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Metadata report for the Northumberland and Solway Basin 1:250 000 geological model

Geology and Landscape Programme

Open Report OR/13/049

BRITISH GEOLOGICAL SURVEY

GEOLOGY AND LANDSCAPE PROGRAMME

OPEN REPORT OR/13/049

Metadata report for the Northumberland and Solway Basin 1:250 000 geological model

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Bibliographical reference

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FIGURES

Summary

This report describes the Northumberland-Solway Basin 1:250 000 model data and workflow. The model is based on the faults and surface contour plots in the map appendix of the following BGS subsurface memoir:

Chadwick, R A, Halliday, D W, Holloway, S and Hulbert, A G. 1995. The structure and evolution of the Northumberland-Solway Basin and adjacent areas. Subsurface Memoir of the British Geological Survey.

1 Modelled volume, purpose and scale

Figure 1 Modelled area (in blue)

This is a faulted GOCAD® regional model extending onshore across North Yorkshire, Cumbria, Northumberland and into Southern Scotland (Figure 1). The model was constructed from digital data compiled for the Northumberland-Solway Subsurface Memoir (Chadwick et al., 1995). The results of the study are contained in the 1:625 000 scale structure contour maps (Figure 2) , preserved thickness and subcrop maps that accompany the Subsurface Memoir, so the data and model generated is regional to national in scale.

The model was developed as part of the Regional UK Lithoframe Programme, the aim of which was to convert the structural data interpreted in the subsurface memoirs into 3D models. Other models in this series include the Craven Basin, the Cheshire Basin and Weald Basin models. The Northumberland-Solway Basin model provides an understanding of the regional bedrock structure in Northern England (particularly for the Carboniferous rocks) and extends from +700 to -9000m OD.

As the Northumberland Solway Basin Model was derived from data compiled for the Regional Subsurface Memoir series, tasks such as drawing seismic interpretation to well control have already been performed. This document describes the process of creating a GOCAD model from derived digital contour data (Figure 3).

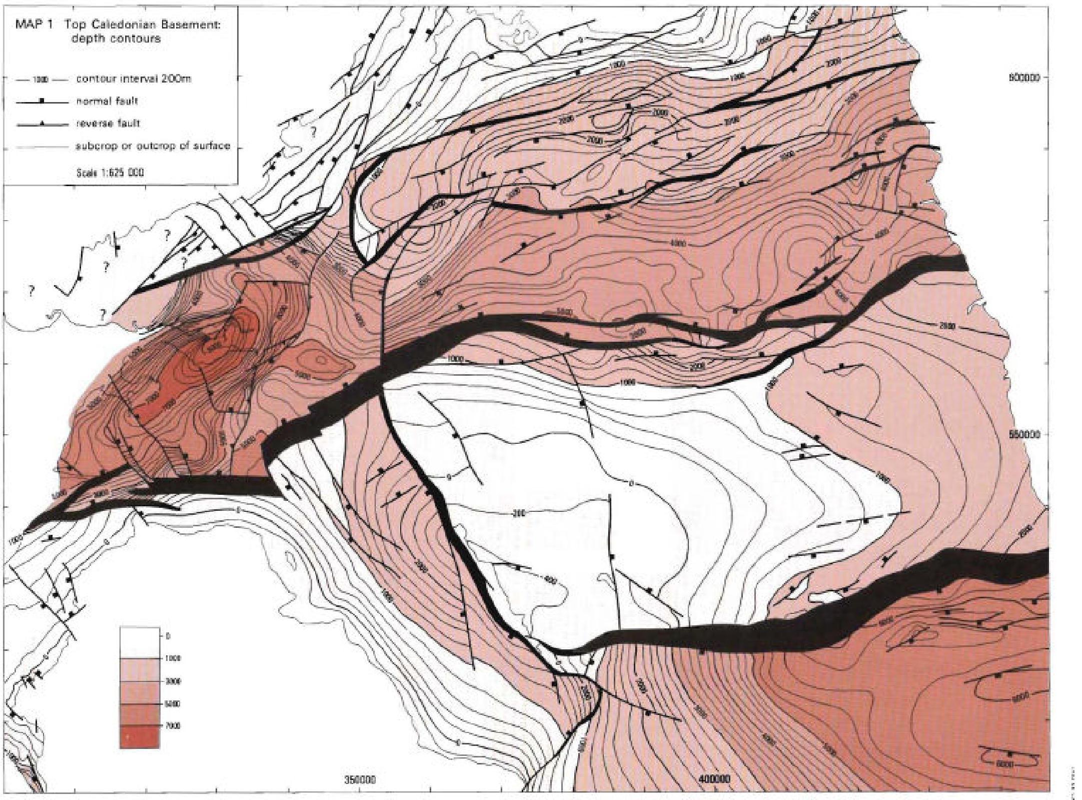

Figure 2 An example structural contour map of the Top Caledonian Basement from the Northumberland and Solway Basin Subsurface Memoir

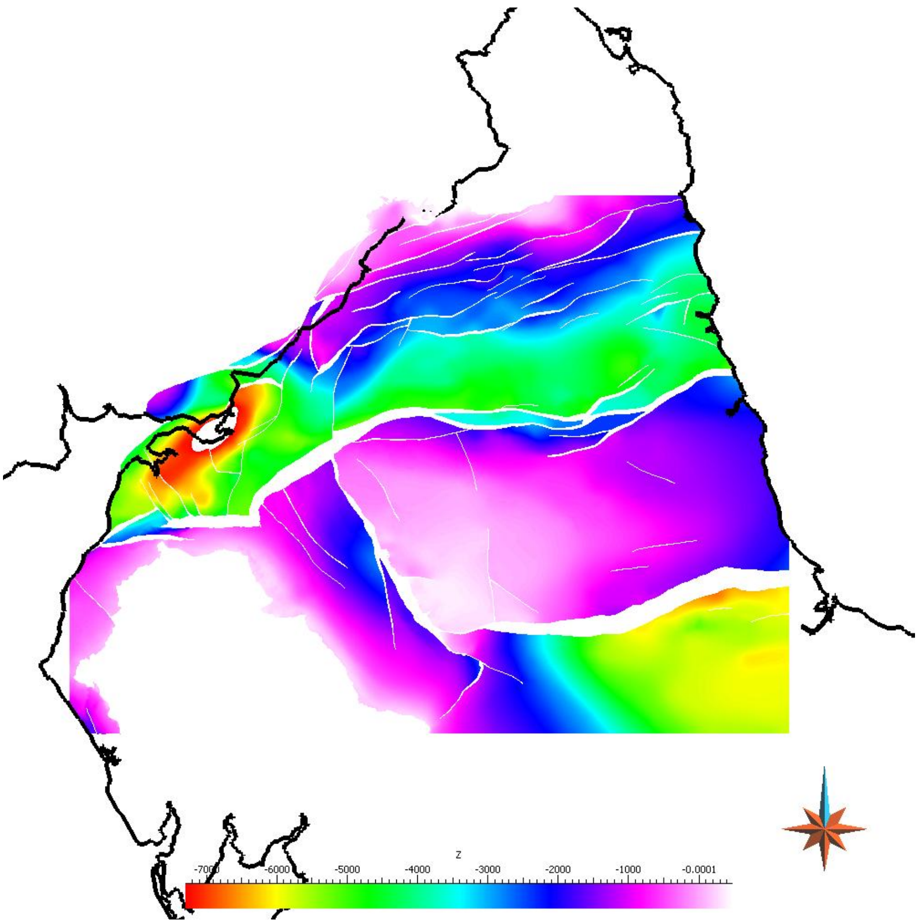

Figure 3 Modelled Top of Caledonian Basement surface (depth range in metres)

2 Modelled surfaces/volumes

The surfaces (Figure 4) were generated from the structural depth contour plots. Well control was *not* directly used.

Surfaces modelled are (numbers relate to stratigraphic order):

Rockhead

01 Base Permian-Triassic

02 Base Coal Measures

03 Base Stainmore Group

04 Base Alston Group (includes the Liddesdale Group)

05 Base Upper Border Group

06 Base Middle Border Group

07 Top Lynebank Beds (Base Lower Border Group)

08 Top Caledonian Basement

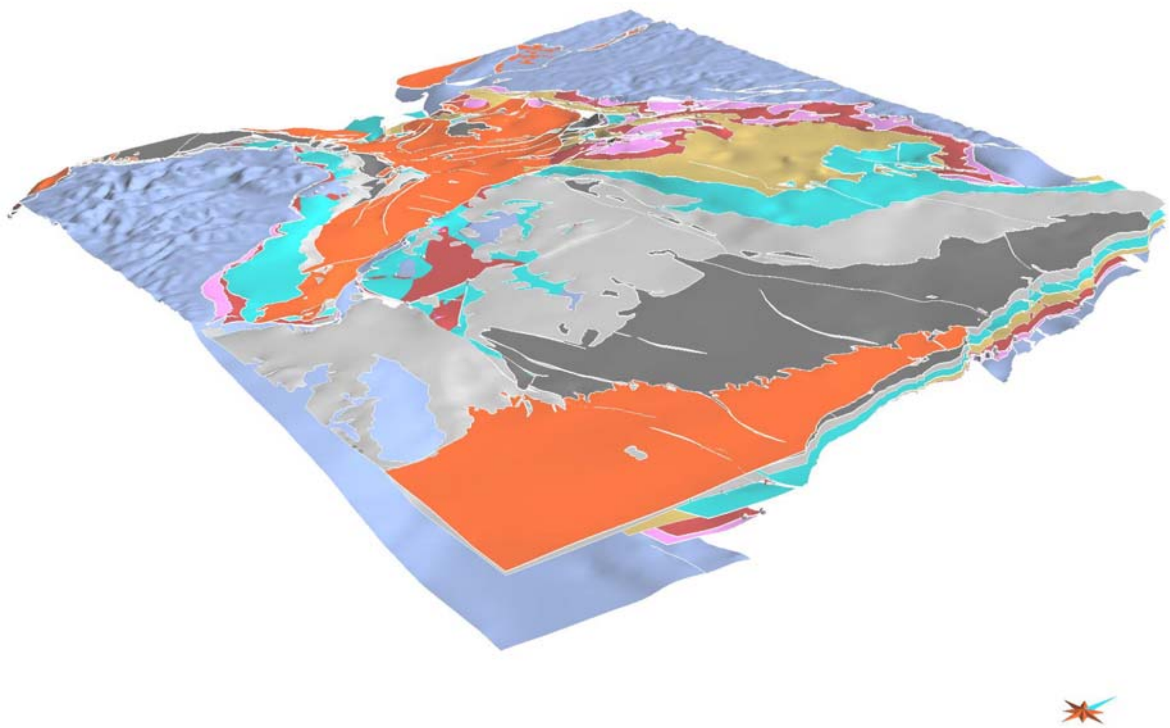

Figure 4 Image of modelled surfaces viewed from the South-East with the Digital Terrain Model (outcrop included)

The table below summarises the general stratigraphy of the Northumberland-Solway 3D geological model:

SUMMARY OF STRATIGRAPHY, GEOLOGICAL AND TECTONIC EVENTS

Period		Epoch/Stage	Unit	Lithology	Thickness	Events	
QUATERNARY		Holocene Pleistocene		Glacial and postglacial deposits	0–100 m	Mainly erosion	
NEOGENE		Pliocene Miocene				Regional uplift, tilting and erosion, basin inversion early Miocene (Alpine Collision)	
PALAEOGENE		Oligocene Eocene Paleocene				Regional uplift, tilting and erosion. Dyke injection ?Basin inversion (?Pyrenean Collision)	
CRETACEOUS		Upper				Regional subsidence	
		Lower				Extensional basin formation with periodic footwall uplift and erosion—details unknown	
JURASSIC		Upper Middle					
		Lower	Lias Group	Mudstone and limestone	120 m		
TRIASSIC		Upper	Penarth Group	Siltstone, mudstone and sandstone	15 m	Regional subsidence	
		Middle	Mercia Mudstone Group	Mudstone, siltstone and halite	300 m		
		Lower	Sherwood Sandstone Group	Sandstone, minor siltstone and mudstone	500 m	Extensional faulting	
PERMIAN		Upper	Cumbrian Coast Group (W) 'Zechstein' (E)	Siltstone, sandstone, mudstone, gypsum and anhydrite, dolomitic limestone	<200 m	Regional subsidence	
		Lower	Appleby Group (W) Yellow Sands (E)	Sandstone and conglomerate	<400 m	Extensional faulting and basin formation	
CARBONIFEROUS		Stephanian				Basin inversion, regional uplift and erosion; intrusion of Whin Sill, Pennine mineralisation	VARISCAN OROGENY
	Silesian	Westphalian	Coal Measures	Siltstone, sandstone and mudstone, red above, grey with coals below	800–1600 m	Mainly regional subsidence with minor extensional faulting; periodic localised minor basin inversion	
		Namurian	Stainmore and Hensingham groups	Sandstone, siltstone, mudstone, limestone and thin coals	50–1000 m		
	Dinantian	Viséan	Liddesdale and Alston groups	Limestone, mudstone, siltstone, sandstone and thin coals	100–900 m		
			Upper Border Group	Siltstone, mudstone, sandstone, limestone and thin coals	0–800m		
			Middle Border, Fell Sandstone and Orton groups	Sandstone, siltstone, mudstone and limestone	0–800 m	Major period of extensional faulting and basin formation; widespread volcanism in early part, sporadic and local thereafter	
			Lower Border and Cementstone groups	Limestone, mudstone, siltstone, sandstone and anhydrite	0–4500 m		
		Tournaisian	Birrenswark, Kelso, Cockermouth lavas	Basaltic lavas	0–50 m		
			Upper Old Red Sandstone	Sandstone, siltstone, mudstone and conglomerate	0–200 m	?Minor extensional faulting	
DEVONIAN		Upper Middle				Acadian deformation, uplift and erosion	CALEDONIAN OROGENY
		Lower	Cheviot Lavas and Lower Old Red Sandstone	Andesitic volcanic rocks, conglomerate and sandstone (Cheviot Block only)	0–?1000 m	Intrusion of Cheviot, Weardale, Shap and Skiddaw granites etc. / Continued subduction	
SILURIAN			'Basement Rocks'	Shale, greywacke, limestone, lavas and pyroclastic rocks, commonly cleaved		Other Lake District intrusions / Collision between Laurentia and E. Avalonia	
ORDOVICIAN						Subduction and ocean closure	

Figure 5 Summary of the stratigraphy, geological and tectonic events for the Northumberland and Solway Basin and adjacent areas

3 Modelled faults

All of the faults used in the construction of the model were sourced from the Northumberland-Solway Basin Subsurface Memoir (Chadwick et al., 1995). These were digitised per surface as ESRI polyline shapefiles as part of the Regional UK Lithoframe programme. As the model was regional in nature, an initial filtering of the faults was applied to ensure that only those that had significant throw/displacement (>100 m) were used for the surface construction. This was achieved in two steps.

The first of these steps was to select faults that had a length of greater than 10 000 m, as it is recognised that the greater the length of the fault (in 2D space) the greater the throw/displacement (Young-Seog and Sanderson, 2005). By selecting faults over 10 000 m, many of the faults with throws of greater than 100 m would be selected for use in the modelling phase. These fault polyline shapefiles were imported and grouped, and then named in the following style:

- **Group name** - Faults_Greater_Than_10000m_pl
- **Name example** - BASE_COAL_MEASURES_*VFLT_10000*

The second of these steps was to select short faults that had estimated throws of greater than 100 m. This was achieved by taking all of the faults that had a length shorter than 10 000 m, and examining the contour values across and within a buffered distance (usually either 250 or 500 m) in order to estimate the change in elevation across the fault. From the results of this, faults that were less than 10 000 m in length but were found to have a throw greater than 100 m were selected for use in the project, grouped and named in the following style:

- **Group name** - Faults_Selected_Less_Than_10000m_pl.
- **Name example** - CM_VFLT_Throw_Selection

The total distribution of faults modelled can be seen in Figure 6.

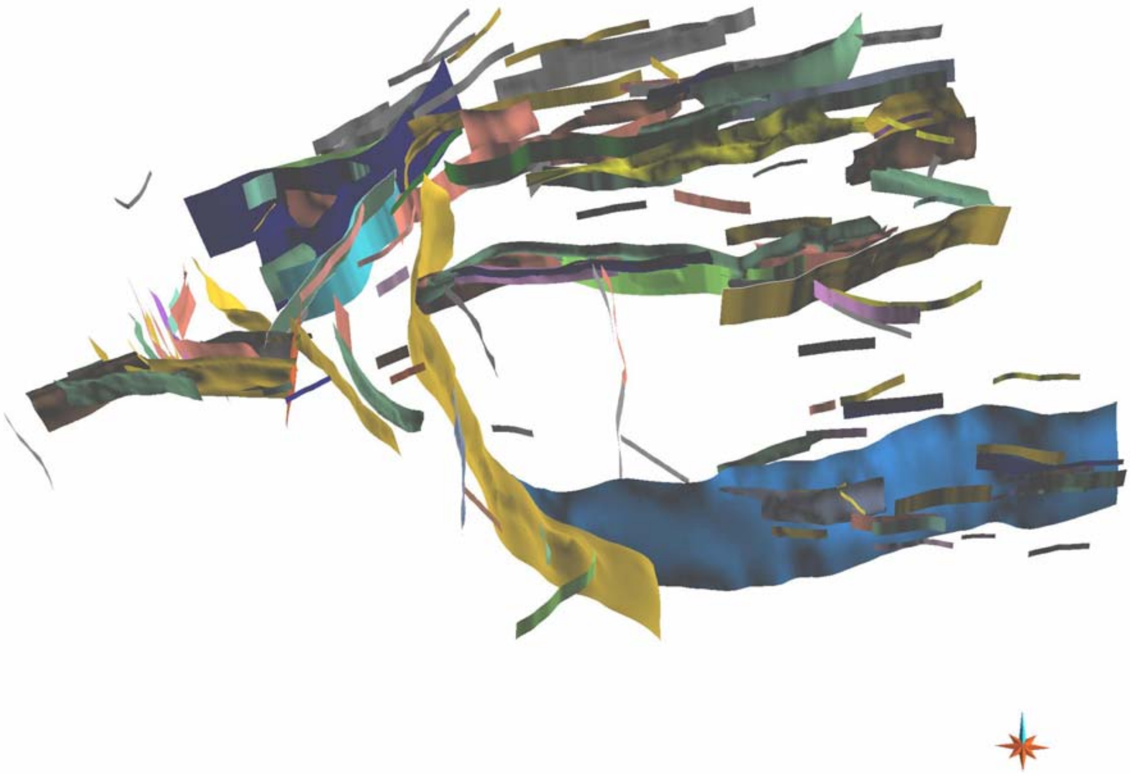

Figure 6 Distribution of the modelled faults for the Northumberland and Solway Basin Model

Two types of faults were produced using the Structural Modelling Workflow in GOCAD®. Some of the faults were produced using the fault sticks method and the rest used the Fault Centre Line method. For both types of faults generated, the Structural Modelling Workflow in GOCAD® was used to develop the contacts between the faults. See below for more information.

3.1 FAULT STICKS

1. Each surface was calculated using the contours digitised from the Northumberland-Solway Basin memoir to give a raw unfaulted surface.
2. The fault traces generated were draped onto their respective surface. For example, the Permo-Trias fault dataset was draped onto the Permo-Trias raw surface. This was repeated for each of the fault datasets per surface.
3. Faults were grouped by their fault location. For example, each of the fault traces for the Closehouse Lunedale Butterknowle fault were grouped into one curve object in GOCAD® (Figure 7).
4. The grouped fault traces were allocated a *Fault Stick* data type in GOCAD® and put through the Structural Modelling Workflow for generating a fault surface. Manual editing of the fault surface was sometimes necessary to smooth out any spikes or anomalous data.

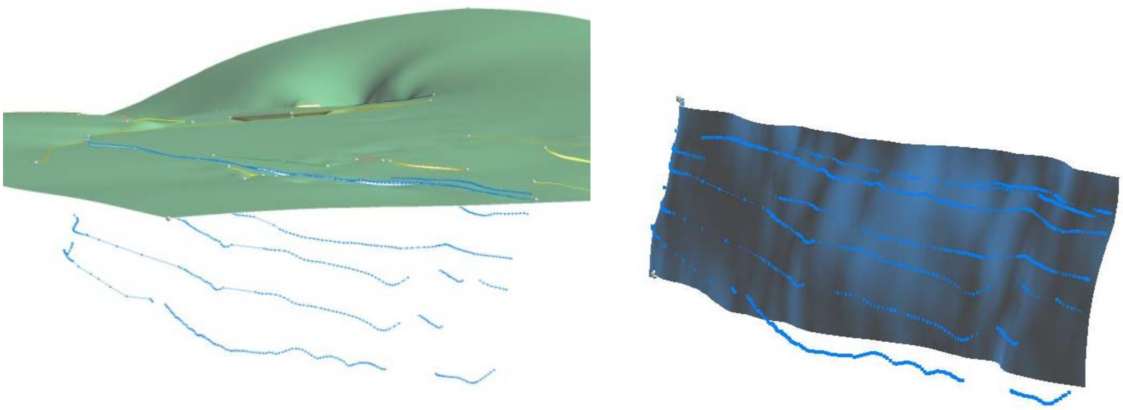

Figure 7 Left image shows the unfaulted Permo-Trias surface (in green) with the faults sticks (in blue) of the Closehouse Lunedale fault. The right image shows the faults sticks with the constructed fault from the draped fault sticks.

3.2 FAULT CENTER LINES

If the fault trace only occurred on a single surface, the *fault centre line* data type was used in GOCAD® Structural Modelling workflow. The *fault centre line* allows the user to specify the elevations of the top and the base of the fault and the dip angle. The fault generated is a simple extrusion of the fault centre line.

3.3 FAULT GROUPING

Faults have been grouped into subsets to help the user of this data ascertain which fault goes with which surface. Some of the faults only cut one horizon, while other faults cut two or more of the horizons in the model. If a fault only penetrated the Base Coal measures and no other horizon, then the fault was given an ID of 02_NDSYF_1001 for example. The fault is identification is broken down into three parts:

- 02 - represents the horizon as described in Section 2, in this case it is the Base Coal Measures
- NDSYF – recognises the object as a fault
- 1001 – Gives the fault a unique identification

If the fault cut though multiple surfaces, an example ID of **00**_NDSYF_1002, where the **00** part recognises it as this type of fault. A table of faults showing which fault cut which surface is an the appendix in Section 10.

*The Stublick fault had to be modelled in several segments as it was too difficult to rationalise between all of the horizons.

4 Model datasets

Digital Terrain Model (DTM)

Used as a reference dataset. The DTM source was NextMap at a 500 m cell size resolution. Saved as *NextMap_DTM_500m* surface data type in the project.

Rockhead Elevation Model (RHEM)

BGS RHEM onshore was used, on which the entire outcrop for each of the surfaces generated in the project was draped. The resolution of the RHEM was 500 m cell size. Saved as *RHEM_500m* surface data in the project.

Borehole data

Boreholes used to construct the modelled surfaces are listed in the Northumberland-Solway basin subsurface memoir (Chadwick et al., 1995). The surfaces described in this report are based on structural contour data from the memoir.

Map data

The map data were generated directly from the Subsurface Memoir (Chadwick et al., 1995) and cross-referenced with DigMap GB 1:250 000.

Mine plan data

No mine plan data were used.

Seismic data

Seismic data were interpreted and used in the generation of the contour data in the Subsurface Memoir (Chadwick et al., 1995).

Geophysical data

Please see the Subsurface Memoir (Chadwick et al., 1995)

4.1 GOCAD® OBJECTS

The following objects relate to the project specific data types within the GOCAD® project file. Each of the horizon datasets will have a pre-cursor number to identify it using the schema:

01 – Base Permo-Trias

02 – Base Coal Measures

03 – Base Stainmore Group

04 – Base Alston/Liddesdale Group

05 – Base Upper Border Group

06 – Base Middle Border/Orton Group

07 – Top Lynebank Beds

08 – Top Caledonian Basement

4.1.1 Pointset – GOCAD® project

- Contains all of the structural contours as points (e.g. 03_Base_Coal_Measures_NthldSol _Structural_Contour_Points_vs)
- Contains all of the structural contour data and outcrop (with elevations) combined as points (e.g. 01basept_NthldSol_PLUS_OUTCROP_vs) – these have been grouped in GOCAD.

4.1.2 Curve - GOCAD® project

- Contains a combined subcrop and outcrop polygon to which the surfaces were clipped by (e.g. 02_Base_Coal_Measures_Outcrop_Subcrop_pl)
- Contains outcrop only for a horizon (e.g. 02_Base_Coal_Measures_Outcrop_Cut_pl)
- Contains a copy of the above but has been draped on the RHEM/DTM to give it an elevation relative to OD (e.g. 02_Base_Coal_Measures_Outcrop_DTM_Draped_pl)
- Other datasets include the overall project area and the coastline

4.1.3 Group - GOCAD® project

- 00_Faults_Greater_Than_2_Surfaces – Fault surfaces cutting through 2 or more horizon
- 01_Faults_PT – Faults cutting through the Permian-Triassic horizon only
- 02_Faults_BCM - Faults cutting through the Base Coal Measures horizon only
- 03_Faults_ST - Faults cutting through the Base Stainmore Group horizon only
- 04-Faults_AG - Faults cutting through the Base Alston Group horizon only
- 05_Faults_UBO – Faults cutting through the Base Upper Border Group horizon only
- 06_Faults_Middle_Border_Group - Faults cutting through the Middle Border Group only
- 07_Faults_LBO - Faults cutting through the Base Lower Border Group/Top Lynebank Beds horizon only
- 08_Faults_CALE - Faults cutting through the Top Caledonian Basement horizon only.
- *Fault_components_pl* – contains all curve elements used to construct the fault objects in the Structural Modelling workflow
- *Fault_Components_vs* - contains all point elements used to construct the fault objects in the Structural Modelling workflow
- *Faults_Greater_Than_10000m_pl* – contains all faults traces that are greater than 10 000 m in length
- *Faults_Selected_Less_Than_10000m_pl* - contains all faults traces that are shorter than 10 000 m in length but have a significant throw/displacement (greater than 100 m)
- *RAW_DATA_SHAPEFILES_pl* – contains all of the raw shapefiles (structural contours, faults traces and outcrop line) used to model each horizon
- *Surface_Components_pl* – contains curve elements used in the Structural Modelling workflow for generating each surface horizon

4.1.4 Surface - GOCAD® project

- Contains all of the unclipped raw surface horizons (e.g. study_01basept_NthldSol_vs_ts)

- Contains those surface horizons that have been clipped to the combined outcrop and subcrop for that horizon (study_01basept_NthldSol_Surface_Cut_V2_ts)
- Contains all of the fault surfaces generated through the Structural Modelling workflow (e.g. study_Alwinton_Fault_ts and study_NDSYF_1009_ts)
- Other datasets include the RHEM Model at 500m resolution and the DTM (NextMap) at 500m resolution

5 Model development log

W:\Teams\UKGF\RegionalLithoframe\Data\Northumberland_Solway_Basin\GOCAD

Northumberland_Solway_V1_0 to V1_8.gprj	Faults traces draped, fault construction started
Northumberland_Solway_V2_0.gprj	95% faults completed - to be checked
Northumberland_Solway_V2_4.gprj	All faults contacts calculated.
Northumberland_Solway_V3_2.gprj	All faults modelled - test surface modelled against faults for base Caledonian basement
Northumberland_Solway_V3_5.gprj	Surface Construction, fault contact to surface and surface cuts for Permo-Trias and coal measures surfaces. Outcrops and subcrop curves made in GIS.
Northumberland_Solway_V4_7_Stainmore.gprj	Project containing surfaces up Base Stainmore
Northumberland_Solway_V4_10_Alston.gprj	Project containing surfaces up Base Alston/Liddesdale group
Northumberland_Solway_V4_13_UBO.gprj	Project containing surfaces up to Base Upper Border Group
Northumberland_Solway_V5_4.gprj	Surface/cross-section checks
Northumberland_Solway_V6_0.gprj	Cross-overs removed - some data discrepancies remain
Northumberland_Solway_V7_9_FINAL.gprj	Edits made based on model approval feedback.

6 Software Used and Model workflow

6.1 SOFTWARE USED

- GOCAD® version 2.1.6 and GOCAD® v2009
- ArcGIS 9.3
- MS Excel

6.2 MODEL WORKFLOW

The following workflow was used to generate the Northumberland-Solway Basin Model:

1. Compiled all raw data into a GIS:

   W:\Teams\UKGF\RegionalLithoframe\Data\Northumberland_Solway_Basin\Northumberland_Solway_V_1_1.mxd

2. Imported all fault traces, outcrop data and structural contours for each horizon into GOCAD® version 2009 onwards.
3. Additional data added included the GB RHEM and the NextMap DTM surfaces (See Model Datasets Section 4)
4. A raw surface (uncut by faults at this stage) for each horizon was modelled using a combination of the structural contours and outcrop which had elevation values applied from the RHEM surface data.
5. Every fault trace was draped onto its corresponding surface using the ‘Transfer Property by Vertical Projection’ tool and then following the methodology established in Sections 3.1 and 3.2, the fault plane was constructed.
6. Once all of the faults had been constructed, branch contacts were established between the faults using the Structural Modelling workflow.

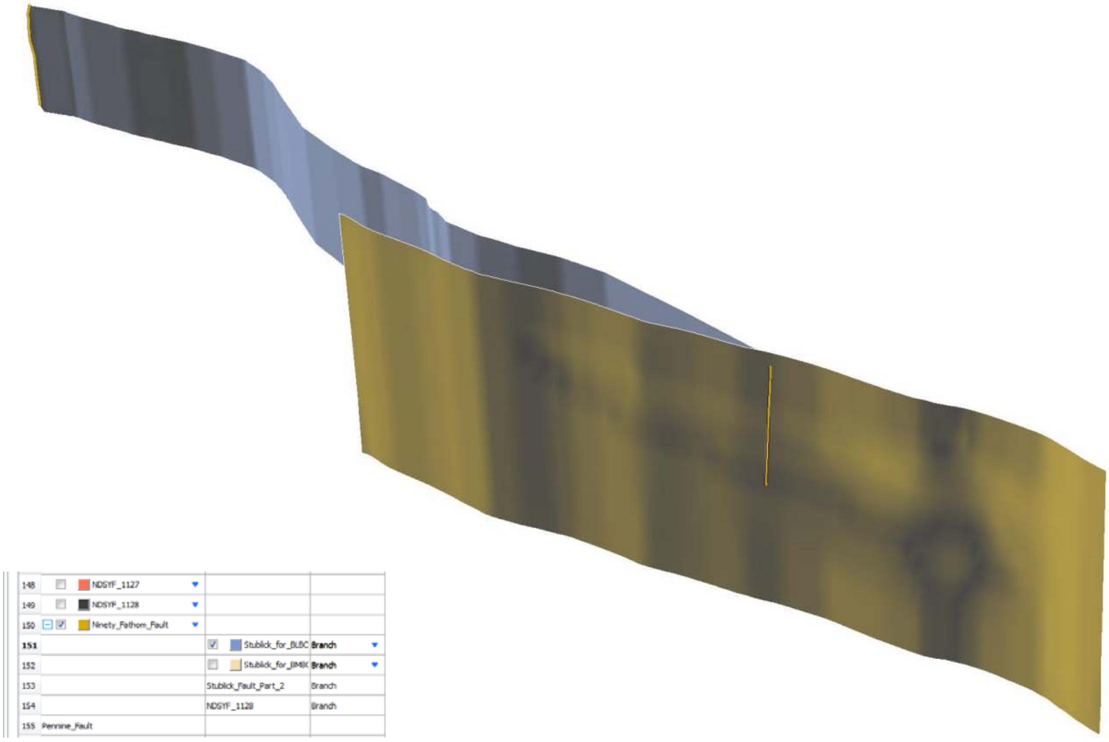

Figure 8 An example fault contact between the Ninety Fathom fault (Main) and the Stublick fault (branch)

7. The faults were then used to cut the raw surface horizons using the ‘Horizon-Fault Contact Modelling’ in the Structural Modelling workflow.
8. Fault contacts and surface horizons were either edited using the Structural Modelling workflow parameters or manually using the tools available in GOCAD®

7 Model limitations

General caveats regarding BGS datasets and interpretations can be described:

- Geological observations and interpretations are made according to the prevailing understanding of the subject at the time. The quality of such observations and interpretations may be affected by the availability of new data, by subsequent advances in knowledge, improved methods of interpretation, improved databases and modelling software, and better access to sampling locations.
- Raw data may have been transcribed from analogue to digital format, or may have been acquired by means of automated measuring techniques. Although such processes are subjected to quality control to ensure reliability where possible, some raw data may have been processed without human intervention and may in consequence contain undetected errors.

The modelled surfaces were directly constructed from the structural contours from the Northumberland-Solway Basin Subsurface Memoir and were not fixed against any boreholes.

Some crossovers may exist between the surfaces. Some of these are directly the result of contours overlapping in vertical space. These have not been resolved either in the Subsurface Memoir or in the model itself.

8 Model image

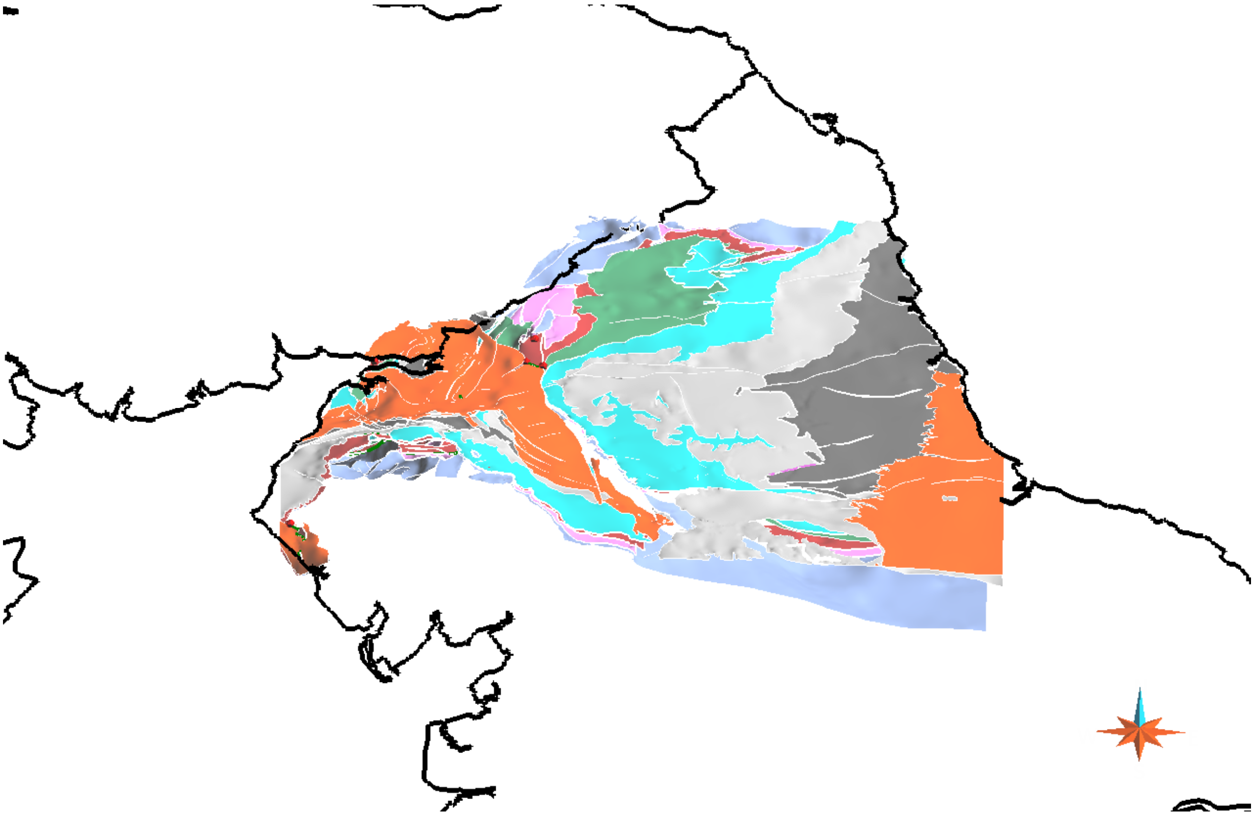

Figure 9 View of the final fault cut surfaces with the UK coastline viewed from the South-East

9 References

CHADWICK, R A, HALLIDAY, D W, HOLLOWAY, S, and HULBERT, A G. 1995. The structure and evolution of the Northumberland-Solway Basin and adjacent areas. *Subsurface Memoir of the British Geological Survey*, 110pp.

YOUNG-SEOG, K, and SANDERSON, D J. 2005. The relationship between displacement and length of faults: a review. *Earth Sciecne Reviews*, Vol. 68, 317-334.

10 Appendix

Fault	PT	Cm	ST	AG	UBO	MBO	Lyn	Cale	Comment (deleted faults outside of area of interest)
08_Alwinton_Fault	N	N	N	N	N	N	N	Y	
08_Antonstown_Fault	N	N	N	N	N	N	N	Y	
00_Back_Burn_Fault	N	Y	Y	Y	Y	Y	Y	N	
00_Bankend_Fault	Y	Y	Y	Y	Y	Y	Y	Y	
00_Brakenhall_Fault	N	N	N	Y	Y	Y	Y	N	
00_Closehouse_Lunedale_Butterknowle_Fault	Y	Y	Y	Y	Y	Y	Y	Y	
00_Cragend_Chartners_Fault	N	N	N	N	Y	Y	Y	Y	
08_Dent_Line_Fault	N	N	N	N	N	N	N	Y	
00_East_Christianbury_Fault	N	N	N	N	N	N	Y	Y	
08_Featherwood_Fault	N	N	N	N	N	N	N	Y	
00_Gilnockie_Fault_1	N	N	N	N	N	Y	Y	Y	
00_Gilnockie_Fault_2	N	N	N	N	Y	Y	Y	Y	
08_Hauxley_Fault	N	N	N	N	N	N	N	Y	
00_Lowling_Fault	N	N	Y	Y	N	Y	N	Y	
00_Maryport_Fault	N	N	Y	Y	N	Y	Y	Y	
00_Fault_1001	N	Y	Y	N	N	N	N	N	
03_Fault_1002	N	N	Y	N	N	N	N	N	
03_Fault_1003	N	N	Y	N	N	N	N	N	
03_Fault_1004	N	N	Y	N	N	N	N	N	
03_Fault_1005	N	N	Y	N	N	N	N	N	
00_Fault_1006	N	N	Y	Y	N	N	N	N	
05_Fault_1007	N	N	N	N	Y	N	N	N	
00_Fault_1008	N	N	Y	Y	Y	N	N	N	
03_Fault_1009	N	N	Y	N	N	N	N	N	
00_Fault_1010	N	N	Y	Y	N	N	N	N	
00_Fault_1011	N	N	N	N	N	Y	Y	N	
03_Fault_1012	N	N	Y	N	N	N	N	N	
02_Fault_1013	N	Y	N	N	N	N	N	N	
00_Fault_1014	N	N	N	N	N	Y	Y	N	
00_Fault_1015	N	N	N	N	N	Y	Y	Y	
00_Fault_1016	Y	Y	Y	Y	N	Y	Y	Y	
1017_Fault	Y	Y	Y	Y	N	Y	Y	Y	
00_Fault_1018	N	N	N	N	Y	Y	Y	Y	
05_Fault_1019	N	N	N	N	Y	N	N	N	
02_Fault_1020	N	Y	N	N	N	N	N	N	
00_Fault_1021	N	N	N	N	N	Y	Y	Y	
06_Fault_1022	N	N	N	N	N	Y	N	N	

00_Fault_1023	Y	Y	Y	Y	Y	Y	Y	Y	
00_Fault_1024	N	N	Y	Y	Y	Y	Y	Y	
1025_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	
00_Fault_1026	N	N	N	N	N	Y	Y	N	
00_Fault_1027	N	N	N	N	N	Y	Y	N	
00_Fault_1028	N	N	N	N	N	Y	N	Y	
1029_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
1030_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
1031_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
08_Fault_1032	N	N	N	N	N	N	N	Y	
1033_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
1034_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
08_Fault_1035	N	N	N	N	N	N	N	Y	
00_Fault_1036	N	N	N	N	N	Y	Y	N	
00_Fault_1037	N	Y	Y	N	N	N	N	N	
00_Fault_1038	N	N	N	Y	N	Y	N	N	
00_Fault_1039	N	Y	Y	Y	Y	Y	Y	Y	Difficult to reconcile, join with 1040
00_Fault_1040	N	Y	Y	Y	N	N	N	N	
00_Fault_1041	N	N	N	N	N	Y	Y	Y	
08_Fault_1044	N	N	N	N	N	N	N	Y	
03_Fault_1045	N	N	Y	N	N	N	N	N	
00_Fault_1046	Y	N	Y	Y	N	Y	Y	Y	
00_Fault_1047	N	N	N	N	N	Y	Y	Y	
06_Fault_1048	N	N	N	N	N	Y	N	N	
01_Fault_1049	Y	N	N	N	N	N	N	N	
03_Fault_1050	N	N	Y	N	N	N	N	N	
08_Fault_1051	N	N	N	N	N	N	N	Y	
08_Fault_1052	N	N	N	N	N	N	N	Y	
05_Fault_1053	N	N	N	N	Y	N	N	N	
1054_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
06_Fault_1055	N	N	N	N	N	Y	N	N	
1056_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
05_Fault_1057	N	N	N	N	Y	N	N	N	
04_Fault_1058	N	N	N	Y	N	N	N	N	
03_Fault_1059	N	N	Y	N	N	N	N	N	
02_Fault_1060	N	Y	N	N	N	N	N	N	
02_Fault_1061	N	Y	N	N	N	N	N	N	
00_Fault_1062	N	N	N	N	N	Y	Y	Y	
03_Fault_1063	N	N	Y	N	N	N	N	N	
00_Fault_1064	N	N	N	N	N	Y	Y	Y	
1065_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
01_Fault_1066	Y	N	N	N	N	N	N	N	
05_Fault_1067	N	N	N	N	Y	N	N	N	
00_Fault_1068	N	N	N	N	N	Y	Y	Y	
05_Fault_1069	N	N	N	N	Y	N	N	N	
08_Fault_1070	N	N	N	N	N	N	N	Y	

03_Fault_1071	N	N	Y	N	N	N	N	N	
00_Fault_1072	N	N	N	Y	Y	N	N	N	
02_Fault_1073	N	Y	N	N	N	N	N	N	
04_Fault_1074	N	N	N	Y	N	N	N	N	
02_Fault_1075	N	Y	N	N	N	N	N	N	
05_Fault_1076	N	N	N	N	Y	N	N	N	
00_Fault_1077	N	N	N	N	N	N	Y	Y	
07_Fault_1078	N	N	N	N	N	N	Y	N	
07_Fault_1079	N	N	N	N	N	N	Y	N	
07_Fault_1080	N	N	N	N	N	N	Y	N	
1081_Fault	Y	Y	Y	Y	Y	Y	Y	Y	
08_Fault_1082	N	N	N	N	N	N	N	Y	
08_Fault_1083	N	N	N	N	N	N	N	Y	
08_Fault_1084	N	N	N	N	N	N	N	Y	
08_Fault_1085	N	N	N	N	N	N	N	Y	
00_Fault_1086	N	N	N	N	N	Y	Y	N	
08_Fault_1087	N	N	N	N	N	N	N	Y	
08_Fault_1088	N	N	N	N	N	N	N	Y	
00_Fault_1089	N	N	N	N	N	Y	Y	Y	
08_Fault_1090	N	N	N	N	N	N	N	Y	
1091_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
08_Fault_1092	N	N	N	N	N	N	N	Y	
1093_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
07_Fault_1094	N	N	N	N	N	N	Y	N	
1095_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
08_Fault_1096	N	N	N	N	N	N	N	Y	
08_Fault_1097	N	N	N	N	N	N	N	Y	
08_Fault_1098	N	N	N	N	N	N	N	Y	
00_Fault_1099	N	N	N	N	Y	Y	Y	Y	
08_Fault_1100	N	N	N	N	N	N	N	Y	
00_Fault_1101	N	N	N	N	N	N	Y	Y	
08_Fault_1102	N	N	N	N	N	N	N	Y	
08_Fault_1103	N	N	N	N	N	N	N	Y	
07_Fault_1104	N	N	N	N	N	N	Y	N	
07_Fault_1105	N	N	N	N	N	N	Y	N	
00_Fault_1106	N	N	N	N	Y	Y	Y	N	
04_Fault_1107	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
04_Fault_1108	N	N	N	Y	N	N	N	N	
00_Fault_1109	N	N	Y	Y	N	N	N	N	
00_Fault_1110	Y	Y	Y	Y	N	N	N	N	
00_Fault_1111	N	N	N	N	N	Y	Y	Y	
1112_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
00_Fault_1113	N	N	N	N	N	Y	Y	Y	
1114_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
08_Fault_1115	N	N	N	N	N	N	N	Y	
00_Fault_1116	N	N	Y	Y	N	N	N	N	
00_Fault_1117	Y	Y	Y	Y	N	N	N	N	

01_Fault_1118	Y	N	N	N	N	N	N	N	
01_Fault_1119	Y	N	N	N	N	N	N	N	
04_Fault_1120	N	N	N	Y	N	N	N	N	
1121_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
02_Fault_1122	N	Y	N	N	N	N	N	N	
00_Fault_1123	Y	N	Y	N	N	N	N	N	
01_Fault_1124	Y	N	N	N	N	N	N	N	
00_Fault_1125	Y	N	Y	Y	N	Y	N	N	
02_Fault_1126	N	Y	N	N	N	N	N	N	
02_Fault_1127	N	Y	N	N	N	N	N	N	
00_Fault_1128	N	N	N	N	N	N	Y	Y	
00_Ninety_Fathom_fault	N	Y	Y	Y	Y	Y	Y	Y	
00_Pennine_Fault	Y	Y	Y	Y	Y	Y	Y	Y	
00_Stakeford_Fault_ts	N	N	Y	Y	Y	Y	Y	Y	
08_Stublick_Fault_Part_2	N	N	N	N	N	N	N	Y	
07_Stublick_Fault_1	N	N	N	N	N	N	Y	N	
07_Stublick_Fault_2	N	N	N	N	N	N	Y	N	
07_Stublick_Fault_3	N	N	N	N	N	N	Y	N	
06_Stublick_Fault_1_ts	N	N	N	N	N	Y	N	N	
06_Stublick_Fault_2_ts	N	N	N	N	N	Y	N	N	
08_Stublick_Part_1_ts	N	N	N	N	N	N	N	Y	
Stublick_Part_4_1	N	N	Y	Y	N	N	N	N	
Stublick_Part_5	N	N	Y	Y	N	N	N	N	
08_Swindon _Fault	N	N	N	N	N	N	N	Y	
Waterbeck_Fault	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**Deleted**
00_Waver_Warnall_Part_1	N	N	N	N	N	Y	Y	Y	
00_Waver_Warnall_Part_2	N	Y	Y	Y	Y	Y	Y	Y	