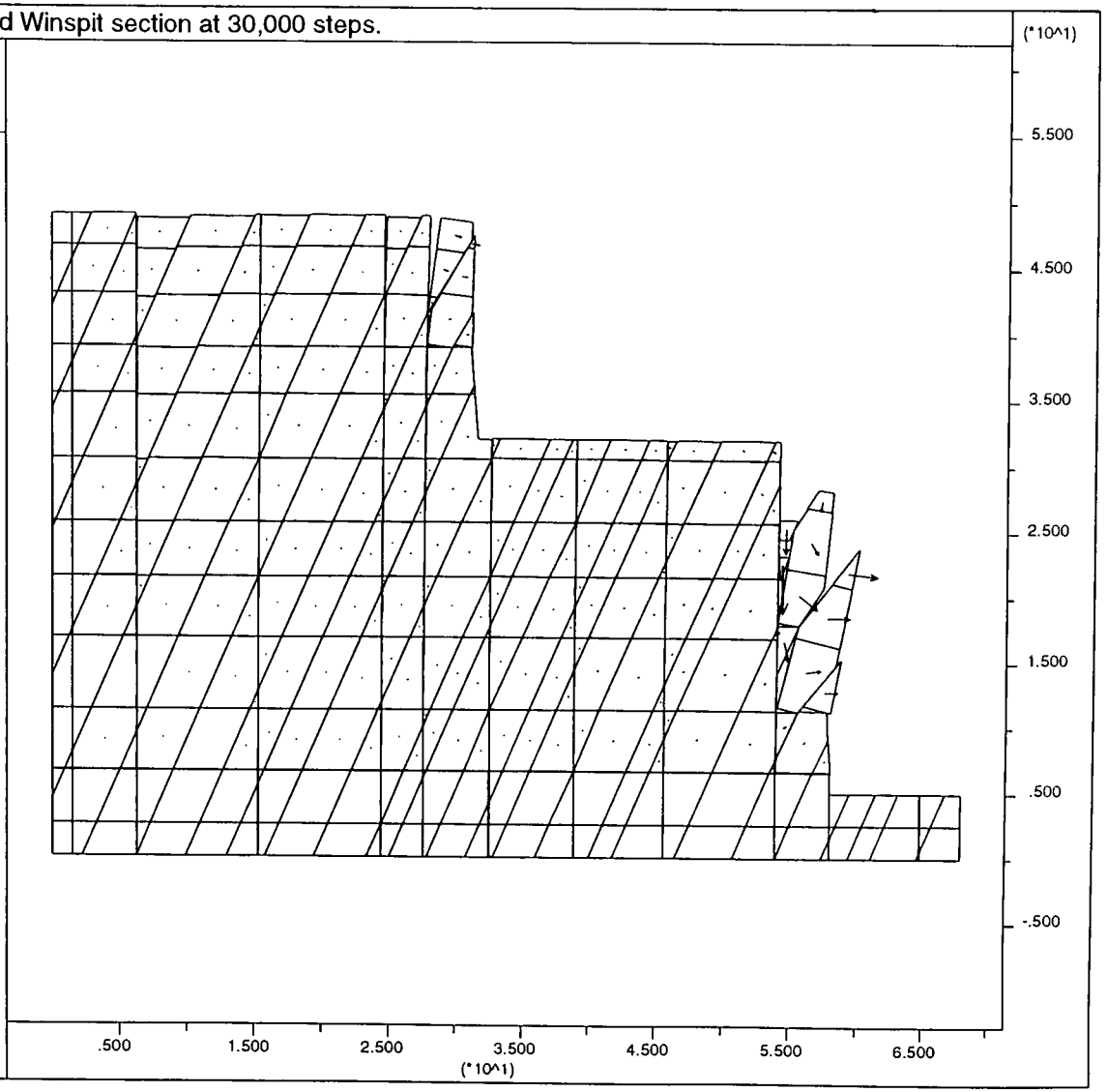
LEGEND

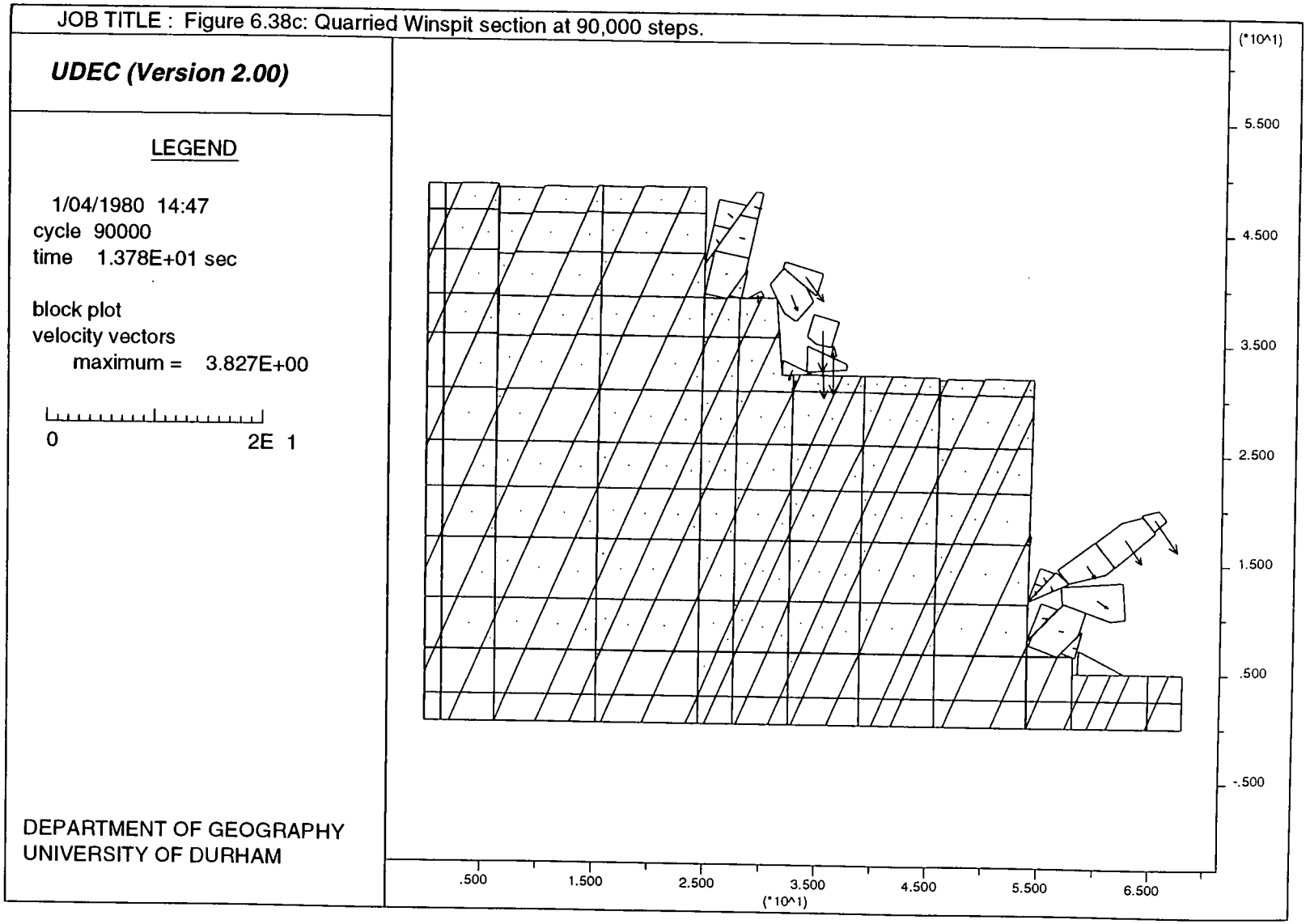
1/04/1980 14:46
cycle 30000
time 4.550E+00 sec

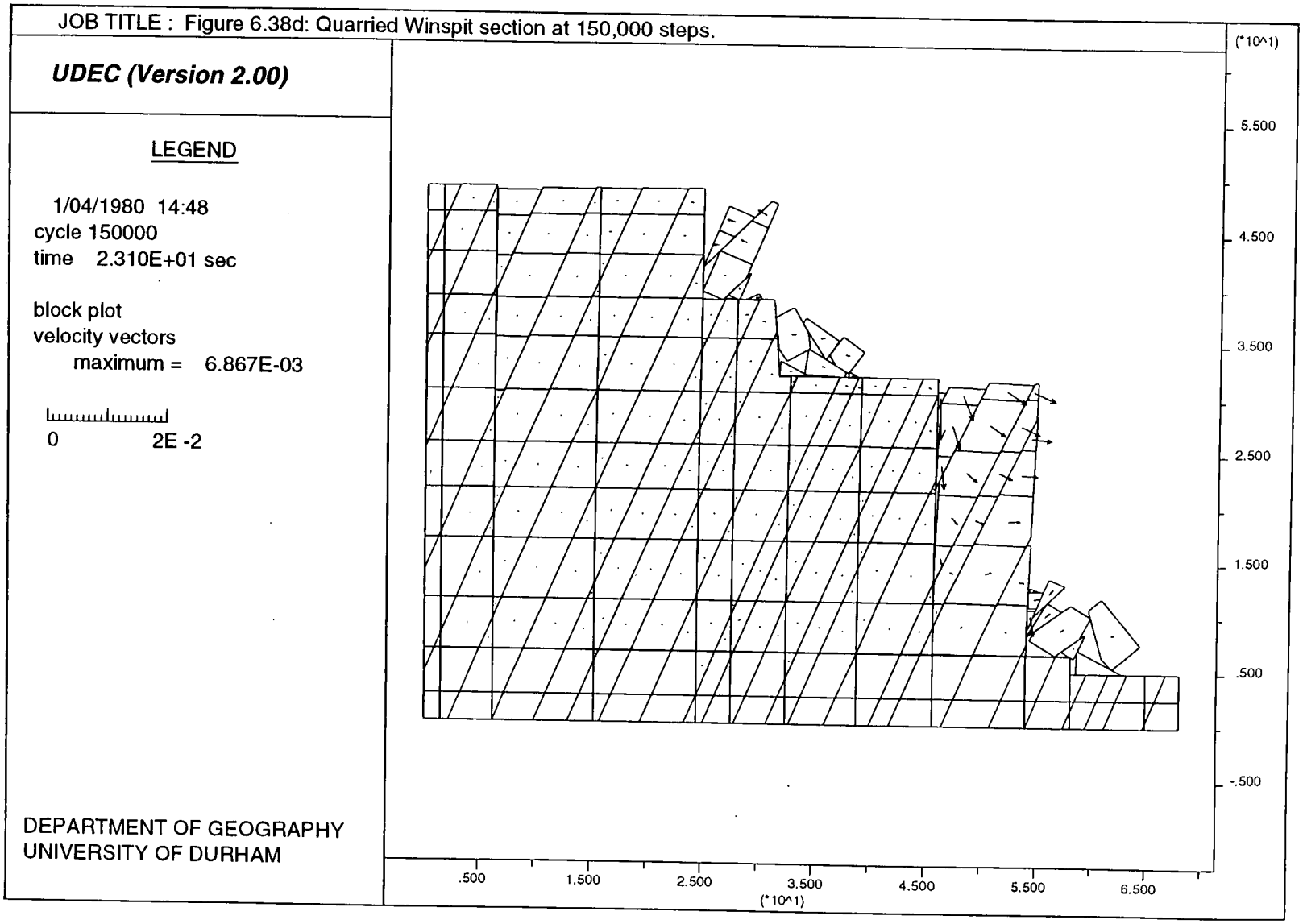
block plot
velocity vectors
maximum = 5.795E-01

0 2E 0

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.38c: Quarried Winspit section at 90,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:47
cycle 90000
time 1.378E+01 sec
block plot
velocity vectors
maximum = 3.827E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.38d: Quarried Winspit section at 150,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:48
cycle 150000
time 2.310E+01 sec
block plot
velocity vectors
maximum = 6.867E-03
0
2E -2
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

JOB TITLE : Figure 6.38e: Quarried Winspit section at 190,000 steps.

UDEC (Version 2.00)

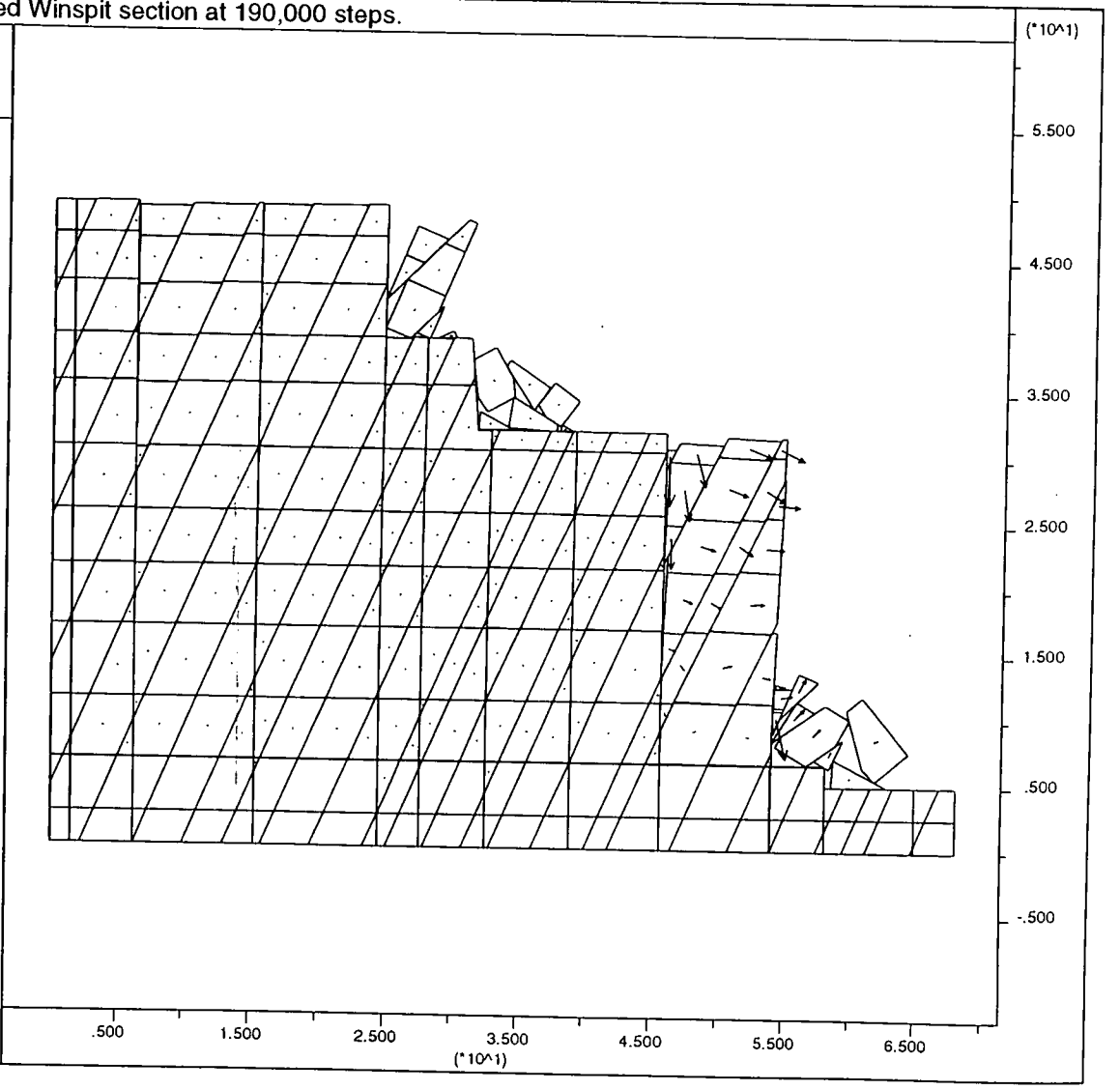
LEGEND

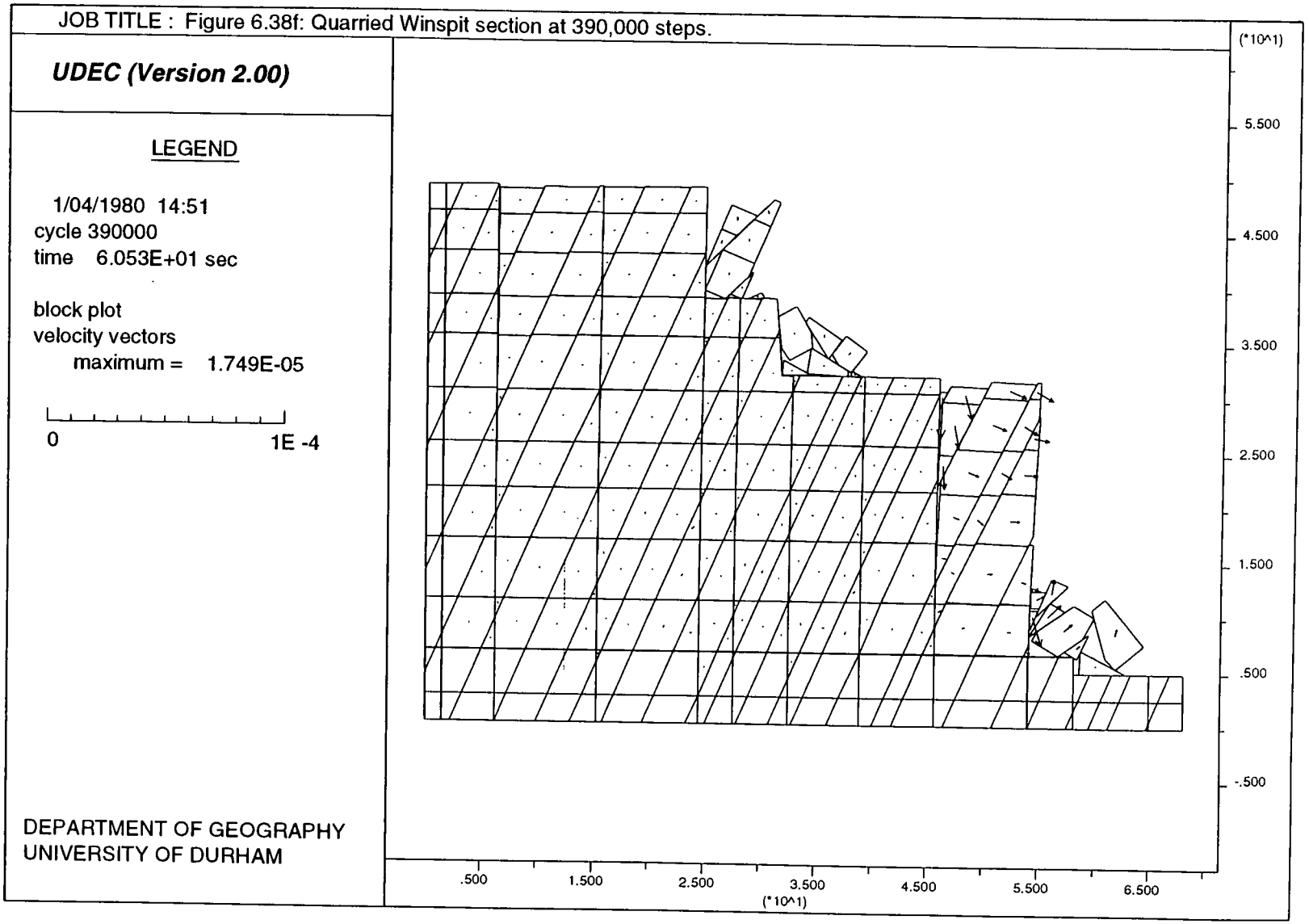
1/04/1980 14:50
cycle 190000
time 2.934E+01 sec

block plot
velocity vectors
maximum = 5.802E-05

0 2E -4

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.38f: Quarried Winspit section at 390,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 14:51
cycle 390000
time 6.053E+01 sec
block plot
velocity vectors
maximum = 1.749E-05
0
1E -4
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

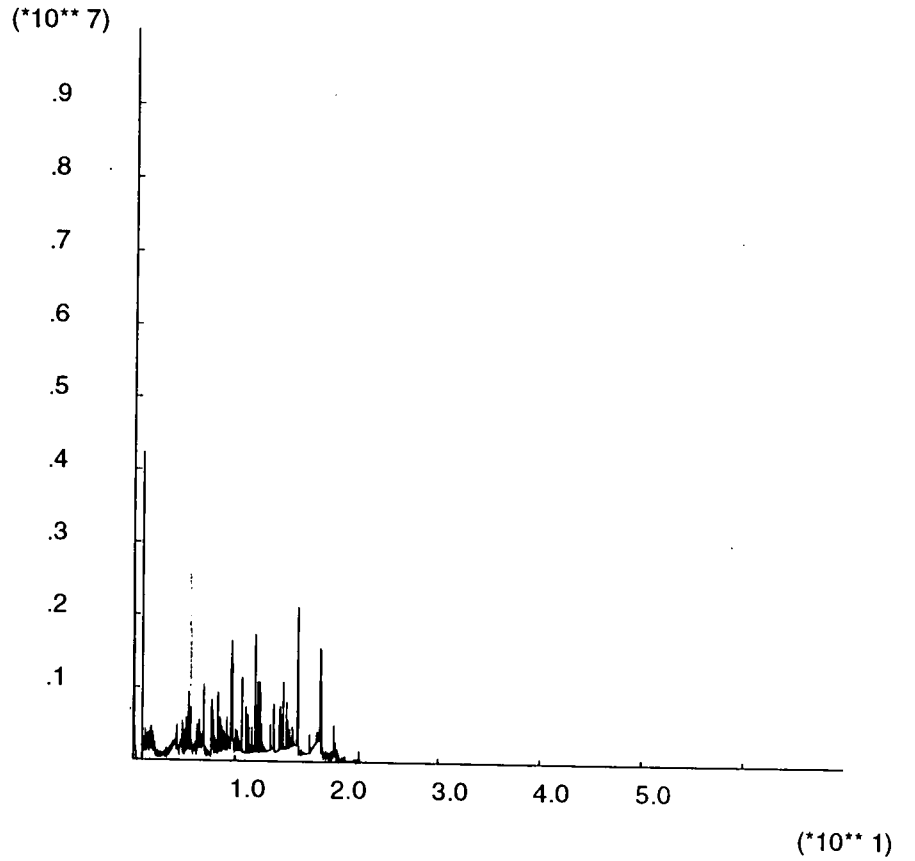
JOB TITLE : Figure 6.39: Forces for the quarried Winspit section at 390,000 steps.

UDEC (Version 2.00)

LEGEND

1/04/1980 14:52
cycle 390000
time 6.053E+01 sec

4.69E-01 <hist 3> 9.60E+06 ———



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

JOB TITLE : Figure 6.40a: Quarried Winspit after debris removal at 170,000 steps.

UDEC (Version 2.00)

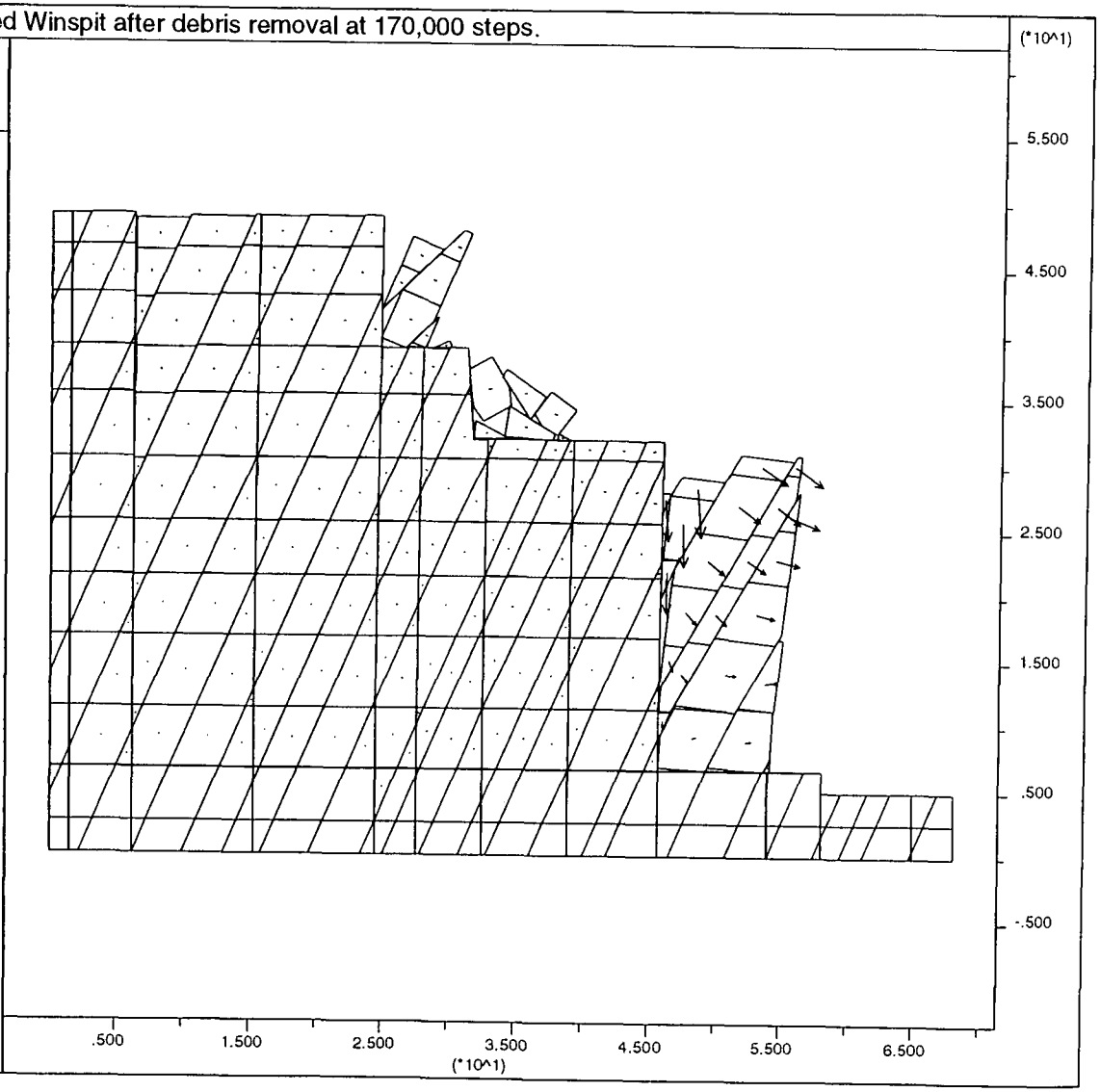
LEGEND

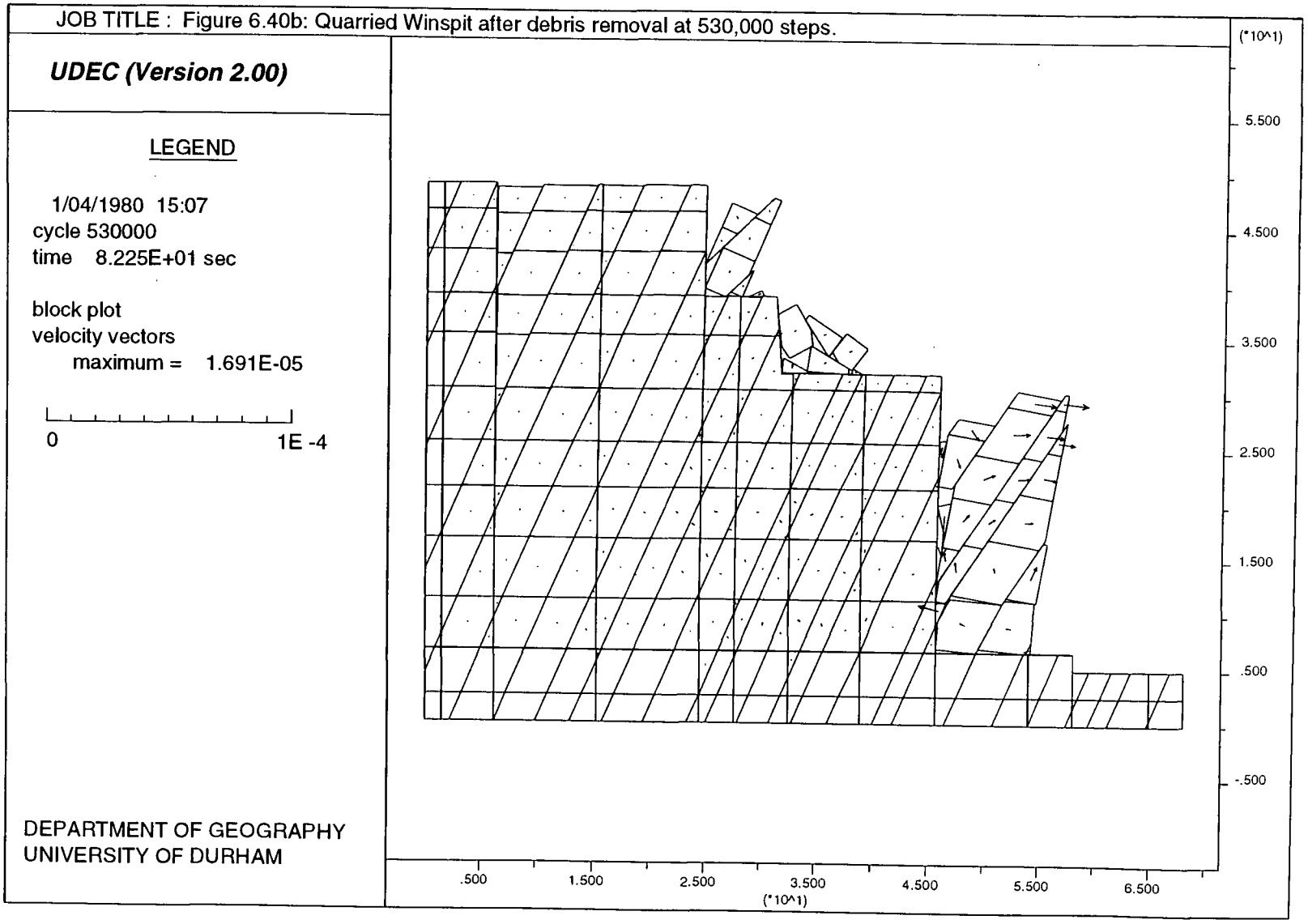
1/04/1980 15:05
cycle 170000
time 2.621E+01 sec

block plot
velocity vectors
maximum = 2.374E-01

0 1E 0

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.40b: Quarried Winspit after debris removal at 530,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 15:07
cycle 530000
time 8.225E+01 sec
block plot
velocity vectors
maximum = 1.691E-05
0
1E -4
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

JOB TITLE : Figure 6.41a: Winspit cliff at 100,000 steps.

UDEC (Version 2.00)

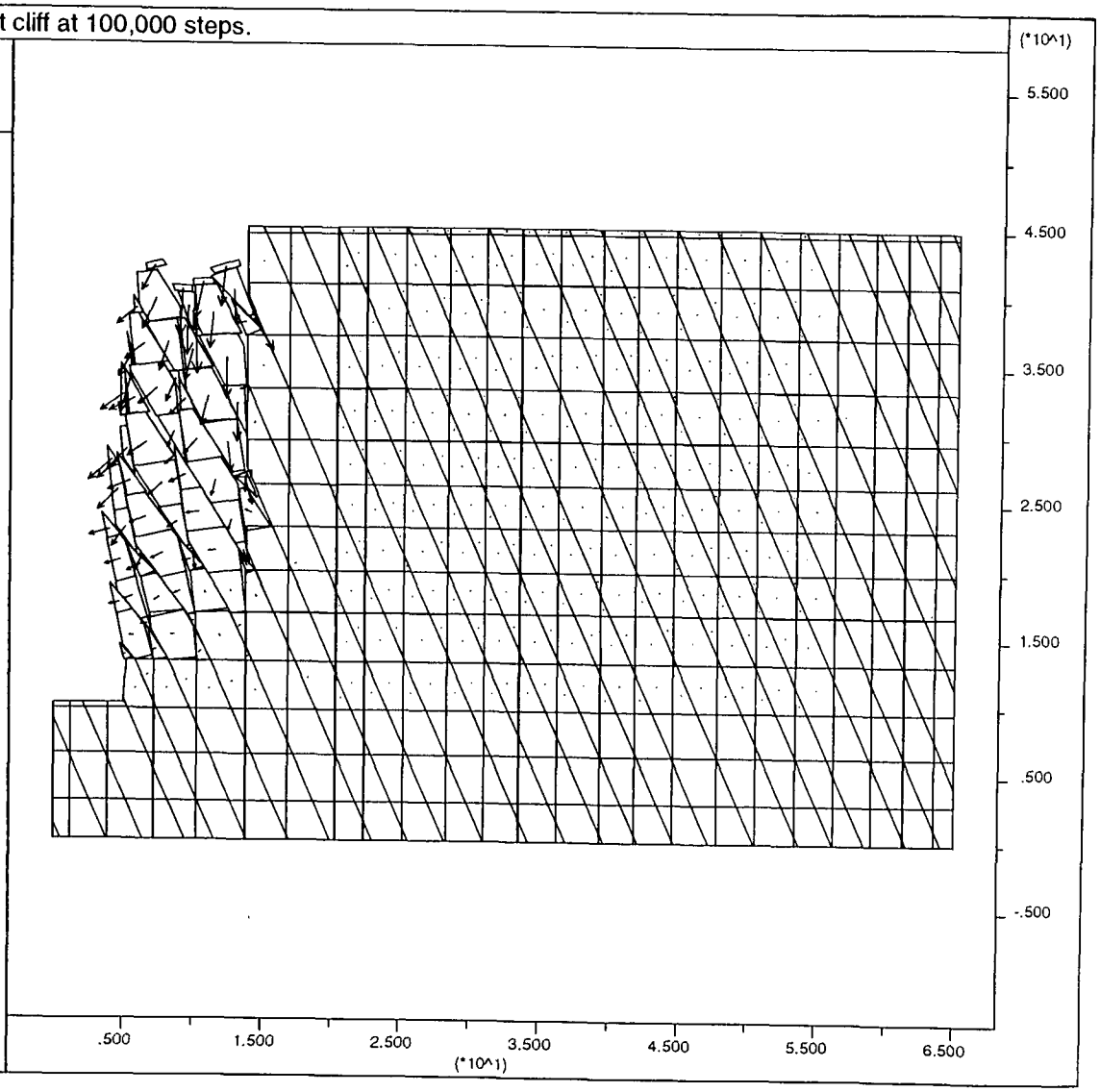
LEGEND

1/04/1980 15:09
cycle 100000
time 1.634E+00 sec

block plot
velocity vectors
maximum = 5.477E+00

0 2E 1

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 6.41b: Winspit cliff at 750,000 steps.

UDEC (Version 2.00)

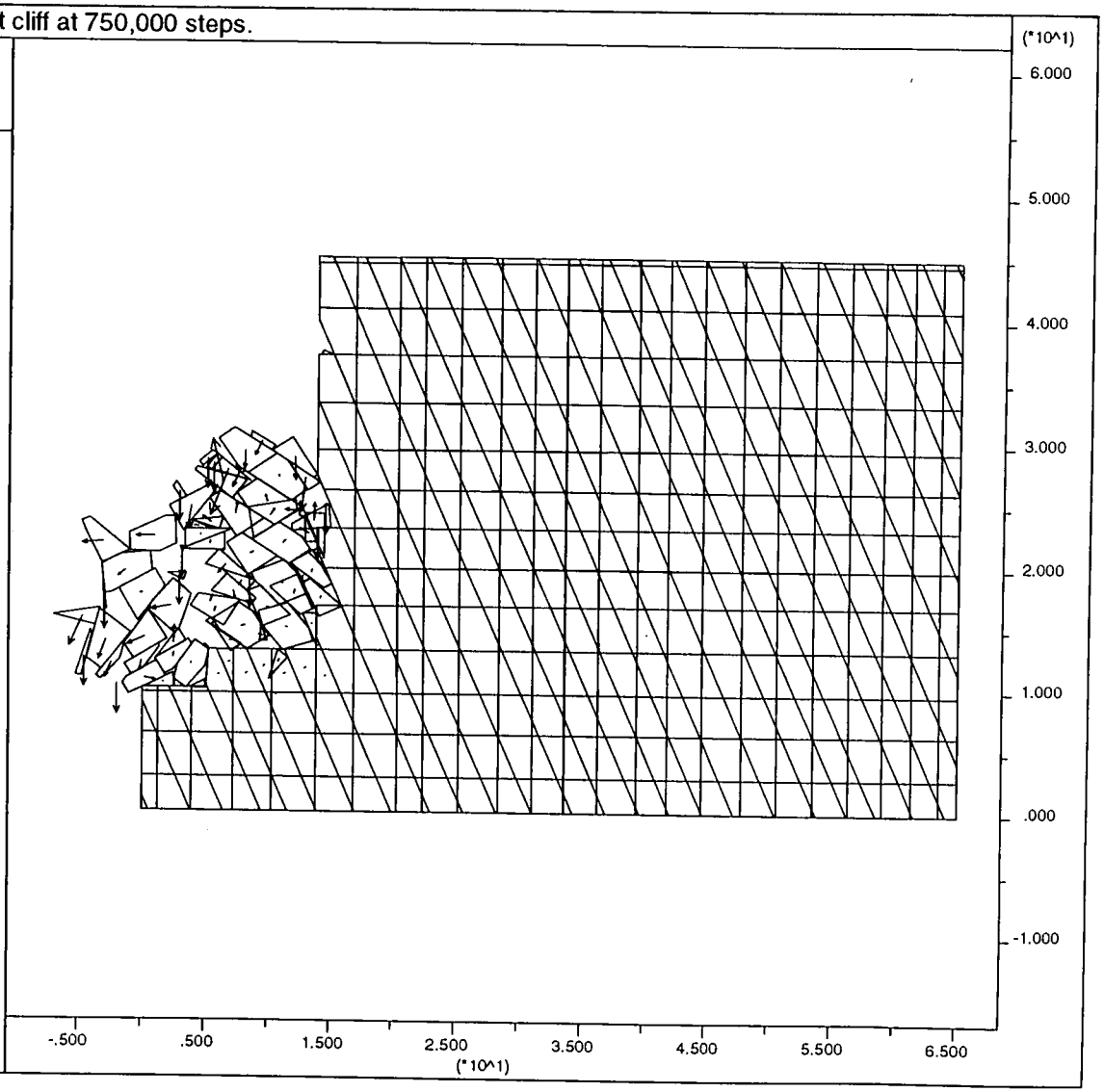
LEGEND

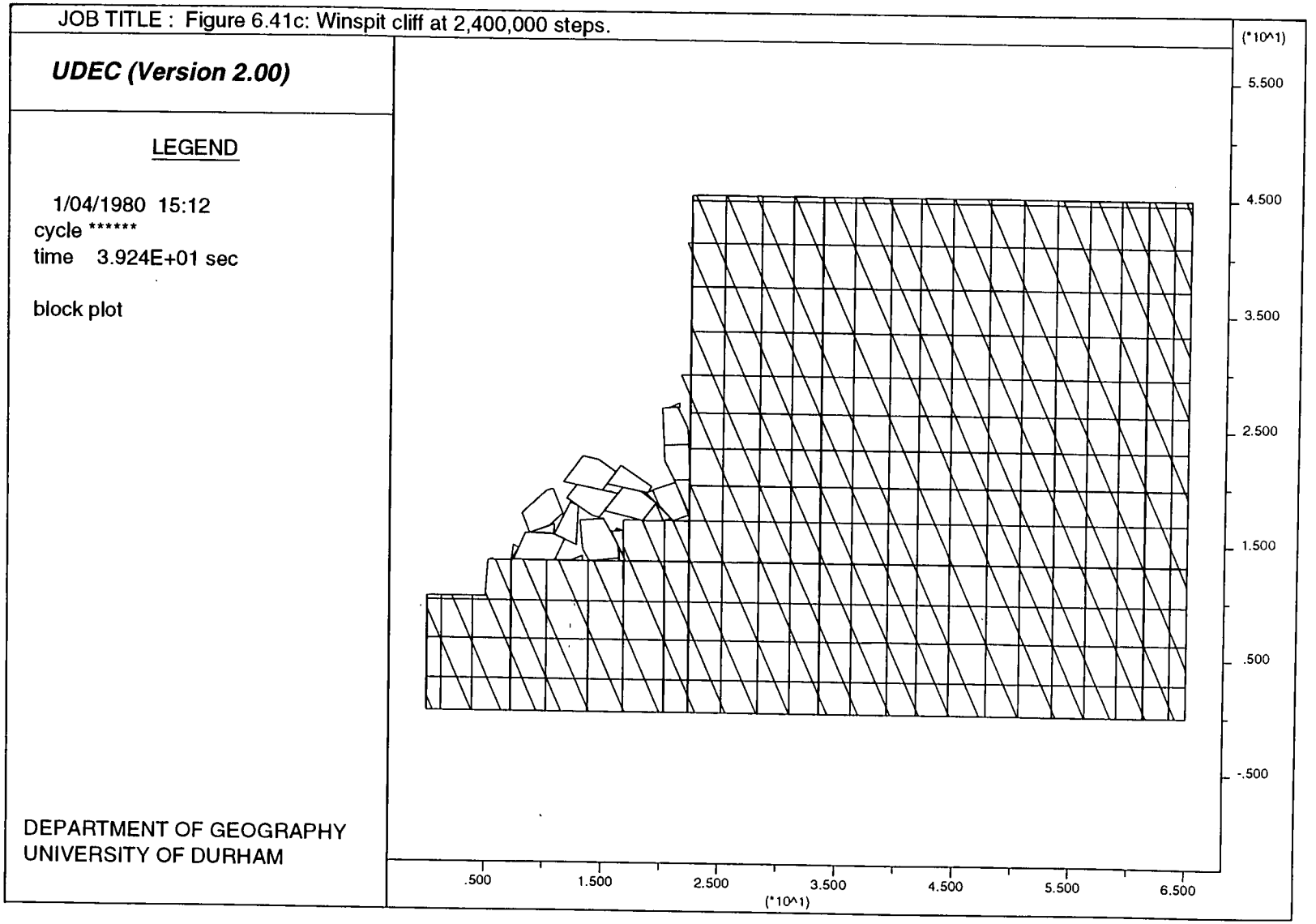
1/04/1980 15:11
cycle 750000
time 1.227E+01 sec

block plot
velocity vectors
maximum = 1.859E-01

0 1E 0

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.41c: Winspit cliff at 2,400,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 15:12
cycle ******
time 3.924E+01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

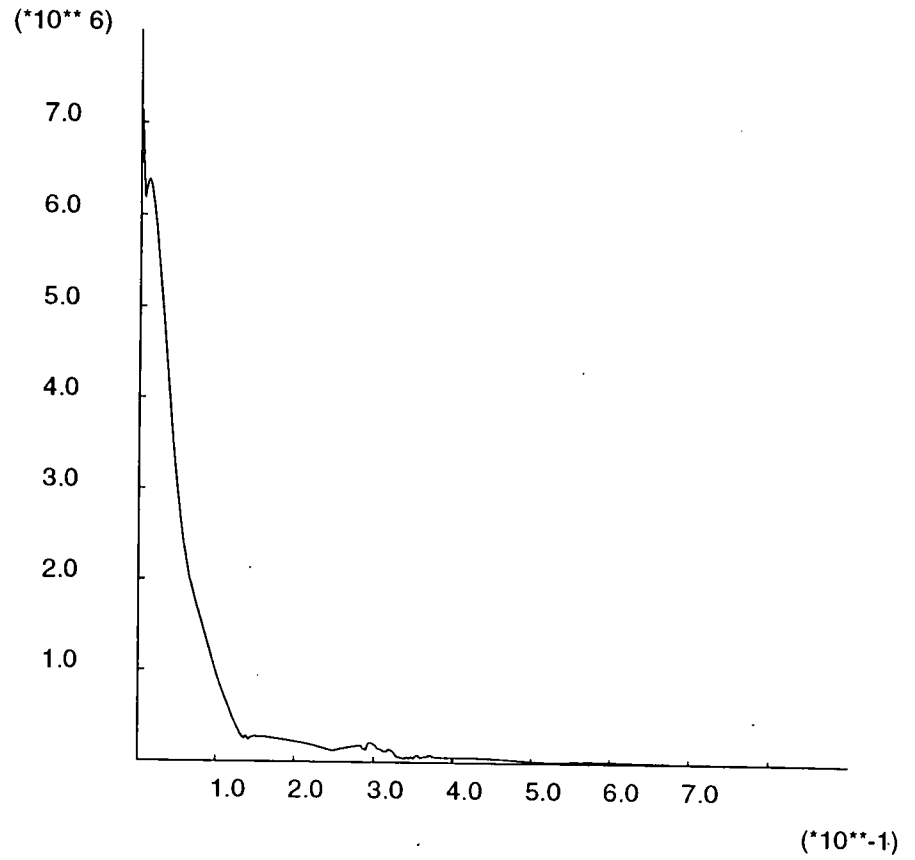
JOB TITLE : Figure 6.42: Total unbalanced forces for Fossil Forest at equilibrium.

UDEC (Version 2.00)

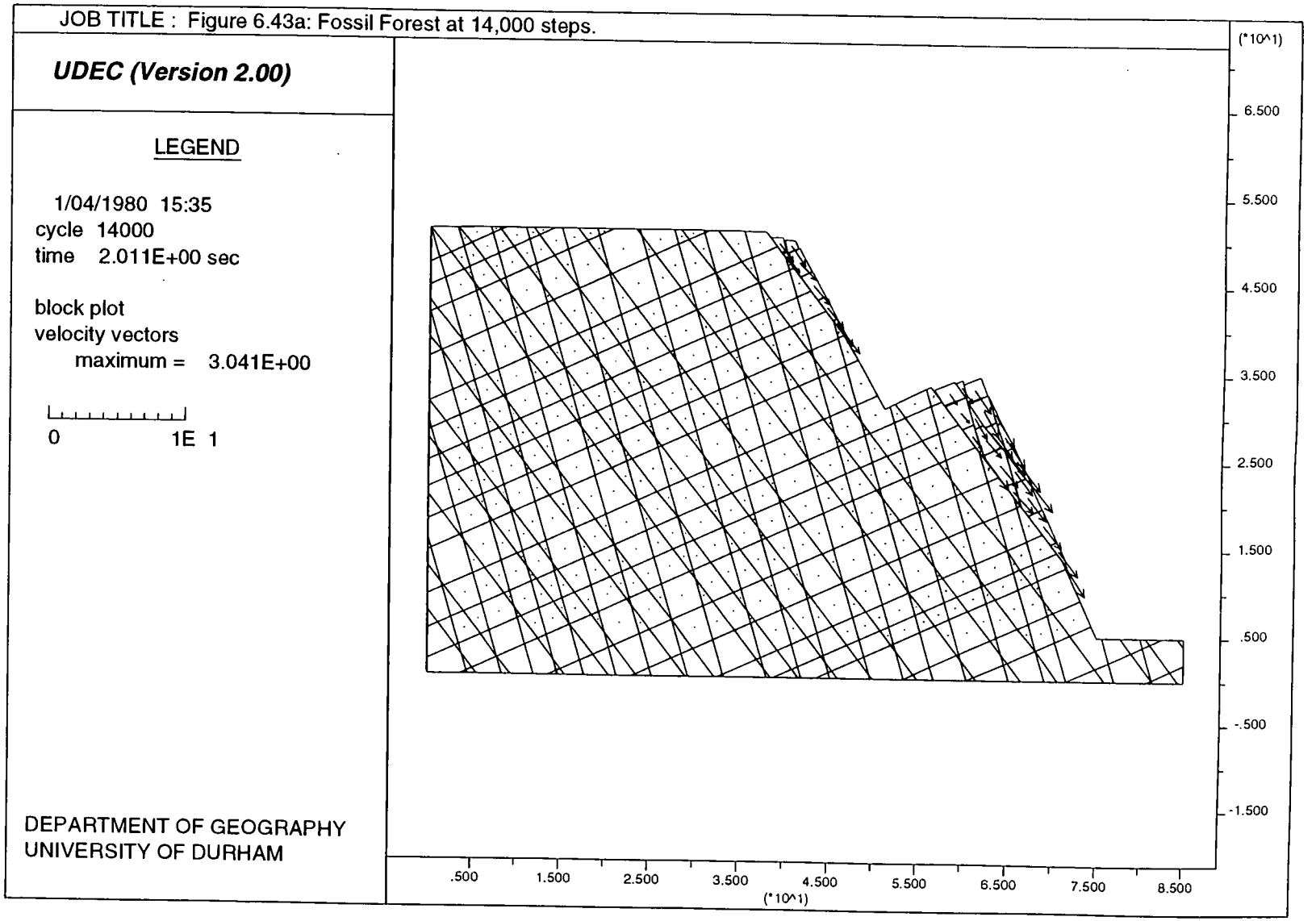
LEGEND

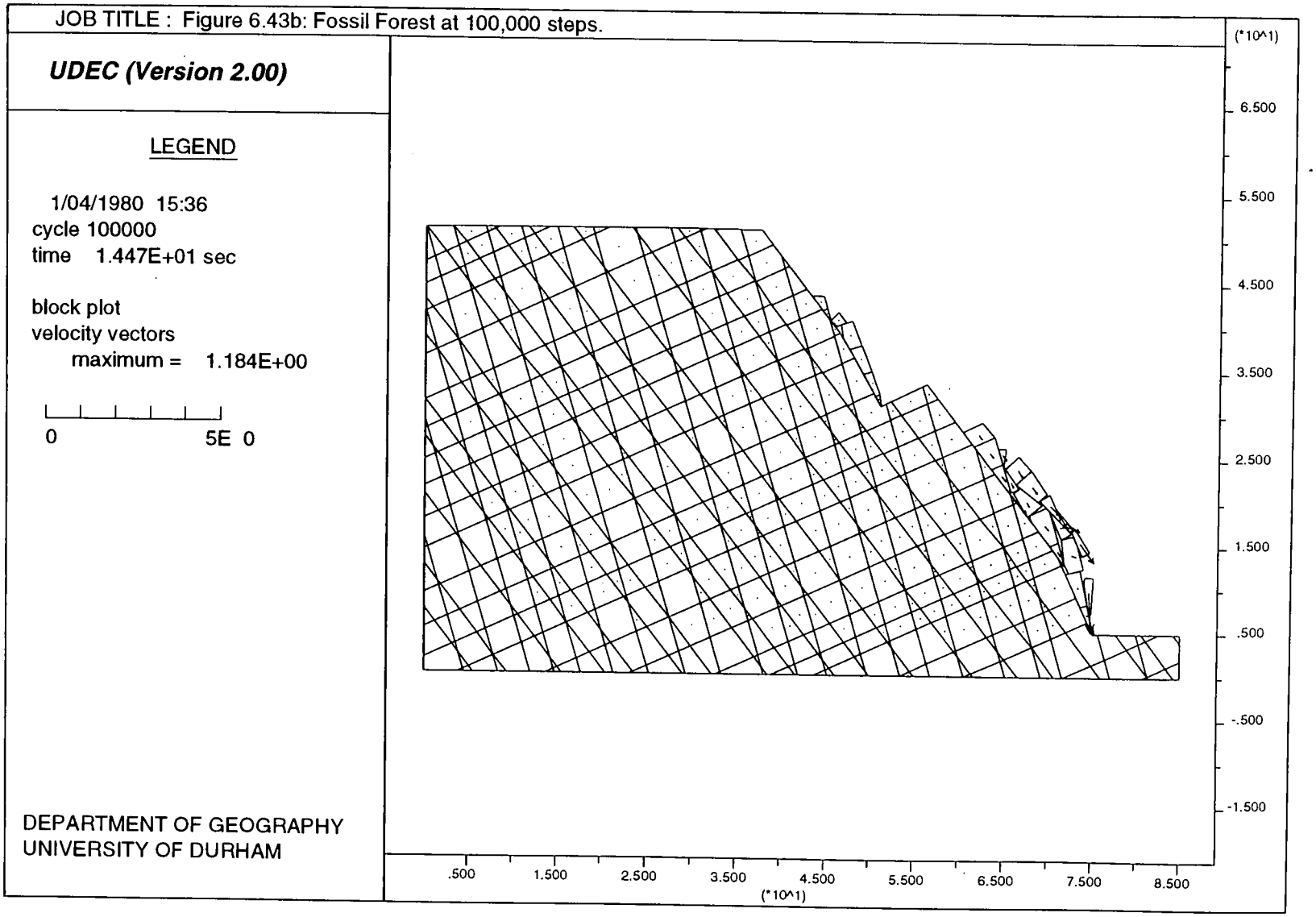
1/04/1980 15:33
cycle 6000
time 8.584E-01 sec

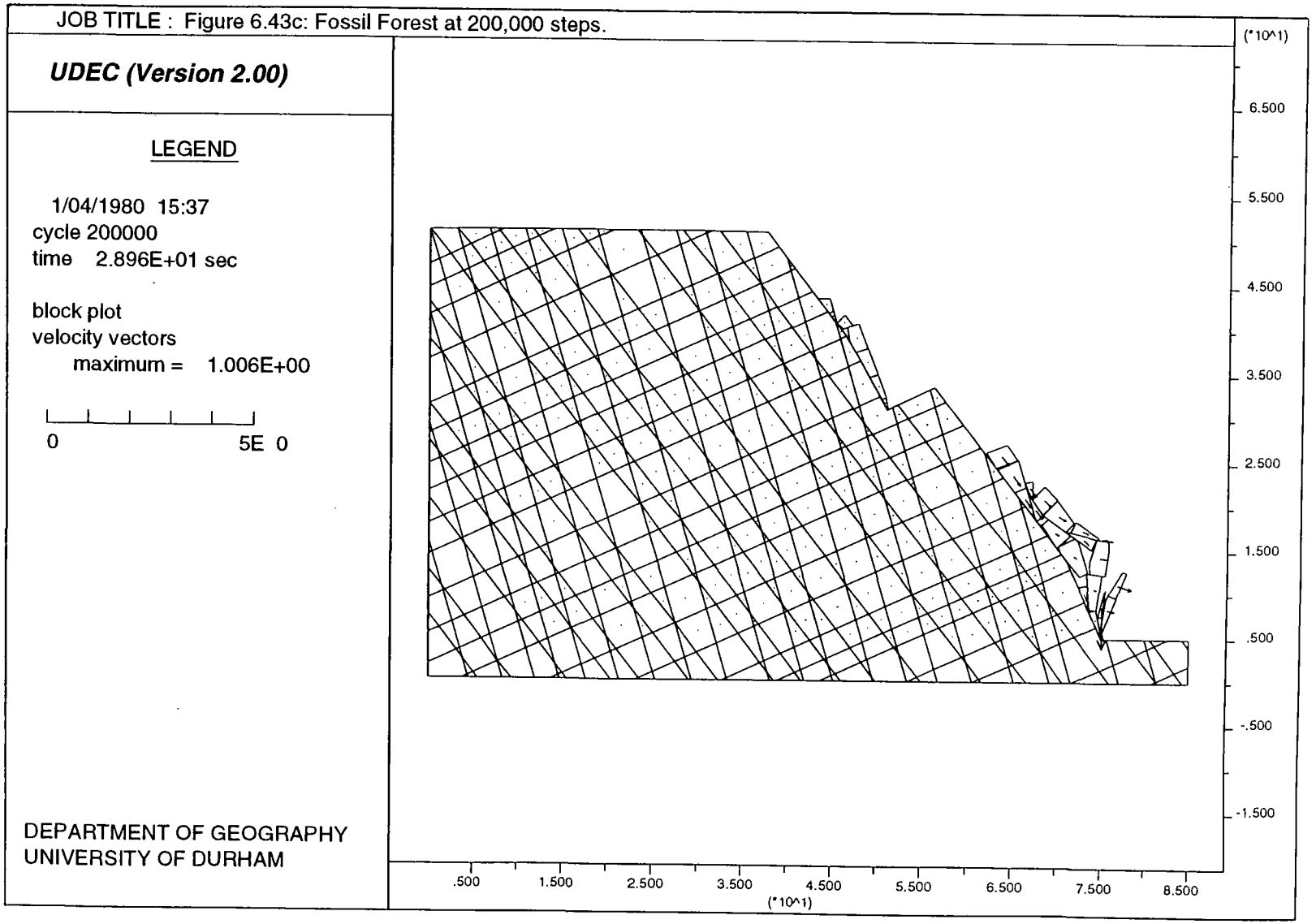
1.17E+03 <hist 2> 7.13E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 6.43a: Fossil Forest at 14,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 15:35
cycle 14000
time 2.011E+00 sec
block plot
velocity vectors
maximum = 3.041E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
8.500
(*10^1)


JOB TITLE : Figure 6.43b: Fossil Forest at 100,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 15:36
cycle 100000
time 1.447E+01 sec
block plot
velocity vectors
maximum = 1.184E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
8.500
(*10^1)


JOB TITLE : Figure 6.43c: Fossil Forest at 200,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 15:37
cycle 200000
time 2.896E+01 sec
block plot
velocity vectors
maximum = 1.006E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
8.500
(*10^1)

JOB TITLE : Figure 6.43d: Fossil Forest at 400,000 steps.

UDEC (Version 2.00)

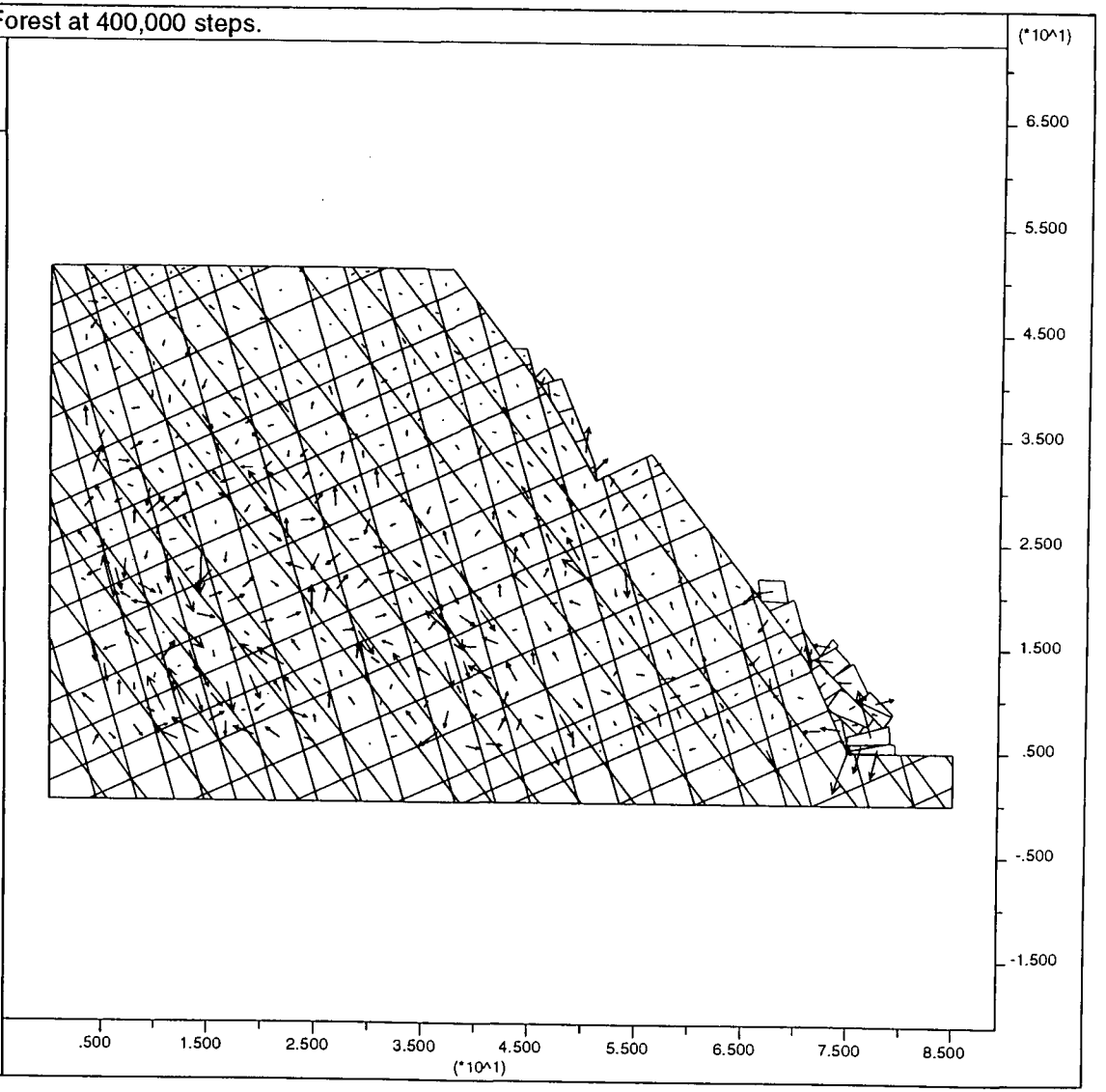
LEGEND

1/04/1980 15:38
cycle 400000
time 5.795E+01 sec

block plot
velocity vectors
maximum = 1.434E-06

0 5E -6

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



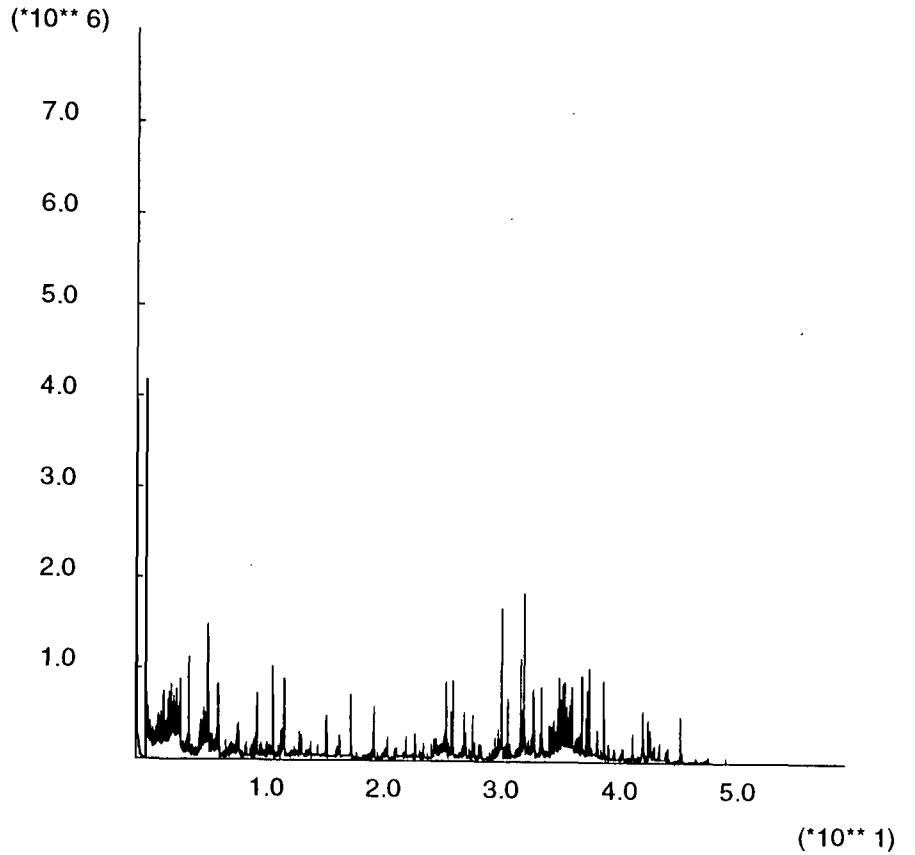
JOB TITLE : Figure 6.44: Total unbalanced forces for Fossil Forest at 400,000 steps.

UDEC (Version 2.00)

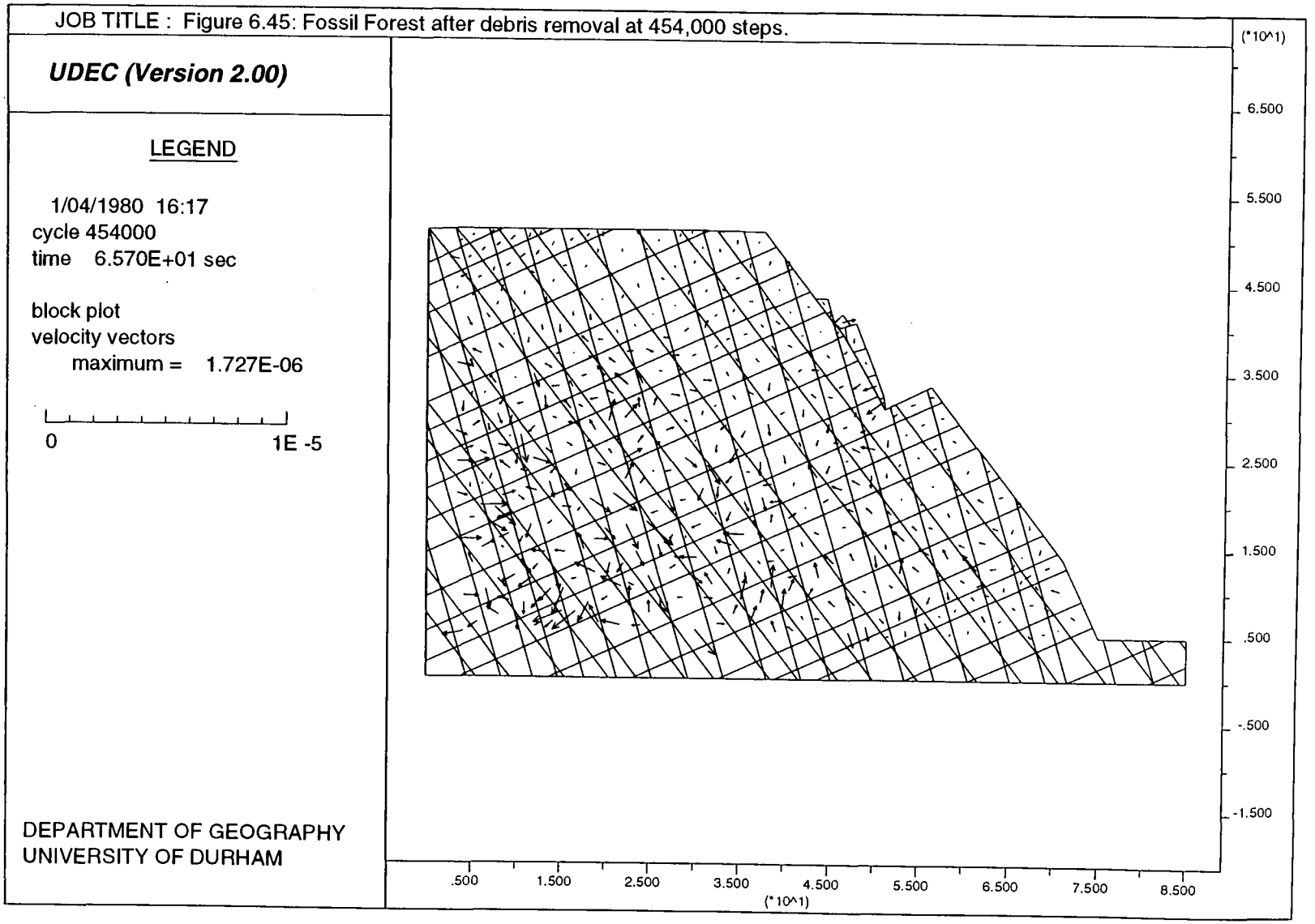
LEGEND

1/04/1980 15:39
cycle 400000
time 5.795E+01 sec

3.59E-01 <hist 2> 7.13E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 6.45: Fossil Forest after debris removal at 454,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:17
cycle 454000
time 6.570E+01 sec
block plot
velocity vectors
maximum = 1.727E-06
0
1E -5
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
6.500
5.500
4.500
3.500
2.500
1.500
.500
-.500
-1.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
8.500
(*10^1)

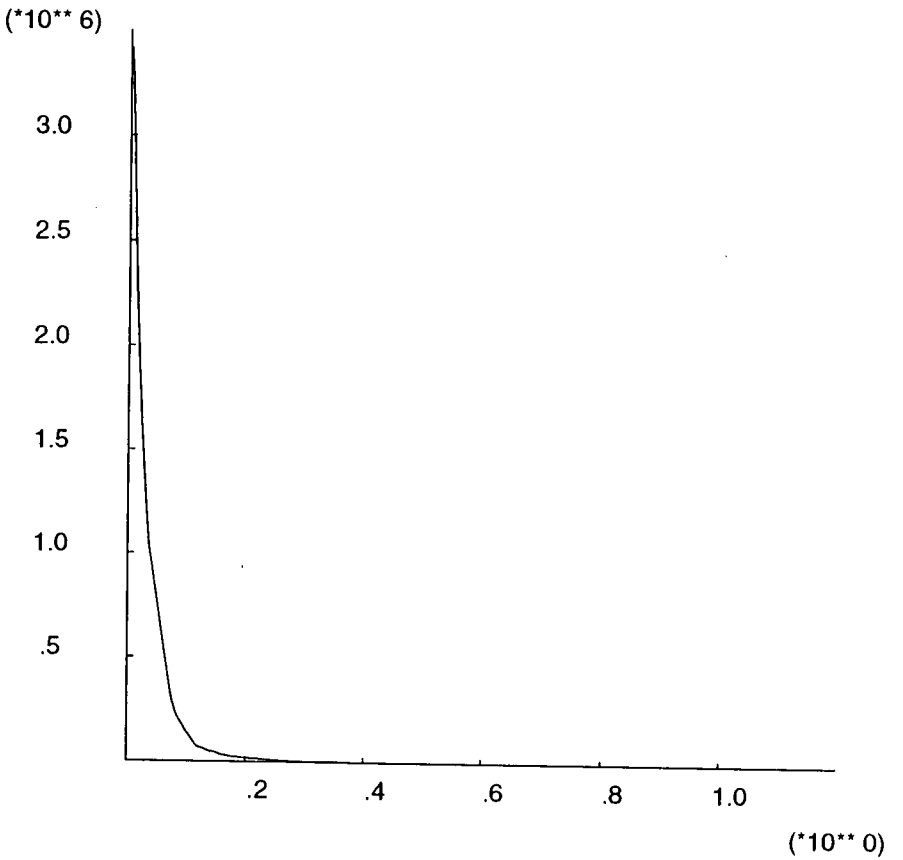
JOB TITLE : Figure 6.46: Forces for the Lulworth Cove pincer at equilibrium.

UDEC (Version 2.00)

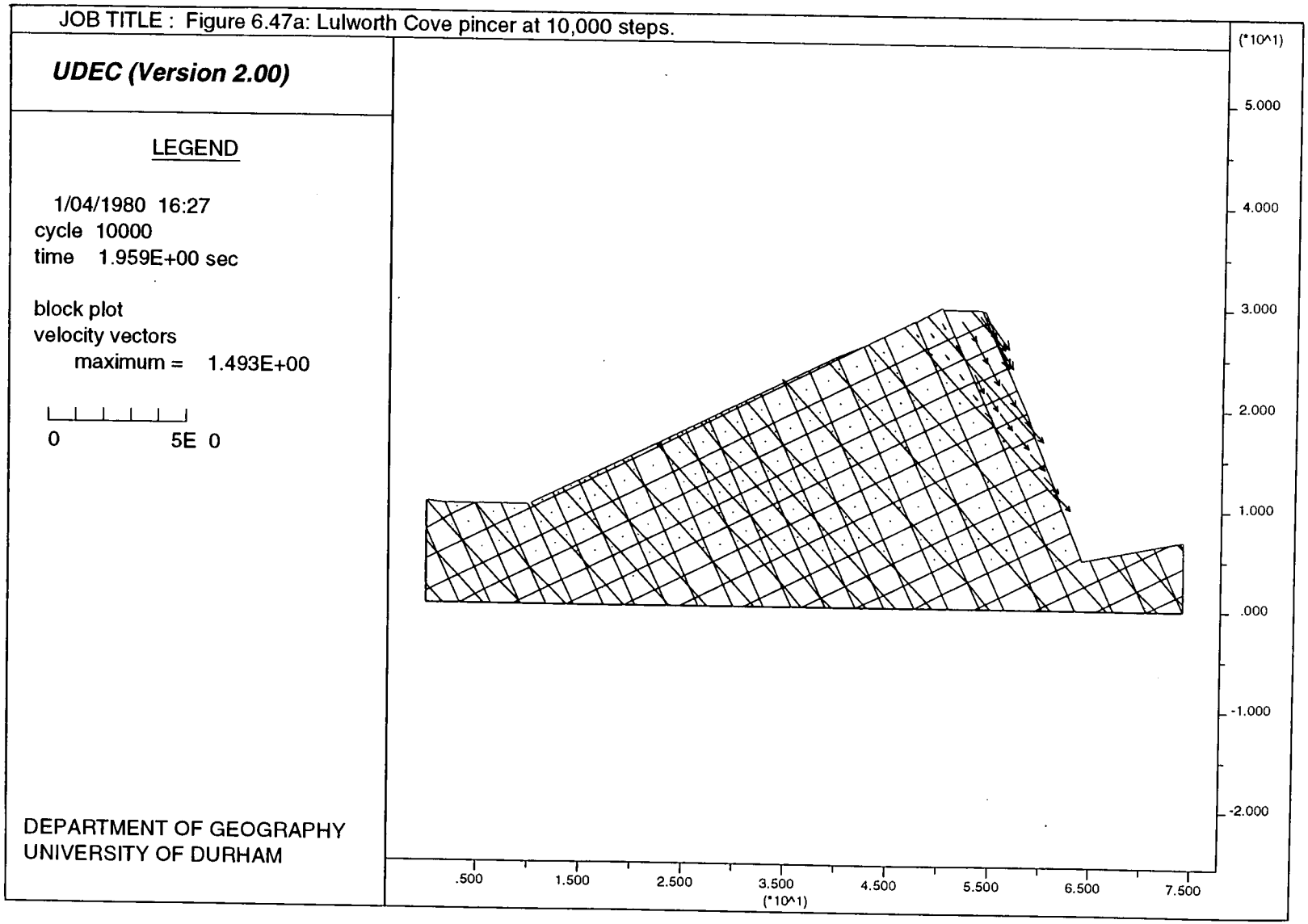
LEGEND

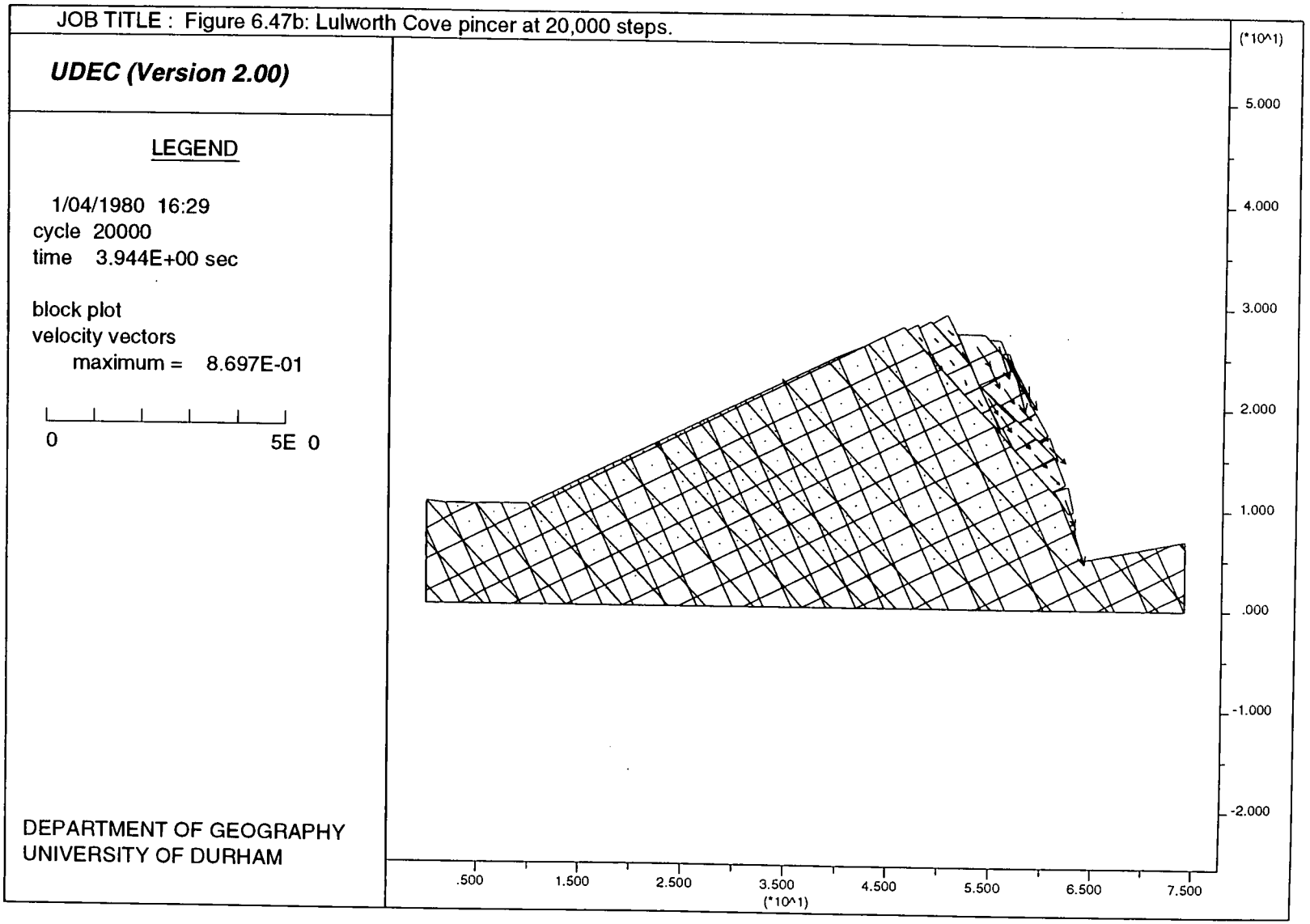
1/04/1980 16:27
cycle 6000
time 1.174E+00 sec

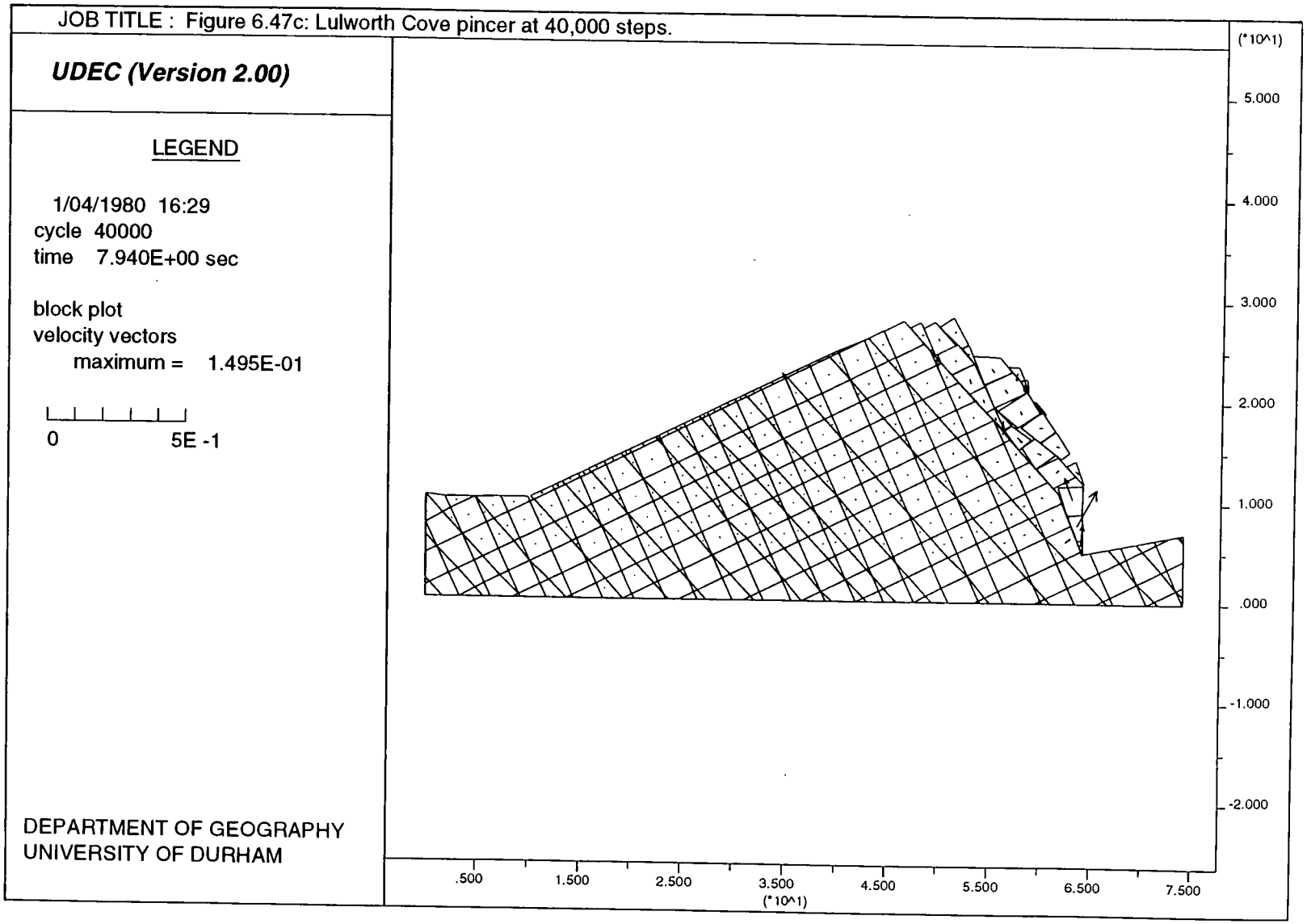
6.88E-01 <hist 3> 3.42E+06 ———



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 6.47a: Lulworth Cove pincer at 10,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:27
cycle 10000
time 1.959E+00 sec
block plot
velocity vectors
maximum = 1.493E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
-2.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 6.47b: Lulworth Cove pincer at 20,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:29
cycle 20000
time 3.944E+00 sec
block plot
velocity vectors
maximum = 8.697E-01
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
-2.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)


JOB TITLE : Figure 6.47c: Lulworth Cove pincer at 40,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:29
cycle 40000
time 7.940E+00 sec
block plot
velocity vectors
maximum = 1.495E-01
0
5E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
-2.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

JOB TITLE : Figure 6.47d: Lulworth Cove pincer at 60,000 steps.

UDEC (Version 2.00)

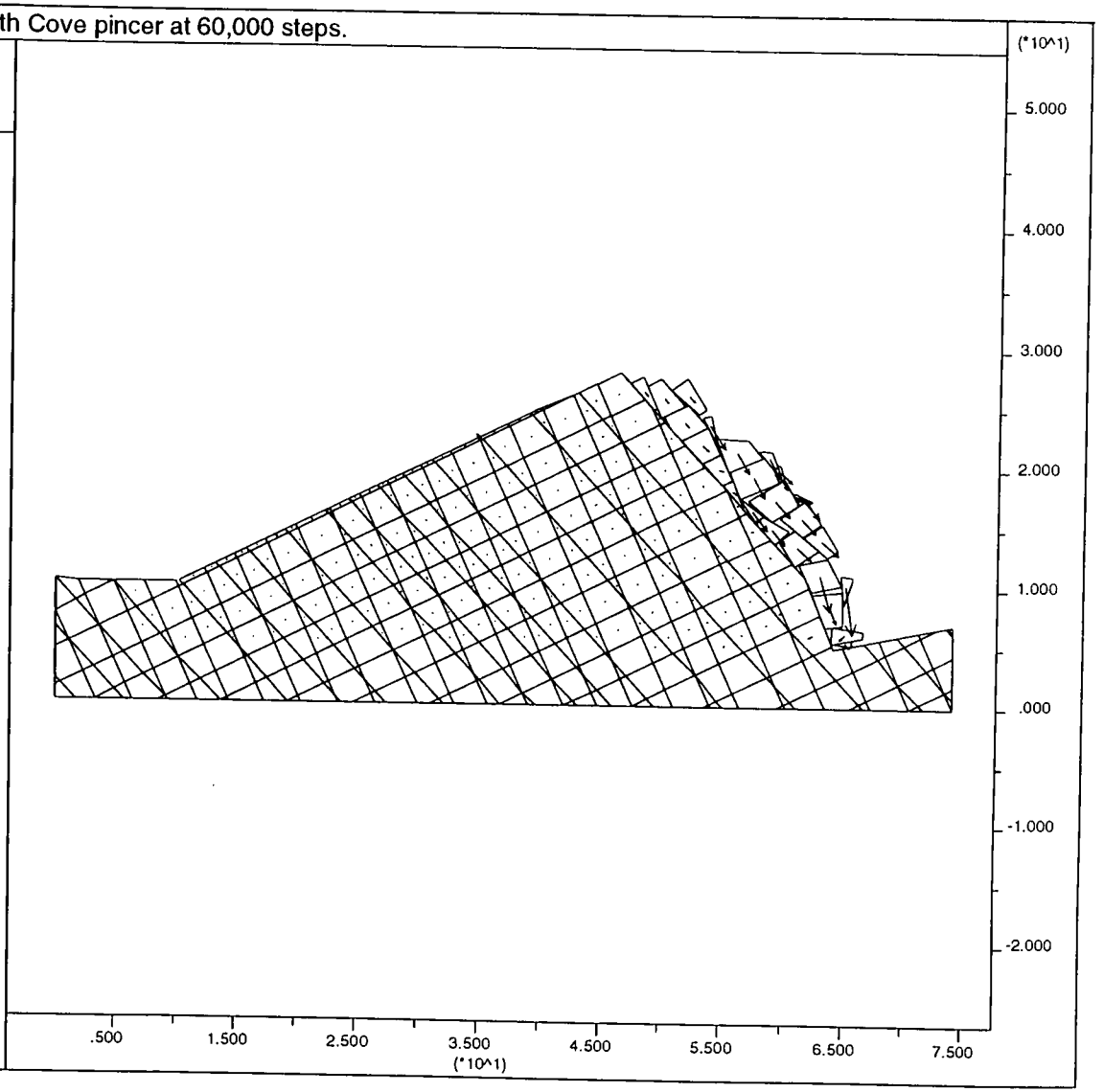
LEGEND

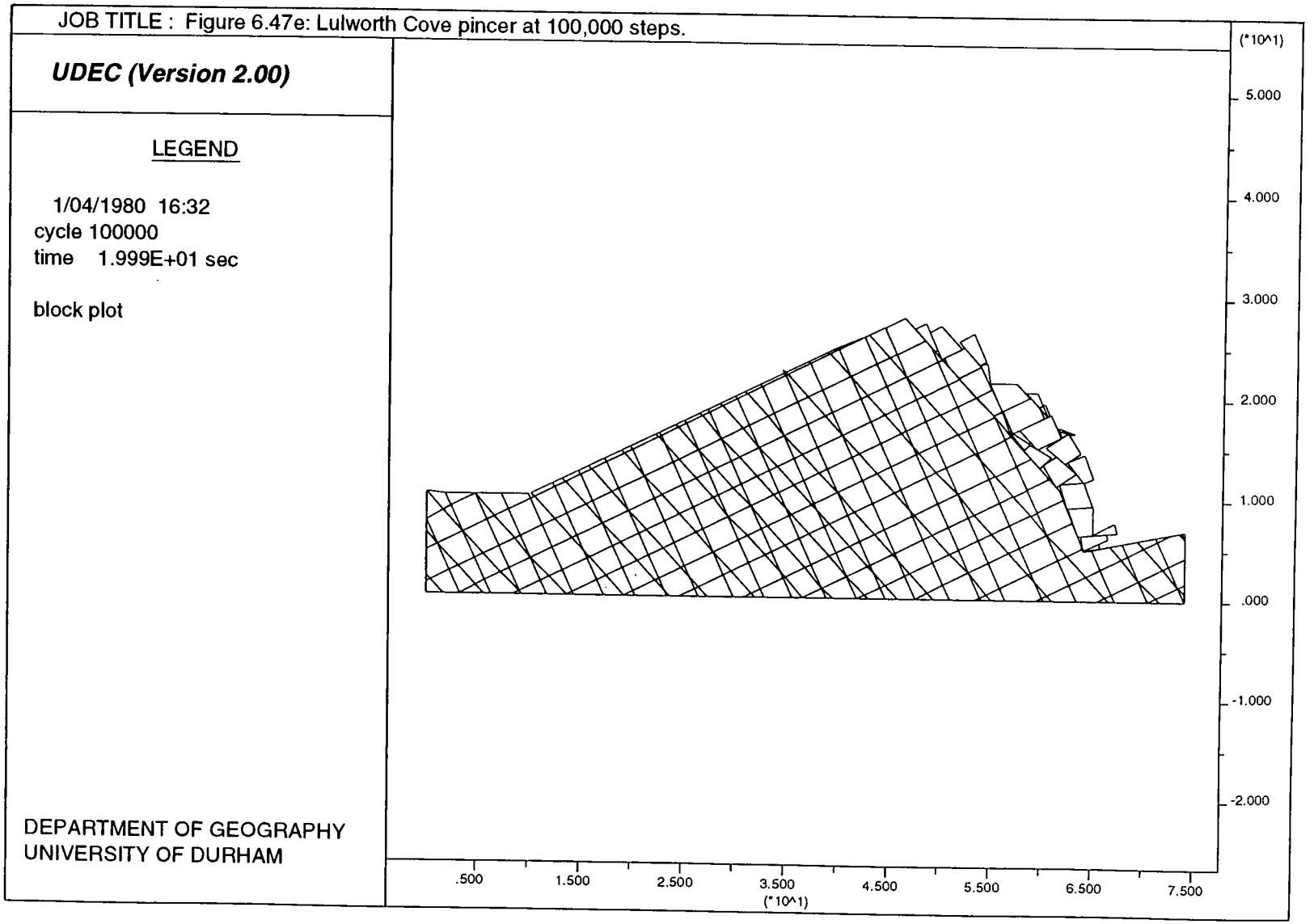
1/04/1980 16:30
cycle 60000
time 1.195E+01 sec

block plot
velocity vectors
maximum = 8.006E-01

0 2E 0

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.47e: Lulworth Cove pincer at 100,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:32
cycle 100000
time 1.999E+01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
-2.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
7.500
(*10^1)

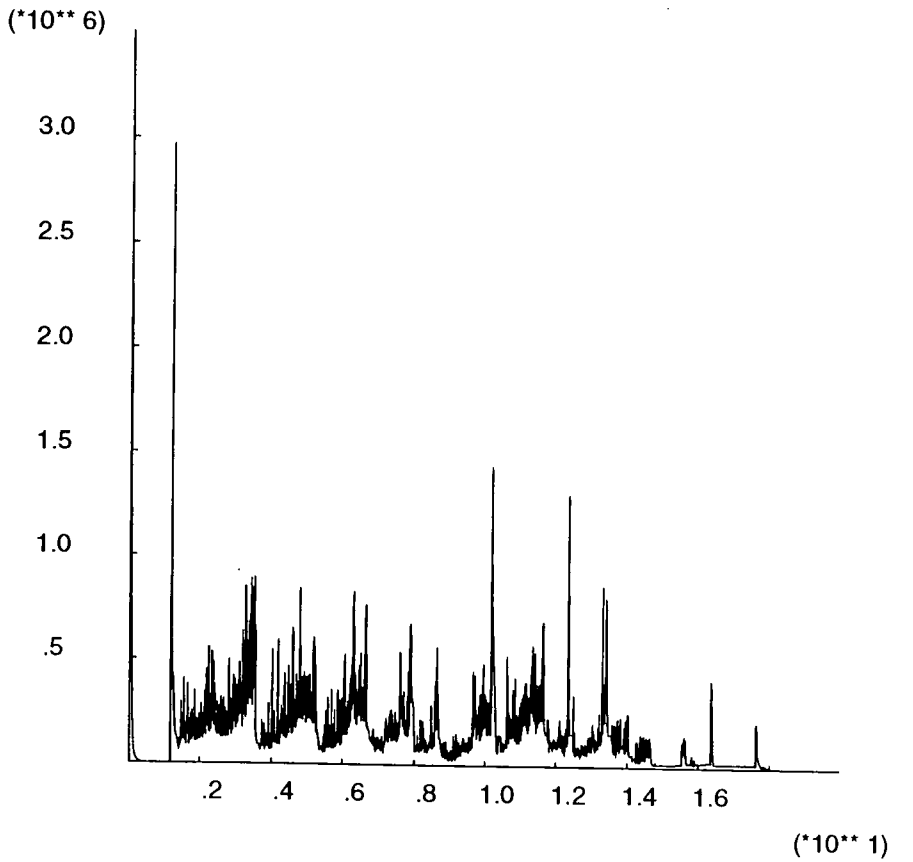
JOB TITLE : Figure 6.48: Forces for the Lulworth Cove pincer at 100,000 steps.

UDEC (Version 2.00)

LEGEND

1/04/1980 16:33
cycle 100000
time 1.999E+01 sec

2.12E-01 <hist 3> 3.42E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

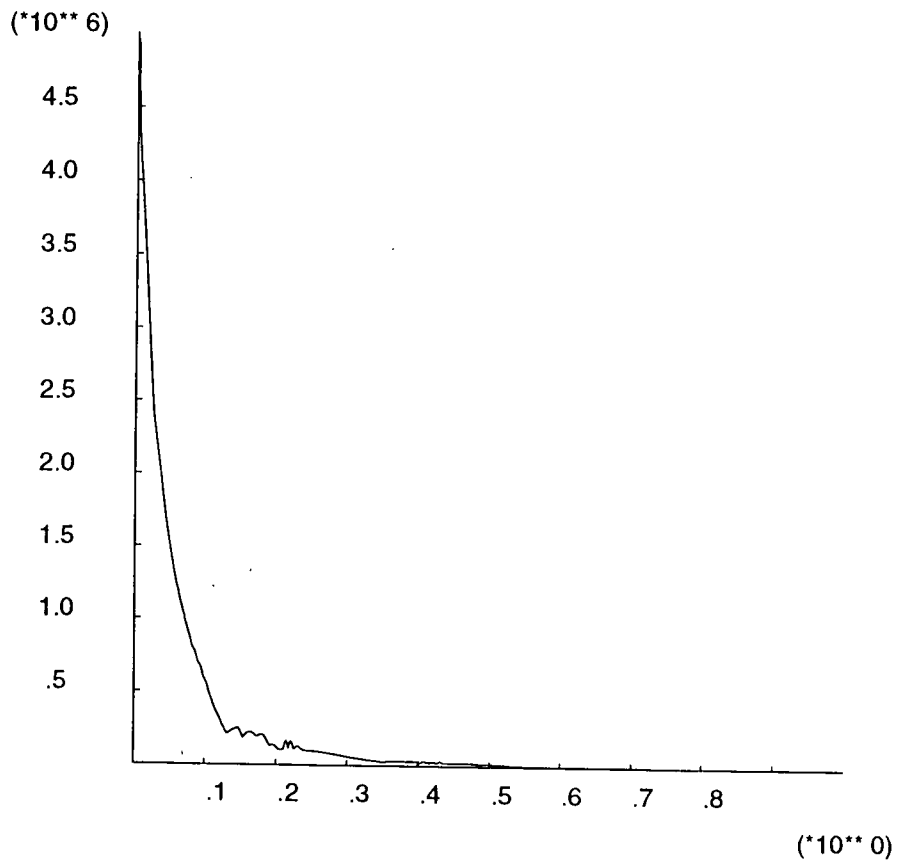
JOB TITLE : Figure 6.49: Forces for the Lulworth Cove cliff at equilibrium.

UDEC (Version 2.00)

LEGEND

1/04/1980 16:45
cycle 6000
time 9.318E-01 sec

3.58E+01 <hist 2> 4.96E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

JOB TITLE : Figure 6.50a: Lulworth Cove cliff at 14,000 steps.

UDEC (Version 2.00)

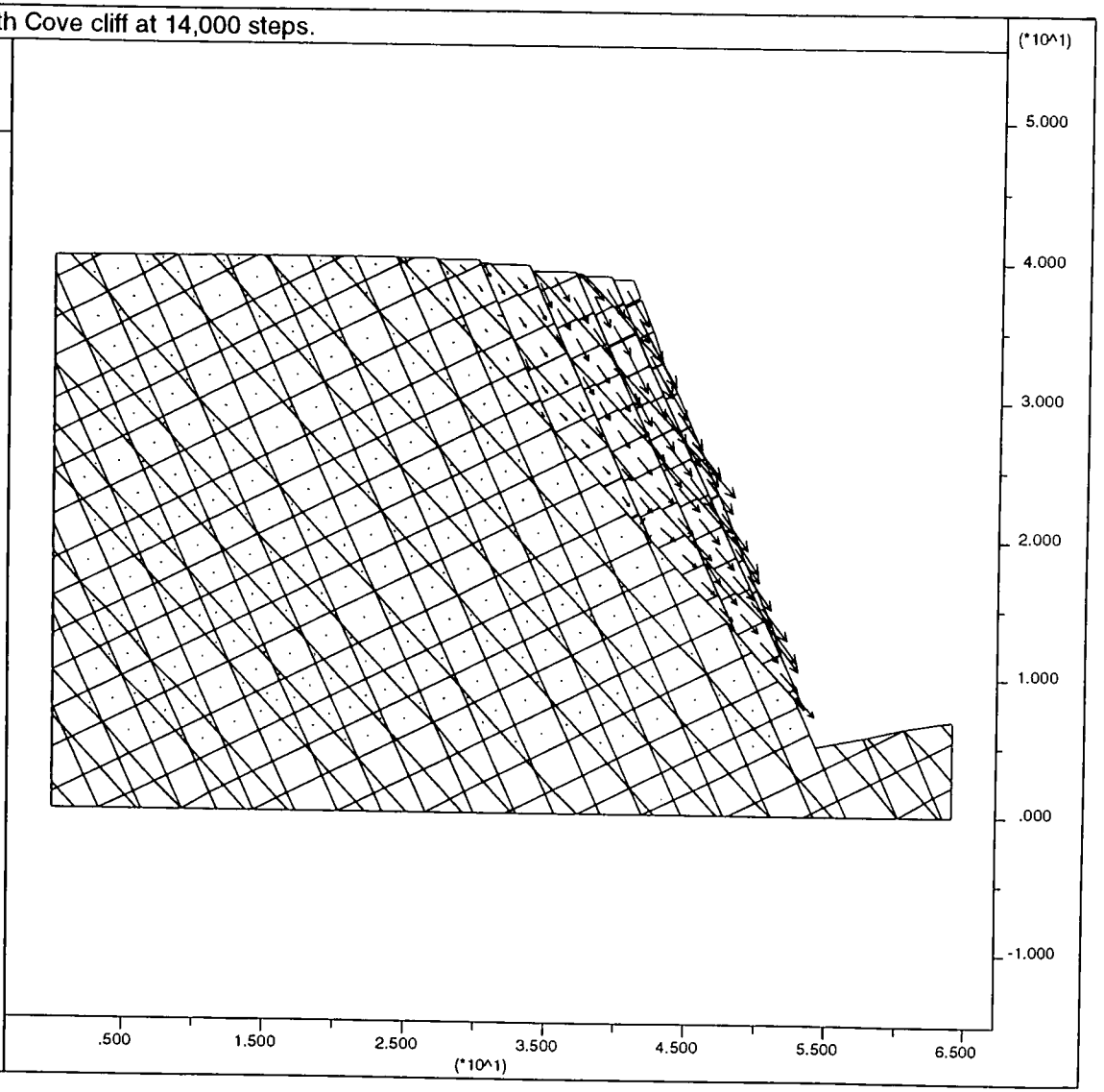
LEGEND

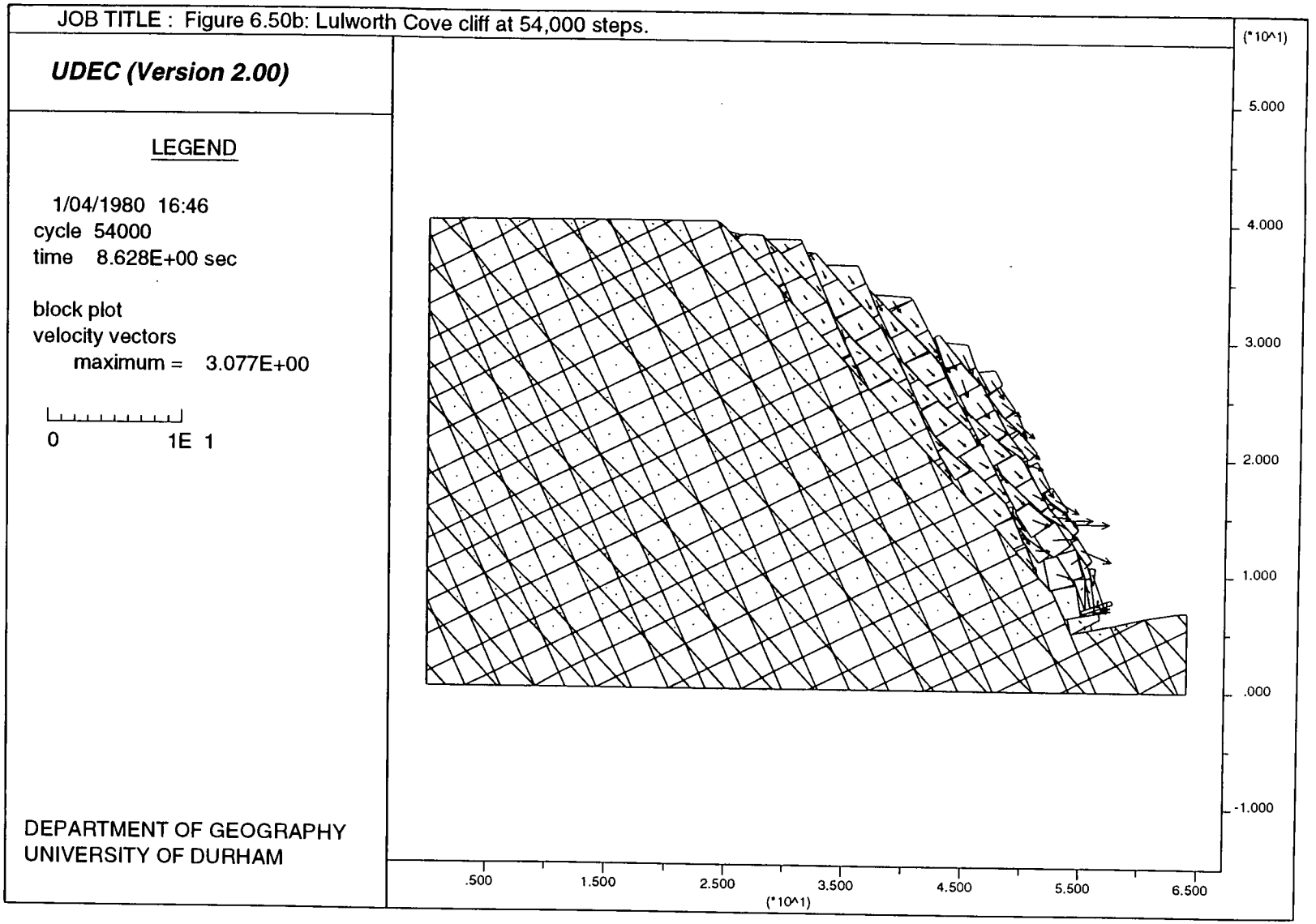
1/04/1980 16:46
cycle 14000
time 2.186E+00 sec

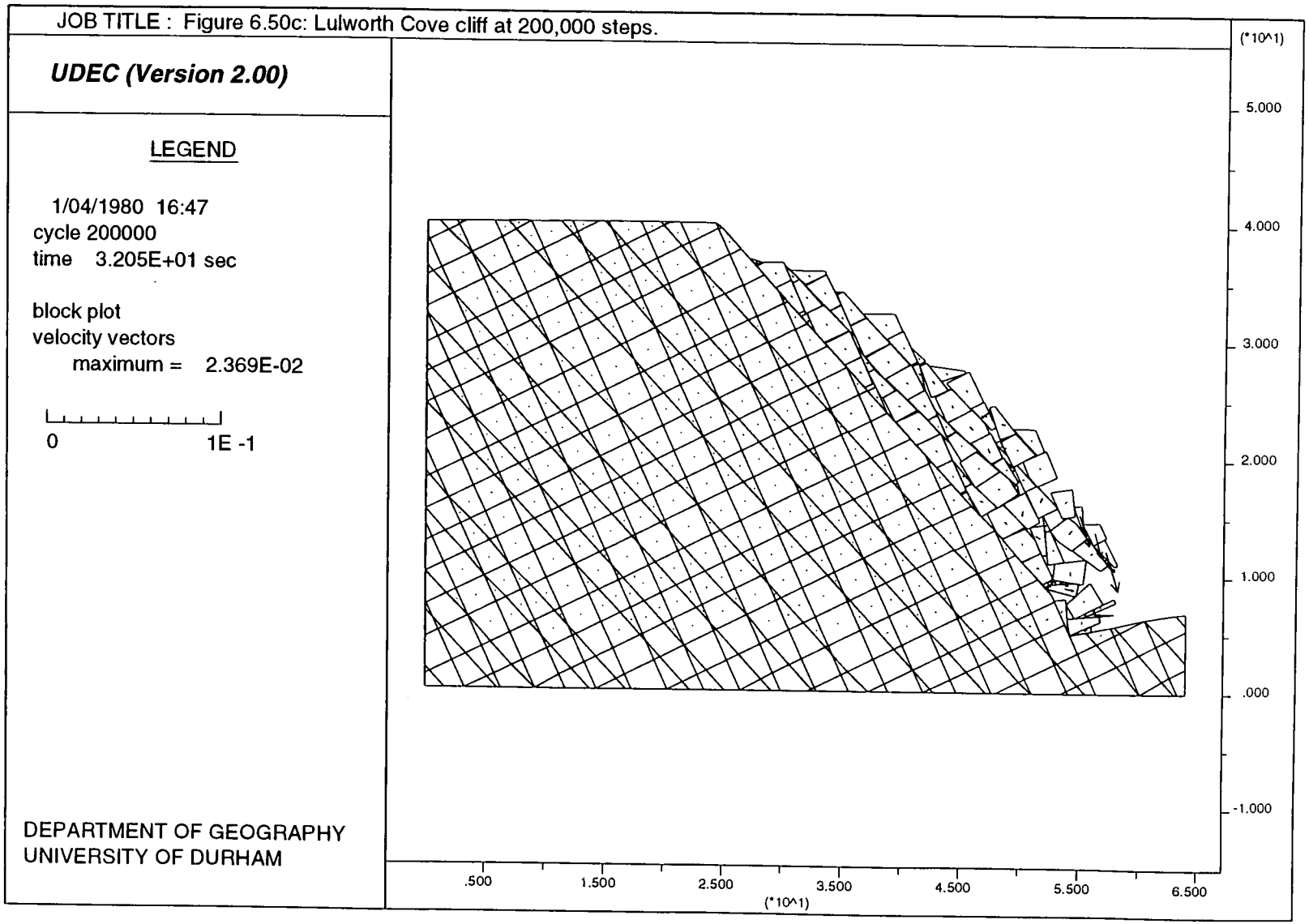
block plot
velocity vectors
maximum = 2.898E+00

0 1E 1

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.50b: Lulworth Cove cliff at 54,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:46
cycle 54000
time 8.628E+00 sec
block plot
velocity vectors
maximum = 3.077E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.50c: Lulworth Cove cliff at 200,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 16:47
cycle 200000
time 3.205E+01 sec
block plot
velocity vectors
maximum = 2.369E-02
0
1E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

JOB TITLE : Figure 6.50d: Lulworth Cove cliff at 600,000 steps.

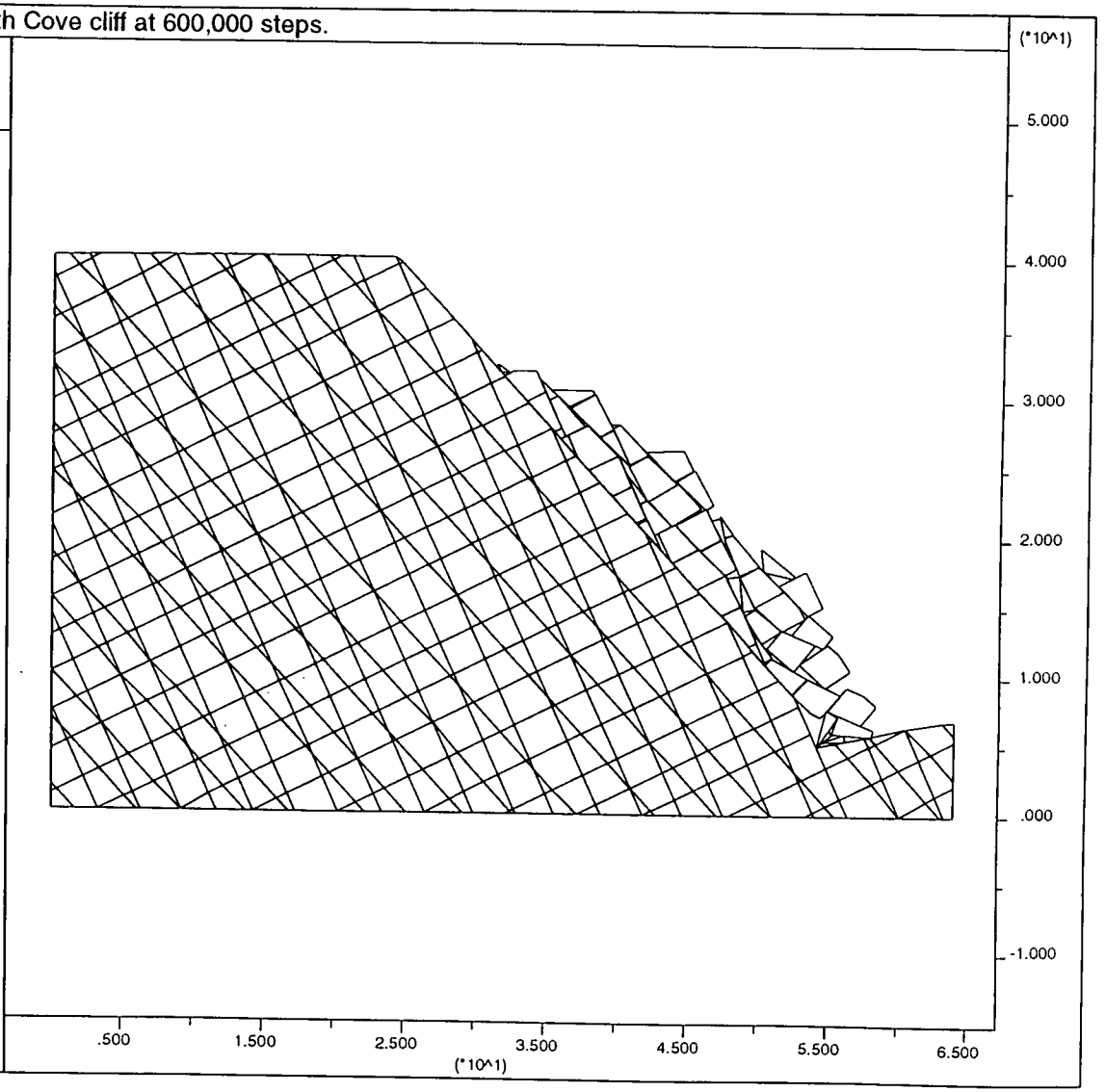
UDEC (Version 2.00)

LEGEND

1/04/1980 16:49
cycle 600000
time 9.559E+01 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



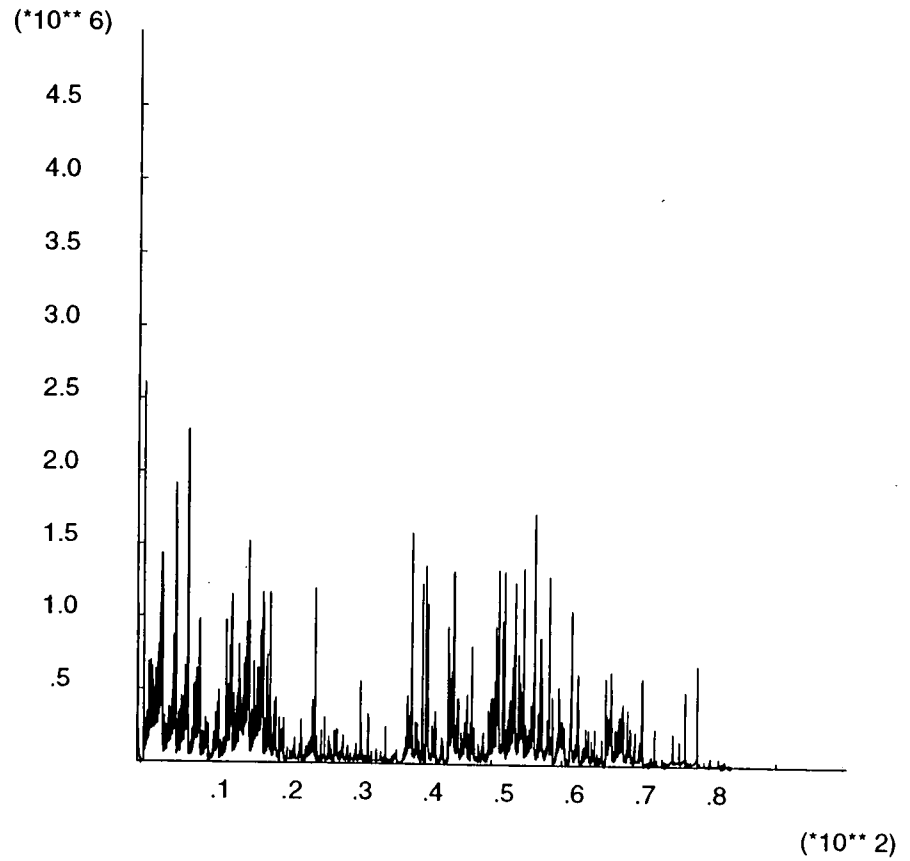
JOB TITLE : Figure 6.51: Forces for the Lulworth Cove cliff at 600,000 steps.

UDEC (Version 2.00)

LEGEND

1/04/1980 16:50
cycle 600000
time 9.559E+01 sec

2.77E-01 <hist 2> 4.96E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

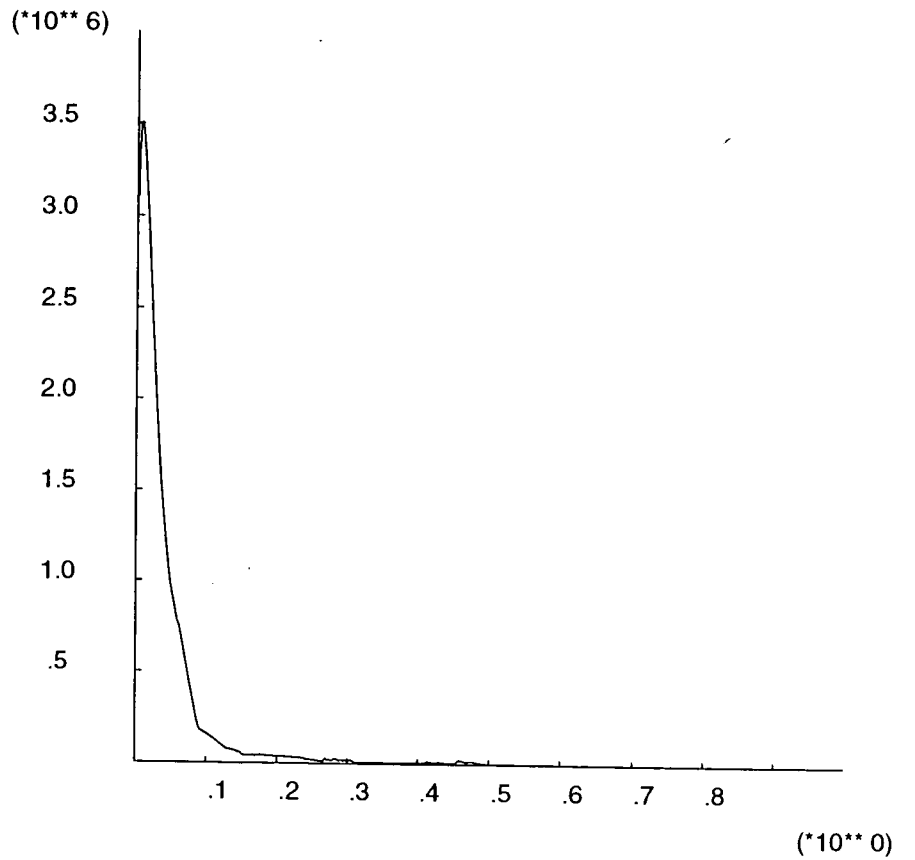
JOB TITLE : Figure 6.52: Forces for the eastern Durdle Promontory at equilibrium.

UDEC (Version 2.00)

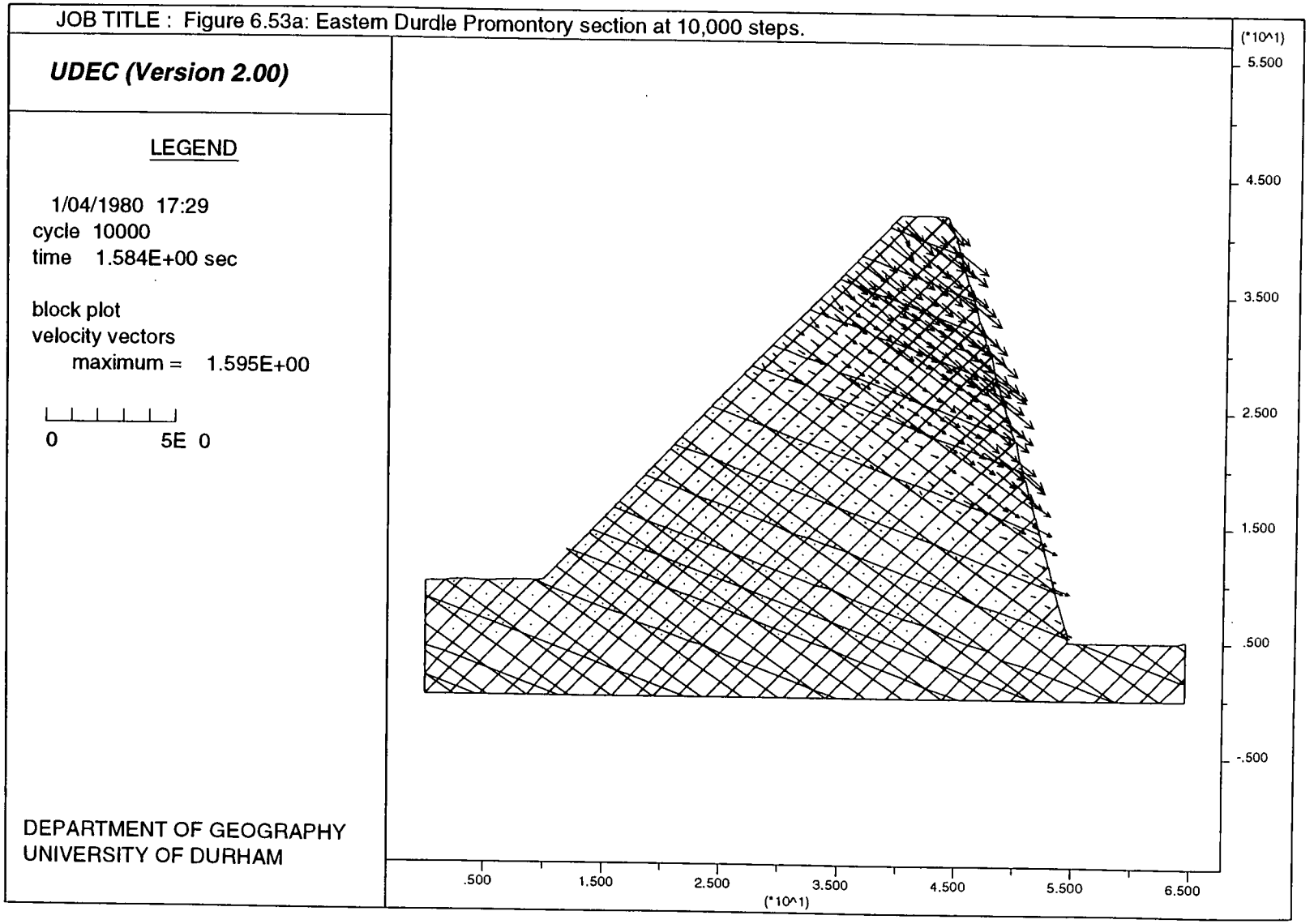
LEGEND

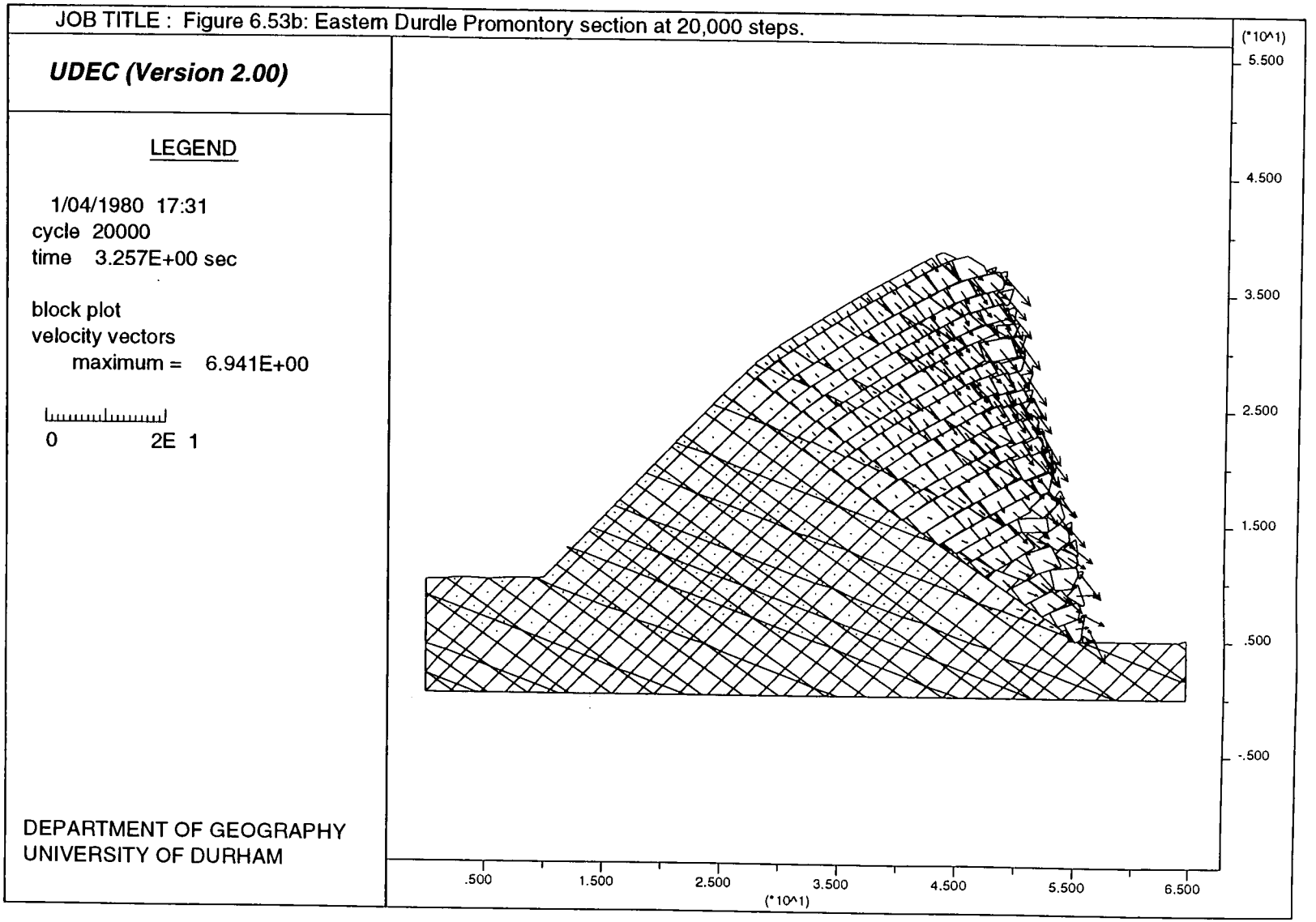
1/04/1980 17:28
cycle 6000
time 9.492E-01 sec

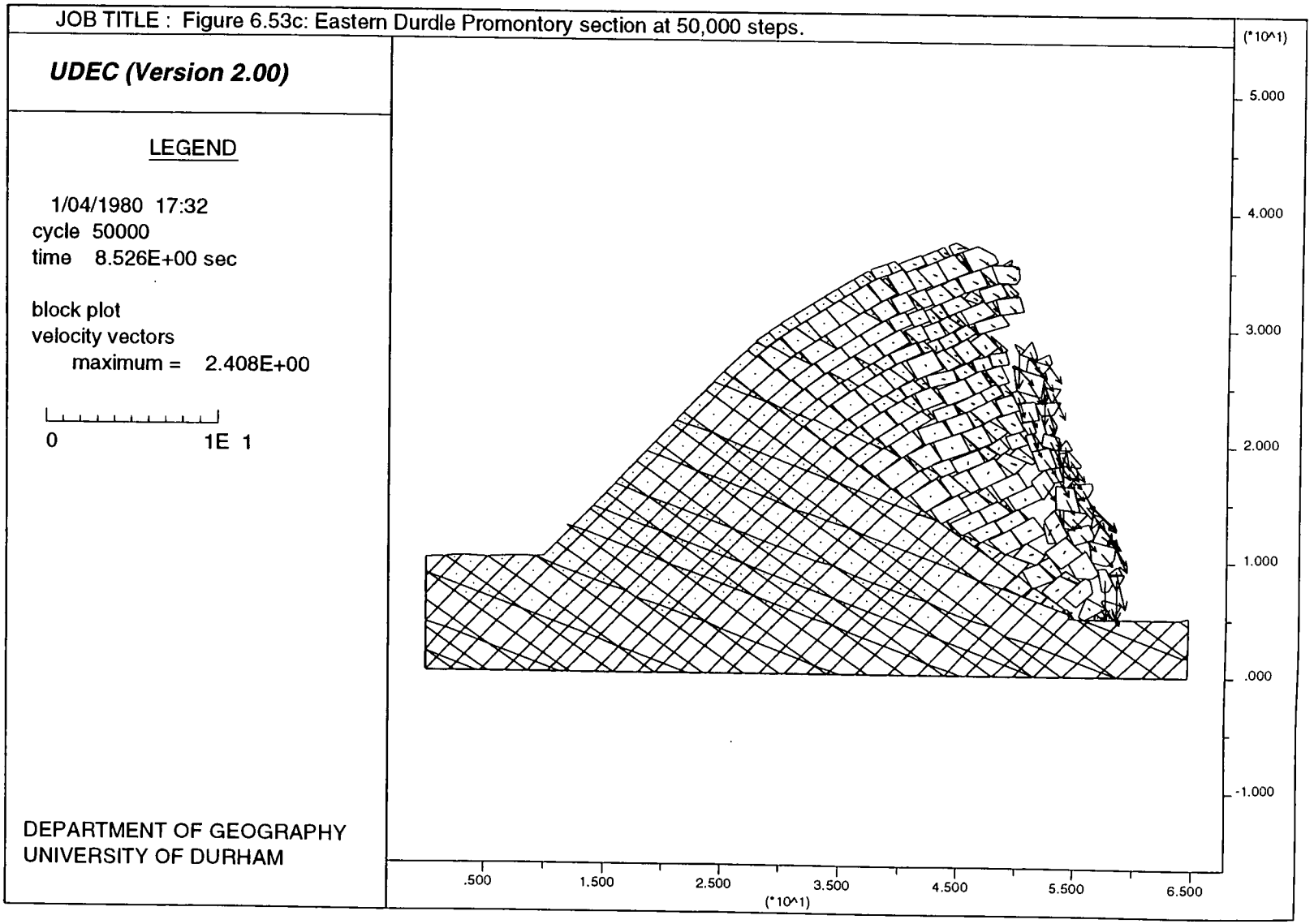
2.25E+00 <hist 3> 3.51E+06

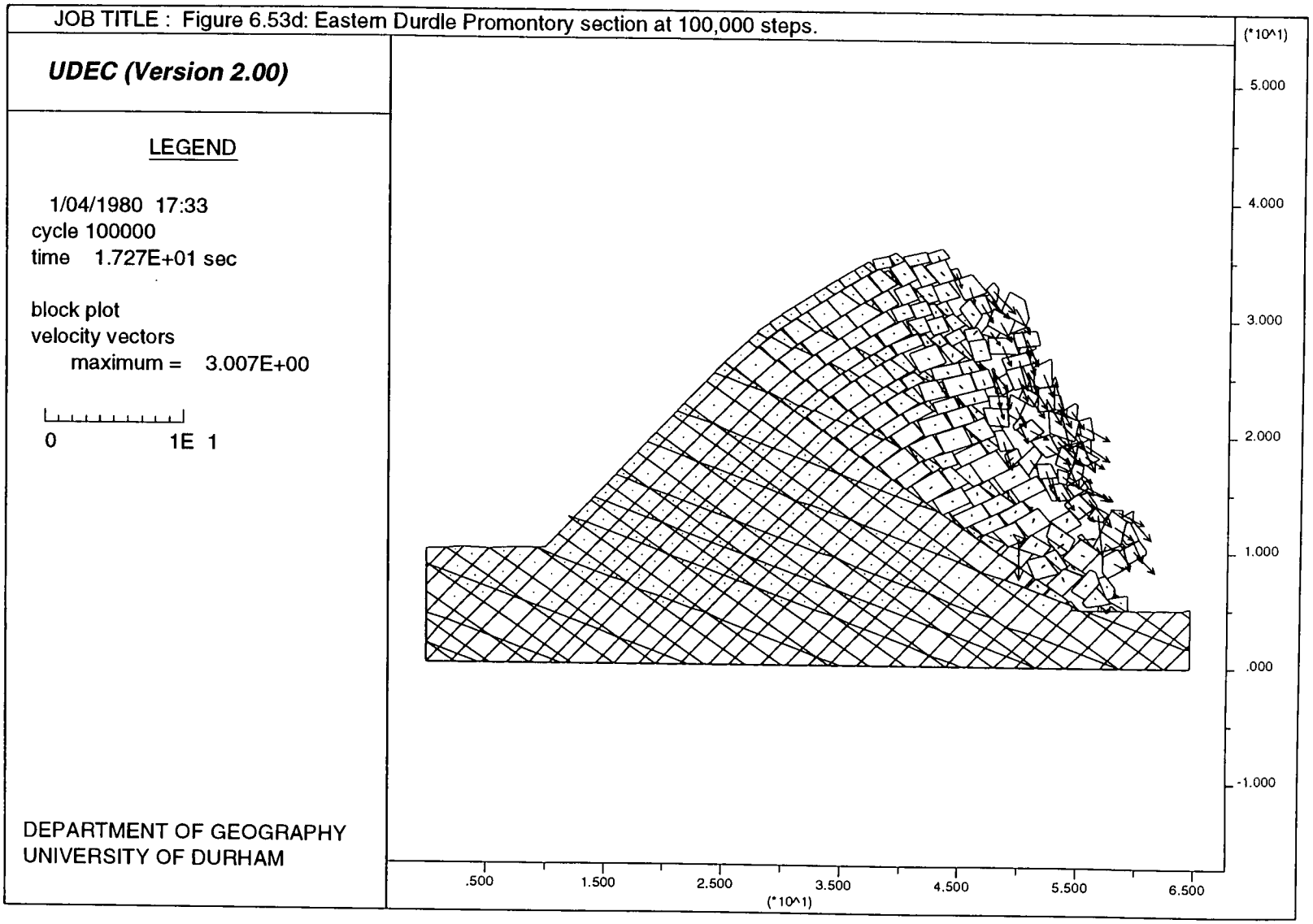


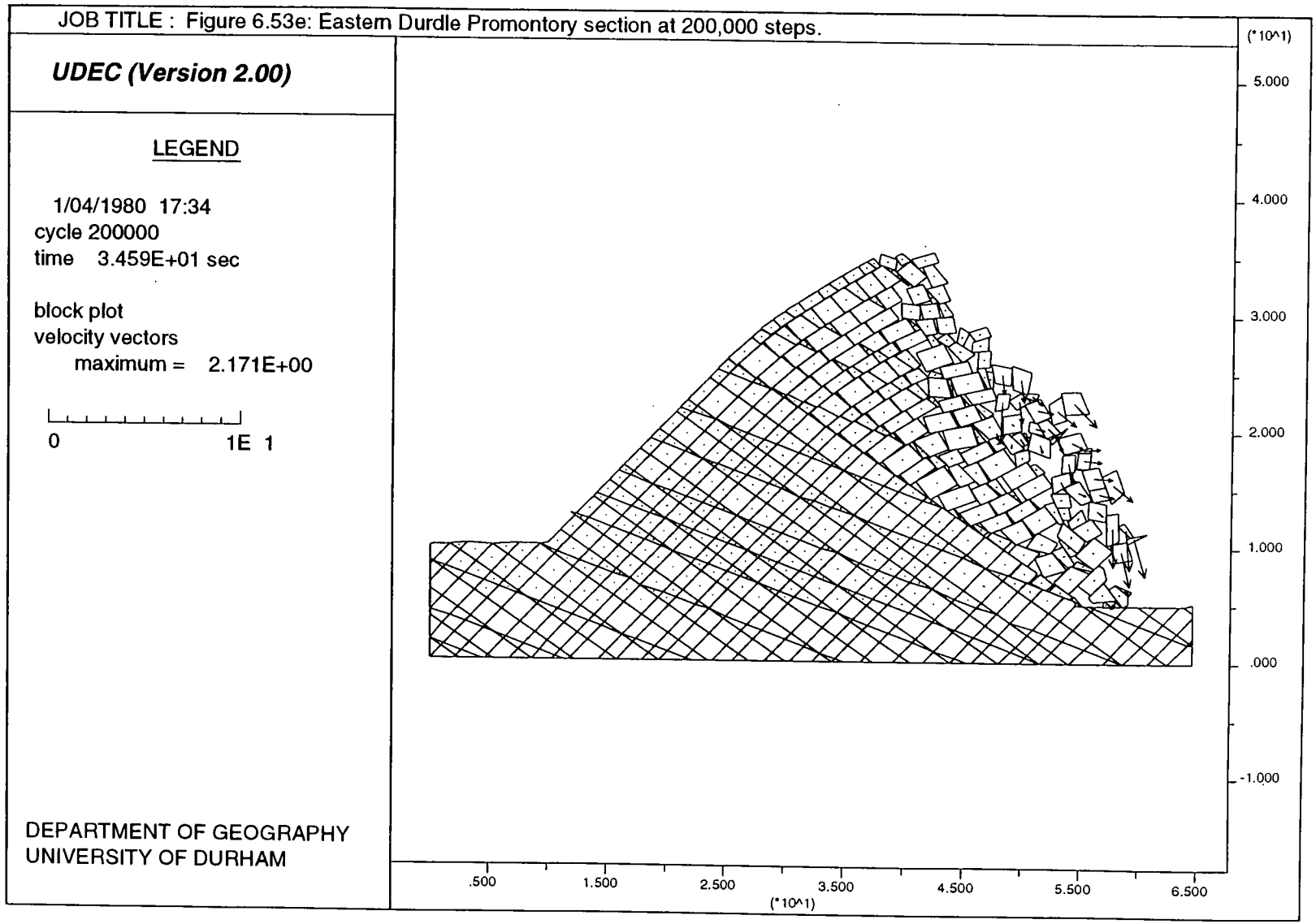
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 6.53a: Eastern Durdle Promontory section at 10,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:29
cycle 10000
time 1.584E+00 sec
block plot
velocity vectors
maximum = 1.595E+00
0
5E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.53b: Eastern Durdle Promontory section at 20,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:31
cycle 20000
time 3.257E+00 sec
block plot
velocity vectors
maximum = 6.941E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.500
4.500
3.500
2.500
1.500
.500
-.500
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.53c: Eastern Durdle Promontory section at 50,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:32
cycle 50000
time 8.526E+00 sec
block plot
velocity vectors
maximum = 2.408E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.53d: Eastern Durdle Promontory section at 100,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:33
cycle 100000
time 1.727E+01 sec
block plot
velocity vectors
maximum = 3.007E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)


JOB TITLE : Figure 6.53e: Eastern Durdle Promontory section at 200,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:34
cycle 200000
time 3.459E+01 sec
block plot
velocity vectors
maximum = 2.171E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
5.000
4.000
3.000
2.000
1.000
.000
-1.000
.500
1.500
2.500
3.500
4.500
5.500
6.500
(*10^1)

JOB TITLE : Figure 6.53f: Eastern Durdle Promontory section at 470,000 steps.

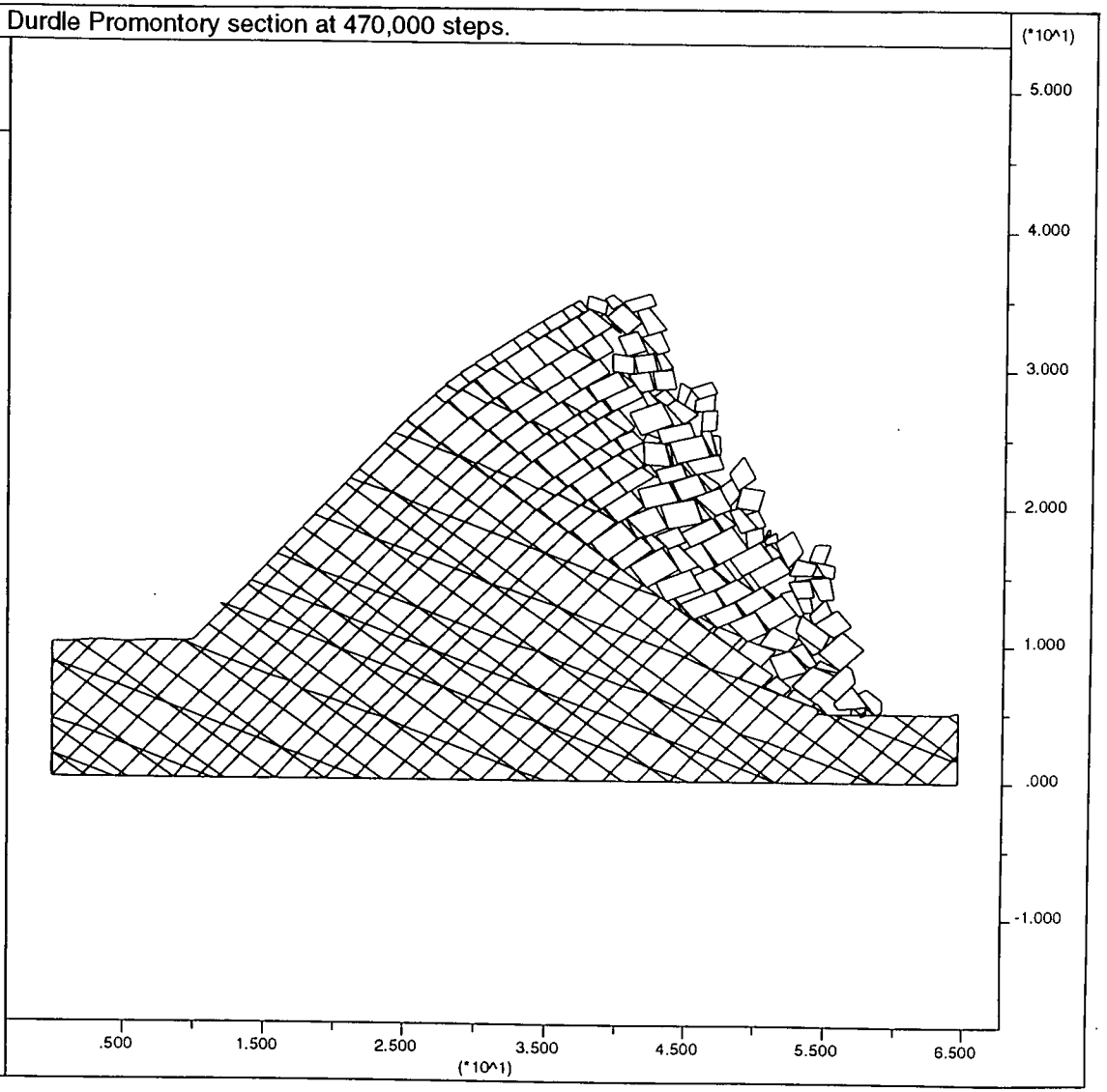
UDEC (Version 2.00)

LEGEND

1/04/1980 17:35
cycle 470000
time 8.097E+01 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



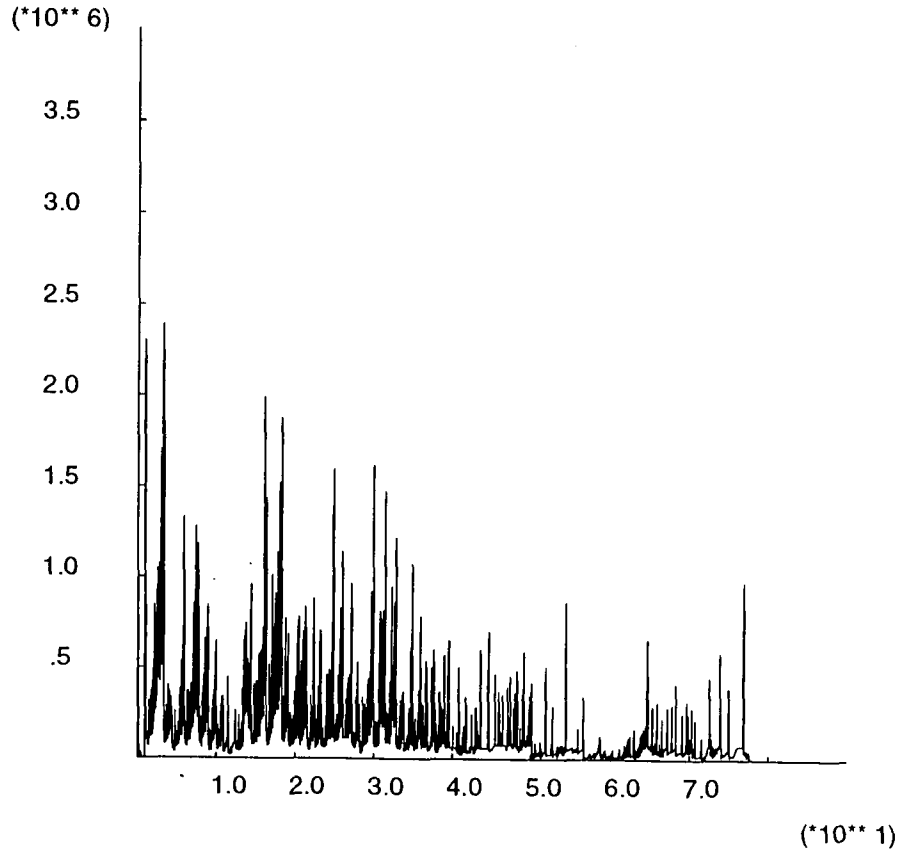
JOB TITLE : Figure 6.54: Forces for the eastern Durdle Promontory at 470,000 steps.

UDEC (Version 2.00)

LEGEND

1/04/1980 17:36
cycle 470000
time 8.097E+01 sec

4.10E-01 <hist 3> 3.51E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

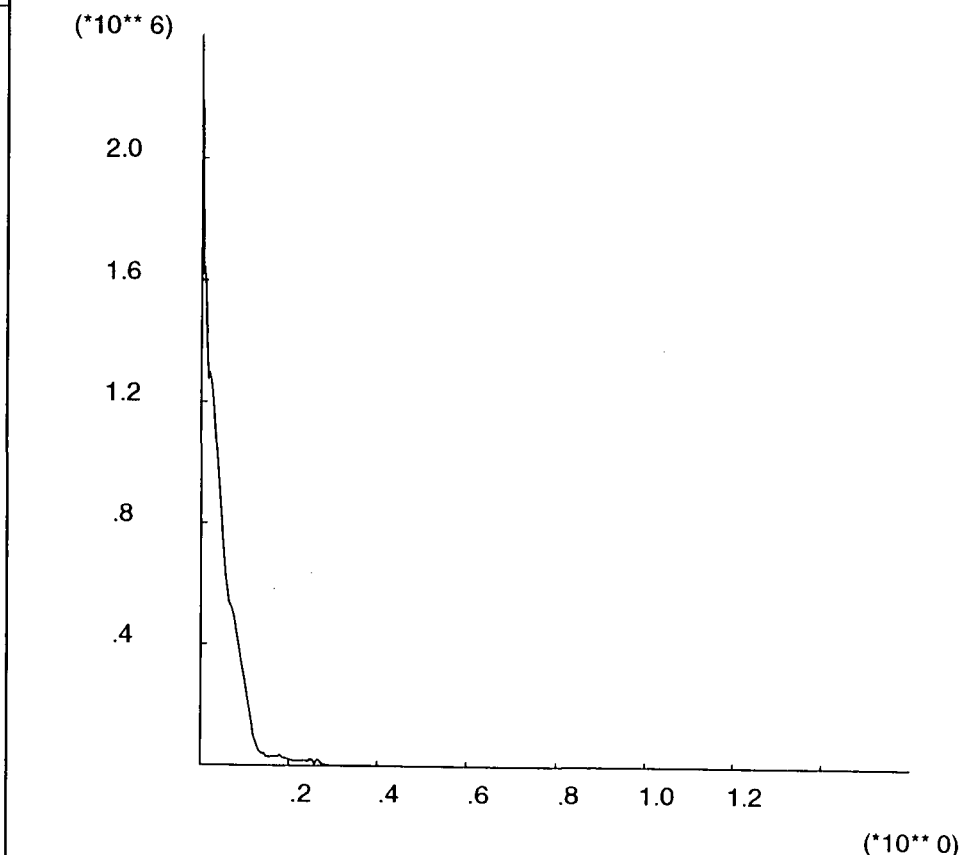
JOB TITLE : Figure 6.55: Forces for the western Durdle Door section at equilibrium.

UDEC (Version 2.00)

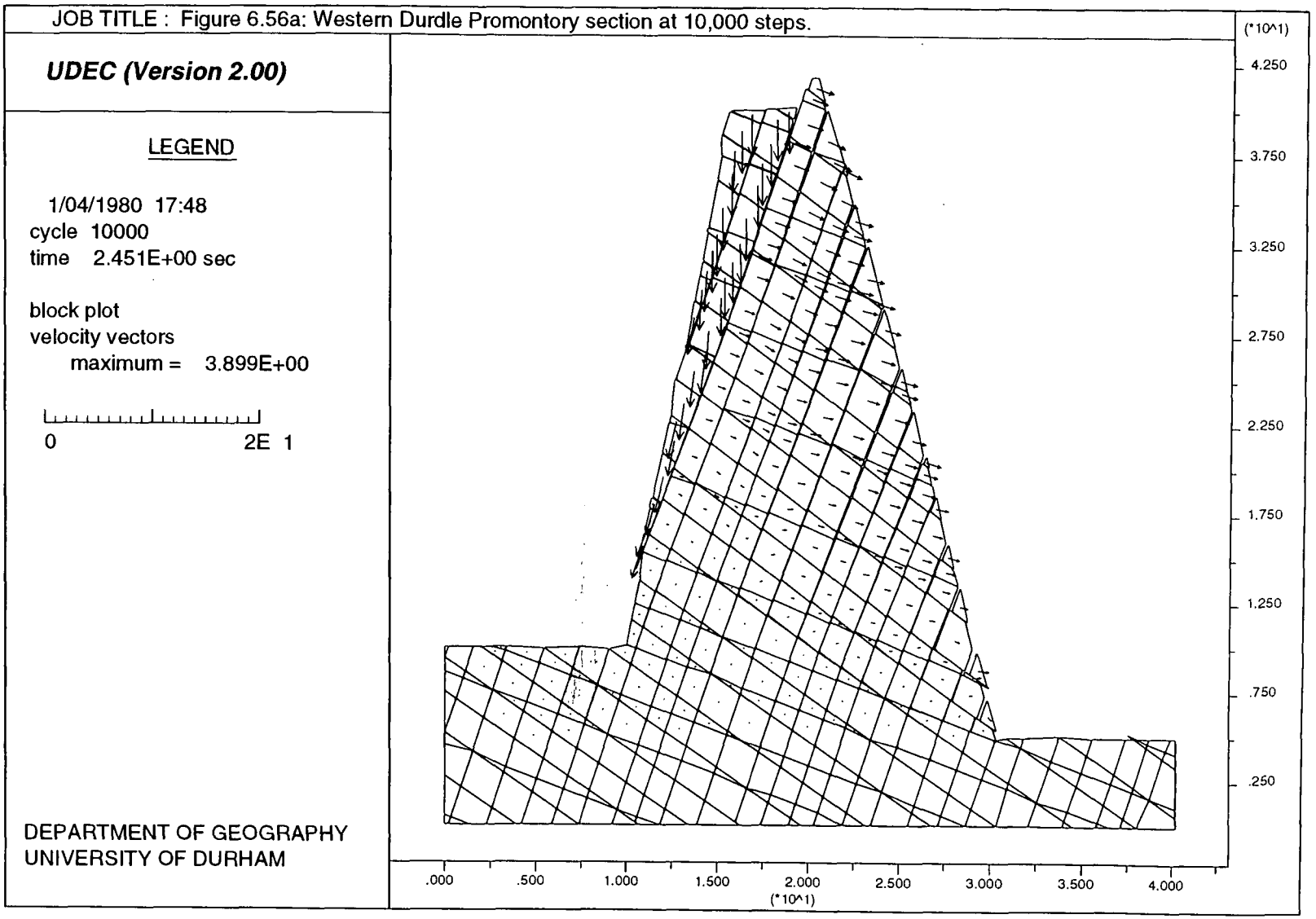
LEGEND

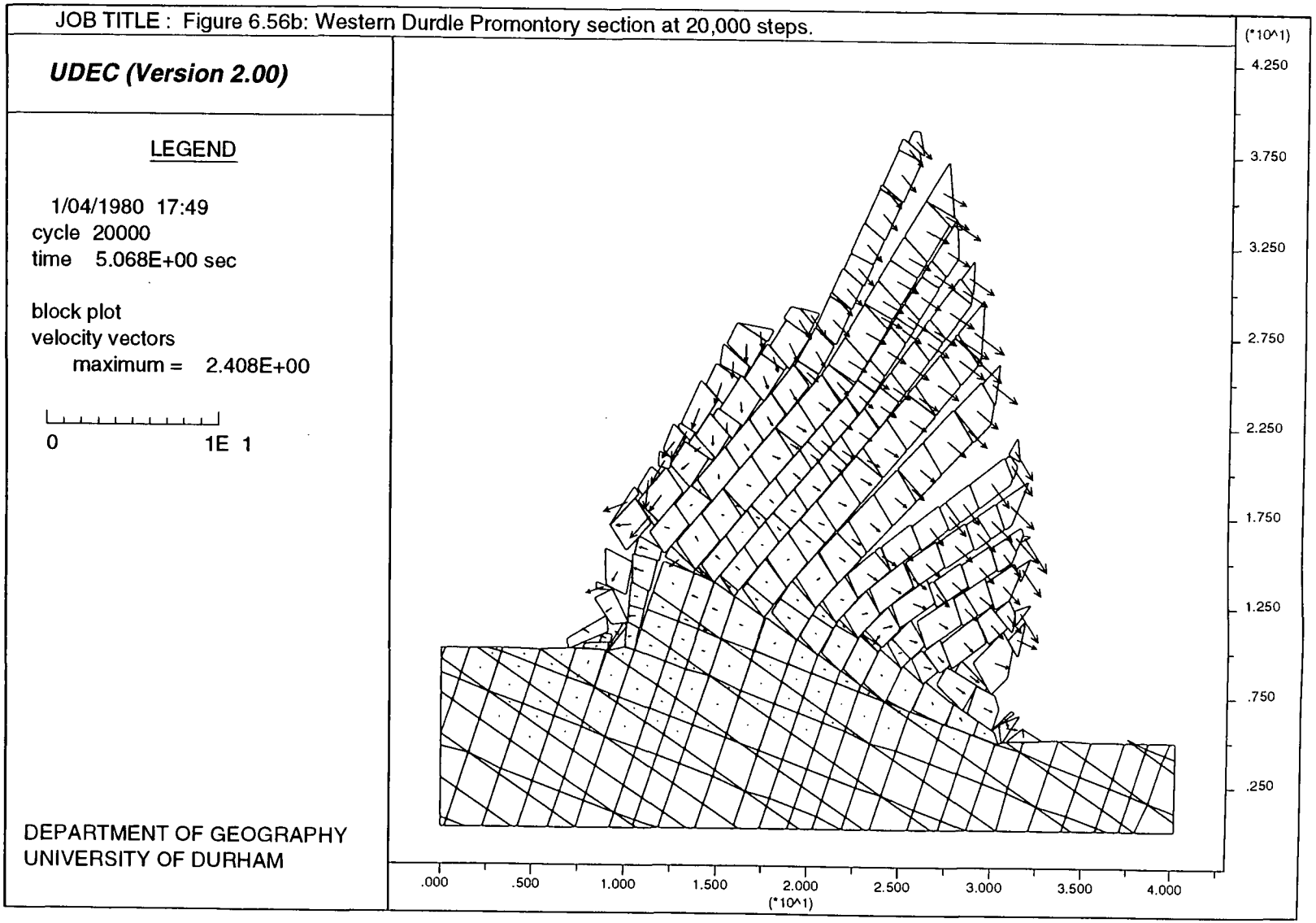
1/04/1980 17:47
cycle 6000
time 1.462E+00 sec

2.64E-01 <hist 3> 2.19E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM


JOB TITLE : Figure 6.56a: Western Durdle Promontory section at 10,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:48
cycle 10000
time 2.451E+00 sec
block plot
velocity vectors
maximum = 3.899E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
4.250
3.750
3.250
2.750
2.250
1.750
1.250
.750
.250
.000
.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
(*10^1)


JOB TITLE : Figure 6.56b: Western Durdle Promontory section at 20,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:49
cycle 20000
time 5.068E+00 sec
block plot
velocity vectors
maximum = 2.408E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
4.250
3.750
3.250
2.750
2.250
1.750
1.250
.750
.250
.000
.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
(*10^1)

JOB TITLE : Figure 6.56c: Western Durdle Promontory section at 50,000 steps.

UDEC (Version 2.00)

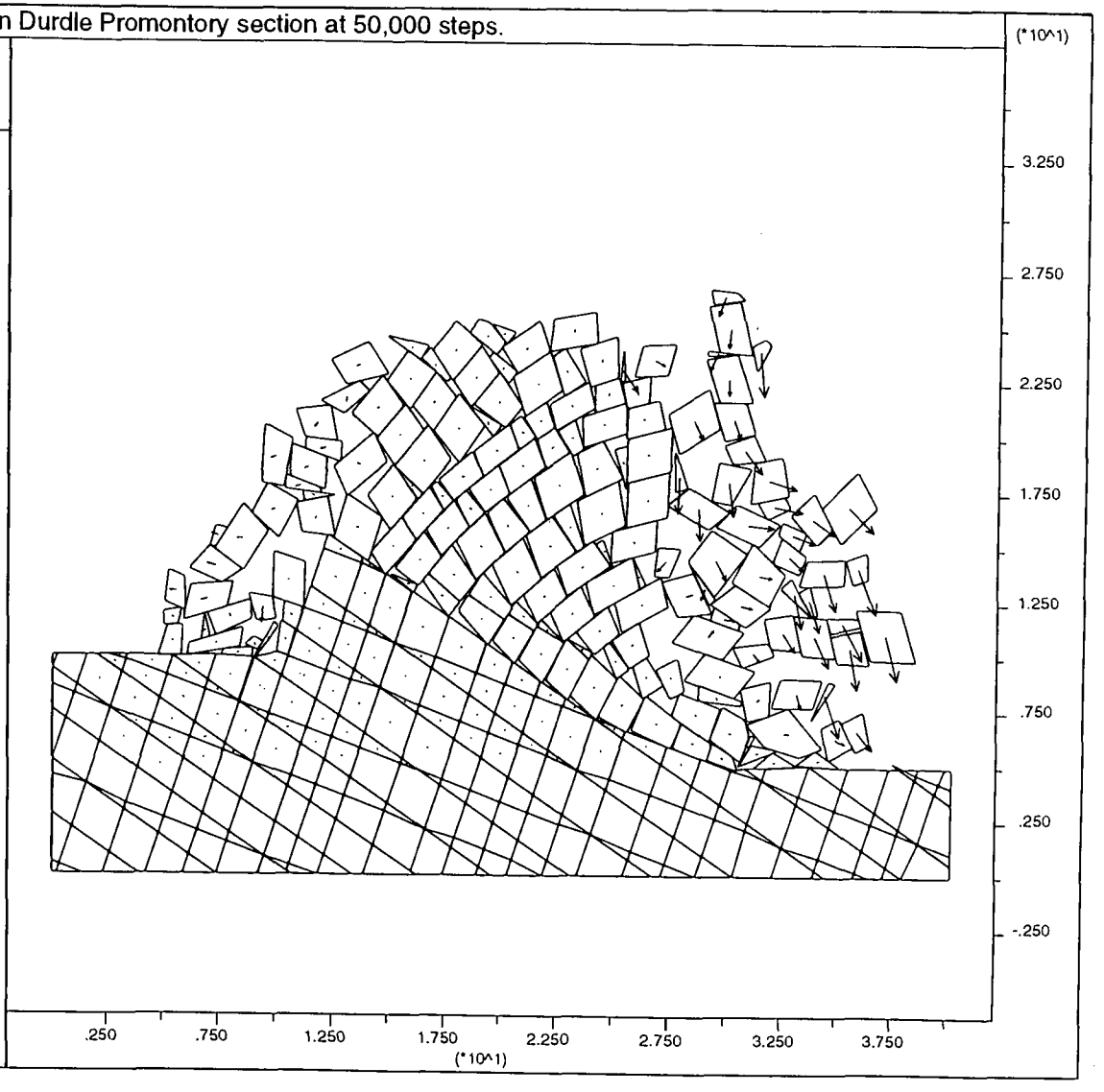
LEGEND

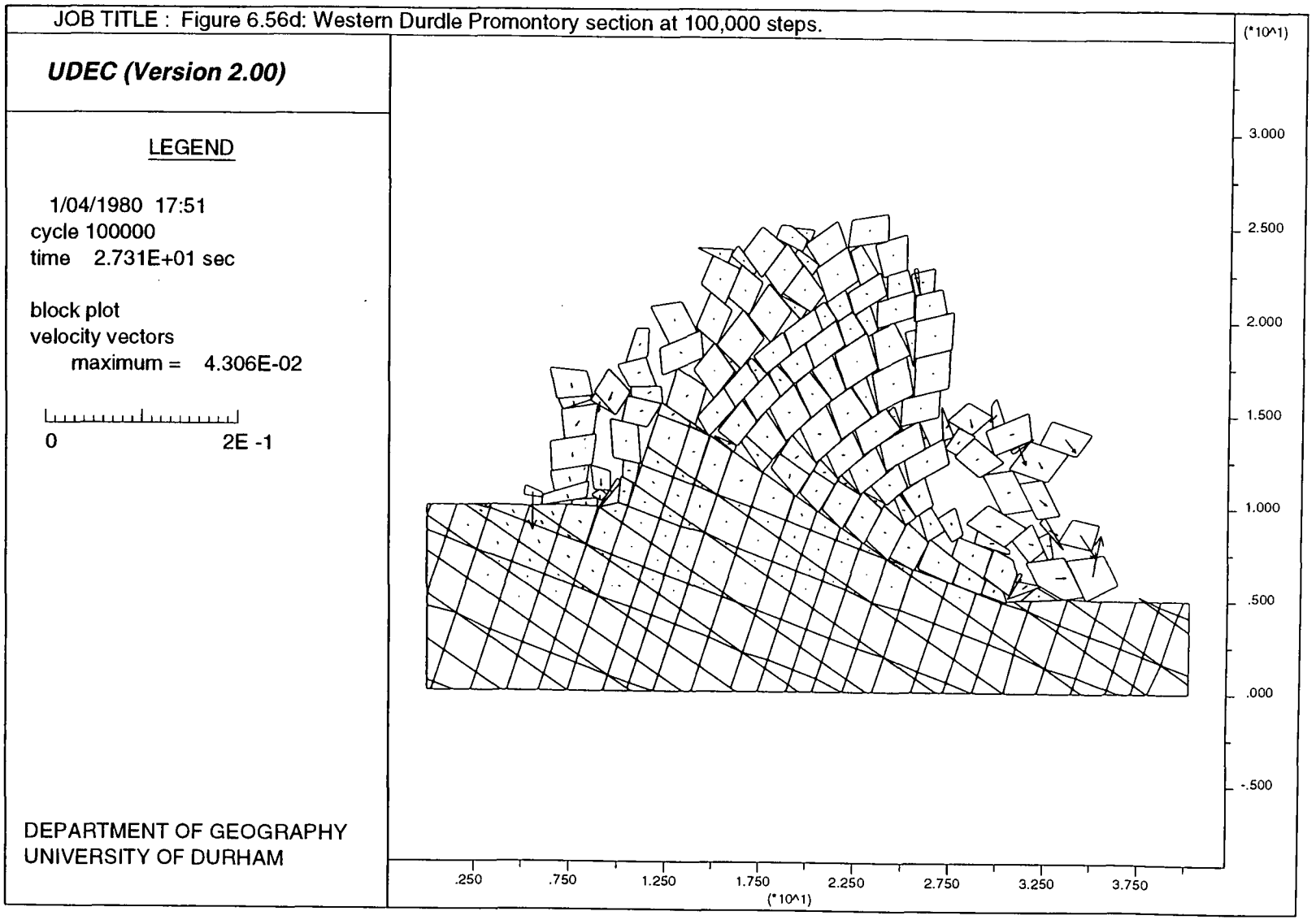
1/04/1980 17:50
cycle 50000
time 1.344E+01 sec

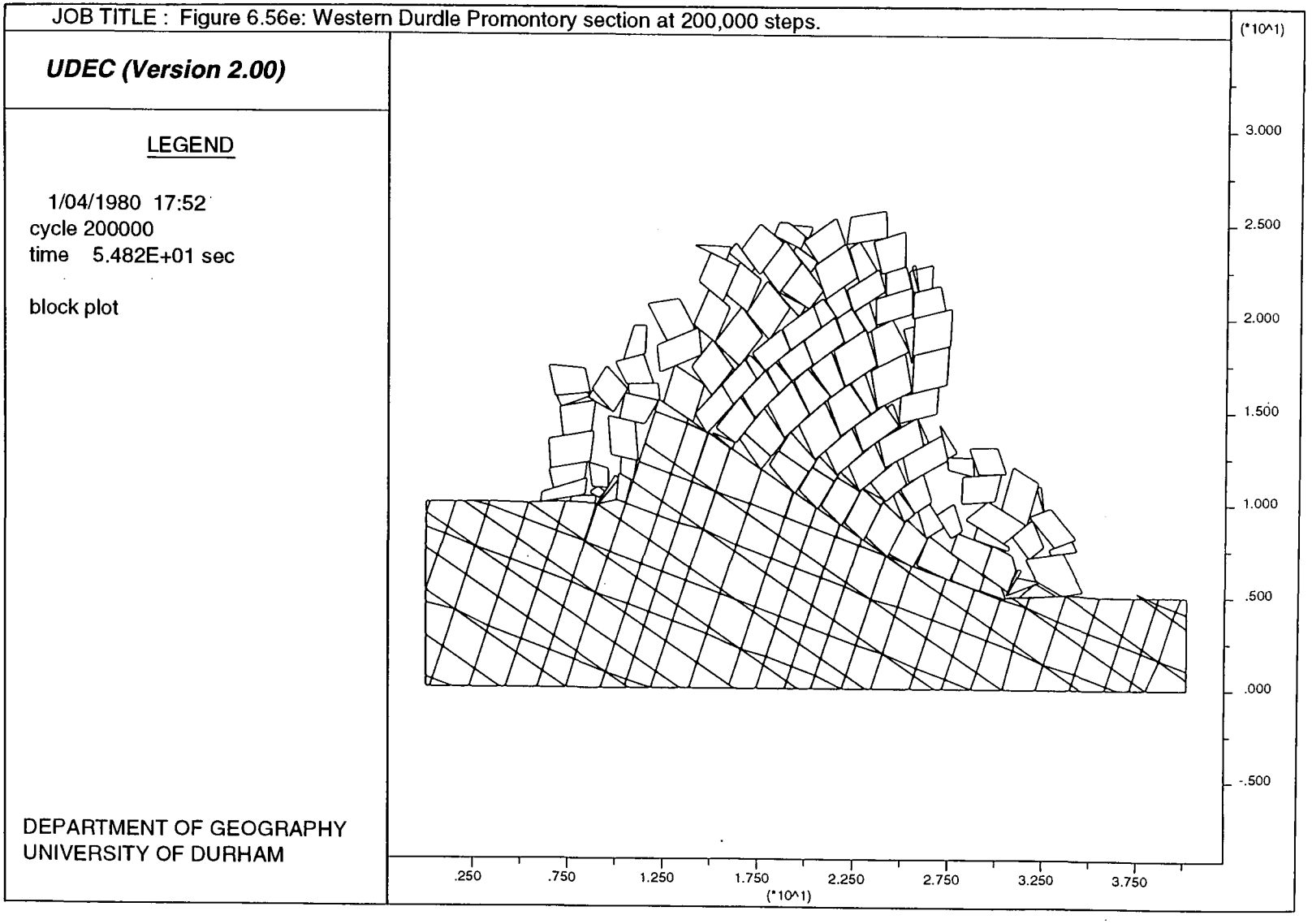
block plot
velocity vectors
maximum = 4.456E+00

0 2E 1

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.56d: Western Durdle Promontory section at 100,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:51
cycle 100000
time 2.731E+01 sec
block plot
velocity vectors
maximum = 4.306E-02
0
2E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
3.000
2.500
2.000
1.500
1.000
.500
.000
-.500
.250
.750
1.250
1.750
2.250
2.750
3.250
3.750
(*10^1)


JOB TITLE : Figure 6.56e: Western Durdle Promontory section at 200,000 steps.
UDEC (Version 2.00)
LEGEND
1/04/1980 17:52
cycle 200000
time 5.482E+01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
3.000
2.500
2.000
1.500
1.000
.500
.000
-.500
.250
.750
1.250
1.750
2.250
2.750
3.250
3.750
(*10^1)

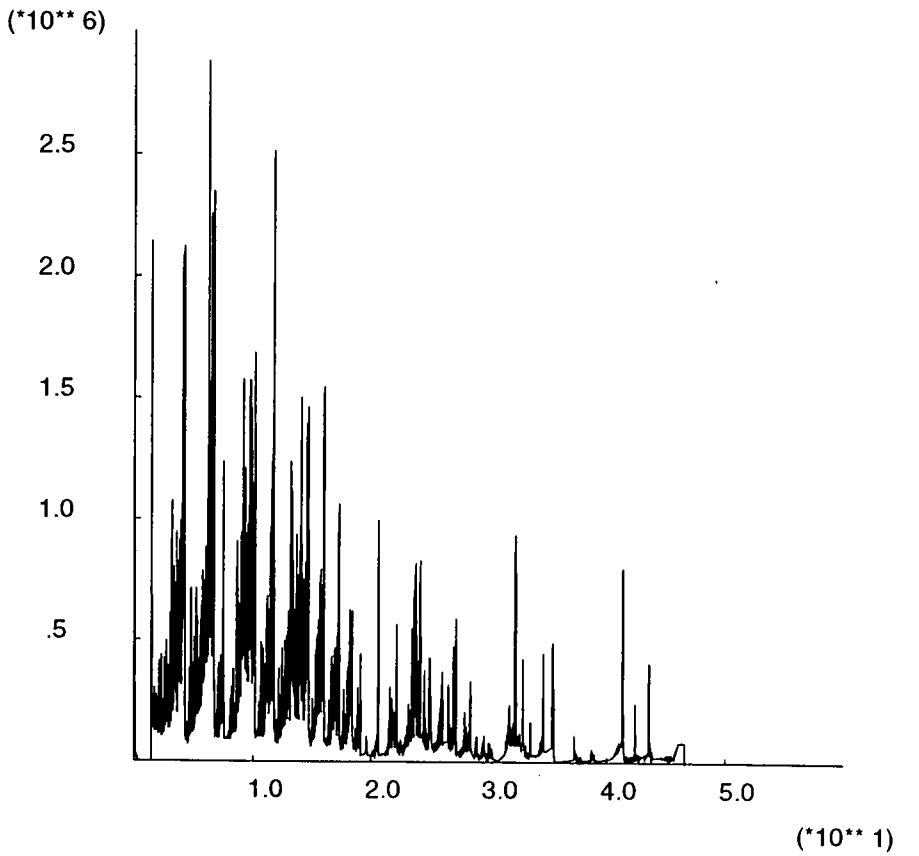
JOB TITLE : Figure 6.57: Forces for western Durdle Promontory at 200,000 steps.

UDEC (Version 2.00)

LEGEND

1/04/1980 17:54
cycle 200000
time 5.482E+01 sec

7.77E-02 <hist 3> 2.88E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

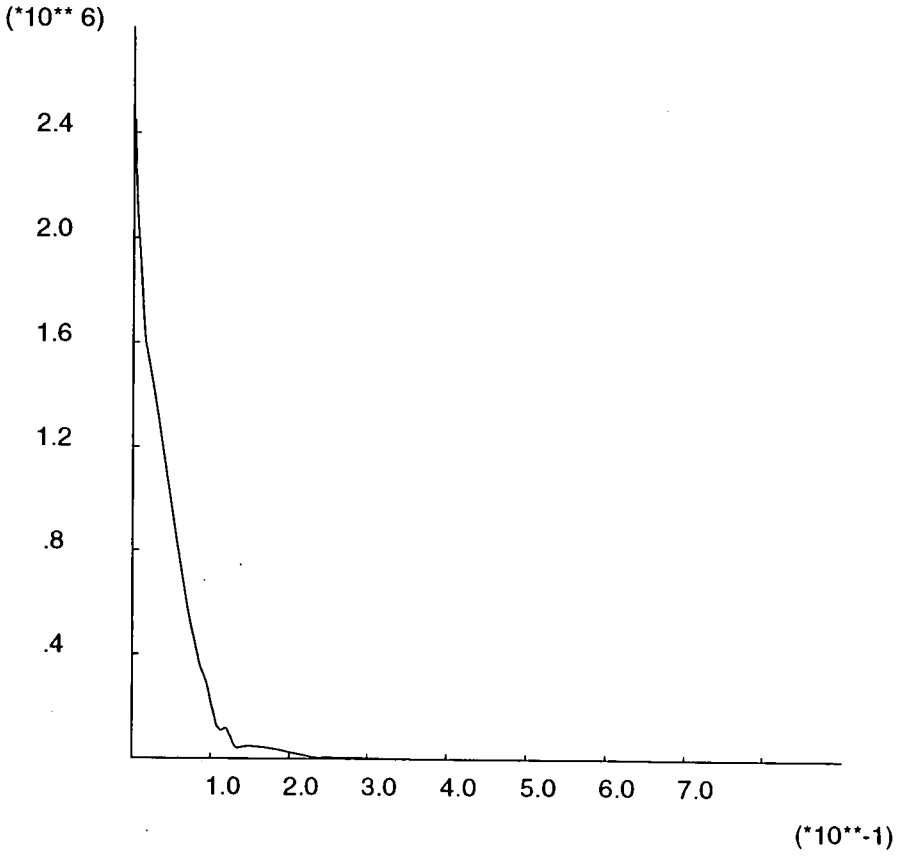
JOB TITLE : Figure 6.58: Forces for the Durdle Door sea arch at equilibrium.

UDEC (Version 2.00)

LEGEND

8/28/1998 18:07
cycle 6000
time 8.877E-01 sec

6.34E-01 <hist 2> 2.45E+06



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

JOB TITLE : Figure 6.59a: Durdle Door sea arch at 10,000 steps.

UDEC (Version 2.00)

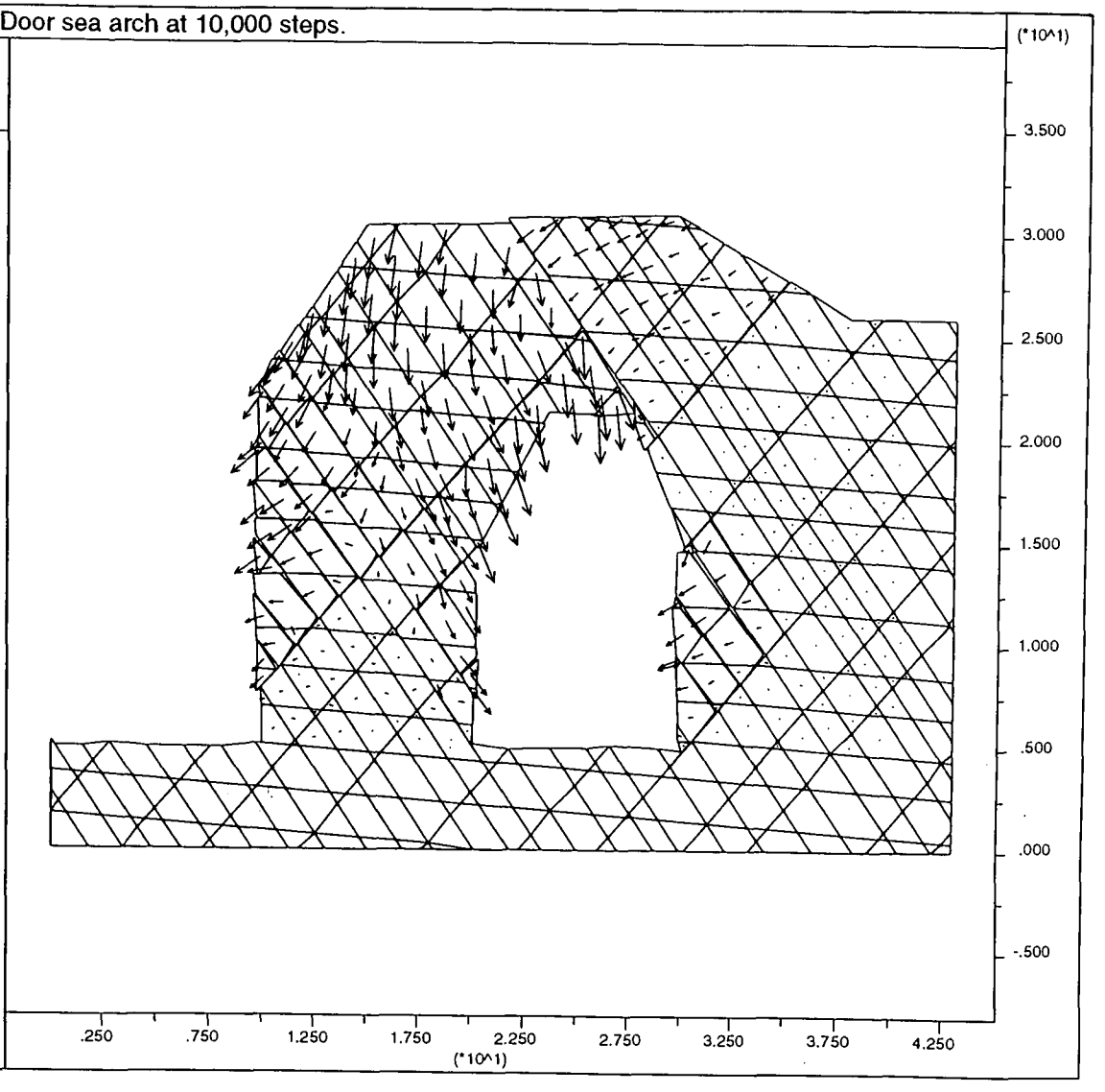
LEGEND

9/06/1998 17:18
cycle 10000
time 1.476E+00 sec

block plot
velocity vectors
maximum = 2.490E+00

0 1E 1

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 6.59b: Durdle Door sea arch at 20,000 steps.

UDEC (Version 2.00)

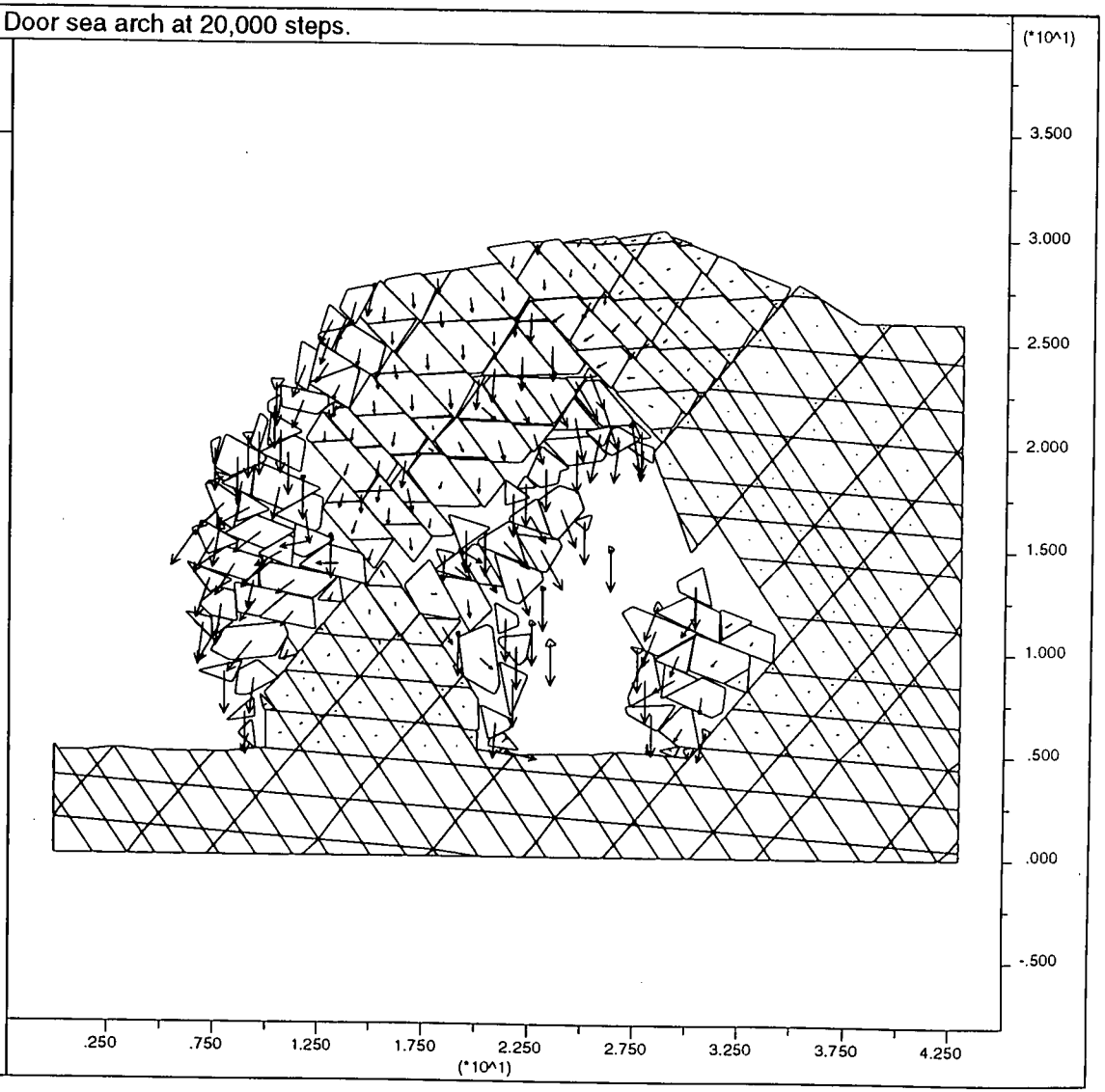
LEGEND

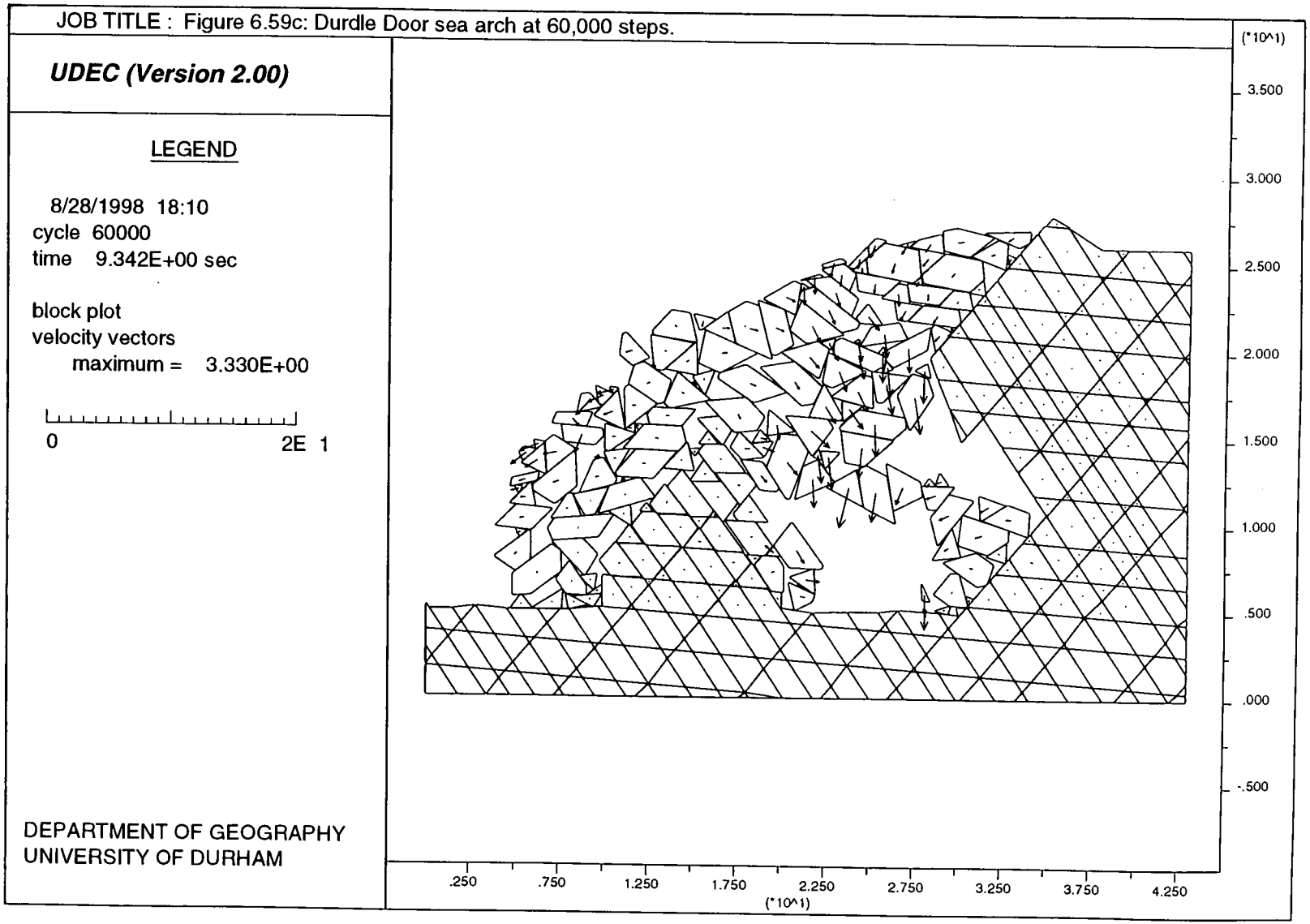
8/28/1998 18:22
cycle 20000
time 3.023E+00 sec

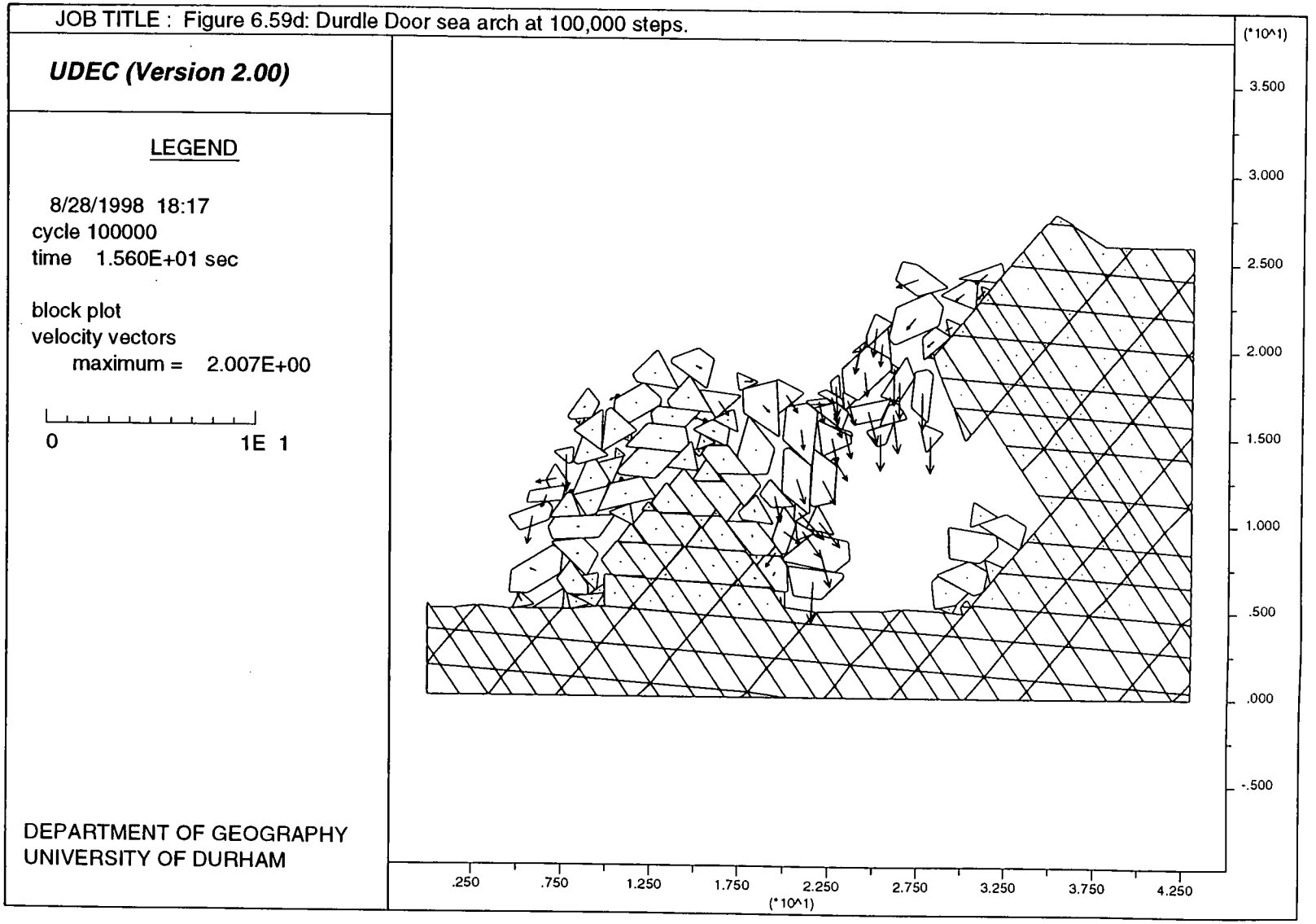
block plot
velocity vectors
maximum = 1.029E+00

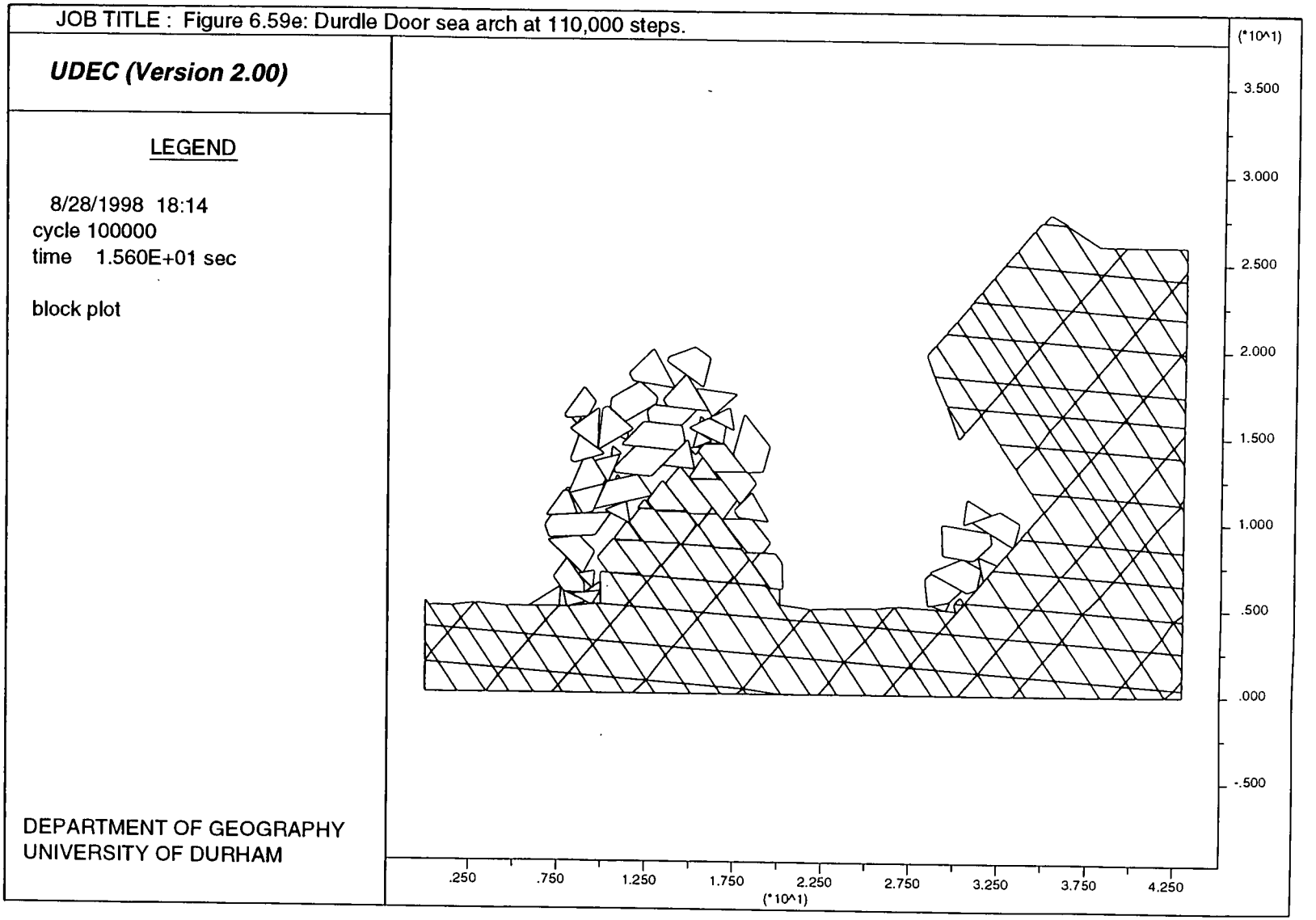
0 5E 0

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 6.59c: Durdle Door sea arch at 60,000 steps.
UDEC (Version 2.00)
LEGEND
8/28/1998 18:10
cycle 60000
time 9.342E+00 sec
block plot
velocity vectors
maximum = 3.330E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
3.500
3.000
2.500
2.000
1.500
1.000
.500
.000
-.500
.250
.750
1.250
1.750
2.250
2.750
3.250
3.750
4.250
(*10^1)


JOB TITLE : Figure 6.59d: Durdle Door sea arch at 100,000 steps.
UDEC (Version 2.00)
LEGEND
8/28/1998 18:17
cycle 100000
time 1.560E+01 sec
block plot
velocity vectors
maximum = 2.007E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
3.500
3.000
2.500
2.000
1.500
1.000
.500
.000
-.500
.250
.750
1.250
1.750
2.250
2.750
3.250
3.750
4.250
(*10^1)


JOB TITLE : Figure 6.59e: Durdle Door sea arch at 110,000 steps.
UDEC (Version 2.00)
LEGEND
8/28/1998 18:14
cycle 100000
time 1.560E+01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^1)
3.500
3.000
2.500
2.000
1.500
1.000
.500
.000
-.500
.250
.750
1.250
1.750
2.250
2.750
3.250
3.750
4.250
(*10^1)

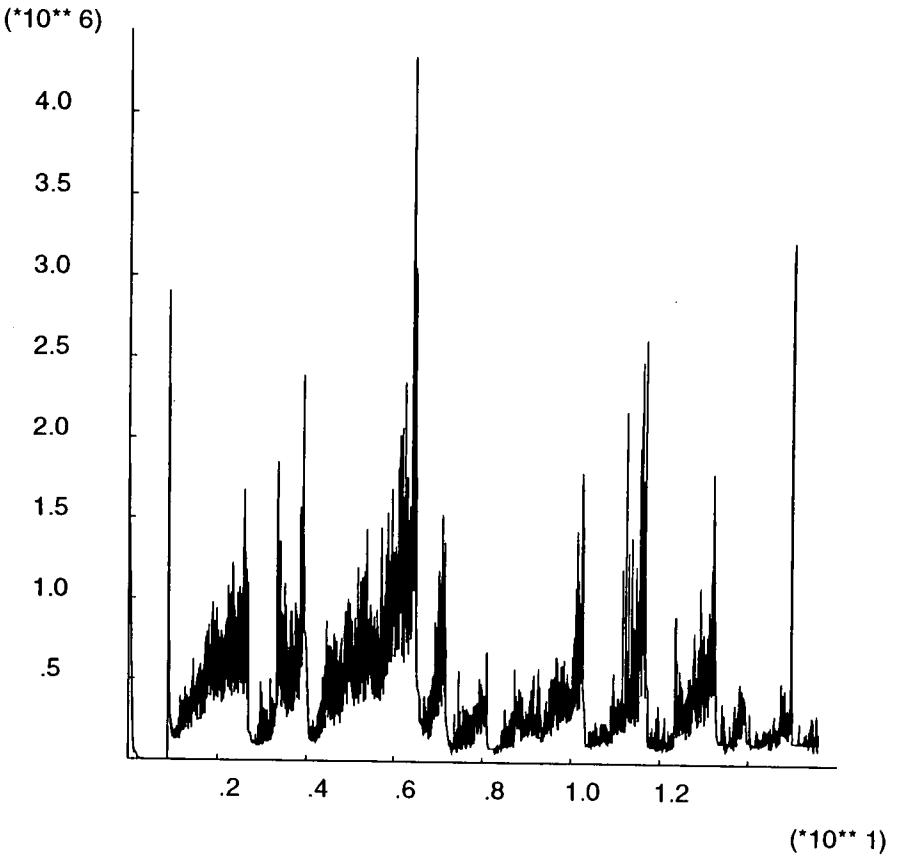
JOB TITLE : Figure 6.60: Forces for the Durdle Door sea arch at 110,000 steps.

UDEC (Version 2.00)

LEGEND

8/28/1998 18:15
cycle 100000
time 1.560E+01 sec

6.34E-01 <hist 2> 4.35E+06 ———



DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

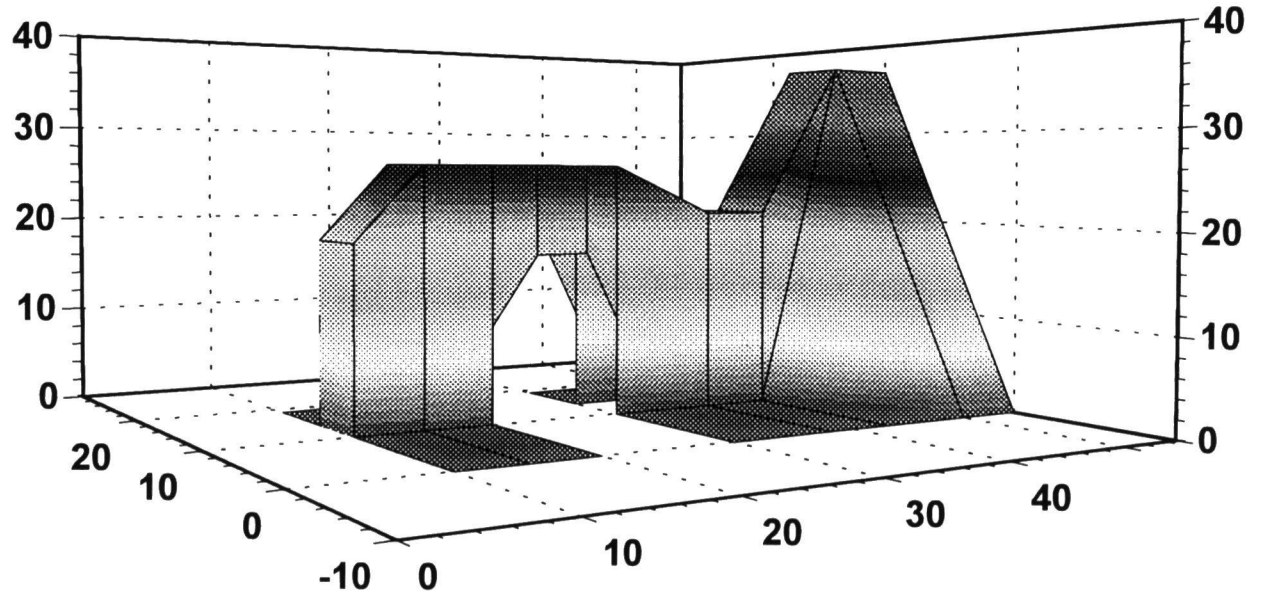


Figure 6.61a: Three-dimensional image of the western part of the present-day Durdle Promontory from the south-west.

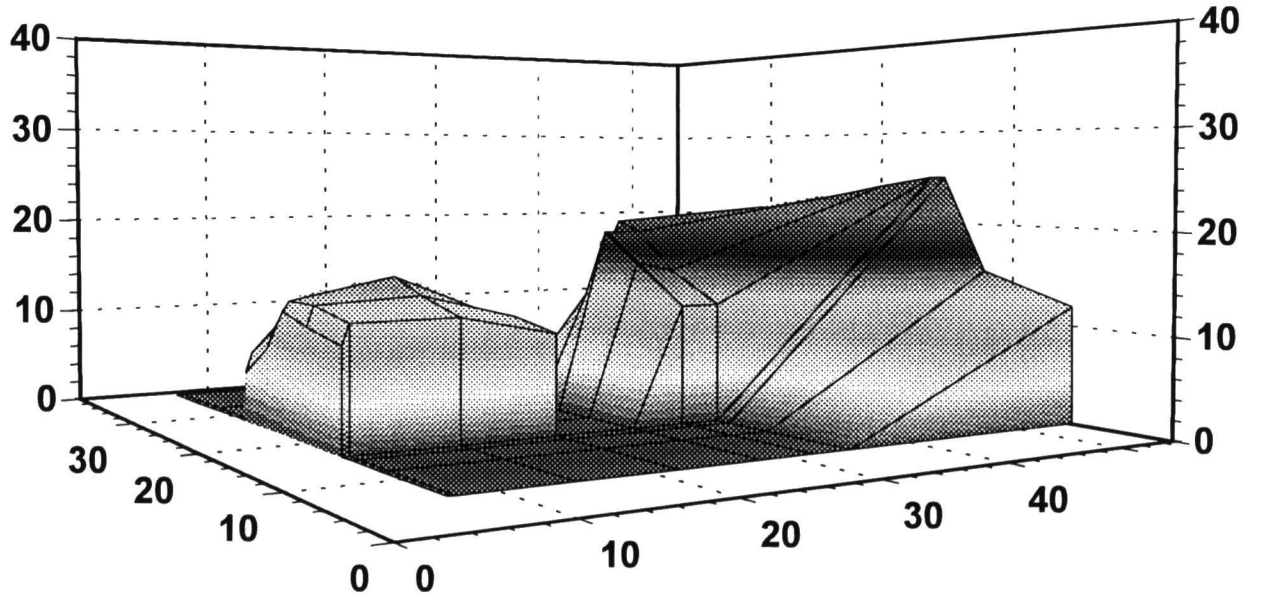


Figure 6.61b: Three-dimensional image of the western part of the present-day Durdle Promontory from the south-west after 100,000 model cycles.

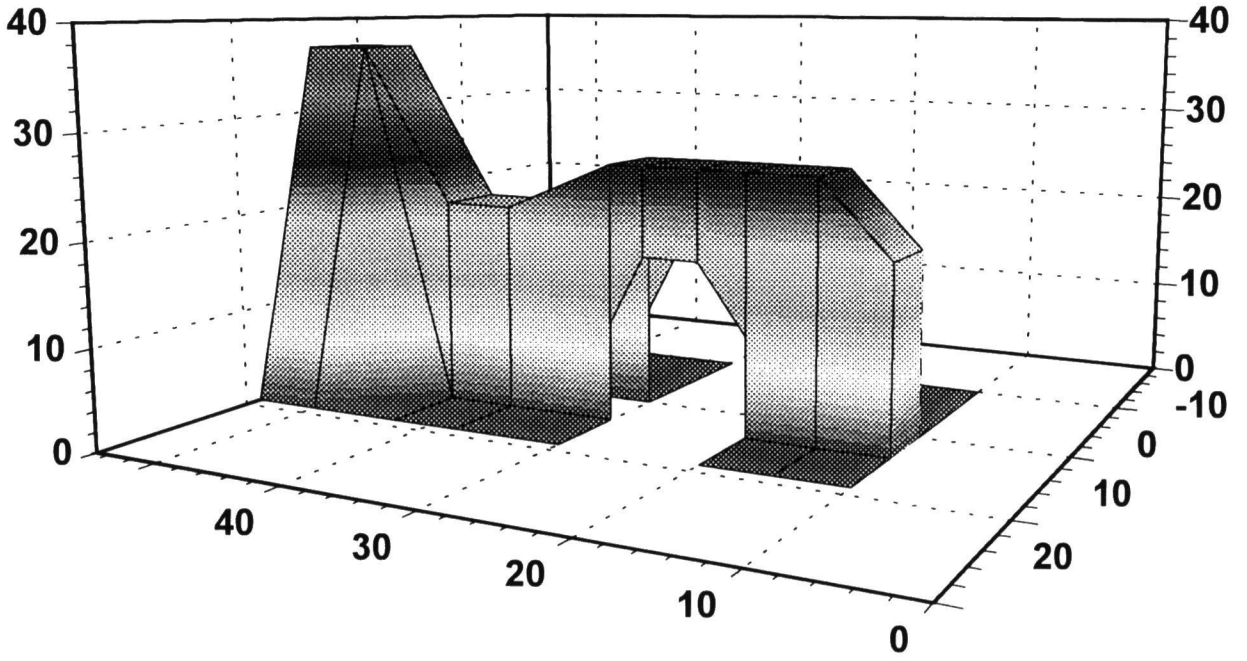


Figure 6.62a: Three-dimensional image of the western part of the present-day Durdle Promontory from the north-west.

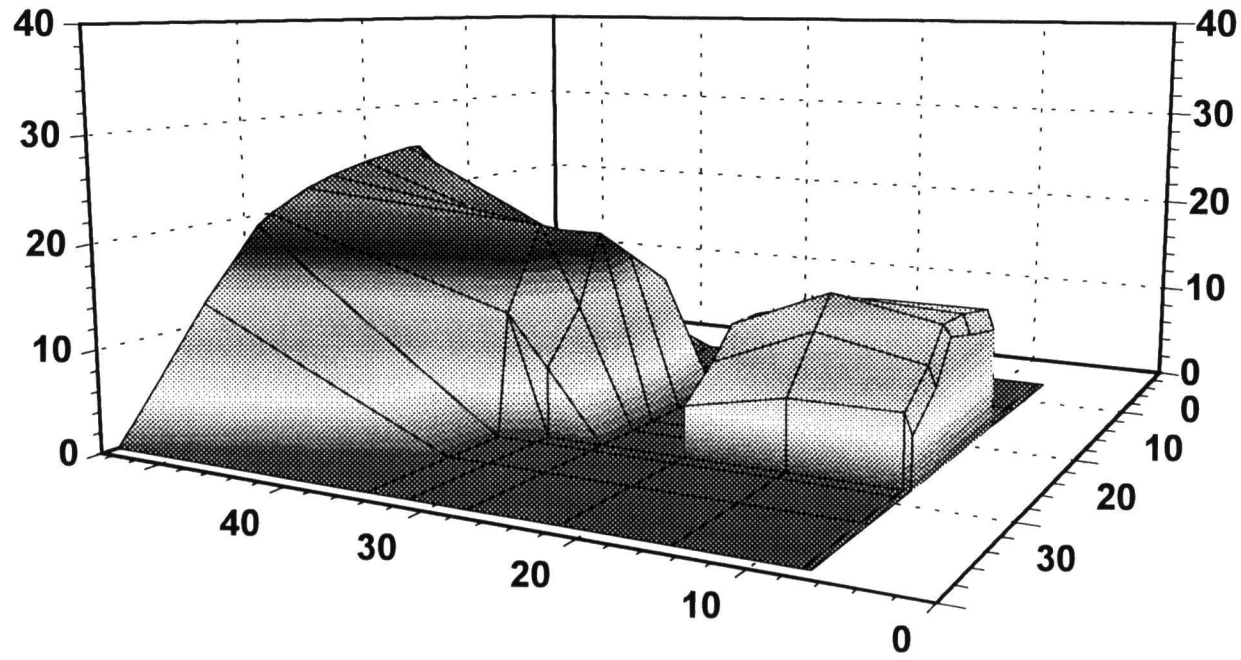


Figure 6.62b: Three-dimensional image of the western part of the present-day Durdle Promontory from the north-west after 100,000 model cycles.

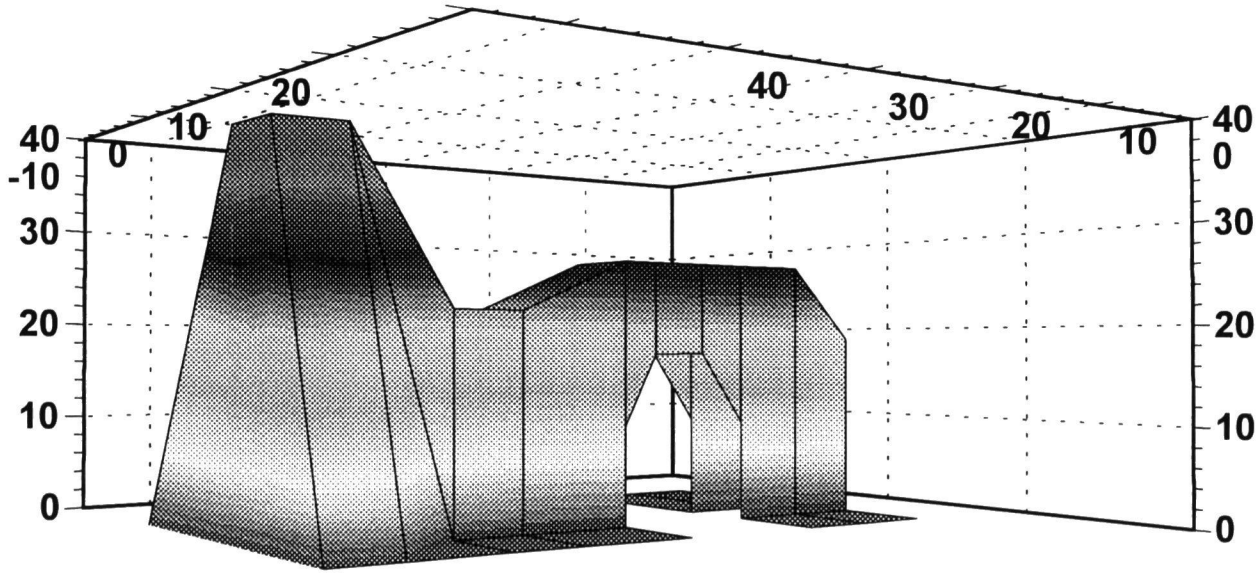


Figure 6.63a: Three-dimensional image of the western part of the present-day Durdle Promontory from the north-east.

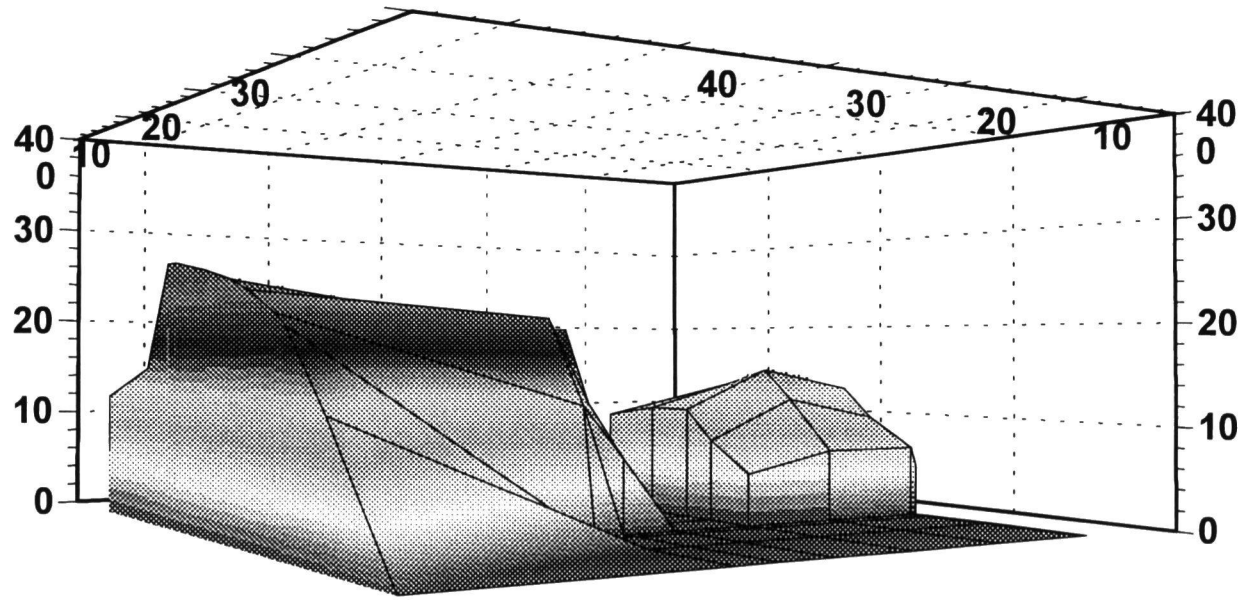


Figure 6.63b: Three-dimensional image of the western part of the present-day Durdle Promontory from the north-east after 100,000 model cycles.

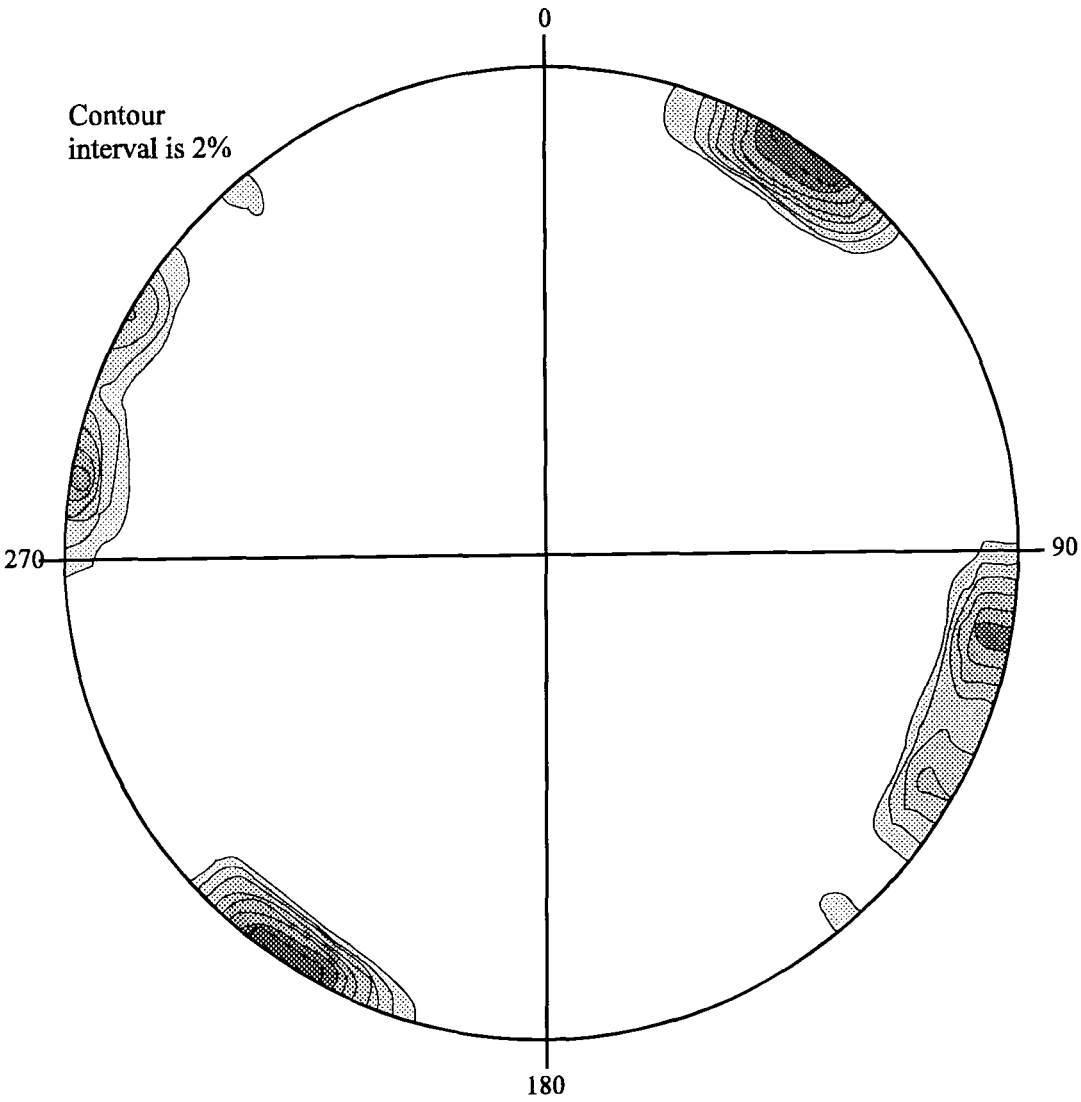


Figure 7.1: Polar projection for the discontinuities in the Kayenta Formation at site DH4E.

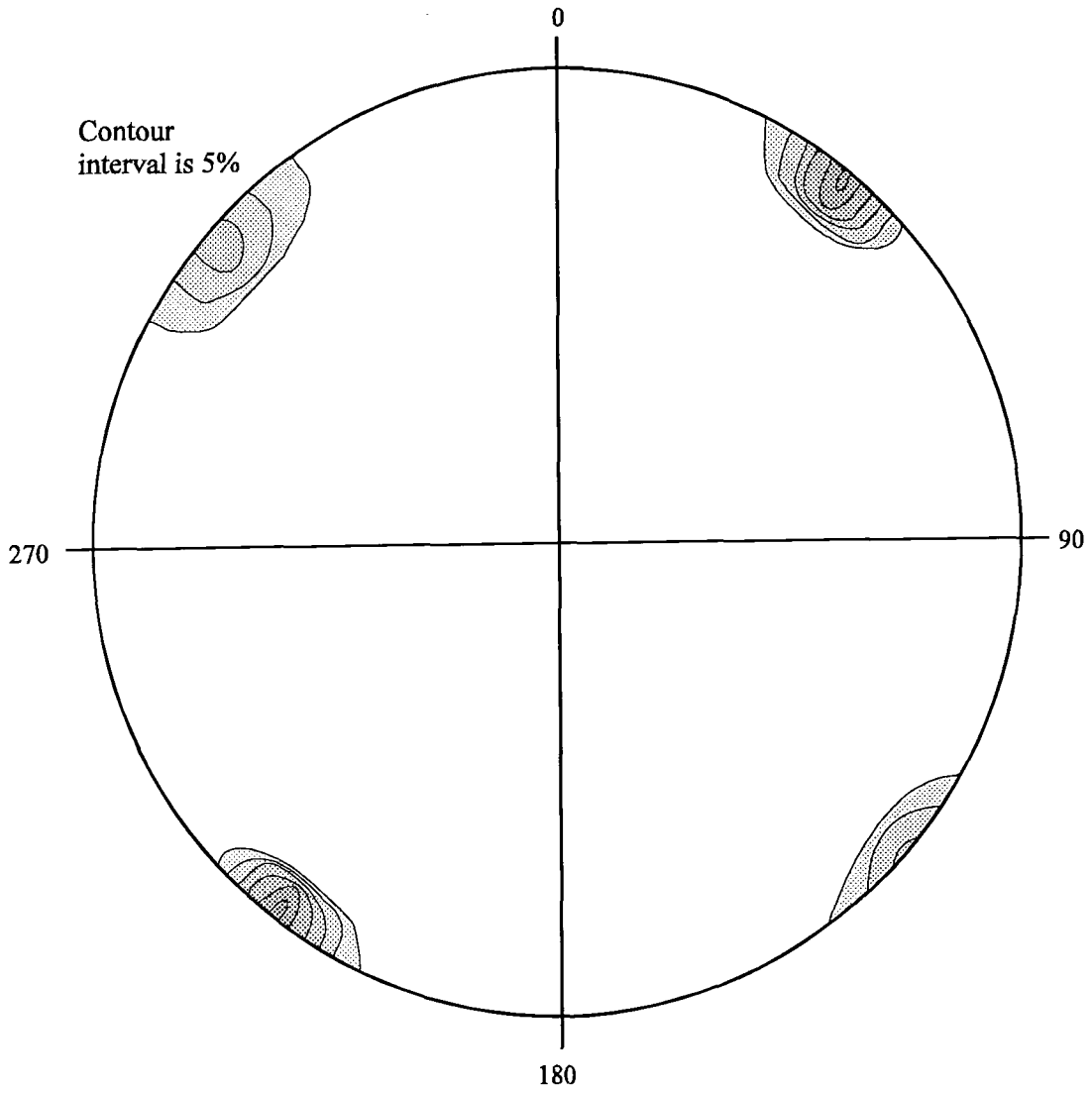


Figure 7.2: Polar projection for the discontinuities in the Kayenta Formation at site DH5H.

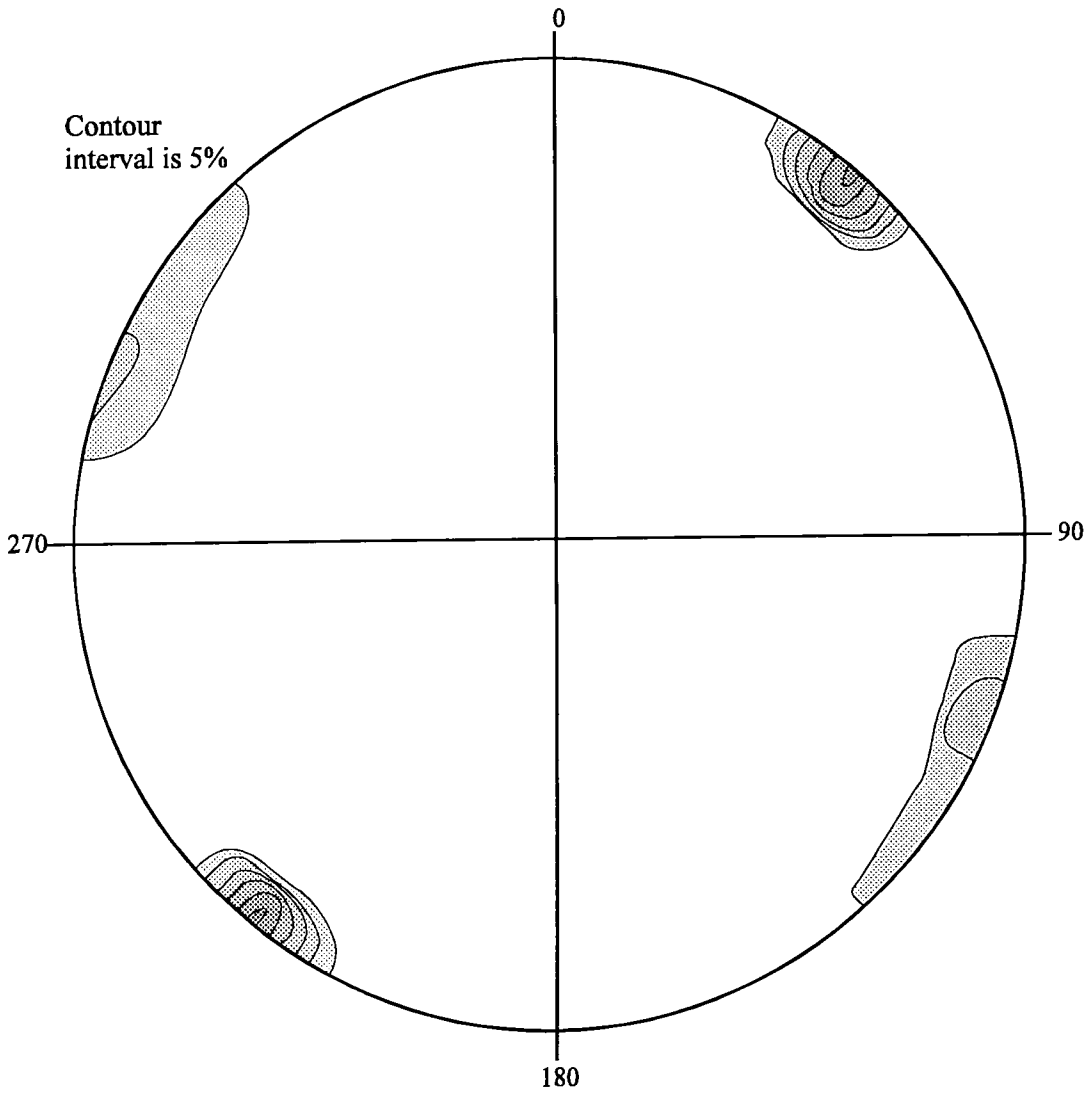


Figure 7.3: Polar projection for the discontinuities in the Kayenta Formation at site DH7E.

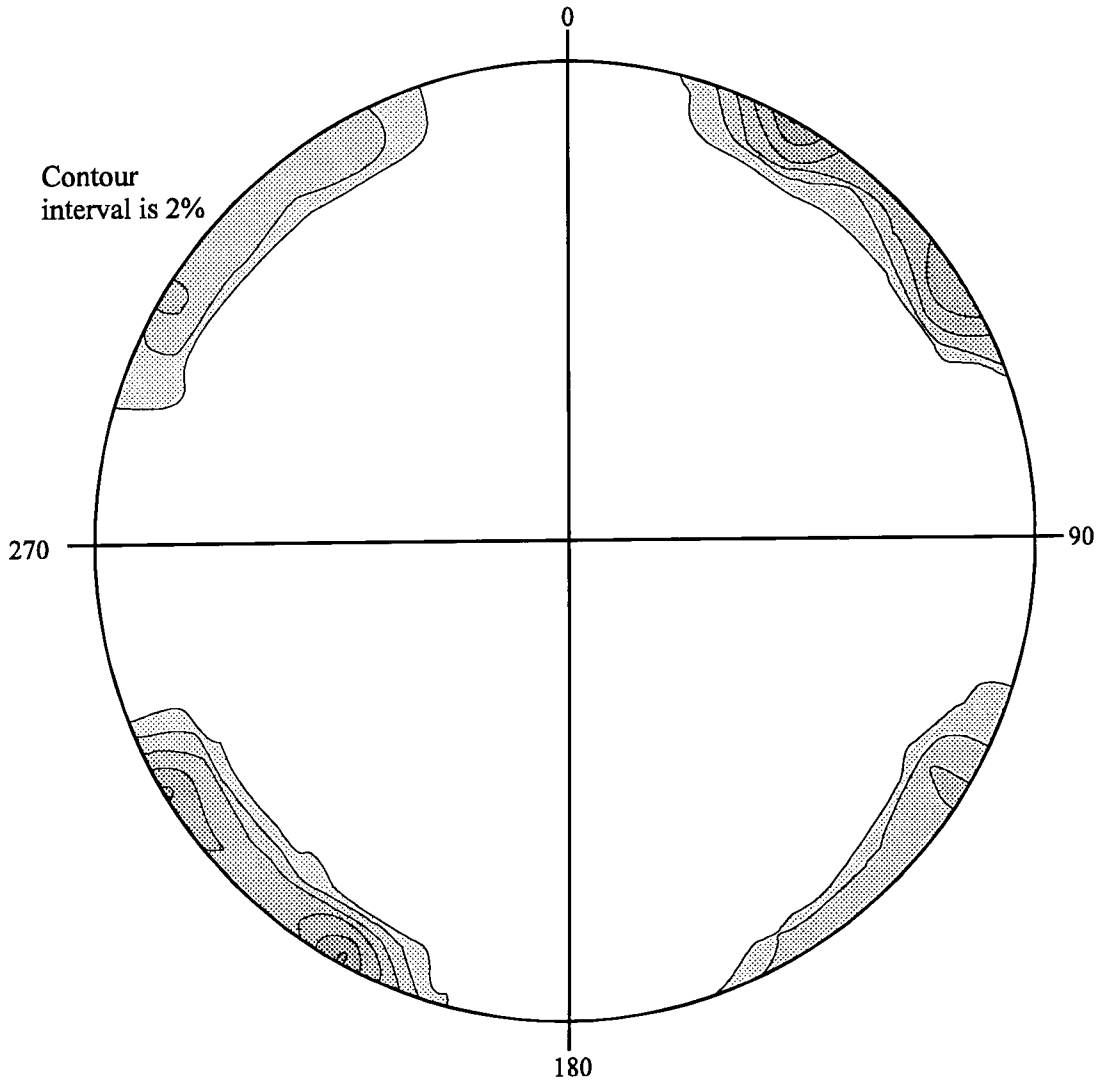


Figure 7.4: Polar projection for the discontinuities in the Kayenta Formation at site DH11H.

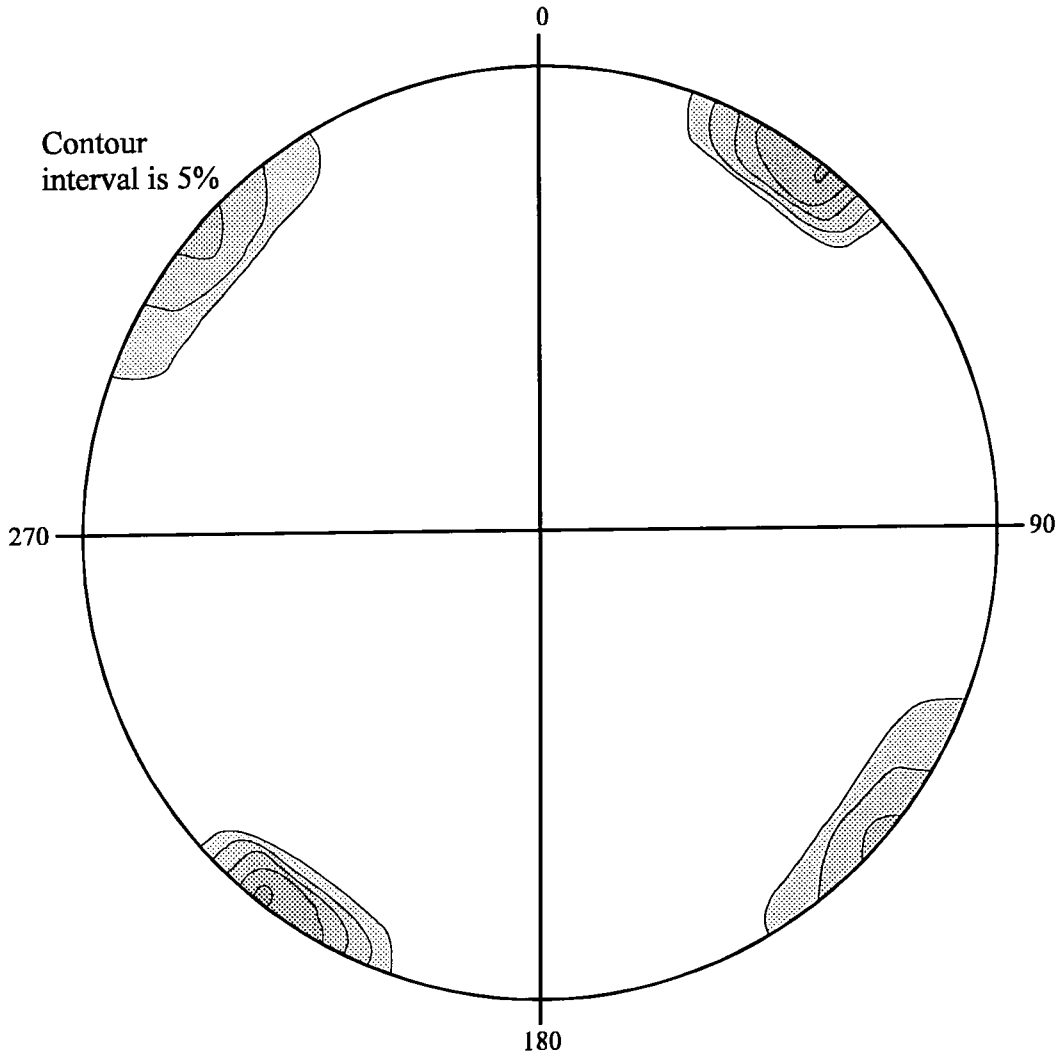


Figure 7.5: Polar projection for the discontinuities in the Kayenta Formation for all of the headland sites at Dead Horse Point.

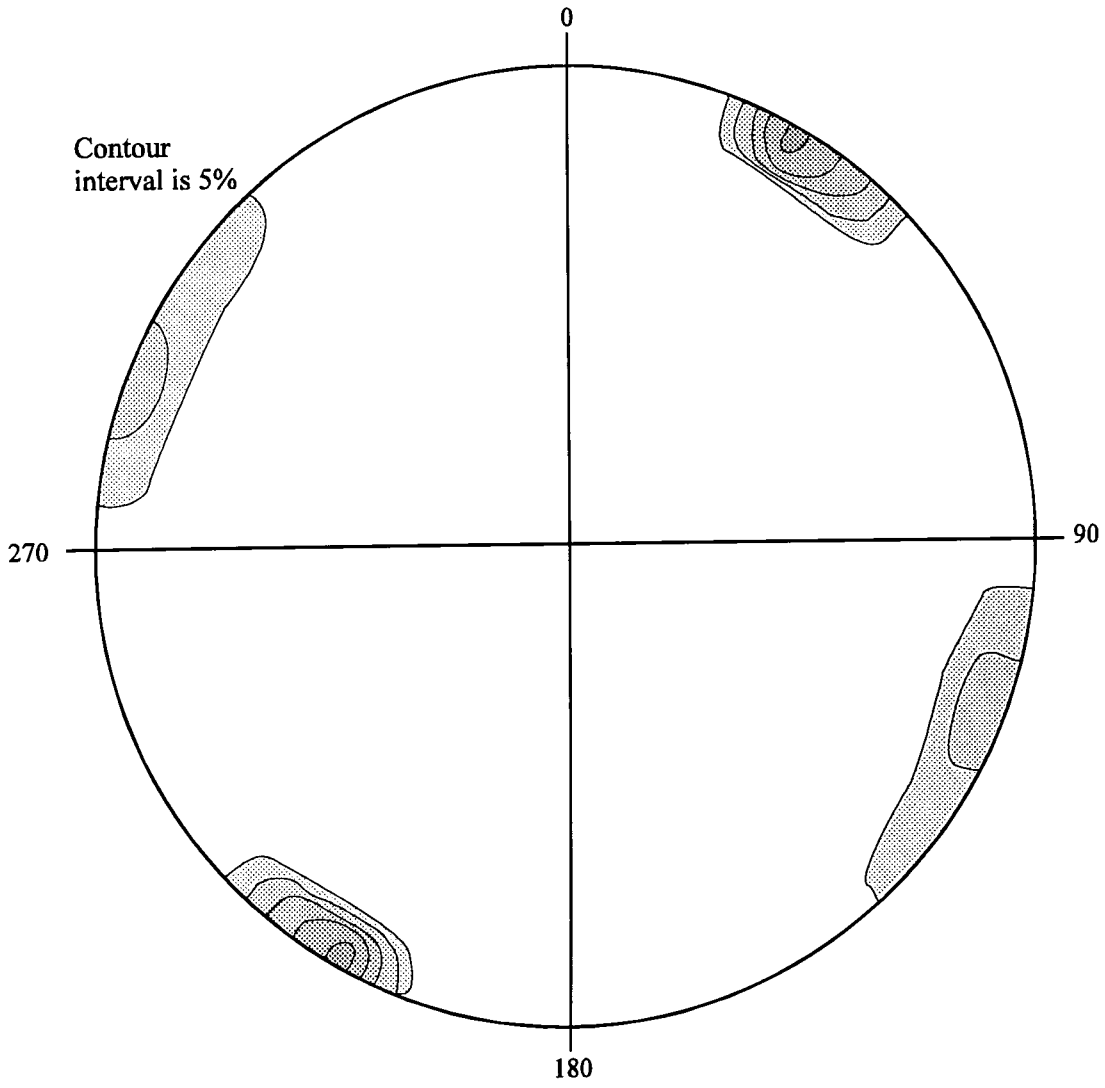


Figure 7.6: Polar projection for the discontinuities in the Kayenta Formation for all of the embayment sites at Dead Horse Point.

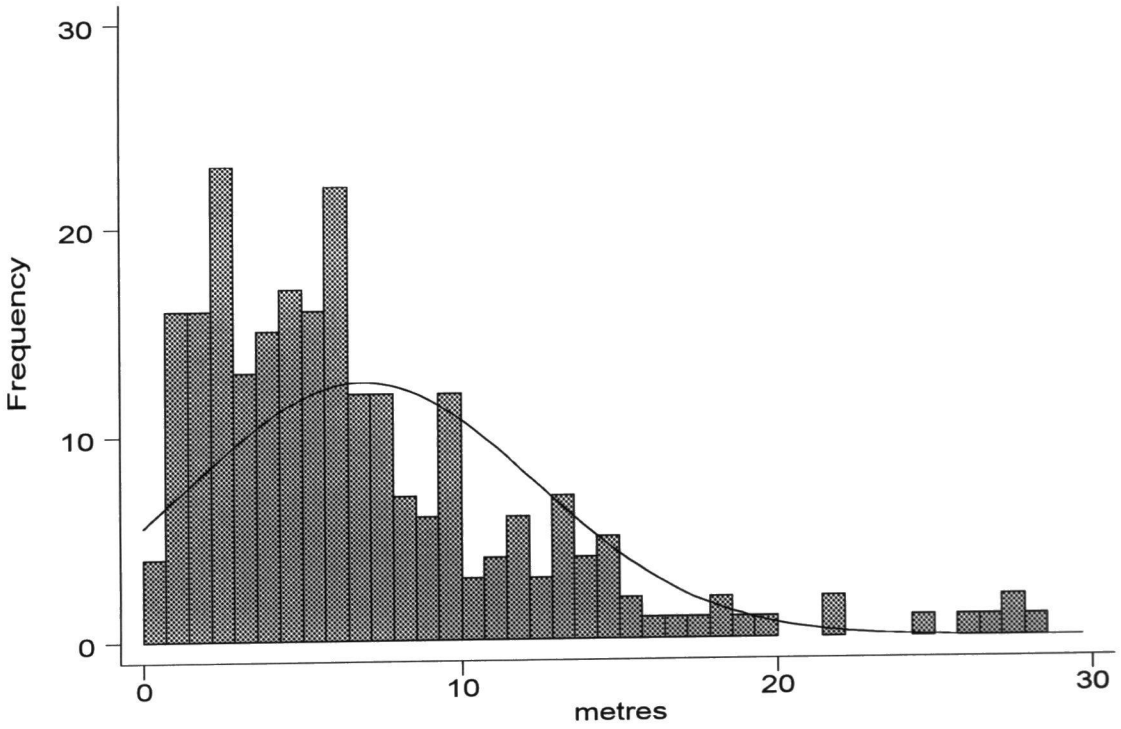


Figure 7.7: Frequency distribution of the total joint spacing readings from Dead Horse Point.

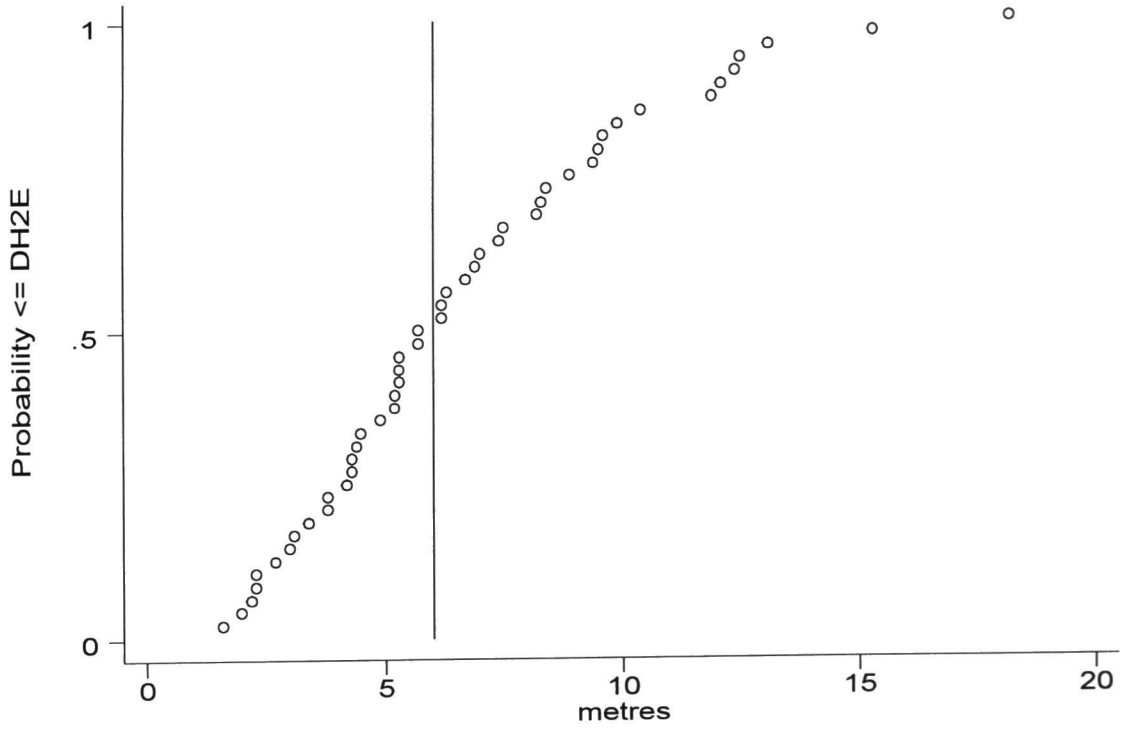


Figure 7.8: The distribution of joint spacing readings from site DH2E against the average for Dead Horse Point.

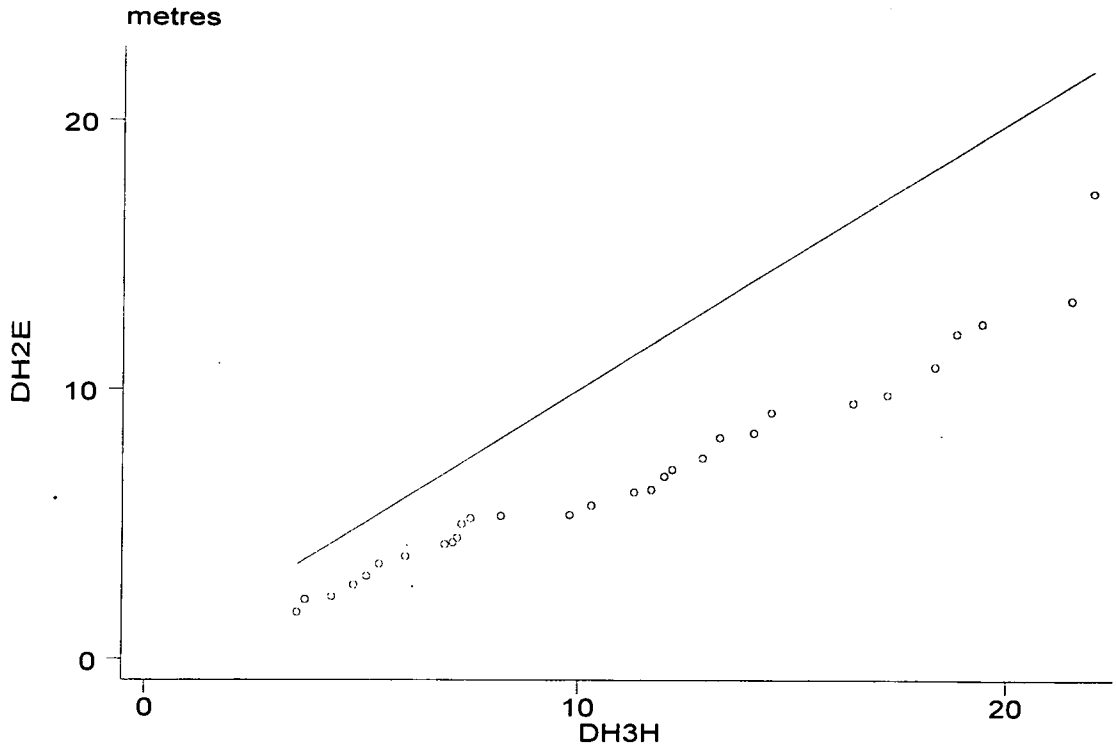


Figure 7.9: A quantile-quantile plot for total joint spacing readings from DH2E and DH3H.

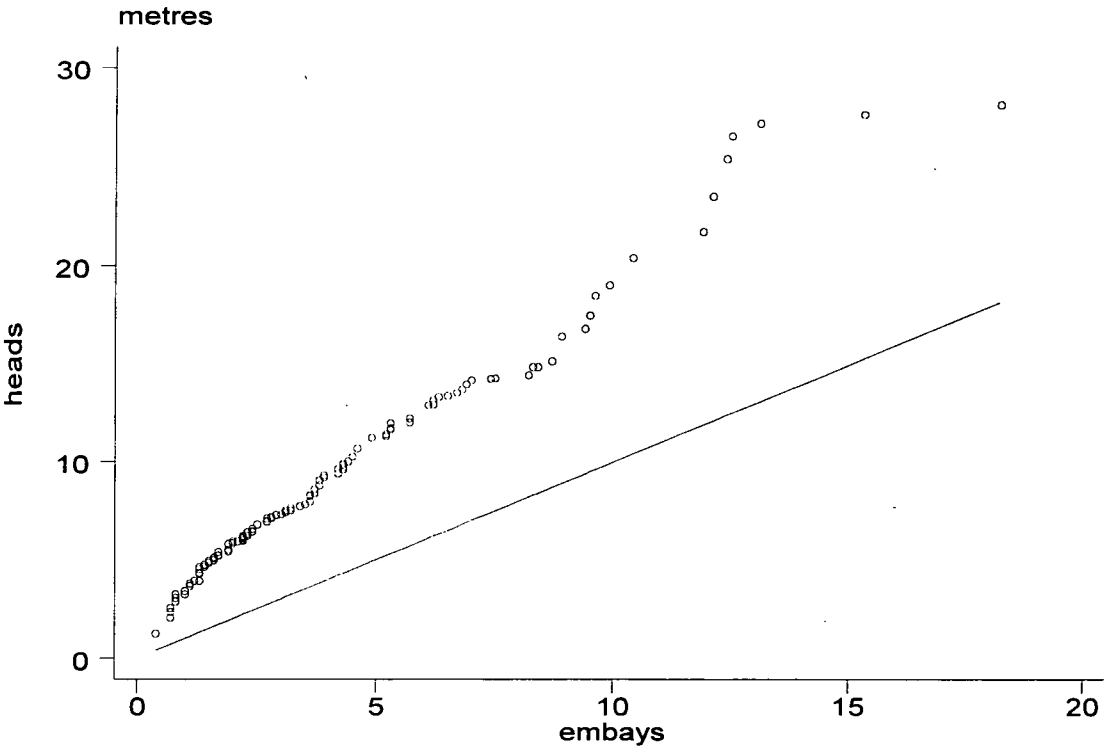


Figure 7.10: A quantile-quantile plot for total joint spacing readings from all headland sites and all embayment sites at Dead Horse Point.

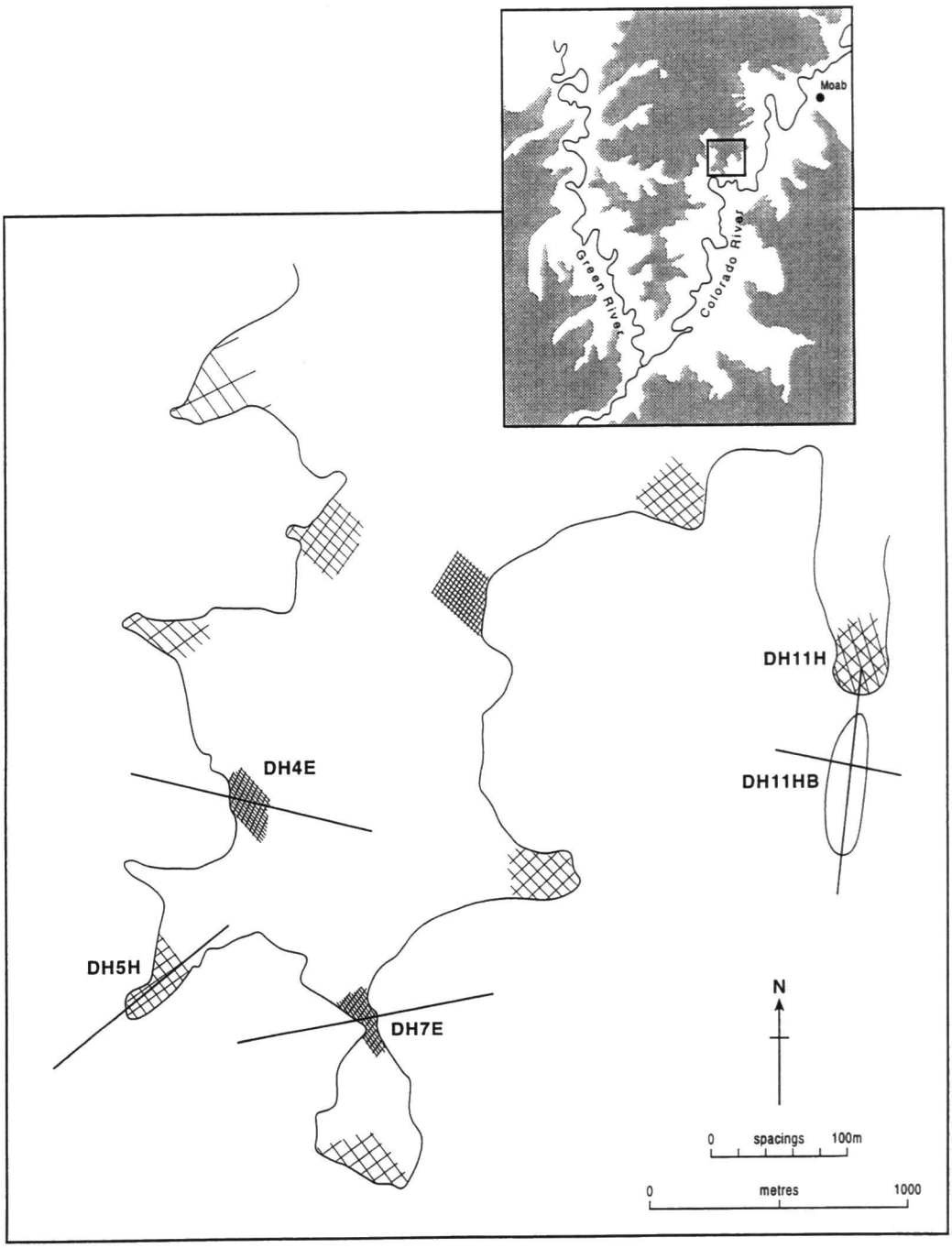


Figure 7.11: Plan of the cliffs at Dead Horse Point State Park showing the surface joint geometry for the field sites.

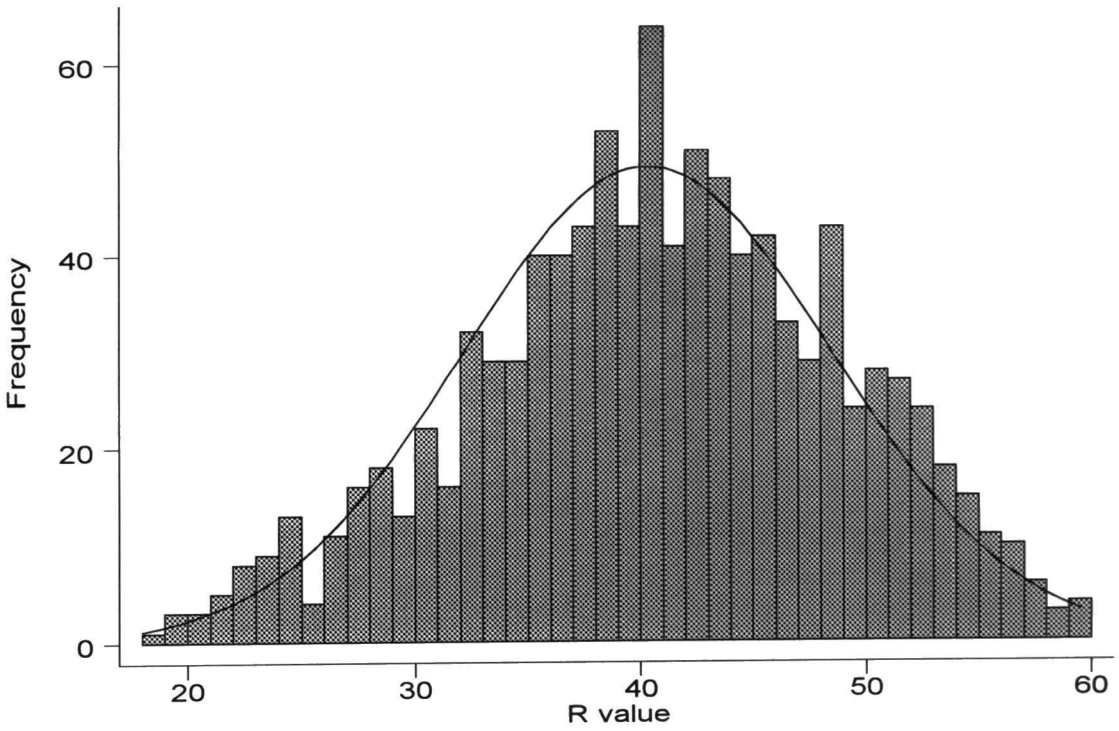


Figure 7.12: Frequency distribution of total Schmidt hammer readings from Dead Horse Point.

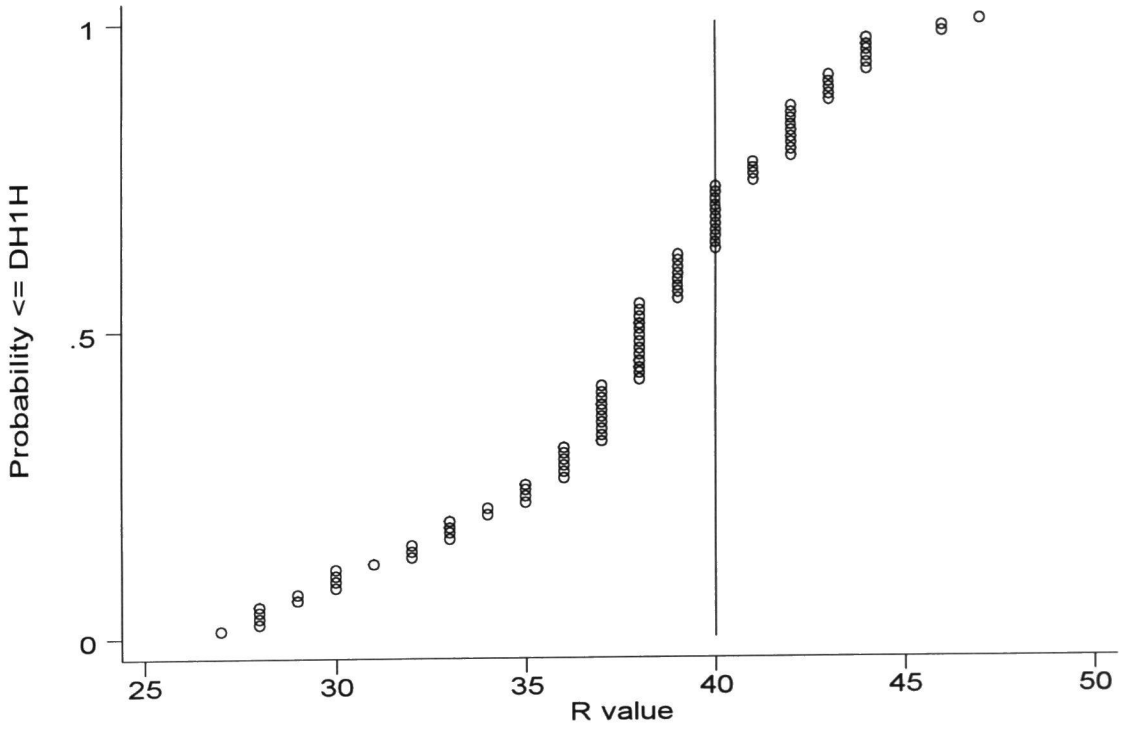


Figure 7.13: The distribution of Schmidt hammer readings from site DH1H against the average for Dead Horse Point.

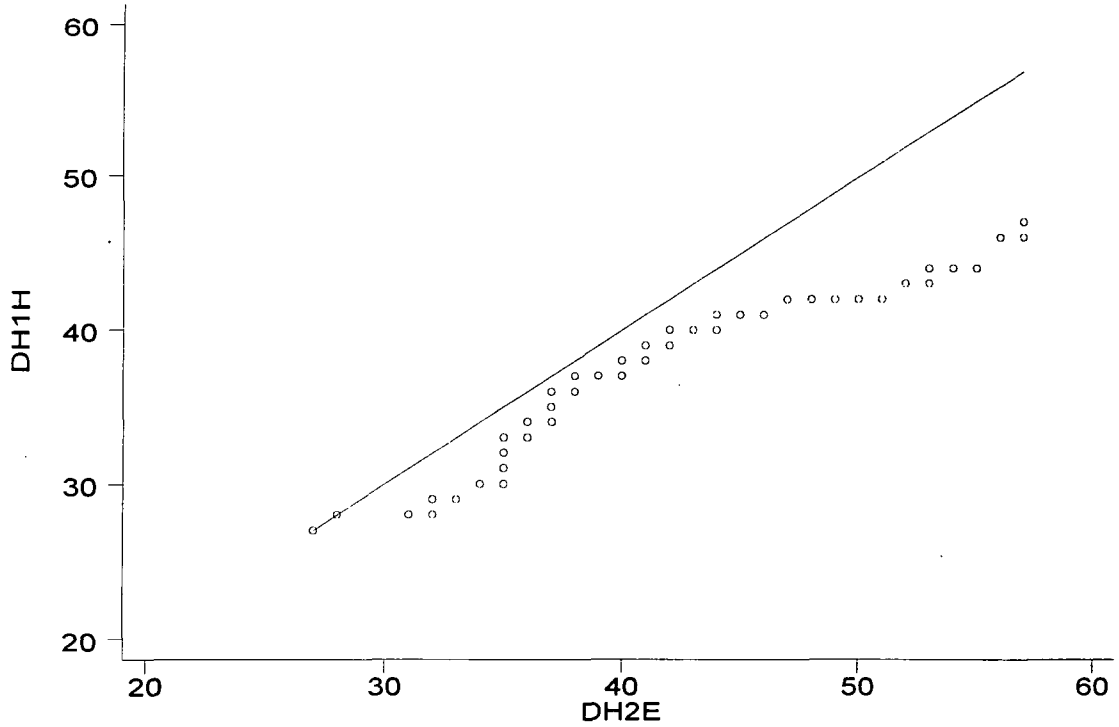


Figure 7.14: A quantile-quantile plot for Schmidt hammer readings from DH1H and DH2E.

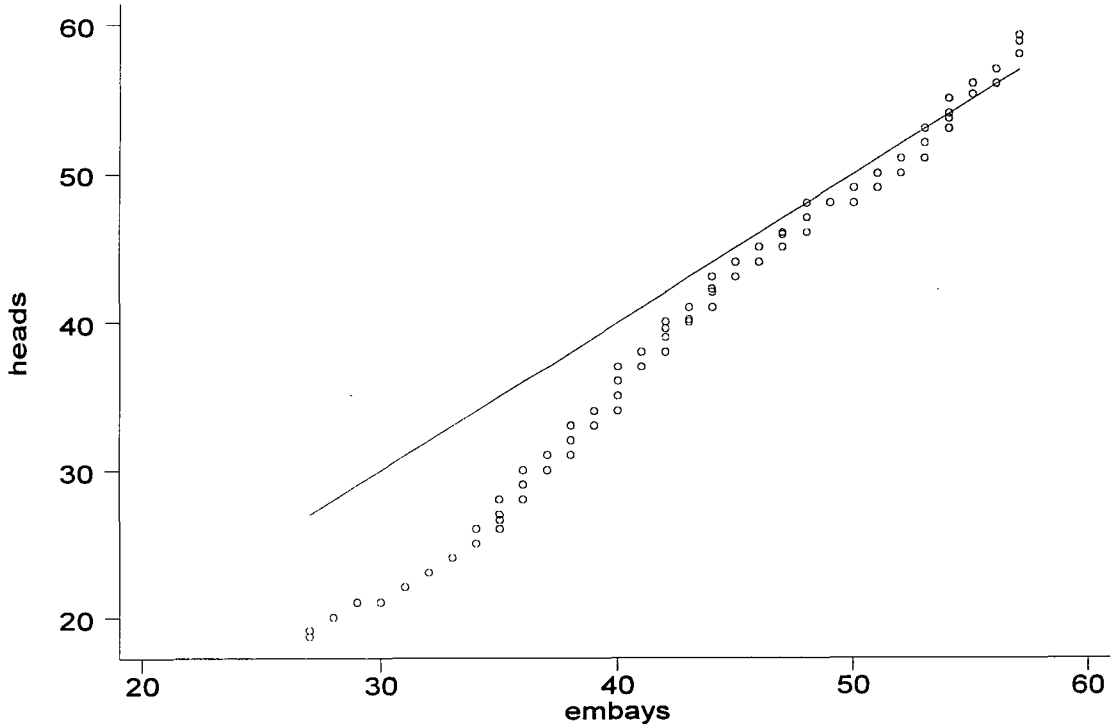


Figure 7.15: A quantile-quantile plot for total Schmidt hammer readings from all headland sites and all embayment sites at Dead Horse Point.

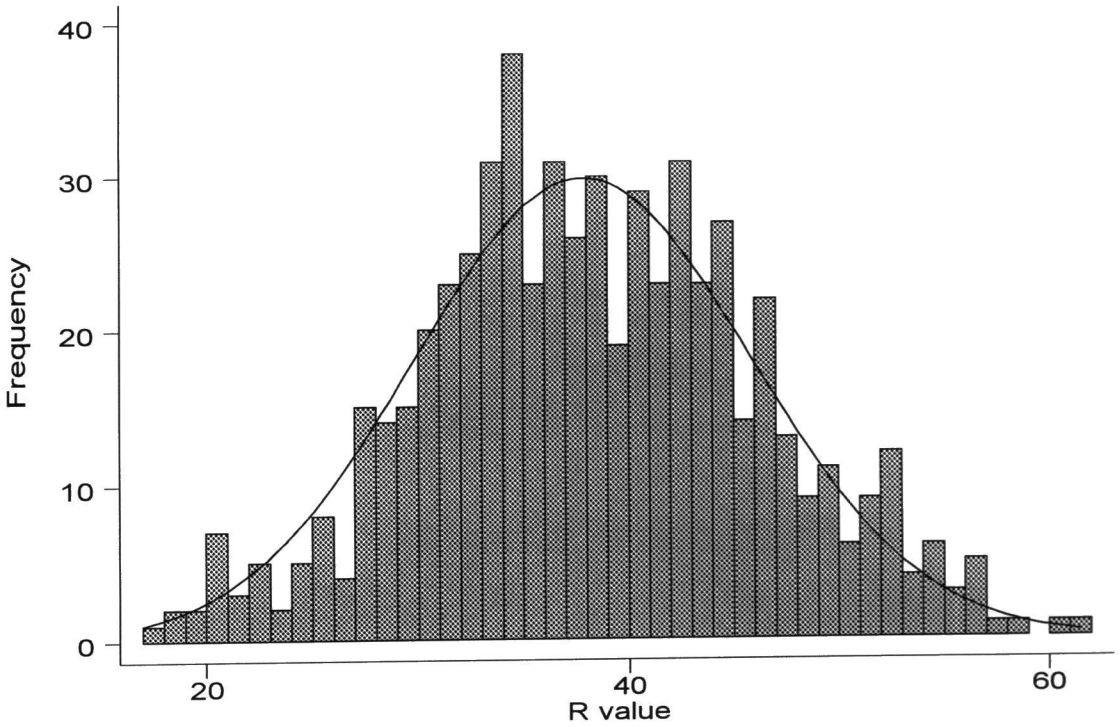


Figure 7.16: Frequency distribution of total Schmidt hammer readings from Canyonlands National Park.

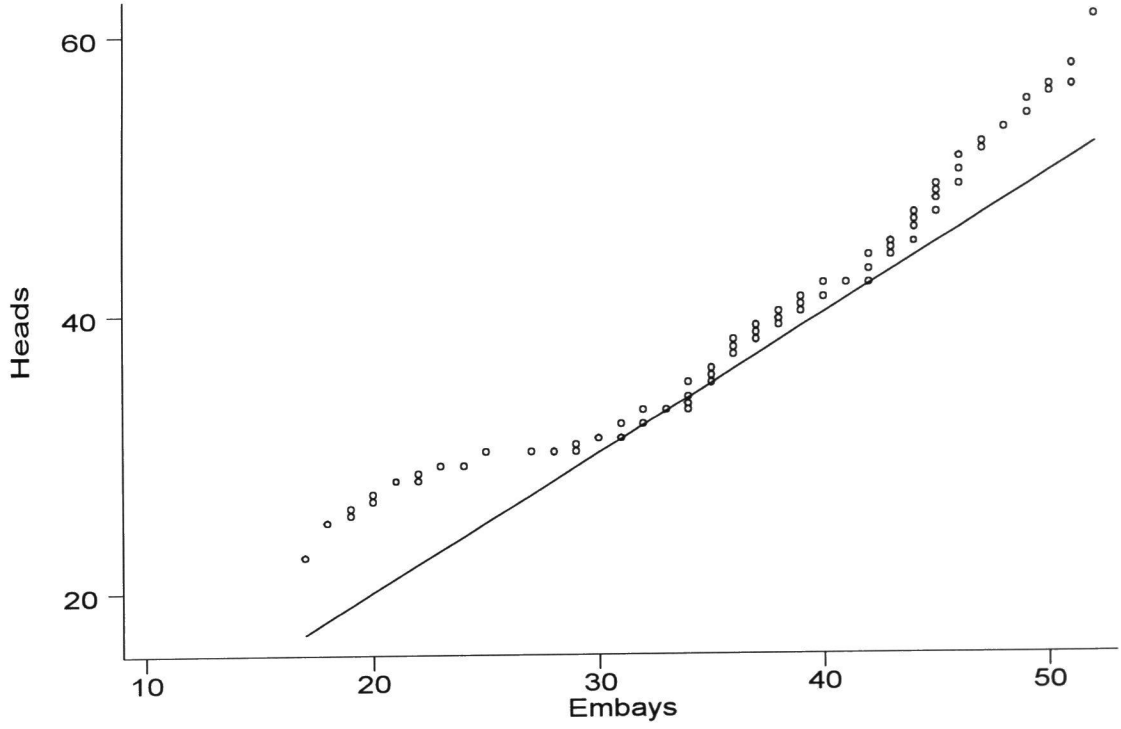


Figure 7.17: A quantile-quantile plot for total Schmidt hammer readings from all headland sites and all embayment sites at Canyonlands National Park.

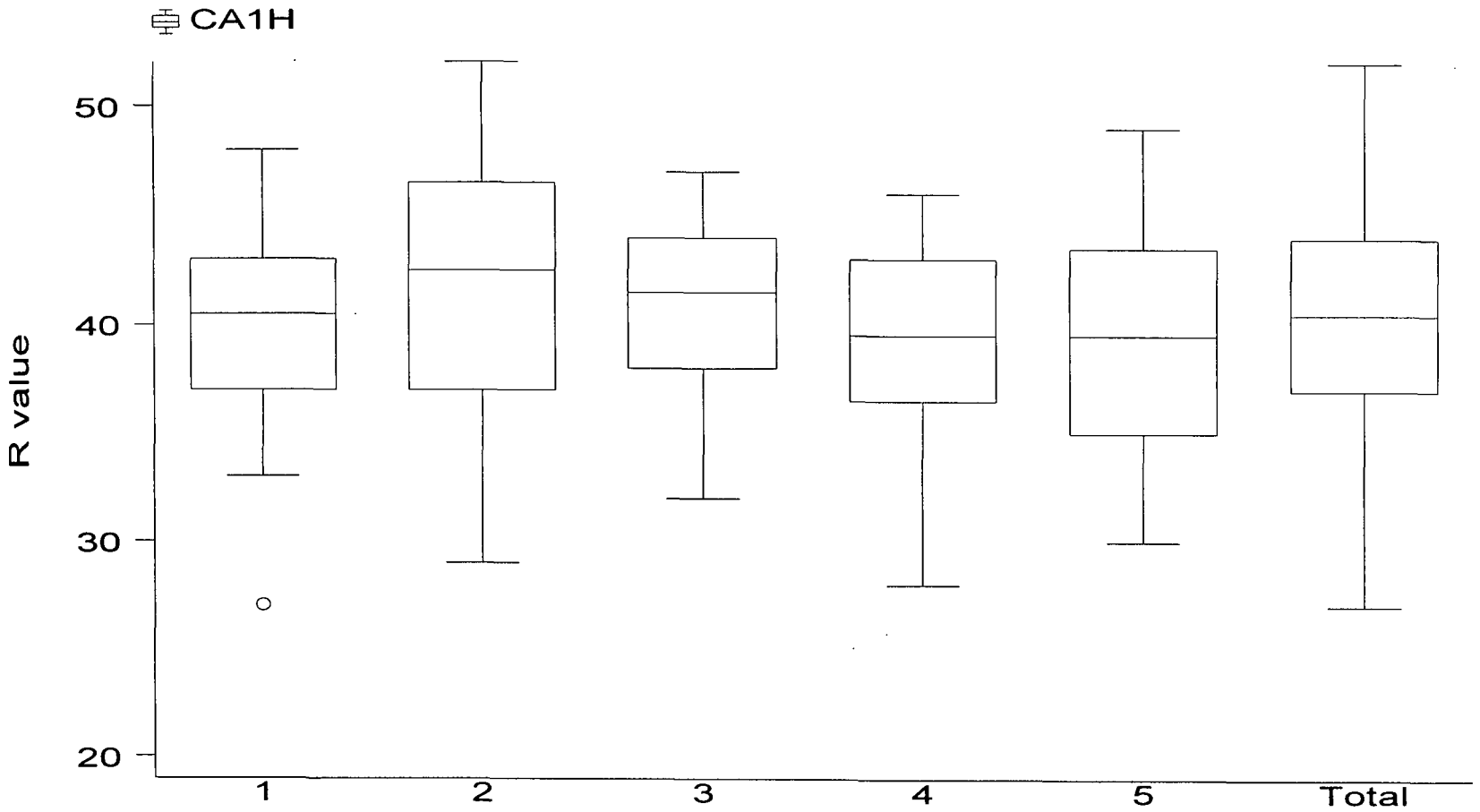


Figure 7.18: The distribution of Schmidt hammer readings on each of the five rock surfaces at site CA1H.

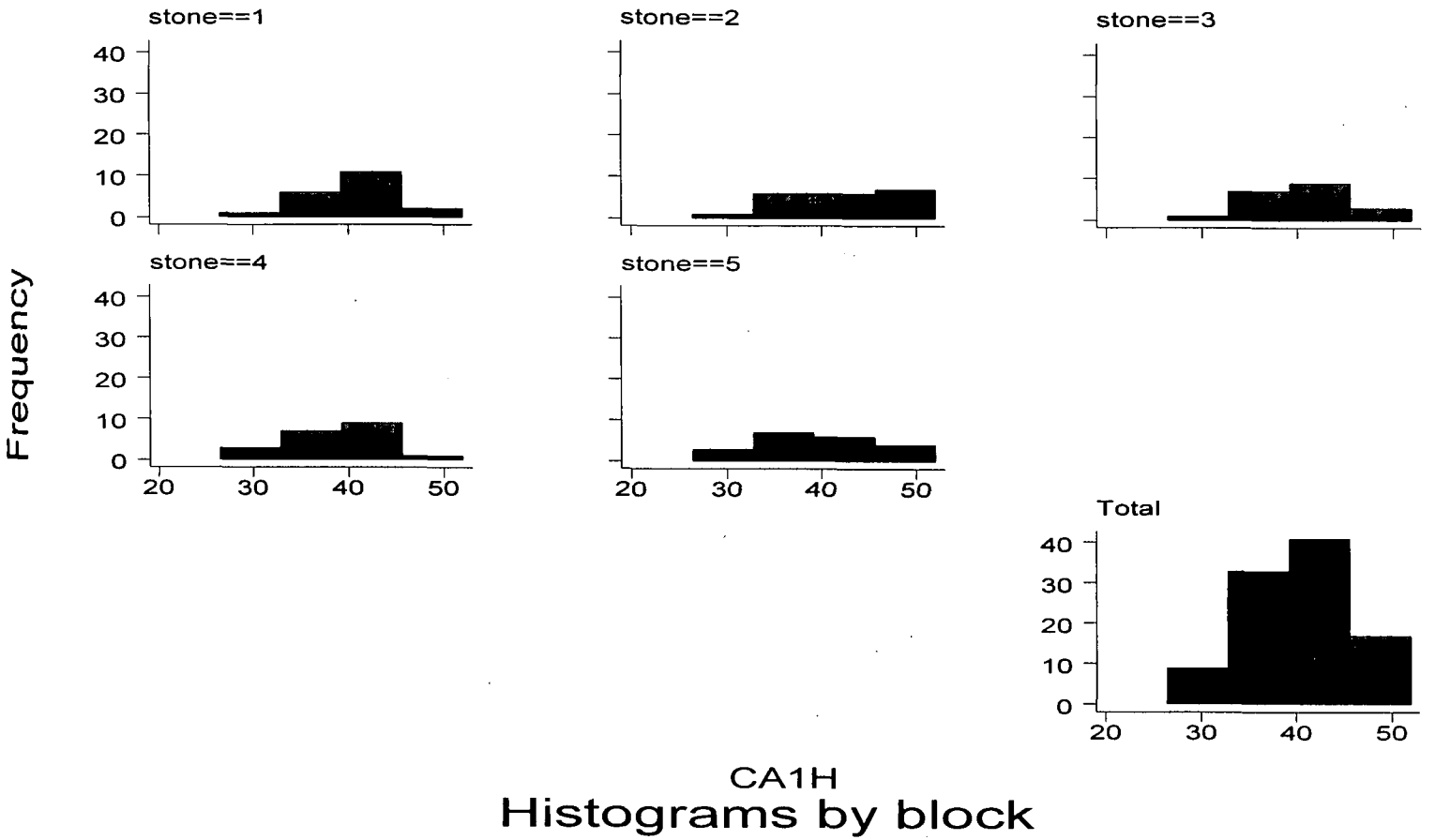


Figure 7.19: Frequency distributions of Schmidt hammer readings for each rock surface at site CA1H.

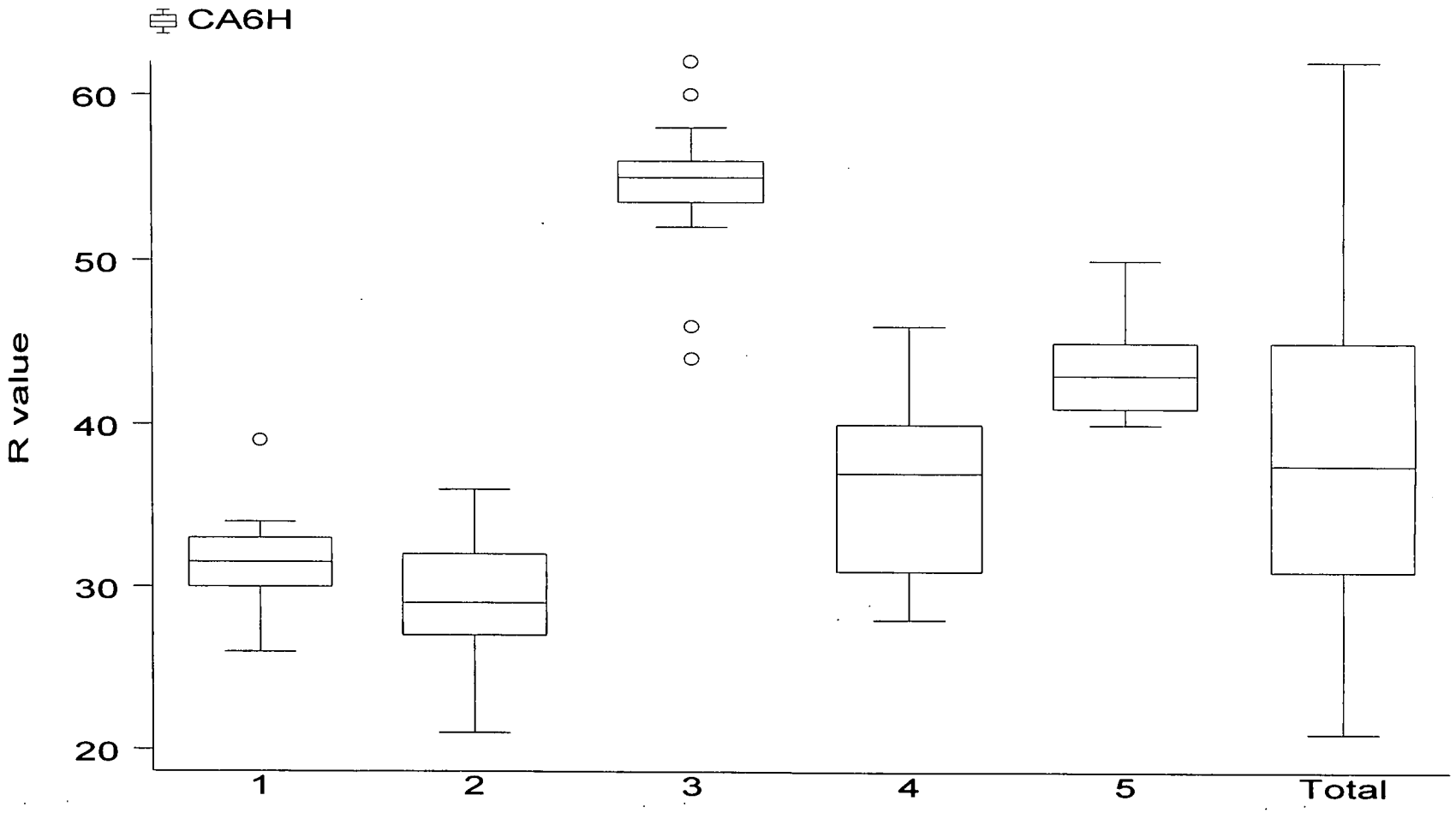


Figure 7.20: The distribution of Schmidt hammer readings on each of the five rock surfaces at site CA6H.

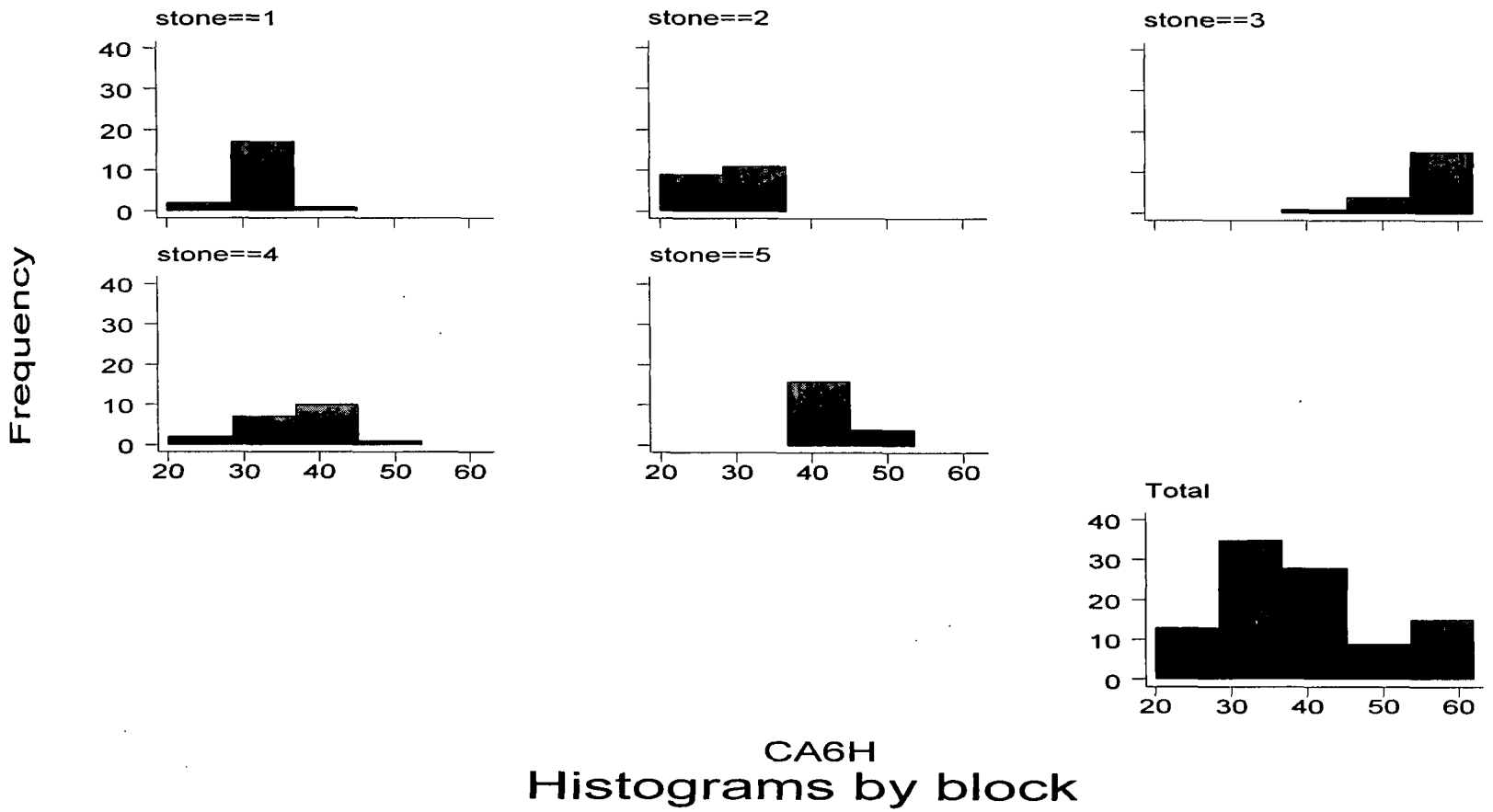


Figure 7.21: Frequency distributions of Schmidt hammer readings for each rock surface at site CA6H.

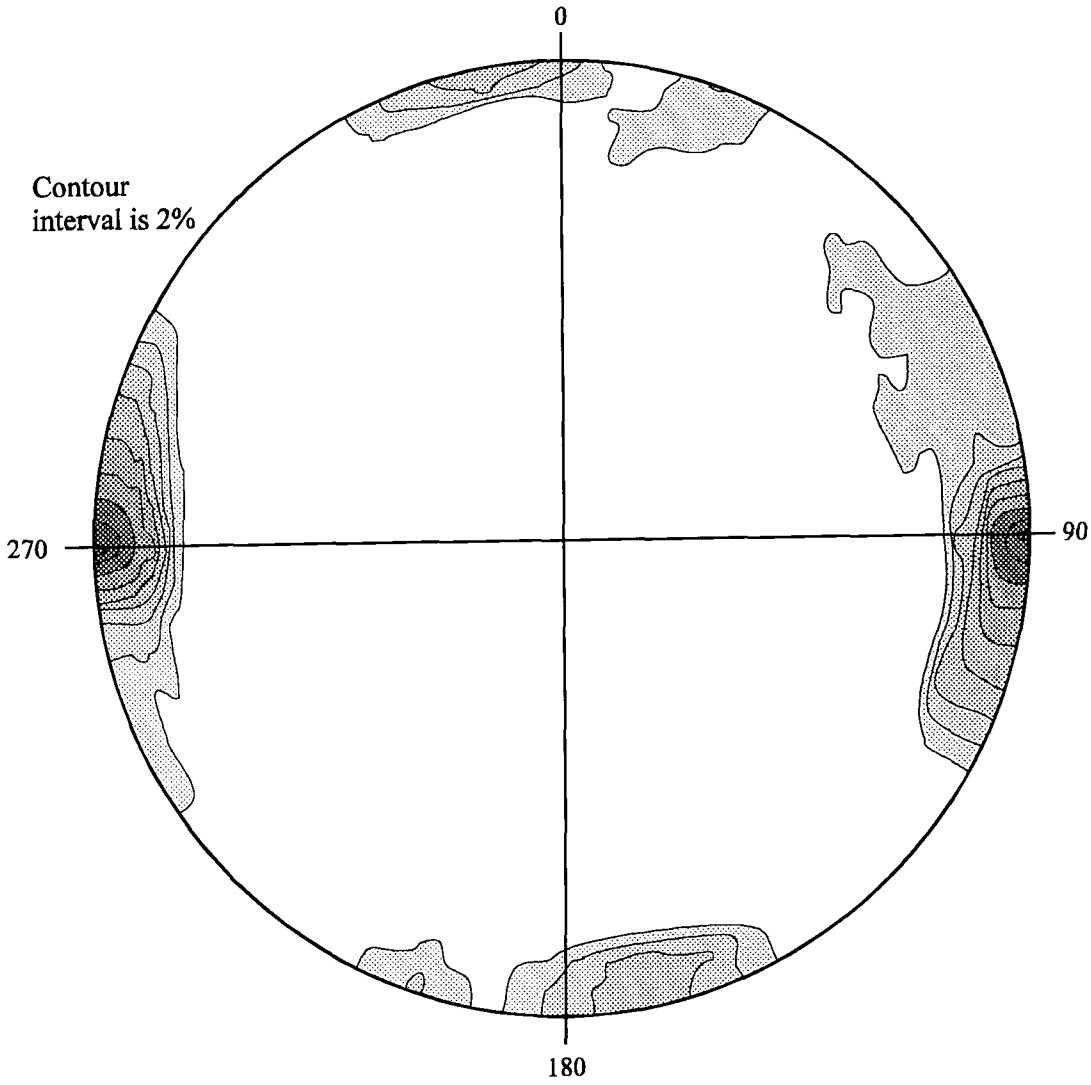


Figure 7.22: Polar projection for the discontinuities in the Kayenta Formation at site CO19E.

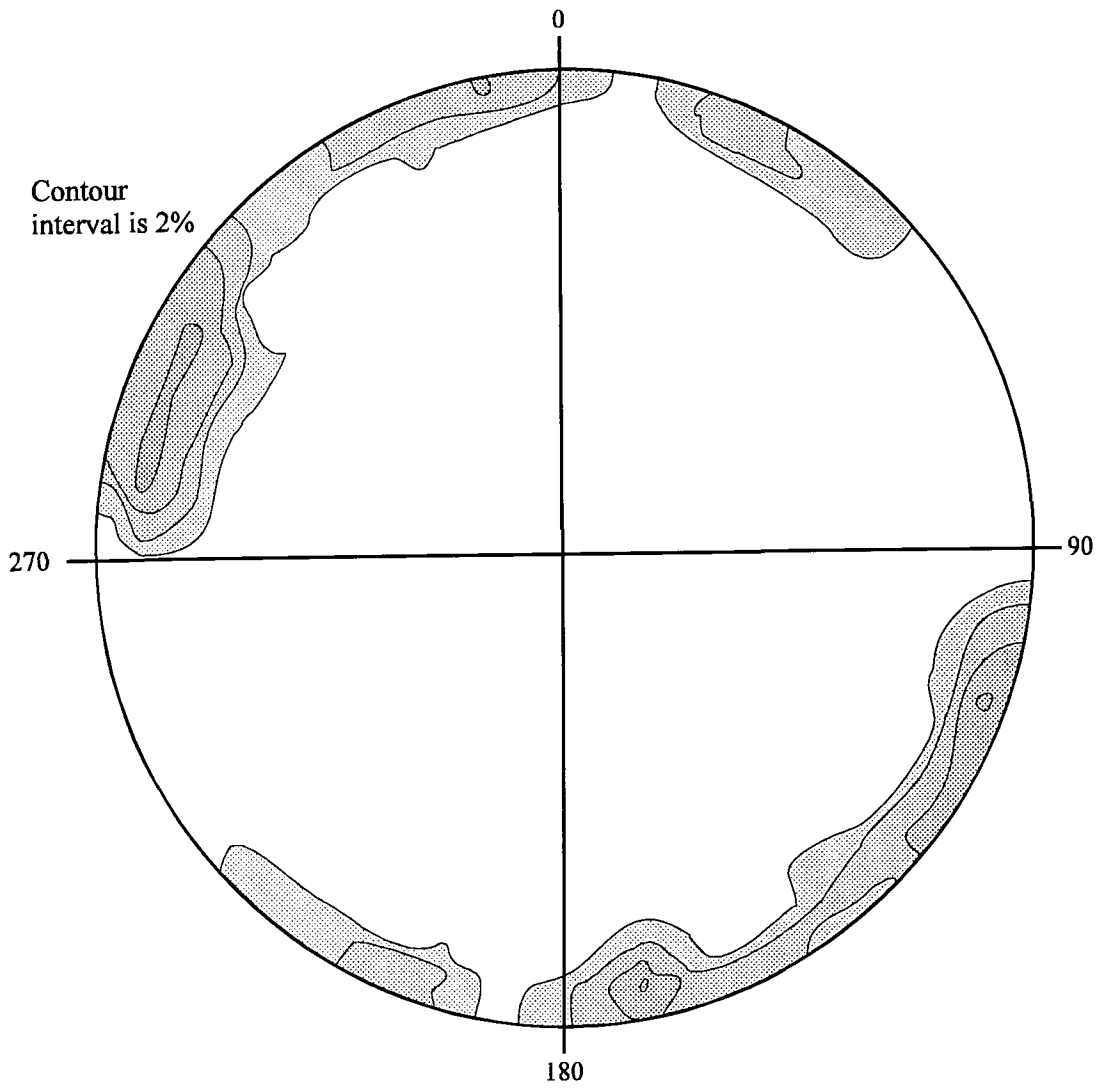


Figure 7.23: Polar projection for the discontinuities in the Kayenta Formation at site CO9E.

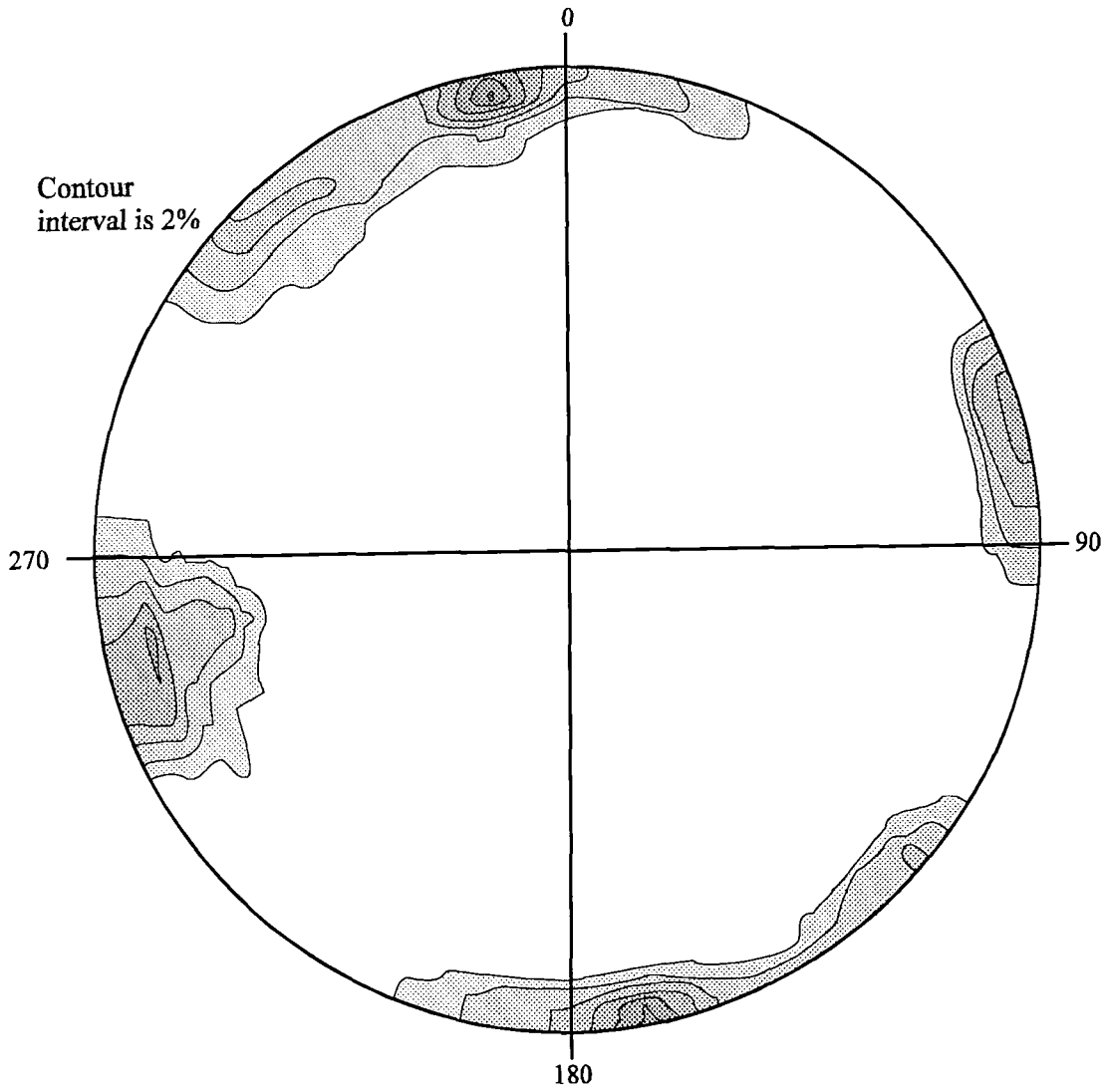


Figure 7.24: Polar projection for the discontinuities in the Kayenta Formation at site CO56H.

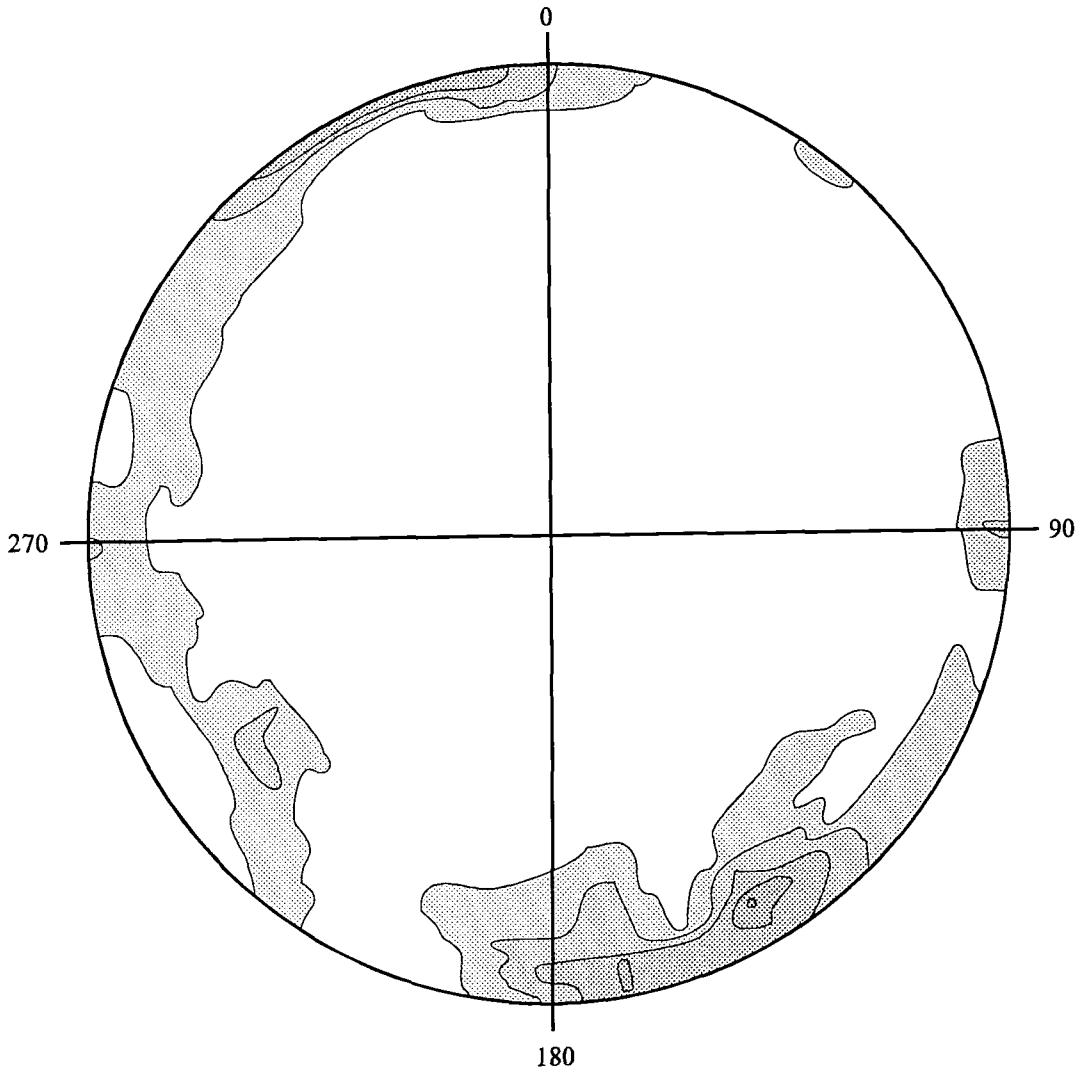


Figure 7.25: Polar projection for the discontinuities in the Kayenta Formation at site CO12E.

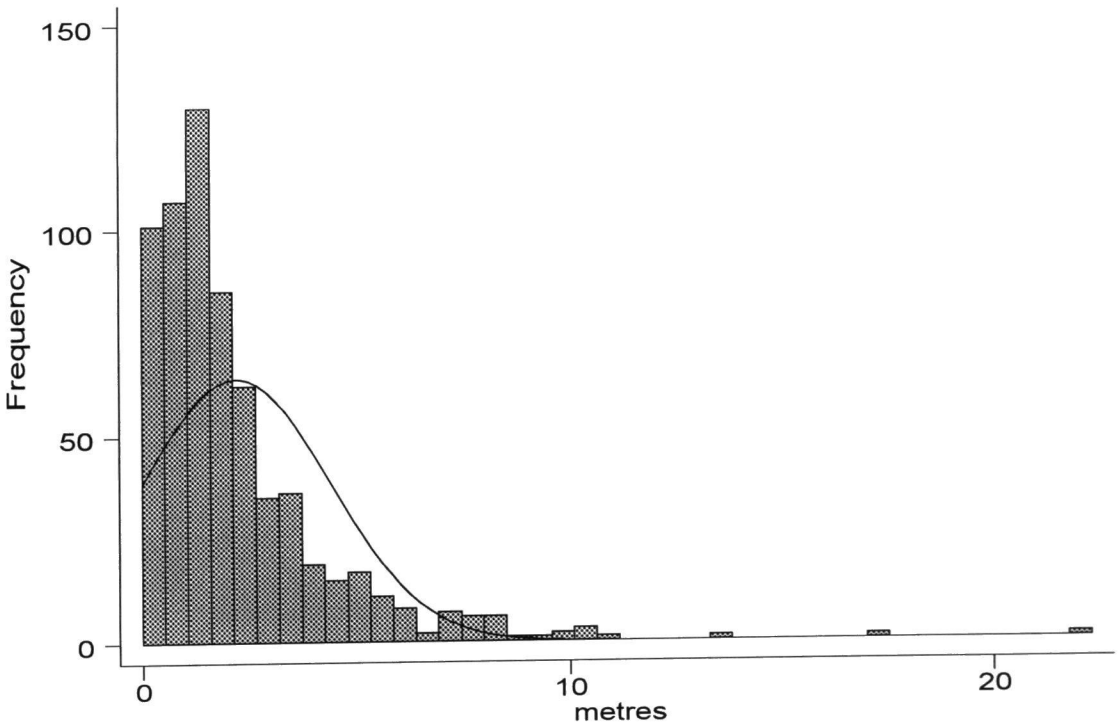


Figure 7.26: Frequency distribution of the total joint spacing readings from the Colorado National Monument.

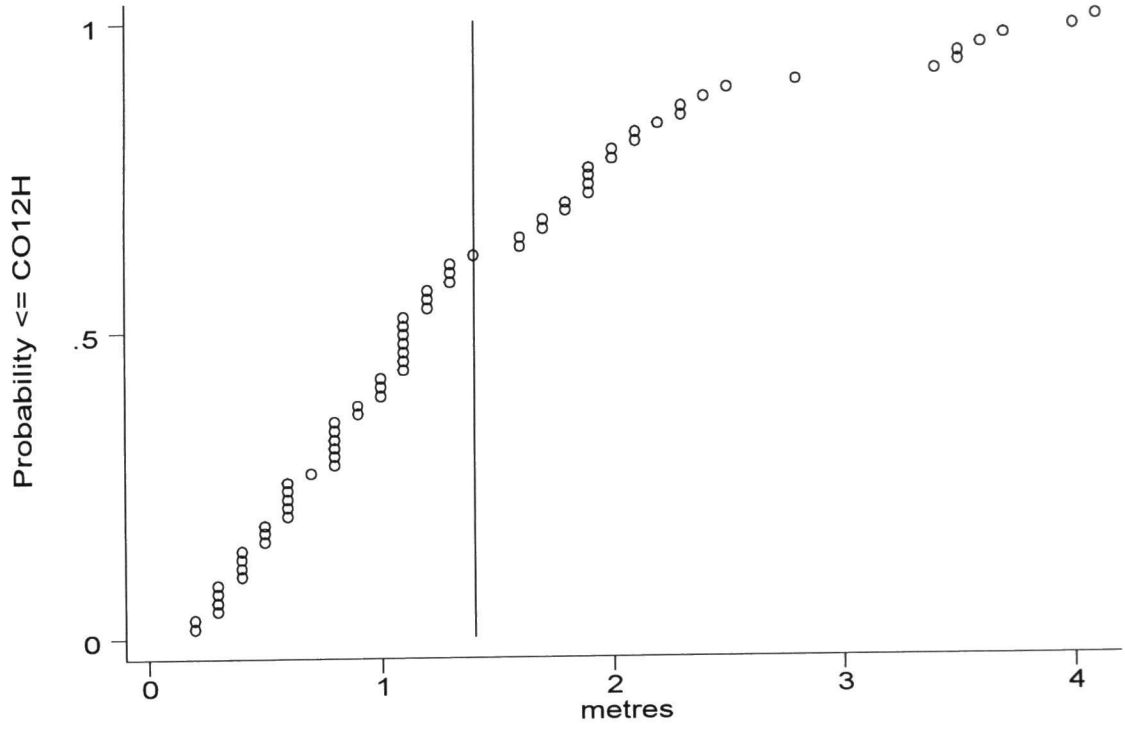


Figure 7.27: The distribution of joint spacing readings from site CO12H against the average for the Colorado National Monument.

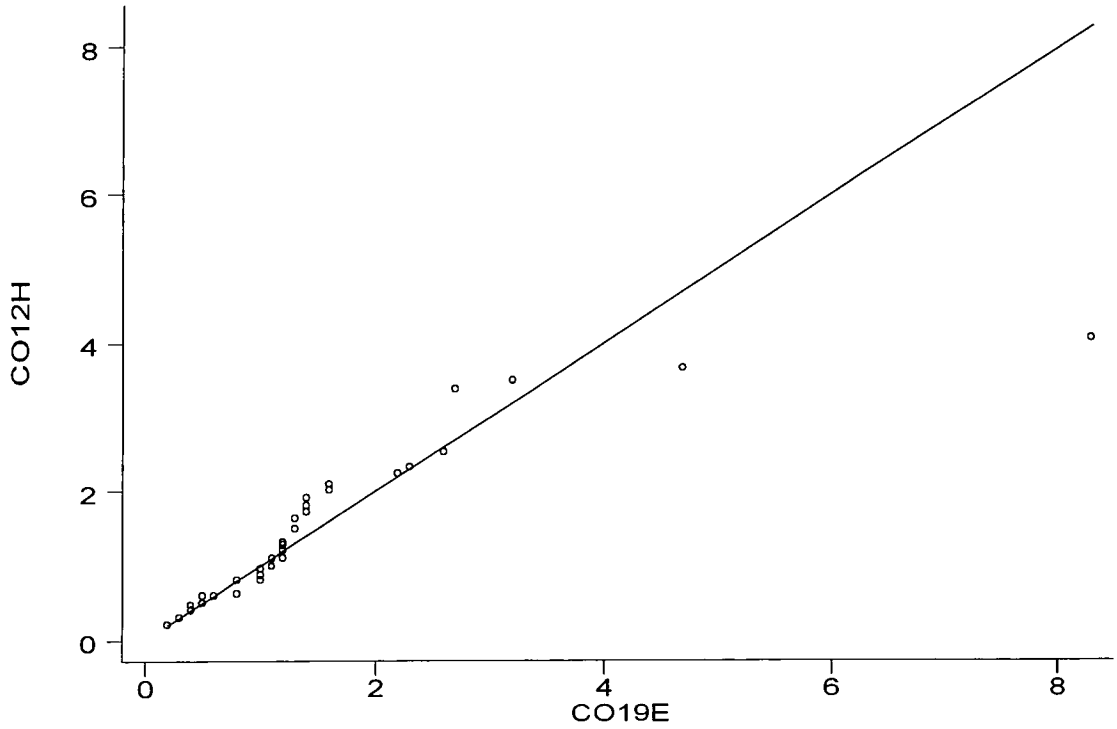


Figure 7.28: A quantile-quantile plot for total joint spacing readings from CO12H and CO19E.

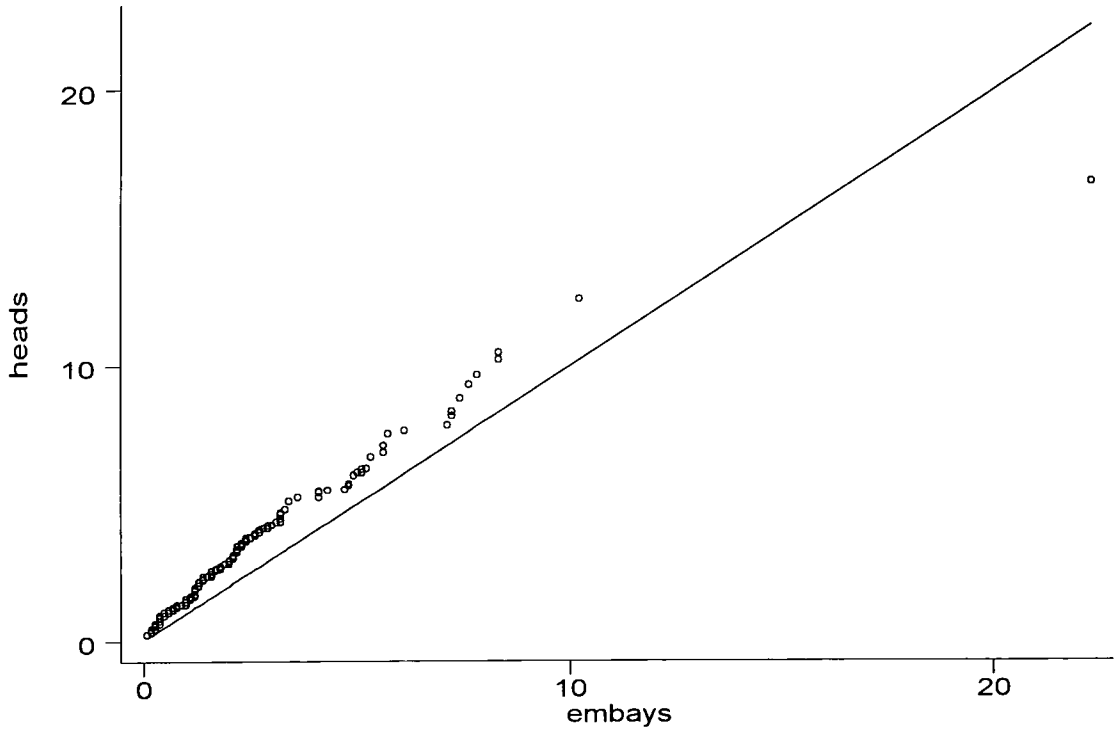


Figure 7.29: A quantile-quantile plot for total joint spacing readings from all headland sites and all embayment sites at the Colorado National Monument.

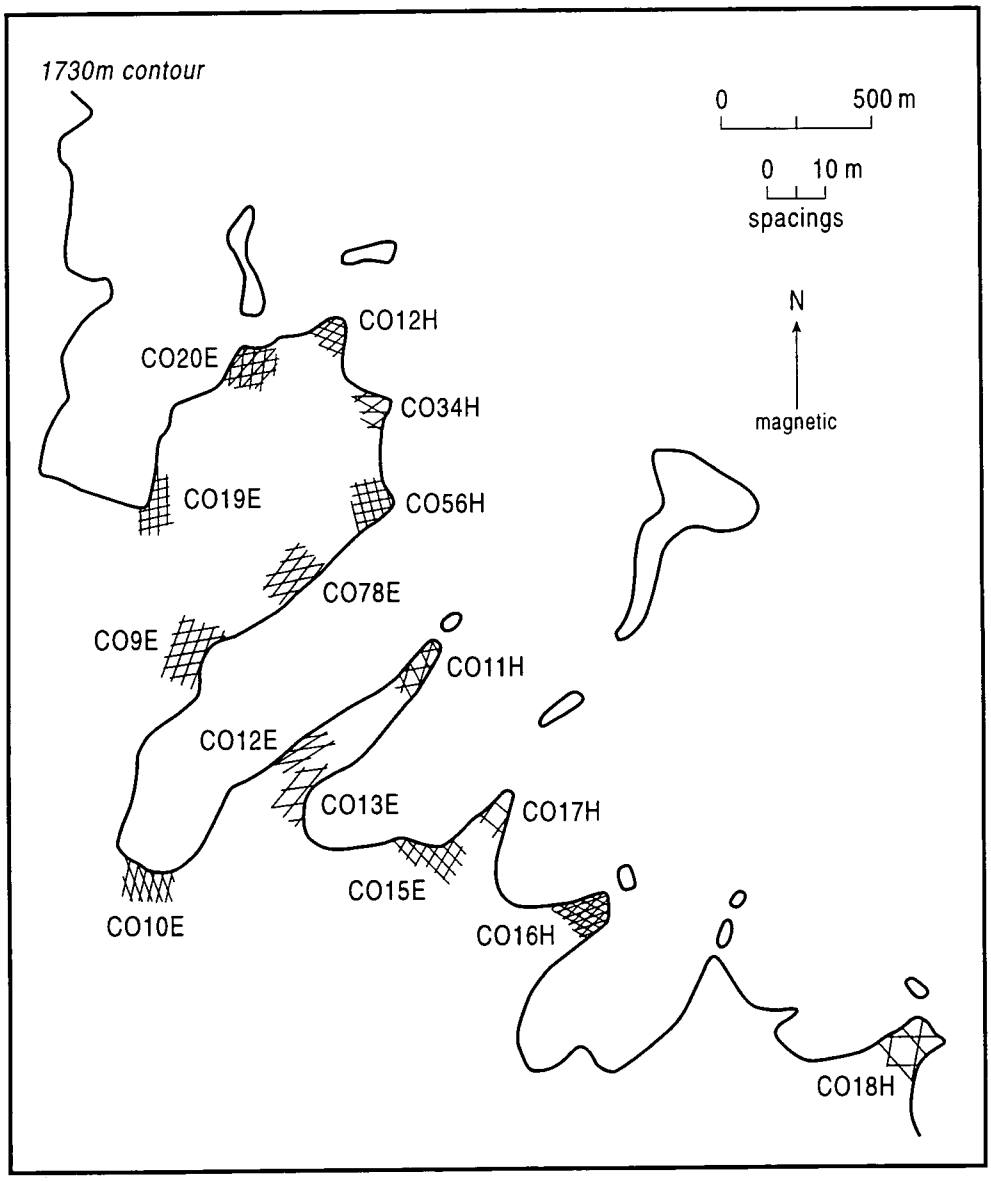


Figure 7.30: Plan of the cliffs at the Colorado National Monument showing the surface joint geometry for the field sites.

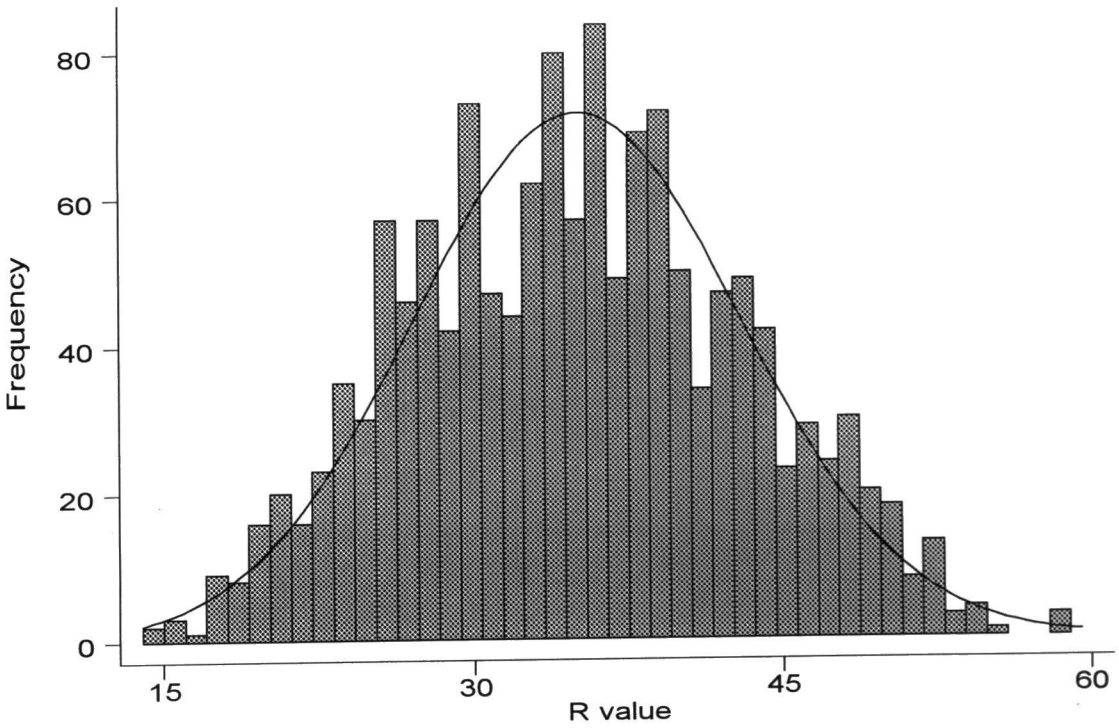


Figure 7.31: Frequency distribution of total Schmidt hammer readings from the Colorado National Monument.

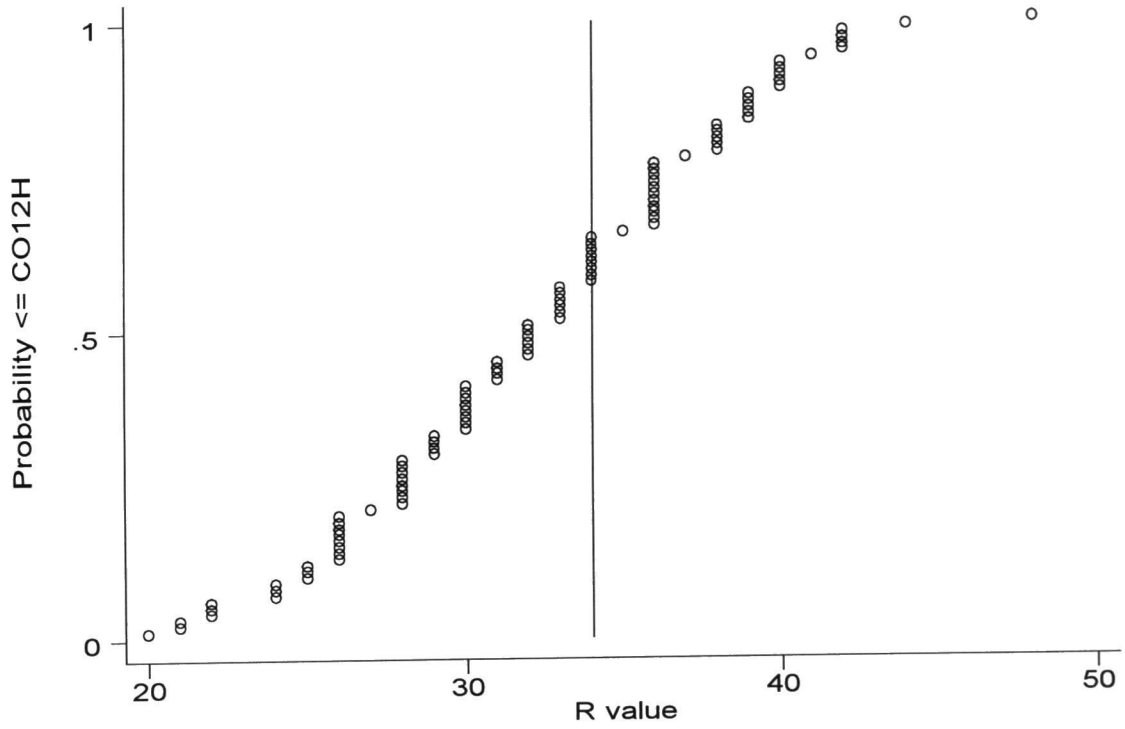


Figure 7.32: The distribution of Schmidt hammer readings from site CO12H against the average for the Colorado National Monument.

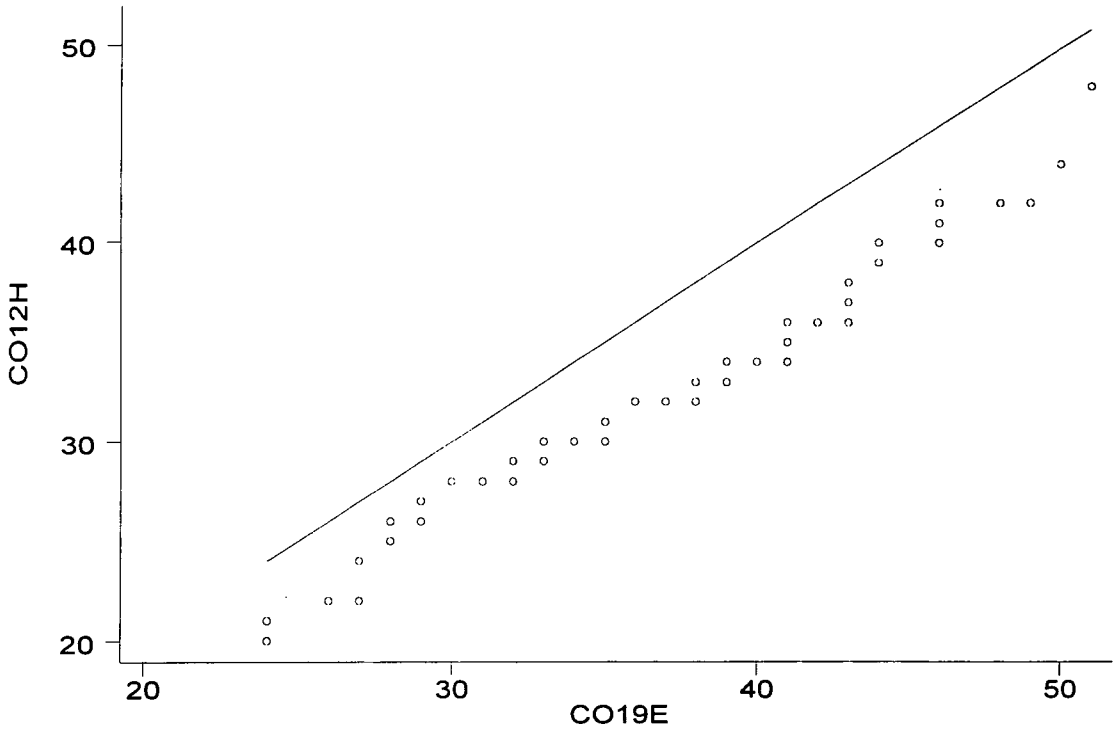


Figure 7.33: A quantile-quantile plot for Schmidt hammer readings from CO12H and CO19E.

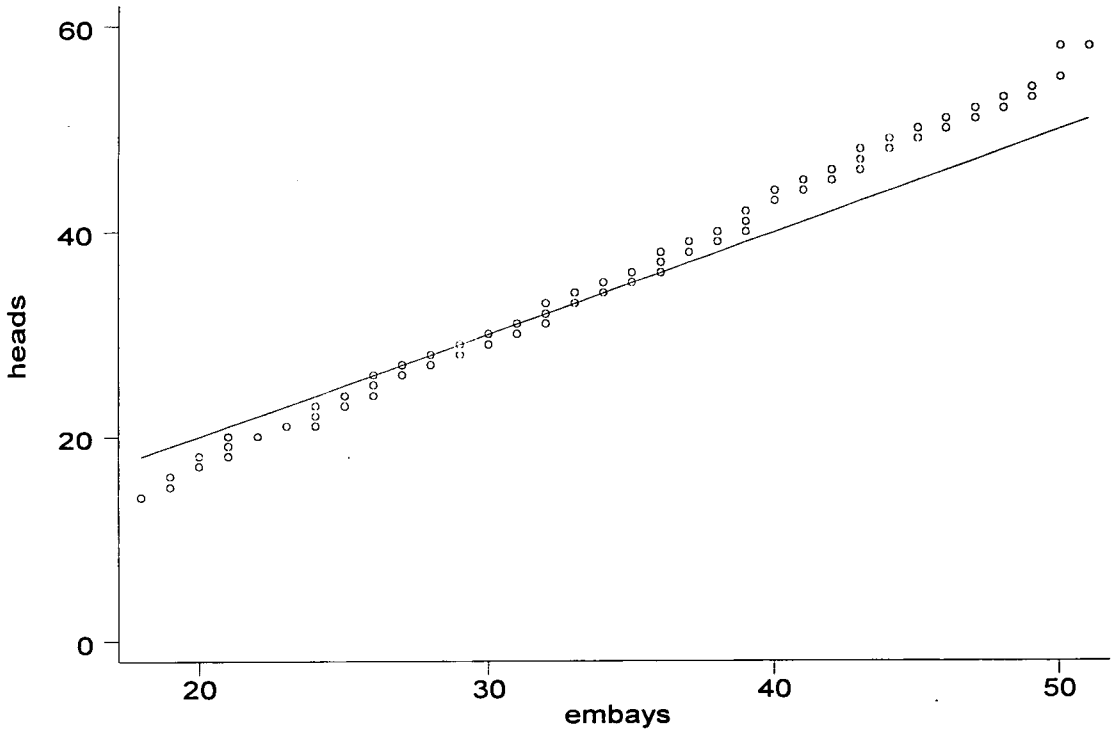
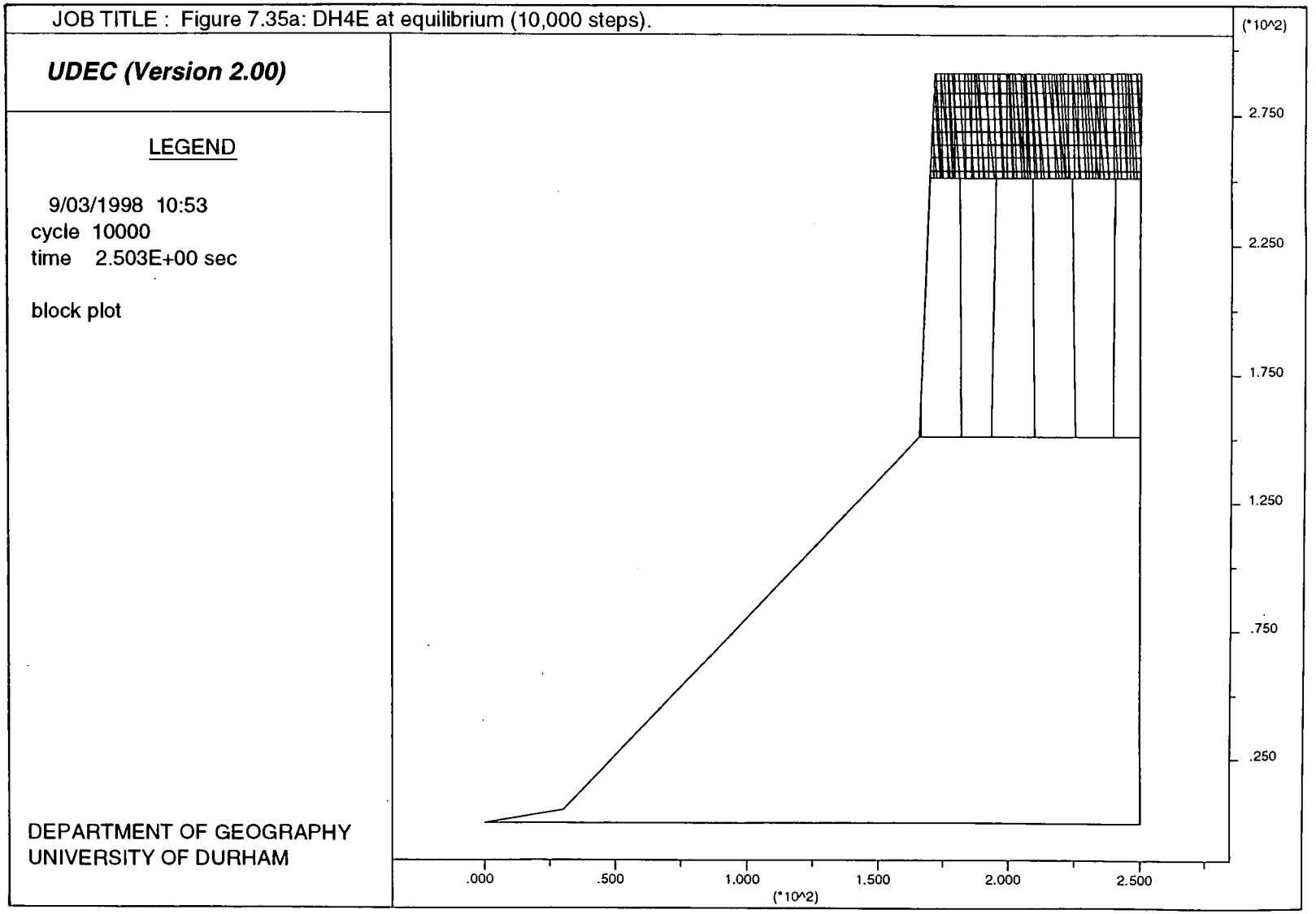
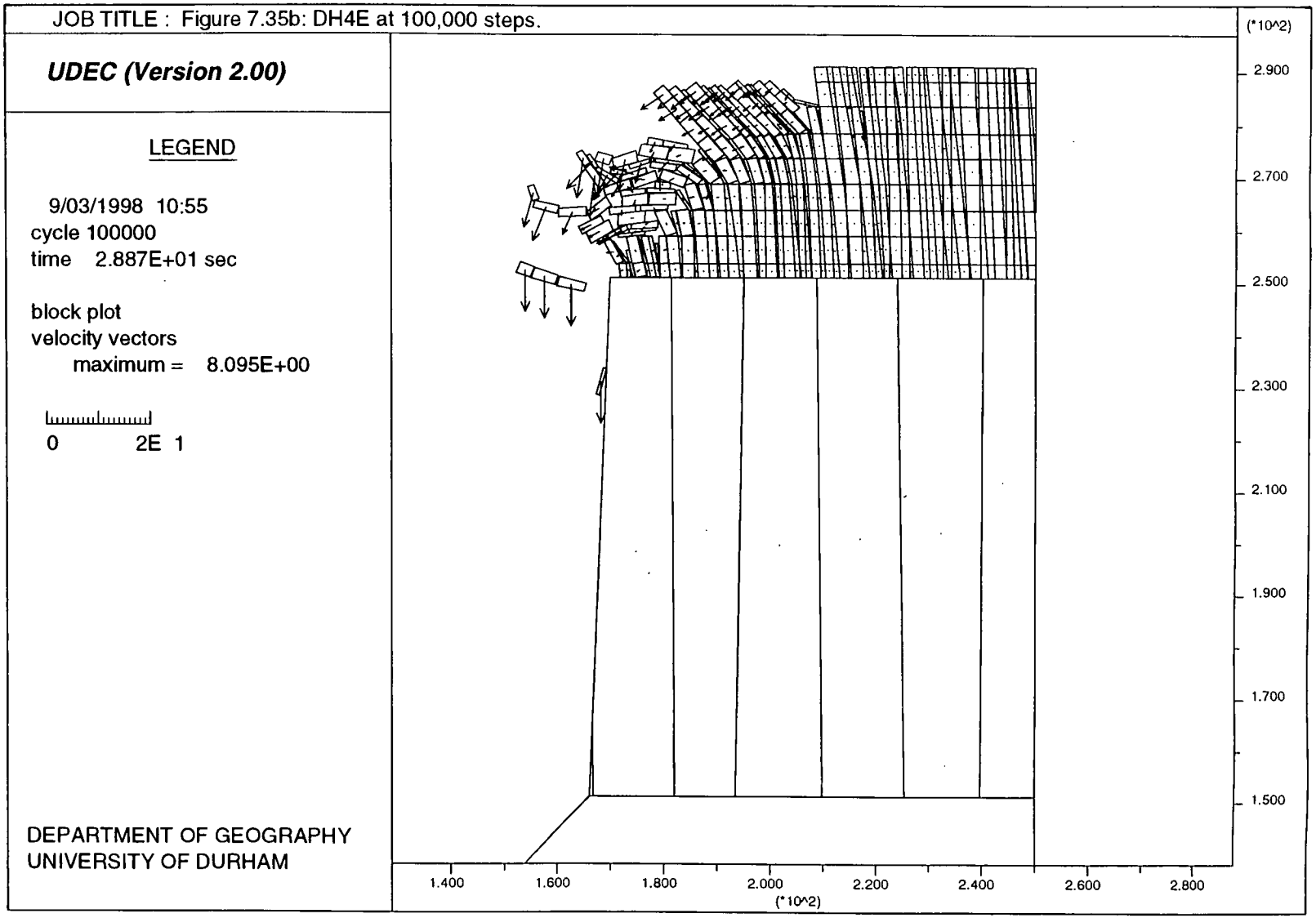


Figure 7.34: A quantile-quantile plot for total Schmidt hammer readings from all headland sites and all embayment sites at the Colorado National Monument.


JOB TITLE : Figure 7.35a: DH4E at equilibrium (10,000 steps).
UDEC (Version 2.00)
LEGEND
9/03/1998 10:53
cycle 10000
time 2.503E+00 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
2.750
2.250
1.750
1.250
.750
.250
.000
.500
1.000
1.500
2.000
2.500
(*10^2)


JOB TITLE : Figure 7.35b: DH4E at 100,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 10:55
cycle 100000
time 2.887E+01 sec
block plot
velocity vectors
maximum = 8.095E+00
0 2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
2.900
2.700
2.500
2.300
2.100
1.900
1.700
1.500
1.400
1.600
1.800
2.000
2.200
2.400
2.600
2.800
(*10^2)

JOB TITLE : Figure 7.35c: DH4E at 200,000 steps.

UDEC (Version 2.00)

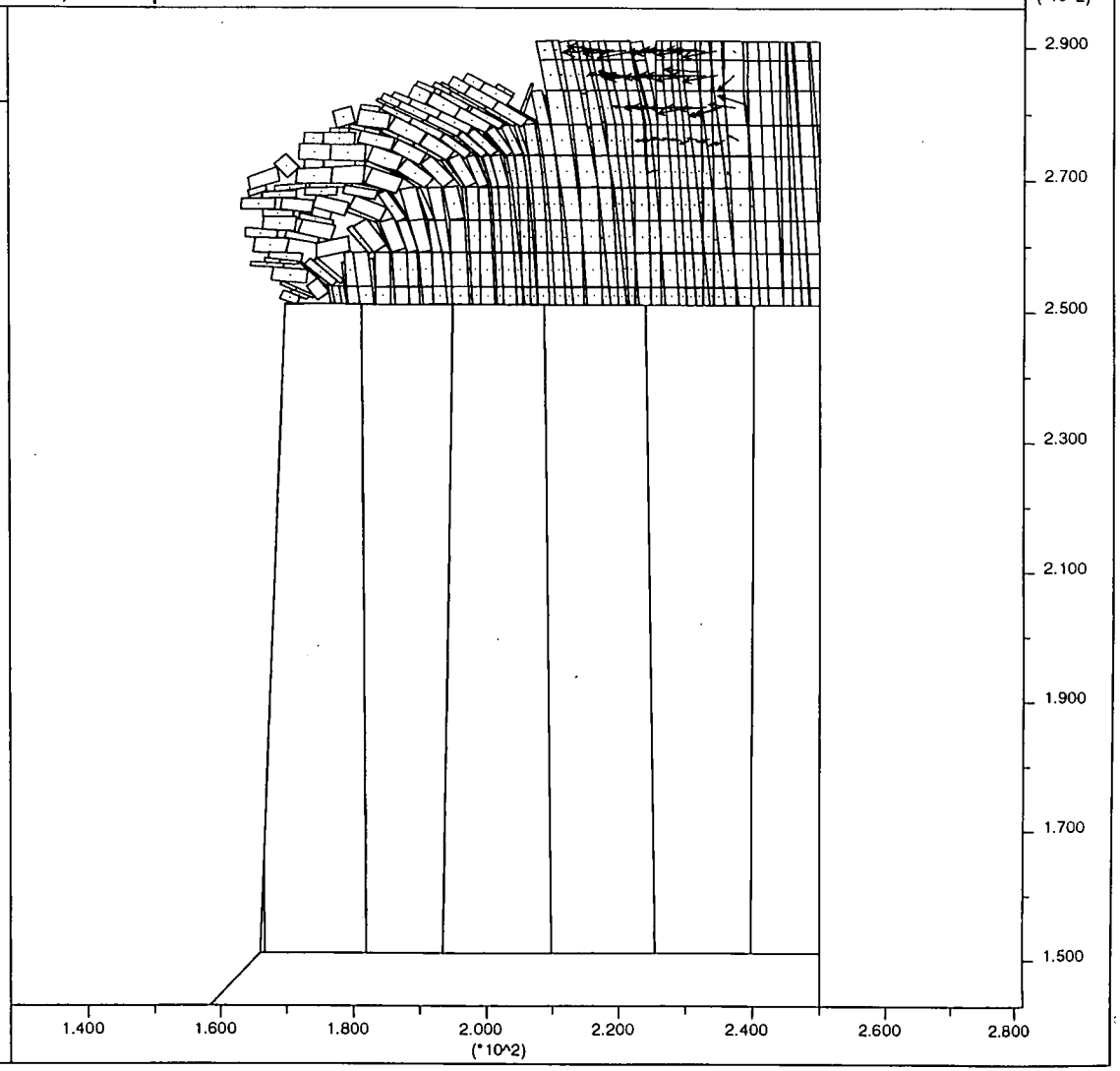
LEGEND

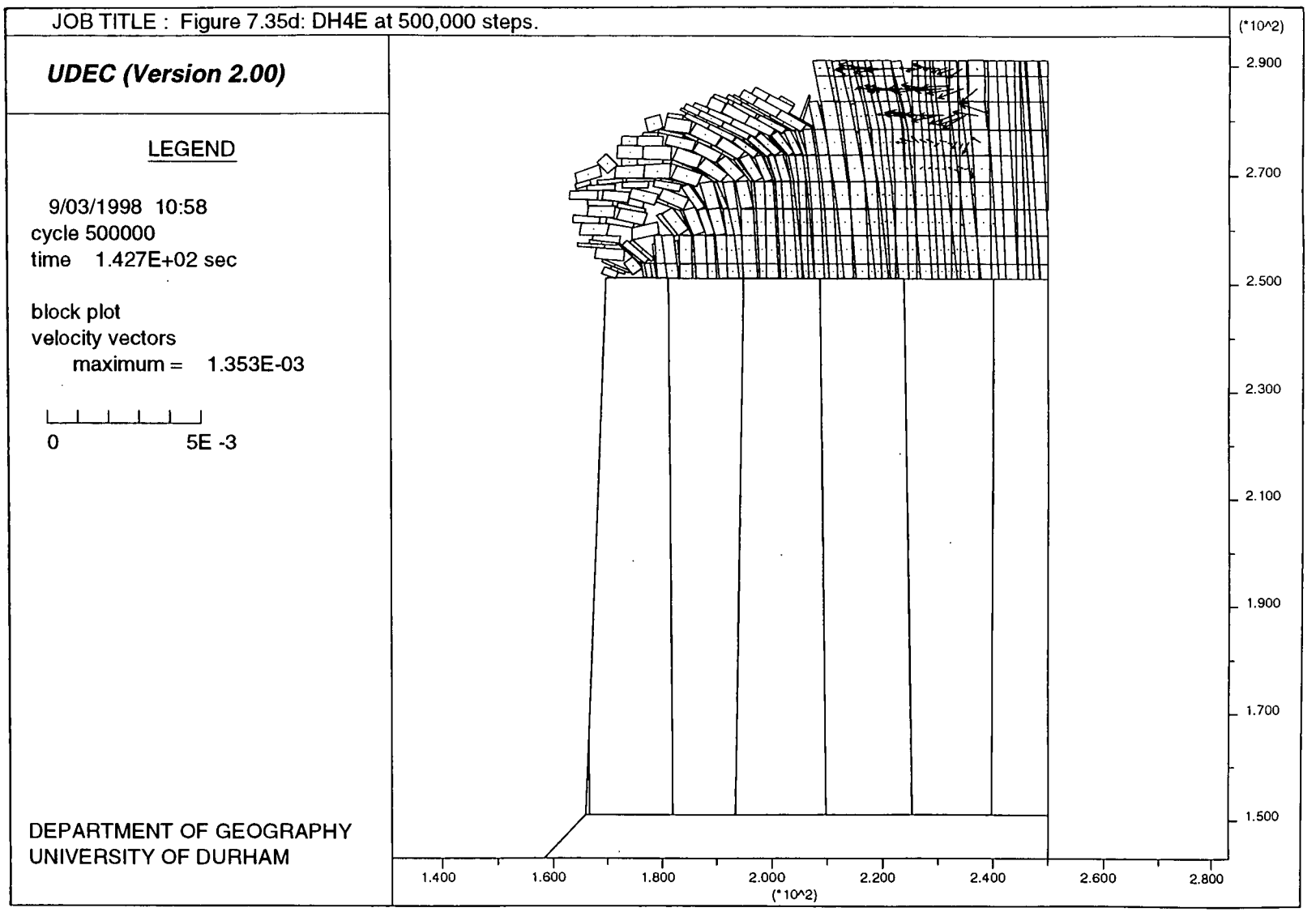
9/03/1998 10:57
cycle 200000
time 5.754E+01 sec

block plot
velocity vectors
maximum = 1.133E-02

0 5E -2

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.35d: DH4E at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 10:58
cycle 500000
time 1.427E+02 sec
block plot
velocity vectors
maximum = 1.353E-03
0
5E -3
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
2.900
2.700
2.500
2.300
2.100
1.900
1.700
1.500
1.400
1.600
1.800
2.000
2.200
2.400
2.600
2.800
(*10^2)

JOB TITLE : Figure 7.36a: Southwest-northeast profile of DH5H at equilibrium.

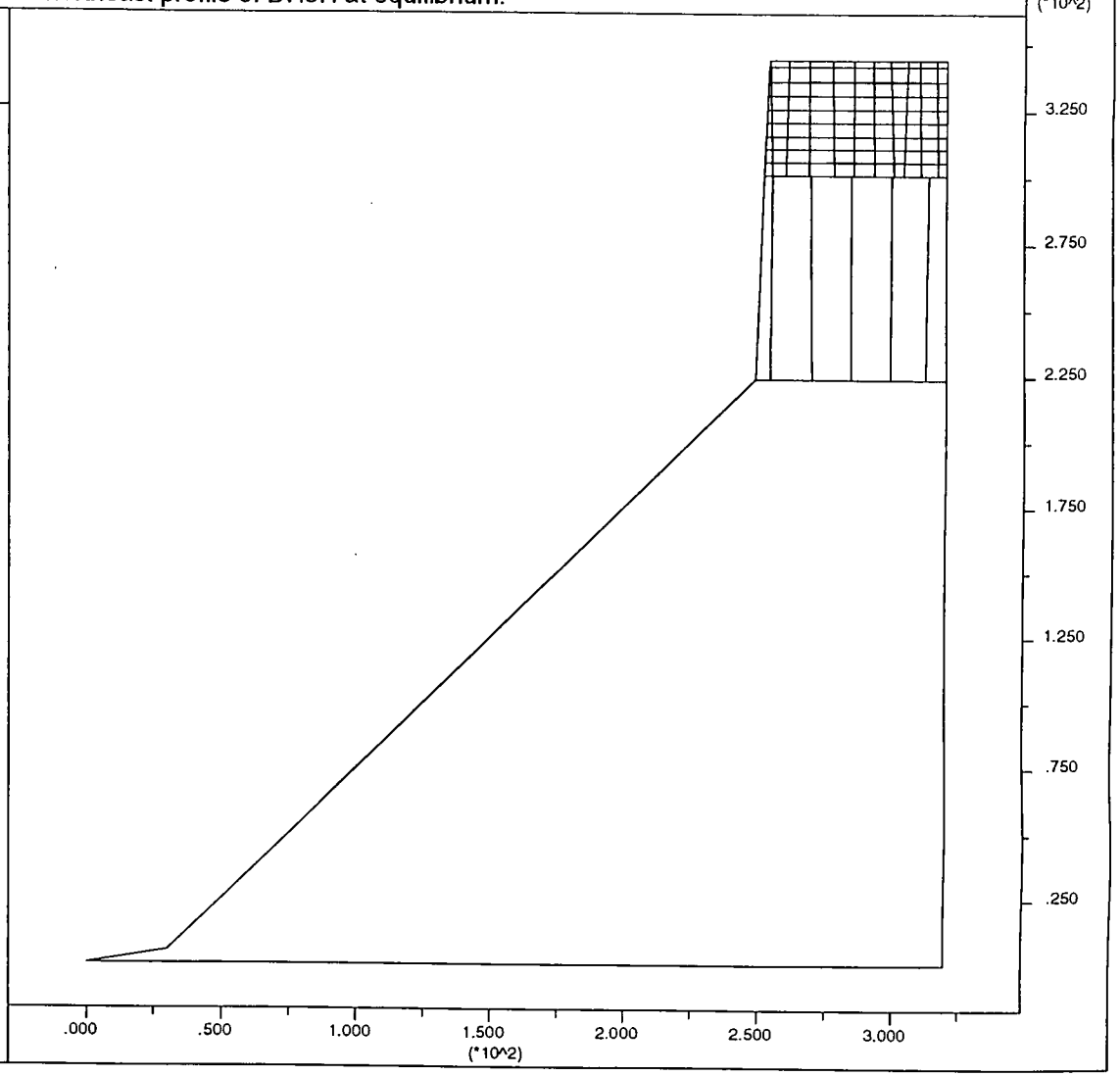
UDEC (Version 2.00)

LEGEND

9/03/1998 11:03
cycle 10000
time 2.957E+00 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.36b: Southwest-northeast profile of DH5H at 100,000 steps.

UDEC (Version 2.00)

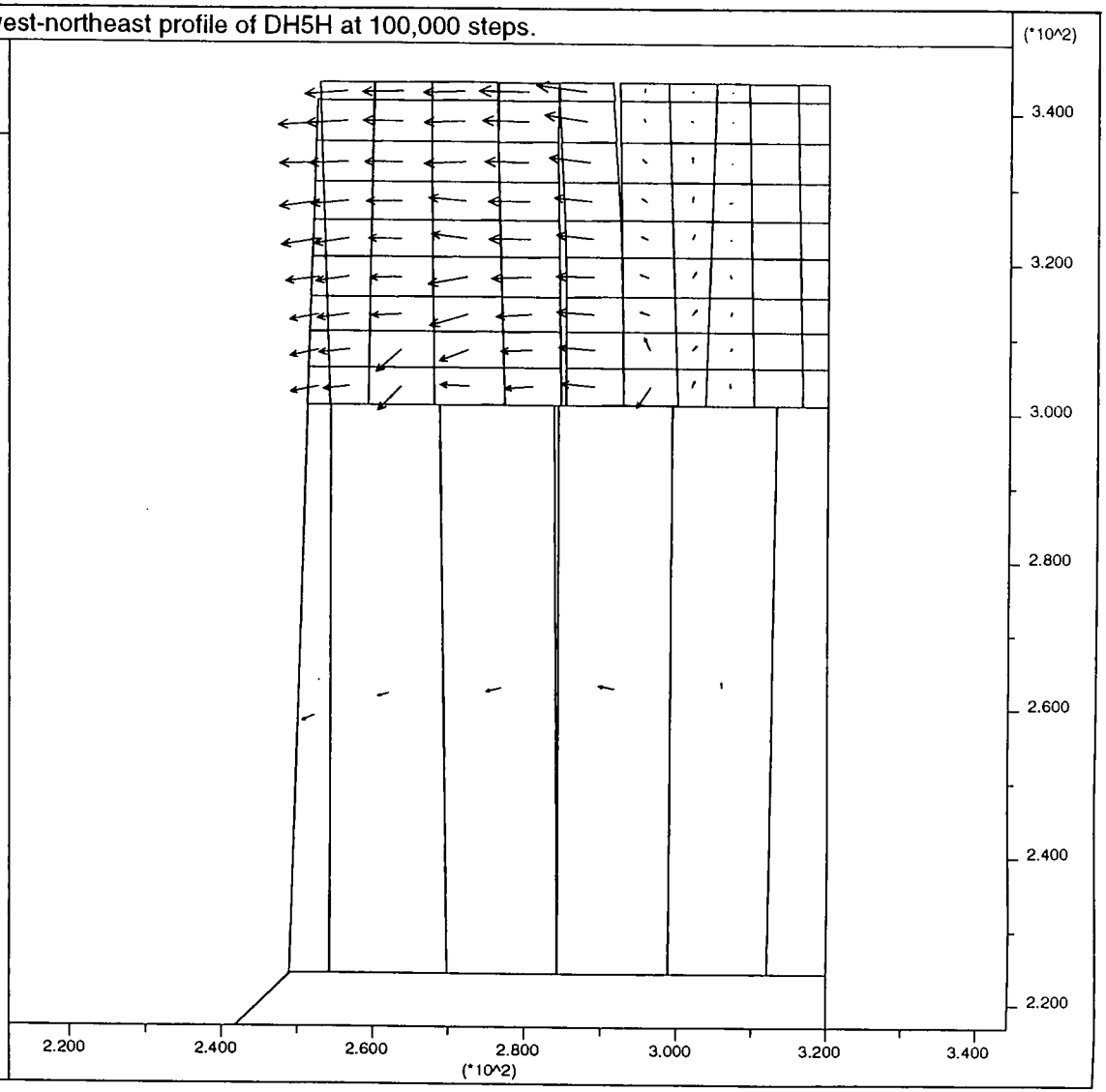
LEGEND

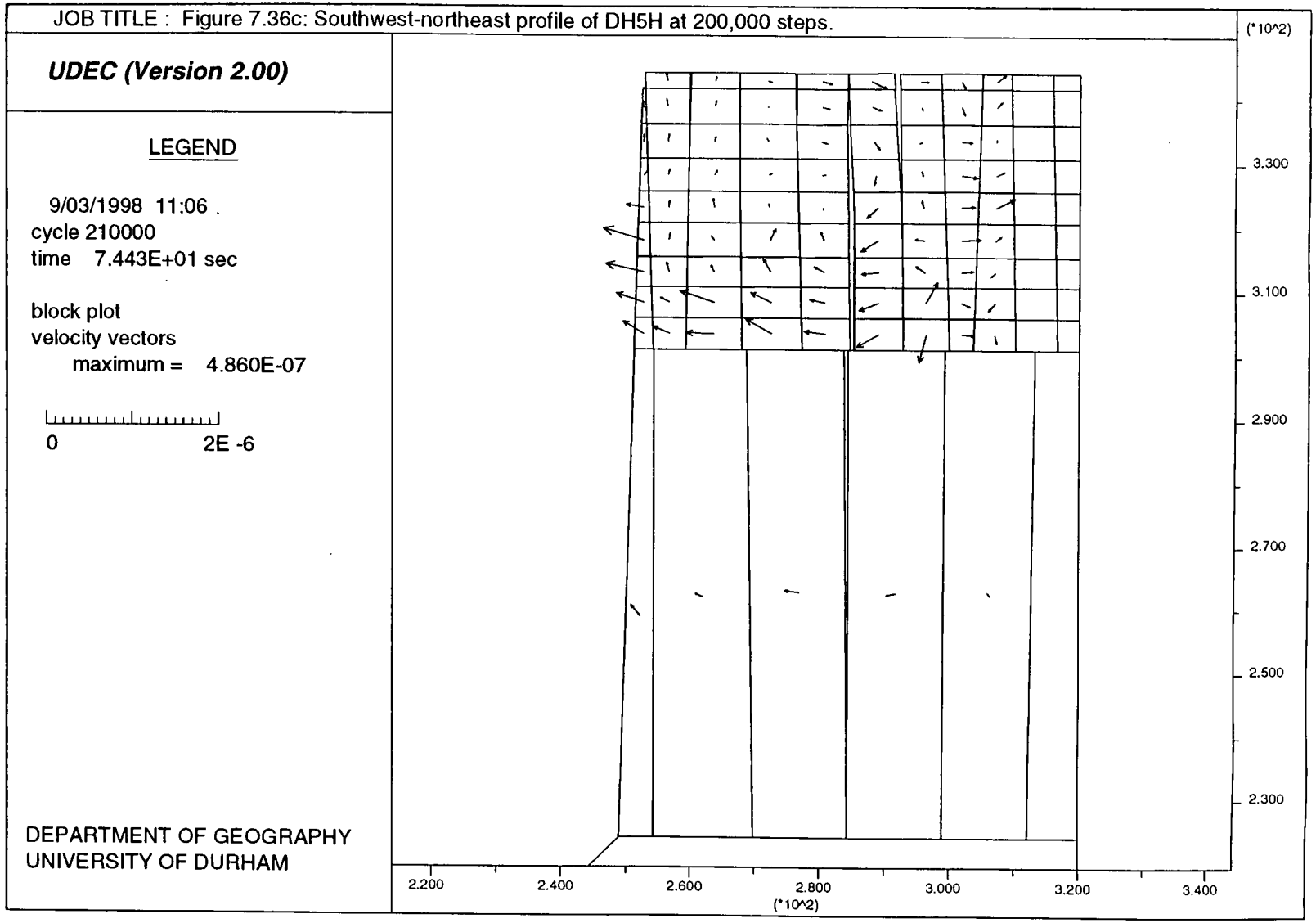
9/03/1998 11:04
cycle 100000
time 3.420E+01 sec

block plot
velocity vectors
maximum = 4.817E-06

0 2E -5

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.36c: Southwest-northeast profile of DH5H at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 11:06
cycle 210000
time 7.443E+01 sec
block plot
velocity vectors
maximum = 4.860E-07
0
2E -6
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.300
3.100
2.900
2.700
2.500
2.300
2.200
2.400
2.600
2.800
3.000
3.200
3.400
(*10^2)

JOB TITLE : Figure 7.36d: Southwest-northeast profile of DH5H at 500,000 steps.

UDEC (Version 2.00)

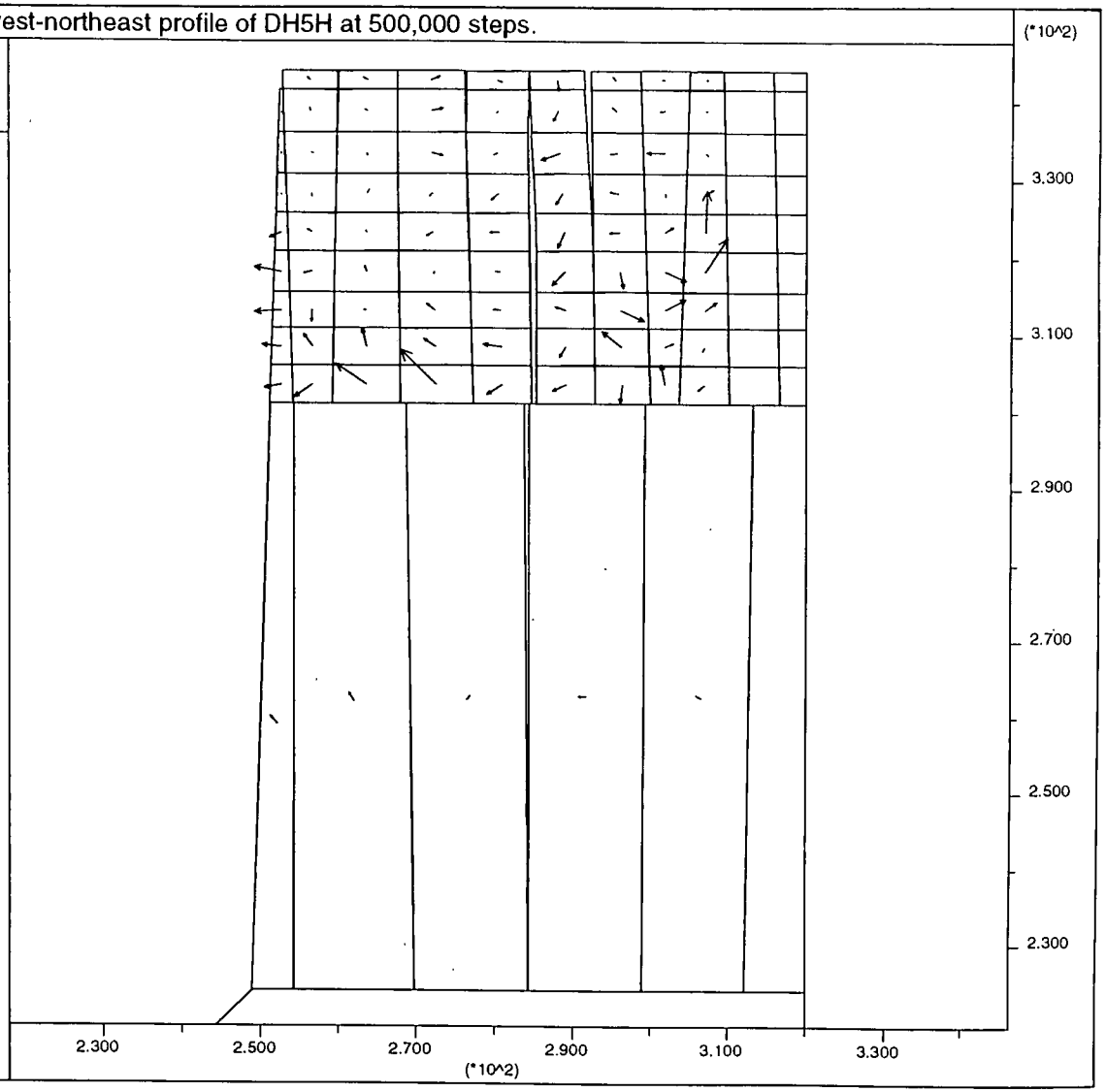
LEGEND

9/03/1998 11:59
cycle 500000
time 1.805E+02 sec

block plot
velocity vectors
maximum = 1.614E-07

0 5E -7

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.37a: Northwest-southeast profile of DH5H at equilibrium.

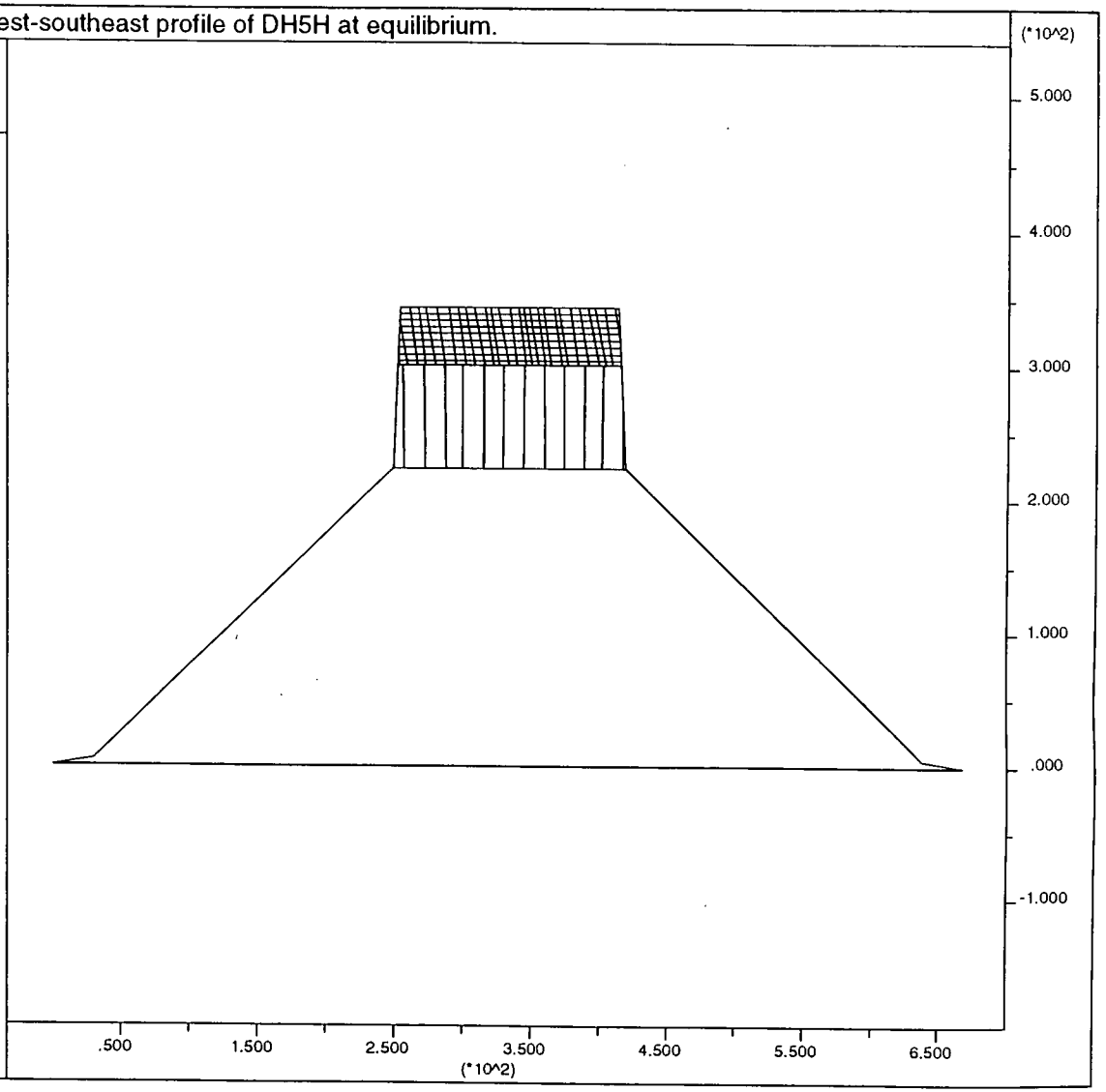
UDEC (Version 2.00)

LEGEND

9/03/1998 12:17
cycle 10000
time 2.078E+00 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.37b: Northwest-southeast profile of DH5H at 100,000 steps.

UDEC (Version 2.00)

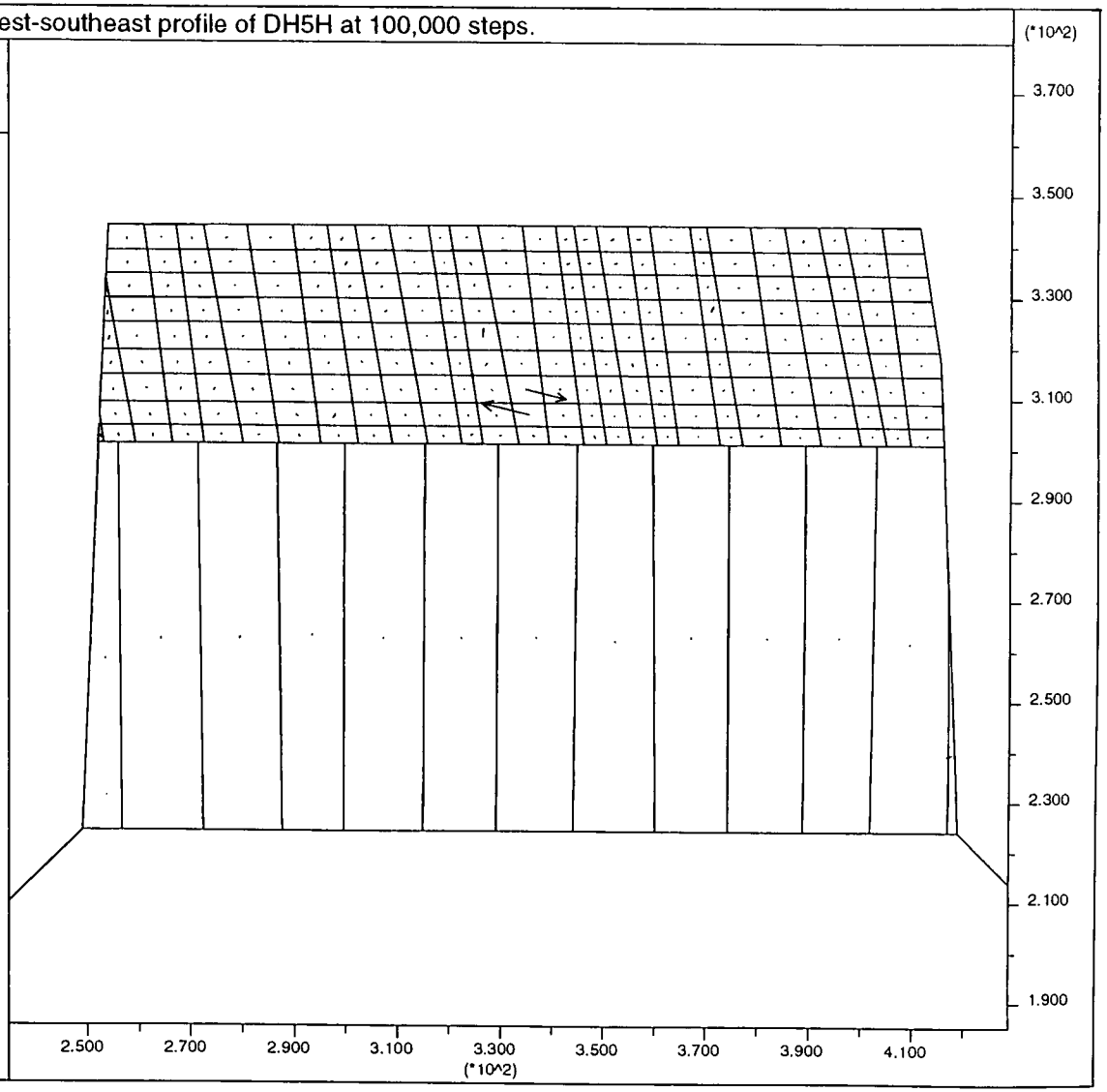
LEGEND

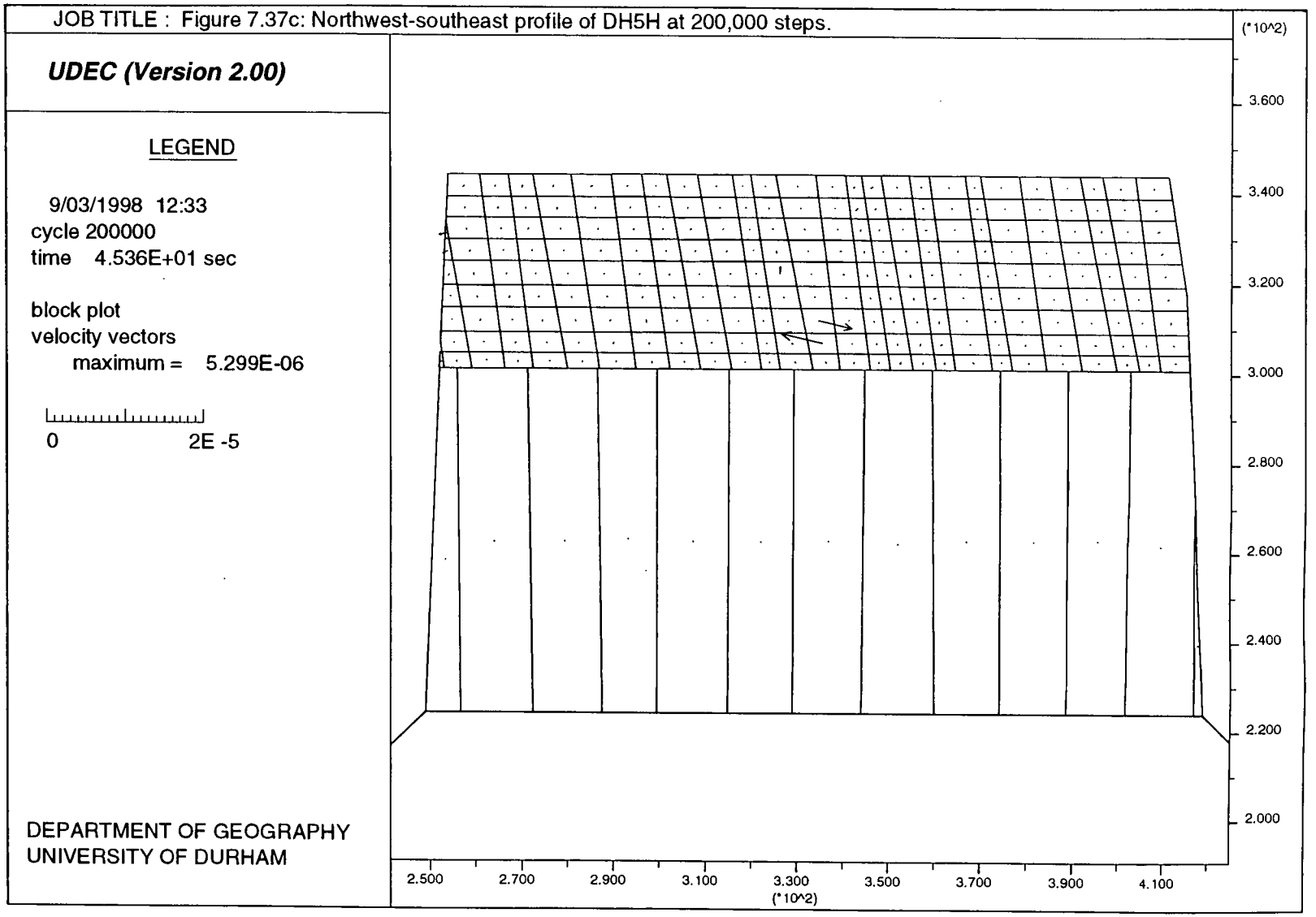
9/03/1998 12:24
cycle 100000
time 2.251E+01 sec

block plot
velocity vectors
maximum = 5.270E-06

0 2E -5

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.37c: Northwest-southeast profile of DH5H at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 12:33
cycle 200000
time 4.536E+01 sec
block plot
velocity vectors
maximum = 5.299E-06
0
2E -5
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.600
3.400
3.200
3.000
2.800
2.600
2.400
2.200
2.000
2.500
2.700
2.900
3.100
3.300
3.500
3.700
3.900
4.100
(*10^2)

JOB TITLE : Figure 7.37d: Northwest-southeast profile of DH5H at 500,000 steps.

UDEC (Version 2.00)

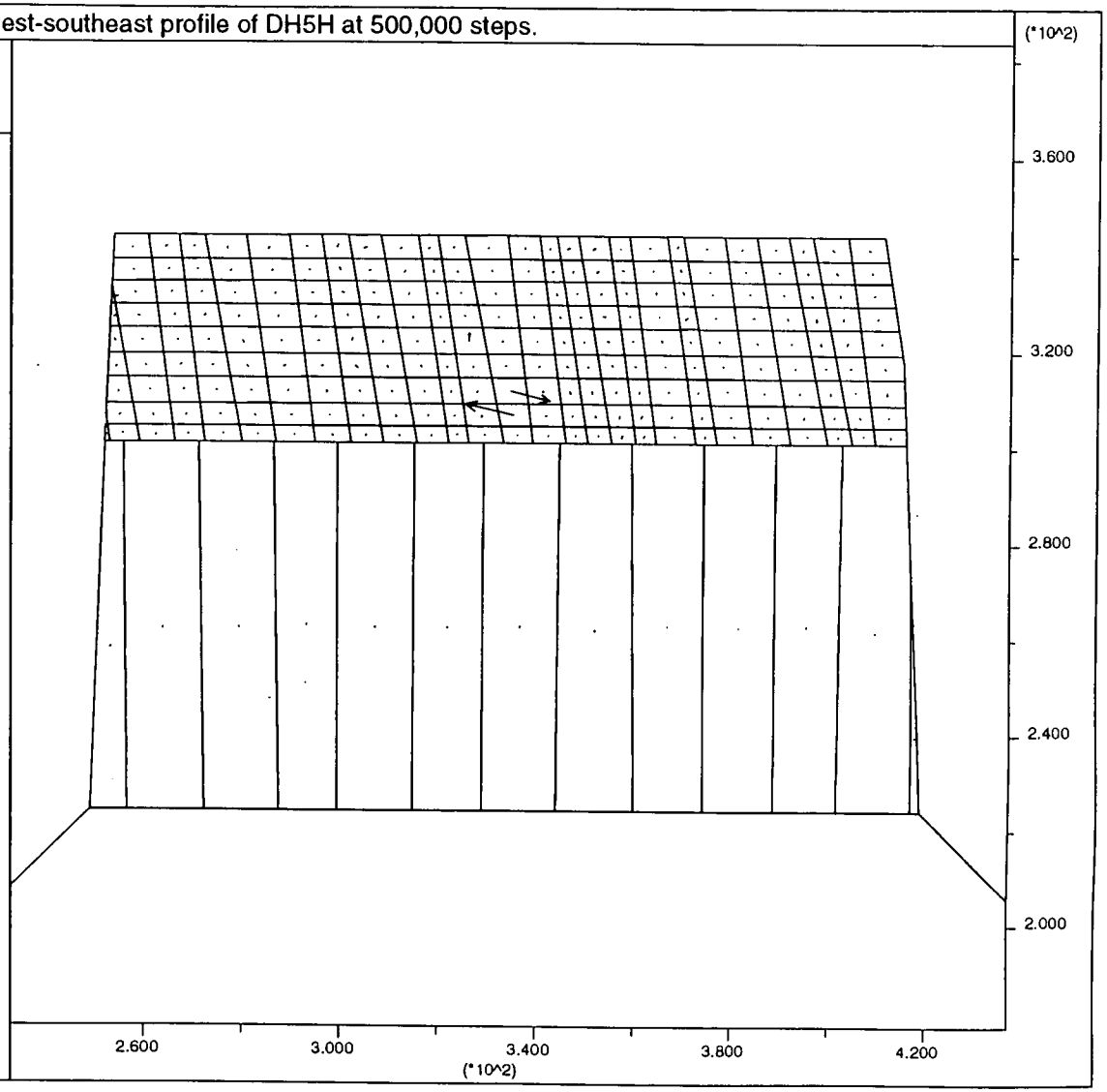
LEGEND

9/08/1998 09:08
cycle 500000
time 1.139E+02 sec

block plot
velocity vectors
maximum = 5.359E-06

0 2E -5

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.38a: DH7E at equilibrium.

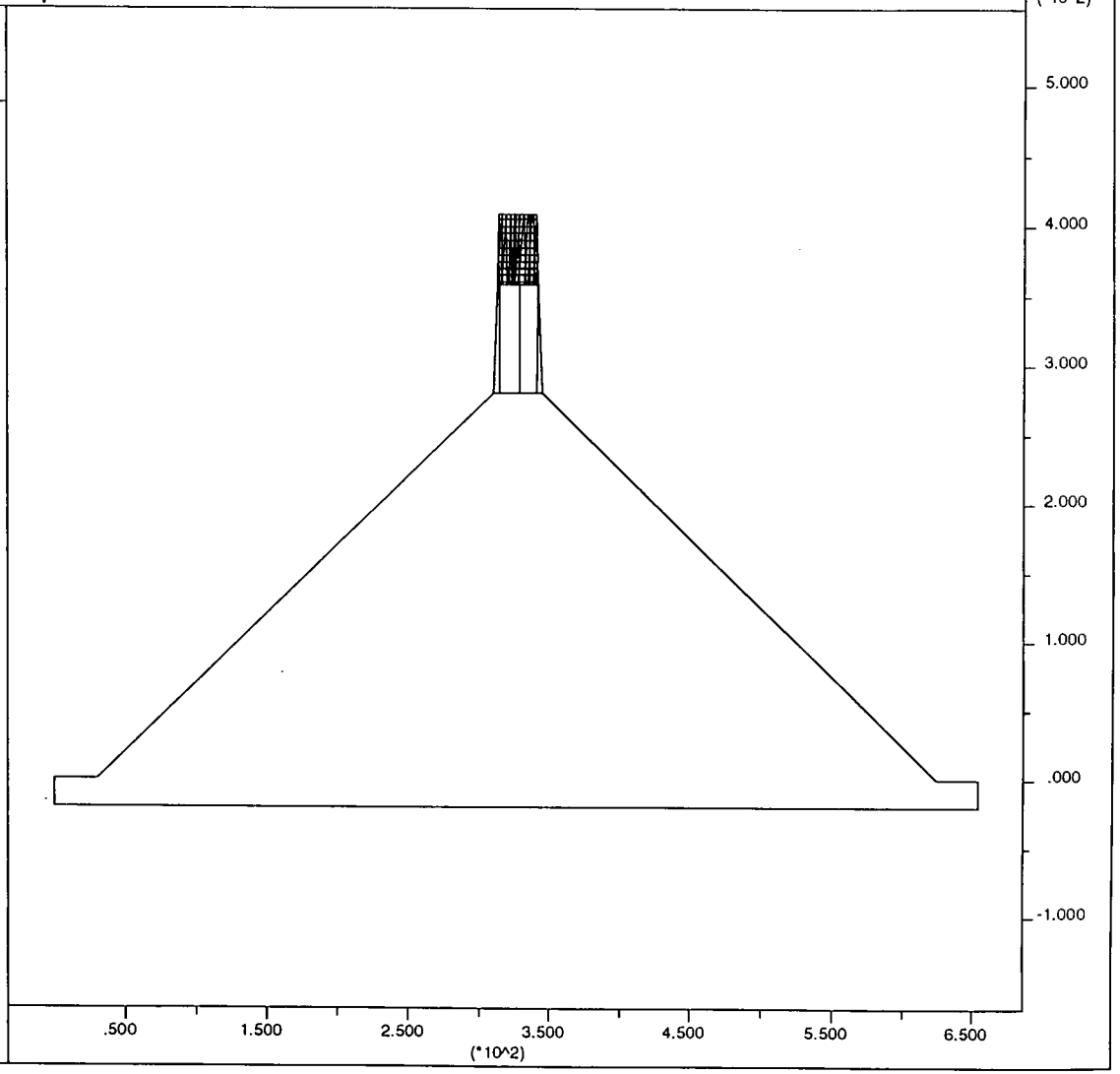
UDEC (Version 2.00)

LEGEND

9/03/1998 12:48
cycle 5000
time 1.024E+00 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.38b: DH7E at 100,000 steps.

UDEC (Version 2.00)

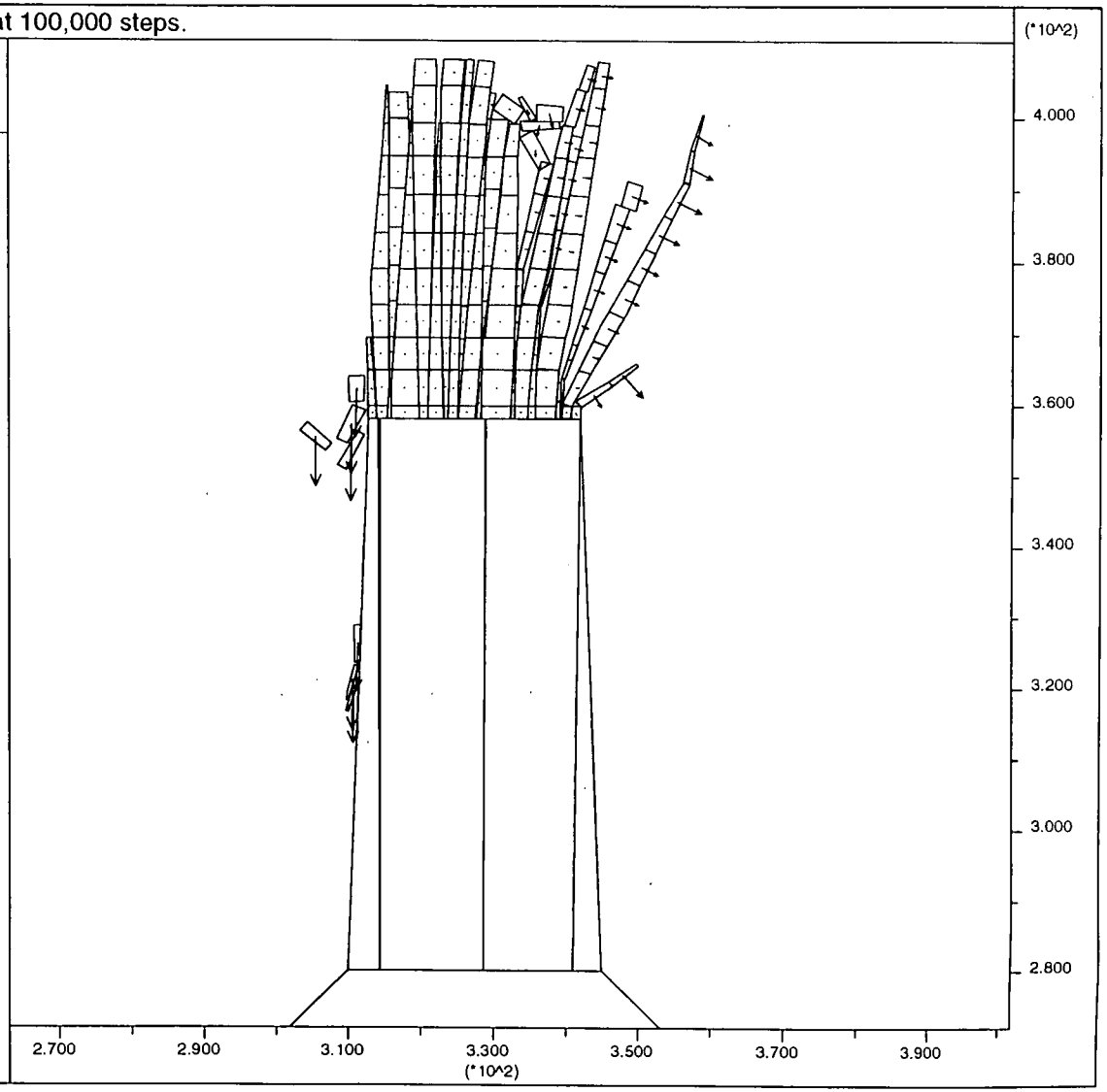
LEGEND

9/03/1998 13:28
cycle 100000
time 2.507E+01 sec

block plot
velocity vectors
maximum = 7.790E+00

0 2E 1

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.38c: DH7E at 200,000 steps.

UDEC (Version 2.00)

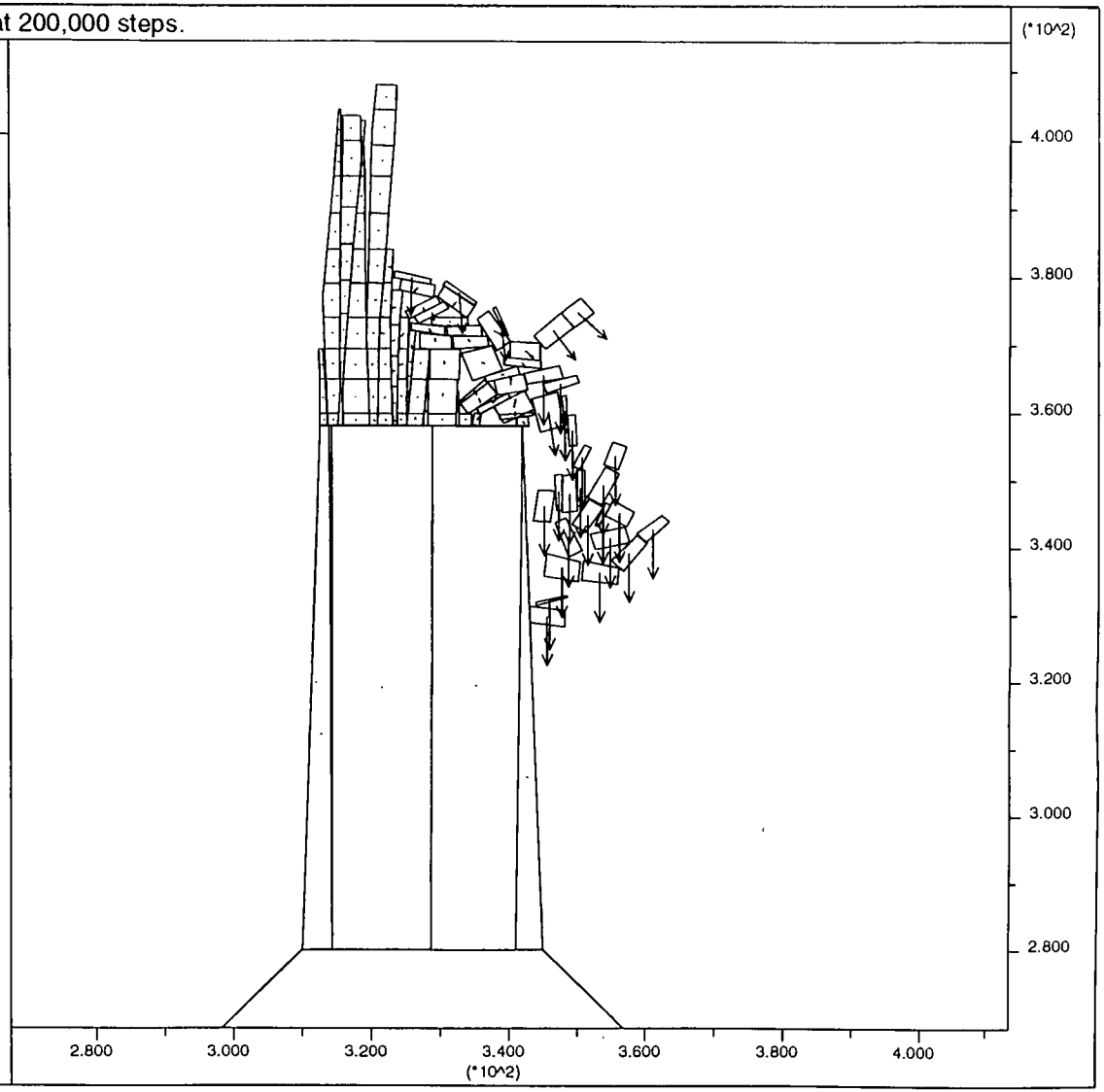
LEGEND

9/03/1998 14:06
cycle 200000
time 5.438E+01 sec

block plot
velocity vectors
maximum = 1.027E+00

0 5E 0

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.38d: DH7E at 500,000 steps.

UDEC (Version 2.00)

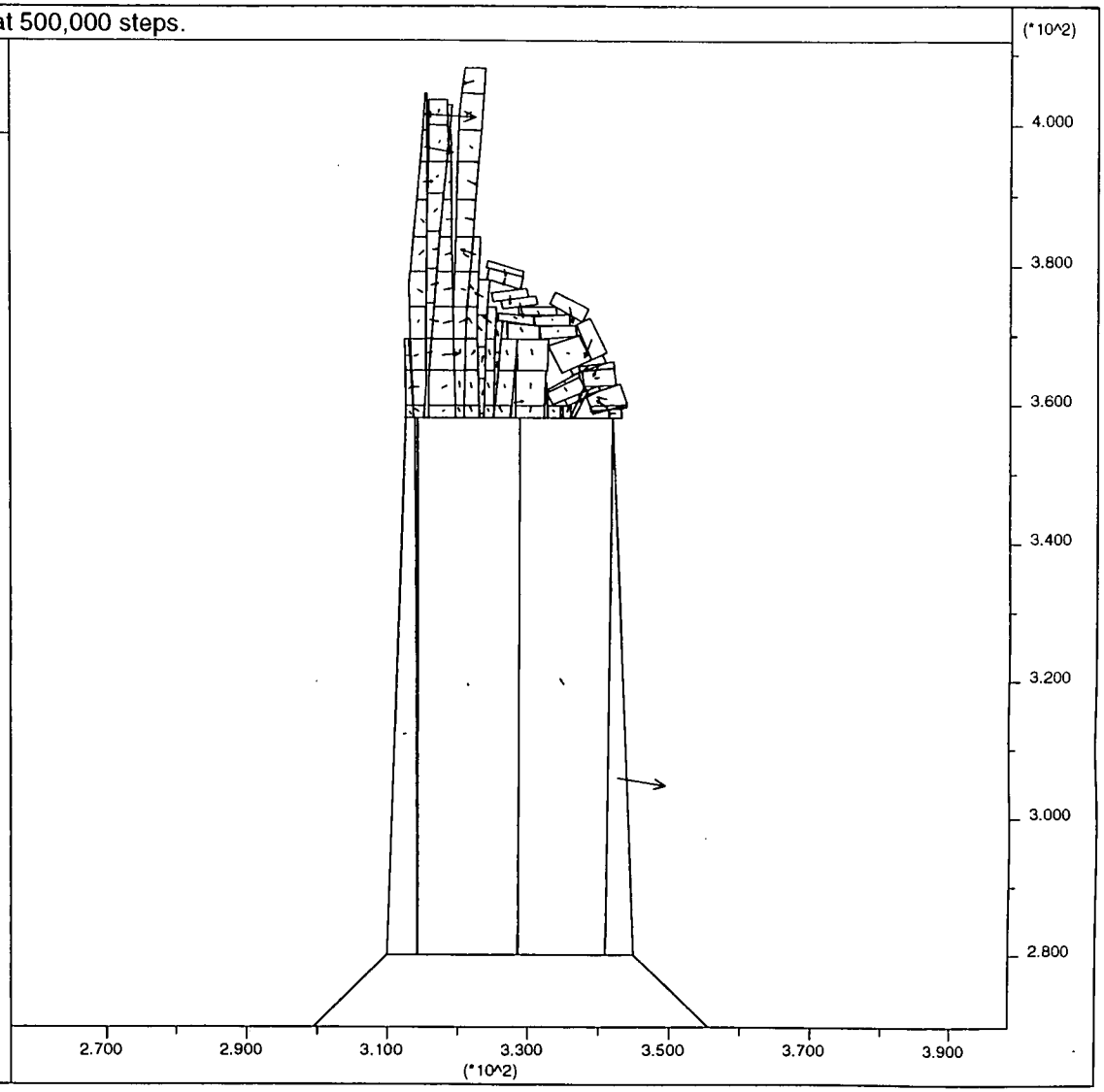
LEGEND

9/03/1998 14:42
cycle 500000
time 1.513E+02 sec

block plot
velocity vectors
maximum = 3.683E-03

0 2E -2

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.39a: East-west profile of DH11H butte at equilibrium.

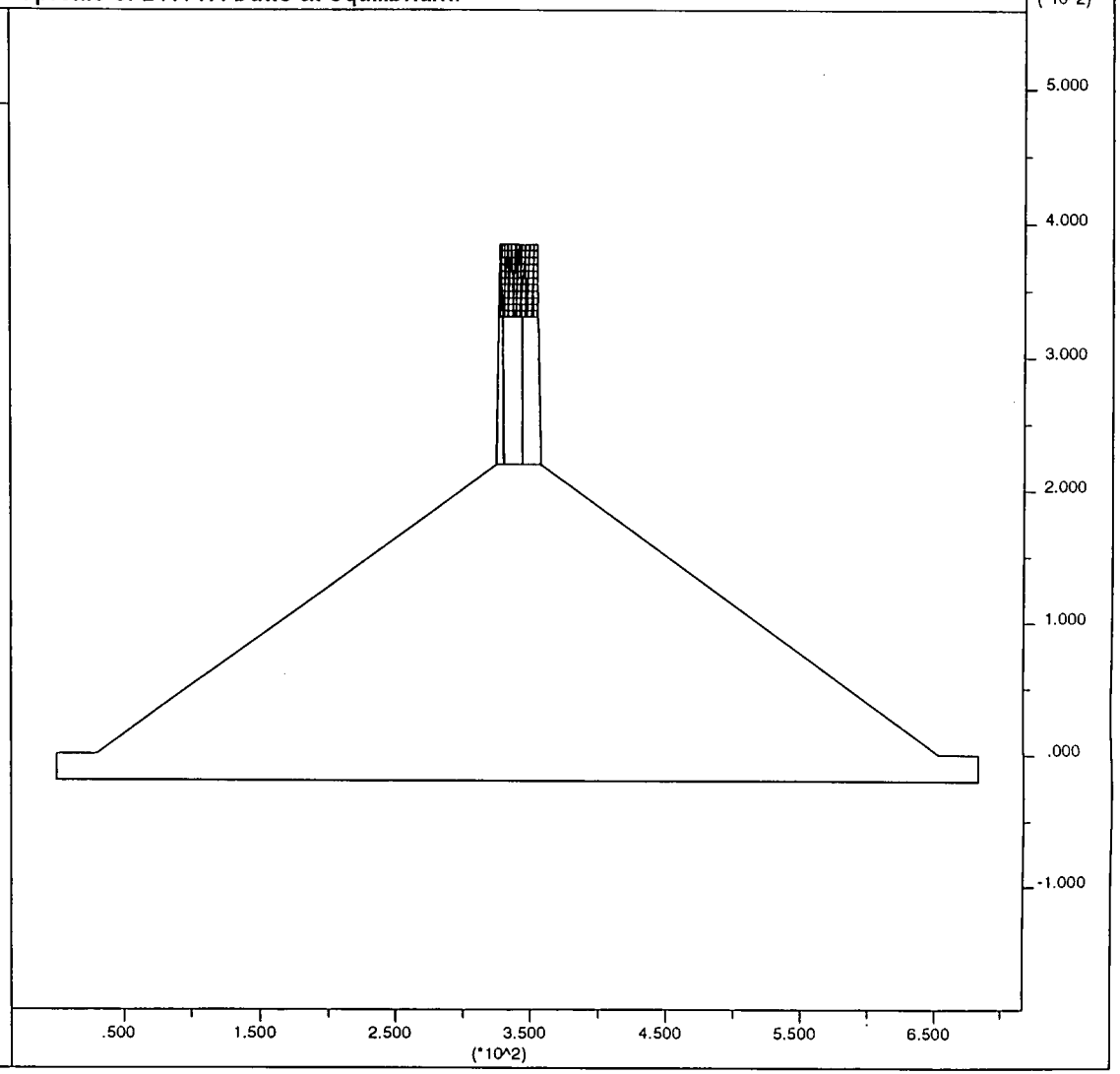
UDEC (Version 2.00)

LEGEND

9/03/1998 14:59
cycle 10000
time 1.698E+00 sec

block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM



JOB TITLE : Figure 7.39b: East-west profile of DH11H butte at 100,000 steps.

UDEC (Version 2.00)

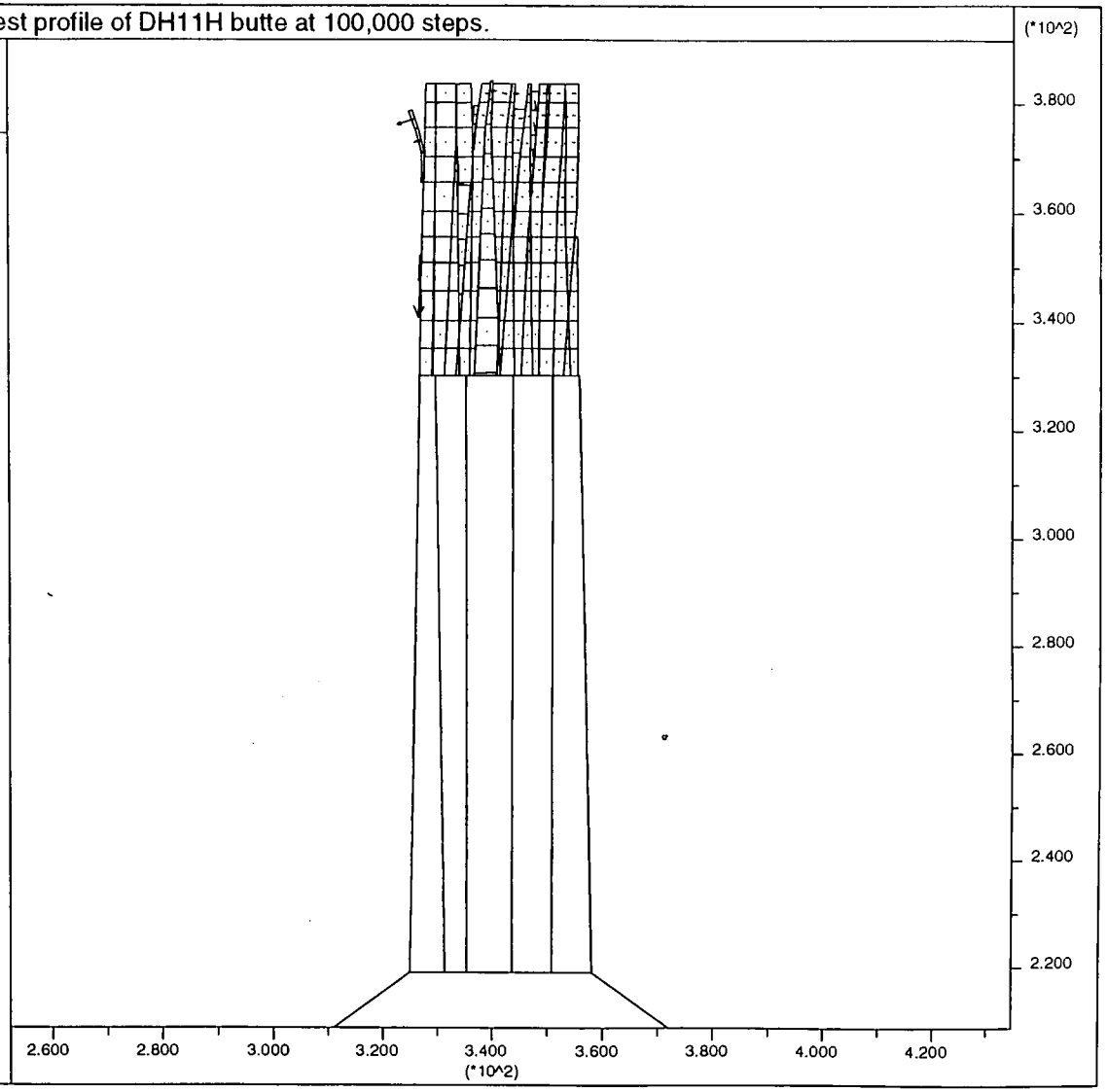
LEGEND

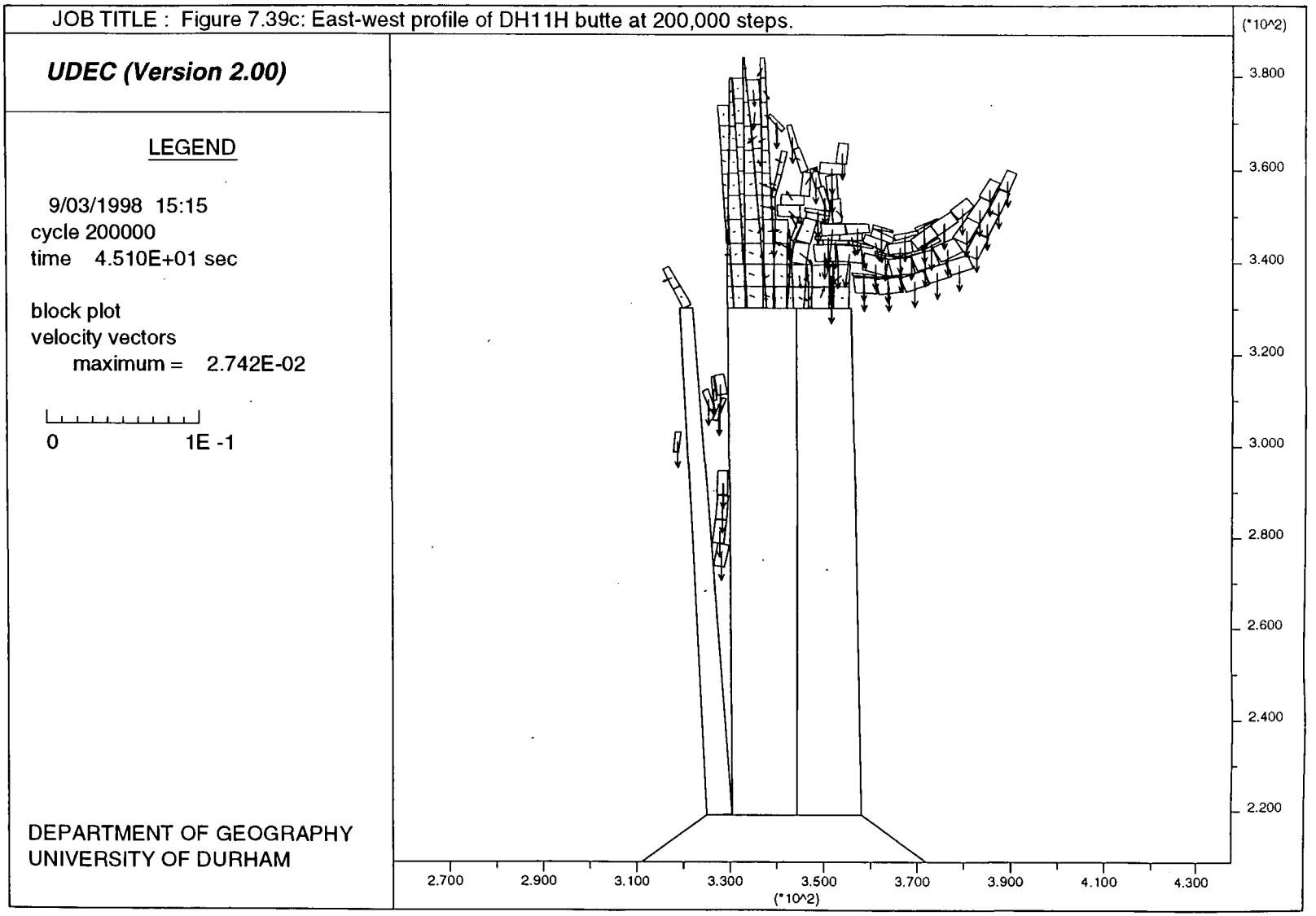
9/03/1998 15:13
cycle 100000
time 1.701E+01 sec

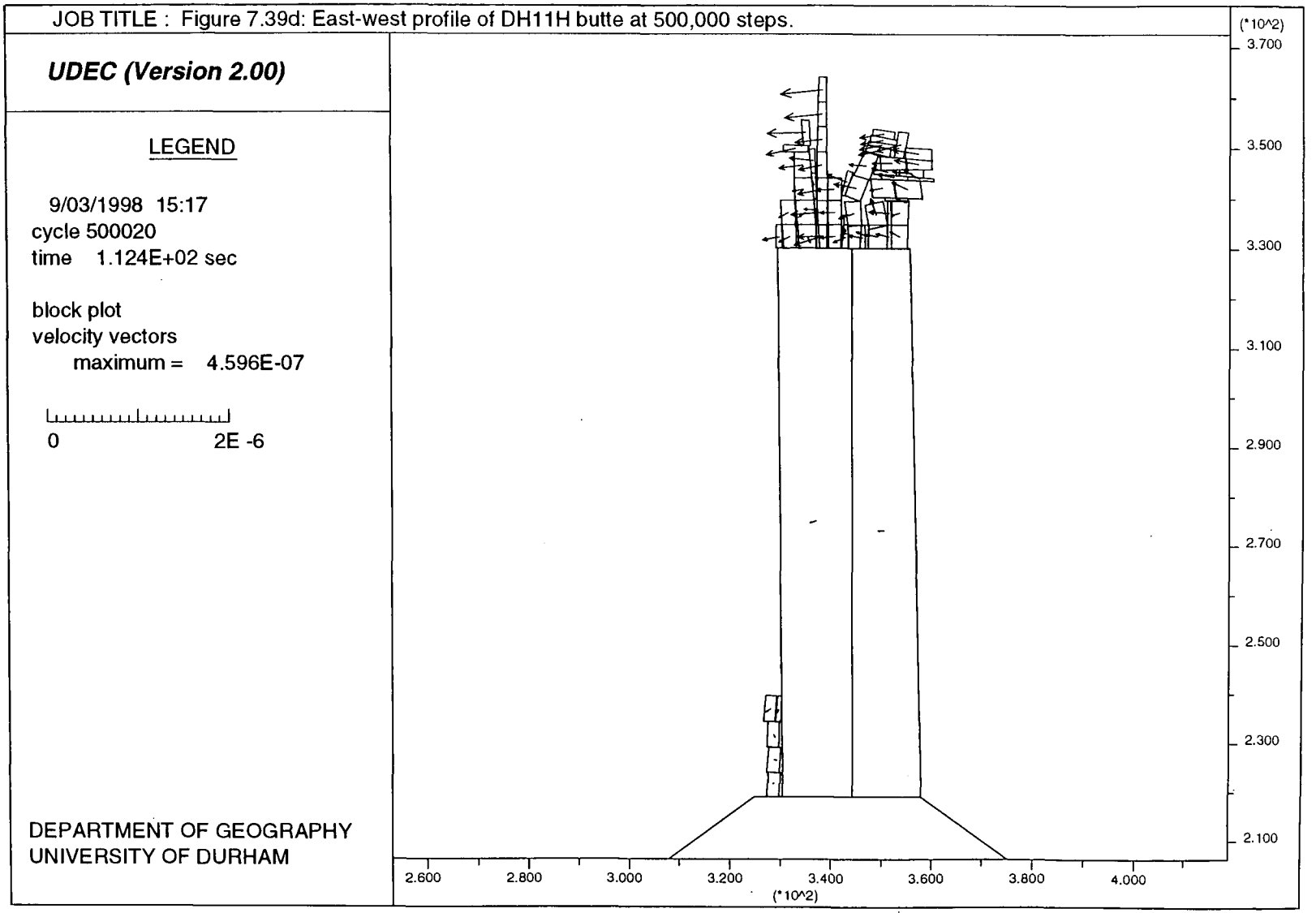
block plot
velocity vectors
maximum = 1.115E+00

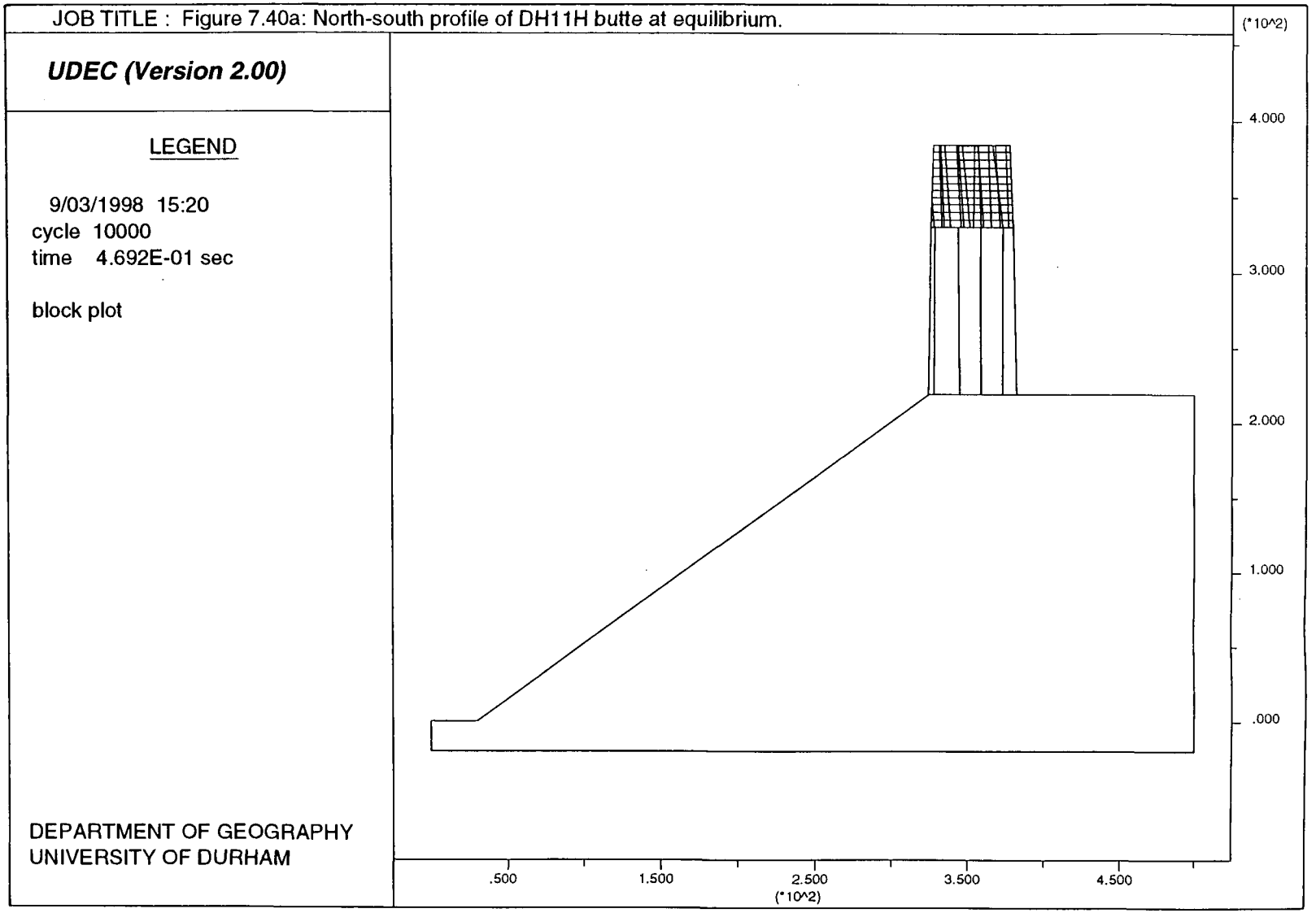
0 5E 0

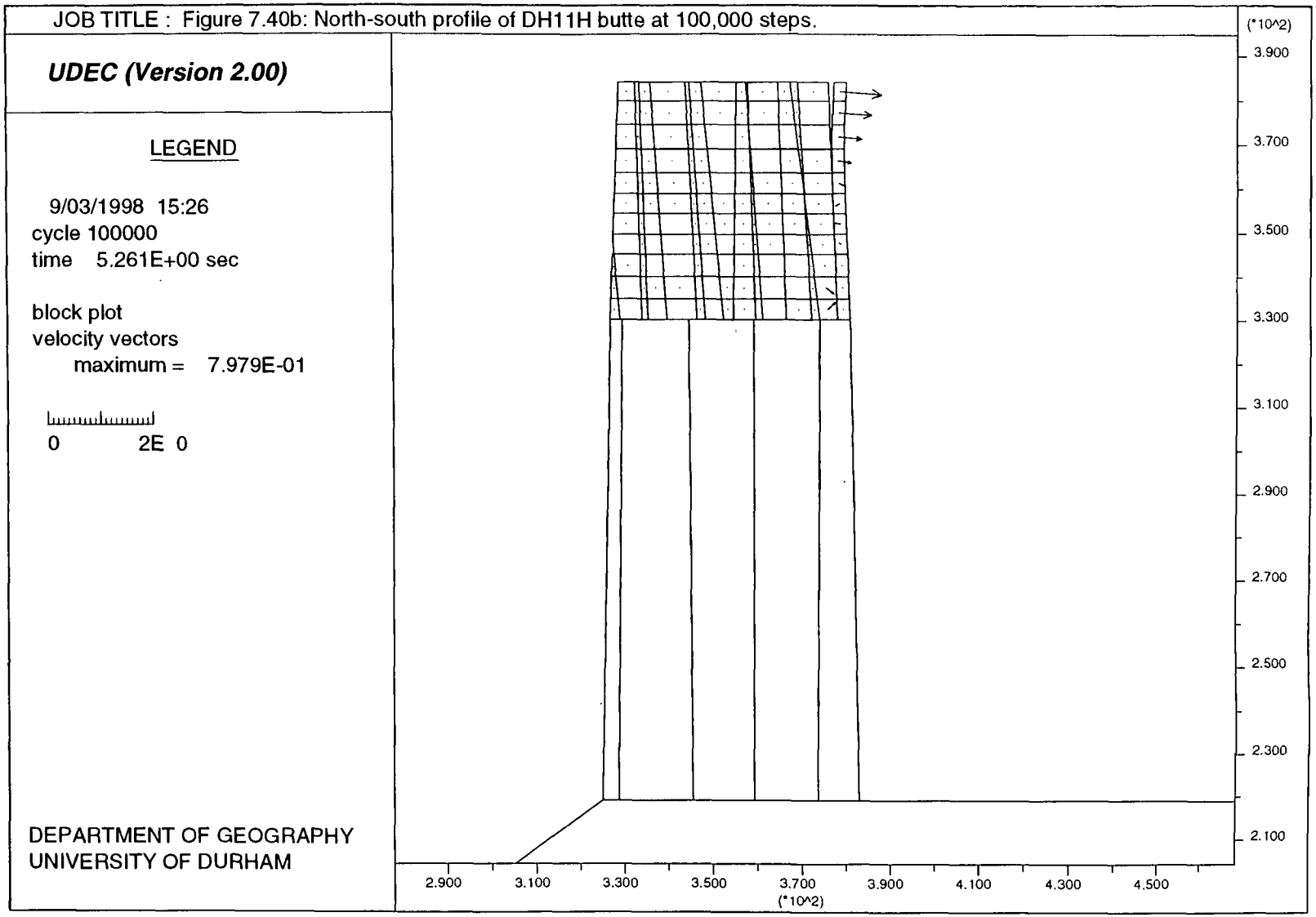
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM

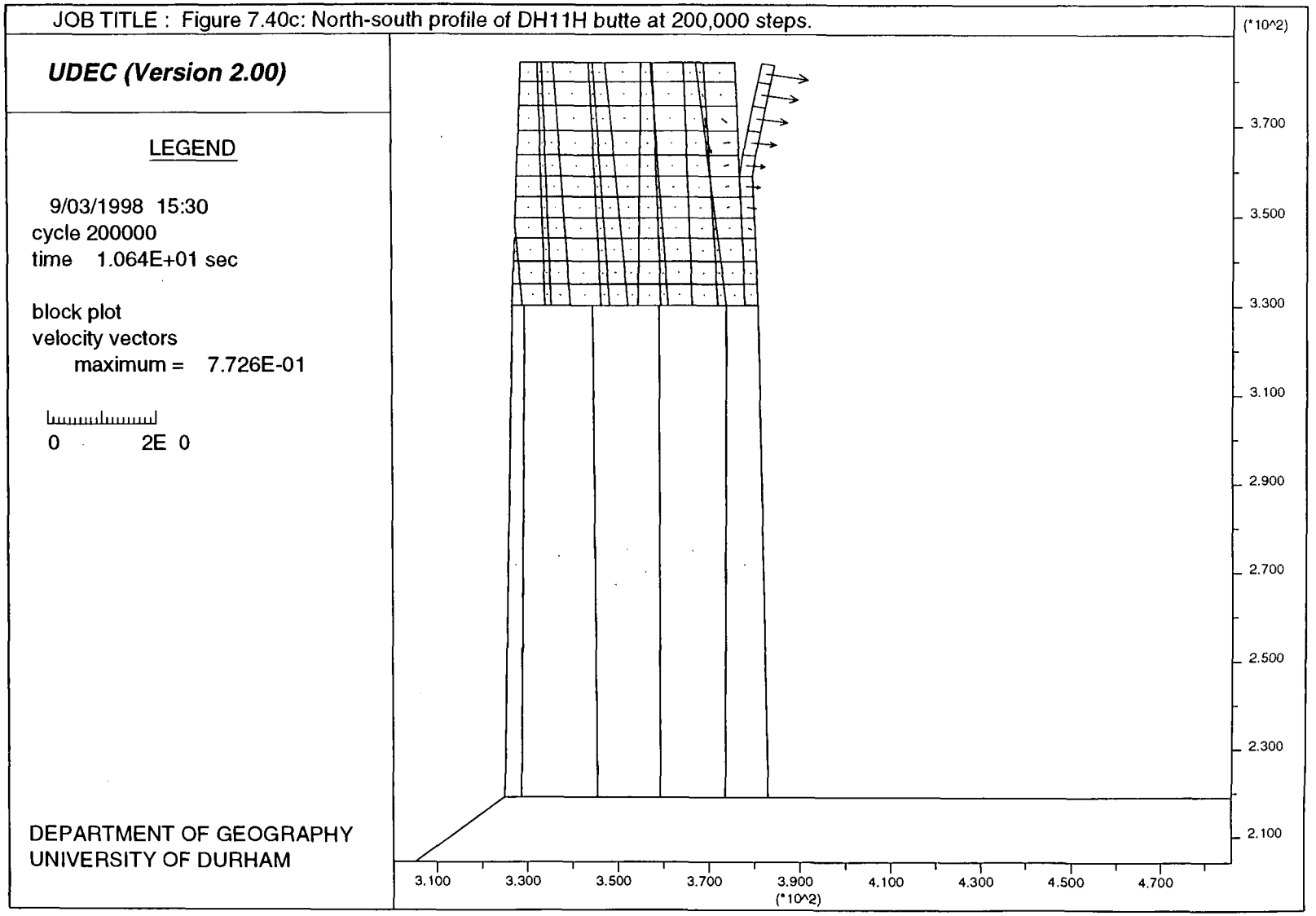


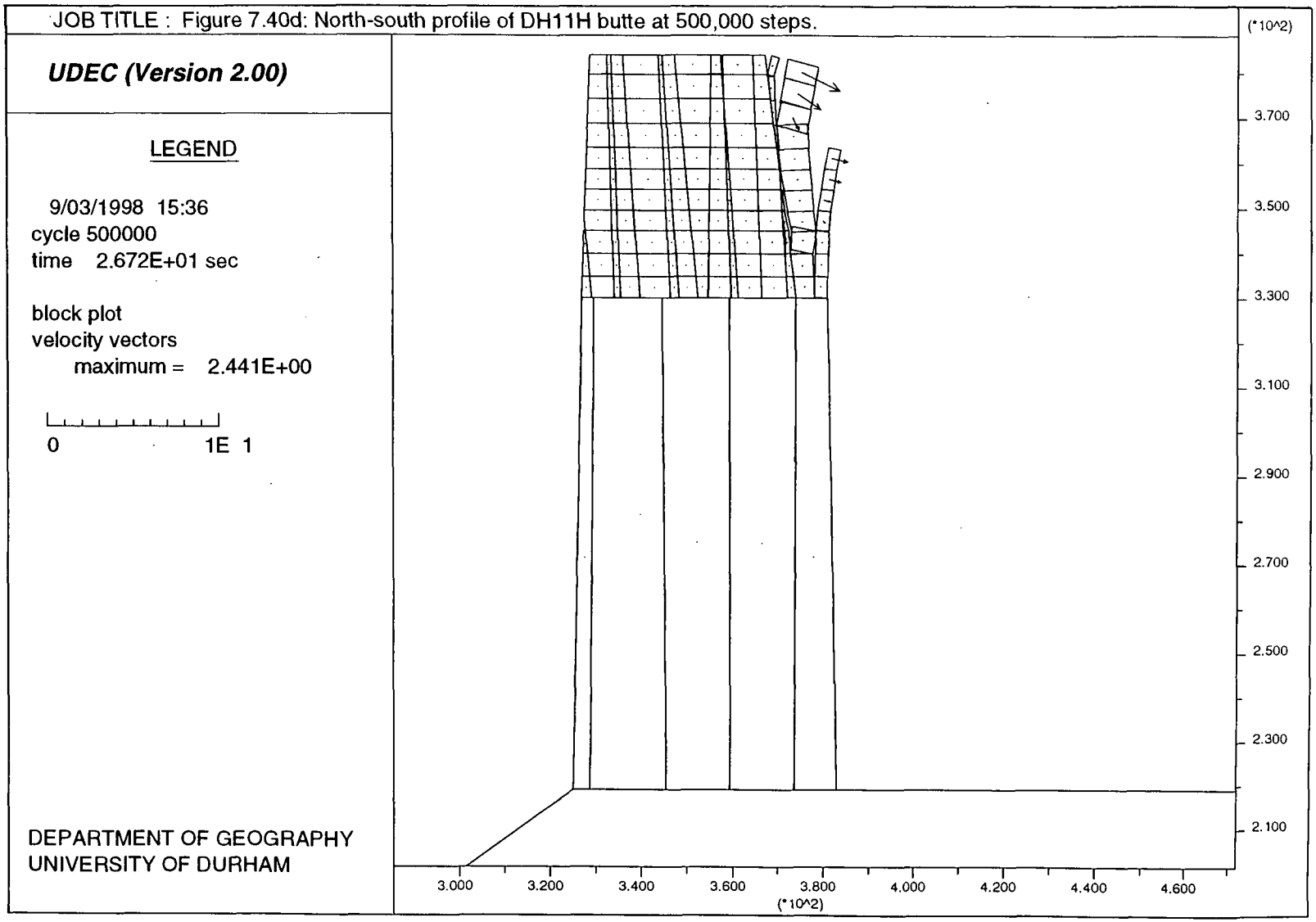

JOB TITLE : Figure 7.39c: East-west profile of DH11H butte at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 15:15
cycle 200000
time 4.510E+01 sec
block plot
velocity vectors
maximum = 2.742E-02
0
1E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.800
3.600
3.400
3.200
3.000
2.800
2.600
2.400
2.200
2.700
2.900
3.100
3.300
3.500
3.700
3.900
4.100
4.300
(*10^2)


JOB TITLE : Figure 7.39d: East-west profile of DH11H butte at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 15:17
cycle 500020
time 1.124E+02 sec
block plot
velocity vectors
maximum = 4.596E-07
0
2E -6
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.700
3.500
3.300
3.100
2.900
2.700
2.500
2.300
2.100
2.600
2.800
3.000
3.200
3.400
3.600
3.800
4.000
(*10^2)


JOB TITLE : Figure 7.40a: North-south profile of DH11H butte at equilibrium.
UDEC (Version 2.00)
LEGEND
9/03/1998 15:20
cycle 10000
time 4.692E-01 sec
block plot
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
4.000
3.000
2.000
1.000
.000
.500
1.500
2.500
3.500
4.500
(*10^2)


JOB TITLE : Figure 7.40b: North-south profile of DH11H butte at 100,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 15:26
cycle 100000
time 5.261E+00 sec
block plot
velocity vectors
maximum = 7.979E-01
0 2E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.900
3.700
3.500
3.300
3.100
2.900
2.700
2.500
2.300
2.100
2.900
3.100
3.300
3.500
3.700
3.900
4.100
4.300
4.500
(*10^2)


JOB TITLE : Figure 7.40c: North-south profile of DH11H butte at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 15:30
cycle 200000
time 1.064E+01 sec
block plot
velocity vectors
maximum = 7.726E-01
0 2E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.700
3.500
3.300
3.100
2.900
2.700
2.500
2.300
2.100
3.100
3.300
3.500
3.700
3.900
4.100
4.300
4.500
4.700
(*10^2)


JOB TITLE : Figure 7.40d: North-south profile of DH11H butte at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 15:36
cycle 500000
time 2.672E+01 sec
block plot
velocity vectors
maximum = 2.441E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
3.700
3.500
3.300
3.100
2.900
2.700
2.500
2.300
2.100
3.000
3.200
3.400
3.600
3.800
4.000
4.200
4.400
4.600
(*10^2)

JOB TITLE : Figure 7.41a: CO56H at equilibrium (10,000 steps).

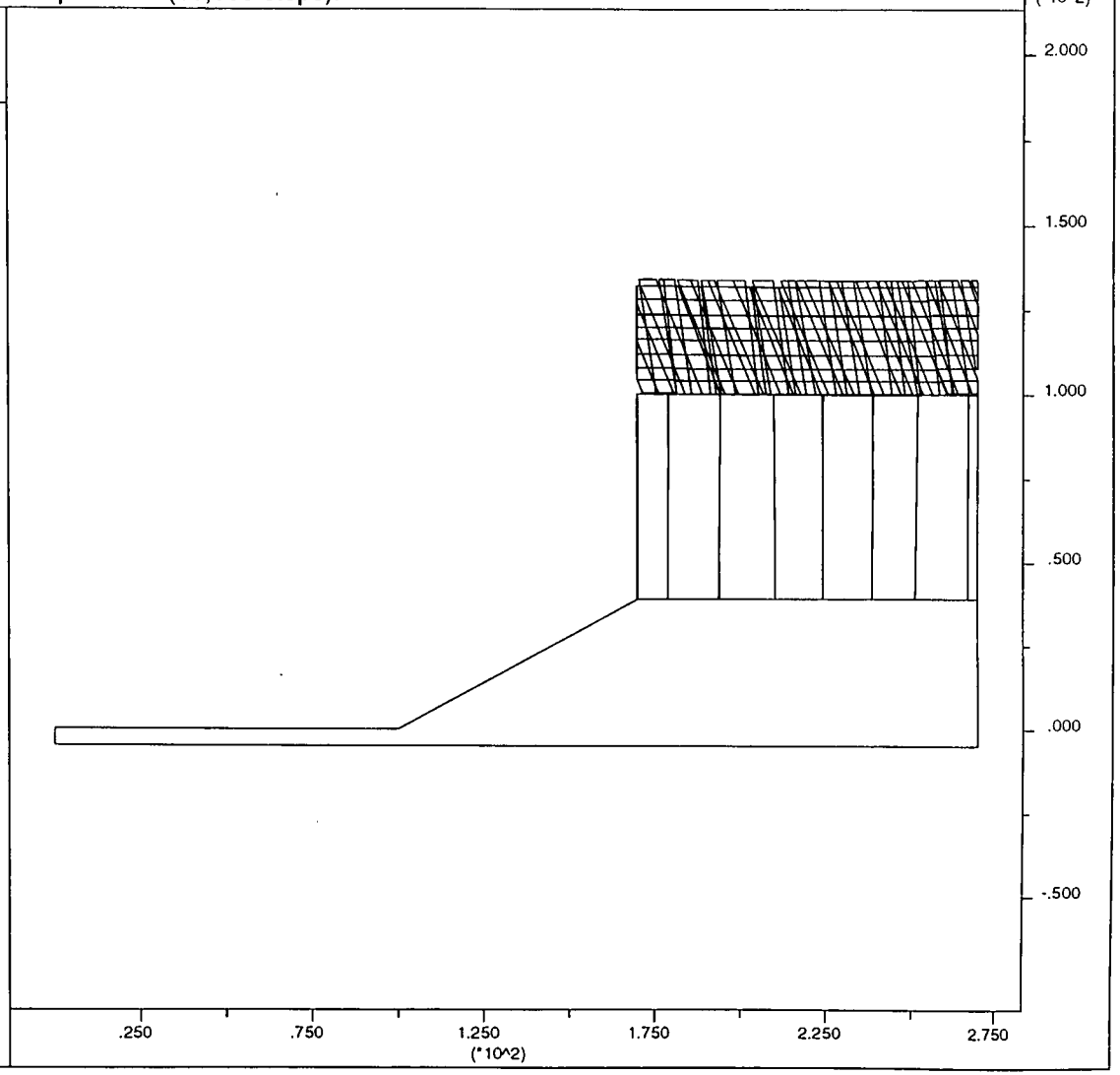
UDEC (Version 2.00)

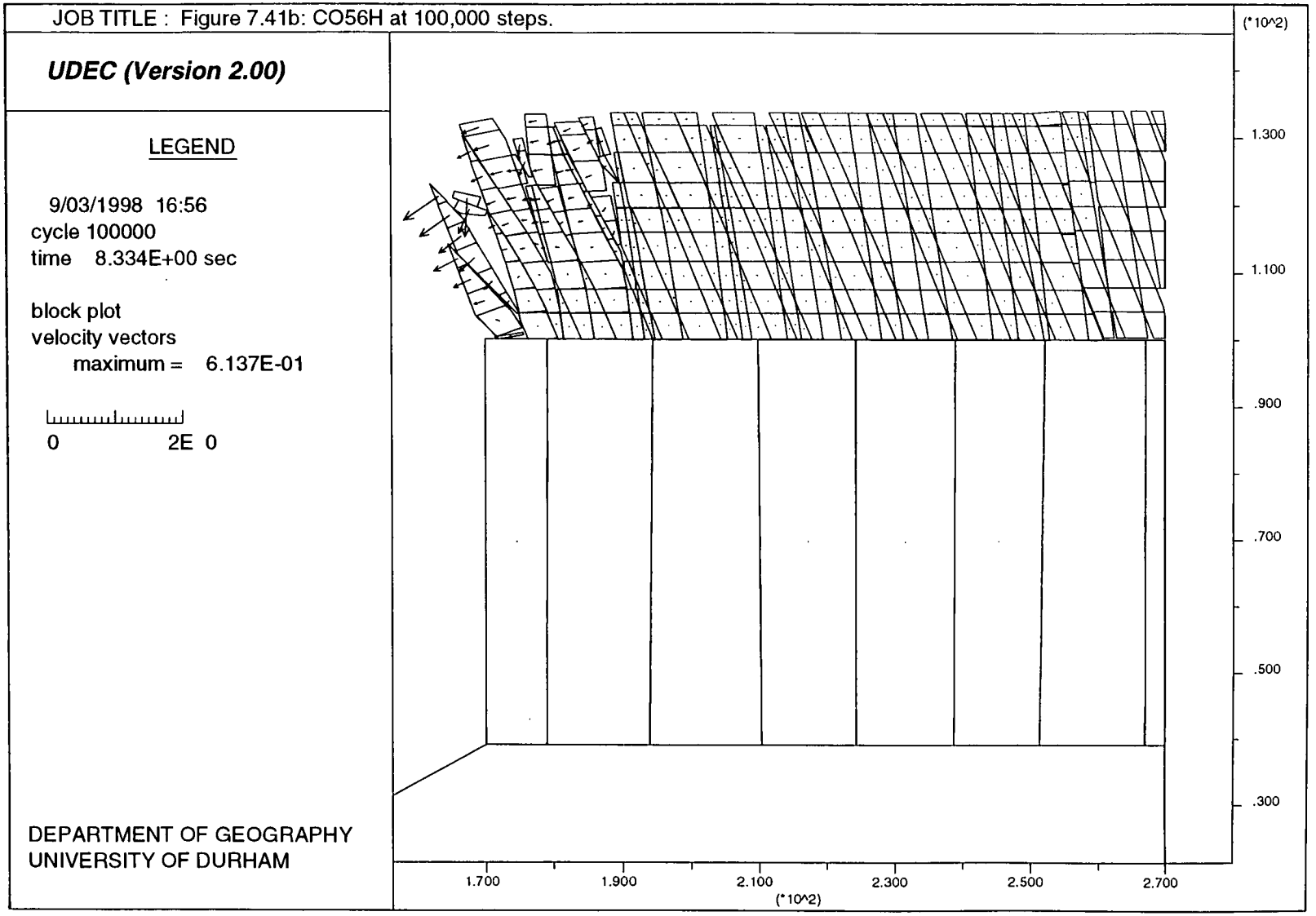
LEGEND

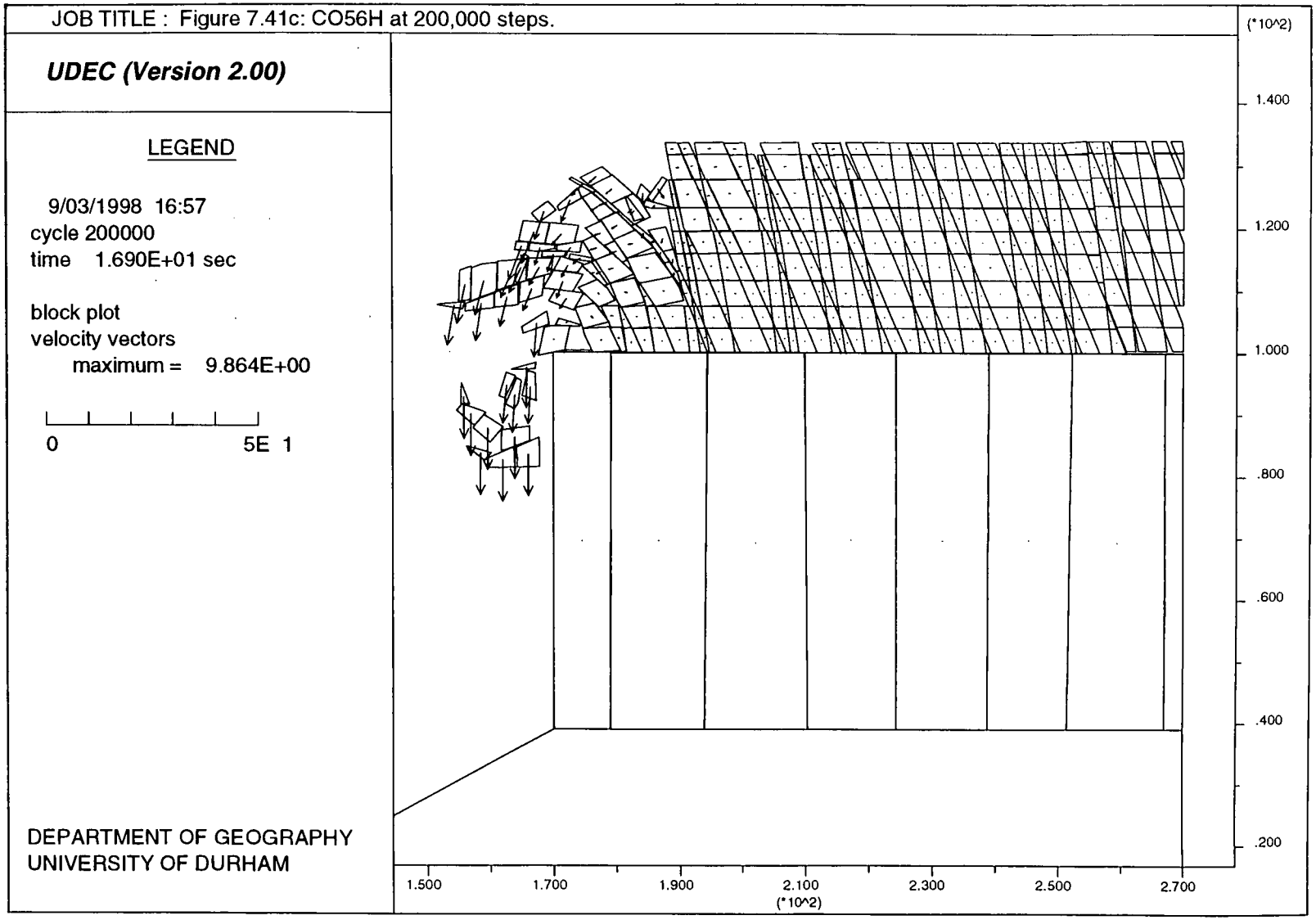
9/03/1998 16:55
cycle 10000
time 6.958E-01 sec

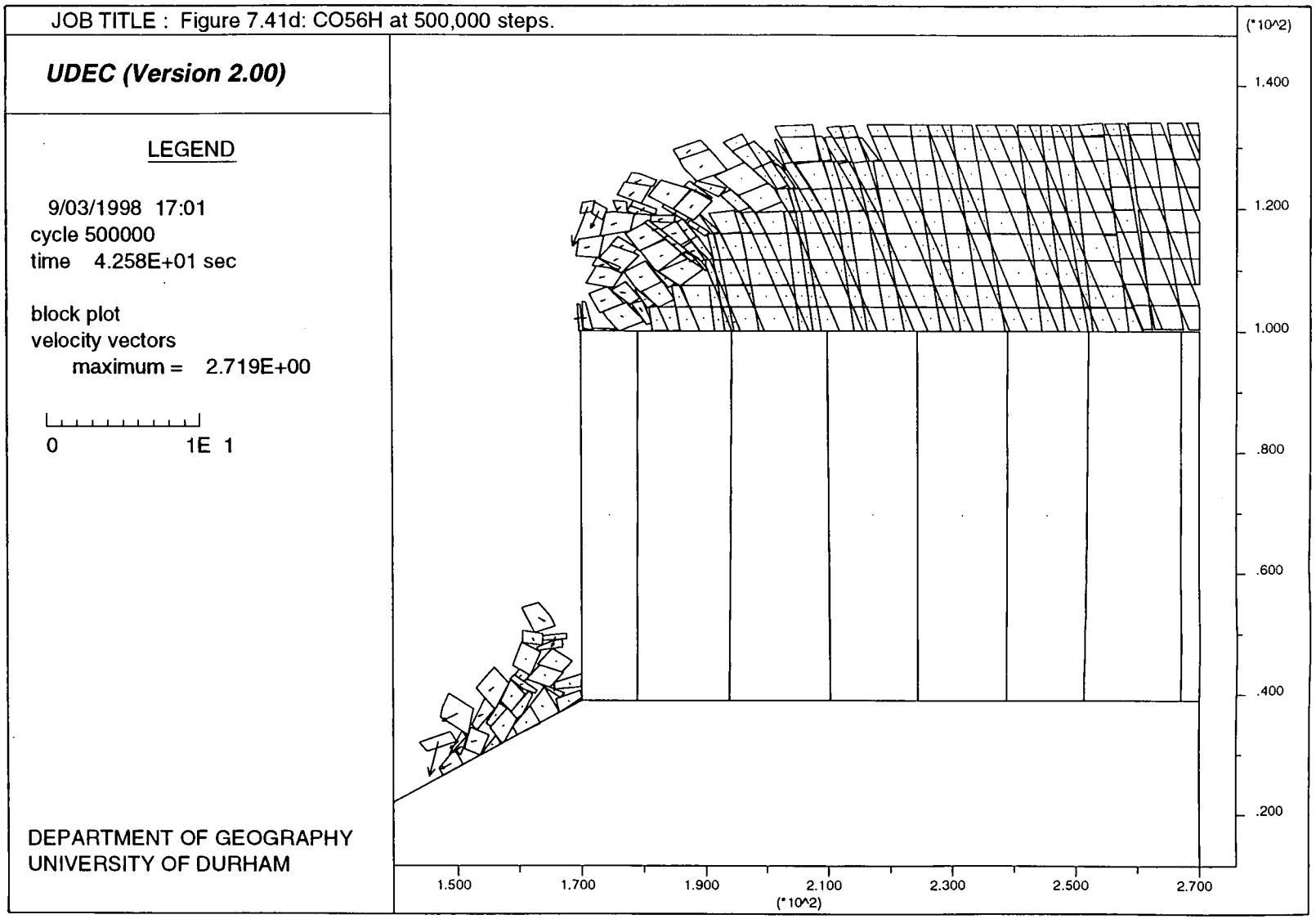
block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.41b: CO56H at 100,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 16:56
cycle 100000
time 8.334E+00 sec
block plot
velocity vectors
maximum = 6.137E-01
0 2E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.300
1.100
.900
.700
.500
.300
1.700
1.900
2.100
2.300
2.500
2.700
(*10^2)


JOB TITLE : Figure 7.41c: CO56H at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 16:57
cycle 200000
time 1.690E+01 sec
block plot
velocity vectors
maximum = 9.864E+00
0
5E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.400
1.200
1.000
.800
.600
.400
.200
1.500
1.700
1.900
2.100
2.300
2.500
2.700
(*10^2)


JOB TITLE : Figure 7.41d: CO56H at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:01
cycle 500000
time 4.258E+01 sec
block plot
velocity vectors
maximum = 2.719E+00
0
1E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.400
1.200
1.000
.800
.600
.400
.200
1.500
1.700
1.900
2.100
2.300
2.500
2.700
(*10^2)

JOB TITLE : Figure 7.42a: CO9E at equilibrium (10,000 steps).

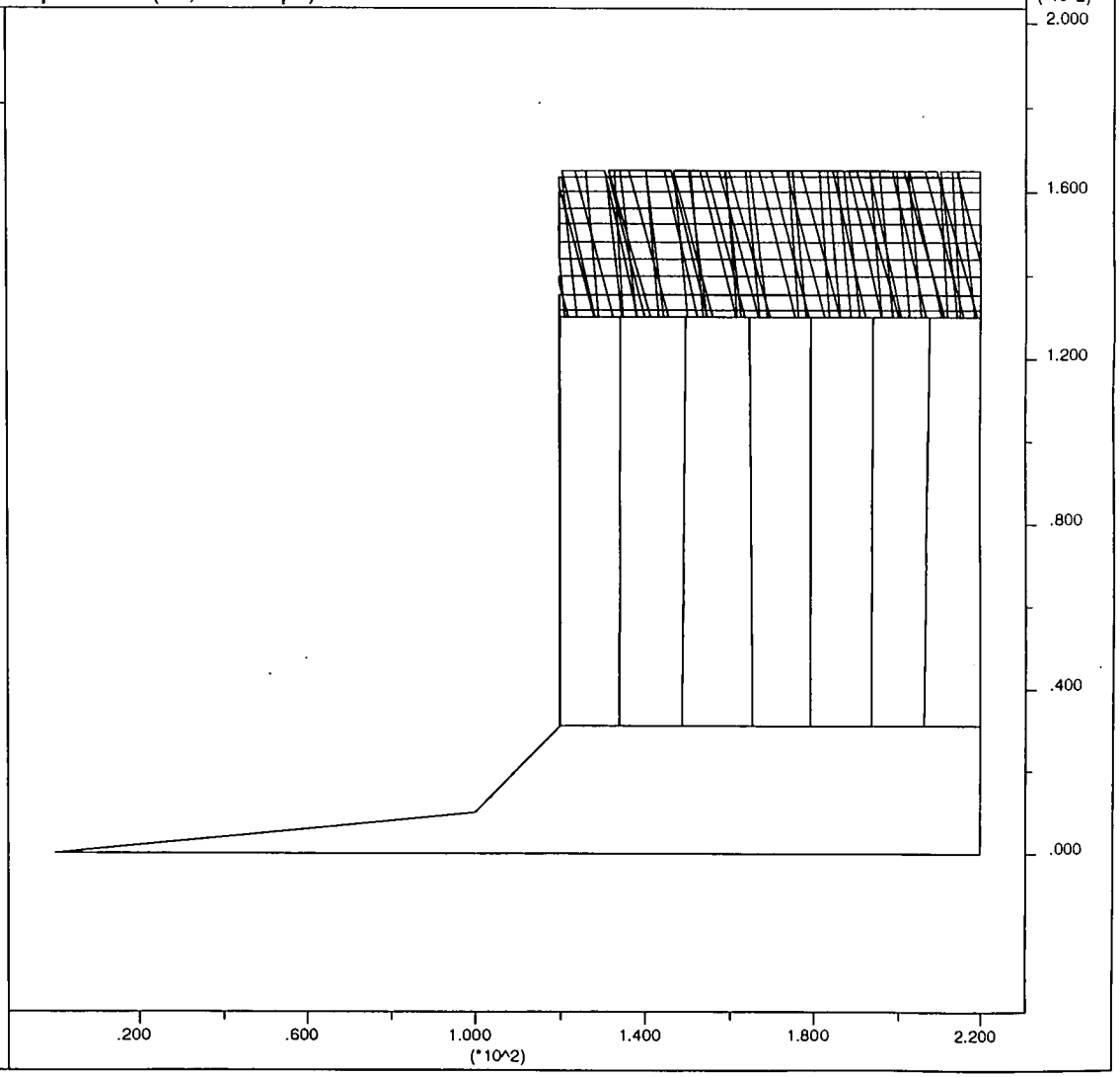
UDEC (Version 2.00)

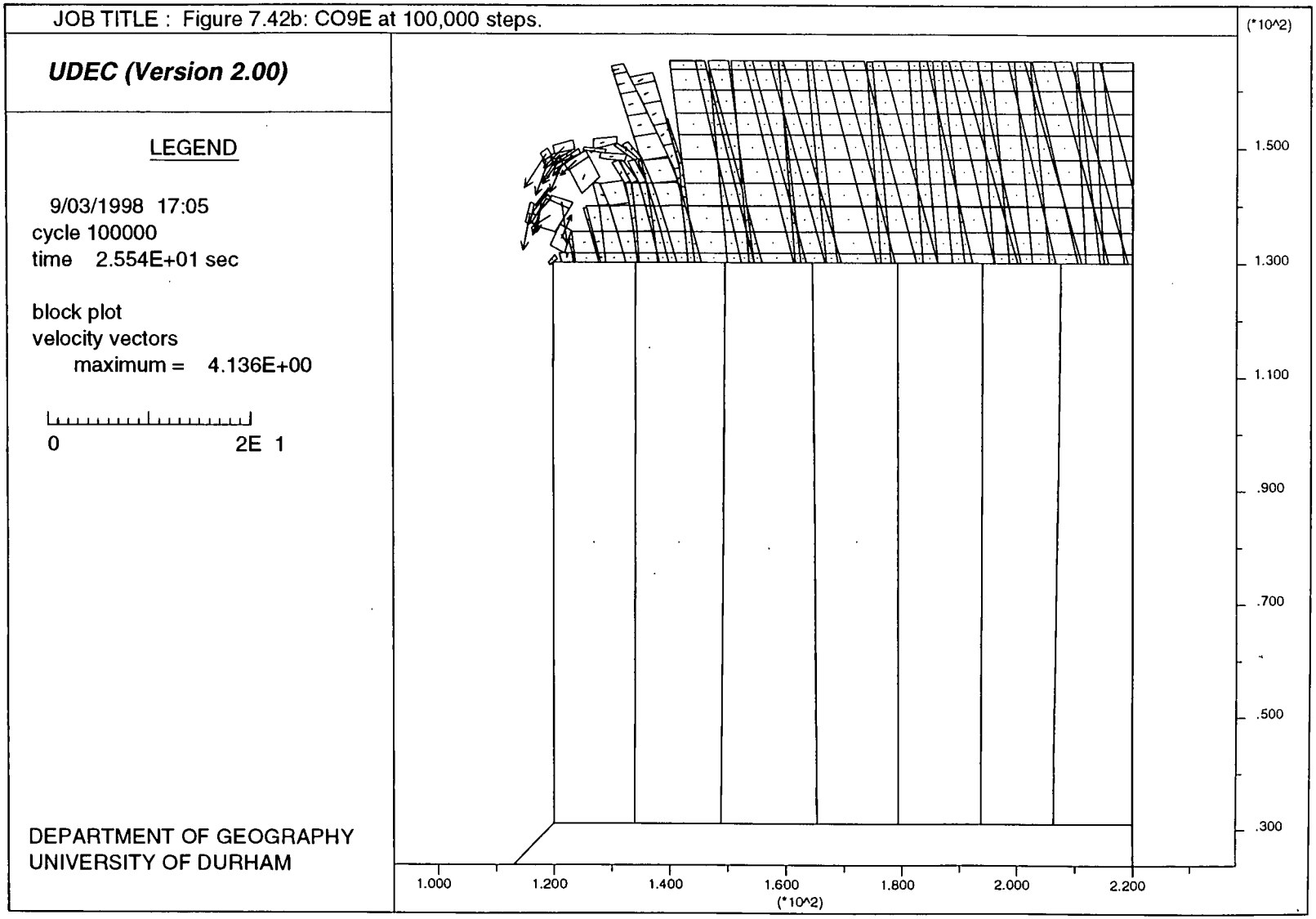
LEGEND

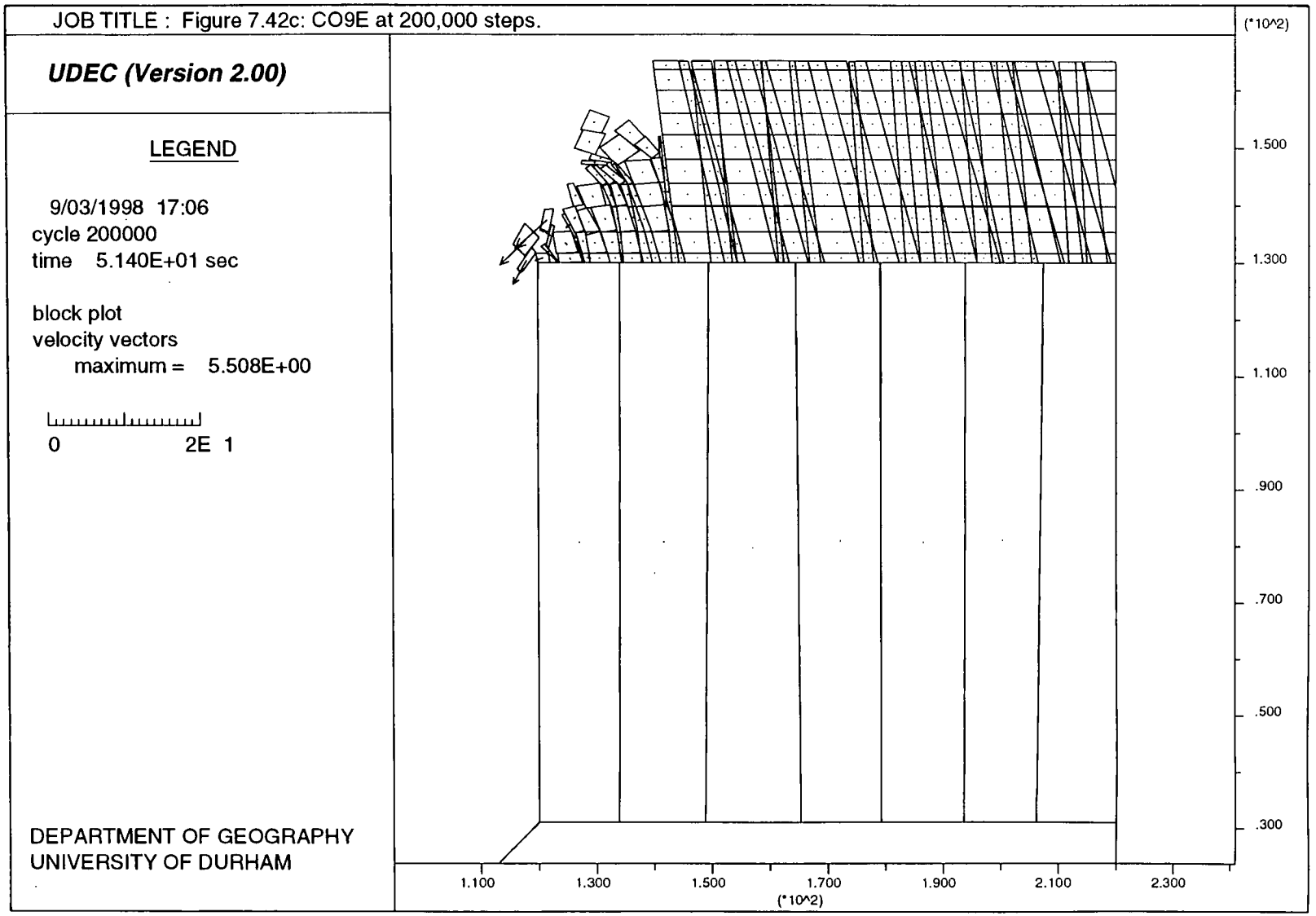
9/03/1998 17:03
cycle 10000
time 2.372E+00 sec

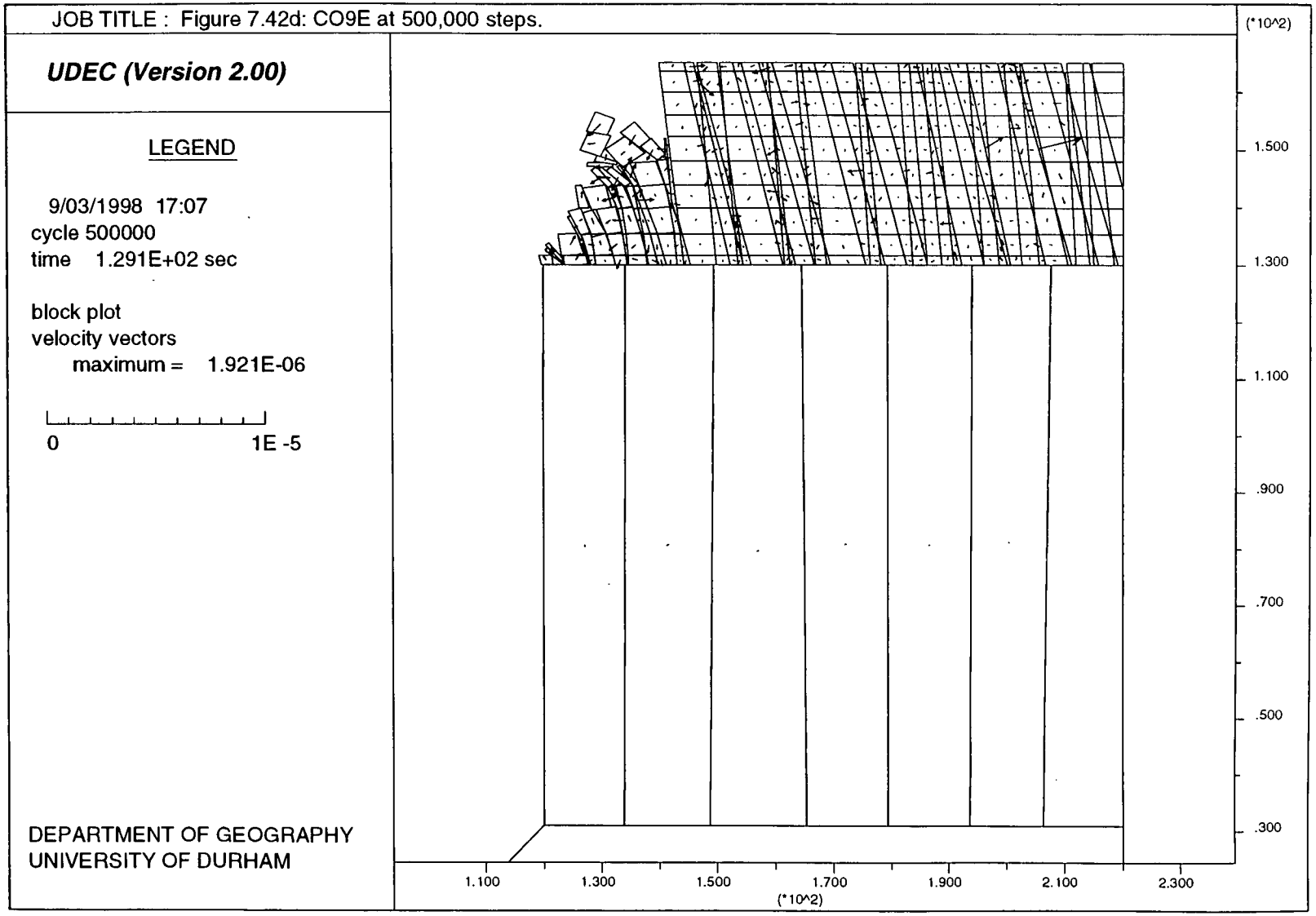
block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.42b: CO9E at 100,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:05
cycle 100000
time 2.554E+01 sec
block plot
velocity vectors
maximum = 4.136E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.500
1.300
1.100
.900
.700
.500
.300
1.000
1.200
1.400
1.600
1.800
2.000
2.200
(*10^2)


JOB TITLE : Figure 7.42c: CO9E at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:06
cycle 200000
time 5.140E+01 sec
block plot
velocity vectors
maximum = 5.508E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.500
1.300
1.100
.900
.700
.500
.300
1.100
1.300
1.500
1.700
1.900
2.100
2.300
(*10^2)


JOB TITLE : Figure 7.42d: CO9E at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:07
cycle 500000
time 1.291E+02 sec
block plot
velocity vectors
maximum = 1.921E-06
0
1E -5
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.500
1.300
1.100
.900
.700
.500
.300
1.100
1.300
1.500
1.700
1.900
2.100
2.300
(*10^2)

JOB TITLE : Figure 7.43a: CO19E at equilibrium.

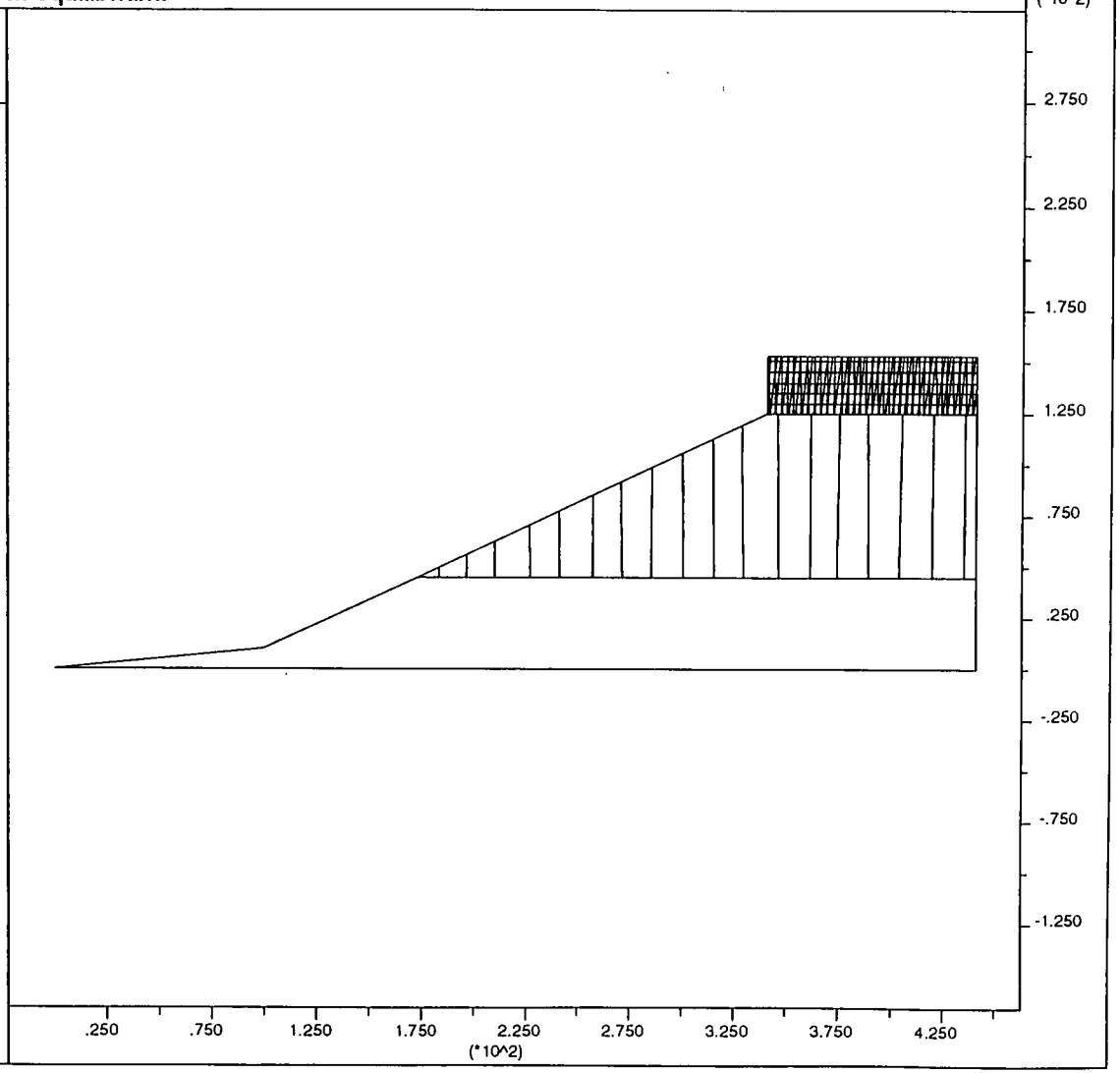
UDEC (Version 2.00)

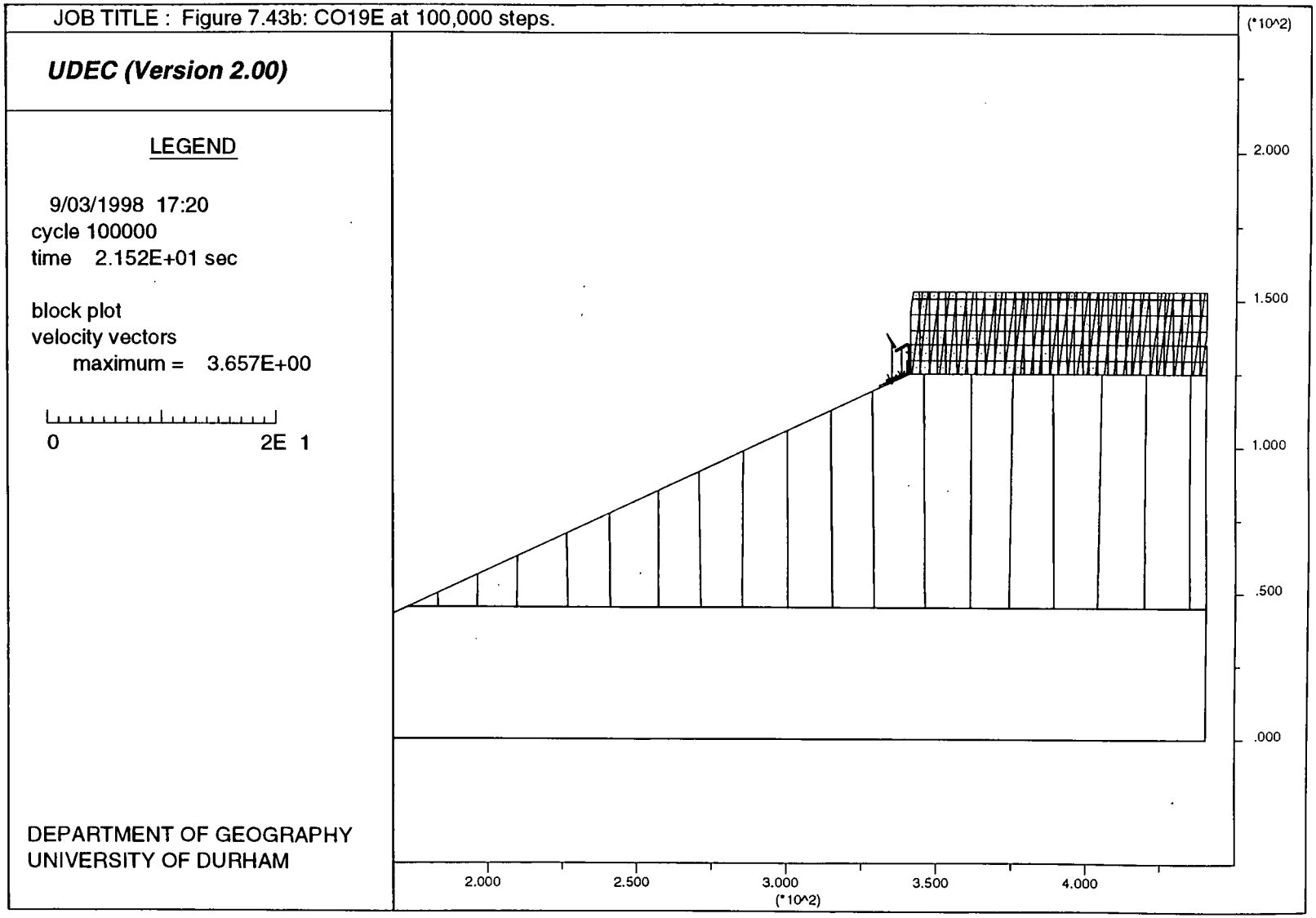
LEGEND

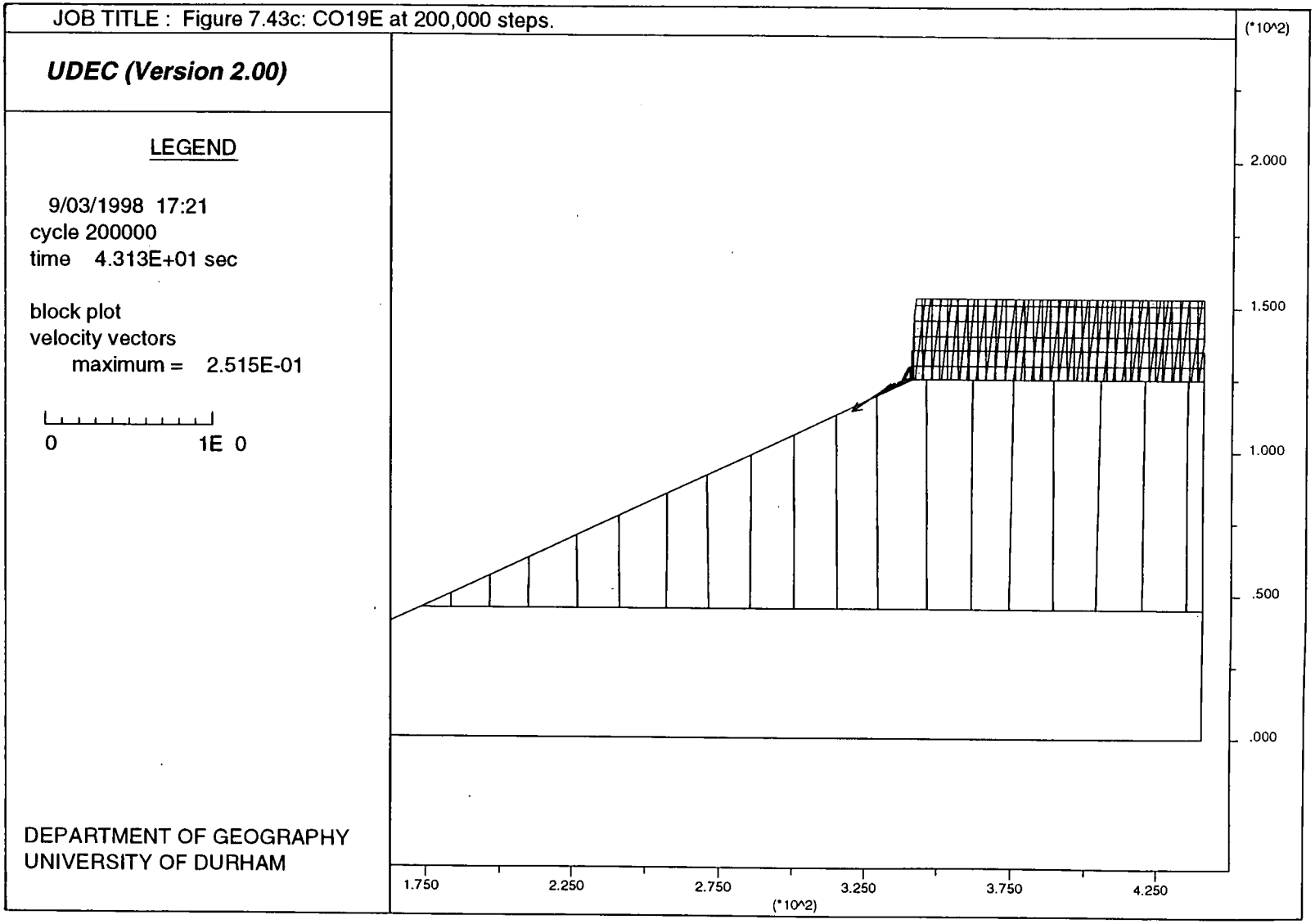
9/03/1998 17:19
cycle 10000
time 2.098E+00 sec

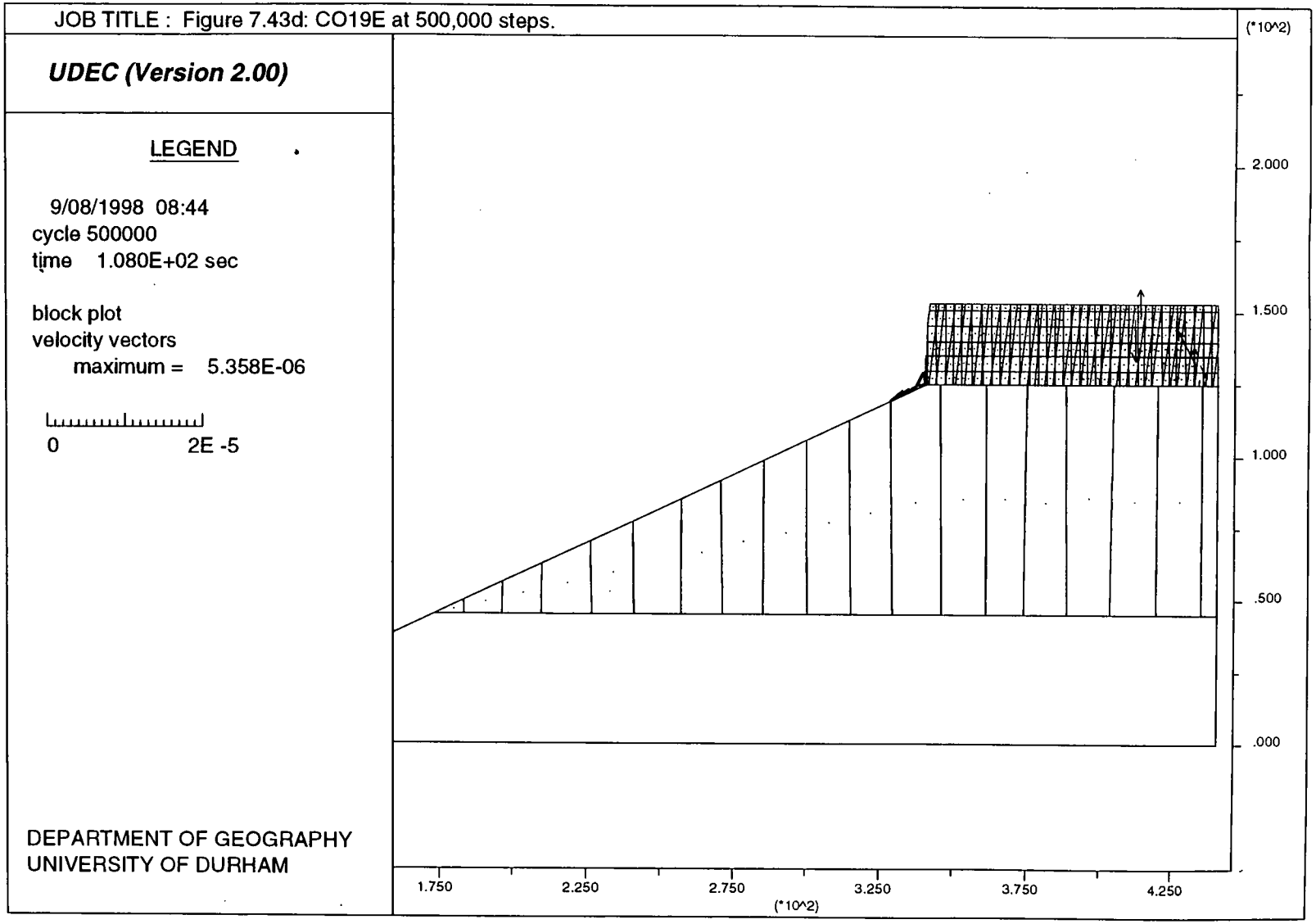
block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.43b: CO19E at 100,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:20
cycle 100000
time 2.152E+01 sec
block plot
velocity vectors
maximum = 3.657E+00
0
2E 1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
2.000
1.500
1.000
.500
.000
2.000
2.500
3.000
3.500
4.000
(*10^2)


JOB TITLE : Figure 7.43c: CO19E at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:21
cycle 200000
time 4.313E+01 sec
block plot
velocity vectors
maximum = 2.515E-01
0
1E 0
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
2.000
1.500
1.000
.500
.000
1.750
2.250
2.750
3.250
3.750
4.250
(*10^2)


JOB TITLE : Figure 7.43d: CO19E at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/08/1998 08:44
cycle 500000
time 1.080E+02 sec
block plot
velocity vectors
maximum = 5.358E-06
0
2E -5
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
2.000
1.500
1.000
.500
.000
1.750
2.250
2.750
3.250
3.750
4.250
(*10^2)

JOB TITLE : Figure 7.44a: CO12E / CO13E neck at equilibrium (10,000 steps).

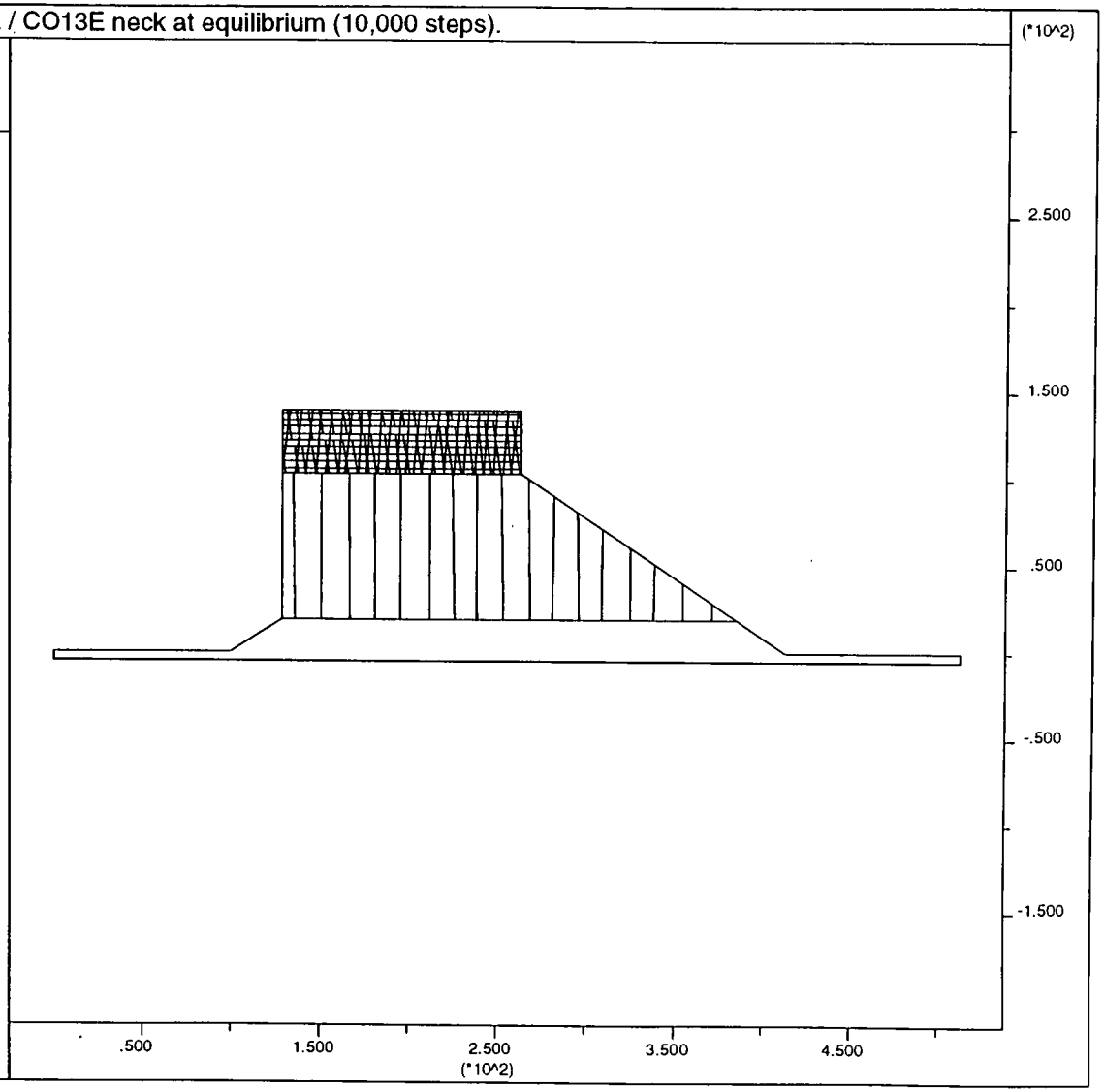
UDEC (Version 2.00)

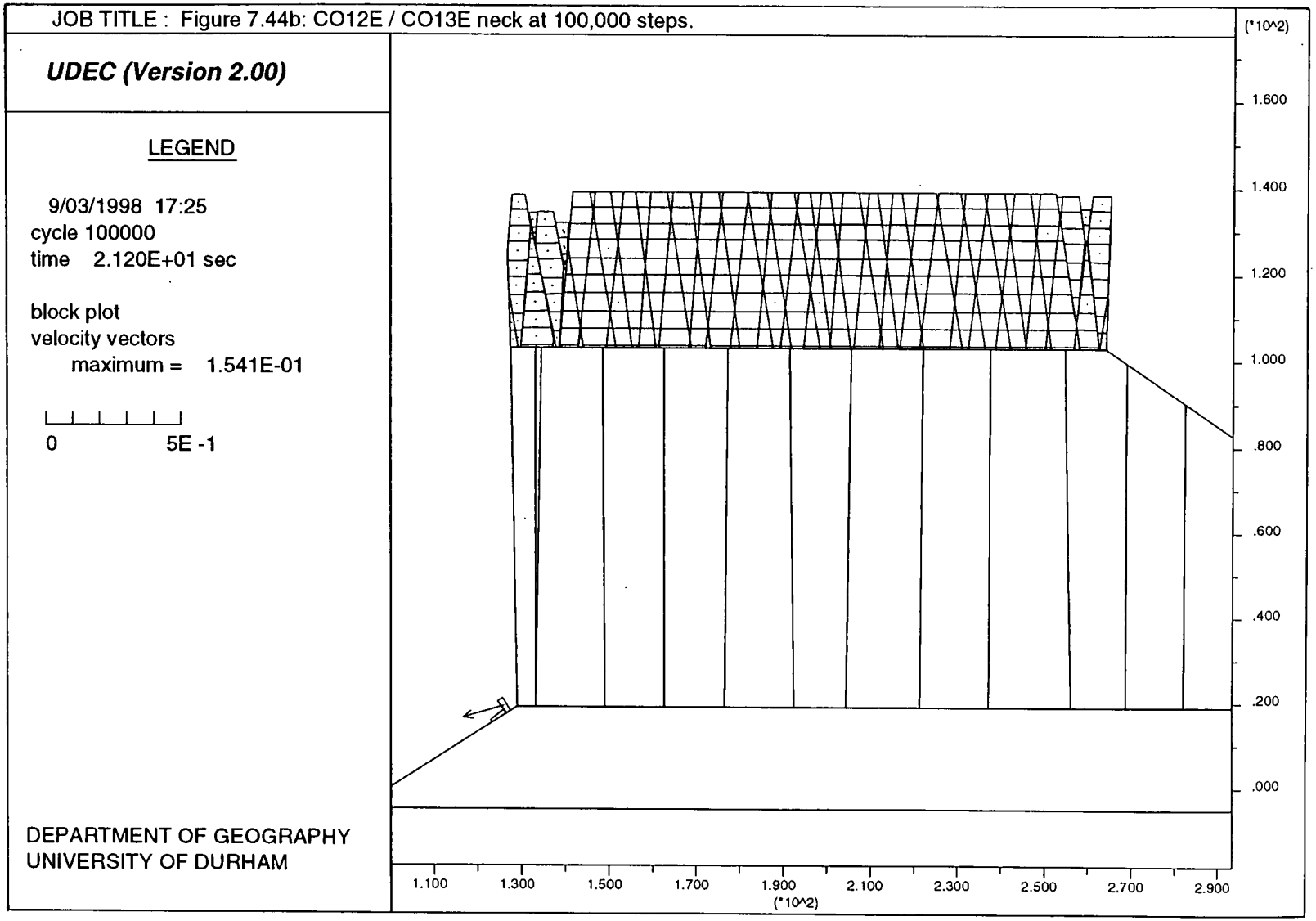
LEGEND

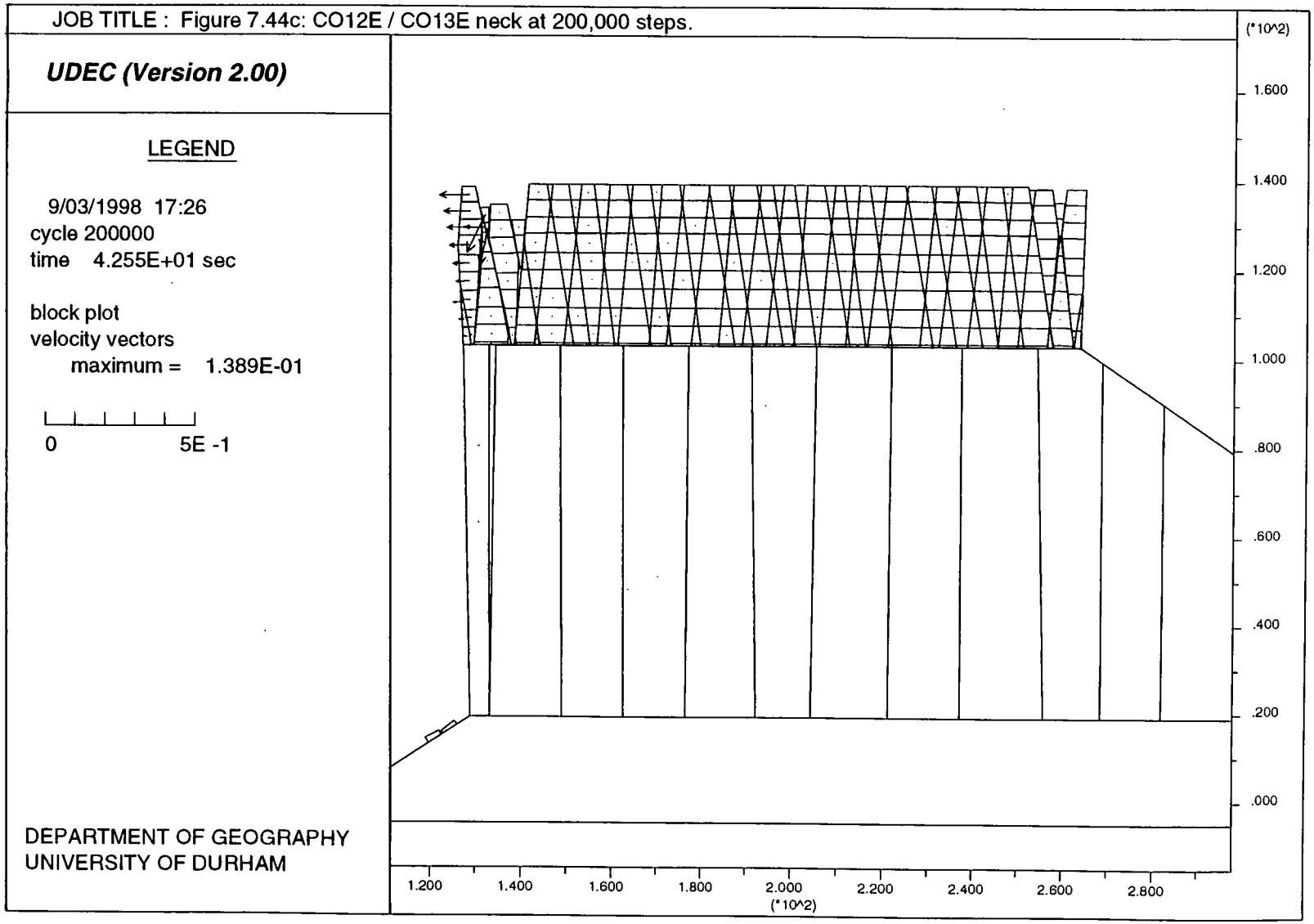
9/03/1998 17:24
cycle 10000
time 2.051E+00 sec

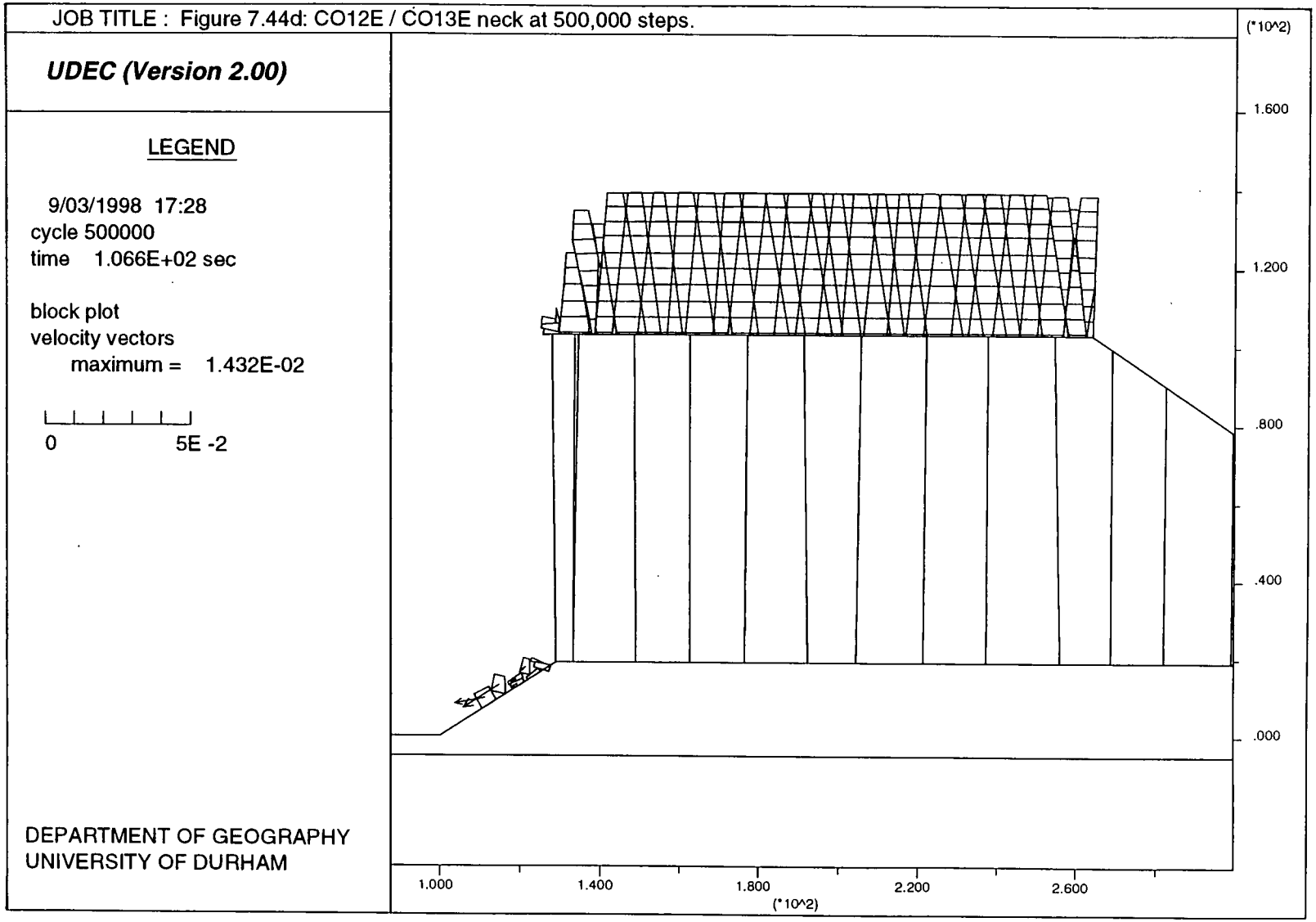
block plot

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM




JOB TITLE : Figure 7.44b: CO12E / CO13E neck at 100,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:25
cycle 100000
time 2.120E+01 sec
block plot
velocity vectors
maximum = 1.541E-01
0
5E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.600
1.400
1.200
1.000
.800
.600
.400
.200
.000
1.100
1.300
1.500
1.700
1.900
2.100
2.300
2.500
2.700
2.900
(*10^2)


JOB TITLE : Figure 7.44c: CO12E / CO13E neck at 200,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:26
cycle 200000
time 4.255E+01 sec
block plot
velocity vectors
maximum = 1.389E-01
0
5E -1
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.600
1.400
1.200
1.000
.800
.600
.400
.200
.000
1.200
1.400
1.600
1.800
2.000
2.200
2.400
2.600
2.800
(*10^2)


JOB TITLE : Figure 7.44d: CO12E / CO13E neck at 500,000 steps.
UDEC (Version 2.00)
LEGEND
9/03/1998 17:28
cycle 500000
time 1.066E+02 sec
block plot
velocity vectors
maximum = 1.432E-02
0
5E -2
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF DURHAM
(*10^2)
1.600
1.200
.800
.400
.000
1.000
1.400
1.800
2.200
2.600
(*10^2)

Plates

Plate 5.1: The western pincer at the entrance to Lulworth Cove. Portland Limestone forms the sea cliff, with the contorted Purbeck Beds behind.

Plate 5.2: Portland Limestone reef across St. Oswald's Bay.

Plate 5.3: Durdle Door arch and the western part of the Durdle Promontory.

Plate 5.4: Portland Limestone cliffs at Stair Hole and the Lulworth Crumple in the Purbeck Beds.

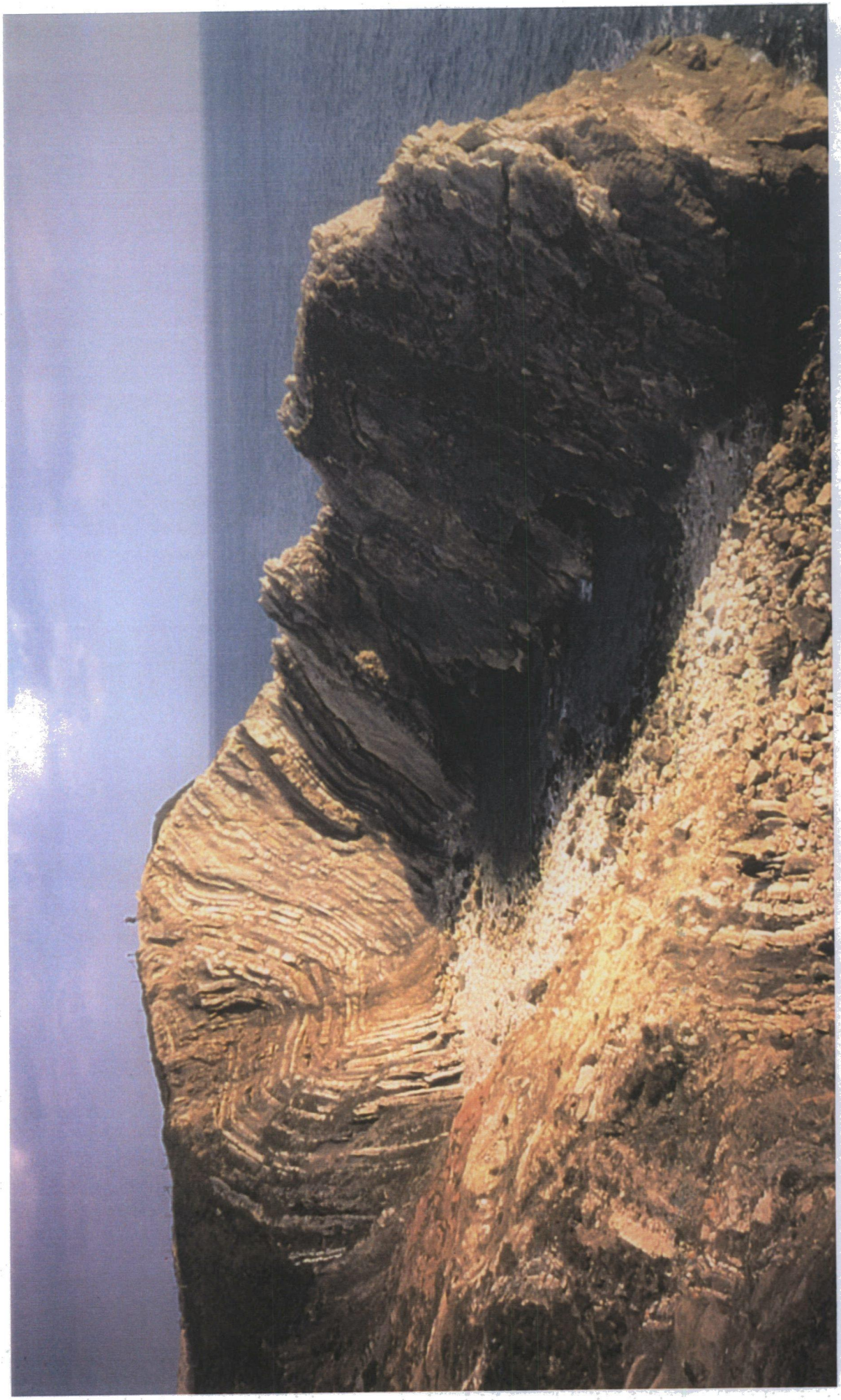


Plate 5.5: The field site on the eastern pincer at Lulworth Cove. Note the dip of the bedding in the Portland Limestone which is measured at 27°.

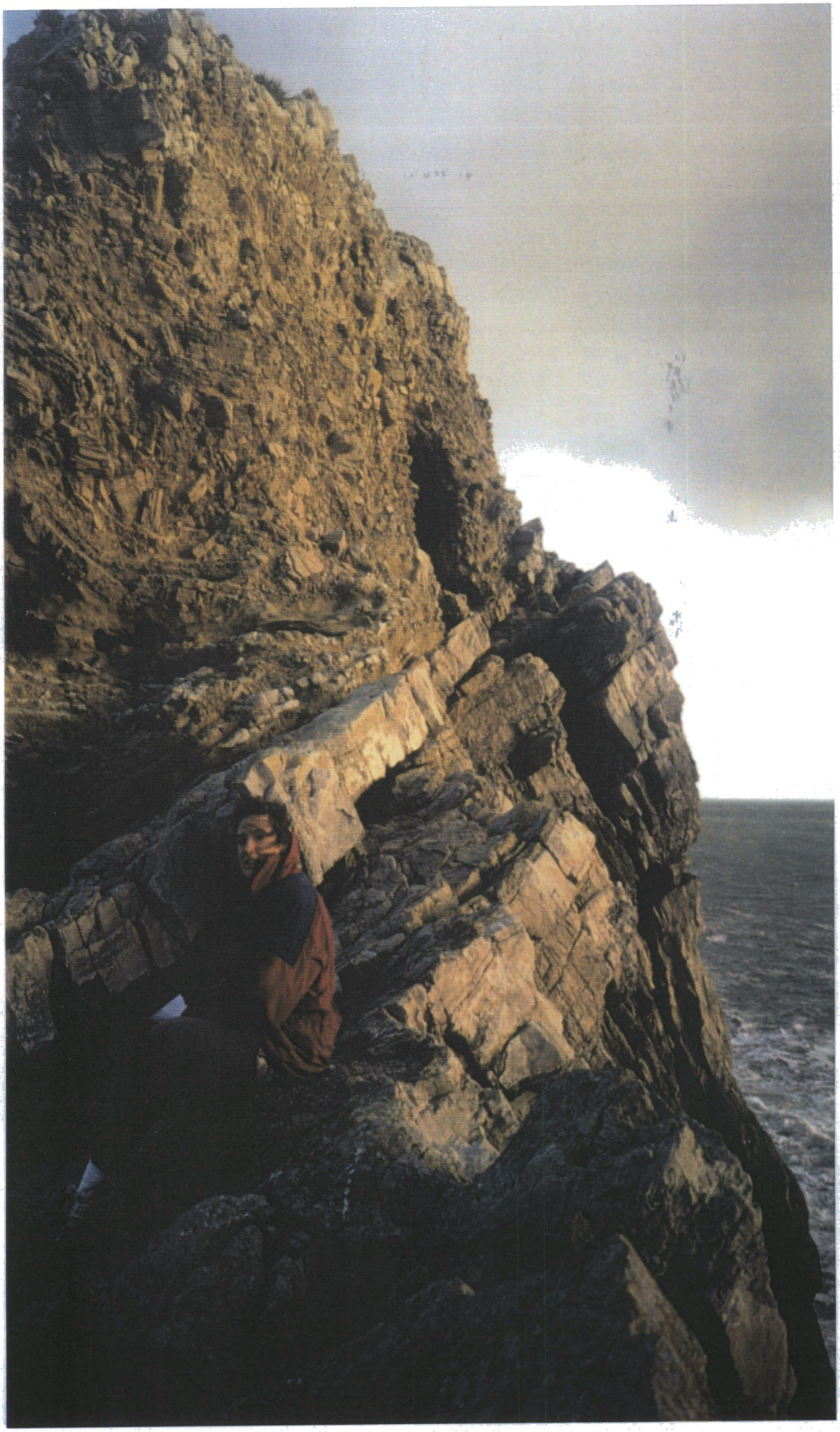


Plate 5.6: The Portland Limestone outcrop at Fossil Forest.

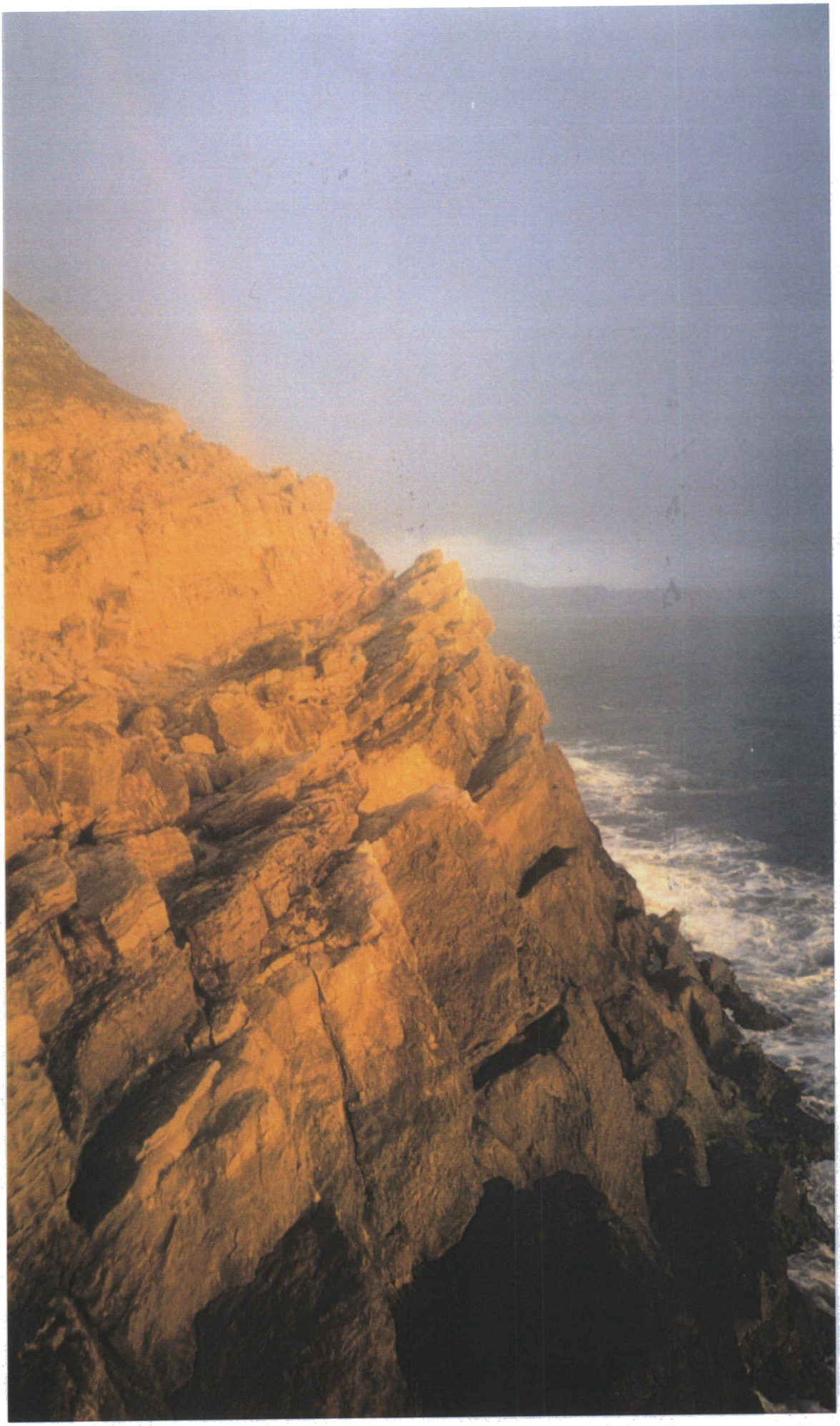


Plate 5.7: The Portland Limestone sea cliffs at the western entrance to Bacon Hole.

Plate 5.8: The field sites at Worbarrow Tout (left) and Pondfield (right). Note how the Portland Limestone outcrop rises above Kimmeridge Clay in Gad Cliff to the east of Pondfield.

Plate 5.9: The quarried Portland Limestone outcrop at Winspit.

Plate 5.10: The Portland Limestone sea cliffs at Seacombe.

Plate 5.11: The horizontally bedded Portland Limestone outcrop at Tillywhim.

Plate 5.12: A toppling block of Portland Limestone embedded within the Kimmeridge Clay at St. Alban's Head.

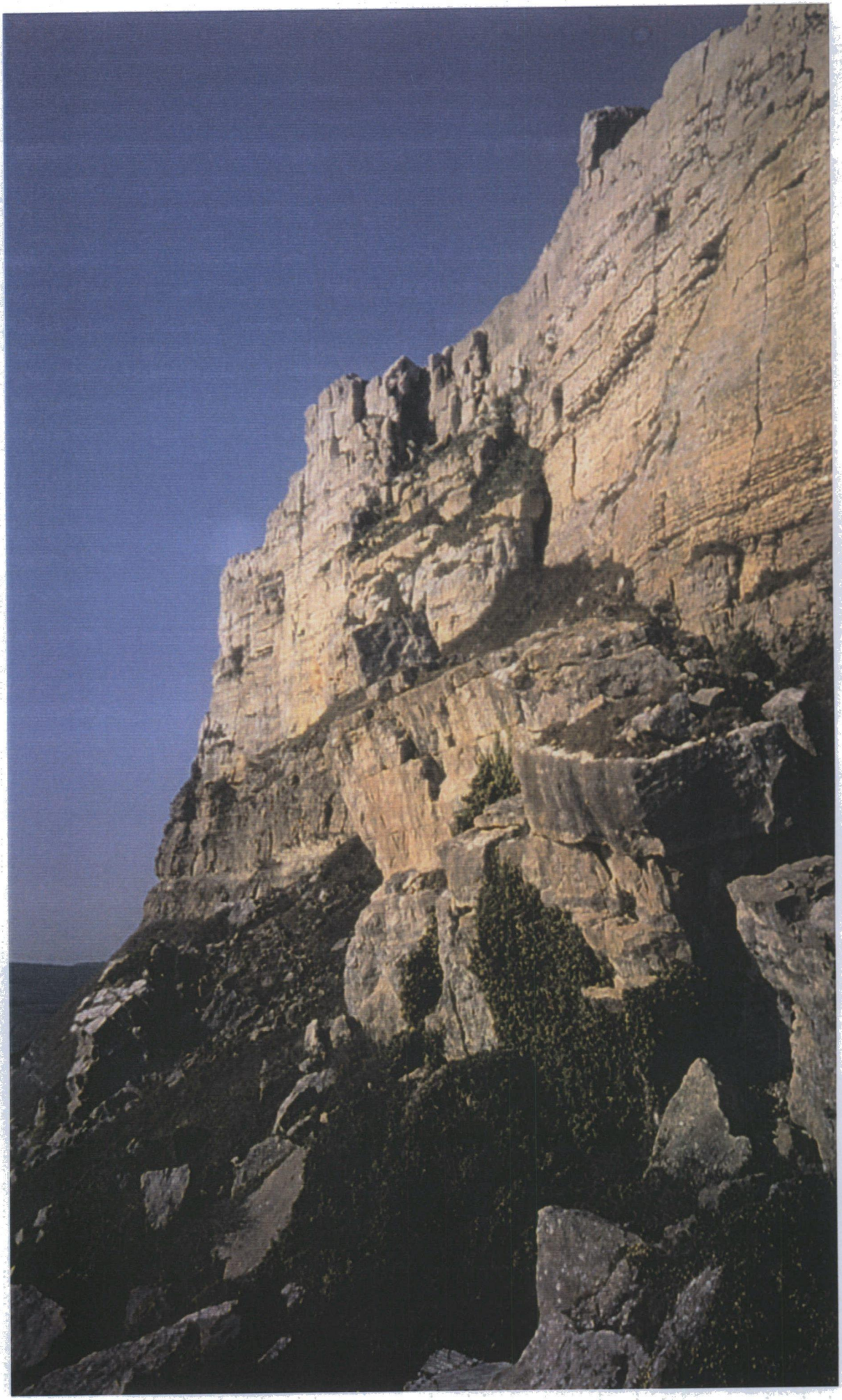


Plate 5.13: Typical view of the Colorado Plateau in the Canyonlands region.

Plate 5.14: White Rim Sandstone scarp plan form in the Canyonlands region.

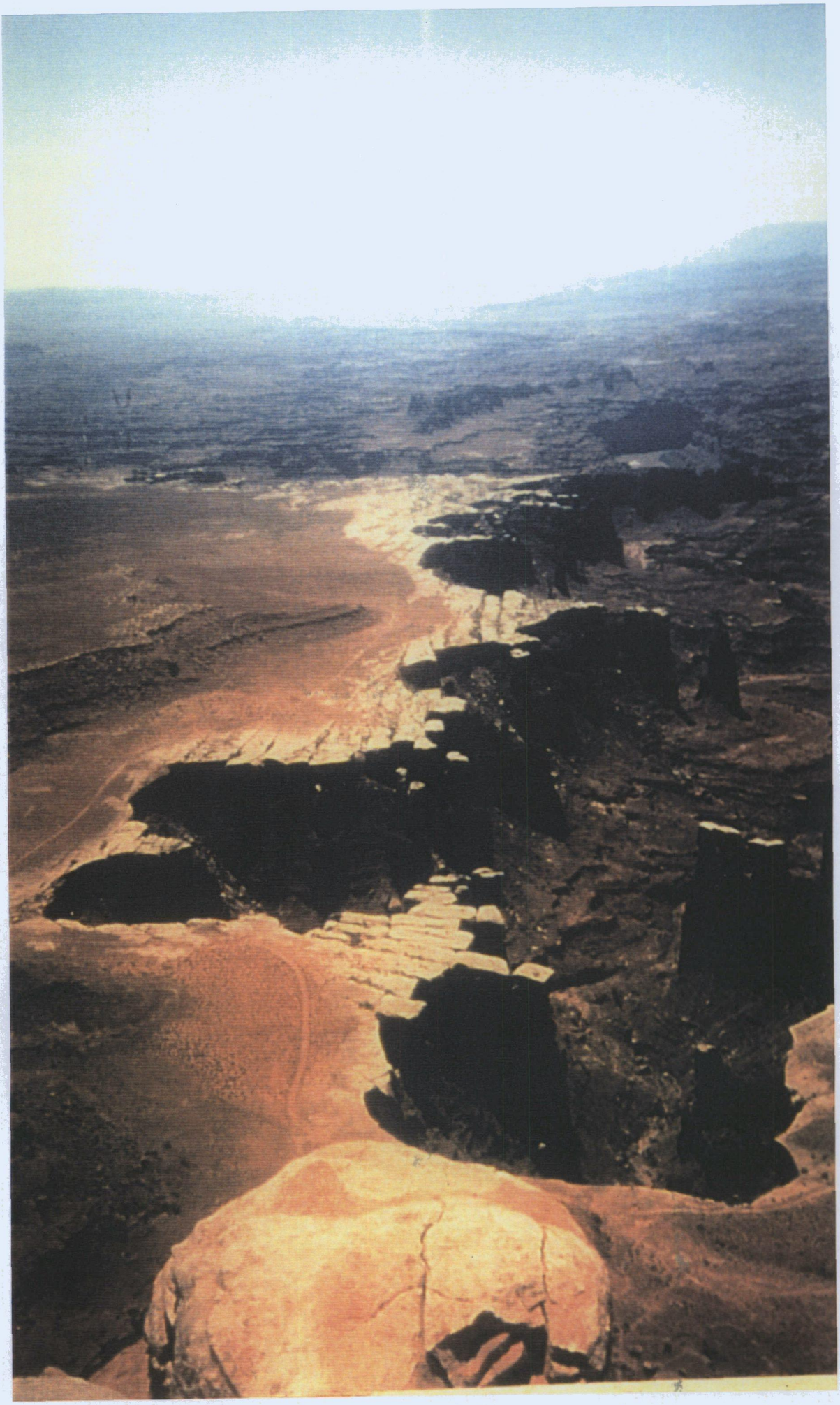


Plate 5.15: The Chinle Formation / Wingate Sandstone / Kayenta Formation cliffs at Dead Horse Point State Park.

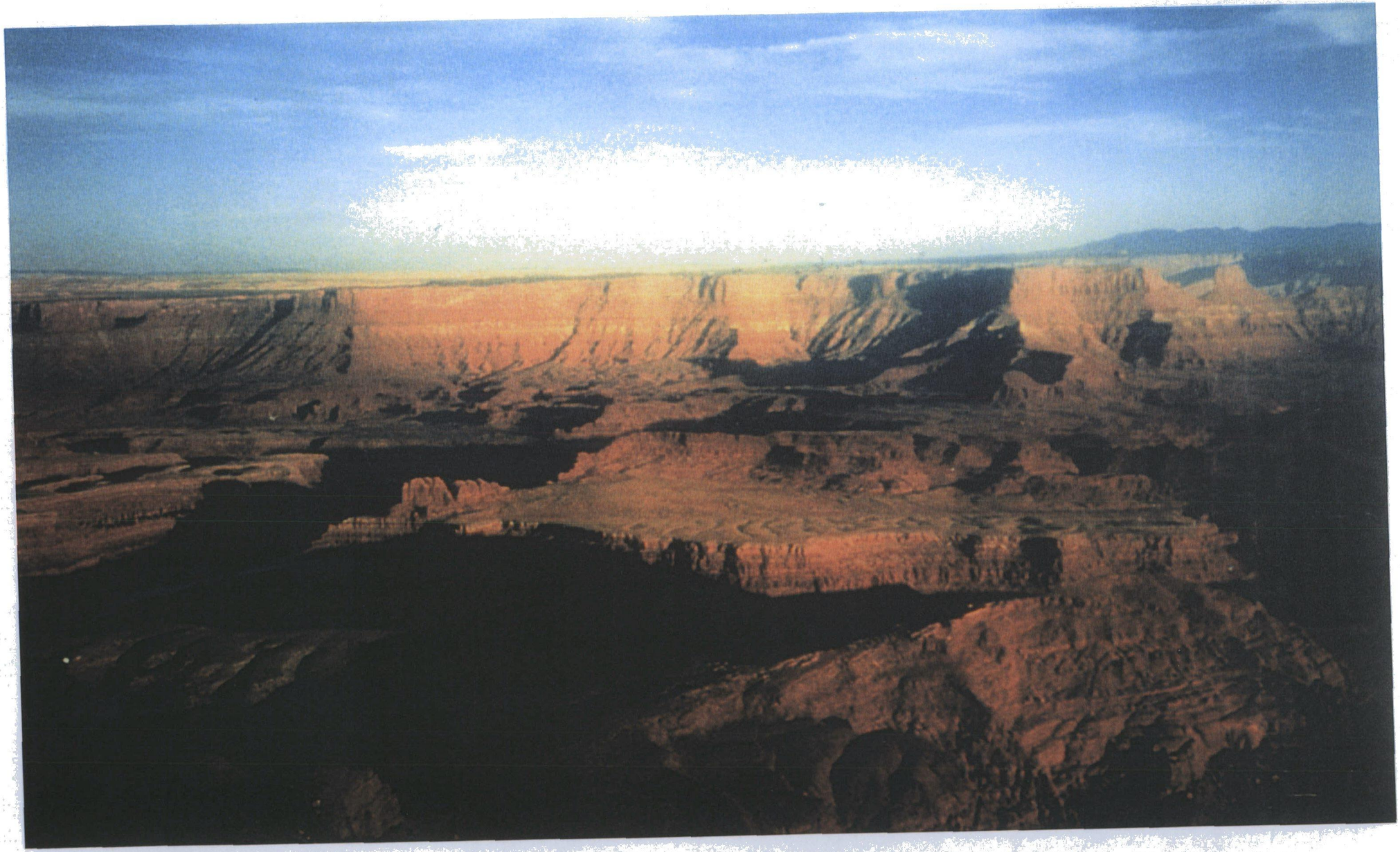


Plate 5.16: Headland site DH6H at Dead Horse Point State Park.

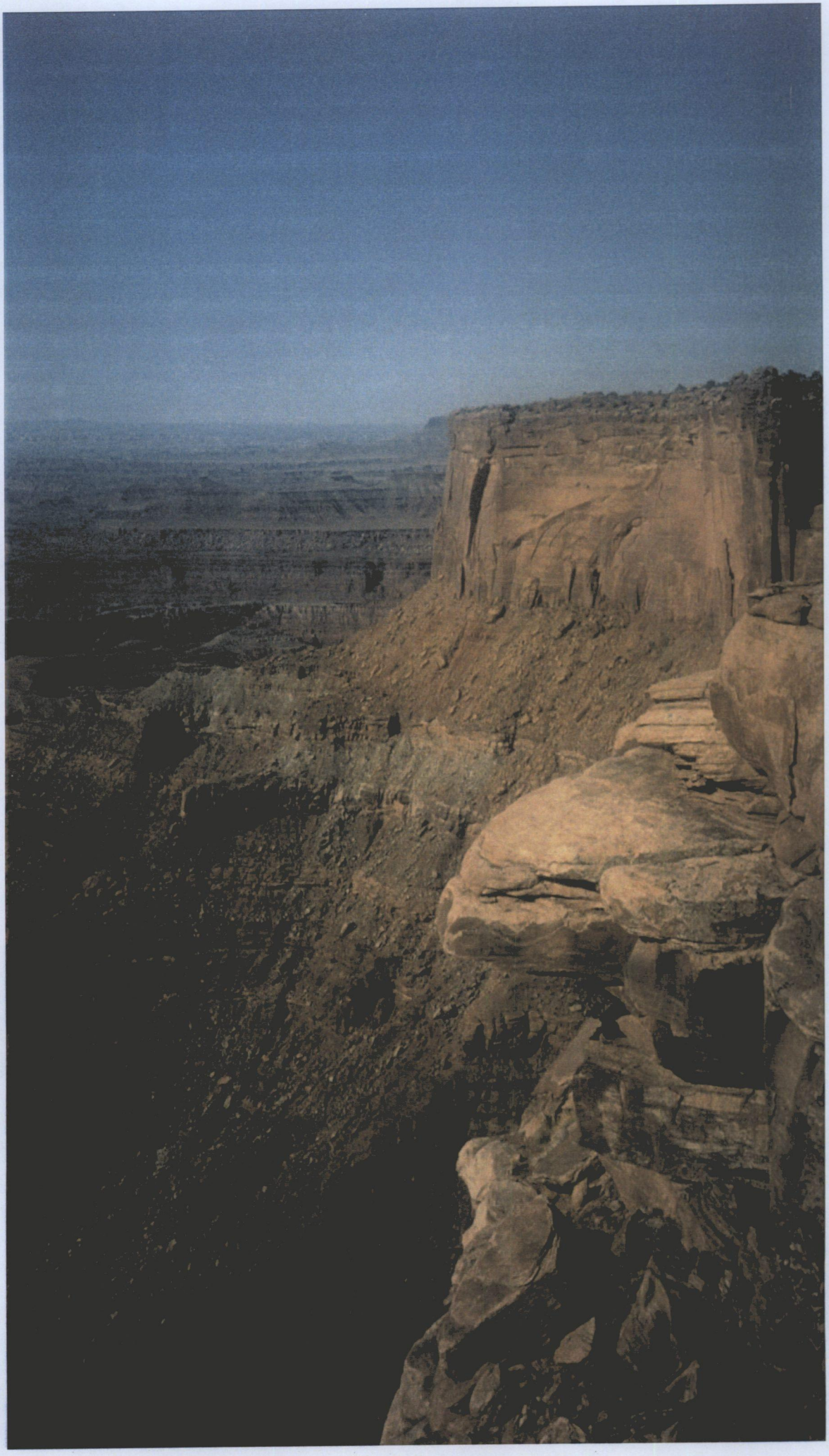


Plate 5.17: Embayment site DH2E at Dead Horse Point State Park.

Plate 5.18: Butte and site DH11H at Dead Horse Point State Park.

Plate 5.19: The Chinle Formation / Wingate Sandstone / Kayenta Formation cliffs at Fruita Canyon, Colorado National Monument.

Plate 5.20: Weathering of unprotected Wingate Sandstone at the Coke Ovens, Colorado National Monument.

Plate 5.21: Monument Canyon, Colorado National Monument. Note differences in cliff profile form across the valley. Embayment site CO15E is on the left (south) side of the canyon and CO13E is on the right.

Plate 5.22: Headland site CO11H at the Colorado National Monument.

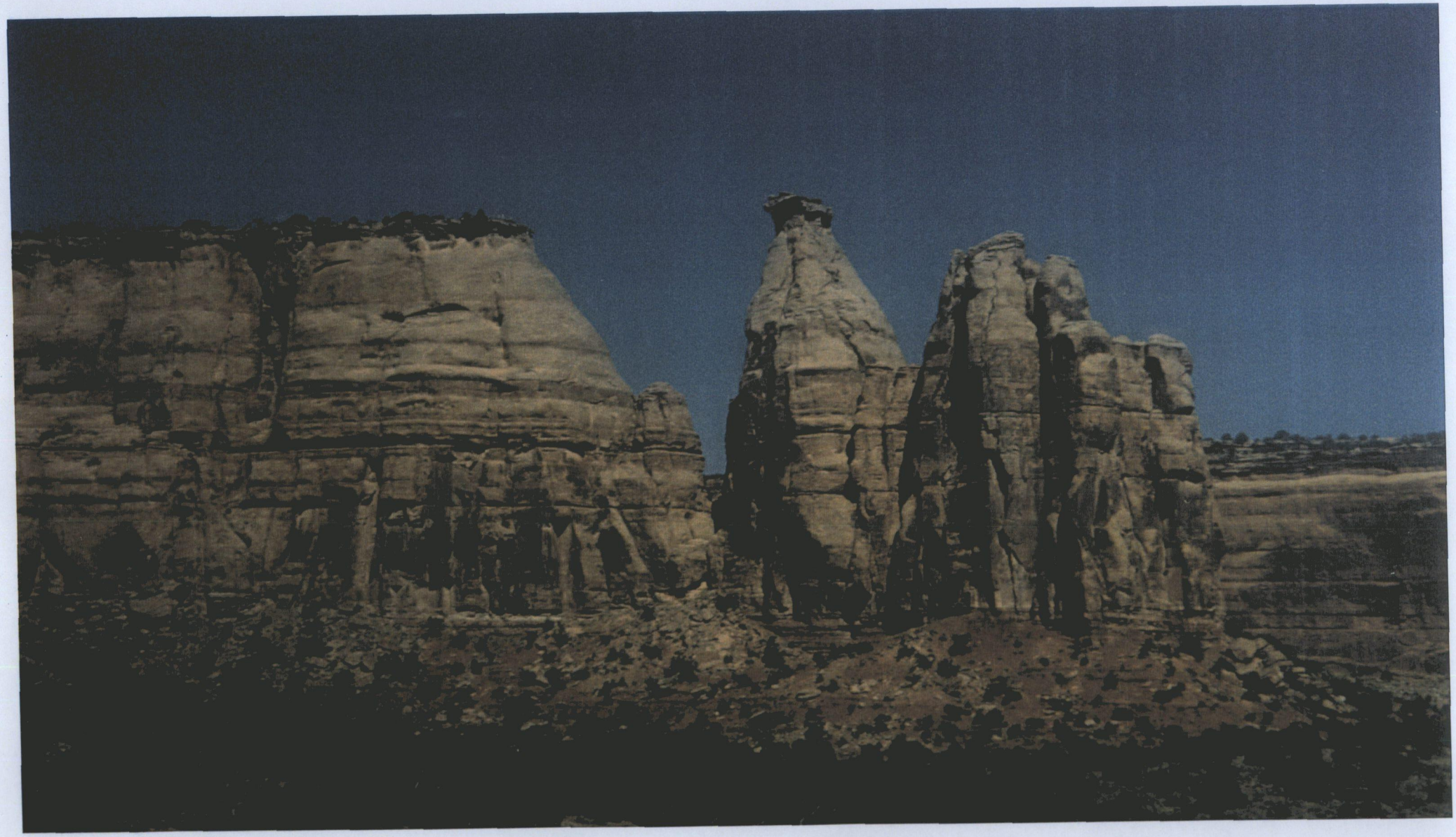


Plate 5.23: Independence Monument, Colorado National Monument.

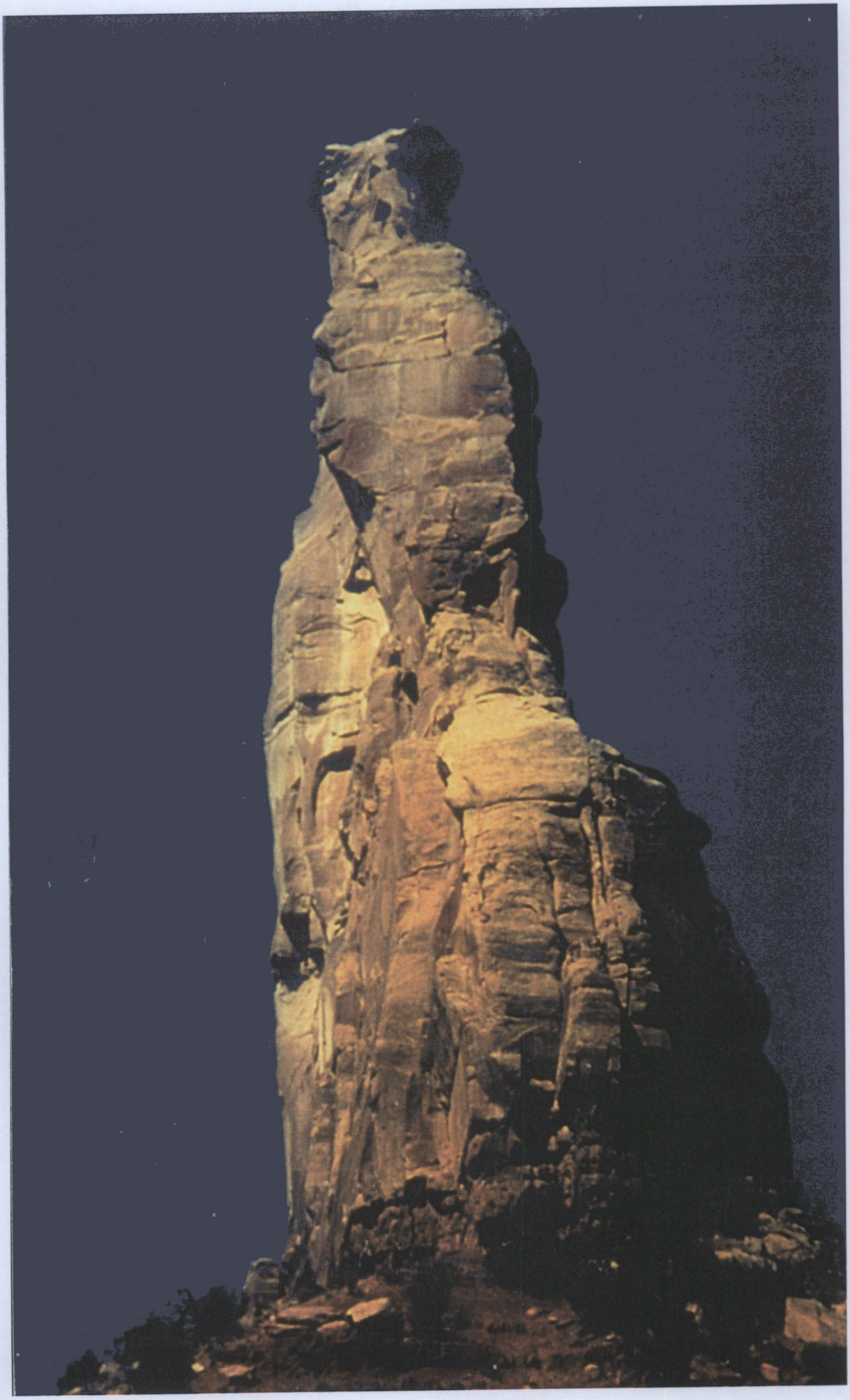


Plate 5.24: Discontinuities in the Winspit Member of the Portland Limestone at Winspit.

Plate 5.25: Discontinuities in the Kayenta Formation at Dead Horse Point State Park.

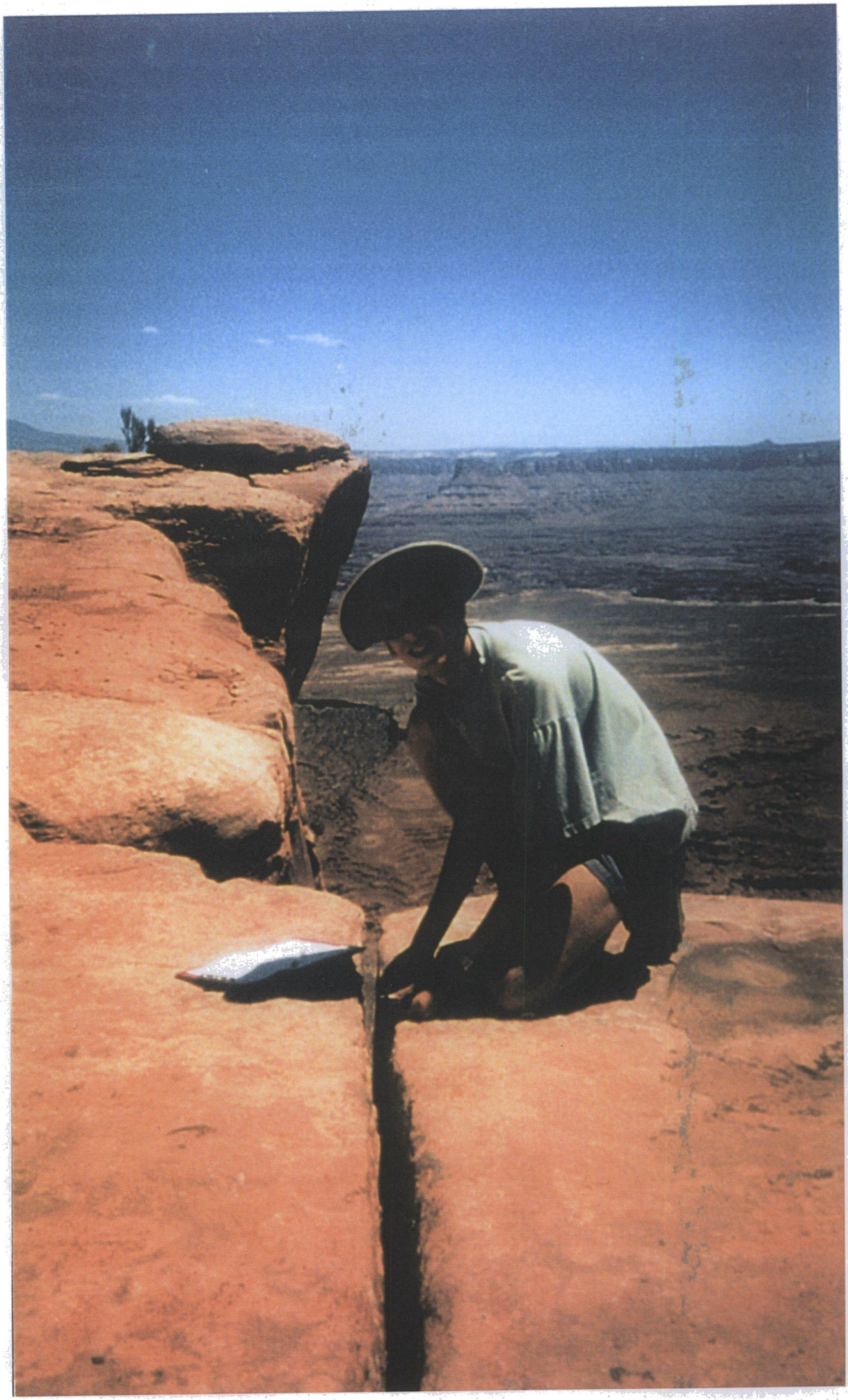


Plate 6.1: A toppling block of Portland Limestone at Winspit.

Plate 6.2: The top of the Durdle Door sea arch. Note the almost vertical bedding of the rock.

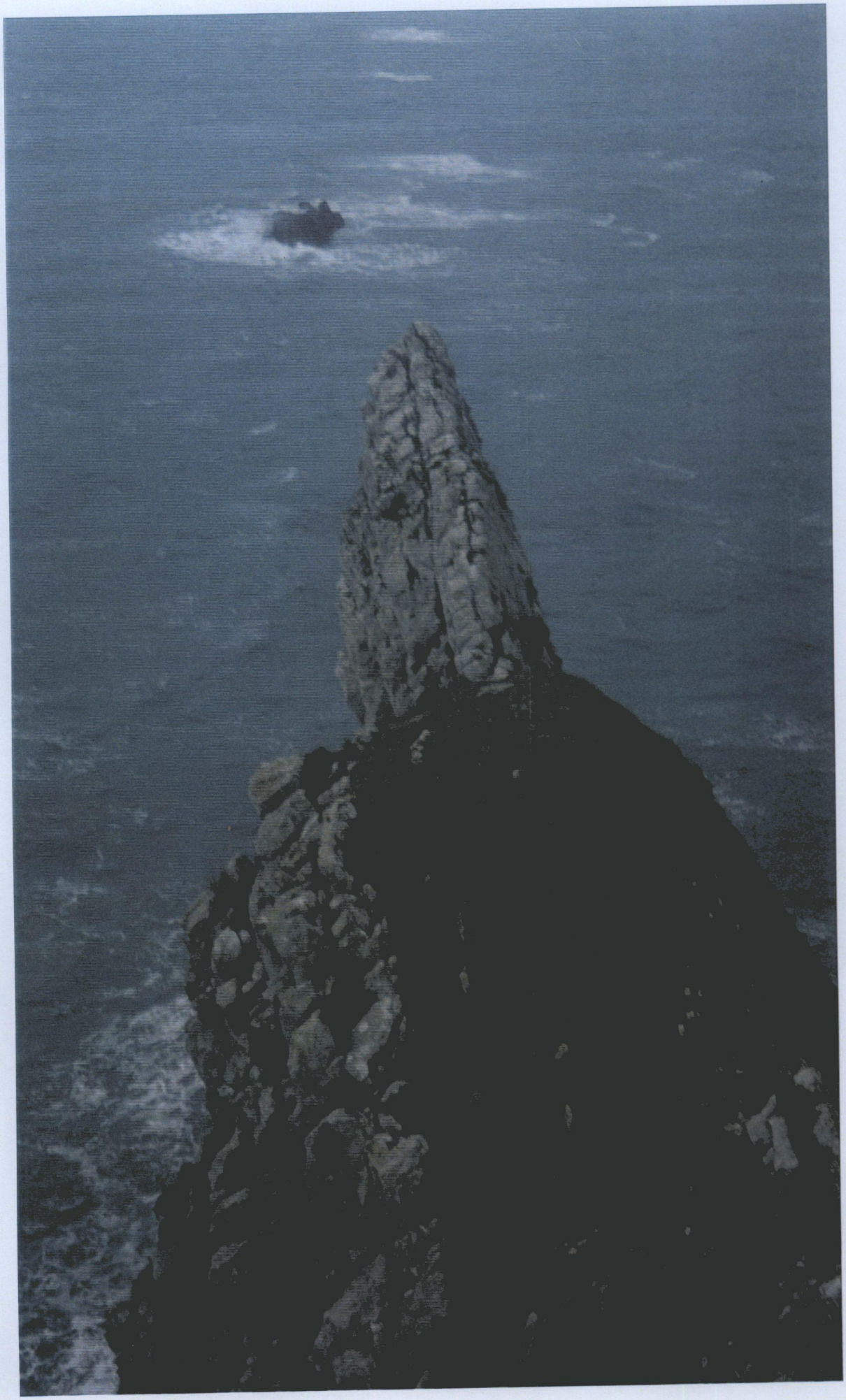


Plate 7.1: The east-west profile of the modelled butte from site DH11H at Dead Horse Point State Park.