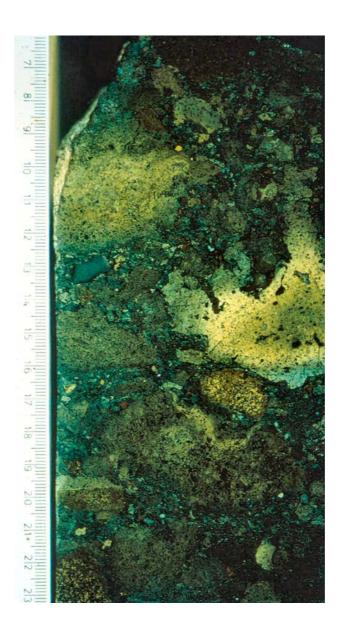


Methodology for Construction of Vulcan Model of the Saltby Volcanic Formation, DGSM Nottingham-Melton project

Internal Report IR/05/064



INTERNAL REPORT IR/05/064

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Dr S Dumpleton

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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 preunconformity 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*.

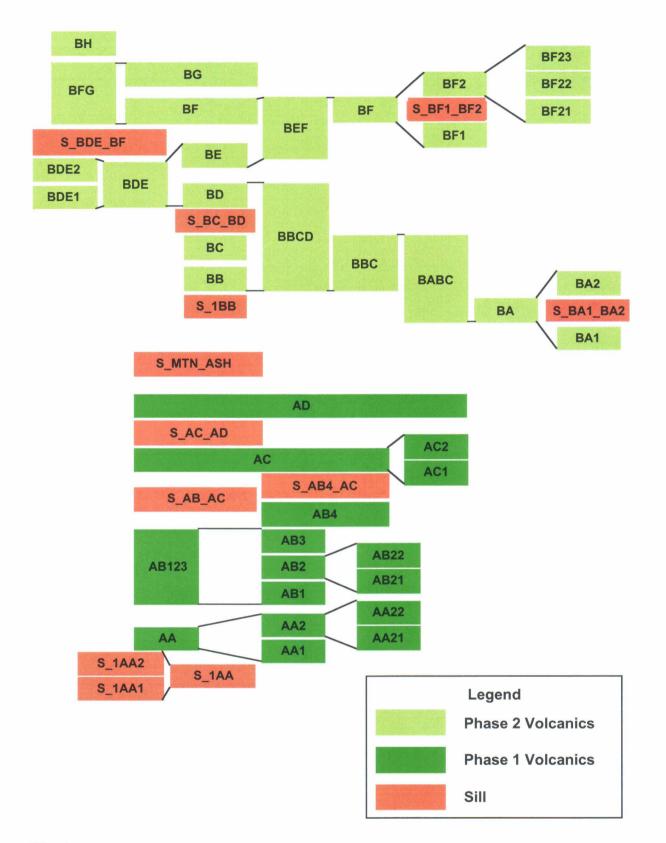
A full list of triangulated surfaces is given in Appendix 3.

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 southwest 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.





Schematic relationships of lithostratigraphic codes in the Saltby Volcanic Formation

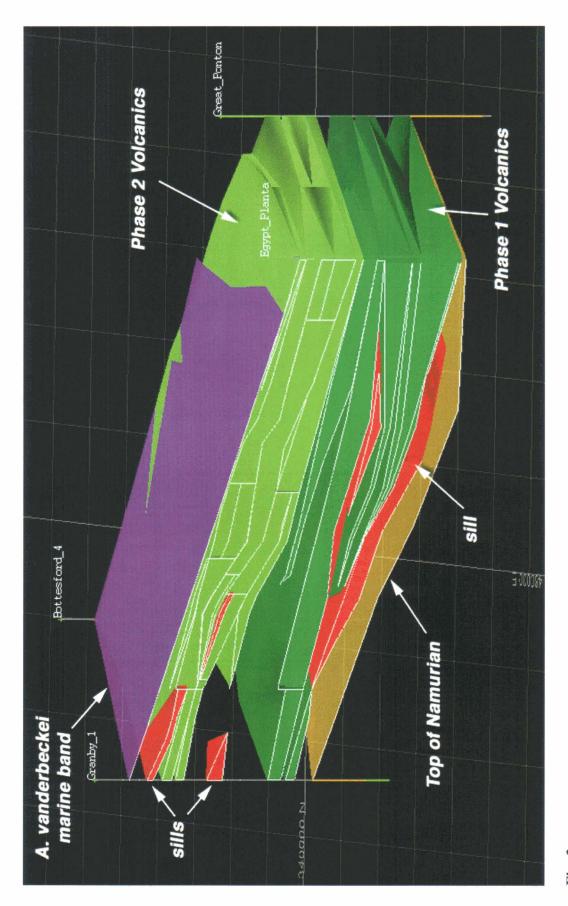


Fig. 2

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

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Stratigraphy	Phase 2 Volcanics	Phase 1 Volcanics	Sills
Q_2_WLOO Quasi-2nd Waterloo	ВН	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		
	ВА		

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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	
BB_DASE_A BB_TOP	Extrapolated points on base BB** 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	<u> </u>
	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 Extent of 2nd Waterloo seam
EXT_2_WLOO	Extent of 2nd waterioo seam

EVT AAI DO	Extent of AA1 base
EXT_AA1_BS	
EXT_AA1_TP	Extent of AA1 Top Extent of AA2 base
EXT_AA2_BS	
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_BD_TOF	Extent of BC base
EXT_BC_DAS	Extent of top BC
EXT_BDE_BS	Extent of BDE base
EXT_BDE_TP	Extent of BDE Top
	Extent of BD base
EXT_BD_BAS	Extent of BD Top
EXT_BD_TOP	Extent of BEF base
EXT_BEF_BS	
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

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EVT DEC DO	Extent of BFG Base
EXT_BFG_BS	
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 VMB_BASE Top of S_MTN_ASH 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 2_ELL.SFT 2_WLOO.SFT 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 DMAIN_BASE.00T NAM_SOLID.00T NAM_TOP.00T PGATE_BASE.00T PHASE1_SOLID.00T PHASE2_SOLID.00T 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 §

Description (where necessary) Base of 2nd Ell seam Base of 2nd Waterloo seam

Base of Blackshale/Ashgate seam Base of Deep Main seam Namurian solid triangulation Top of Namurian Base of Parkgate seam Solid triangulation of all Phase 1 ('A' codes) volcanics Solid triangulation of all Phase 2 ('B' codes) volcanics S_BF1_BF2_SOLID.00T §S_MTN_ASH_SOLID.00T §SILLS_ALL_SOLID.00TVMB.RLTSolid triangulation of all sillsBase 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

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HOLEID	FROM	то	ROCK1	ROCK2	CODE	HORIZ
Harston_1	41.9		Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Harston_1	44.3	44.5		undivided	2_ELL	2nd Ell
Harston_1	49.0		Marine	Band	VMB	A. vanderbeckei Marine Band
					+	
Harston_1	62.0		Tuff	Tuff	BG	
Harston_1	73.0		Lava	basaltic	BF	
Harston_1	90.0	126.0	•	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		Peperite	breccia	AB4	
Harston_1	290.0		1 1	Tuff	AB3	
	COLUMN TRANSPORT			basaltic	AB2	
Harston_1	310.0					
Harston_1	327.0			Tuff	AB1	
Harston_1	342.0		Contraction and the second sec	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		Coal	undivided	2_ELL	2nd Ell
Woolsthorpe_Bridge	49.0		Tuff	Tuff	BG	
Woolsthorpe_Bridge	54.0		Lava	basaltic	BF	
Woolsthorpe_Bridge	80.0		Tuff	Tuff	BDE2	
Woolsthorpe_Bridge	86.0		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		Coal	undivided	2_ELL	2nd Ell
			-	· · · · · · · · · · · · · · · · · · ·		
Redmile_1	49.0		Marine	Band	VMB	A. vanderbeckei Marine Band
Redmile_1	66.0	70.0	· · · · · · · · · · · · · · · · · · ·	Tuff	BG	
Redmile_1	70.0		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		Peperite	breccia	BA2	
Redmile_1	153.0	162.0		basaltic or doleritic	S_BA1_BA2	
	167.0	170.0	•••	Tuff		
Redmile_1			·	• · · · · · · · · · · · · · · · · · · ·	BA1	
Redmile_1	175.0	176.0		undivided	BSH_ASH	Blackshale/Ashgate
Redmile_1	179.0	197.0		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	AB4	
Redmile_1	271.0	279.0		Tuff	AB123	
Redmile_1	279.0	294.0		basaltic or doleritic		
					S_1AA2	
Redmile_1	299.0	304.0		basaltic or doleritic	S_1AA1	
Redmile_1	306.0	306.5		undivided	BLAWN	Belper Lawn
Redmile_1	330.0		Marine	Band	SMB	G. subcrenatum Marine Band
Redmile_1	331.0		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		undivided	2_ELL	2nd Ell
Bottesford_4	49.0		Marine	Band	VMB	A. vanderbeckei Marine Band
		C. S. M. S. C. Marchana and S.				
Bottesford_4	54.0	60.0		Tuff	BG	
Bottesford_4	60.0	86.0		basaltic	BF	······································
Bottesford_4	86.0	97.0		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	BA1	
Bottesford_4	159.0	197.0		basaltic	AD	
						<u>↓</u>
Bottesford_4	197.0	221.0		basaltic or doleritic	S_AC_AD	
Bottesford_4	228.0	229.0		undivided	KLBN	Kilburn
Bottesford_4	231.0	244.0		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		basaltic	AA1	
Bottesford_4	383.0		Marine	Band	SMB	G. subcrenatum Marine Band
Bottesford_4	384.0		Undivided			
· · · · · · · · · · · · · · · · · · ·	444.0		Undivided	Undivided Undivided	NAM DIN	Namurian Dinantian
Bottesford_4						

Middesate, Bridge 24 25 Cod undivided 2, WLOQ 2nd Waterbo (assumed 0.1 m arbitrary Microsci) Middesite, Bridge 1.10 1.11 Cad	HOLEID	FROM	то	ROCK1	ROCK2	CODE	HORIZ
Maddesize, Bridge 41 0 Col Market Earl VMB A vanderbeel Marine Band Modesteile, Bridge 50.0 75.0 11.4 Tuff BS A vanderbeel Marine Band Modesteile, Bridge 50.0 75.0 Lawa besattic BF2 Modesteile, Bridge 100.0 Lawa besattic BF2 Modesteile, Bridge 100.0 Lawa besattic SOE D Modesteile, Bridge 100.0 15.7<0	Middle atta Datas	04.0		Coat		2 141 00	2nd Metalog (commod 0.1 m arbitrary thickness)
Modelselie, Bridge 49.0 50.0 Main Band VME A vanderbecker Maine Band Modelselie, Bridge 50.0 50.0 70.0 Lava basable BF2				and the second			
Madastase Bridge Sol o Sol o Link BP Maddeslag, Bridge B30 o Dispatitio BF2 Addressite Addressite BF1 Maddeslag, Bridge 103 0 Lava basalitio BF1 Addressite Addressite Addressite BF1 Addressite BF21 Addressite Addressite Addressite Addressite BF21 Addressite Addressite <td></td> <td>· -· · · · · · · · · · · · · · · · · ·</td> <td></td> <td></td> <td></td> <td></td> <td></td>		· -· · · · · · · · · · · · · · · · · ·					
Maddesse, Bröge 53.0 79.0 Lava Desaitio BF1 Maddesse, Bröge 103.0 104.0 Sill Desaitio or doettio S, BDE, BF Maddesse, Bröge 103.0 105.0 Desaitio AD Maddesse, Bröge 104.0 Sill Desaitio AD Maddesse, Bröge 205.0 Call Desaitio AD Maddesse, Bröge 205.0 205.0 Desaitio AD Maddesse, Bröge 205.0 2.0 Desaitio AD Autore Desaitio AD Maddesse, Bröge 205.0 2.0 Desaitio MME A vanderbröcker Marine Band Redmite, Bröge 2.0 D.0 Marine Desaitio BF21 Redmite, Bröge 2.0 D.0 Nark Desaitio BF21 Redmite, Bröge 2.0 D.0 Nark Desaitio BF21 Redmite, Bröge 7.0 1.5.0 Lava Desaitio BE1 Redmite, Bröge 7.0 1.5.0 <td>· · · · · · · · · · · · · · · · · · ·</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>A. vanderbeckei Marine Band</td>	· · · · · · · · · · · · · · · · · · ·						A. vanderbeckei Marine Band
Middexise Bridge Bits Description Bits Description Bits Description Bits Description Description <thdescription< th=""> <thdescription< th=""> <thde< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></thde<></thdescription<></thdescription<>							
Madd estile, Bridge 103 0	Middlestile_Bridge	53.0	79.0	Lava	basaltic		
Meddesite_Bridge 100 140.0 150.0 Lange Meddesite_Bridge 140.0 150.0 Lange Lange<	Middlestile_Bridge	88.0	103.0	Lava	basaltic	BF1	
Middesile_Bridge 14.9 15.7 0 value basalic AD Estimated - below BASEBH Middesile_Bridge 25.0 0.80 Law basalic AD Estimated - below BASEBH Redmie_Bridge 25.0 0.20 0.20 0.20 Coal undvided 2.8.4 2.7.6 2.7.6 Advaterio	Middlestile_Bridge	103.0	109.0	Sill	basaltic or doleritic	S_BDE_BF	
Middesile_Bridge 14.9 15.7 0 value basalic AD Estimated - below BASEBH Middesile_Bridge 25.0 0.80 Law basalic AD Estimated - below BASEBH Redmie_Bridge 25.0 0.20 0.20 0.20 Coal undvided 2.8.4 2.7.6 2.7.6 Advaterio	Middlestile_Bridge	109.0	149.0	Basaltic breccia	pillow fragments	BBC	
Moddesite, Bindge 157 2 06 0, 249.0 Usaaltic AD Estimated - below BASEBH Redmite, Bridge 20.6 20.8 0.80 Status St		149.0	157.0	Lava	+•	AD	
Maddestie_Bridge 206.0 206.0 SI basatic or dolerinc S.A.C.AD Estimated - below BASEBH Redmie_Bridge 209.0 21.0 Cond undivided 2, MLO 2nd Userfoot (assured 0.1 m arbitrary thicknes). Redmie_Bridge 33.0 Gal undivided 2, ELL 2nd EL 2nd EL Redmie_Bridge 52.0 53.0 Name Band VME A vanderbecket Maine Band Redmie_Bridge 63.0 64.0 Cond undivided Deep Main Redmie_Bridge 63.0 64.0 Cond undivided Deep Main Redmie_Bridge 63.0 64.0 Cond undivided Deep Main Redmie_Bridge 70.0 12.0 Lava basatic Deep Main Redmie_Bridge 13.0 13.0 Coal undivided MTK Medive Trok Redmie_Bridge 19.0 13.0 Lava basatic AO Estimated - below BASEBH Redmie_Bridge 19.0 Lava basatic <							Estimated - below BASEBH
Reaming Burge 7.0 Coal undivided 2_VLOD 2nd Waterloo (assumed 0.1 m arbitrary thickness) Reaming Bridge 93.0 0.33.1 Coal undivided 2_ELL 2nd Ell Reaming Bridge 58.0 Coal undivided 2_ELL 2nd Ell Reaming Bridge 58.0 Coal Undivided PE23							
Padmine Badding Z ELL Znd Ell Radmine Badding Second Second </td <td>inducorio_bildge</td> <td>200.0</td> <td>200.0</td> <td></td> <td></td> <td>0_/10_/10</td> <td></td>	inducorio_bildge	200.0	200.0			0_/10_/10	
Padmine Badding Z ELL Znd Ell Radmine Badding Second Second </td <td>Bodmilo Bridgo</td> <td>20.0</td> <td>21.0</td> <td>Coal</td> <td>undivided</td> <td>2 141 00</td> <td>2nd Waterloo (assumed 0.1 m arbitrary thickness)</td>	Bodmilo Bridgo	20.0	21.0	Coal	undivided	2 141 00	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Pacentie, Brodge 94 0 50 0 Name Band VME A vanderbecker Marine Band Redmile, Brodge 58 0 62 0 1.11 Tuff BF2 Image: State StateS							AL PALL PROMINE AND A PROVIDE AND A
Redmine_Bridge 68.0 58.0 Lava besattic BF23 Redmine_Bridge 63.0 64.0 Coal und/vided OMAN Deep Main Redmine_Bridge		4. V.L		 Comparison of the second se Second second sec			
Redmite_Bridge 58.0 62.0 Tuff DF22 Image: Control of Cont							A. vanderbeckel Marine band
Picotelie Bridge For Ao Lawa Description Description<							
Redmie, Bridge 67:0 74:0 Leastitic 6F1 Redmie, Bridge 105:0 Lawa basalitic 6F1 Redmie, Bridge 118:0 Basalitic 6B Redmie, Bridge 113:0 Lawa basalitic 6B Redmie, Bridge 133:0 Call undivided SRI-ASH Biackshale/Ashgate Redmie, Bridge 139:0 Call undivided MTN Mickley Thin Redmie, Bridge 159:0 Coall undivided MTN Mickley Thick Redmie, Bridge 170:0 Coall undivided ZWLOO Zod Watehoo (assumed 0.1 m arbitrary thickness) Granby 1 44:0 45:0 Call undivided ZWLOO Zod Watehoo (assumed 0.1 m arbitrary thickness) Granby 1 44:0 0 0 Deal undivided ZWLOO Zod Watehoo (assumed 0.1 m arbitrary thickness) Granby 1 45:0 Goal undivided ZWLO Zod Watehoo (assumed 0.1 m arbitrary thickness) Granby 1 90:0 Goal <td></td> <td>- +</td> <td></td> <td></td> <td></td> <td></td> <td></td>		- +					
Fachmic Bridge P10 105.0 Lava basaltic PF1 Redmik Bridge 118.0 Pasaltic PB PA PA <td< td=""><td></td><td>63.0</td><td></td><td></td><td>undivided</td><td>DMAIN</td><td>Deep Main</td></td<>		63.0			undivided	DMAIN	Deep Main
Fadmic Bridge 118.0 Basatic brecon pillow fragments BC Redmic Bridge 128.0 128.0 128.0 138.0 Cal undivided SH ASH Biackshale/Ashgate SH ASH Redmic Bridge 158.0 159.0 Coal undivided MTN Mickley Thin Redmic Bridge 168.0 Lova Losatinc AD AD Redmic Bridge 169.0 Lova Losatinc AD Estimated - below BASEBH Redmic Bridge 169.0 Lova Losatinc AD Estimated - below BASEBH Redmic Bridge 169.0 Lova Losatinc AD Estimated - below BASEBH Granby.1 42.0 Coal undivided 2_WLOO 2nd Waterfor (assumed 0.1 m arbitrary thickness) Granby.1 49.0 50.0 Marine Band VMAN A vanderbecker Marine Band Granby.1 91.0 50.0 Marine Bandivided TNTO TuptonThreequarters Granby.1 91.0 Coal undivid	Redmile_Bridge	67.0	74.0	Lava	basaltic	BF21	
Fadmic Bridge 118.0 Basatic brecon pillow fragments BC Redmic Bridge 128.0 128.0 128.0 138.0 Cal undivided SH ASH Biackshale/Ashgate SH ASH Redmic Bridge 158.0 159.0 Coal undivided MTN Mickley Thin Redmic Bridge 168.0 Lova Losatinc AD AD Redmic Bridge 169.0 Lova Losatinc AD Estimated - below BASEBH Redmic Bridge 169.0 Lova Losatinc AD Estimated - below BASEBH Redmic Bridge 169.0 Lova Losatinc AD Estimated - below BASEBH Granby.1 42.0 Coal undivided 2_WLOO 2nd Waterfor (assumed 0.1 m arbitrary thickness) Granby.1 49.0 50.0 Marine Band VMAN A vanderbecker Marine Band Granby.1 91.0 50.0 Marine Bandivided TNTO TuptonThreequarters Granby.1 91.0 Coal undivid	Redmile_Bridge	79.0	105.0	Lava	basaltic	BF1	
Redmik Bridge 118.0 128.0 Laws basaltic BB Redmik Bridge 138.0 133.0 Sill basaltic or doleritic		105.0			pillow fragments	BC	
Redmie_Bridge 128.0 139.0 Col. Undivided SPLASH Deschalt Deschalt <thdeschalt< th=""> Deschalt <thdes< td=""><td>·····</td><td></td><td></td><td></td><td>······································</td><td></td><td></td></thdes<></thdeschalt<>	·····				······································		
Bedmile_Bridge 138.0 139.0 Coal undivided MSH Blackshafter Redmile_Bridge 159.0 Coal undivided MTN Mickley Thin			and the second s		and the second sec		
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Pedmile Bridge 170.0 199.0 Lava basaltic AD Redmile Bridge 189.0 199.0 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 Model Quico 2.ELL 2.M El Anno Deep Main Granby_1 66.0 67.0 Coal undivided MAN A vanderbeckei Marine Band Granby_1 91.0 92.0 Coal undivided TMTO Tupton/Threequarters Granby_1 91.0 92.0 Coal undivided TMTO Tupton/Threequarters Granby_1 199.0 133.0 Lava basaltic BSH_ASH Blackshale/Ashgate Granby_1 199.0 133.0 Lava basaltic MiX HM MixLey Thin Granby_1 192.0 193.0 Coal undivided MTN MixLey Thin Granby_1 192.0 </td <td></td> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td></td>		1					
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Granby_1 14.9 15.0 Coal undivided 2_wiLOO 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_vanderbeckel Marine Band Granby_1 66.0 67.0 Coal undivided DMAN Deep Main Granby_1 97.0 98.0 Coal undivided TNTC Tupton/Threequarters Granby_1 97.0 98.0 Coal undivided TNTC Tupton/Threequarters Granby_1 97.0 98.0 Coal undivided BSH_ASH Bickshale/Ashgate Granby_1 197.0 133.0 Lava basalito BSH_ASH Bickshale/Ashgate Granby_1 199.0 133.0 Lava basalito ASH ASH Granby_1 192.0 193.0 Coal undivided MTN Mickley Thin Granby_1 216.0 217.0 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>							
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Granby_1 42 0 43 0 Coal undivided 2. ELL 2. Ref Granby_1 49 0 50 0 Marine Band VMB A. vanderbeckei Marine Band Granby_1 76 0 85 0 Isin basalito or doleritic S.BF1_BF2 Granby_1 97 0 98 0 Coal undivided PATE Parkgate Granby_1 97 0 98 0 Coal undivided PATE Parkgate Granby_1 97 0 98 0 Coal undivided PATE Parkgate Granby_1 190 0 131 0 Lava basalito PB Granby_1 142 0 183 0 Coal undivided MTN McKety Thin Granby_1 192 0 193 0 Coal undivided MTN McKety Thin Granby_1 216 0 217 0 Coal undivided KLBN Kilburn Granby_1 226 0 228 0 Lava basalito AA21 Granby_1		:					
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Granby_1 66.0 67.0 Coal undivided DMANN Deep Main Granby_1 91.0 92.0 Coal undivided PARtz Parkgate Granby_1 97.0 98.0 Coal undivided TUPton/Threequarters Granby_1 97.0 98.0 Coal undivided TUPton/Threequarters Granby_1 19.0 131.0 Lava basaltic BB Granby_1 142.0 143.0 Coal undivided MTN Mickley Thin Granby_1 192.0 193.0 Coal undivided MTN Mickley Thin Granby_1 Granby_1 197.0 198.0 Coal undivided MTN Mickley Thick Granby_1 Granby_1 216.0 217.0 Coal undivided MTN Mickley Thick Granby_1 Granby_1 280.0 280.0 Lava basaltic AA22 Granby_1 308.0 Sealtic AA21 Granby_1 323.0	Granby 1	49.0	50.0	Marine	Band	VMB	A. vanderbeckei Marine Band
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Granby_2 325.0 394.0 Undivided Undivided NAM Namurian	Granby_2	325.0	394.0	Undivided	Undivided	NAM	Namurian
Granby 2 394.0 397.0 Undivided Undivided DNN Dinantian	· ··· ··· ··· ··· · · · · · · · · · ·			······································			

HOLEID	FROM	то	ROCK1	ROCK2	CODE	HORIZ
				<u> </u>		
Grimmer	11.9	12.0		undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Grimmer	33.7	33.8		undivided	2_ELL	2nd Ell
Grimmer	49.0		Marine	Band	VMB	A. vanderbeckei Marine Band
Grimmer	56.0	64.0	Tuff	Tuff	EG	
Grimmer	64.0	74.0	Lava	basaltic	BF	
Grimmer	75.0	89.0	Lava	basaltic	BE	
Grimmer	89.0		Tuff	Tuff	BD	
					BC	
Grimmer	92.0		Lava	basaltic		
Grimmer	97.0	105.0		basaltic or doleritic	S_BC_BD	
Grimmer	105.0		Basaltic breccia	pillow fragments	BB	
Grimmer	126.0	144.0	Peperite	breccia	BA	
Plungar_23	1.9	20	Coal	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Plungar_23	37.0	37.5	* Contractor of the contrac	undivided	2_ELL	2nd Ell
			•			
Plungar_23	49.0		Marine	Band	VMB	A. vanderbeckei Marine Band
Plungar_23	60.7	65.0		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		basaltic	BDE	
Plungar_23	110.0	115.0		basaltic	BC	
Plungar_23	115.0	134.0		basaltic	86	
Plungar_23	134.0		Peperite	breccia	BA2	
Plungar_23	138.0	148.0	Lava	basaltic	BA1	
Plungar_23	155.0	155.2	Coal	undivided	МТК	Mickley Thick
Plungar_23	190.0	206.0		basaltic	AC	
Plungar_23	215.5	215.9		undivided	KLBN	Kilburn
	-					
Plungar_23	218.0	232.0		basaltic or doleritic	S_AB_AC	
Plungar_23	282.0	293.0		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
Chathern Couth	4.0		Caal		0.141.000	
Stathern_South	4.9		Coat	undivided	2_WLOO	2nd Waterloo (assumed 0.1 m arbitrary thickness)
Stathern_South	29.0	29.5		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	BH	
· · · · · · · · · · · · · · · · · · ·						
Stathern_South	89.0	105.0		basaltic	BFG	
Stathern_South	108.0	113.0		basaltic	BDE	
Stathern_South	113.0	146.0		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		undivided	MTK	Mickley Thick
Stathern_South	178.0	197.0		basaltic or doleritic	S_AC_AD	
Stathenn_South	-+ 170.0	137.0		Dasanic of dolernic	<u>0_70_70</u>	
				·		· + · · · · · · · · · · · · · · · · · ·
Plungar_11	2.4		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	· · · · · · · · · · · · · · · · · · ·	basaltic	8F	
Plungar_11	91.0	108.0		basaltic	BE	
Plungar_11	108.0	146.0	· · · · · · · · · · · · · · · · · · ·	basaltic	BBCD	
Plungar_11	152.0	159.0		basaltic	BA1	
Plungar_11	217.0	261.0	· · · · · · · · · · · · · · · · · · ·	basaltic	AC	
Plungar_11	280.0	301.0		basaltic or doleritic	S_1AA	
Plungar_11	327.0	328.0	Marine	Band	SMB	G. subcrenatum Marine Band
Plungar_11	328.0		Undivided	Undivided	NAM	Namurian
Plungar_11	394.0		Undivided	Undivided	DIN	Dinantian
i ungal_1	394.0	400.0		Chuivideu		
.	-+		<u> </u>			
Plungar_18	6.9		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	and the second s	Tuff	BG	
Plungar_18	95.0	112.0		basaltic	BEF	
	++					-+
Plungar_18	117.0	144.0		basaltic	BBCD	
Plungar_18	146.0	149.0		basaltic	BA	
Plungar_18	193.0	201.0		basaltic	AC	
Plungar_18	272.0	285.0	Sill	basaltic or doleritic	S_1AA	
Plungar_18	311.0	312.0		Band	SMB	G. subcrenatum Marine Band
Plungar_18	312.0		Undivided	Undivided		
i iuliyai_io	012.0		The second		NAM	Namurian
Plungar_18	399.0		Undivided	Undivided	DIN	Dinantian

HOLEID	FROM	то	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/		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Hose	42.9	43.0		undivided	2_ELL	2nd Ell		l
			+ ··· · · · · · · · · · · · · · · · · ·			· · ·		
lose	49.0		Marine	Band	VMB		ei Marine Band	
lose	84.0	86.0	Coal	undivided	DMAIN	Deep Main		
lose	108.0	110.0	Coal	undivided	PGATE	Parkgate		
lose	141.0	142.0	Coal	undivided	BSH ASH	Blackshale/As	haate	
lose			· · · · · · · · · · · · · · · · · · ·				ligate	· · · · · · · · · · · · · · · · · · ·
1056	182.0	182.5	Coal	undivided	MTN	Mickley Thin		
Vhite_Lodge	8.9	9.0	Coal	undivided	2_WLOO	2nd Waterloo	(assumed 0.1	m arbitrary thickness)
Vhite_Lodge	27.5	28.0	Coal	undivided	4WL_1ELL	4th Waterloo/	1st Ell	
Vhite_Lodge	37.8	38.0	Coal	undivided	2_ELL	2nd Ell		
The Analysis of The Analysis and the second se								
Vhite_Lodge	49.0		Marine	Band	VMB		ei Marine Band	
Vhite_Lodge	71.0	73.0		undivided	DMAIN	Deep Main		
Vhite_Lodge	82.0	83.0	Coal	undivided	PGATE	Parkgate		
Vhite_Lodge	85.0	124.0	Lava	basaltic	BF1			
Vhite_Lodge	128.0					+		
	-+	153.0		basaltic	BB	+		
Vhite_Lodge	153.0	170.0		Tuff	BA2			
Vhite_Lodge	175.0	181.0	Lava	basaltic	BA1			
Vhite_Lodge	184.0	186.0	Coal	undivided	BSH ASH	Blackshale/As	hoate	
Vhite_Lodge	192.0	198.0				S.askanale/As		
nine_couye	192.0	190.0	Lava	basaltic	AD			
	· ·						1	
ioadby_Gorse	17.9	18.0		undivided	2_WLOO	2nd Waterloo	(assumed 0.1	m arbitrary thickness)
ioadby_Gorse	32.9	33.0	Coal	undivided	4WL_1ELL	4th Waterloo/		
ioadby_Gorse	42.9	43.0		undivided	2_ELL	2nd Ell		· · · · · · · · · · · · · · · · · · ·
	+							
boadby_Gorse	49.0		Marine	Band	VMB	A. vanderbeck	ei Marine Band	
oadby_Gorse	65.0	74.0	Sill	basaltic or doleritic	S_BF1_BF2			
oadby_Gorse	79.0	122.0	Lava	basaltic	BF1			
loadby_Gorse	124.0	142.0		basaltic	BB	+		<u>├</u> ━
	+				-			
loadby_Gorse	142.0	161.0		Tuff	BA2			
ioadby_Gorse	170.0	172.6	Coal	undivided	BSH_ASH	Blackshale/As	hgate	
ioadby_Gorse	172.8	190.3	Lava	basaltic	AD		-	
	1			bubuillo				
Jabbana Lasa	140	45.0	0		0.1111.000	0.1.11	(· · · · · · · · · · · · · · · · · · ·
Valtham_Lane	14.9	15.0		undivided	2_WLOO			m arbitrary thickness)
Valtham_Lane	25.5	26.0	Coal	undivided	4WL_1ELL	4th Waterloo/	1st Ell	
Valtham_Lane	37.0	37.5	Coal	undivided	2_ELL	2nd Ell		
Valtham_Lane	49.0		Marine	Band	VMB	A. vanderbeck	ei Marine Band	
	· · · · · · · · · · · · · · · · · · ·					A. Validerbeck	er wanne band	
Valtham_Lane	53.0	65.0		basaltic	BF2			
Valtham_Lane	71.0	82.0	Sill	basaltic or doleritic	S_BF1_BF2			
Valtham_Lane	82.0	106.0	Lava	basaltic	BF1			
herricliffe_Farm	8.9	۵ ۵	Coal	undivided	2_WLOO	2nd Waterloo	(accumed 0.1	m arbitrany thickness)
	+							m arbitrary thickness)
herricliffe_Farm	28.5	29.0		undivided	4WL_1ELL	4th Waterloo/	IST EII	
herricliffe_Farm	36.3	36.5	Coal	undivided	2_ELL	2nd Ell		
Sherricliffe_Farm	49.0	50.0	Marine	Band	VMB	A. vanderbeck	ei Marine Band	
herricliffe_Farm	52.0	62.0		basaltic	BF2			
	t				+			
herricliffe_Farm	64.0	79.0		basaltic or doleritic	S_BF1_BF2			
herricliffe_Farm	83.0	101.0	Lava	basaltic	BF1			
errace_Hills	23.9	24.0	Coat	undivided	2_WLOO	2nd Waterloo	(assumed 0.1	m arbitrary thickness)
							_	
errace_Hills	33.8	34.0		undivided	4WL_1ELL	4th Waterloo/	151 1	
errace_Hills	40.8	41.0		undivided	2_ELL	2nd Ell		
errace_Hills	49.0	50.0	Marine	Band	VMB	A. vanderbeck	ei Marine Band	
errace_Hills	51.0	77.0		basaltic	BF2			
errace_Hills	· · · · · · · · · · · · · · · · · · ·	85.0						
	77.0			Tuff	BF1	1		
errace_Hills	85.0	112.0	Lava	basaltic	BF1			
arston_Hall	18.9	19.0	Coal	undivided	2_WLOO	2nd Waterloo	(assumed 0.1	m arbitrary thickness)
arston_Hail	38.8	39.0		undivided	4WL_1ELL	4th Waterloo/		······································
a second and the second s	 a	45.0						
arston_Hall	44.7			undivided	2_ELL	2nd Ell		
arston_Hall	49.0		Marine	Band	VMB	A. vanderbeck	ei Marine Band	
arston_Hall	54.0	64.0	Lava	basaltic	BF			
arston_Hall	64.0	70.0	Tuff	Tuff	8F			
	1				1	1 1		
rance_Plantation	33.9	34.0	Coal	undivided	2_WLOO	2nd Waterloc	(accumed 0 1	m arbitrary thickness)
							• · · · · · · · · · · · · · · · · · · ·	m aronuary unckness)
rance_Plantation	49.0		Marine	Band	VMB	A. vanderbecke	e Marine Band	
rance_Plantation	52.0	65.0	Tuff	Tuff	BG			
rance_Plantation	65.0	91.0	Tuff	Tuff	BF			
rance_Plantation	91.0	109.0				+ İ	· · · · · · · · · · · · · · · · · · ·	
				Tuff	BE			
rance_Plantation	109.0	121.0		basaltic	BD			
D 1 1 1	121.0	145.0	Lava	basaltic	BABC			
rance_Plantation				Tuff	AD	++		
rance_Plantation	1/1 0							
rance_Plantation	145.0	186.0				+		
	145.0 186.0	186.0		basaltic	AC			

HOLEID	FROM	то	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	4	Marine	Band	VMB	A, vanderbeckei Marine Band
Harston Road	53.0		Tuff	Tuff	BG	
Harston Road	58.0	÷	Lava	basaltic	BF	
Harston_Road	91.0	•	Lava	basaltic	BE	
	99.0		· · · · · · · · · · · · · · · · · · ·	basaitic	BD	
Harston_Road	99.0	120.0	Lava	Dasanic		
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	Æ	
Roman_Plantation	109.5	• • • • • • • • • •		basaltic	BO	
Count Disstation	i		Permo-Trias		म	Permo Trias
Egypt_Plantation	0.0			Tuff		
Egypt_Plantation	47.2		Tuff		EG PF	
Egypt_Plantation	56.2		Lava	basaltic	BF	
Egypt_Plantation	79.2		Lava	basaltic	BE	
Egypt_Plantation	99.2			basaltic	BD	
Egypt_Plantation	130.2		**************************************	basaltic	BABC	
Egypt_Plantation	141.2	· • · · · · · · · · · · · · · · · · · ·	• • • •	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		Permo-Trias		PT	Permo Trias
Great_Ponton	65.3		Lava	basaltic	BF	
	91.3			basaltic	8E	
Great_Ponton			Lava			
Great_Ponton	102.3			basaltic	BD	
Great_Ponton	125.3	• • • • • • • • • • • • •		basaltic	BABC	
Great_Ponton	161.3	(4) 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.	Lava	basaltic	AB4	
Great_Ponton	199.3	· · · · · · · · · · · · · · · · · · ·		Tuff	AB3	
Great_Ponton	217.3		•	basaltic	AB22	
Great_Ponton	256.3	-	+	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	an a	Coal	undivided	2_ELL	2nd Ell
Croxton_Abbey	49.0		Marine	Band	VMB	A. vanderbeckei Marine Band
Croxton_Abbey	51.0		Lava	basaltic	BF	
CIONUL_ADDEY	51.0	91.0	Lava	Vasanic	ur	