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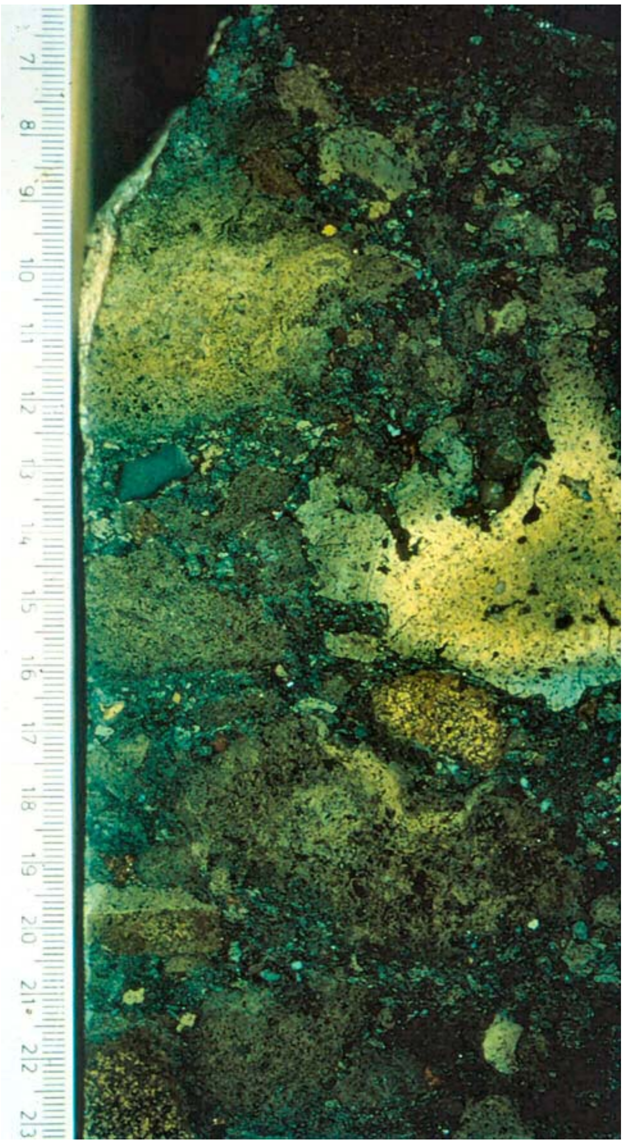
Methodology for Construction of Vulcan Model of the Saltby Volcanic Formation, DGSM Nottingham-Melton project

Internal Report IR/05/064



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/05/064

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Dr S Dumpleton

Front cover

Core sample of basaltic pillow breccia from the Saltby Volcanic Formation. Intersected at 679 m depth in the Grimmer Borehole (see Melton Mowbray Sheet Description for further details)

Bibliographical reference

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Methodology for construction of Vulcan model of the Saltby Volcanic Formation, DGSM Nottingham-Melton project.

Author: Dr S. Dumpleton.

Introduction

The object of constructing the Vulcan model was to create a quantitative 3-D visualisation of the concealed Saltby Volcanic Formation (SVF) (Carboniferous) within the area covered by the Nottingham and Melton Mobray 1:50 000 scale geological sheets (Nos. 126 and 142) which forms part of the current (2003) DGSM Nottingham-Melton Project. The model was not intended to be a structural geological representation; rather, a lithostratigraphic visualisation 'normalised' to an arbitrary horizon related to the (near) time-plane represented by the A. vanderbeckei Marine Band. This is a common concept in 2-D stratigraphic cross-sections and fence diagrams, but an unusual application for the Vulcan 3-D modelling software. Once complete, the model would allow fully interactive rotation, visualisation and dynamic cross-sectional slicing in any orientation.

The Vulcan model was developed in three versions from interpretations of borehole geophysical logs. Initially 8 boreholes were used, but as digitised geophysical logs from additional boreholes became available, successive Vulcan models were developed using 13, and finally, 26 boreholes. The modelling methodology was refined in each version, building on what had gone before but, as later versions included boreholes situated within the envelope area of the previous versions, the earlier Vulcan models were not retained.

Lithostratigraphic coding

Prior to any Vulcan modelling, the borehole geophysical logs were manually interpreted and an initial lithostratigraphic correlation between boreholes established. This was carried out by John Carney (Principal Mapping Geologist). Individual SVF units were assigned a stratigraphic code to enable modelling of particular units or combination of units. The coding system used was a branched alphanumeric code based on a method employed for coal seams by British Coal Opencast, which is well-suited to deposits exhibiting multiple leaves, splits and recombinant 'Z'-linkages. A schematic illustration of the coding used is given in Fig.1 and a full list of codes used in the Vulcan model is given in Appendix 1. The earlier Vulcan models highlighted a very few instances of mis-coding which were subsequently amended in the final version.

The alphanumeric stratigraphic code was also suffixed by a lithological code, principally based on the lithology name. This ensured that the Vulcan model, although based on stratigraphic relationships, could also be interrogated to reveal the lithology at any particular borehole intersection. It was originally intended that a lithological 'drape' overlay could be applied to any stratigraphic unit over any part of Vulcan model. This is quite feasible, but has had to be postponed to a possible later stage of modelling.

Datum for Vulcan model

The A. vanderbeckei Marine Band (VMB) was identified in the majority of the boreholes and enabled all lithological units to be related to an arbitrary datum of 50 m above the VMB. The

VMB is absent in 4 boreholes. In Woolsthorpe Bridge and Roman Plantation boreholes, the VMB appears to be absent as a result of non-deposition due to the positive topographic (possibly sub-aerial) feature formed by tuffs (BG). In these locations, the horizon of the VMB was estimated based on the position of the 2nd Ell coal. In Great Ponton and Egypt Plantation boreholes, where the Permo-Triassic erosion surface cuts out the VMB, a pre-unconformity horizon for the VMB was estimated from elevations of units within the SVF – a rather uncertain procedure and hence liable to error.

Creation of borehole database

For each borehole, the following parameters were required:

- Borehole Name
- National Grid coordinates
- Surface elevation
- Depth to VMB (or estimated equivalent horizon, where VMB is absent)
- Top and bottom depths for each coded horizon to be input
- Total depth (BASEBH) of borehole

From these parameters, an Excel spreadsheet was created which calculated the depth to each coded horizon, relative to the VMB. The stratigraphic and lithology codes were also added. From the spreadsheet, two further spreadsheets 'collars.dat' and 'lith.dat' were created in ASCII text format and imported within 'Envisage' (the core Vulcan modelling module) to form the Vulcan borehole database. A detailed description of the Vulcan methodology is beyond the scope of this report, but the data listings are given in Appendices 4 and 5.

Spatial limits of Vulcan model

Once the borehole database had been defined and created, Vulcan modelling could begin. The spatial limits of the model were defined as follows:

Min. Easting 465000
Max. Easting 496000
Min. Northing 319000
Max. Northing 346000
Max. elevation 500 m relative to modelling datum (i.e. 50 m above VMB)
Min. elevation –1000 m relative to modelling datum.

These limits gave plenty of room for subsequent expansion of the model if required.
A vertical exaggeration of x 15 was also applied.

Creation of the Vulcan model

Overview

The model was created in the following key steps:

1. From the borehole database, points, lines and/or polygons were generated to define the top surface, base surface and lateral extent for each stratigraphic coded unit to be modelled. These were saved in Envisage 'layers'.

2. From the objects and layers in *step 1*, a Vulcan solid triangulation was created for each of the stratigraphic coded units to be modelled. The solid triangulation enclosed and modelled the top, base and lateral extent of each unit. Each solid triangulation was created either directly from the data points using the Envisage solid triangulation creation routine, or by appending two or more 'simple' (i.e. non-solid) triangulations together. Additionally, some simple triangulations representing surfaces of 'zero thickness' (i.e. the bases of the VMB and selected coal seams) were created and used in the model visualisation.

3. The solid triangulations in *step 2* were then used to create a Vulcan 'block model' of all the coded units. The block model allowed colour-filled cross-section slices to be generated at any orientation through the model. Fig. 2 is an oblique view (Vulcan 'screen-shot') of the model showing a block model cross-section slice combined with solid triangulations.

Step 1 - Generating stratigraphic surface extents

The boreholes were loaded into Envisage using the [Geology > Drilling] option and modelling of the top and base surfaces for each stratigraphic coded unit was achieved using the [Geology > Drilling > Model] option. This created points for the top/base intersections which were saved to an appropriate Envisage layer with a layer name of the form <CODE>_TOP or <CODE>_BASE.

The modelling option also automatically generated a polygon(s) which separated area(s) where the coded unit was present or absent, with points on the polygon lying midway between 'present-absent' boreholes. Points on the polygons thus generated initially had a 0 m default z-value (i.e. elevation), but this was amended manually and interactively by the user viewing and manipulating the points in Envisage cross-section mode. In this way, the polygons became the limiting lateral extents of the coded units, but also having 'true' (i.e. meaningful) z-values. The extent polygons were also saved to an appropriate Envisage layer with a layer name of the form EXT_<CODE>_TOP/BASE, etc.

In order to control the subsequent triangulations exactly, it was frequently necessary to manually input additional control points (usually in Envisage cross-section mode). These were saved in the appropriate Envisage layer <CODE>_TOP/BASE_X. Control points were also used to provide a z-value point for given coded units where these were thought to be present at a borehole location but where the borehole was not deep enough to intersect that horizon. In this case, the elevation of the control point was estimated manually, on-screen, in cross-section mode.

See Appendix 2 for the full list of Envisage layers and their descriptions.

Step 2 – creating solid triangulations

(i) Creating solid triangulations directly

For each coded unit to be triangulated, the layers representing the top and base surfaces and the lateral extent polygons were loaded. The solid triangulation was created using the

Envisage option [Model > Triangle Solid > Create]. First, the top and base extent polygons were selected to generate a vertical 'wall' triangulation; secondly, the base and top surface layers were selected in turn to generate the 'End plates' [Model > Triangle solid > End_plate].

(ii) Creating solid triangulations by appending simple triangles

It was sometimes easier and more control achieved by generating the top and base surfaces triangulations separately using the option [Model > Triangle Surface > Create] as an intermediate step. The simple triangles were subsequently appended to the 'wall' triangulation (generated in (i) above) using the option [Model > Triangle Utility > Append]. The advantage of using this method was that it enabled easier editing of the triangles [Mode > Triangle Edit > Flip Triangles] to ensure congruence between modelled, coded, units so that the top of one unit did not inadvertently intersect the base of the overlying unit.

(iii) Other triangulations

In addition to the solid triangulations, simple triangulations were created to model the VMB and the coal seams Deep Main, Parkgate and Blackshale/Ashgate. The data points used in these triangulations were derived in the manner described in *Step 1*.

A full list of triangulated surfaces is given in Appendix 3.

Step 3 Block model

A requirement of the Vulcan model was the facility to generate cross-sections at any orientation through the model which could be displayed with a 'solid' fill. This was achieved by creating a block model – essentially a 3-D stack of orthorhombic 'bricks' colour-coded by variable (in this case, according to stratigraphic code). A full description of the methodology for block model creation is outside the scope of this report, but the general parameters are as follows:

Origin: Easting 473900, Northing 325900, elevation -450 m. This locates the lowest south-west corner of the block model. Additionally, the block model was assigned a bearing of 90°, and a dip/plunge of zero, meaning that the overall block model extends from the origin to the east, and with zero dip in x and y. This created a 'block model definition' i.e. an envelope volume within which all the horizons to be modelled would be contained. The solid triangulations (from *step 2*) were used to constrain the generation of the individual blocks.

The maximum size ('parent' block size) of any individual block was set (after some trial and error) at x = 500 m, y = 500 m and z = 50 m. Where a parent block intersected a solid triangulation surface, sub-blocks were generated to increase the resolution of the model. The sub-block size (i.e. highest resolution) was similarly set by trial and error to be x = 100 m, y = 100, z = 1 m. This resolution was found to be fine enough to allow a reasonable representation of the coded units along their boundaries, yet not too fine such that file size became unwieldy and interactive model rotation/manipulation became too slow. On completion, the block model could be viewed in multiple cross-sections together with triangulations, borehole 'stick' plots, etc. The solid triangulations used to create the block model are indicated in Appendix 3.

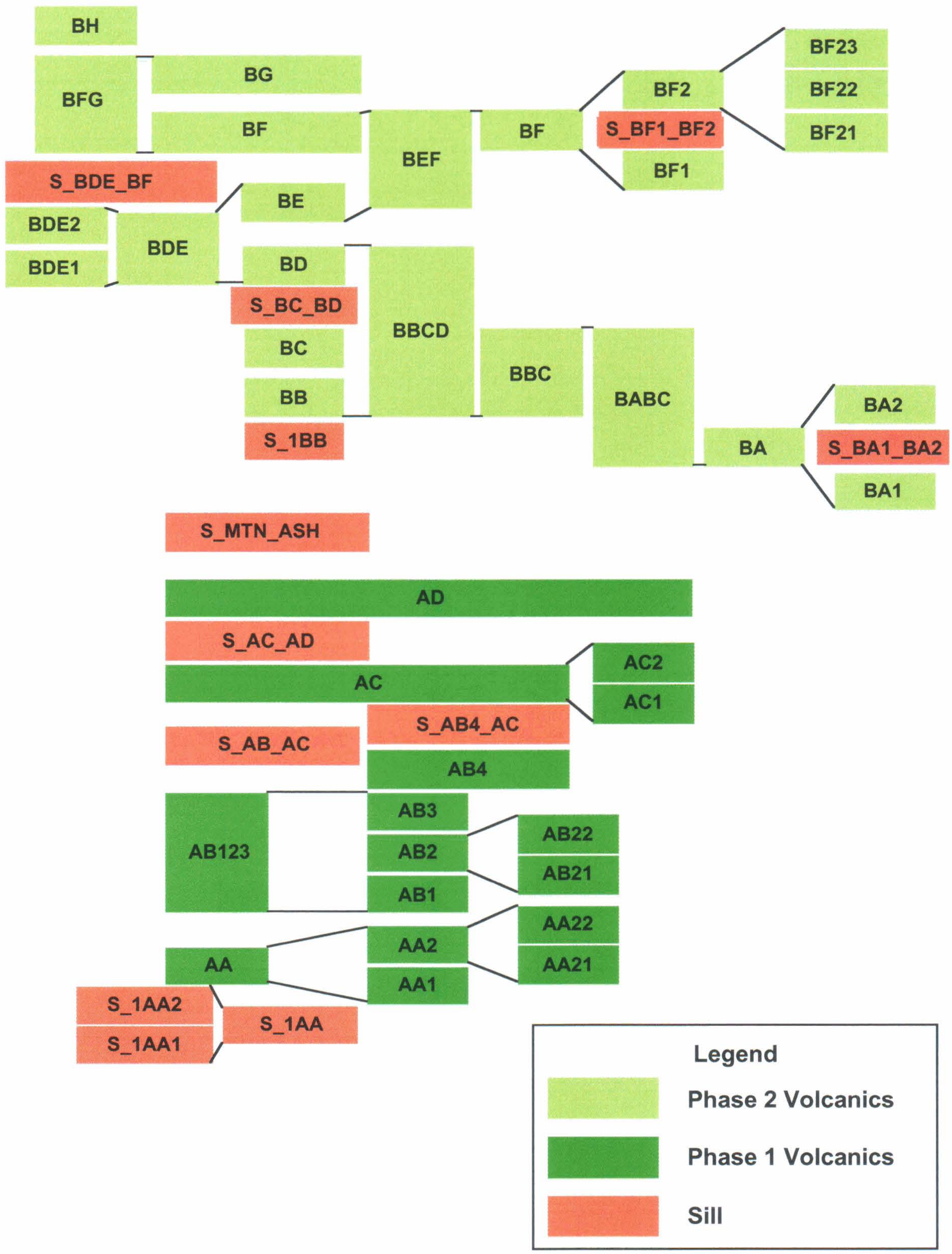

Fig. 1
Schematic relationships of lithostratigraphic codes in the Saltby Volcanic Formation

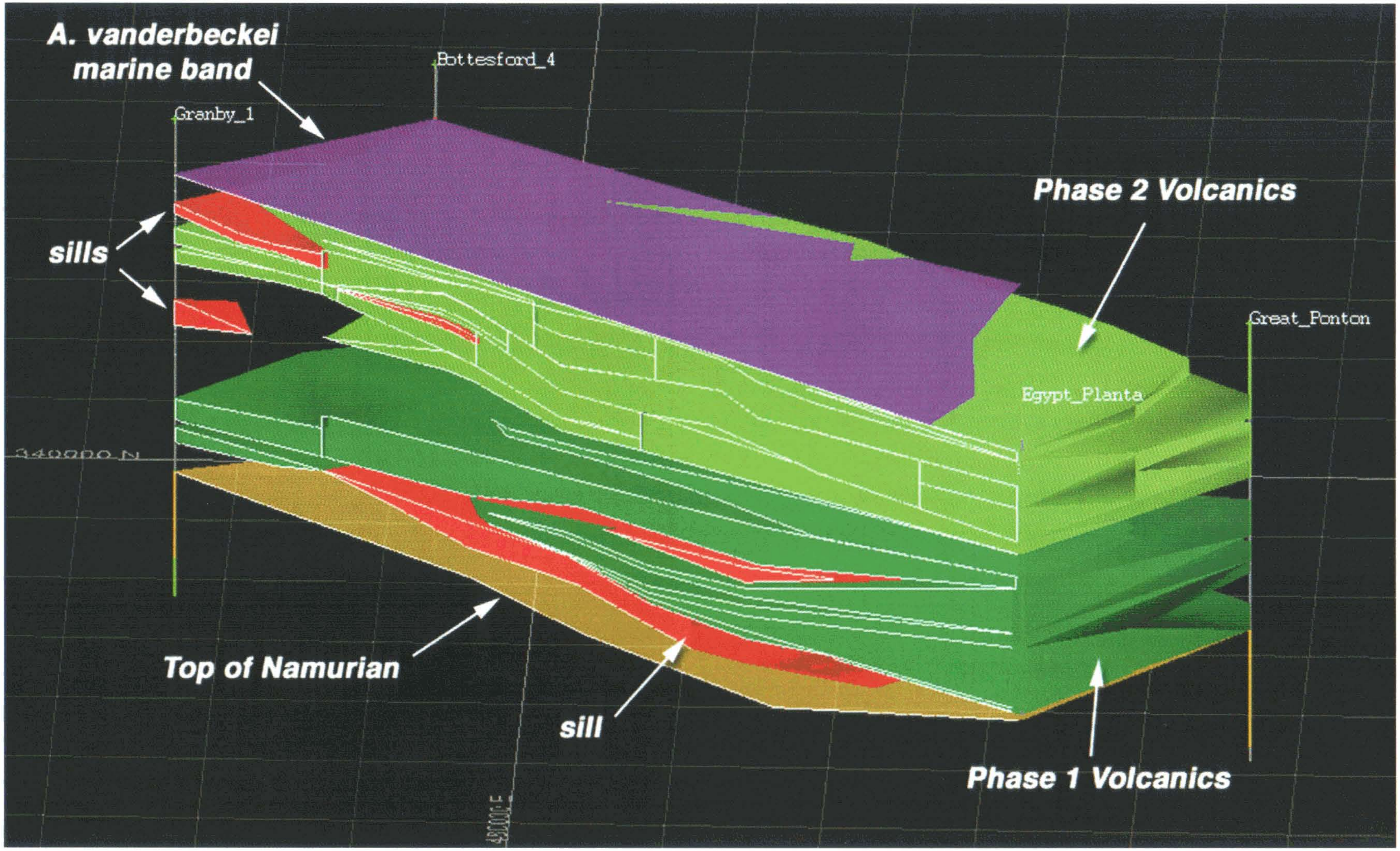

Fig. 2
Oblique view northwards (Vulcan 'screen-shot') showing a block model cross-section slice combined with solid triangulations to the rear of the slicing plane. The grid lines are at 2000 m intervals. Vertical exaggeration x 15.

Appendix 1
List of lithostratigraphic codes

Stratigraphy	Phase 2 Volcanics	Phase 1 Volcanics	Sills
Q_2_WLOO *Quasi-2nd Waterloo*	BH	AD	S_MTN_ASH
2_WLOO *2nd Waterloo*	BG	AC2	S_BF1_BF2
4_WLOO_1_ELL *4th Waterloo/1st Ell*	BFG	AC1	S_BDE_BF
2_ELL *2nd Ell*	BF23	AC	S_BC_BD
VMB *A. vanderbeckei Marine Band*	BF22	AB4	S_BA1_BA2
DMAIN *Deep Main*	BF21	AB3	S_AC_AD
PGATE *Parkgate*	BF2	AB22	S_AB_AC
TNTQ *Tupton/Three-quarter*	BF1	AB21	S_AB4_AC
BSH_ASH *Blackshale/Ashgate*	BF	AB2	S_1BB
MTN *Mickley Thin*	BEF	AB123	S_1AA2
MTK *Mickley Thick*	BE	AB1	S_1AA1
KLBN *Kilburn*	BDE2	AA22	S_1AA
BLAWN *Belper Lawn*	BDE1	AA21	
SMB *G. subcrenatum Marine Band*	BDE	AA2	
NAM *Namurian*	BD	AA1	
DIN *Dinantian*	BC	AA	
	BBCD		
	BBC		
	BB		
	BABC		
	BA2		
	BA1		
	BA		

Appendix 2

List of Layers created during construction of the Vulcan model

Note: * = 'wildcard' i.e. any alphanumeric character

Layer Name	Description
2_ELL_BASE	Base of 2nd Ell
2_WLOO_BAS	Base of 2nd Waterloo
AA1_BASE	Base of AA1
AA1_TOP	Top of AA1
AA2_BASE	Base of AA2
AA2_TOP	Top of AA2
AB123_TOP	Top of AB123
AB1_BASE	Base of AB1
AB1_TOP	Top of AB1
AB21_TOP	Top of AB21
AB22_BASE	Base of AB22
AB2_BASE	Base of AB2*
AB2_TOP	Top of AB2*
AB3_BASE	Base of AB3
AB3_TOP	Top of AB3
AB4_BASE	Base of AB
AB4_TOP	Top of AB4
AC1_BASE	Base of AC1
AC1_TOP	Top of AC1
AC1_TOP_X	Extrapolated points on top AC1
AC2_BASE	Base of AC2
AC2_TOP	Top of AC2
AC_BASE	Base of AC
AC_BASE_X	Extrapolated points on base AC
AC_TOP	Top of AC
AC_TOP_X	Extrapolated points on top AC
AD_BASE	Base of AD
AD_TOP	Top of AD
BA1_BASE	Base of BA1
BA1_TOP	Top of BA1
BA2_BASE	Base of BA2
BA2_TOP	Top of BA2
BABC_BASE	Base of BABC
BABC_TOP	Top of BABC
BA_BASE	Base of BA
BA_BASE_X	Extrapolated points on base BA
BA_TOP	Top of BA
BA_TOP_X	Extrapolated points on top BA
BBCD_BASE	Base of BBCD
BBCD_TOP	Top of BBCD
BBC_BASE	Base of BBC

BBC_TOP	Top of BBC
BB_BASE	Base of BB
BB_BASE_X	Extrapolated points on base BB**
BB_TOP	Top of BB
BB_TOP_X	Extrapolated points on top BB
BC_BASE	Base of BC
BC_BASE_X	Extrapolated points on base BC
BC_TOP	Top of BC
BC_TOP_X	Extrapolated points on top of BC
BDE_BASE	Base of BDE
BDE_TOP	Top of BDE
BD_BASE	Base of BD
BD_BASE_X	Extrapolated pts on base BD, BDE and mid-BBDC
BD_TOP	Top of BD
BD_TOP_X	Extrapolated points on top BD
BEF_BASE	Base of BEF
BEF_TOP	Top of BEF
BE_BASE	Base of BE
BE_BASE_X	Extrapolated points on base BE
BE_BDE_T_X	Extrapolated points on top BE and top BDE
BE_TOP	Top of BE
BF1_BASE	Base of BF1
BF1_TOP	Top of BF1
BF1_TOP_X	Extrapolated points on top BF1
BF2*_BASE	Base of BF2*
BF2*_BASEX	Extrapolated points on base BF2*
BF2*_TOP	Top of BF2*
BFG_BASE	Base of BFG
BFG_BASE_X	Extrapolated points on base of BFG
BFG_TOP	Top of BFG
BF_BASE	Base of BF
BF_BASE_X	Extrapolated points on BF base
BF_TOP	Top of BF
BF_TOP_X	Extrapolated points on BF top
BG_BASE	Base of BG
BG_BASE_X	Extrapolated points on BG base
BG_BFG_TOX	Extrapolated points on BG/BFG top
BG_TOP	Top of BG
BH_BASE	Base of BH
BH_TOP	Top of BH
BLOCK_XRS	Section lines for block model slicing
BSH_ASH_B	Base of Blackshale/Ashgate seam
BSH_ASH_X	Extrapolated points on (base) Blackshale/Ashgate seam
DMAIN_BASE	Base of Deep Main seam
DMAIN_B_X	Extrapolated points on base Deep Main seam
EXT_2_WLOO	Extent of 2nd Waterloo seam

EXT_AA1_BS	Extent of AA1 base
EXT_AA1_TP	Extent of AA1 Top
EXT_AA2_BS	Extent of AA2 base
EXT_AA2_TP	Extent of AA2 Top
EXT_AB1	Extent of AB1 top and base
EXT_AB21	Extent of AB21
EXT_AB22	Extent of AB22
EXT_AB2_BS	Extent of AB2 base
EXT_AB2_TP	Extent of AB2 Top
EXT_AB3_BS	Extent of base of AB3
EXT_AB3_TP	Extent of AB3 Top
EXT_AB4_BS	Extent of base AB4
EXT_AB4_TP	Extent of top of AB4
EXT_AC1_BS	Extent of AC1 base
EXT_AC1_TP	Extent of top of AC1
EXT_AC2_BS	Extent of AC2 base
EXT_AC2_TP	Extent of top of AC2
EXT_AC_BAS	Extent of AC base
EXT_AC_TOP	Extent of top of AC
EXT_AD_BAS	Extent of AD base
EXT_AD_TOP	Extent of AD top
EXT_BA*_BS	Extent of BA* base
EXT_BA*_TP	Extent of BA* Top
EXT_BABC_B	Extent of BABC Base
EXT_BABC_T	Extent of top BABC
EXT_BA_BAS	Extent of BA Base
EXT_BBCD_B	Extent of BBCD Base
EXT_BBCD_T	Extent of top BBCD
EXT_BBC_BS	Extent of BBC Base
EXT_BBC_TP	Extent of top BBC
EXT_BB_BAS	Extent of BB Base
EXT_BB_TOP	Extent of BB Top
EXT_BC_BAS	Extent of BC base
EXT_BC_TOP	Extent of top BC
EXT_BDE_BS	Extent of BDE base
EXT_BDE_TP	Extent of BDE Top
EXT_BD_BAS	Extent of BD base
EXT_BD_TOP	Extent of BD Top
EXT_BEF_BS	Extent of BEF base
EXT_BEF_TP	Extent of BEF top
EXT_BE_BS	Extent of BE base
EXT_BE_TOP	Extent of BE Top
EXT_BF1_BS	Extent of BF1 Base
EXT_BF1_TP	Extent of BF1 top
EXT_BF2*_B	Extent of BF2* Base
EXT_BF2*_T	Extent of BF2* top

EXT_BFG_BS	Extent of BFG Base
EXT_BFG_TO	Extent of BFG top
EXT_BF_BAS	Extent of BF Base
EXT_BF_TOP	Extent of BF top
EXT_BG_BAS	Extent of base of BG
EXT_BG_TOP	Extent of BG top
EXT_BH_TB	Extent of BH (top and base)
EXT_DMAINB	Extent of base of Deep Main seam
EXT_NAM_BS	Extent of base of Namurian
EXT_NAM_TP	Extent of top of Namurian
EXT_SACADT	Extent of S_AC_AD top
EXT_S_1AAB	Extent of S_1AA base
EXT_S_1AAT	Extent of S_1AA top
EXT_S_1BB	Extent of S_1BB (top and base)
EXT_VMB_BS	Extent of base of vanderbeckei MB
EX_SACAD_B	Extent of base of S_AC_AD
EX_SMTNASH	Extent S_MTN_ASH
EX_S_ABACB	Extent of base of S_AB(4)_AC
EX_S_ABACT	Extent of S_AB(4)_AC top
EX_S_BBBCB	Extent of S_BB_BC base
EX_S_BBBCT	Extent of S_BB_BC top
E_SBDEBF_B	Extent S_BDE_BF Base
E_SBDEBF_T	Extent S_BDE_BF top
E_S_BF1BF2	Extent SBF1_BF2
NAM_BASE	Base of Namurian
NAM_BASE_X	Extrapolated points on base of Namurian
NAM_TOP	Top of Namurian
NAM_TOP_X	Extrapolated points on top of Namurian
PGATE_BASE	Base of Parkgate seam
PGATE_B_X	Extrapolated points on base of Parkgate seam
S_1AA_BASE	Base of S_1AA
S_1AA_TOP	Top of S_1AA
S_1AA_TOPX	Extrapolated points on top of S_1AA
S_1BB_BASE	Base of S_1BB
S_1BB_TOP	Top of S_1BB
S_AB_AC_BS	Base of S_AB(4)_AC
S_AB_AC_TP	Top of S_AB(4)_AC
S_AC_AD_BS	Base of S_AC_AD
S_AC_AD_TP	Top of S_AC_AD
S_BB_BC_BS	Base of S_BB_BC
S_BB_BC_TP	Top of S_BB_BC
S_BDE_BF_B	Base of S_BDE_BF
S_BDE_BF_T	Top of S_BDE_BF
S_BF1BF2_B	Base of S_BF1_BF2
S_BF1BF2_T	Top of S_BF1_BF2
S_MTNASH_B	Base of S_MTN_ASH

S_MTNASH_T	Top of S_MTN_ASH
VMB_BASE	Base of A. vanderbeckei Marine Band

Appendix 3

List of Triangulations created during construction of the Vulcan model

Note: § denotes solid triangulation used in creation of block model

Triangulation name	Description (where necessary)
2_ELL.SFT	Base of 2nd Ell seam
2_WLOO.SFT	Base of 2nd Waterloo seam
AA1_SOLID.00T §	
AA2_SOLID.00T §	
AB1_SOLID.00T §	
AB2_SOLID.00T §	
AB3_SOLID.00T §	
AB4_SOLID.00T §	
AC1_SOLID.00T §	
AC2_SOLID.00T §	
AC_SOLID.00T §	
AD_SOLID.00T §	
BA_SOLID.00T §	
BABC_SOLID.00T §	
BB_SOLID.00T §	
BBC_SOLID.00T §	
BBCD_SOLID.00T §	
BC_SOLID.00T §	
BD_SOLID.00T §	
BDE_SOLID.00T §	
BE_SOLID.00T §	
BEF_SOLID.00T §	
BF1_SOLID.00T §	
BF2_SOLID.00T §	
BF_SOLID.00T §	
BFG_SOLID.00T §	
BG_SOLID.00T §	
BH_SOLID.00T §	
BSH_ASH_BASE.00T	Base of Blackshale/Ashgate seam
DMAIN_BASE.00T	Base of Deep Main seam
NAM_SOLID.00T	Namurian solid triangulation
NAM_TOP.00T	Top of Namurian
PGATE_BASE.00T	Base of Parkgate seam
PHASE1_SOLID.00T	Solid triangulation of all Phase 1 ('A' codes) volcanics
PHASE2_SOLID.00T	Solid triangulation of all Phase 2 ('B' codes) volcanics
S_1AA_SOLID.00T §	
S_1BB_SOLID.00T §	
S_AB_AC_SOLID.00T §	
S_AC_AD_SOLID.00T §	
S_BB_BC_SOLID.00T §	
S_BDE_BF_SOLID.00T §	

S_BF1_BF2_SOLID.00T §	
S_MTN_ASH_SOLID.00T §	
SILLS_ALL_SOLID.00T	Solid triangulation of all sills
VMB.RLT	Base of A. vanderbeckei Marine Band

Appendix 4
Borehole listing 'collars.dat' for input to Vulcan database

HOLEID	EAST	NORTH	ELEV	BASEBH
Harston_1	484522	331657	0	482
Woolsthorpe_Br	484342	334881	0	118
Redmile_1	480860	334400	0	395
Bottesford_4	478590	338810	0	458
Middlestile_Br	480854	336146	0	208
Redmile_Br	479472	335684	0	198
Granby_1	475320	336830	0	438
Granby_2	476890	337450	0	397
Grimmer	479077	334037	0	147
Plungar_23	476308	331946	0	439
Stathern_South	477173	330555	0	213
Plungar_11	477850	333040	0	400
Plungar_18	475870	332760	0	416
Hose	473980	329052	0	225.5
White_Lodge	477680	327870	0	198
Goadby_Gorse	478701	325921	0	190.26
Waltham_Lane	479619	327540	0	106
Sherricliffe	479002	330543	0	101
Terrace_Hill	480280	331720	0	112
Harston_Hall	483180	331846	0	70
France_Plant	485788	333398	0	238
Harston_Road	485173	331944	0	120
Roman_Plant	487850	330862	0	121.52
Egypt_Plant	486600	327857	0	289.16
Great_Ponton	489395	330530	0	402.33
Croxton_Abbey	482841	327188	0	91.47

Appendix 5

Borehole listing 'lith.dat' for input to Vulcan database

HOLEID	FROM	TO	ROCK1	ROCK2	CODE	HORIZ
Harston_1	41.9	42.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Harston_1	44.3	44.5	Coal	undivided	2_ELL	2nd Ell
Harston_1	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Harston_1	62.0	73.0	Tuff	Tuff	BG	
Harston_1	73.0	90.0	Lava	basaltic	BF	
Harston_1	90.0	126.0	Lava	basaltic	BDE	
Harston_1	126.0	153.0	Lava	basaltic	BABC	
Harston_1	153.0	193.0	Lava	basaltic	AD	
Harston_1	193.0	246.0	Lava	basaltic	AC	
Harston_1	246.0	273.0	Sill	basaltic or doleritic	S_AB4_AC	
Harston_1	273.0	290.0	Peperite	breccia	AB4	
Harston_1	290.0	310.0	Tuff	Tuff	AB3	
Harston_1	310.0	327.0	Lava	basaltic	AB2	
Harston_1	327.0	342.0	Tuff	Tuff	AB1	
Harston_1	342.0	371.0	Sill	Sill	S_1AA	
Harston_1	371.0	371.1	Marine	Band	SMB	G. subcrenatum Marine Band (estimated horizon)
Harston_1	371.1	438.0	Undivided	Undivided	NAM	Namurian
Harston_1	438.0	482.0	Undivided	Undivided	DIN	Dinantian
Woolsthorpe_Bridge	27.9	28.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Woolsthorpe_Bridge	47.8	48.0	Coal	undivided	2_ELL	2nd Ell
Woolsthorpe_Bridge	49.0	54.0	Tuff	Tuff	BG	
Woolsthorpe_Bridge	54.0	80.0	Lava	basaltic	BF	
Woolsthorpe_Bridge	80.0	86.0	Tuff	Tuff	BDE2	
Woolsthorpe_Bridge	86.0	91.0	Lava	basaltic	BDE1	
Woolsthorpe_Bridge	91.0	118.0	Lava	basaltic	BDE1	Estimated - below BASEBH
Redmile_1	32.9	33.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Redmile_1	34.8	35.0	Coal	undivided	2_ELL	2nd Ell
Redmile_1	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Redmile_1	66.0	70.0	Tuff	Tuff	BG	
Redmile_1	70.0	96.0	Lava	basaltic	BF	
Redmile_1	96.0	98.0	Sill	basaltic or doleritic	S_BDE_BF	
Redmile_1	98.0	122.0	Tuff	Tuff	BDE	
Redmile_1	122.0	146.0	Basaltic breccia	pillow fragments	BBC	
Redmile_1	146.0	153.0	Peperite	breccia	BA2	
Redmile_1	153.0	162.0	Sill	basaltic or doleritic	S_BA1_BA2	
Redmile_1	167.0	170.0	Tuff	Tuff	BA1	
Redmile_1	175.0	176.0	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Redmile_1	179.0	197.0	Lava	basaltic	AD	
Redmile_1	200.0	200.5	Coal	undivided	KLBN	Kilburn
Redmile_1	212.0	247.0	Lava	basaltic	AC	
Redmile_1	247.0	254.0	Sill	basaltic or doleritic	S_AB4_AC	
Redmile_1	254.0	269.0	Tuff	Tuff	AB4	
Redmile_1	271.0	279.0	Tuff	Tuff	AB123	
Redmile_1	279.0	294.0	Sill	basaltic or doleritic	S_1AA2	
Redmile_1	299.0	304.0	Sill	basaltic or doleritic	S_1AA1	
Redmile_1	306.0	306.5	Coal	undivided	BLAWN	Belper Lawn
Redmile_1	330.0	331.0	Marine	Band	SMB	G. subcrenatum Marine Band
Redmile_1	331.0	387.2	Undivided	Undivided	NAM	Namurian
Redmile_1	387.2	395.0	Undivided	Undivided	DIN	Dinantian
Bottesford_4	11.9	12.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Bottesford_4	32.0	32.1	Coal	undivided	2_ELL	2nd Ell
Bottesford_4	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Bottesford_4	54.0	60.0	Tuff	Tuff	BG	
Bottesford_4	60.0	86.0	Lava	basaltic	BF	
Bottesford_4	86.0	97.0	Sill	basaltic or doleritic	S_BDE_BF	
Bottesford_4	97.0	104.0	Tuff	Tuff	BDE	
Bottesford_4	104.0	141.0	Basaltic breccia	pillow fragments	BBC	
Bottesford_4	141.0	149.0	Peperite	breccia	BA2	
Bottesford_4	149.0	159.0	Tuff	Tuff	BA1	
Bottesford_4	159.0	197.0	Lava	basaltic	AD	
Bottesford_4	197.0	221.0	Sill	basaltic or doleritic	S_AC_AD	
Bottesford_4	228.0	229.0	Coal	undivided	KLBN	Kilburn
Bottesford_4	231.0	244.0	Lava	basaltic	AC2	
Bottesford_4	247.0	303.0	Lava	basaltic	AC1	
Bottesford_4	308.0	339.0	Lava	basaltic	AA2	
Bottesford_4	342.0	382.0	Lava	basaltic	AA1	
Bottesford_4	383.0	384.0	Marine	Band	SMB	G. subcrenatum Marine Band
Bottesford_4	384.0	444.0	Undivided	Undivided	NAM	Namurian
Bottesford_4	444.0	458.0	Undivided	Undivided	DIN	Dinantian

HOLEID	FROM	TO	ROCK1	ROCK2	CODE	HORIZ
Middlestile_Bridge	24.9	25.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Middlestile_Bridge	41.0	41.1	Coal	undivided	2_ELL	2nd Ell
Middlestile_Bridge	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Middlestile_Bridge	50.0	53.0	Tuff	Tuff	BG	
Middlestile_Bridge	53.0	79.0	Lava	basaltic	BF2	
Middlestile_Bridge	88.0	103.0	Lava	basaltic	BF1	
Middlestile_Bridge	103.0	109.0	Sill	basaltic or doleritic	S_BDE_BF	
Middlestile_Bridge	109.0	149.0	Basaltic breccia	pillow fragments	BBC	
Middlestile_Bridge	149.0	157.0	Lava	basaltic	AD	
Middlestile_Bridge	157.0	206.0	Lava	basaltic	AD	Estimated - below BASEBH
Middlestile_Bridge	206.0	208.0	Sill	basaltic or doleritic	S_AC_AD	Estimated - below BASEBH
Redmile_Bridge	20.9	21.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Redmile_Bridge	33.0	33.1	Coal	undivided	2_ELL	2nd Ell
Redmile_Bridge	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Redmile_Bridge	52.0	58.0	Lava	basaltic	BF23	
Redmile_Bridge	58.0	62.0	Tuff	Tuff	BF22	
Redmile_Bridge	63.0	64.0	Coal	undivided	DMAIN	Deep Main
Redmile_Bridge	67.0	74.0	Lava	basaltic	BF21	
Redmile_Bridge	79.0	105.0	Lava	basaltic	BF1	
Redmile_Bridge	105.0	118.0	Basaltic breccia	pillow fragments	BC	
Redmile_Bridge	118.0	128.0	Lava	basaltic	BB	
Redmile_Bridge	128.0	133.0	Sill	basaltic or doleritic	S_1BB	
Redmile_Bridge	138.0	139.0	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Redmile_Bridge	158.0	159.0	Coal	undivided	MTN	Mickley Thin
Redmile_Bridge	169.9	170.0	Coal	undivided	MTK	Mickley Thick
Redmile_Bridge	170.0	189.0	Lava	basaltic	AD	
Redmile_Bridge	189.0	198.0	Lava	basaltic	AD	Estimated - below BASEBH
Granby_1	14.9	15.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Granby_1	42.0	43.0	Coal	undivided	2_ELL	2nd Ell
Granby_1	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Granby_1	66.0	67.0	Coal	undivided	DMAIN	Deep Main
Granby_1	76.0	85.0	Sill	basaltic or doleritic	S_BF1_BF2	
Granby_1	91.0	92.0	Coal	undivided	PGATE	Parkgate
Granby_1	97.0	98.0	Coal	undivided	TNTQ	Tupton/Threequarters
Granby_1	99.0	113.0	Lava	basaltic	BF1	
Granby_1	119.0	131.0	Lava	basaltic	BB	
Granby_1	142.0	143.0	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Granby_1	165.0	188.0	Sill	basaltic or doleritic	S_MTN_ASH	
Granby_1	192.0	193.0	Coal	undivided	MTN	Mickley Thin
Granby_1	197.0	198.0	Coal	undivided	MTK	Mickley Thick
Granby_1	216.0	217.0	Coal	undivided	KLBN	Kilburn
Granby_1	256.0	275.0	Lava	basaltic	AC1	
Granby_1	282.0	288.0	Lava	basaltic	AA22	
Granby_1	291.0	296.0	Lava	basaltic	AA21	
Granby_1	308.0	309.0	Coal	undivided	BLAWN	Belper Lawn
Granby_1	322.0	323.0	Marine	Band	SMB	G. subcrenatum Marine Band
Granby_1	323.0	402.0	Undivided	Undivided	NAM	Namurian
Granby_1	402.0	438.0	Undivided	Undivided	DIN	Dinantian
Granby_2	13.9	14.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Granby_2	35.0	36.0	Coal	undivided	2_ELL	2nd Ell
Granby_2	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Granby_2	64.0	65.0	Coal	undivided	DMAIN	Deep Main
Granby_2	67.0	68.0	Lava	basaltic	BF21	
Granby_2	70.0	85.0	Sill	basaltic or doleritic	S_BF1_BF2	
Granby_2	90.0	91.0	Coal	undivided	PGATE	Parkgate
Granby_2	96.0	97.0	Coal	undivided	TNTQ	Tupton/Threequarters
Granby_2	98.0	117.0	Lava	basaltic	BF1	
Granby_2	117.0	124.0	Lava	basaltic	BB	
Granby_2	157.0	158.0	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Granby_2	174.0	175.0	Coal	undivided	MTN	Mickley Thin
Granby_2	181.0	182.0	Coal	undivided	MTK	Mickley Thick
Granby_2	203.0	204.0	Coal	undivided	KLBN	Kilburn
Granby_2	233.0	265.0	Lava	basaltic	AC1	
Granby_2	270.0	298.0	Lava	basaltic	AA2	
Granby_2	313.0	315.0	Tuff	Tuff	AA1	
Granby_2	315.0	315.5	Coal	undivided	BLAWN	Belper Lawn
Granby_2	324.0	325.0	Marine	Band	SMB	G. subcrenatum Marine Band
Granby_2	325.0	394.0	Undivided	Undivided	NAM	Namurian
Granby_2	394.0	397.0	Undivided	Undivided	DIN	Dinantian

HOLEID	FROM	TO	ROCK1	ROCK2	CODE	HORIZ
Grimmer	11.9	12.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Grimmer	33.7	33.8	Coal	undivided	2_ELL	2nd Ell
Grimmer	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Grimmer	56.0	64.0	Tuff	Tuff	BG	
Grimmer	64.0	74.0	Lava	basaltic	BF	
Grimmer	75.0	89.0	Lava	basaltic	BE	
Grimmer	89.0	92.0	Tuff	Tuff	BD	
Grimmer	92.0	97.0	Lava	basaltic	BC	
Grimmer	97.0	105.0	Sill	basaltic or doleritic	S_BC_BD	
Grimmer	105.0	126.0	Basaltic breccia	pillow fragments	BB	
Grimmer	126.0	144.0	Peperite	breccia	BA	
Plungar_23	1.9	2.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Plungar_23	37.0	37.5	Coal	undivided	2_ELL	2nd Ell
Plungar_23	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Plungar_23	60.7	65.0	Coal	undivided	DMAIN	Deep Main
Plungar_23	76.5	76.9	Coal	undivided	PGATE	Parkgate
Plungar_23	83.0	98.0	Tuff	Tuff	BFG	
Plungar_23	101.0	110.0	Lava	basaltic	BDE	
Plungar_23	110.0	115.0	Lava	basaltic	BC	
Plungar_23	115.0	134.0	Lava	basaltic	BB	
Plungar_23	134.0	138.0	Peperite	breccia	BA2	
Plungar_23	138.0	148.0	Lava	basaltic	BA1	
Plungar_23	155.0	155.2	Coal	undivided	MTK	Mickley Thick
Plungar_23	190.0	206.0	Lava	basaltic	AC	
Plungar_23	215.5	215.9	Coal	undivided	KLBN	Kilburn
Plungar_23	218.0	232.0	Sill	basaltic or doleritic	S_AB_AC	
Plungar_23	282.0	293.0	Sill	basaltic or doleritic	S_1AA	
Plungar_23	328.0	329.0	Marine	Band	SMB	G. subcrenatum Marine Band
Plungar_23	329.0	436.0	Undivided	Undivided	NAM	Namurian
Plungar_23	436.0	439.0	Undivided	Undivided	DIN	Dinantian
Stathern_South	4.9	5.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Stathern_South	29.0	29.5	Coal	undivided	2_ELL	2nd Ell
Stathern_South	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Stathern_South	69.5	72.0	Coal	undivided	DMAIN	Deep Main
Stathern_South	85.5	87.0	Coal	undivided	PGATE	Parkgate
Stathern_South	87.0	89.0	Tuff	Tuff	BH	
Stathern_South	89.0	105.0	Lava	basaltic	BFG	
Stathern_South	108.0	113.0	Lava	basaltic	BDE	
Stathern_South	113.0	146.0	Lava	basaltic	BBC	
Stathern_South	146.0	156.0	Lava	basaltic	BA	
Stathern_South	165.4	165.6	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Stathern_South	173.5	175.5	Coal	undivided	MTK	Mickley Thick
Stathern_South	178.0	197.0	Sill	basaltic or doleritic	S_AC_AD	
Plungar_11	2.4	2.5	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Plungar_11	31.0	31.3	Coal	undivided	2_ELL	2nd Ell
Plungar_11	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Plungar_11	69.0	71.0	Tuff	Tuff	BG	
Plungar_11	78.0	91.0	Lava	basaltic	BF	
Plungar_11	91.0	108.0	Lava	basaltic	BE	
Plungar_11	108.0	146.0	Lava	basaltic	BBCD	
Plungar_11	152.0	159.0	Lava	basaltic	BA1	
Plungar_11	217.0	261.0	Lava	basaltic	AC	
Plungar_11	280.0	301.0	Sill	basaltic or doleritic	S_1AA	
Plungar_11	327.0	328.0	Marine	Band	SMB	G. subcrenatum Marine Band
Plungar_11	328.0	394.0	Undivided	Undivided	NAM	Namurian
Plungar_11	394.0	400.0	Undivided	Undivided	DIN	Dinantian
Plungar_18	6.9	7.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Plungar_18	28.0	28.2	Coal	undivided	2_ELL	2nd Ell
Plungar_18	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Plungar_18	76.0	84.0	Tuff	Tuff	BG	
Plungar_18	95.0	112.0	Lava	basaltic	BEF	
Plungar_18	117.0	144.0	Lava	basaltic	BBCD	
Plungar_18	146.0	149.0	Lava	basaltic	BA	
Plungar_18	193.0	201.0	Lava	basaltic	AC	
Plungar_18	272.0	285.0	Sill	basaltic or doleritic	S_1AA	
Plungar_18	311.0	312.0	Marine	Band	SMB	G. subcrenatum Marine Band
Plungar_18	312.0	399.0	Undivided	Undivided	NAM	Namurian
Plungar_18	399.0	416.0	Undivided	Undivided	DIN	Dinantian

HOLEID	FROM	TO	ROCK1	ROCK2	CODE	HORIZ
Hose	9.9	10.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Hose	35.0	36.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
Hose	42.9	43.0	Coal	undivided	2_ELL	2nd Ell
Hose	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Hose	84.0	86.0	Coal	undivided	DMAIN	Deep Main
Hose	108.0	110.0	Coal	undivided	PGATE	Parkgate
Hose	141.0	142.0	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Hose	182.0	182.5	Coal	undivided	MTN	Mickley Thin
White_Lodge	8.9	9.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
White_Lodge	27.5	28.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
White_Lodge	37.8	38.0	Coal	undivided	2_ELL	2nd Ell
White_Lodge	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
White_Lodge	71.0	73.0	Coal	undivided	DMAIN	Deep Main
White_Lodge	82.0	83.0	Coal	undivided	PGATE	Parkgate
White_Lodge	85.0	124.0	Lava	basaltic	BF1	
White_Lodge	128.0	153.0	Lava	basaltic	BB	
White_Lodge	153.0	170.0	Tuff	Tuff	BA2	
White_Lodge	175.0	181.0	Lava	basaltic	BA1	
White_Lodge	184.0	186.0	Coal	undivided	BSH_ASH	Blackshale/Ashgate
White_Lodge	192.0	198.0	Lava	basaltic	AD	
Goadby_Gorse	17.9	18.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Goadby_Gorse	32.9	33.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
Goadby_Gorse	42.9	43.0	Coal	undivided	2_ELL	2nd Ell
Goadby_Gorse	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Goadby_Gorse	65.0	74.0	Sill	basaltic or doleritic	S_BF1_BF2	
Goadby_Gorse	79.0	122.0	Lava	basaltic	BF1	
Goadby_Gorse	124.0	142.0	Lava	basaltic	BB	
Goadby_Gorse	142.0	161.0	Tuff	Tuff	BA2	
Goadby_Gorse	170.0	172.6	Coal	undivided	BSH_ASH	Blackshale/Ashgate
Goadby_Gorse	172.8	190.3	Lava	basaltic	AD	
Waltham_Lane	14.9	15.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Waltham_Lane	25.5	26.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
Waltham_Lane	37.0	37.5	Coal	undivided	2_ELL	2nd Ell
Waltham_Lane	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Waltham_Lane	53.0	65.0	Lava	basaltic	BF2	
Waltham_Lane	71.0	82.0	Sill	basaltic or doleritic	S_BF1_BF2	
Waltham_Lane	82.0	106.0	Lava	basaltic	BF1	
Sherricliffe_Farm	8.9	9.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Sherricliffe_Farm	28.5	29.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
Sherricliffe_Farm	36.3	36.5	Coal	undivided	2_ELL	2nd Ell
Sherricliffe_Farm	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Sherricliffe_Farm	52.0	62.0	Lava	basaltic	BF2	
Sherricliffe_Farm	64.0	79.0	Sill	basaltic or doleritic	S_BF1_BF2	
Sherricliffe_Farm	83.0	101.0	Lava	basaltic	BF1	
Terrace_Hills	23.9	24.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Terrace_Hills	33.8	34.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
Terrace_Hills	40.8	41.0	Coal	undivided	2_ELL	2nd Ell
Terrace_Hills	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Terrace_Hills	51.0	77.0	Lava	basaltic	BF2	
Terrace_Hills	77.0	85.0	Tuff	Tuff	BF1	
Terrace_Hills	85.0	112.0	Lava	basaltic	BF1	
Harston_Hall	18.9	19.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Harston_Hall	38.8	39.0	Coal	undivided	4WL_1ELL	4th Waterloo/1st Ell
Harston_Hall	44.7	45.0	Coal	undivided	2_ELL	2nd Ell
Harston_Hall	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Harston_Hall	54.0	64.0	Lava	basaltic	BF	
Harston_Hall	64.0	70.0	Tuff	Tuff	BF	
France_Plantation	33.9	34.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
France_Plantation	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
France_Plantation	52.0	65.0	Tuff	Tuff	BG	
France_Plantation	65.0	91.0	Tuff	Tuff	BF	
France_Plantation	91.0	109.0	Tuff	Tuff	BE	
France_Plantation	109.0	121.0	Lava	basaltic	BD	
France_Plantation	121.0	145.0	Lava	basaltic	BABC	
France_Plantation	145.0	186.0	Tuff	Tuff	AD	
France_Plantation	186.0	225.0	Lava	basaltic	AC	
France_Plantation	225.0	238.0	Peperite	breccia	AB	

HOLEID	FROM	TO	ROCK1	ROCK2	CODE	HORIZ
Harston_Road	30.9	31.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Harston_Road	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Harston_Road	53.0	58.0	Tuff	Tuff	BG	
Harston_Road	58.0	91.0	Lava	basaltic	BF	
Harston_Road	91.0	99.0	Lava	basaltic	BE	
Harston_Road	99.0	120.0	Lava	basaltic	BD	
Roman_Plantation	33.4	33.5	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Roman_Plantation	40.5	54.5	Tuff	Tuff	BG	
Roman_Plantation	54.5	88.5	Lava	basaltic	BF	
Roman_Plantation	88.5	109.5	Lava	basaltic	BE	
Roman_Plantation	109.5	121.5	Lava	basaltic	BD	
Egypt_Plantation	0.0	36.2	Permo-Trias		PT	Permo Trias
Egypt_Plantation	47.2	56.2	Tuff	Tuff	BG	
Egypt_Plantation	56.2	79.2	Lava	basaltic	BF	
Egypt_Plantation	79.2	99.2	Lava	basaltic	BE	
Egypt_Plantation	99.2	130.2	Lava	basaltic	BD	
Egypt_Plantation	130.2	141.2	Lava	basaltic	BABC	
Egypt_Plantation	141.2	162.2	Lava	basaltic	AD	
Egypt_Plantation	162.2	173.2	Lava	basaltic	AC	
Egypt_Plantation	173.2	176.2	Peperite	breccia	AB4	
Egypt_Plantation	176.2	215.2	Lava	basaltic	AB4	
Egypt_Plantation	215.2	228.2	Tuff	Tuff	AB3	
Egypt_Plantation	228.2	285.2	Lava	basaltic	AB2	
Egypt_Plantation	288.2	289.2	Lava	basaltic	AA	
Great_Ponton	0.0	65.3	Permo-Trias		PT	Permo Trias
Great_Ponton	65.3	87.3	Lava	basaltic	BF	
Great_Ponton	91.3	102.3	Lava	basaltic	BE	
Great_Ponton	102.3	125.3	Lava	basaltic	BD	
Great_Ponton	125.3	141.3	Lava	basaltic	BABC	
Great_Ponton	161.3	194.3	Lava	basaltic	AB4	
Great_Ponton	199.3	217.3	Tuff	Tuff	AB3	
Great_Ponton	217.3	229.3	Lava	basaltic	AB22	
Great_Ponton	256.3	281.3	Lava	basaltic	AB21	
Great_Ponton	281.3	389.3	Undivided	Undivided	NAM	Namurian
Croxton_Abbey	27.9	28.0	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Croxton_Abbey	46.5	47.0	Coal	undivided	2_ELL	2nd Ell
Croxton_Abbey	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
Croxton_Abbey	51.0	91.5	Lava	basaltic	BF	

* Note - the datum for this list is taken as an arbitrary horizon 50 m above the base of the A. vanderbeckei Marine Band
* Where the A. vanderbeckei Marine Band is absent, an approximate horizon for it was assumed, based on the Vulcan model v.3