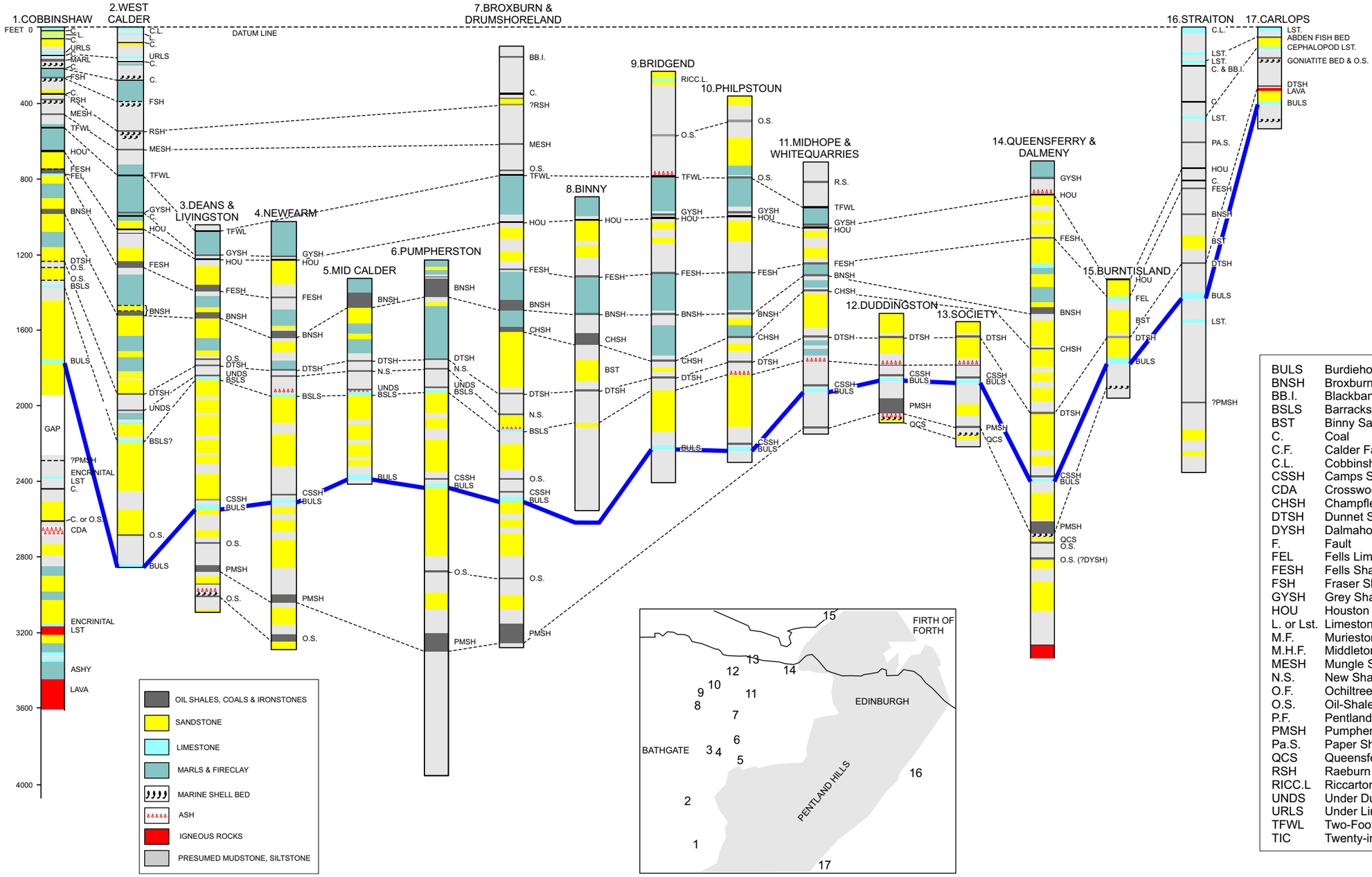


Figure 30 Summary stratigraphic sections through the West Lothian Oil-Shale Formation in selected mined areas, redrawn from Carruthers et al. (1927).

250000

300000

350000

700000

650000

Widespread lacustrine deposition with marine incursions. Sediment supply and palaeocurrents from the north-east. Marine incursions from the east.

Remnant volcanic high forms basin boundary in the west, sandier Lawmuir Formation around the basin margin.

Kinghorn and Bathgate Volcanic Fms active

E-W fault and NNE fold influence

BGS/DECC study area

FIFE

Heterolithic succession with varying marine influence

No volcanic rock thin succession

some thick mudstone in wells

Volcanic rock at Kinghorn V. Fm level

Firth of Forth

Kinghorn Volcanic Fm may be extensive over this area; interbedded with sediments

volcanic high

boundary of fluvial- to lacustrine-dominated facies unknown

Bathgate Hills Volcanic Fm, extends to Rashiehill borehole

Bathgate Hills Volc. interbedded with West Lothian Oil-Shales at surface and in boreholes

EDINBURGH

LOTHIAN

no data, possible low

Lawmuir Fm

GLASGOW

Lacustrine/non marine sediments with marine incursions

no data, possible low

Lawmuir Fm

volcanic high

extent of West Lothian Oil-Shale Fm and lateral equivalents

Ayrshire not considered/described

0 5 10 20km

High

Mudstone with siltstone and sandstone

Sandstone, siltstone and mudstone

Sandstone with siltstone and mudstone

Calcareous mudstone dominated

Stromatolitic limestone dominated

Volcanic rocks (lava, tuff and ash)

Volcanic lava and tuff interbedded with sedimentary rocks

Unconformity

Figure 32 Latest West Lothian Oil-Shale unit times (near the top of the unit, c.331 Ma, NM palynomorph zone).
a) Evidence from well/borehole and surface exposures. Note that wells/boreholes proving the upper West Lothian Oil-Shale unit are surrounded by shading, other wells/boreholes do not prove the upper West Lothian Oil-Shale unit.

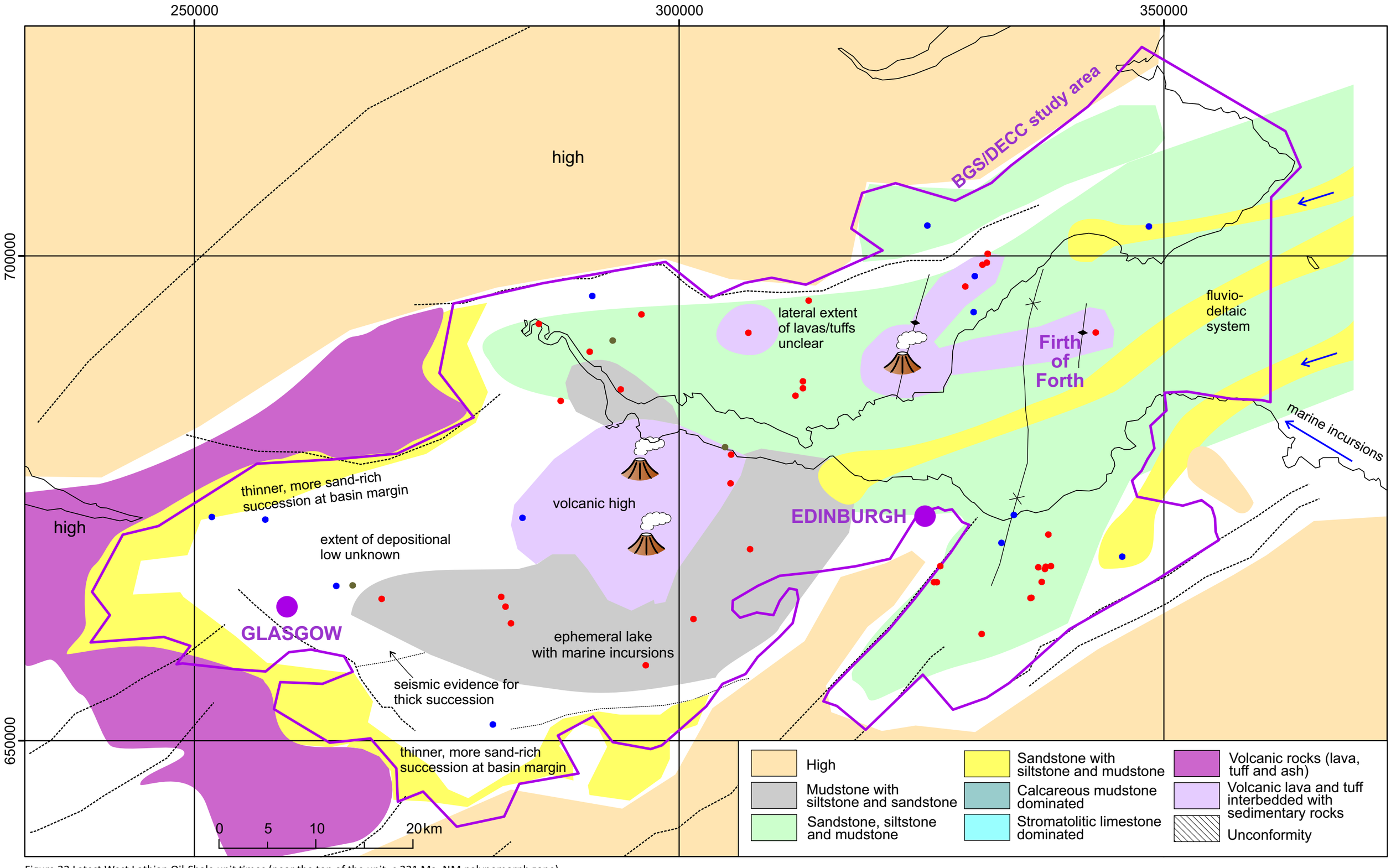


Figure 32 Latest West Lothian Oil-Shale unit times (near the top of the unit, c.331 Ma, NM palynomorph zone).
b) Summary of the palaeogeography. Evidence is patchy and the reconstruction is tentative. Dashed lines are faults and folds with evidence for active growth.

250000

300000

350000

700000

650000

Widespread lacustrine and fluvio-deltaic deposition with marine incursions.

Sediment supply and palaeocurrents from the north-east. Marine incursions from the east.

Volcanic high forms depositional basin boundary in the west. Relatively little volcanic activity.

Fault pattern uncertain

BGS/DECC study area

Unconformity/not present
Lomond Hills/
Glenrothes borehole

no data

FIFE

Thin ?Sandy
Craig Fm
Inch of Ferryton

mudstone,
limestone
rich

no data

Firth
of
Forth

Stromatolitic
reefs

volcanic high

?

extent of volcanics unknown

?

no data,
possible low

Lacustrine/ non-marine
sediments with
marine incursions

no data

Unconformity in
Rashiehill borehole,
over Clyde Plateau
Volc Fm.

EDINBURGH

LOTHIAN

Stromatolitic
reefs

GLASGOW

Salsburgh Volcanic
Formation until
Burdiehouse Limestone

no data,
possible low

volcanic high

extent West Lothian
Oil-Shale
Fm and lateral
equivalents

0 5 10 20km

High

Mudstone with
siltstone and sandstone

Sandstone, siltstone
and mudstone

Sandstone with
siltstone and mudstone

Calcareous mudstone
dominated

Stromatolitic limestone
dominated

Volcanic rocks (lava,
tuff and ash)

Volcanic lava and tuff
interbedded with
sedimentary rocks

Unconformity

Figure 33 Early West Lothian Oil-Shale unit times (around the level of the Burdiehouse Limestone, c.333.5 Ma, around NM/TC palynomorph zones)
a) Evidence from well/borehole and surface exposures. Note that wells/boreholes proving the lower West Lothian Oil-Shale unit are surrounded by shading, other wells/boreholes do not prove the lower West Lothian Oil-Shale unit.

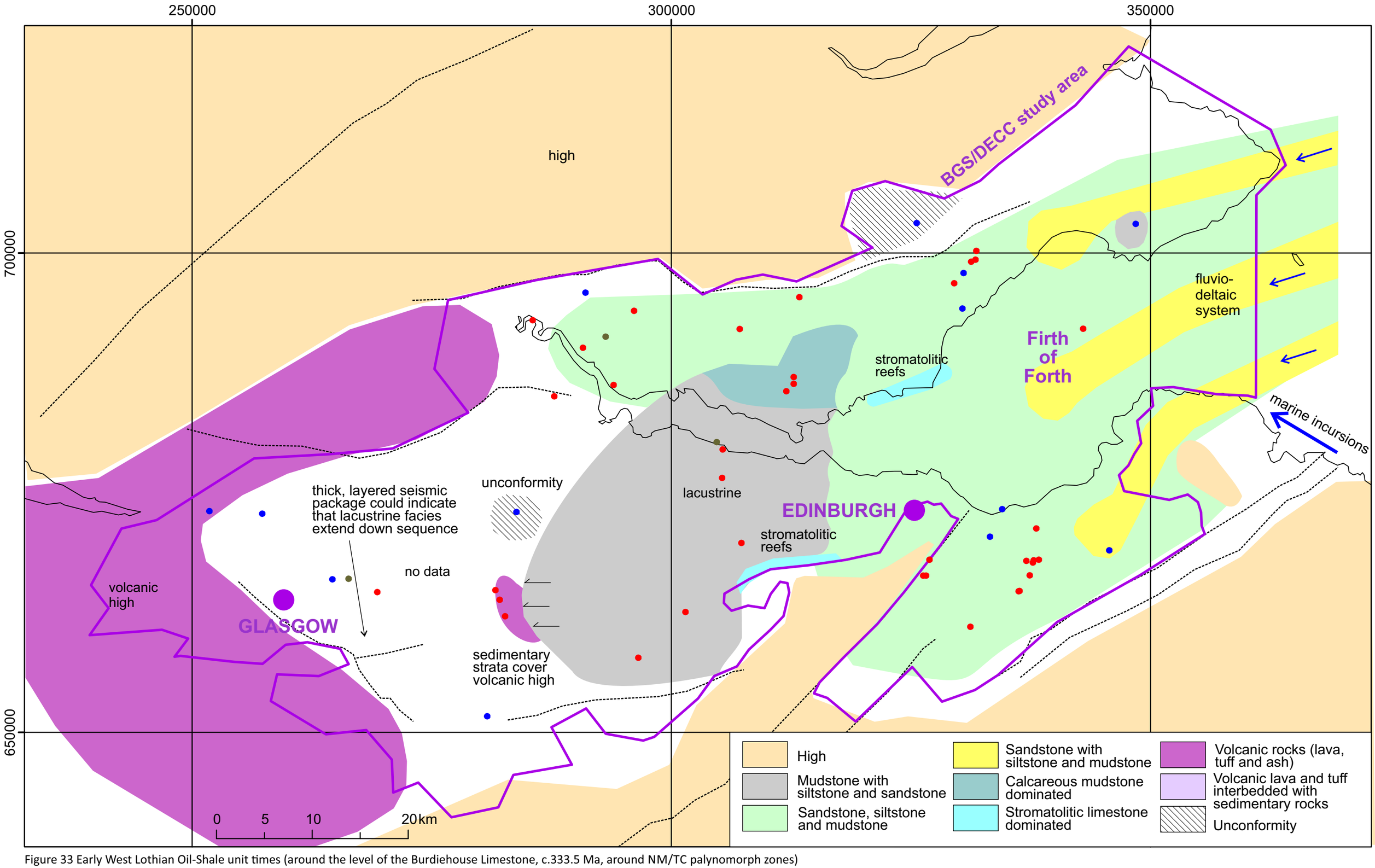


Figure 33 Early West Lothian Oil-Shale unit times (around the level of the Burdiehouse Limestone, c.333.5 Ma, around NM/TC palynomorph zones)
b) Summary of the palaeogeography. Evidence is patchy and the reconstruction is tentative. Dashed lines are faults and folds with evidence for active growth.

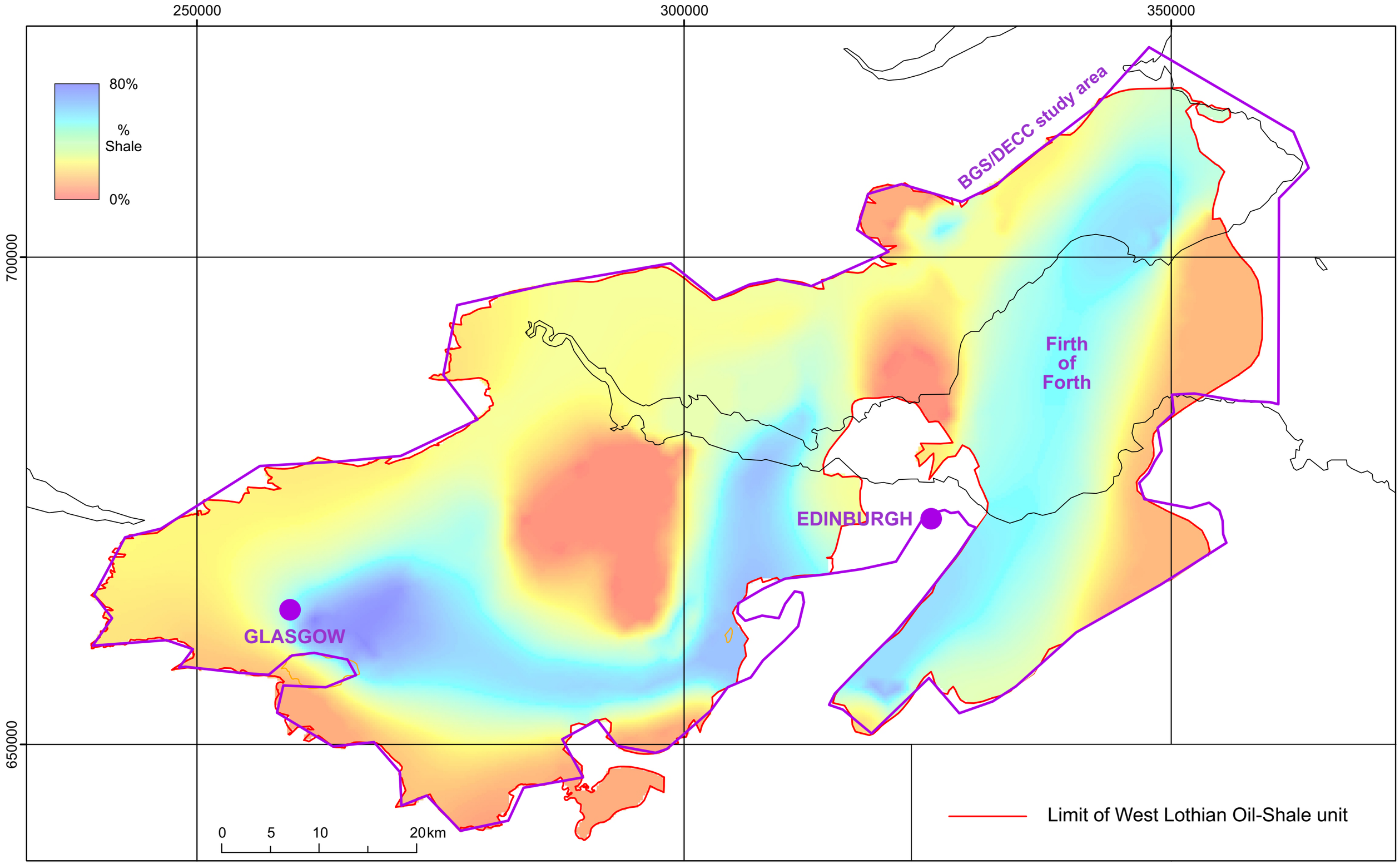


Figure 34 Percentage shale map for West Lothian Oil-Shale unit.

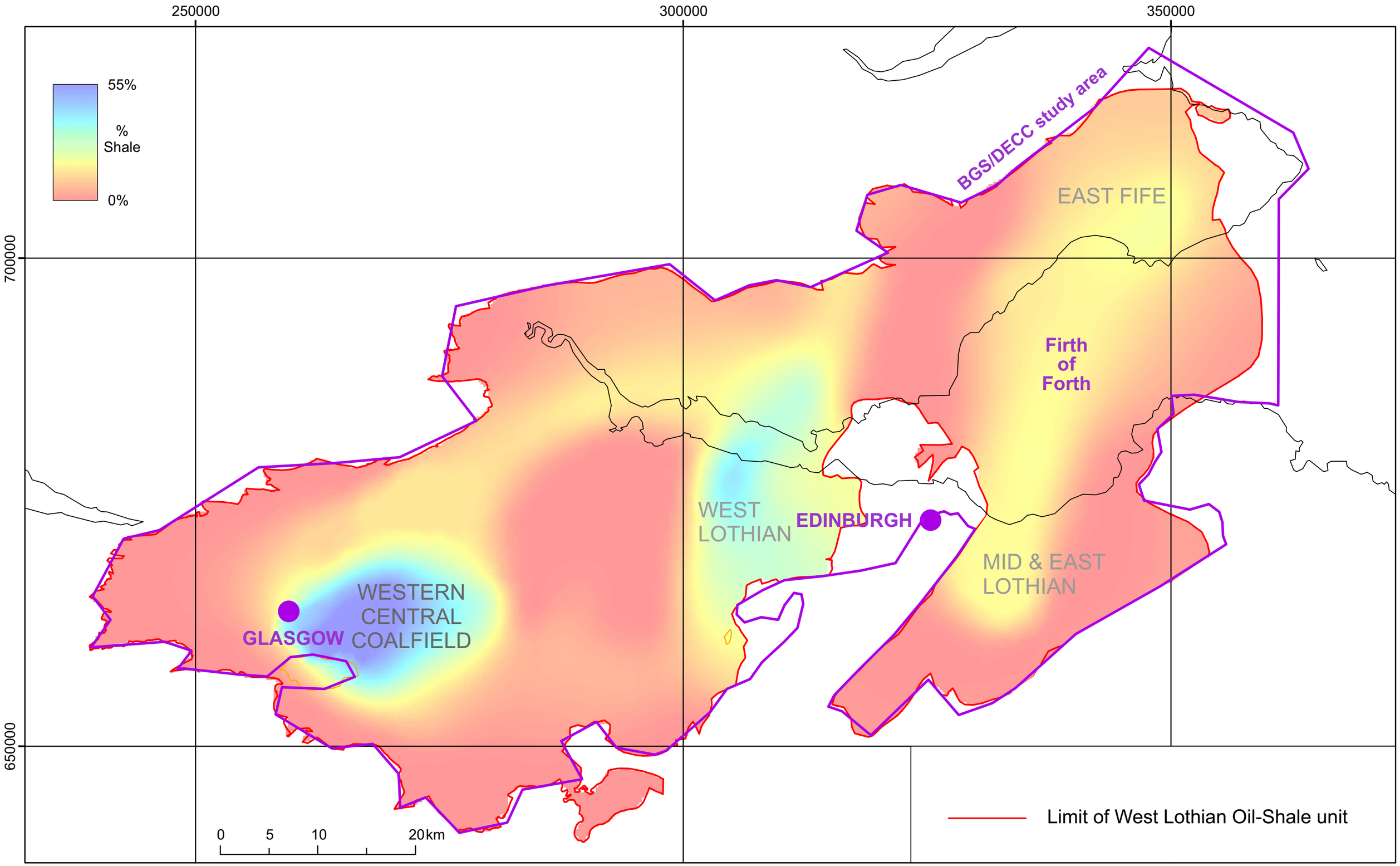


Figure 35 Percentage shale map for shale intervals greater than 50 ft (15 m) thick within the West Lothian Oil-Shale unit.

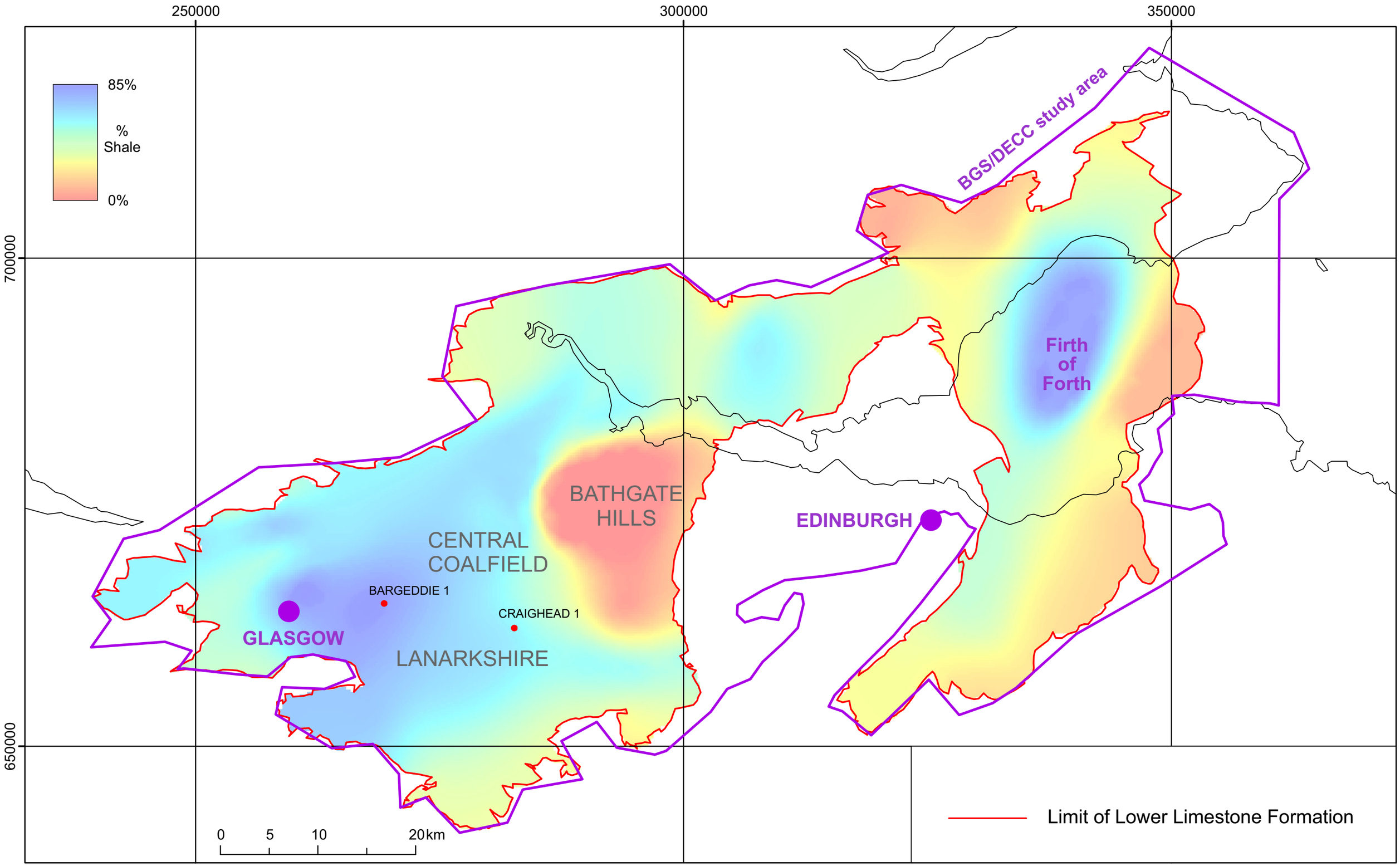


Figure 36 Percentage shale map for the Lower Limestone Formation, the position of wells discussed in the text is shown.

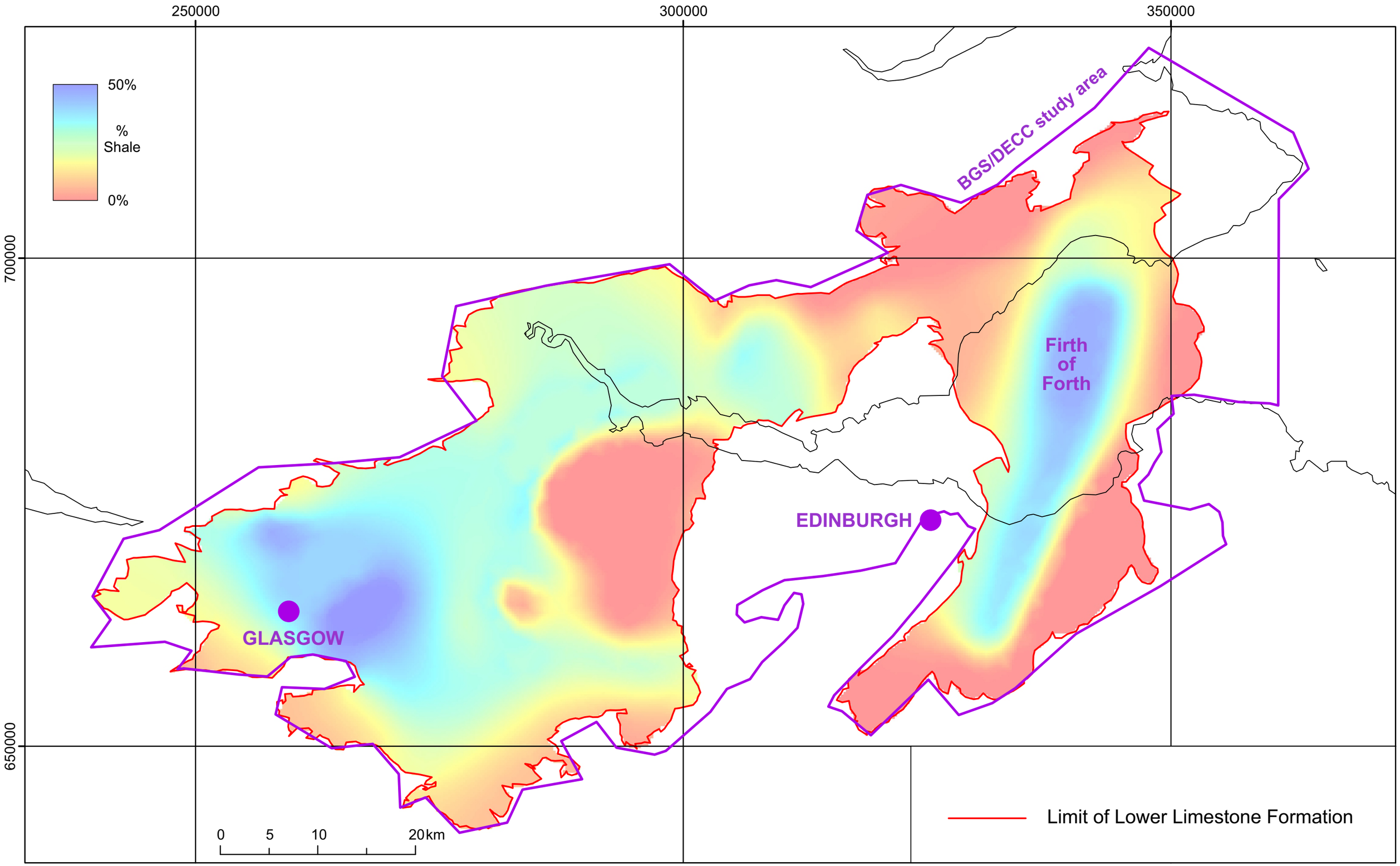


Figure 37 Percentage shale map for shale intervals greater than 50 ft (15 m) thick within the Lower Limestone Formation.

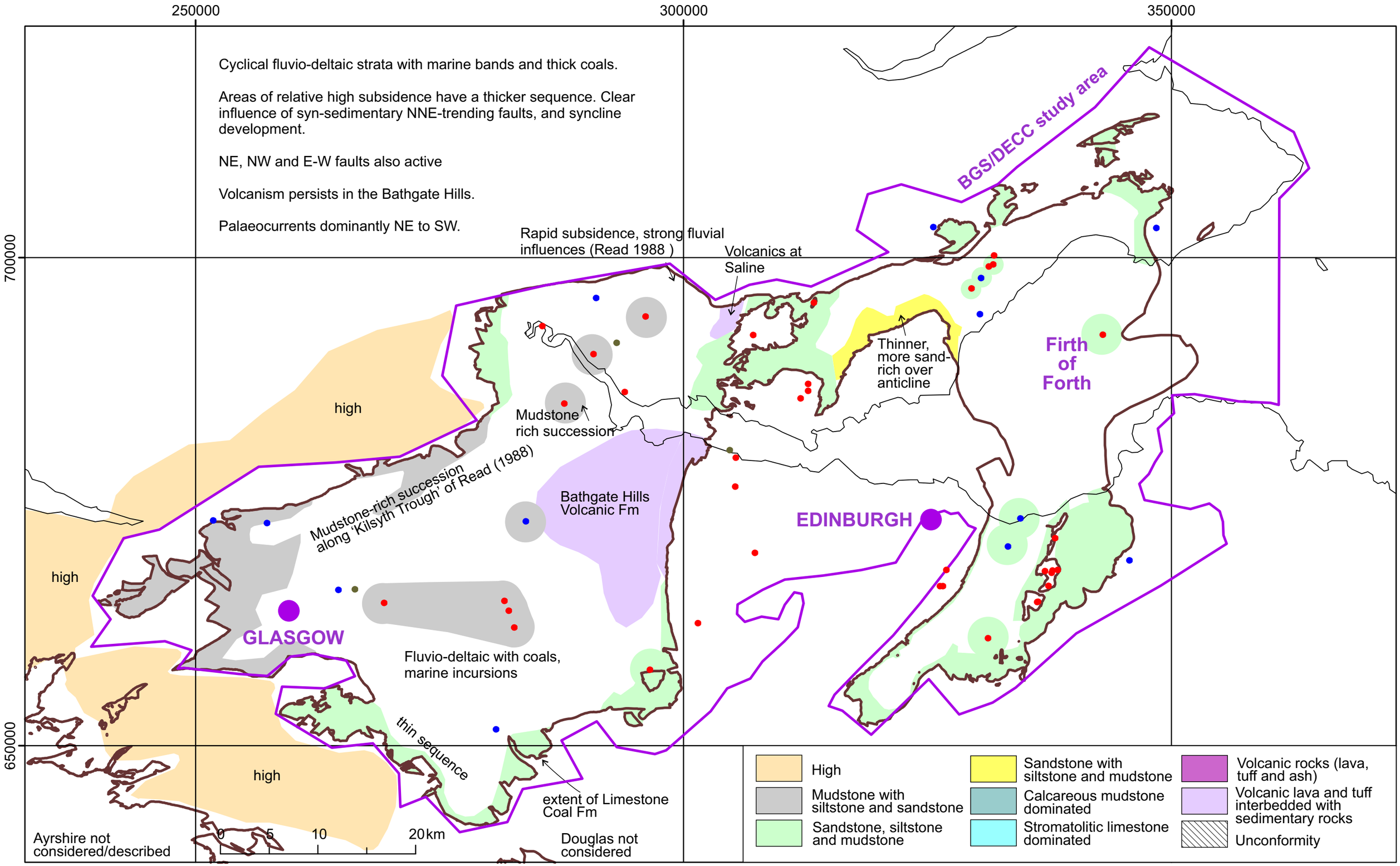


Figure 38 Limestone Coal Formation times (around c.329 Ma, NC palynomorph zone)
a) Evidence from well/borehole and surface exposures. Note that wells/boreholes proving the Limestone Coal Formation unit are surrounded by shading, other wells/boreholes do not prove the Limestone Coal Formation

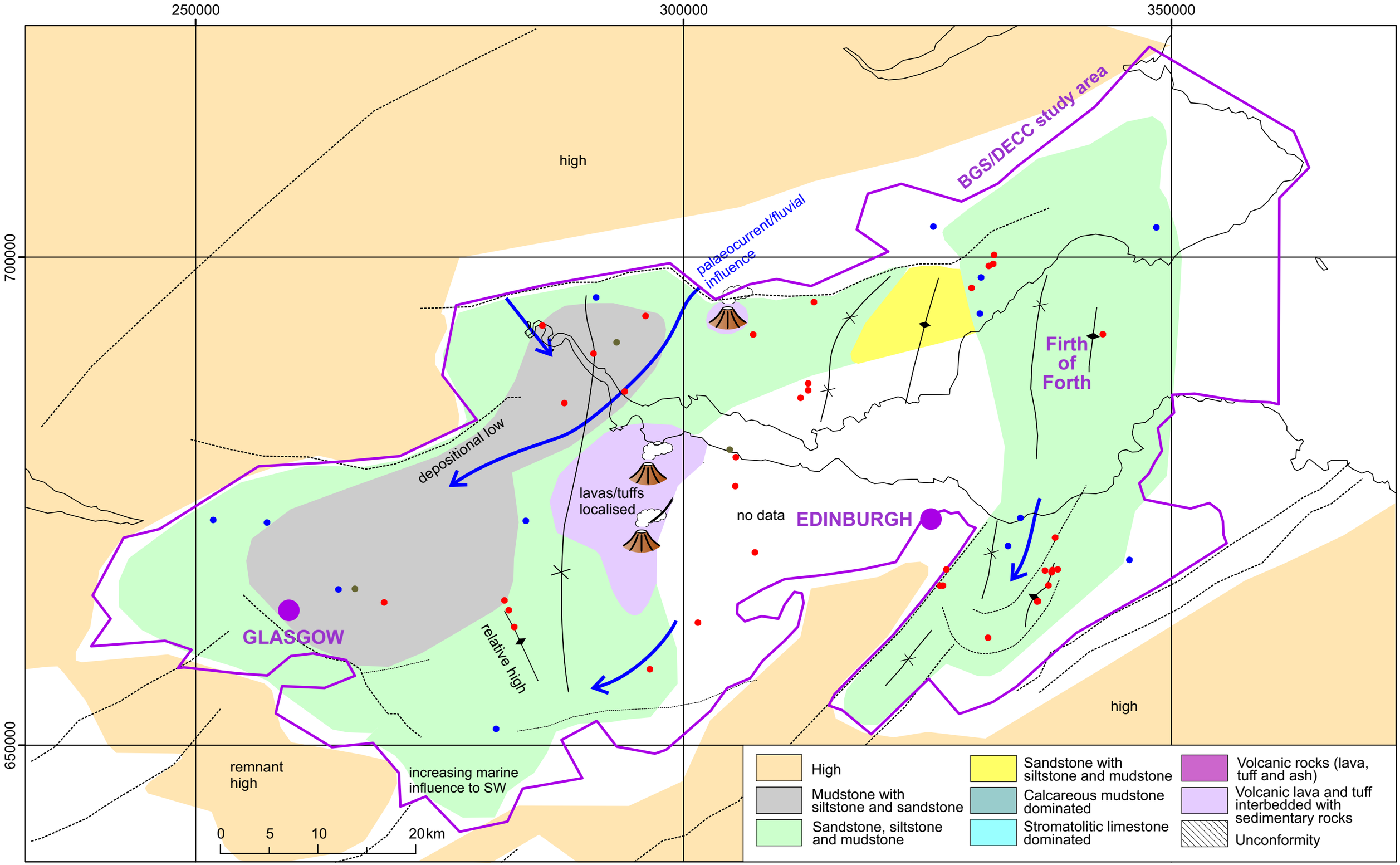


Figure 38 Limestone Coal Formation times (around c.329 Ma, NC palynomorph zone)
b) Summary of the palaeogeography. Evidence is patchy and the reconstruction is tentative. Dashed lines are faults and folds with evidence for active growth. Blue arrows show fluvial paleocurrent directions

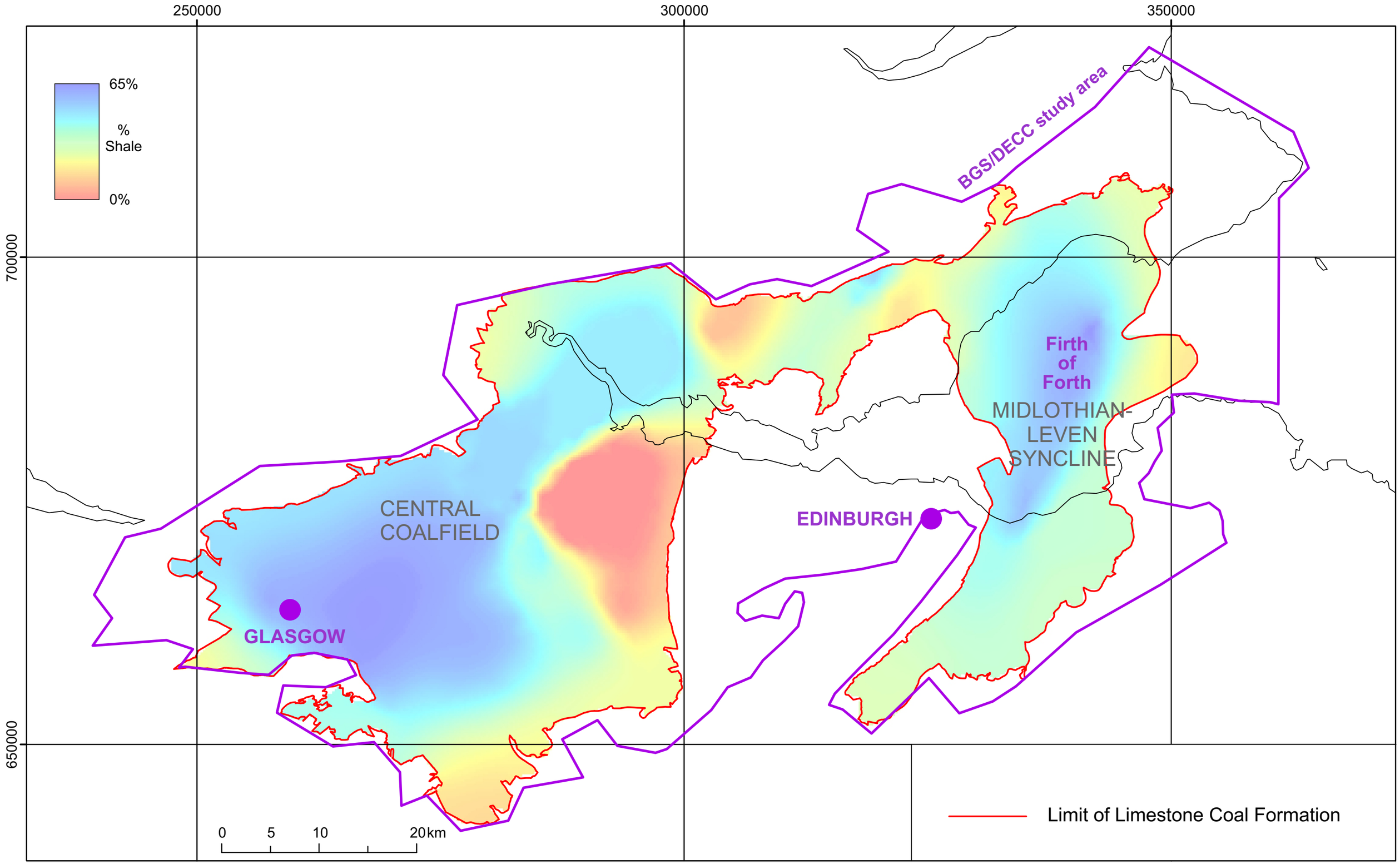


Figure 39 Percentage shale map for the Limestone Coal Formation

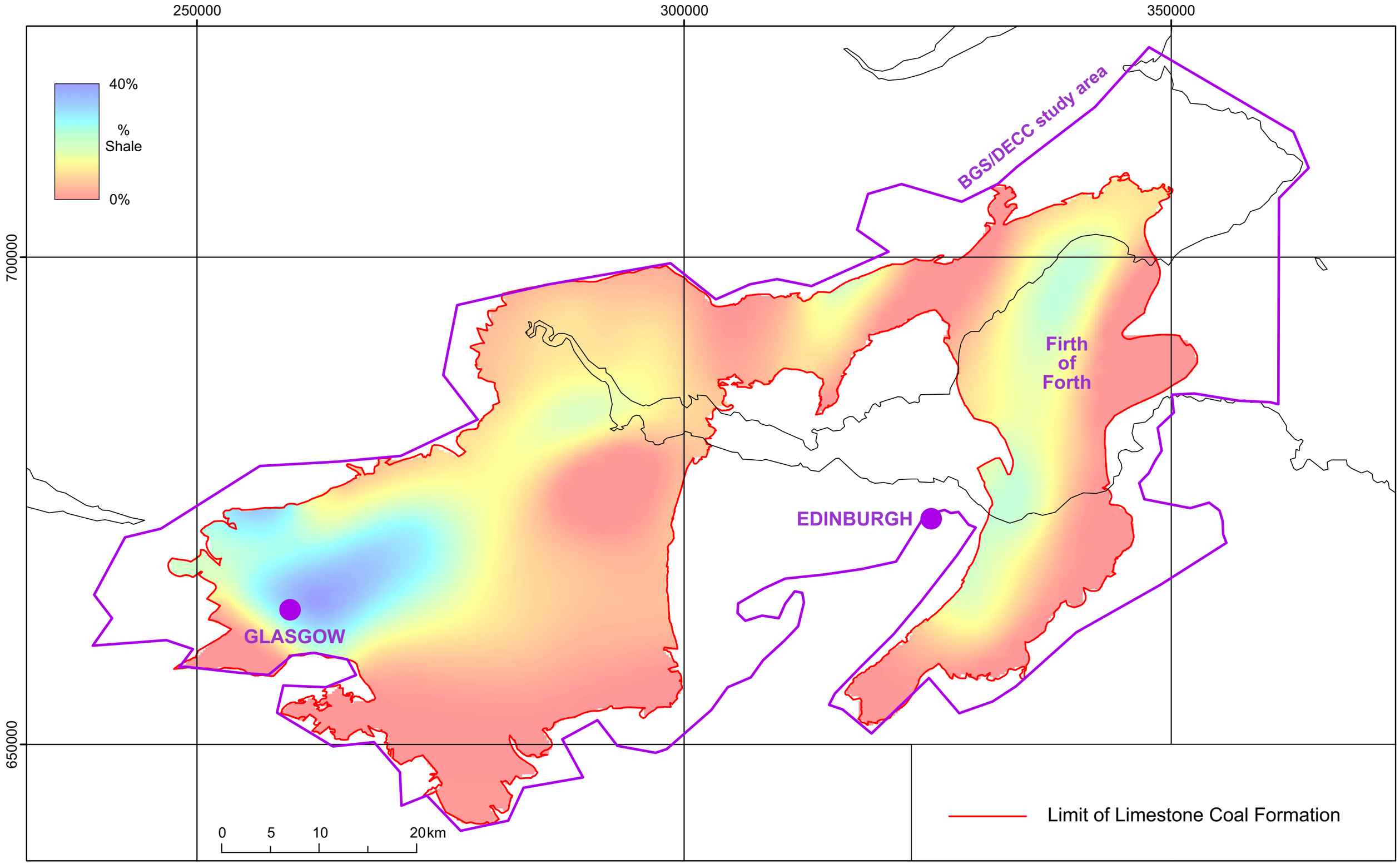


Figure 40 Percentage shale map for shale intervals greater than 50 ft (15 m) thick within the Limestone Coal Formation

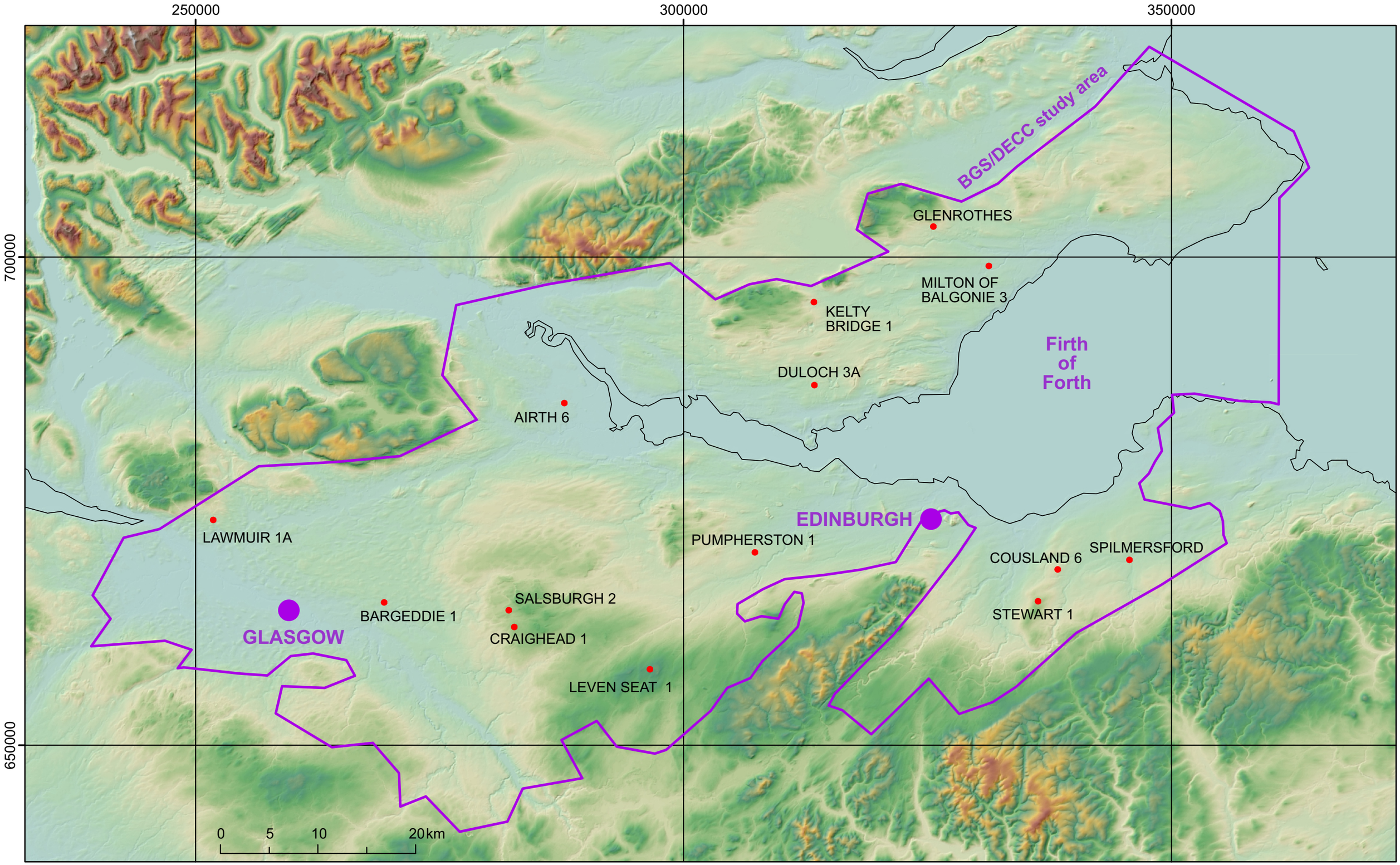


Figure 41 Location of wells and boreholes sampled for geochemistry and mineralogy by BGS in 2014

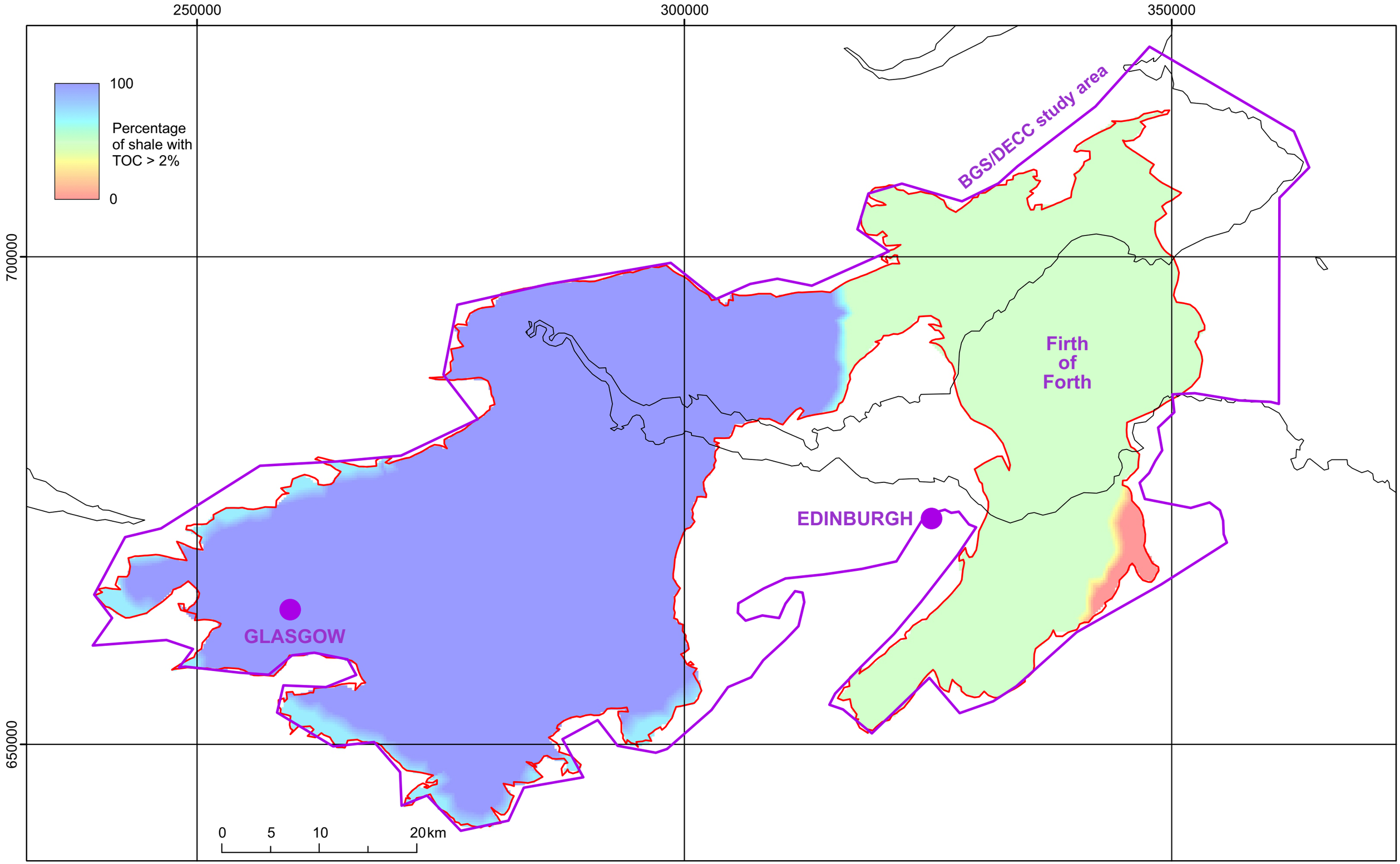


Figure 49 Percentage of shale with TOC >2% map for the Lower Limestone Formation

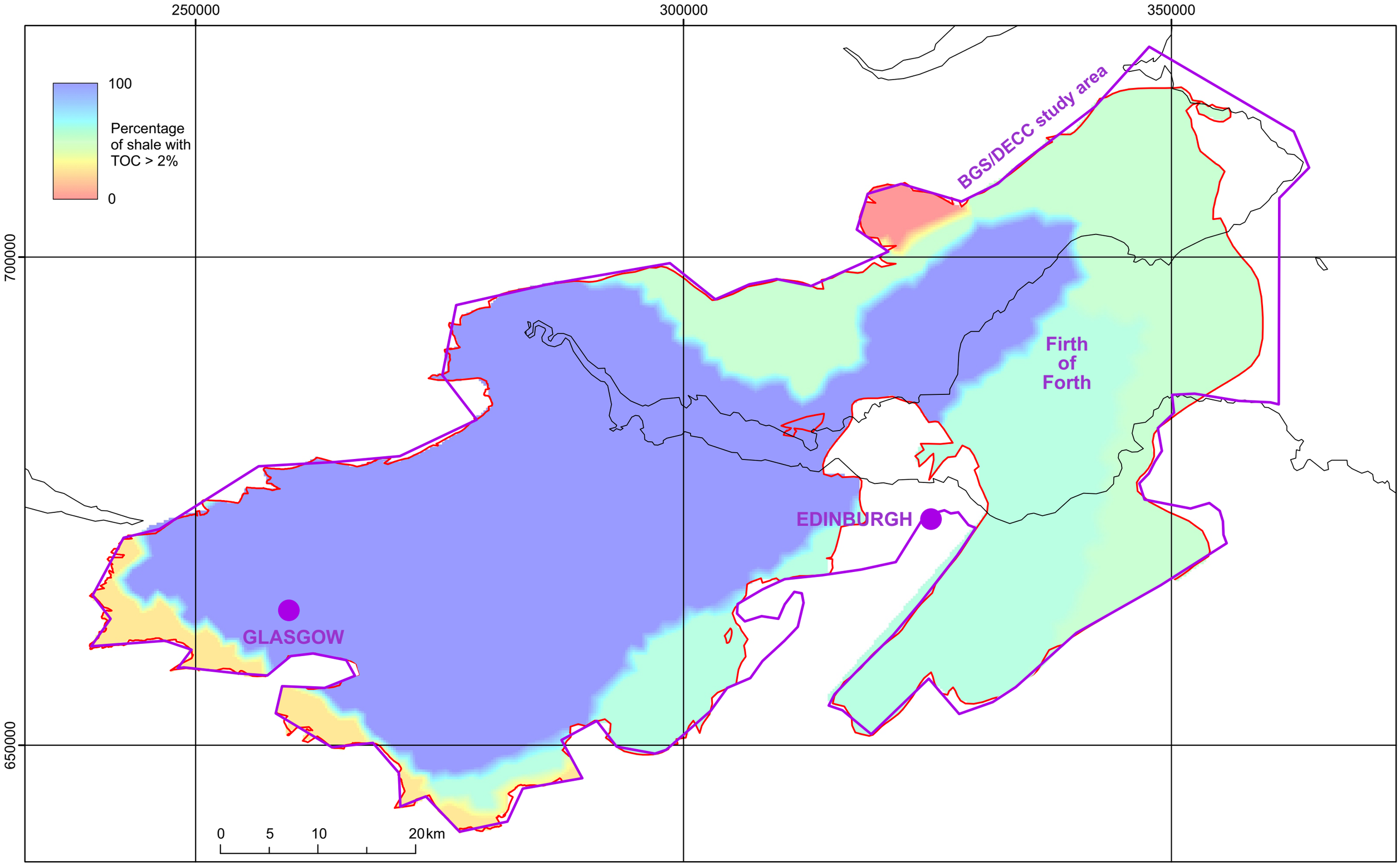


Figure 50 Percentage of shale with TOC > 2% map for the West Lothian Oil-Shale unit

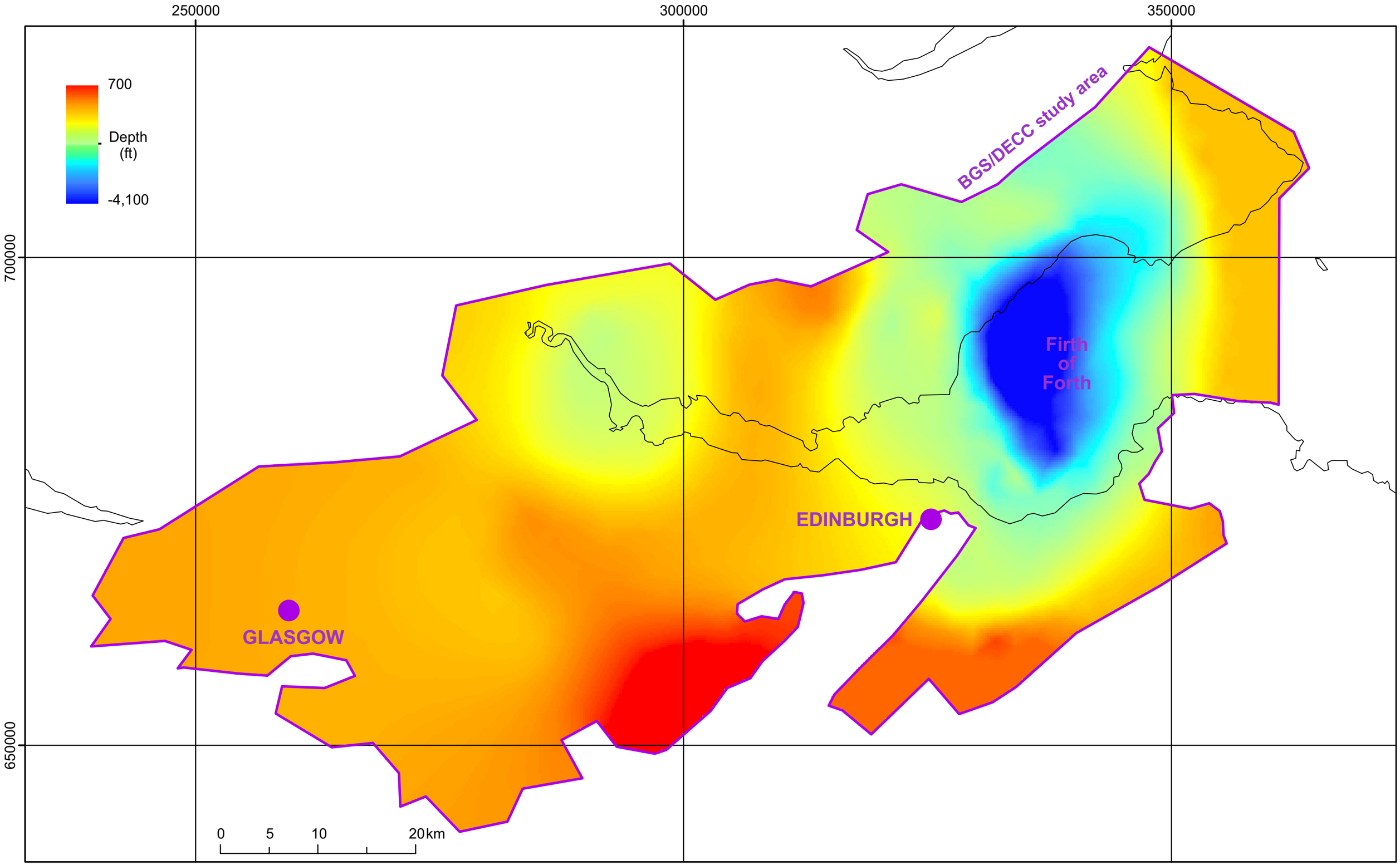


Figure 59 Simplified regional overview of estimated depth to R_o =0.6 (oil mature) in feet referenced to Ordnance Datum (note the depth scale is different from the depth to R_o =1.1 image)

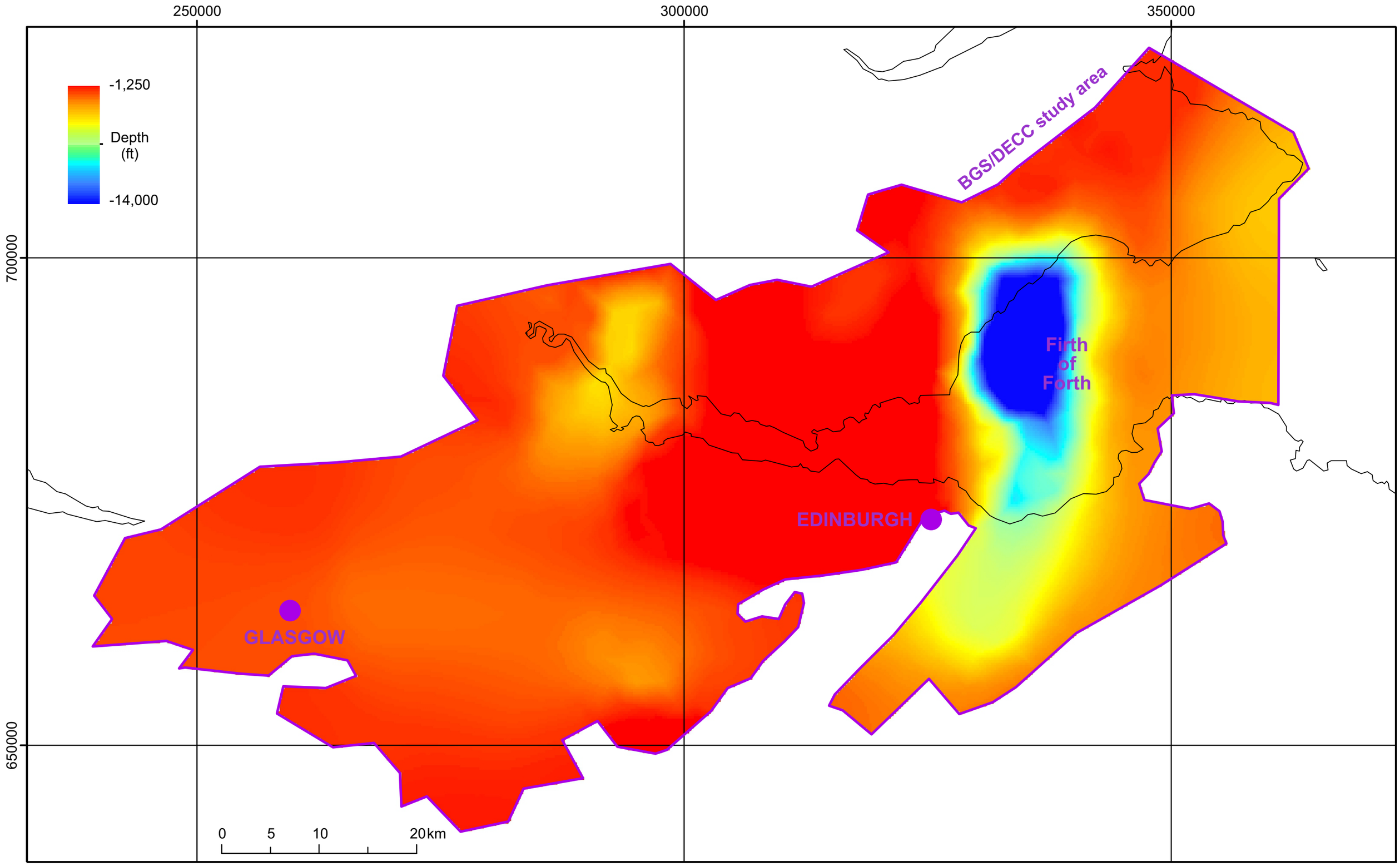


Figure 60 Simplified regional overview of estimated depth to R_o =1.1% (gas mature) in feet referenced to Ordnance Datum (note the depth scale is different from the depth to R_o =0.6 image)

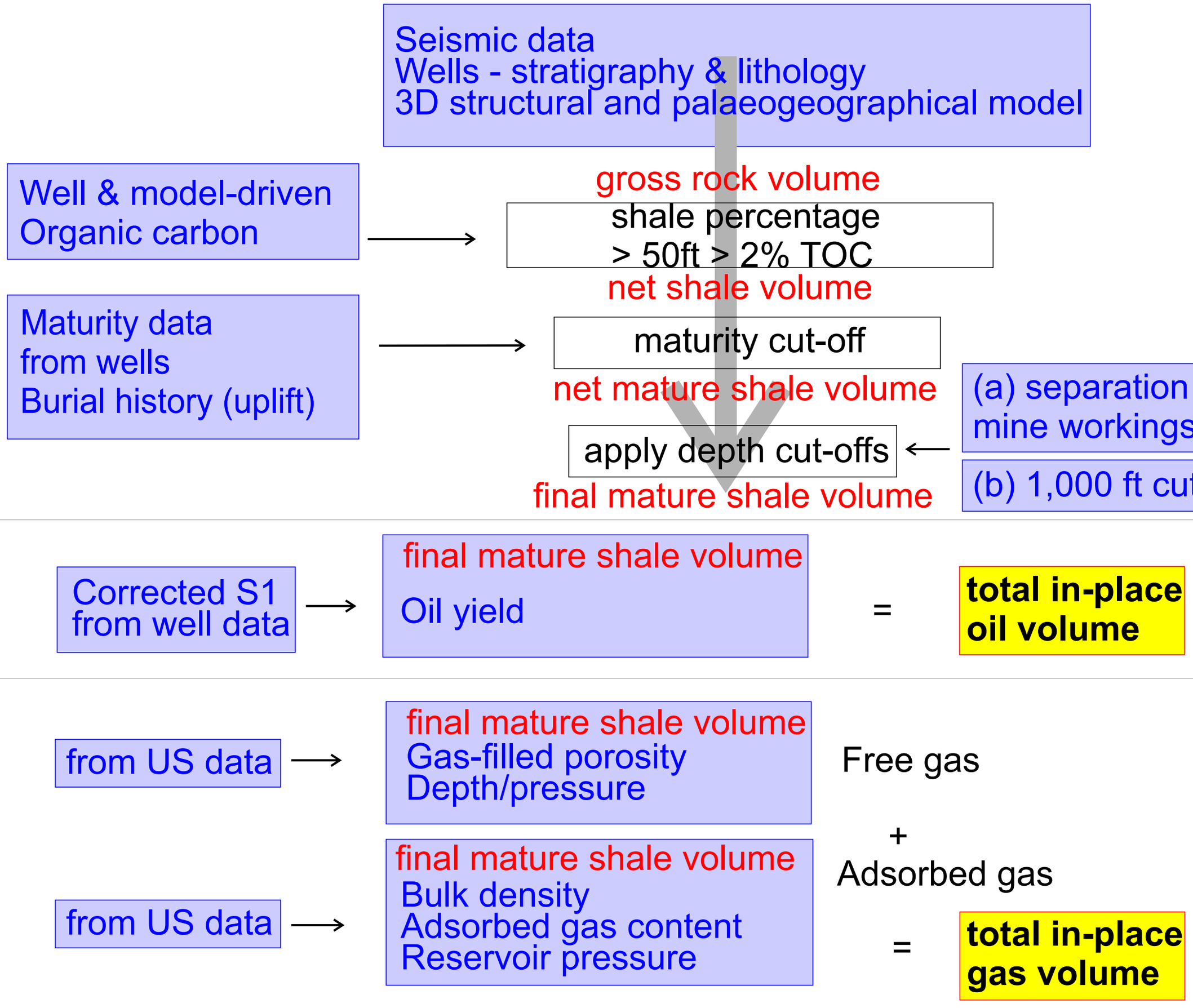


Figure 62 Overview of method used to calculate mature shale gas and shale oil volumes

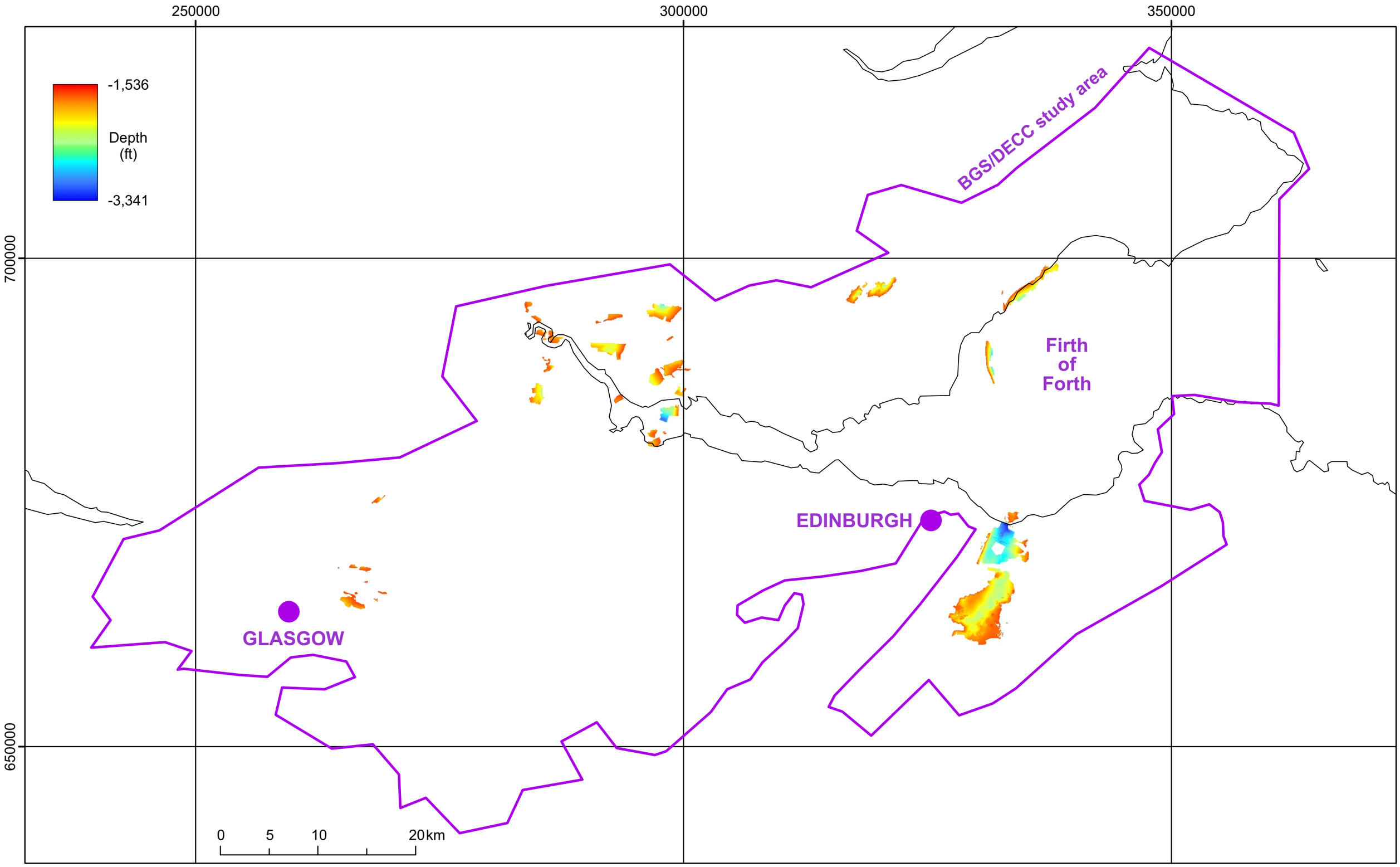


Figure 63 Extent and deepest depth of mine abandonment plans greater than 1,640 ft (500 m) relative to Ordnance Datum based on data licensed from The Coal Authority, plus mine abandonment plan information collated by BGS in the Firth of Forth

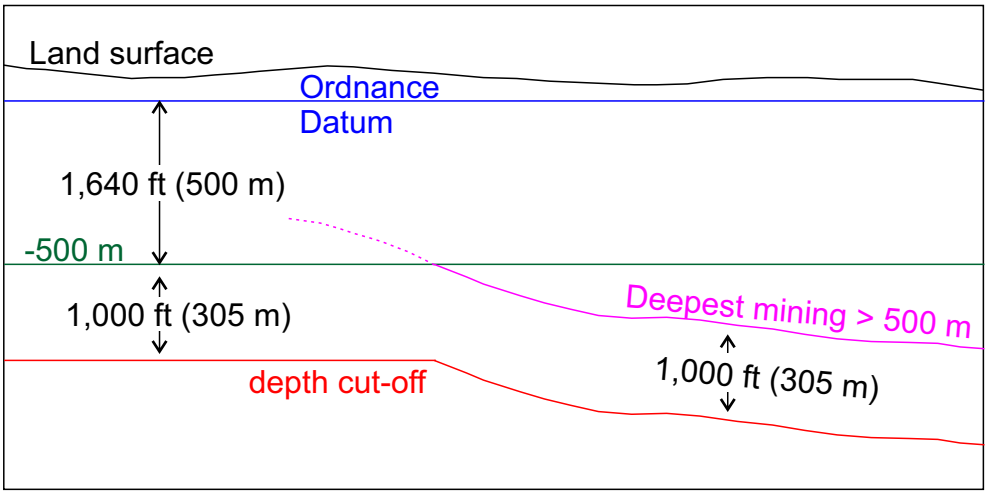


Figure 64 Sketch illustrating the depth cut-off used in the resource calculation

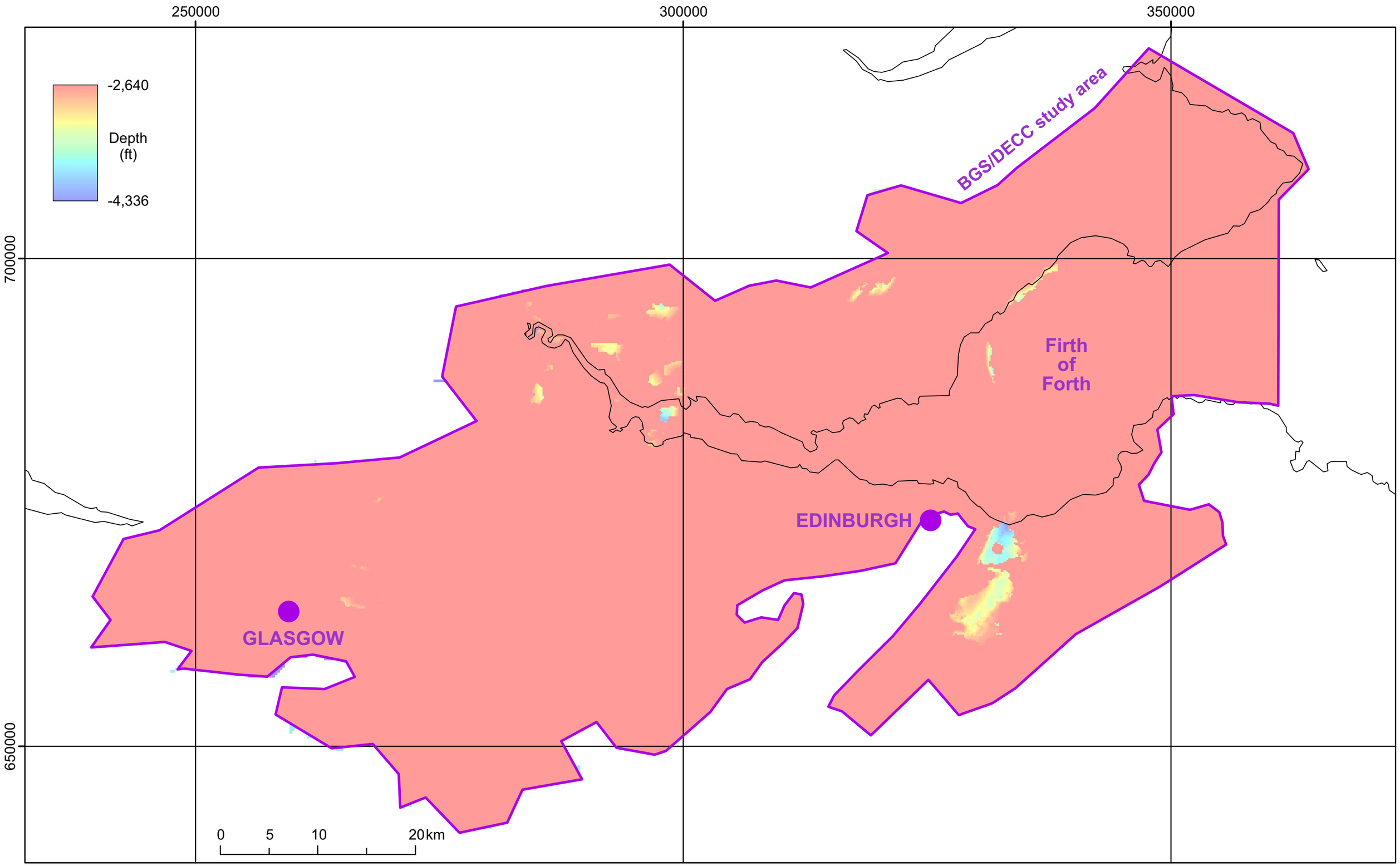
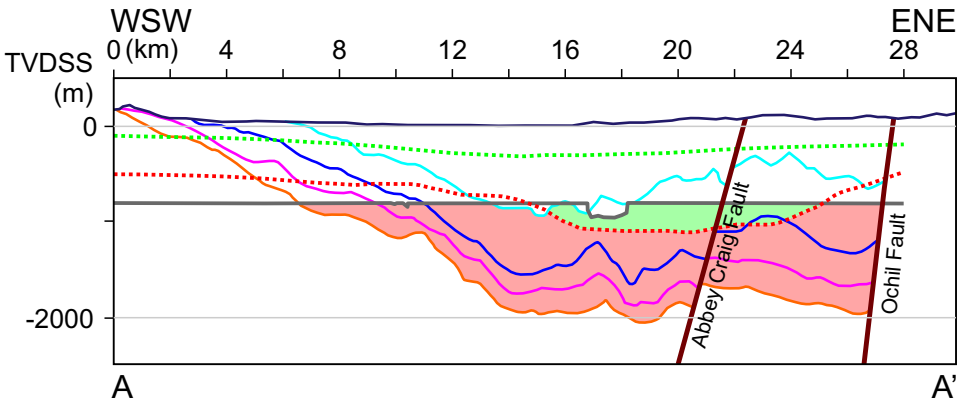
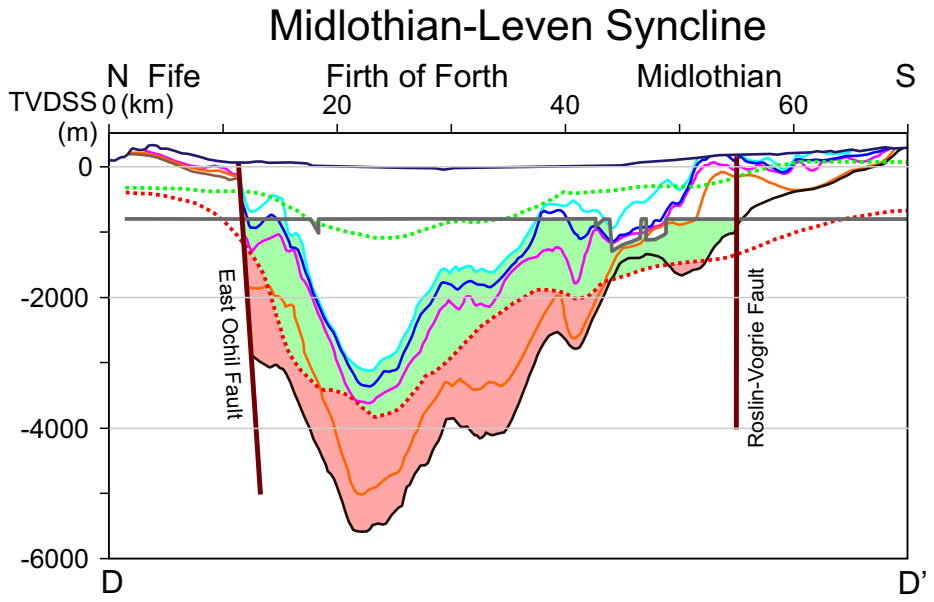
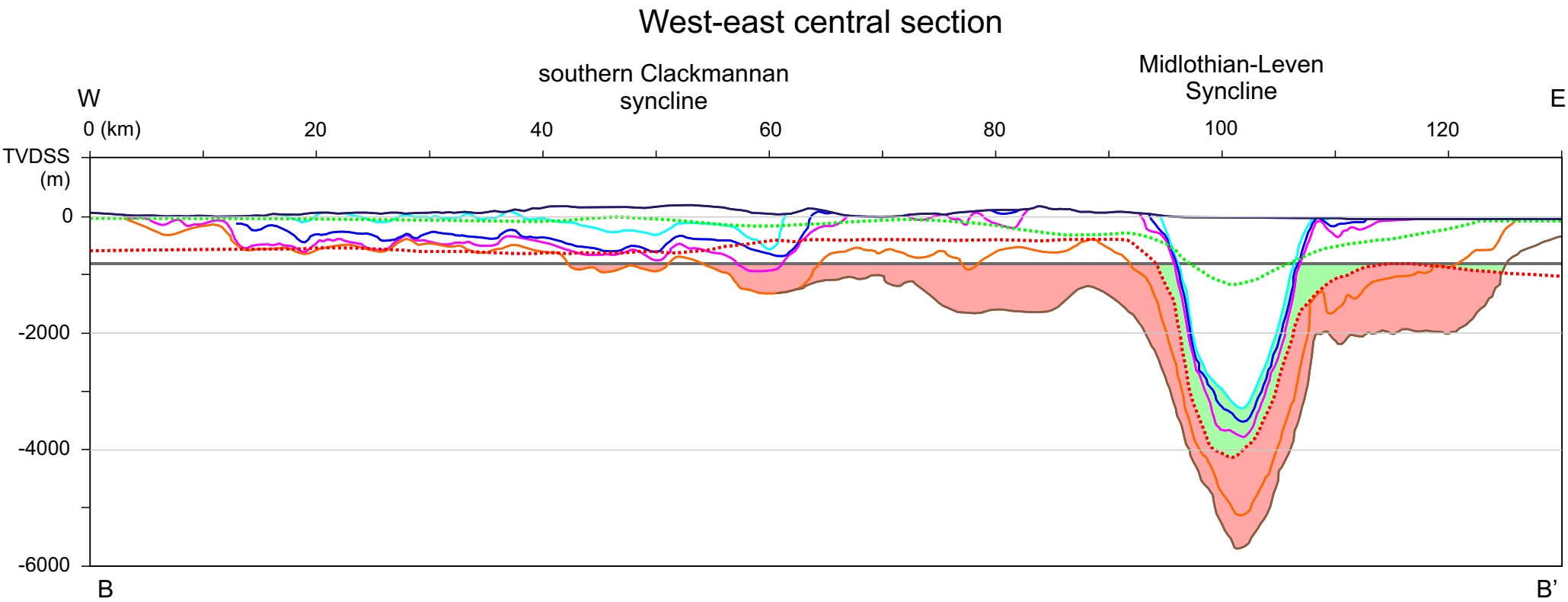
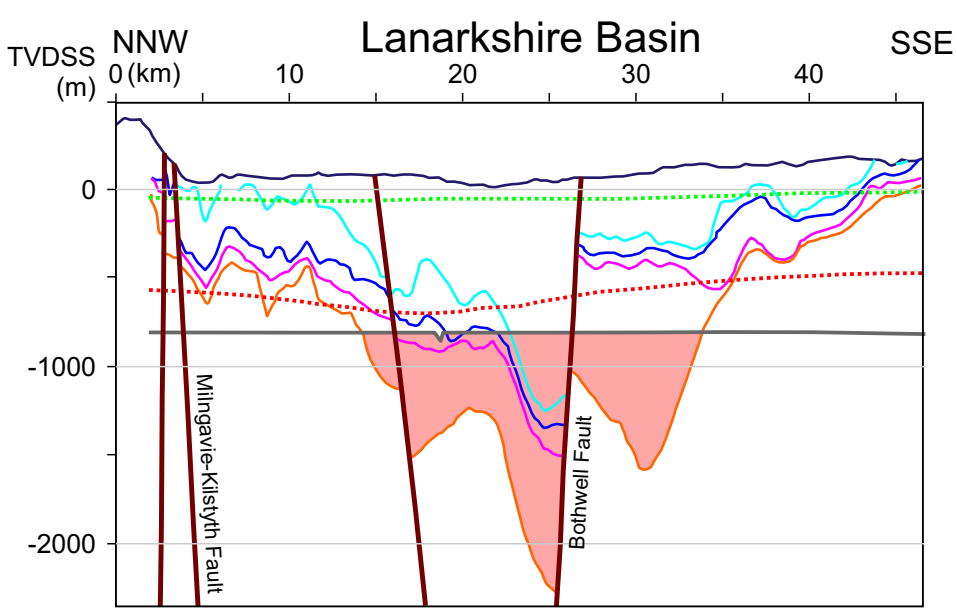


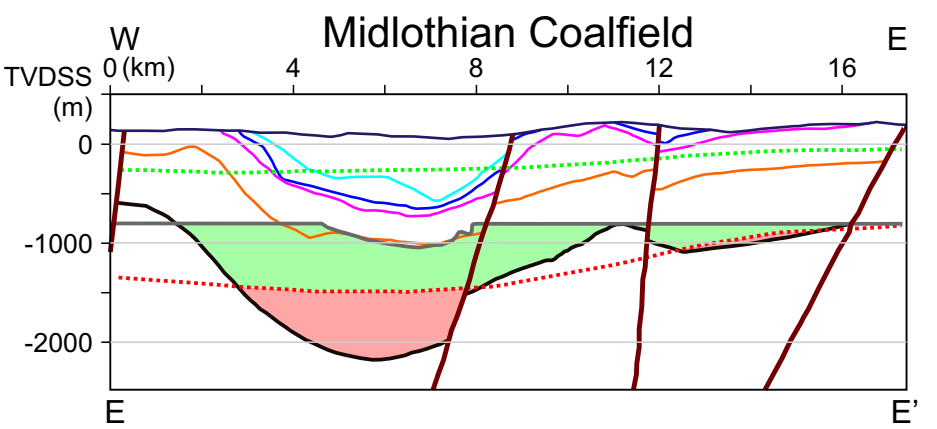
Figure 65 Mining-related depth cut-off map for the study area. Strata shallower than the depths shown here were not included in the best technical case resource estimation, see text for discussion. The red colour is the depth cut-off at 2,640 ft (805 m) below Ordnance Datum

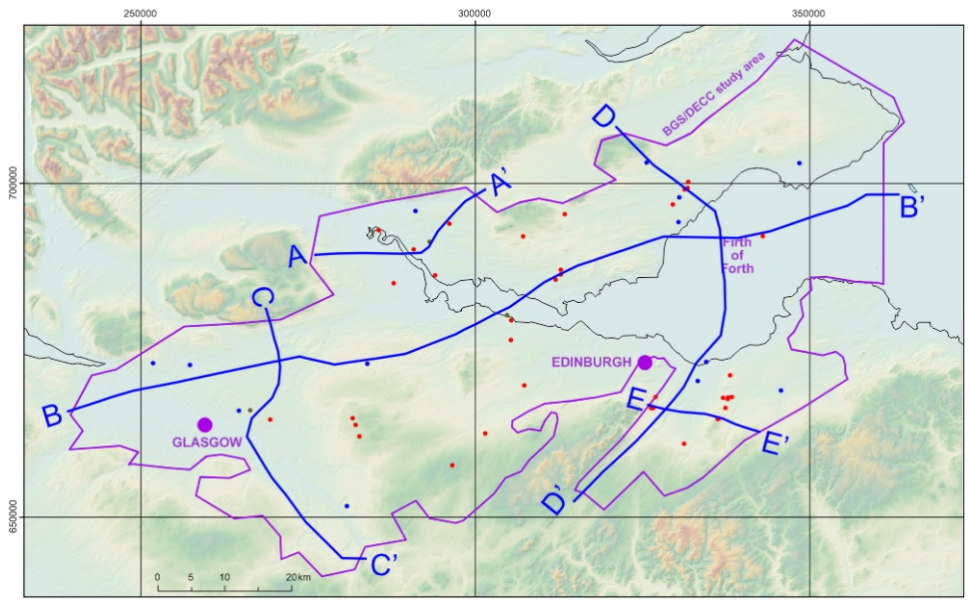












Key

- Oil-mature beneath mining-related depth cut-off
- Gas-mature beneath mining-related depth cut-off
- Land surface/sea bed
- Base Upper Limestone Fm and younger
- Base Limestone Coal Fm
- Base Lower Limestone Fm
- Base West Lothian Oil-shale unit
- Base Gullane unit
- Approximate upper limit of oil maturity
- Approximate upper limit of gas maturity
- Mining and depth cut-off
- Fault

Figure 66 Cross-sections showing maturity and mining-related depth cut- off surfaces as output from the 3D geological model. Note each cross-section has a different horizontal and vertical scale. The modelled surfaces appear irregular and with considerable relief due to the high vertical exaggeration of the section and because smaller faults have been excluded from the model

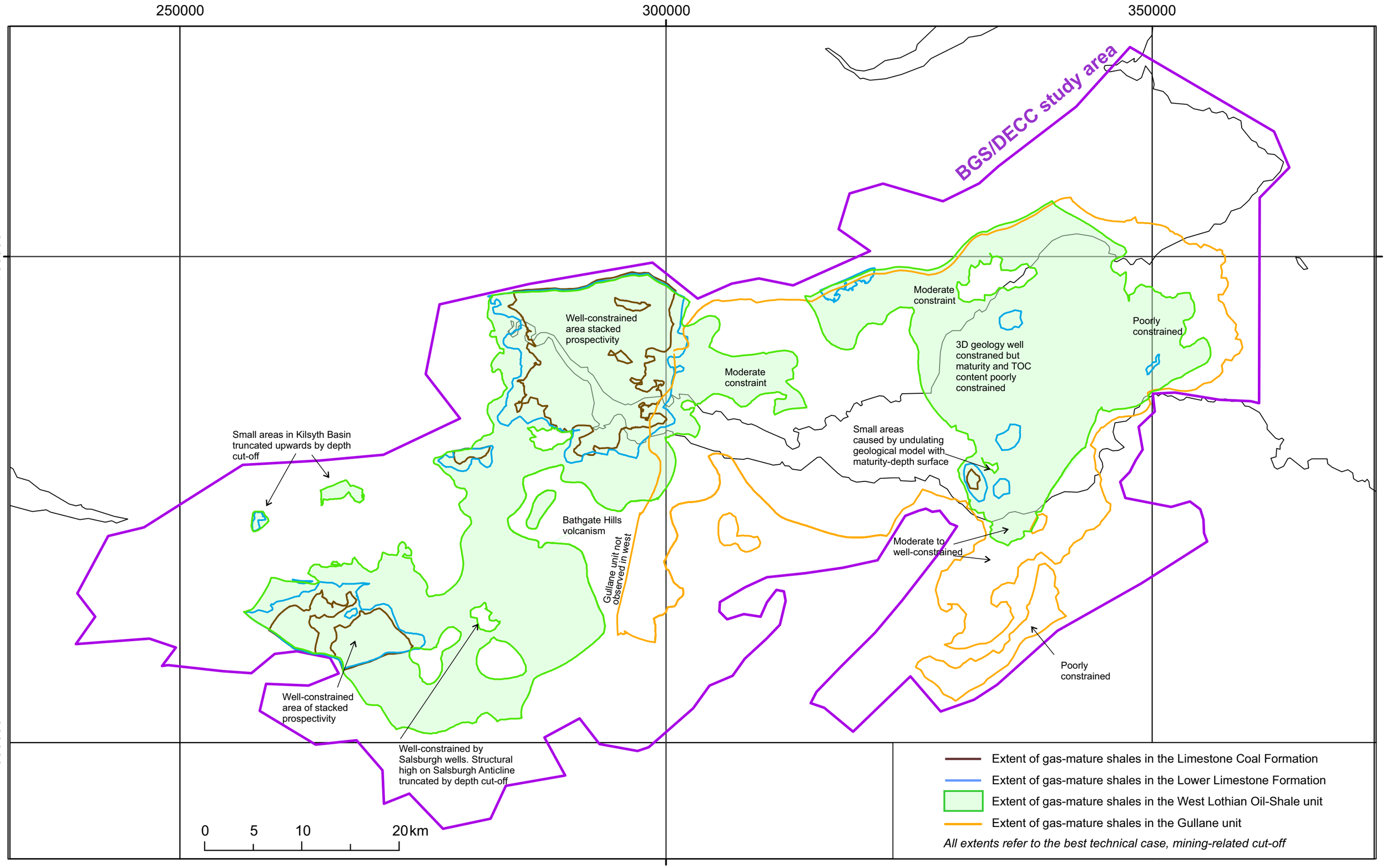


Figure 67 Summary of areas prospective for shale gas in the Limestone Coal and Lower Limestone formations, West Lothian Oil-Shale and Gullane units using the best technical case, mining-related cut-off

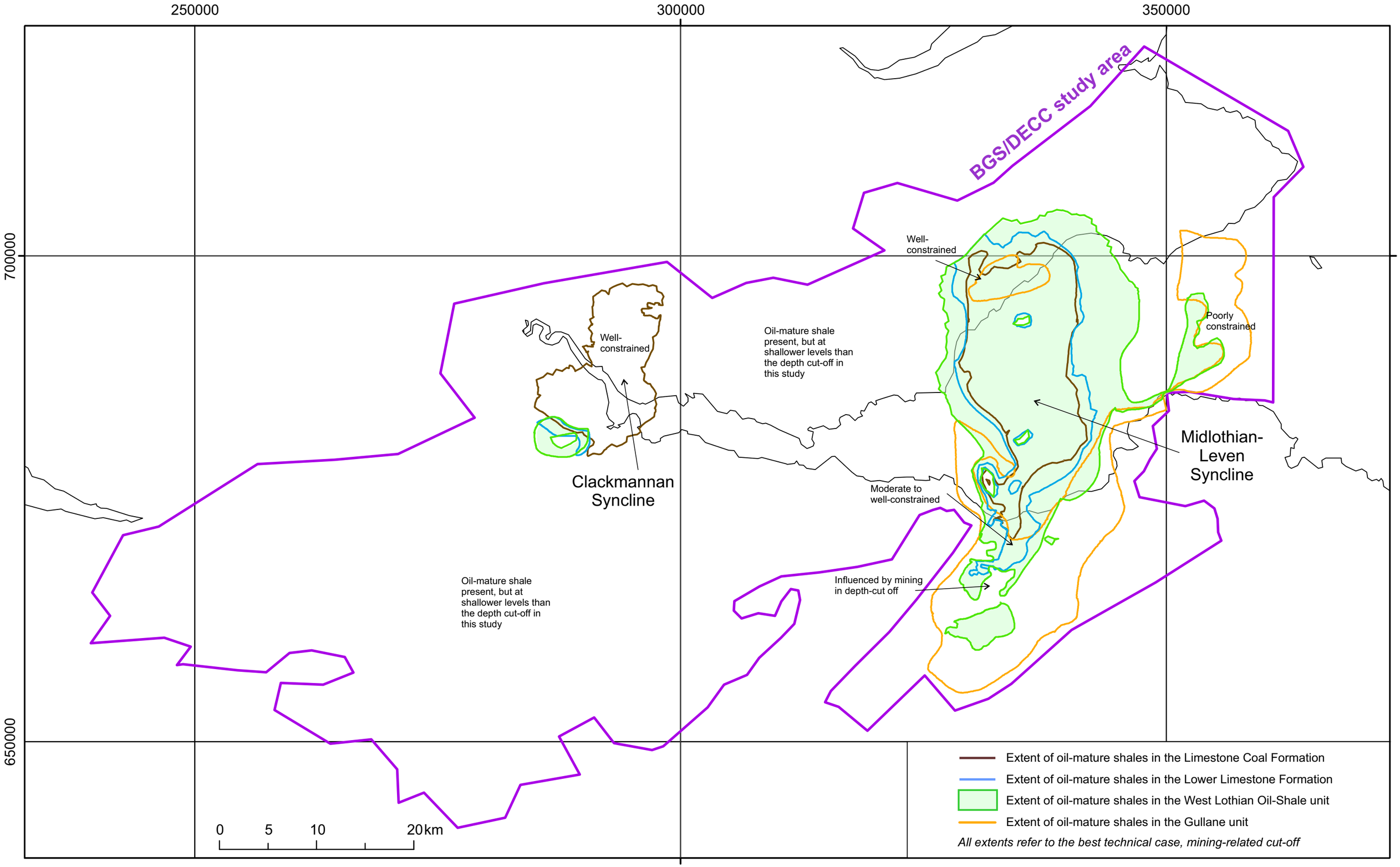
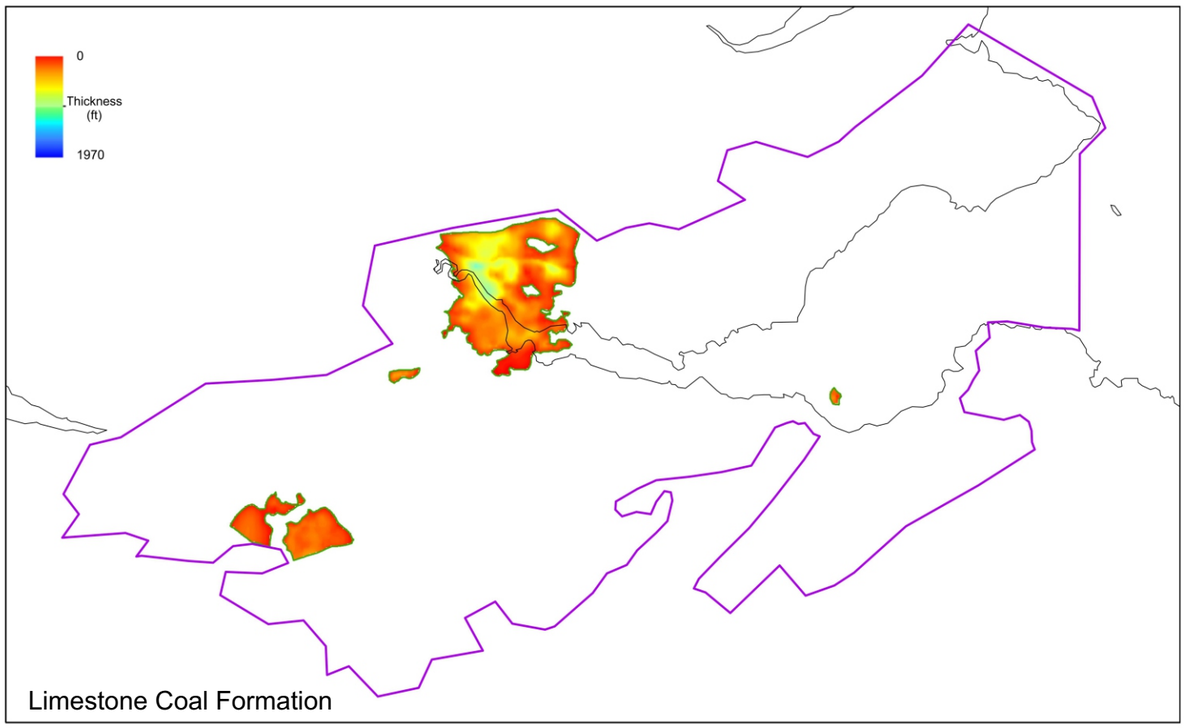
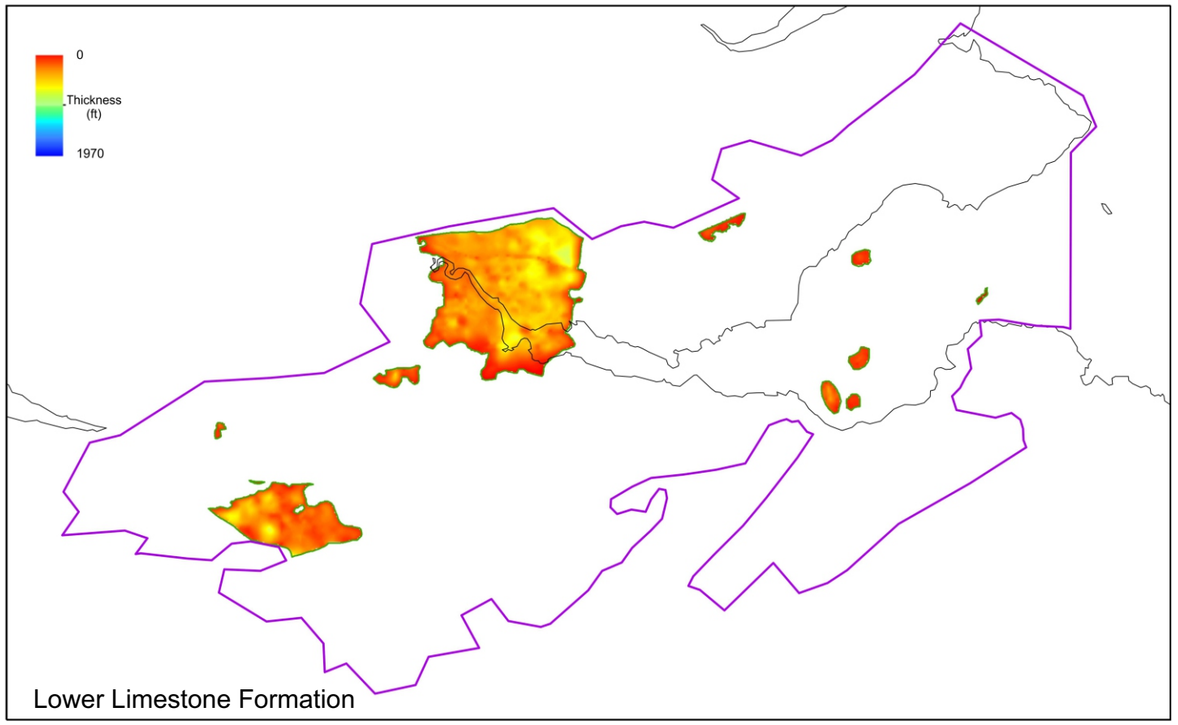
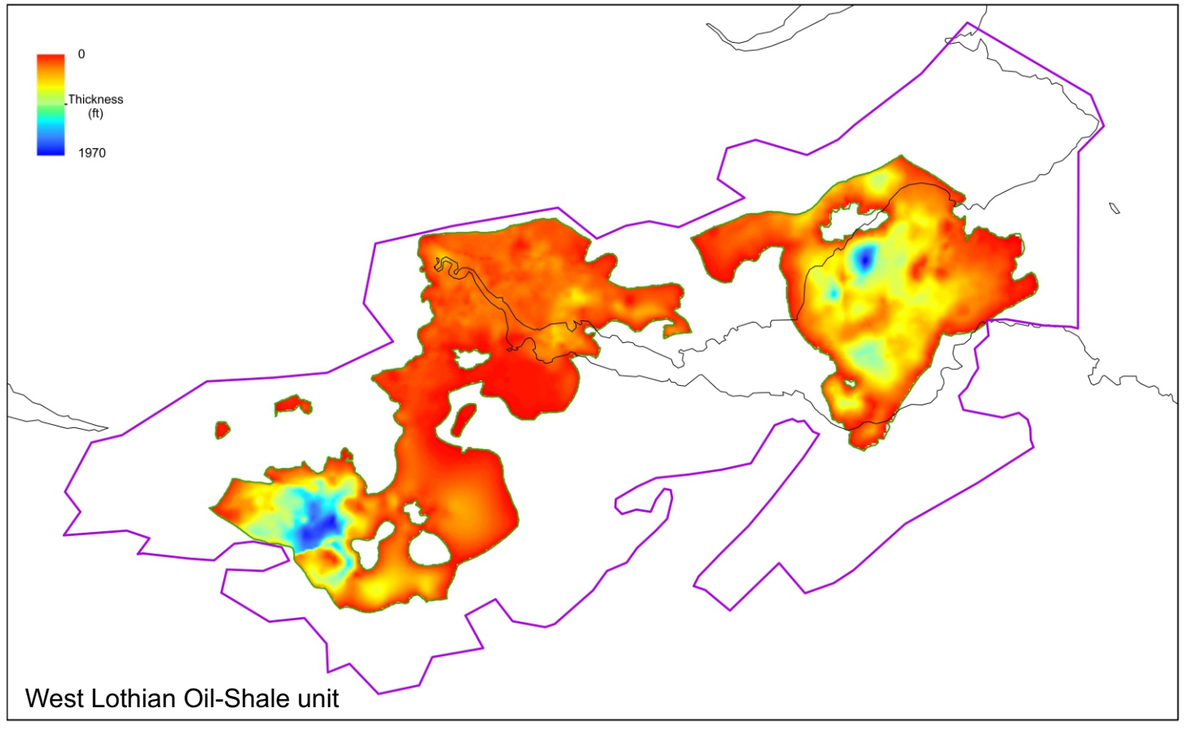


Figure 68 Summary of areas prospective for shale oil in the Limestone Coal and Lower Limestone formations, West Lothian Oil-Shale and Gullane units using the best technical case, mining-related cut-off







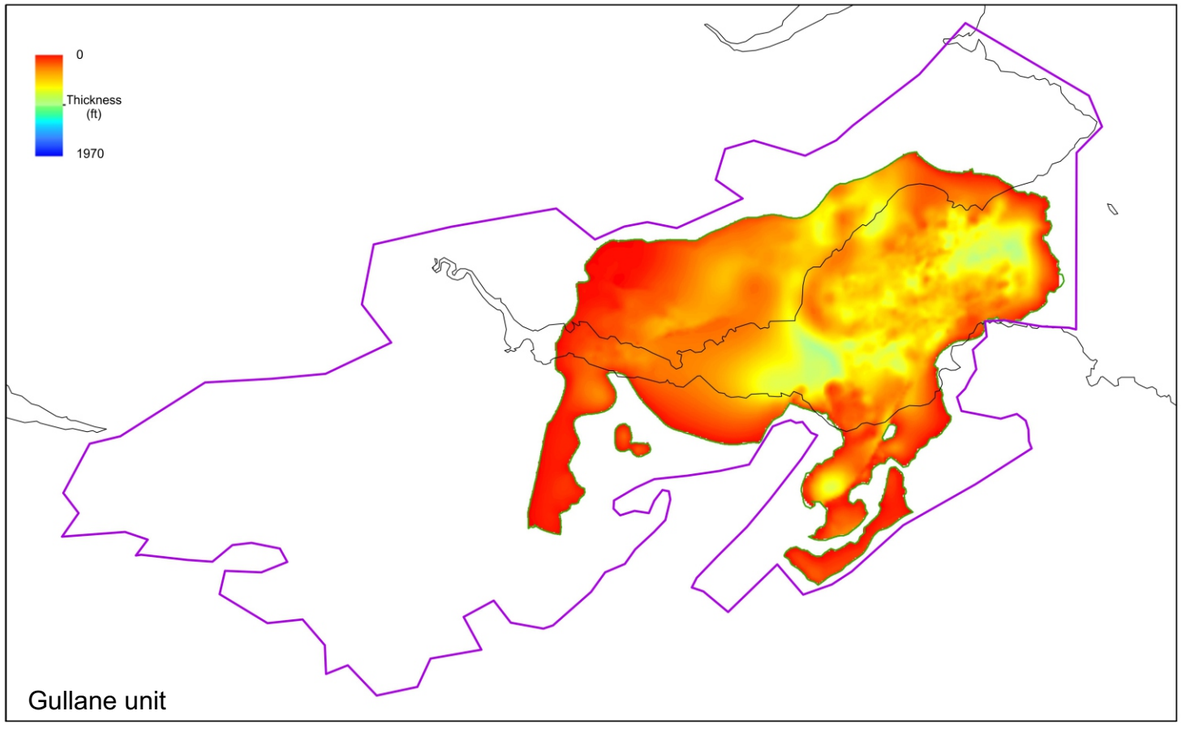
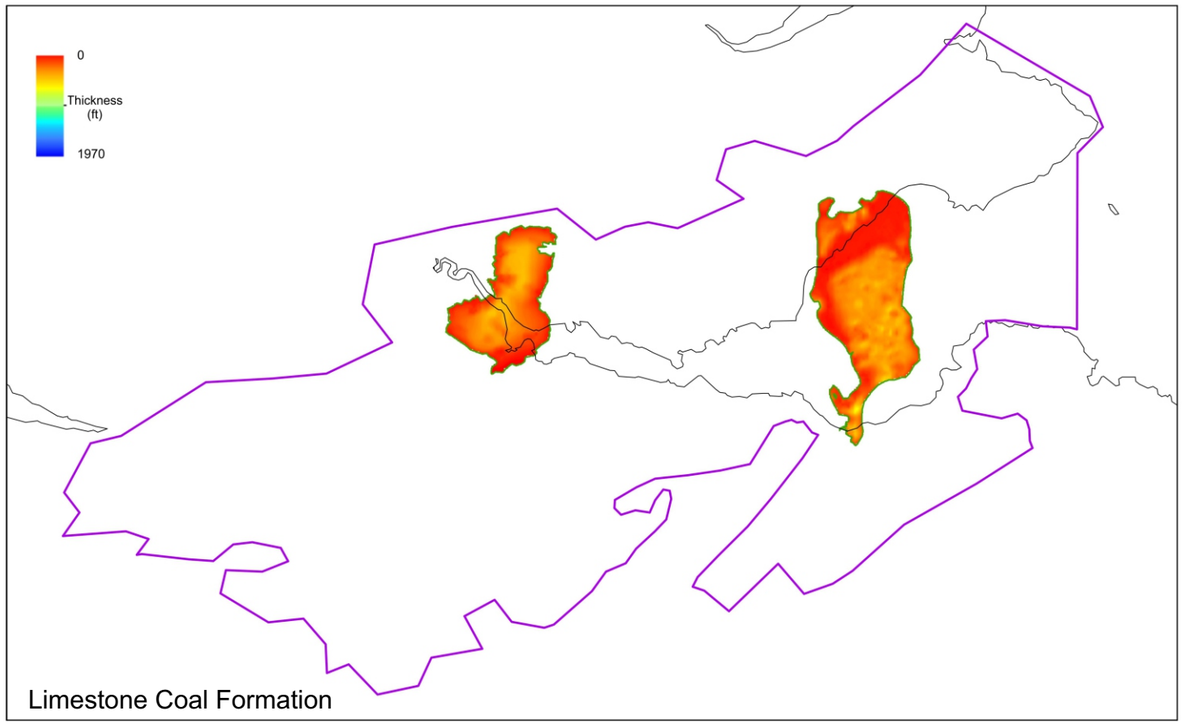
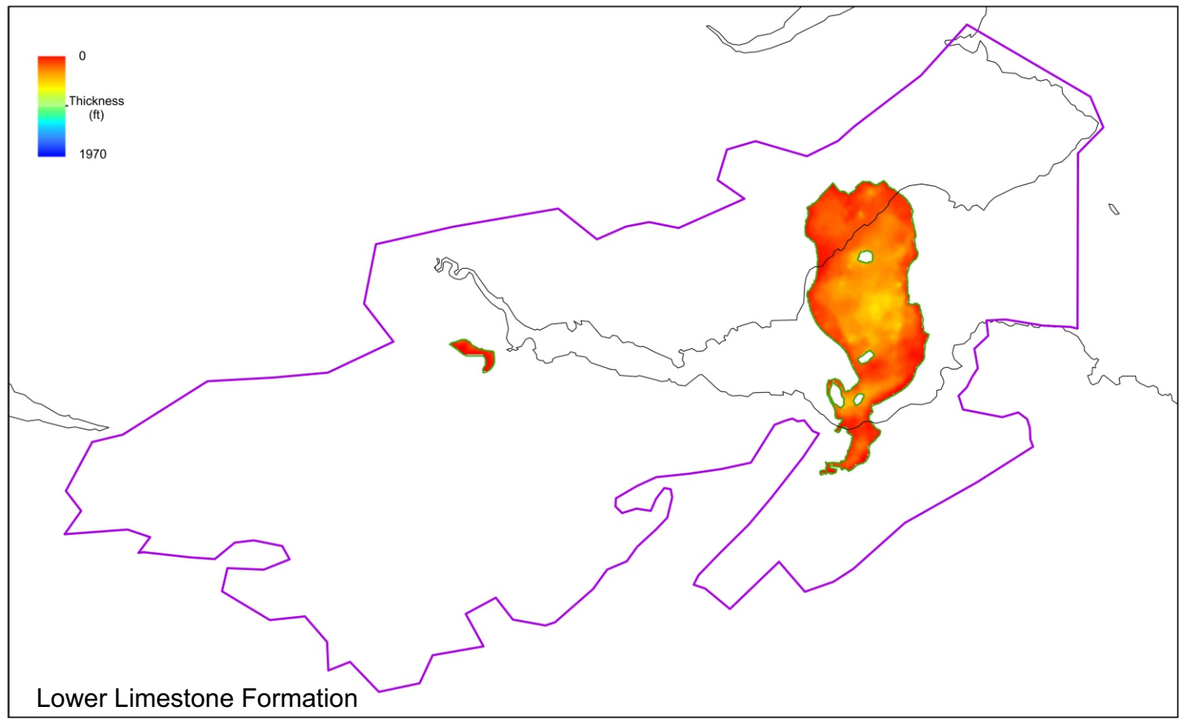
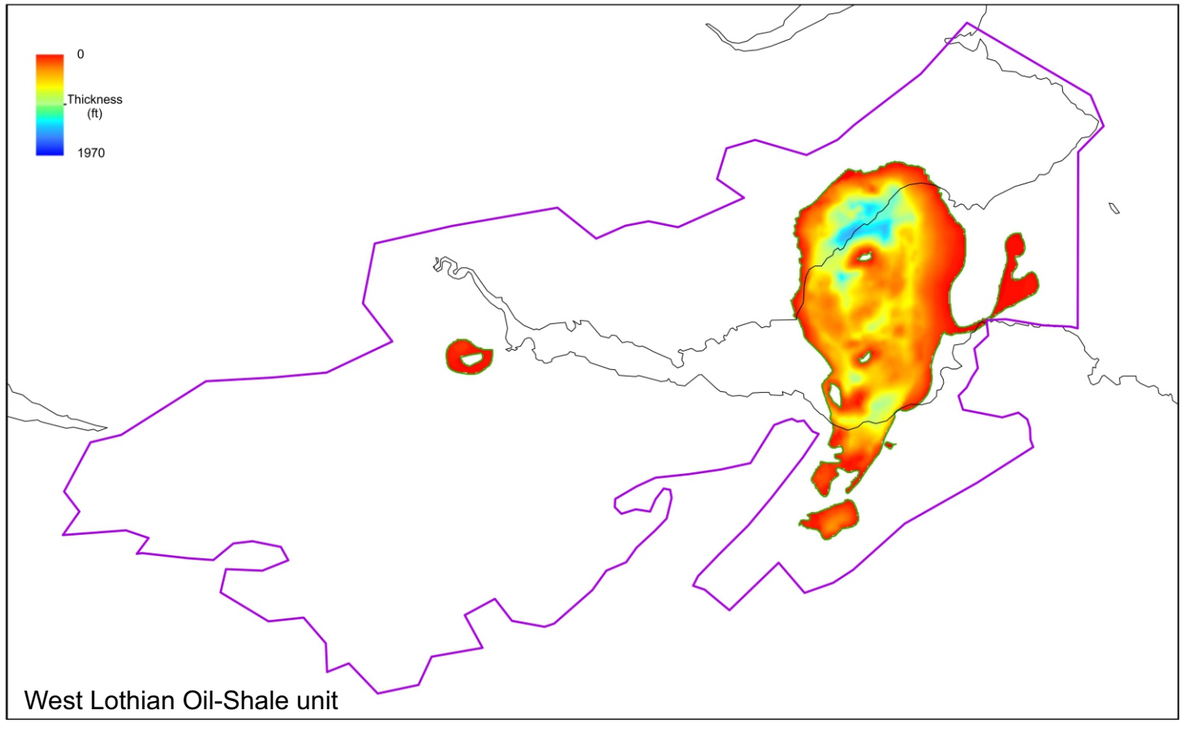


Figure 69 Net mature thickness and distribution of potential shale gas units in the Midland Valley of Scotland using the best technical case, mining-related cut-off







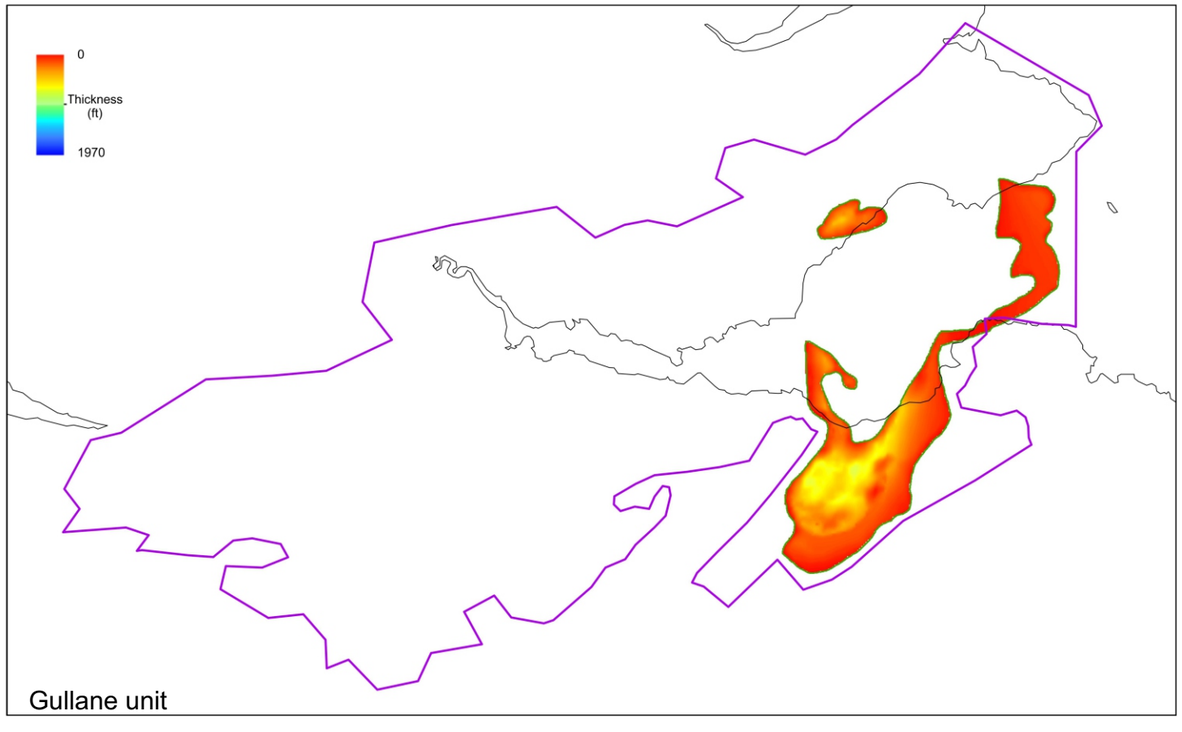


Figure 70 Net mature thickness and distribution of potential shale oil units in the Midland Valley of Scotland using the best technical case, mining-related cut-off

250000

300000

350000

700000

650000

Best technical case extent of prospective oil-mature Carboniferous shale, Midland Valley of Scotland beneath mining-related depth cut-off

Extent of prospective oil-mature Carboniferous shale, Midland Valley of Scotland in a sensitivity test using a 1,000 ft depth cut-off (holes within the extent are dotted)

BGS/DECC study area

Currently licensed acreage (June 2014)

0 5 10 20km

Figure 72 Summary of areas considered prospective for shale oil (blue) beneath a mining-related depth cut-off in the Carboniferous shales of the Midland Valley of Scotland. Study area in purple. Ordnance Survey data © Crown copyright 2014

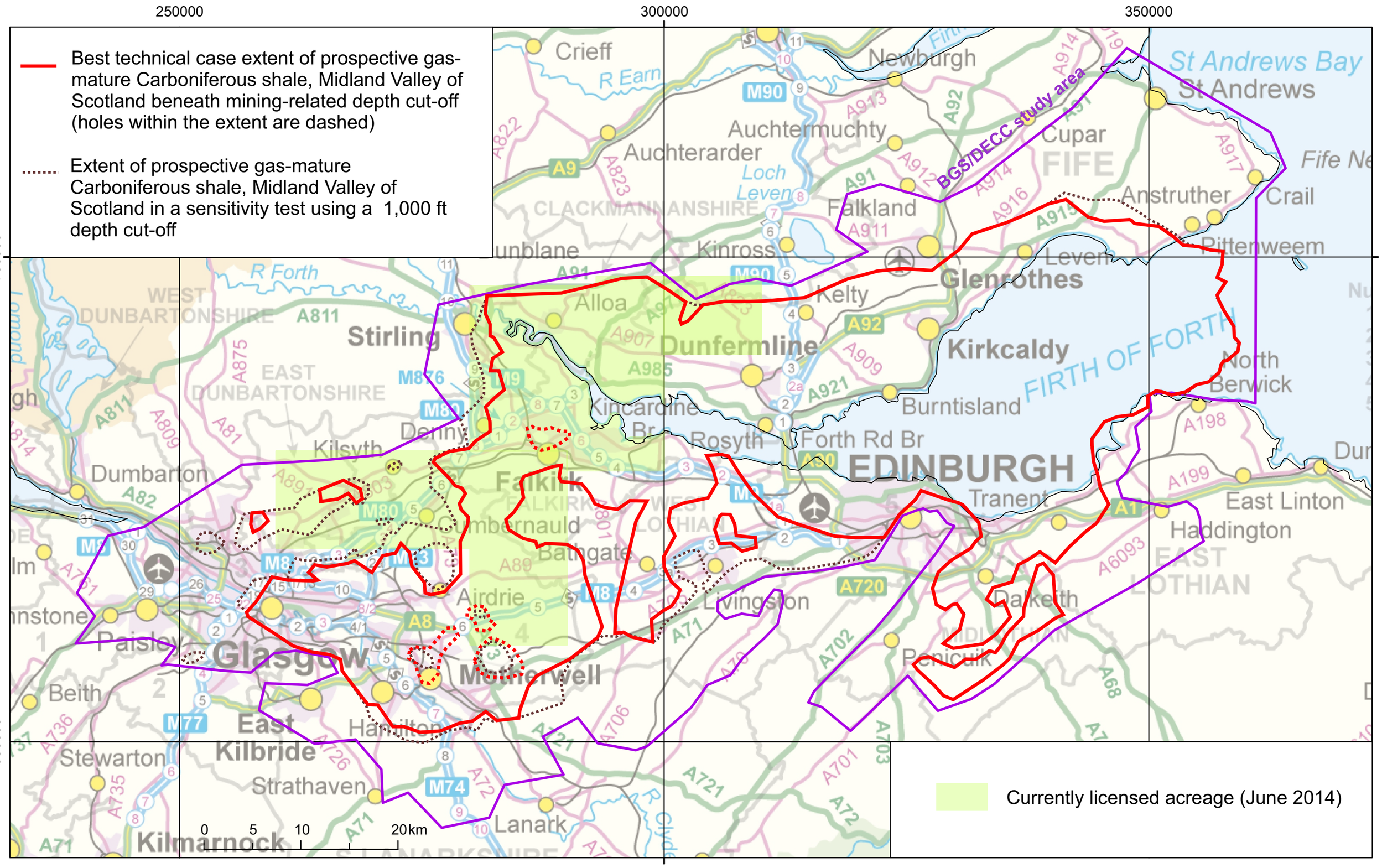


Figure 73 Summary of areas considered prospective for shale gas (red) beneath a mining-related depth cut-off in the Carboniferous shales of the Midland Valley of Scotland. Study area in purple. Ordnance Survey data © Crown copyright 2014