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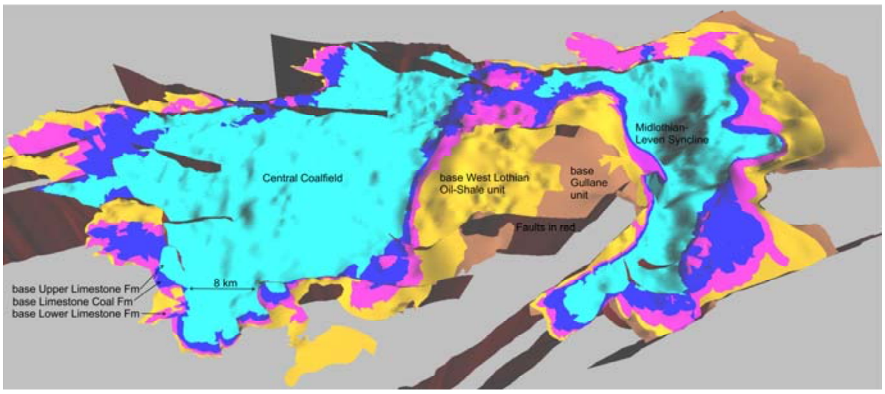
Model metadata report for BGS-DECC shale study model, central and eastern Midland Valley of Scotland

National Geological Model Team

Open Report OR/14/050



BRITISH GEOLOGICAL SURVEY

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OPEN REPORT OR/14/050

Model metadata report for BGS-DECC shale study model, central and eastern Midland Valley of Scotland

A A Monaghan

Keywords

3D model, DECC-BGS shale resource estimation.

National Grid Reference

SW corner 238000,641000
NE corner 365000,722000

Front cover

Overview of the modelled surfaces, looking north across the Central Coalfield and Midlothian-Leven Syncline

Bibliographical reference

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British Geological Survey offices

BGS Central Enquiries Desk
Tel 0115 936 3143 Fax 0115 936 3276
email enquiries@bgs.ac.uk

Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG
Tel 0115 936 3241 Fax 0115 936 3488
email sales@bgs.ac.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA
Tel 0131 667 1000 Fax 0131 668 2683
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road, London SW7 5BD
Tel 020 7589 4090 Fax 020 7584 8270
Tel 020 7942 5344/45 email bgslondon@bgs.ac.uk

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff CF15 7NE
Tel 029 2052 1962 Fax 029 2052 1963

Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB
Tel 01491 838800 Fax 01491 692345

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF
Tel 028 9038 8462 Fax 028 9038 8461

www.bgs.ac.uk/gsni/

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

Website www.bgs.ac.uk
Shop online at www.geologyshop.com

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Summary

For the purpose of detailed documentation and inclusion in the National Geological Model, this report describes the five stratigraphic surfaces and 19 faults which formed the geological framework for the BGS-DECC Midland Valley shale resource estimation (Monaghan, 2014). The model was made by integration of seismic, well, borehole, mining and map data and a small component of the previous Midland Valley regional model (Monaghan, 2013). The modelled surfaces and accompanying report are available for download from the DECC website (https://www.gov.uk/oil-and-gas-onshore-exploration-and-production#seismic-and-wells) and are copyright DECC 2014.

The volumetric grids, cut-off surface, maturity-depth surface, percentage shale and Total Organic Carbon maps used to calculate gross rock volumes and net shale volumes for the resource estimation are not included in this report or accompanying model files.

1 Modelled volume, purpose and scale

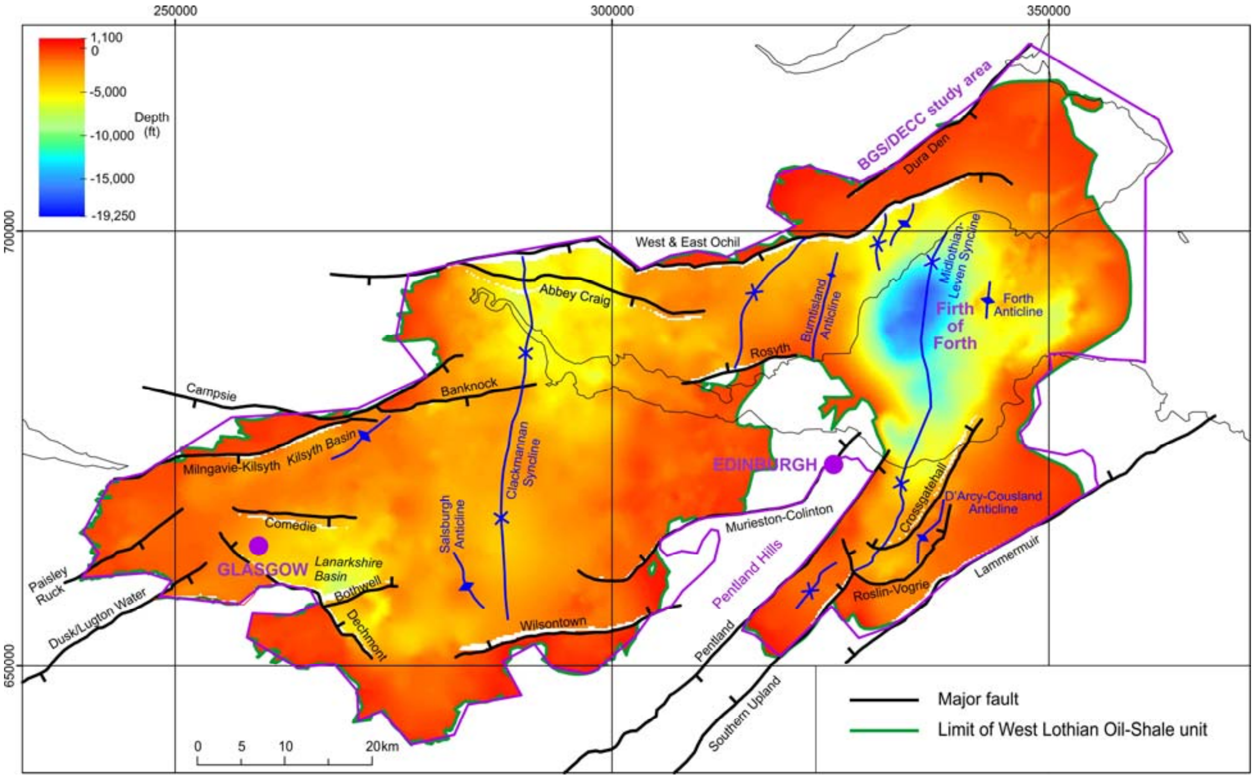


Figure 1 Extent of the model as illustrated by a map showing the outcrop position of the regional-scale faults included, together with the main structural features, using the base of the West Lothian Oil-Shale unit (in feet) depth map from Monaghan (2014) ©DECC.

The modelled surfaces cover the central and eastern areas of the Midland Valley of Scotland with the corner coordinates being approximately SW 238000, 641000 to NE 365000, 722000. The model scale is approximately 1:250 000 and the Z range of modelled surfaces is from +350 to -5870 m relative to Ordnance Datum.

The purpose of the model was to form a regional scale geological framework on which to calculate gross rock and net mature shale volumes. Only the largest, regionally important faults were included.

2 Modelled surfaces/volumes

Names of modelled surface	Lexicon-RCS code	Equivalent names
DTM/bathymetry	n/a	n/a
Base Upper Limestone Formation bULGS	ULGS-CYCC	Marking top Limestone Coal Formation. Base Index Limestone ILS
Base Limestone Coal Formation bLSC	LSC-CYCC	LSC and the top of limestone beds TOHO-URKI-DNLS-MCDL- MCLS . Marks the top of the Lower Limestone Formation
Base Lower Limestone Formation bLLGS	LLGS-CYCC	Marking the top of the West Lothian Oil-Shale Unit. Base Clackmannan Group CKN, Hurlet Limestone Member HUR and other equivalent limestone names HUR=BRLS=DMLS=UCRC=GILS=STMB=CHSL=WKL=HAWL=CBLS=PALS
Base West Lothian Oil-Shale Formation bWLO = base Aberlady Formation ABY = base Calders Member CDE= base Pittenweem Fm PMB	WLO-CYCS	Base is Humbie Shell bed/Marine band (lowest McGregor Marine Band) HUSB = Redhall marine band RDH= Cuniger Rock Marine Band CRMB= Saltoun marine Band SAMB. In boreholes, the Lawmuir Formation (LWM) was also recalled as it is the base of possible prospective succession. Legacy codes including URO (Upper Oil Shale Group) were recalled and examined to see if they penetrated into Burdiehouse Lmst or Gullane equivalent strata, also UCSM (Upper Calciferous Sandstone Measures)
Base Gullane bGUL /Fife Ness FNB and/or Top CPV/ASV/GHV	GUL-CYCS	Strathclyde Group SYG was also recalled and checked to see if it was base GUL equivalent. Legacy codes used include Lower Oil-Shale Group LRO and Lower Calciferous Sandstone Measures LCLC and Calciferous Sandstone Measures CSM

Table 1 Modelled surfaces and the equivalent stratigraphic nomenclature used in boreholes and wells

Further detail of the modelled stratigraphy is given in Monaghan (2014).

3 Modelled faults

The DECC model contains only the 19 largest, regional-scale faults with throw greater than approximately 200–400 m, and/or length greater than 8 km, in the central and eastern Midland Valley of Scotland (Table 2). These are predominantly the largest, basin-bounding structures with throws up to 1800 m. Some of the modelled faults with the smallest throws such as the Comedie and Abbey Craig faults (see Figure 1) occur within the Carboniferous basin, and were included as they were well constrained by seismic and mining data. Other faults with similar throws may be present, but have not been included in the model due to lack of data constraint. Numerous faults with throws less than 200–400 m are known but have been excluded from the regional-scale model. An additional 7 faults, such as the Highland Boundary and Southern

Upland faults, that are not within the DECC area of interest have been included in the model files (Table 2) as they provide a useful context for the overall basin structure.

Fault extents are taken largely from DiGMap 1:50 000 scale with dips taken from a variety of seismic interpretation, mine plan data and BGS memoir descriptions (Table 2)

Fault name	**Source**	**Outside DECC AOI**
Highland Boundary	MVS2012/13 model (Monaghan, 2013)	x
Southern Upland	MVS2012/13 model (Monaghan, 2013)	x
West and East Ochil	MVS2012/13 model (Monaghan, 2013). Where these faults are picked on seismic lines it is consistent with the existing, simplified modelled fault	
Campsie	MVS2012/13 model (Monaghan, 2013) with an edit - deleted east end where not proven or the fault is proven with much shallower dips in mining/seismic data and small offset, possibly a different structure	
Dura Den	MVS2012/13 model (Monaghan, 2013)	
Dusk/Lugton Water	MVS2012/13 model (Monaghan, 2013)	
Inchgotrick	MVS2012/13 model (Monaghan, 2013)	x
Kerse Loch	MVS2012/13 model (Monaghan, 2013)	x
Revised Dechmont	Extended to greater depth (-5000 m) than in previous versions, dip of 75° (previous version had the northern segment at 90°). Suggestions from seismic picks of an extension to north or an extension and splay to the south have not been incorporated, as there is no map/mine evidence for this in the higher resolution Glasgow models.	
Milngavie-Kilsyth	MVS2012/13 model (Monaghan, 2013)	
Pentland	MVS2012/13 model (Monaghan, 2013)	
Lammermuir	MVS2012/13 model (Monaghan, 2013)	x
Archerfield	Forth Approaches and MVS2012/13 model (Monaghan, 2013). Only the far eastern end of the fault is within the AOI but there is no seismic evidence to constrain it here, so it has been excluded	x
Crossgatehall	CASSEM (Monaghan, 2012). The DECC seismic interpretation has steeper dip on this fault than previously modelled but as the seismic data quality is poor the existing modelled fault has been used.	
Firth of Forth	CASSEM (Monaghan, 2012). The fault is only interpreted below the horizons modelled here and so does not affect the modelled horizons	x
Roslin-Vogrie	CASSEM (Monaghan, 2012). The current seismic line interpreted position is slightly different than the mapped position, though with similar dip. The well-constrained mapped position is taken in preference as the seismic data are poor quality.	
Dunbar-Gifford	CASSEM (Monaghan, 2012)	
Rosyth	New interpretation, dip assumed 60° to north. From +1000 to -5000 m. Eastward extension of this structure was examined but not supported by seismic interpretations in the Forth Estuary.	
Abbey Craig	New interpretation constrained by map and mining data with a 55° dip. Seismic picks not wholly honoured as they indicate a complex non-planar structure,	

	without enough constraining data to adequately define such a structure.	
Colinton-Murieston	New interpretation combining the Colinton and Murieston mapped faults for the purpose of a simplified structure for modelling. Dip assumed 60°.	
Banknock	Modified existing interpretation to produce a simplistic structure with 80° dip using the map trace. Seismic interpretations indicate a non-planar structure but without enough data constraint to define such a structure. (the southerly bounding fault of the small 'Forth Graben' was not included as the throw appears to die out quickly laterally and was not consistent with the seismic interpretation)	
Wilstontown	New interpretation from map and seismic data, dip of 50°. Seismic picks suggested the western end of this fault was offset by a NW-trending structure and continued further west than currently modelled. This local complexity was not included in the regional model, the fault was terminated where truncated by the NW-trending fault.	
Comedie	Modified the dip of the existing modelled Comedie Fault to 50° based on seismic interpretation. This does not quite fit all mining/seismic data but is the best planar fit	
Bothwell	New interpretation, modified the mapped 'Bothwell Fault' trace (Forsyth et al., 1996) to match the well-constrained seismic interpretation trending slightly more to the ENE. Dip of 60°	
Clarkston-Castlemilk	New interpretation to bound the Clyde Plateau Volcanic Formation south of Glasgow. Dip 60°. 'Gleniffer Fault' western segment subsequently not included due to this being a very complex fault system (though the modelled fault name is still called Gleniffer-Castlemilk)	

Table 2 Summary of fault information and dips used to create modelled faults along with inclusion and exclusion criteria

Faults which were considered but excluded due to poor or inconsistent constraining datasets, or having only short segments with throws of a few hundred metres, include the Middleton Hall and Ochiltree Fault in West Lothian, the Leven Fault in Fife and the Slammanan Fault in the Central Coalfield.

4 Model datasets

4.1 DTM/BATHYMETRY

An existing combined 500 m resolution DTM and bathymetry surface derived for the Lithoframe 250k 2008 (Monaghan and Pouliquen, 2012) model was used as the capping surface to the model. For a model at this scale, improvements to the DTM/bathymetry since 2008 should make negligible difference. The DTM/bathymetry is used as an approximation to the rockhead surface. In some areas of the Midland Valley with a thick covering of superficial deposits this approximation is not ideal and future work should use a rockhead surface which incorporates recent superficial deposits modelling.

4.2 BOREHOLE AND WELL DATA

Borehole data for base stratigraphic units were recalled from the BGS.Borehole_Geology database using the 'Magpie' Access application in April 2014 for the stratigraphic codes given in Table 1 and for boreholes greater than 20 m drilled depth. During the recall, interpreters were prioritised in the order AAMI, other interpreters entering 'DV' or 'OV' content codes, TMCM, then DJLO. The recalled data was edited manually and saved in a new file to give records reaching only the base of the stratigraphic horizons.

Base stratigraphic surface depths from DECC wells not entered into BGS.Borehole_Geology, or where a new interpretation to that in BGS.Borehole_Geology was made during the work, were manually added to each data file.

4.3 MAP DATA

Outline and outcrop curves were extracted for the modelled horizons from DiGMapGB at 1:50 000 scale (BGS, 2013) and from previous studies in the Firth of Forth (Monaghan, 2012).

The outline curves were filtered and densified to an appropriate resolution (e.g. filter 150 m, densified 750 m on base West Lothian Oil-Shale unit) in GOCAD® and edited manually where necessary to lie on the outer side of faulted boundaries (to ensure a continuous faulted contact in GOCAD®). As only deeply buried strata were of interest to the DECC shale study, only the major extent polygons have been included, such that smaller isolated extents mapped at 1:50 000 scale are missing.

4.4 MINE PLAN DATA

Two sources of mining data were incorporated into the model. BGS compilations of mine abandonment plan data for coals within the Limestone Coal and Upper Limestone formation were used as a guide to the base of depth of these formations by addition of a standard thickness (derived from generalised vertical sections on BGS 1:10 000 and 1:50 000 maps). Table 3 shows the seams used and assumed thickness to the base of the Limestone Coal Formation. Where there was more than one seam covering an area, the lowermost seam was used. These thicknesses are a simplification, as thicknesses are known to vary laterally.

Glasgow	Lanarkshire	Clackmannan	West Fife	Lothian
Meiklehill Main MEM (231)				
			Kelty Main KYMA (171)	
				Great Seam GSC (116)
	Wilstontown Main WNMA (124)	Bannockburn Upper Main Coal BNUMA (240)		
		Bannockburn Main Coal BNMA (210)		
Knightswood Gas KDG (183)				
		Kilsyth Coking KHCC (102) and (62) on NW side central coalfield	Dunfermline Splint DESP (60)	Kailblades/Corbie Craig KCG (43)
				Arniston Parrot ARP (7)

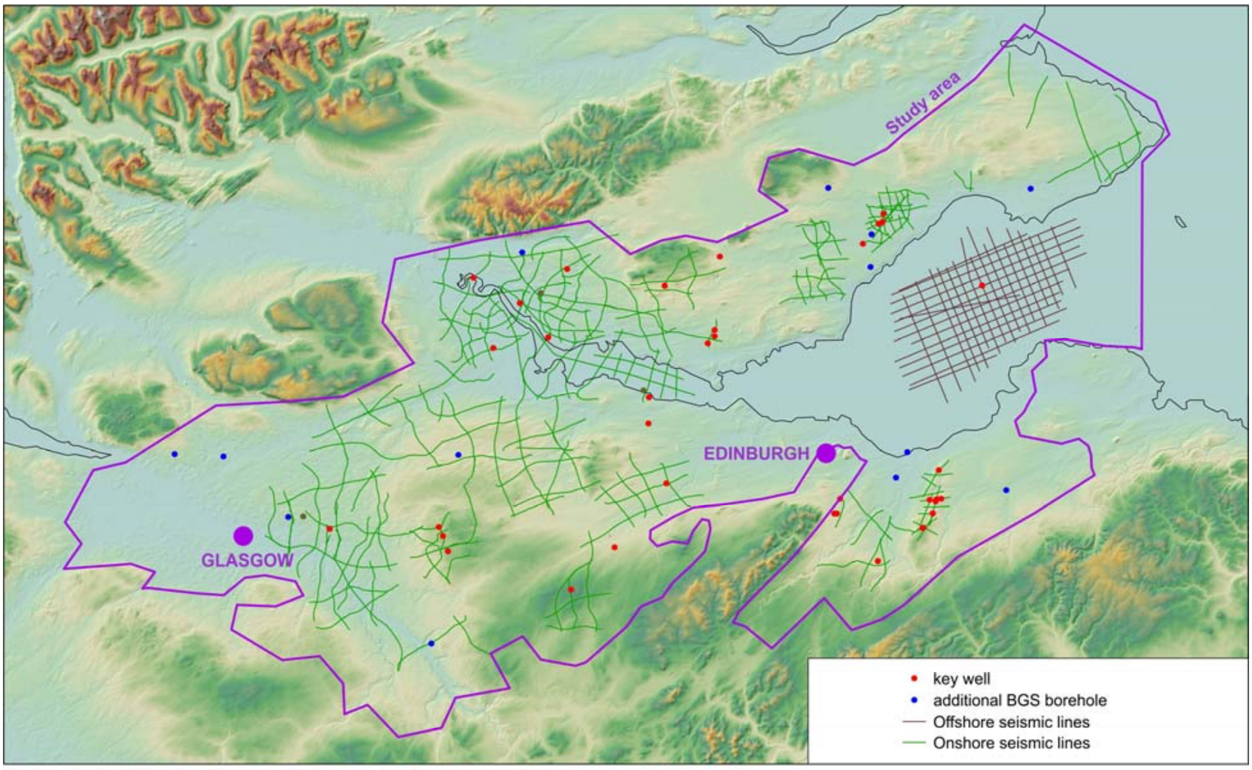
Table 3 Coal seam abandonment plan data in the Limestone Coal Formation that was used to guide the depth of the base of that unit in the model. The thickness from the coal seam to

the base Limestone Coal Formation is given in brackets (in metres) and the approximate stratigraphic position is indicated by the position in the table.

The standard thickness used from the Upper Hirst coal seam to the base of the Upper Limestone Formation was 200 m.

A second mining-data constraint was given by the 'mining data for all seams greater than 500 m' licensed from The Coal Authority. This dataset was used to inform a depth cut-off for the shale resource estimation (Figure 63 of Monaghan, 2014) but as the deepest worked coals are in the Limestone Coal Formation, it also provided a 'deeper than' constraint for the base of that stratigraphic horizon.

4.5 SEISMIC DATA



Location of 2D seismic profiles used to assess the shale potential of the Midland Valley of Scotland study area

Figure 2 Location of 2D seismic profile interpretations used to constrain the DECC model. Image after Monaghan, 2014 ©DECC.

A total of 1,325 km (823 miles) of onshore seismic data was interpreted along with 478 km (297 miles) of previously interpreted offshore 2D seismic data (Figure 2). The seismic data, dating from 1977-88, are of variable quality, ranging from poor in the Midlothian area and around the Rashiehill borehole and Bathgate Hills, to moderate-good in the Firth of Forth. An iterative approach was employed, finding seismic lines with the good evidence for horizon mapping and well ties, then circling back through the poorer quality lines, with an interpretation that was consistent with the BGS outcrop mapping and with nearby wells. Some areas of seismic data such as over the Burntisland Anticline and Kilsyth Basin had no well ties and time-converted borehole and mining data were used as a guide.

Seismic data from the National Coal Board were not utilised as it is focused at shallow depths and some Geological Survey lines (e.g. Line IGS-1982, Forsyth et al., 1996) were not available in digital format. In the Firth of Forth, existing BGS interpretations made on reprocessed seismic data tied to the Firth of Forth 1 well were used (Monaghan et al., 2012).

The seismic horizon and fault interpretations were depth converted using a linear correlation derived from velocity-time data measured from 8 wells (this was all the available velocity data).

The velocity data from several of the wells plotted some way off the linear correlation (on both the high and low side) with the result that the depth-converted seismic interpretation did not fit exactly the observed well depths. After import of XYZ data points interpreted for each horizon and faults from the 2D seismic data, several steps were undertaken in GOCAD® to remedy the depth-data mismatch:

1. The base Limestone Coal Formation (bLSC) surface was used as a reference surface since it can be constrained by a great deal of projected mining data as well as a good quantity of borehole data. An unfaulted bLSC surface was created with all the borehole, mining and outcrop data.
2. The bLSC surface was fitted to the borehole and well picks pointset '*surface-tools-fit-to pointset*' using 2 iterations and setting control nodes.
3. In selected regions with extreme disparity between the projected mining and seismic data (areas where there is no well control but good mining control) the bLSC was fitted to the borehole+mining+outcrop derived pointset (using 2 iterations and without setting control nodes).
4. In the selected regions identified, the seismic data points were then edited to fit the depth surface (transfer the Z property subtract the difference using the calculator). A new combined data file for bLSC was then created with the revised seismic-depth data points included.
5. To maintain the consistency of /thicknesses within the seismic interpretation the following method was used for the remaining four surfaces:
    a. A thickness isopach from original seismic pick to the revised bLSC pick was created.
    b. The thickness isopach was added onto the bLSC depth-corrected seismic pick to maintain consistency.
    c. The revised seismic depth picks were merged with the other data sources.
6. When the faulted modelled surfaces were created, a fit to borehole/well point iteration was performed for each surface (inserting control nodes) to ensure that the modelled surfaces honoured the well/borehole points.

The depth conversion process introduced significant uncertainty into the dataset. Due to the observed variability in seismic velocities, future work would benefit from building a more complex velocity model representative of individual wells.

4.6 PREVIOUS MODELS USED BY THIS MODEL

Small parts of existing models were utilised by this model namely:

- an area of the Lower Limestone Formation in central-west Fife with no constraining seismic datasets from Monaghan (2013)
- the base of the Lawmuir Formation (= base West Lothian Oil-Shale unit) at the margins of the Clyde Plateau Volcanic Formation blocks around Glasgow after Millward and Stephenson (2011).
- The base Upper Limestone Formation and base Lower Limestone Formation at the margins of the western Central Coalfield after McCormac (2012, 2013) and/or Monaghan (2013)

Pointsets were extracted from regions of these surfaces and included within the combined data file for each stratigraphic surface.

In the Firth of Forth, the base Upper Limestone Formation was not previously interpreted on seismic data and is not present in the Firth of Forth 1 well, nor in any borehole that ties to the seismic data. For the purposes of this study a standard thickness of 220 m was added to the base

Limestone Coal Formation seismic interpretation (based on the formation thickness in boreholes to the north and south of the Firth of Forth). Subsequent reductions to that thickness were made to ensure consistency with overlying surfaces and rockhead. The result is that the base Upper Limestone Formation surface is particularly poorly constrained between the offshore seismic and onshore datasets at the north-eastern end of the Midlothian-Leven syncline. In this area the unit as modelled is very thin and steeply dipping and could be improved upon by further work.

5 Dataset integration

Borehole, well, seismic, mining, outcrop and selected parts of previous modelled data were combined to a single data file for each stratigraphic horizon (Table 4). Prior to that combination, each dataset was visually compared in GOCAD® and erroneous data or inconsistencies were identified and resolved. The main inconsistency resulted from the seismic depth conversion compared to well/borehole picks and mining information (the method of resolution is described in section 4.5 above).

Surface/ Gocad project name	**Borehole/ well**	**Ex-tent**	**Out-crop line**	**Mining data**	**Seismic pick name**	**Existing model**	**Interpreted data**
bULGS/top LSC bULGS_data.gprj	Y	Y	Y	Upper Hirst data (projected 200m to bULGS)	Top Limestone Coal.dat 220m above bLSC assumed in Firth of Forth seismic picks but later edited to fit rockhead etc	Margin of western Central Coalfield from McCormac (2013)	
bLSC/tLLGS bLSC_data.gprj	Y deleted NS66NE4, NT39NW10N T08NW 254, NS98NE28 as inconsistent	Y	Y	Mining data to base LSC using thicknesses as in Table 3	Top LowerLimestone.dat	Margin of western Central Coalfield from McCormac (2013)	
bLLGS/tWLO bLLGS_data.gprj	Y Rashiehill added manually. Not included Valleyfield shaft as near base but not at base	Y	Y	n/a	Base Lower Lmst.dat	Central Fife small area from Monaghan (2013)	
bWLO/tGUL bWLO_data.gprj	Y	Y	Y	n/a (no depth data from shale workings)	Base oilshales.dat, top Gullane fm.dat. Top volcanics in Levenseat area Cassem base Pittenweem	Base Lawmuir Formation around western Central Coalfield from Millward and Stephenson (2011)	Manual edits around Carrington as seismic picks were not deep enough compared to well
bGUL/tvolcBGN bGUL_data.prj	Y	Y	Y	n/a	Top Inverclyde.dat, Top Ballagan.dat, TopCPV lavas.dat Top volcanics.dat	n/a	Manual edits of seismic points around Carrington well. Seismic interpretation South Fod/Blackness goes beneath TD for bGUL, though bGUL is probably around the TD of the well

Table 4 Summary of datasets integrated for each stratigraphic surface modelled

Appendix 1, the model development log, lists in more detail the modelling projects created and actions taken.

6 Model workflow

The GOCAD® structural workflow manager (GOCAD® version 2009.4) was used as standard to create a fault model and faulted horizon surfaces.

During the faulted horizon modelling, data points within a tolerance of 200 m of faults were excluded. Some additional manual exclusion of seismic pick data points was made close to faults where the faults had a more complex geometry than the planar structures modelled.

Manual editing of fault-horizon contacts was necessary in some cases to create a more consistent throw. Horizon crossovers were also removed manually. Control nodes were inserted at borehole/well data points (see section 4.5). Edits were also made such that horizon surfaces were:

- *deeper than* boreholes proving the modelled stratigraphic units but not reaching the base (e.g. total depth (TD) within LSC)
- the base Limestone Coal Formation was *deeper than* The Coal Authority deep coal mining dataset (see section4.4)
- the base West Lothian Oil-Shale Formation was *deeper than* contours on the Burdiehouse Limestone given in Mitchell and Mykura (1962)

7 Model assumptions, geological rules used

It was assumed that the borehole and well data proving the base of a unit was a correct interpretation at the correct depth and that this dataset has the highest confidence to fit the modelled surface. Visible inconsistencies were checked and removed as part of the modelling process.

An assumed thickness, known to be a simplification, was used from a coal seam to a modelled horizon (Table 3) for the purpose of using the mining dataset as a projected constraint.

Unit thicknesses are extremely variable within and between basins of the Midland Valley and so it is not possible to have a set of rules of unit thicknesses to be maintained

8 Model limitations

The main limitations of the regional-scale model are the exclusion of numerous faults with throws less than a few hundred metres (approx. 700-1000 ft), the lack of mapped surfaces for volcanic units and igneous intrusions, and the large uncertainties on the interpretation of the base Gullane unit and base West Lothian Oil-Shale unit surfaces resulting from lack of data/poor quality seismic data.

Monaghan (2014) gives further detail on these three aspects.

An additional limitation included the simplification of faults as planar structures. Seismic data indicate greater complexity (varying dip, curved structures etc) but do not provide enough constraint to adequately construct a model of a complex structure.

It should also be noted that where there are both seismic and projected mining data constraints the GOCAD® surface takes both into account, but does not fit either exactly, representing the similar levels of uncertainty in these datasets.

Comparison with previously modelled surfaces for the base Coal Measures and base Carboniferous (Monaghan, 2013) highlighted that edits are required to maintain consistency with the DECC model.

9 Model images

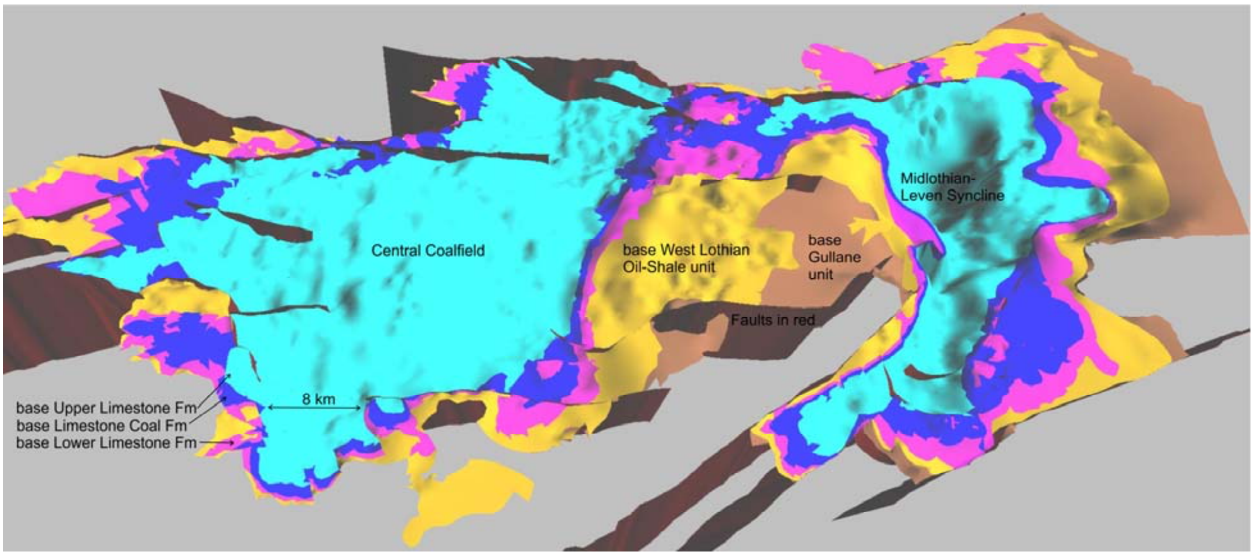


Figure 3 Overview of the modelled depth surfaces

Depth maps, isopachs and cross-sections derived from the model are shown in Monaghan (2014 Figures 15-18, 66, 69, 70).

10 Model uncertainty

No formal uncertainty analysis of the 3D geological model was undertaken. Figures 67 and 68 of Monaghan (2014) summarise how well different areas of the resource estimation are constrained.

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British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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Appendix 1 Model development log

Version name	Brief description	Modeller	Date
MVS2012existing_v2009_3.gprj	Existing model project used to examine additional faults to be included in DECC model (by incorporation of regional fault network from Clyde Catchment model, Clyde Volcanic models etc)	ALS	9/1/14
Minedata_surfaces.prj	Used to compile data on Upper Hirst coal (URH) in ULGS to define shape of Kincardine Basin from borehole and mining data and outcrop – very rough extent and quick fault modelling done of new faults assuming 60 degree dip. To import to Landmark to aid seismic interpretation.	ALS	30/1/14
CPV.prj	Used to compile data extracted from the CPV GSI3D models defining top and base CPV as well as LWM and LLGS and LSC	ALS	06/02/14
Thick.prj	Used to contour the thickness of the BKME, and also contour the depth-maturity surfaces	ALS	25/3/14
bULGS_data.prj and four more	Created Gocad projects to collate data for each modelled surface (bULGS, LSC, LLGS, WLO, GUL). Boreholes base and deeper than, extents etc added in	ALS	2/4/14
Faultmodel_v1.prj	Gocad project to collect existing modelled fault surfaces and to start modelling new ones. Updated 29/4 with all working fault data	ALS	3/4/14 and 29/4/14
Shalepercentagemaps	Project with the % shale and % shale > 50ft maps/surface. Densify AOI curve to 3000m and filter to 750m, contour line densify to 1000m, smooth result 10 times, then use script `if(Z < 0 ) {Z=0;}` . Some area required manual editing e.g. Bathgate Hills. Use the versions *without* the Shpercent in front	ALS	8/4/14
Alldata.prj	Sorting out seismic data and draft unfaulted surfaces	ALS	24/4/14
Faultmodel_v2.prj	Cleaned, contacted faults to be used. Outline curves added and edited so outside basin bounding faults. These	ALS	29/4/14

	versions not edited for contact errors (see v3)		
Faultmodel_v3.prj and v4	Faulted surfaces made. Regions made close to faults and where fault not fitting well for data exclusion by doing fault calculation and then manual edit. Exclusion distance 200m Moved to v4 due to a crash.	ALS	30/4/14
Faultmodel_v5.prj	Used this project to start horizon editing process – 1. Fit to boreholes by addition of control nodes 2. Re-interpolate to fit back to other data away from boreholes 3. Remove slivers along faults 4. Fault-horizon edits	ALS	4/5/14
Faultmodel_v6.prj	Manual edits for 'deeper than' boreholes etc and overlap with rockhead	ALS	4/5/14
Faultmodel_v7.prj	Manual editing of overlap surfaces. Added Gleniffer-Castlemilk Fault dipping at 60° to N	ALS	4/5/14
Faultmodel_v8.prj	Cleaned project for model QC check. Added curves for making holes after model checked. Post-check corrections on 7/5, checked overlaps, isopachs and made holes.	ALS	6/5/14
Faultmodel_v9.prj (saved as 9aa then 9ab when crashed)	Cut horizons by depth-cut off and other work for volumetric estimation	ALS	8/5/14
Faultmodel_v10S grids	Cleaned a lot of data out. Made SGrids of the four volumes using the stratigraphic surfaces and depth cut-off. Used 350*350*75 divisions on AOI. This is coarse compared to the mine data detail but finer than TIN spacing so gives a good representation of the volume	ALS	11/5/14
Skua_volumes_fromv10.sprj and subsequent versions a,b,c (crashes, version c should be used)	In SKUA. Brought over SGrids from fault model v10. Imported bounding polygons for the basal unit as 'lease boundary' to exclude areas of model unwanted eg GUL western area Imported shale percentage surfaces and TOC %, transferred properties to SGrids. Calculated net shale volumes using reservoir volumetrics. Calculated net shale thicknesses as in oil and gas regions for each unit and exported via a pointset, for the mining-related depth cut off.	ALS	11/5/14 and on to 31/05/14
Faultmodel_v11_1000ft.prj	Created project for Mike McCormac who created combined depth and 1000 ft cut off surfaces and then SGrids for the 1000 ft cut-off surface	MMCC/ALS	05/06/14
DECC_MVS_SKUA_model.sprj and DECC_properties_MVS_SKUA_model.sprj	Mike McCormac used to calculate volumes for 1000ft cut off and then regions for oil and gas extents	MMCC	12/06/14
Curveediting.gprj	Simplifying extent curves for 1000 ft oil and gas	ALS	16/06/14
NGM_cleaned version_faultmodel_v9ab.prj	Cleaned copy of the final Gocad project containing the complete 3D geological framework model, for submission to NGM	ALS	August 2014