A Gravity Collapse Origin for the Hampshire Basin, U.K.*

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Abstract

The Hampshire Basin is a topographic depression in southern England, some 3500 km^2 in area. It extends about 140 km from west to east and up to 40 km from north to south. Geologically it is a half-graben, with normal faulting along its north edge, and the Purbeck monocline forming a hangingwall rollover fold along the south edge. Starting in the 19th century, the structural history of the region had been described in terms of Mid-Cretaceous rifting followed by Tertiary (Alpine) compression. The 1973 discovery of the Wytch Farm oilfield in Mesozoic sediments provided well and seismic data leading to a new model for the evolution of the area through the mechanism of inversion tectonics. That model postulated Cretaceous rifting with normal faults that became inverted during the Tertiary to form supposedly Alpine-related folds, reverse, and thrust faults.

Our study supports neither the original interpretation nor the inversion tectonic model. There is no evidence for compressive folding and repetition in the shallow basin section nor evidence that Cretaceous normal faults in the deeper reservoir section became reactivated and inverted in the Tertiary to form “Alpine” compressional structures in the shallow section. Instead, we propose that the present-day structure is a result of large-scale sub-horizontal southward movements along blind bedding-plane detachments in overpressured and mobile Upper Cretaceous and Jurassic clays and Triassic salt, with emphasis, on the vital role of the Upper Cretaceous Gault Clay as a lubricant for large-scale bedding-plane slippage. This mechanism is consistent with a structural model of Miocene or later extension, driven by southward gravity collapse along blind detachment faults, a process proved through marine seismic profiles of huge scale gravity collapse structures along the continental margins of the equatorial Atlantic Ocean.

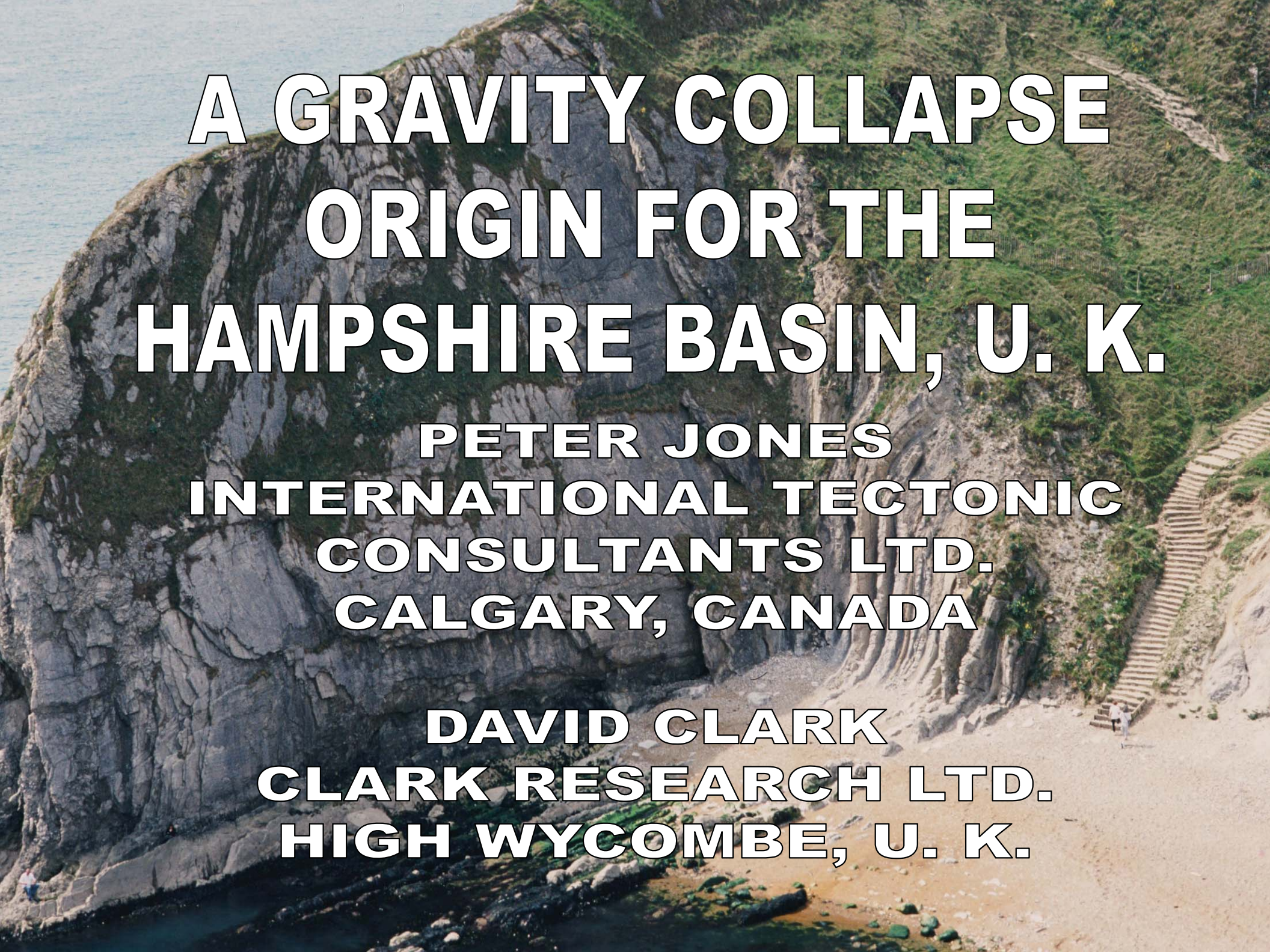
Removal of “Alpine” deformation implicit in older versions of the structural evolution of the Hampshire basin suggests that its development can be related to the catastrophic opening of the English Channel, some 450,000 years ago. The conclusions of this study radically alter earlier views of the Wytch Farm and regional petroleum system, suggesting the need for detailed review of burial history, hydrocarbon maturation, and migration, leading to renewed exploration.

Selected References

Brunsden, D. and T. Badman (editors), 2003, The Official Guide to the Jurassic Coast: Dorset and East Devon’s World Heritage Coast: A Walk through Time: Coastal Publications, Wareham, Dorset, England, 64 p.

Ridd, M.F., 1973, The Sutton Poyntz, Poxwell and Chaldon Herring anticlines, Southern England; A Reinterpretation: Proceedings of The Geologists' Association (London), v. 1/1, p. 1-8.

Wernicke, Brian and B.C. Burchfiel, 1982, Modes of extensional tectonics: Journal of Structural Geology, v. 4/2, p. 105-115.



A GRAVITY COLLAPSE ORIGIN FOR THE HAMPSHIRE BASIN, U. K.

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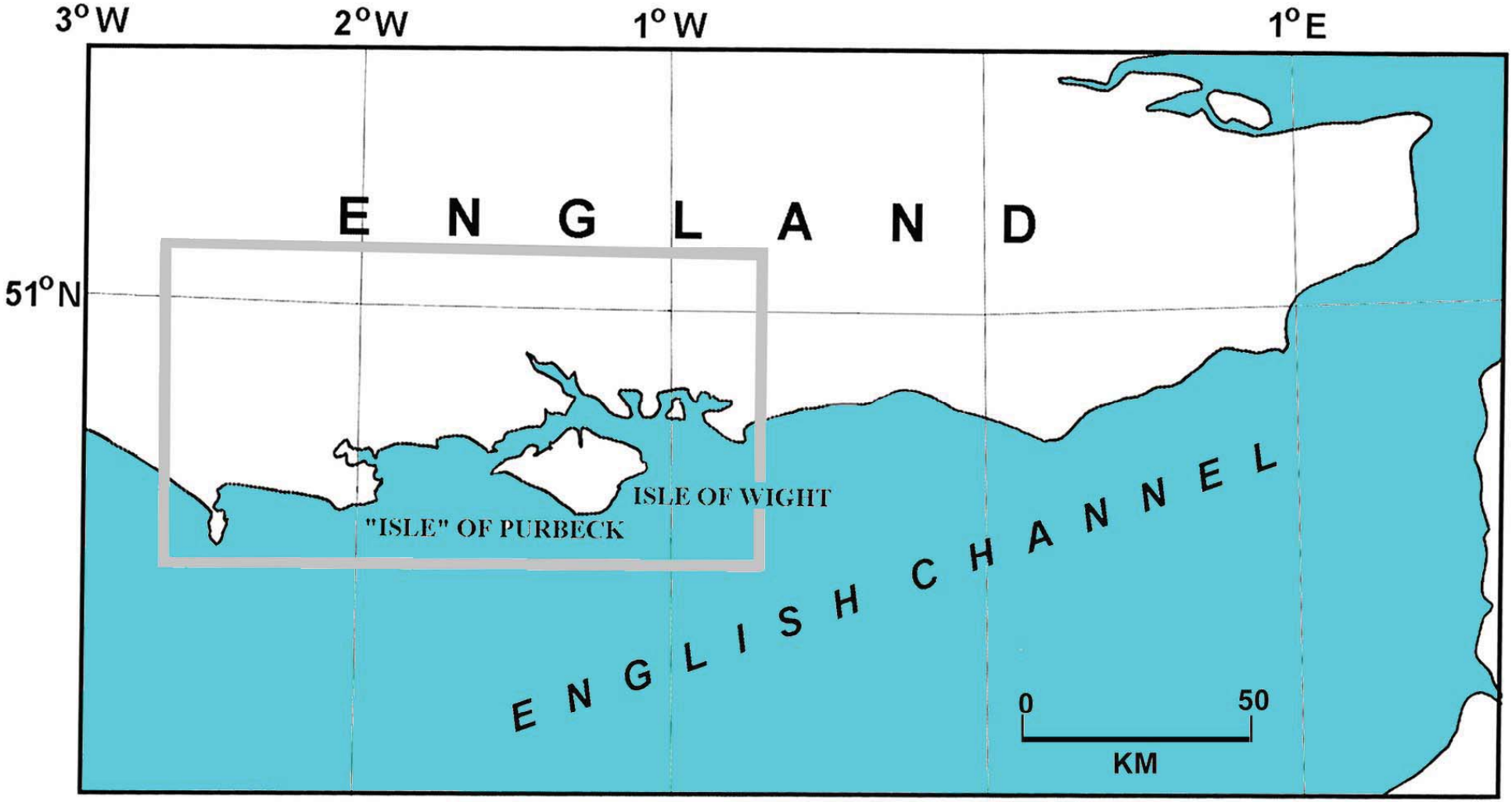
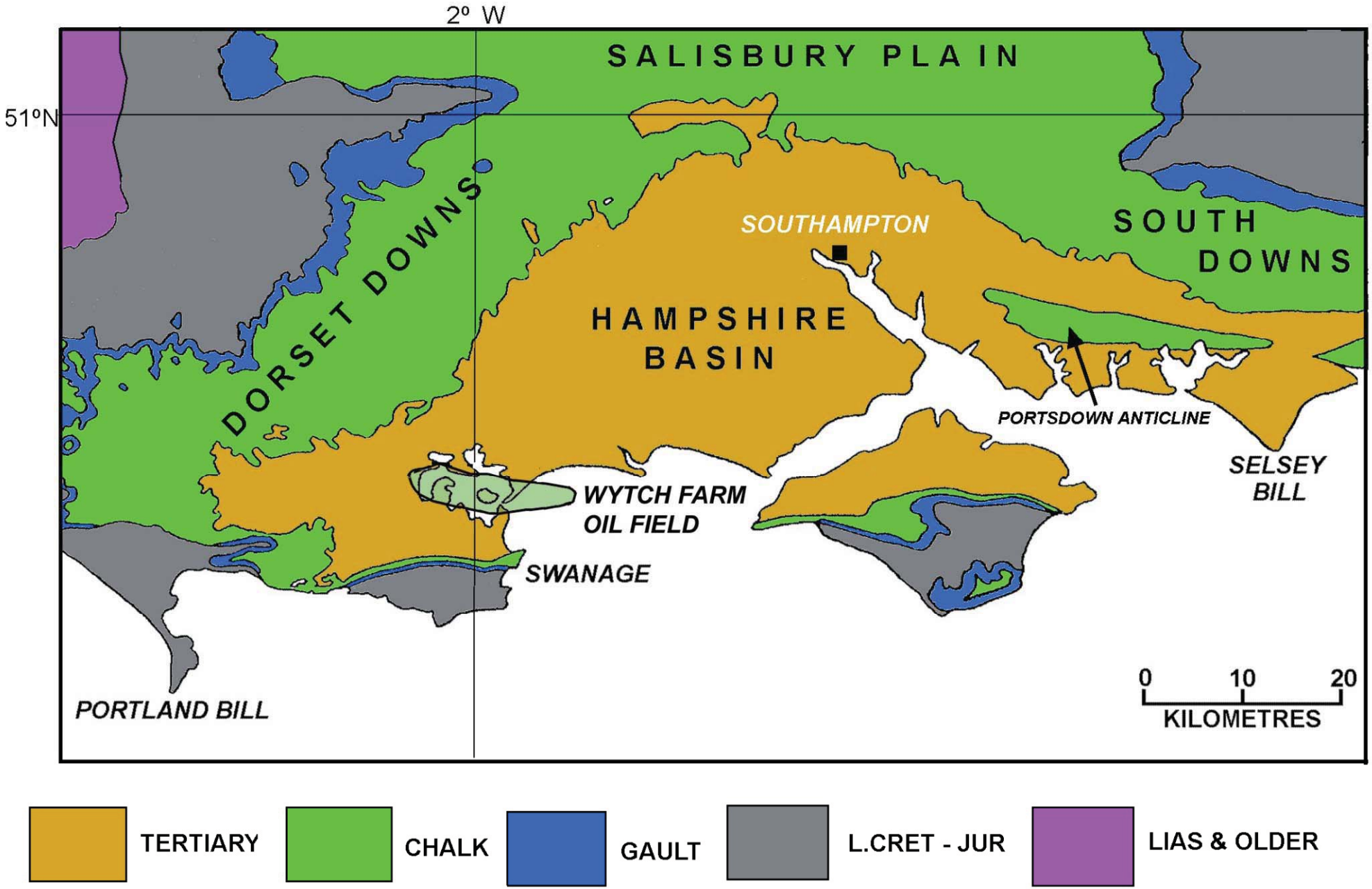
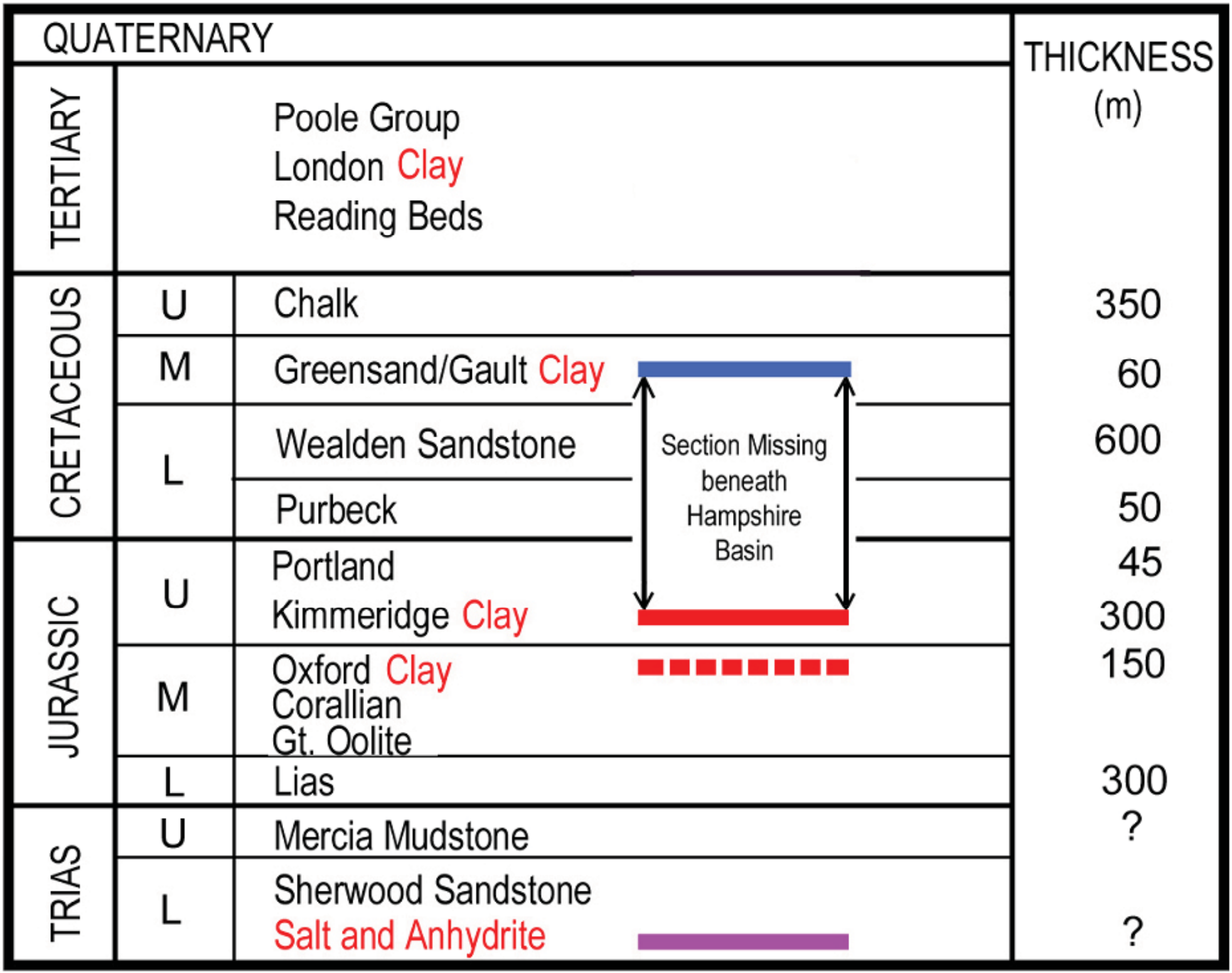
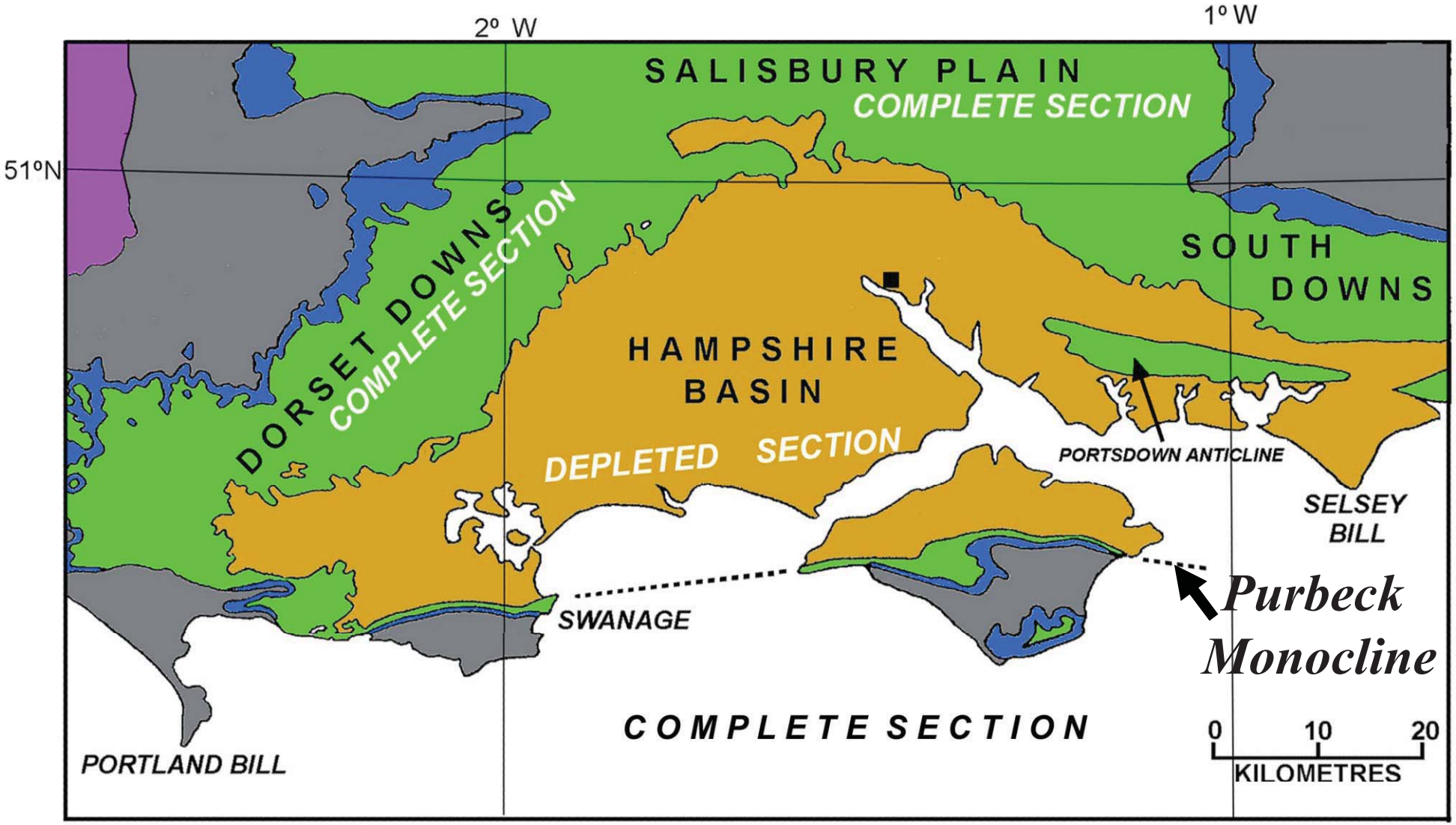

3°W
2°W
1°W
1°E
51°N
ENGLAND
ISLE OF WIGHT
"ISLE" OF PURBECK
ENGLISH CHANNEL
0
50
KM

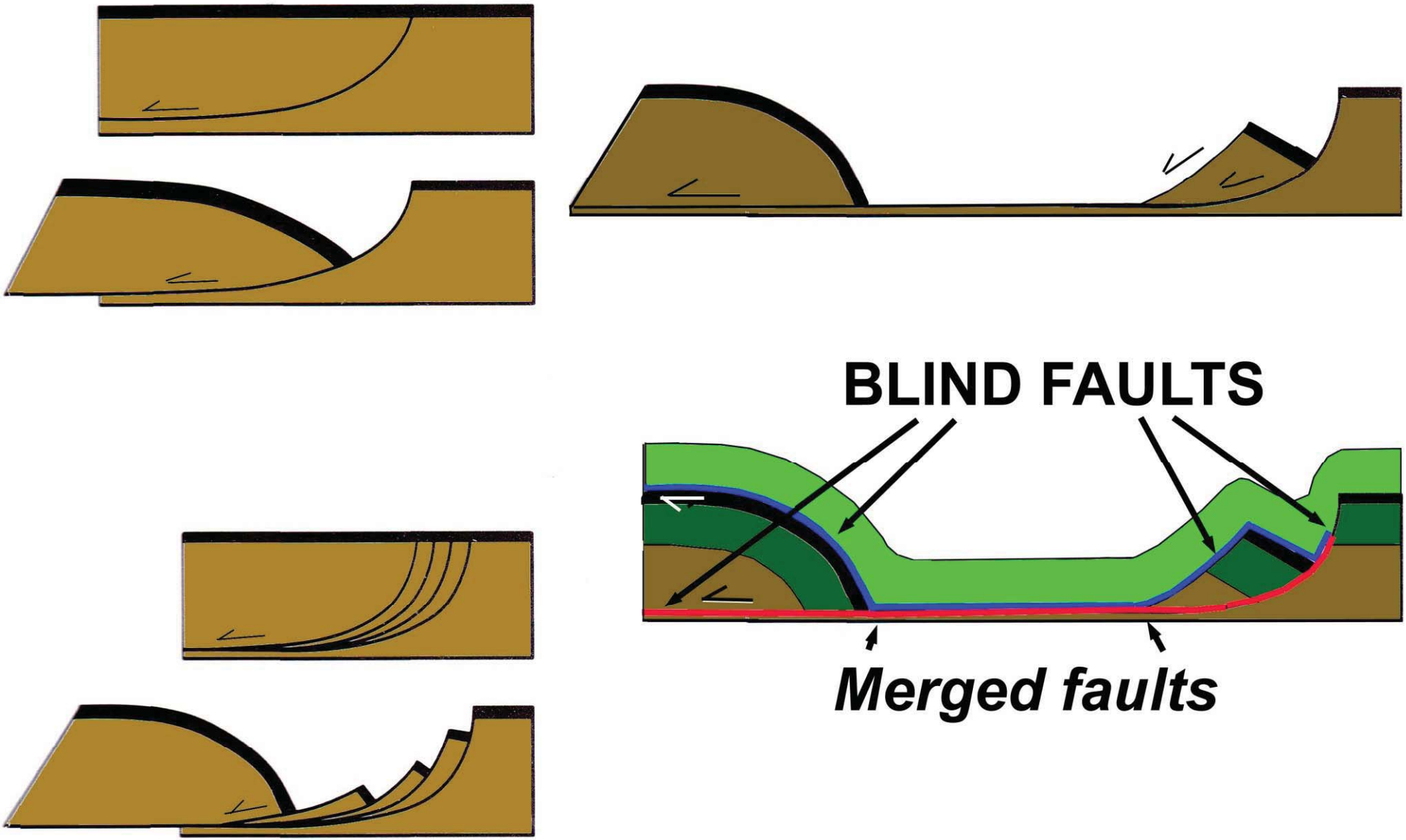

2º W
51ºN
SALISBURY PLAIN
DORSET DOWNS
SOUTHAMPTON
SOUTH DOWNS
HAMPSHIRE BASIN
PORTSDOWN ANTICLINE
SELSEY BILL
WYTCH FARM OIL FIELD
SWANAGE
PORTLAND BILL
0 10 20
KILOMETRES
TERTIARY
CHALK
GAULT
L.CRET - JUR
LIAS & OLDER

Our talk describes a conflict between history and geometry

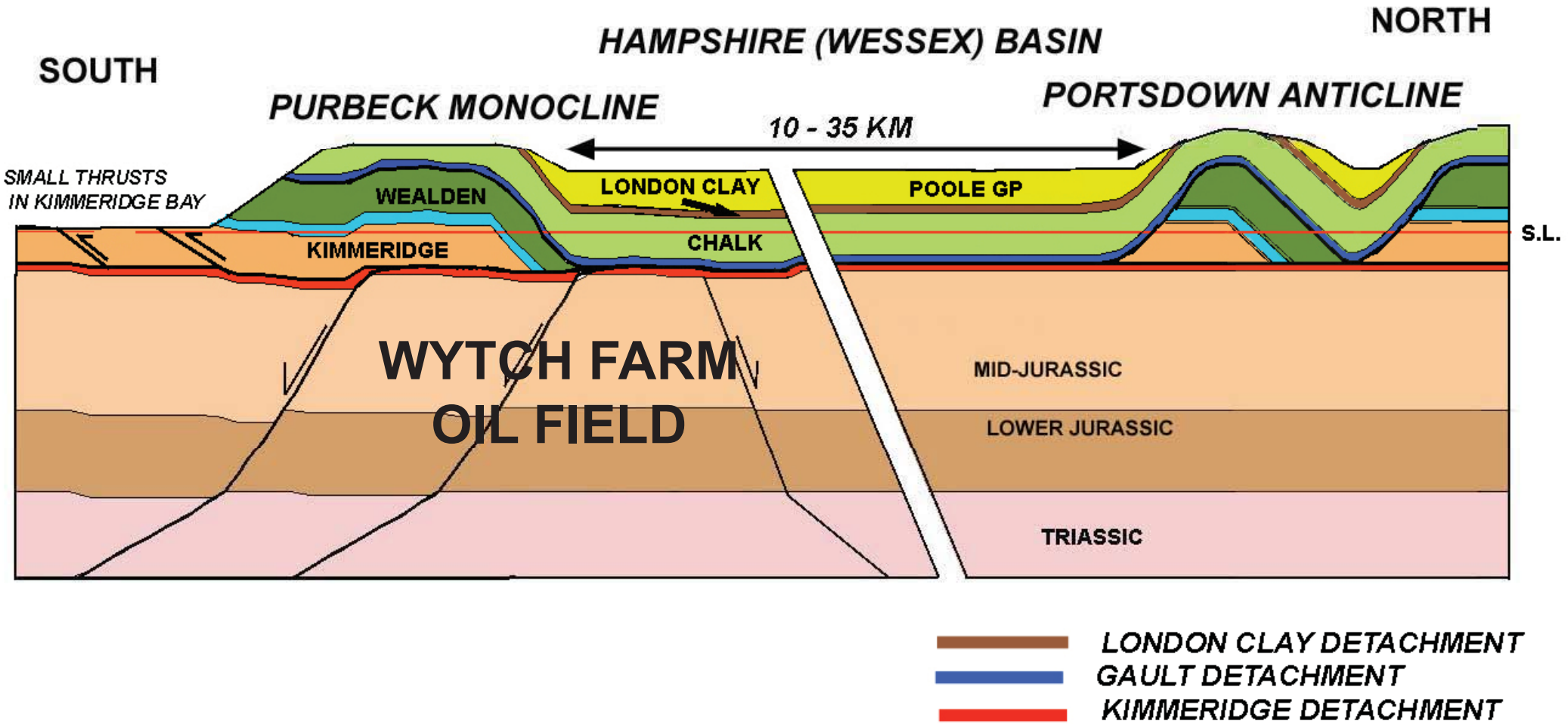

QUATERNARY
THICKNESS (m)
TERTIARY
Poole Group
London Clay
Reading Beds
CRETACEOUS
U
Chalk
350
M
Greensand/Gault Clay
60
L
Wealden Sandstone
600
Purbeck
50
Section Missing beneath Hampshire Basin
JURASSIC
U
Portland
45
Kimmeridge Clay
300
M
Oxford Clay
150
Corallian
Gt. Oolite
L
Lias
300
TRIAS
U
Mercia Mudstone
?
L
Sherwood Sandstone
Salt and Anhydrite
?

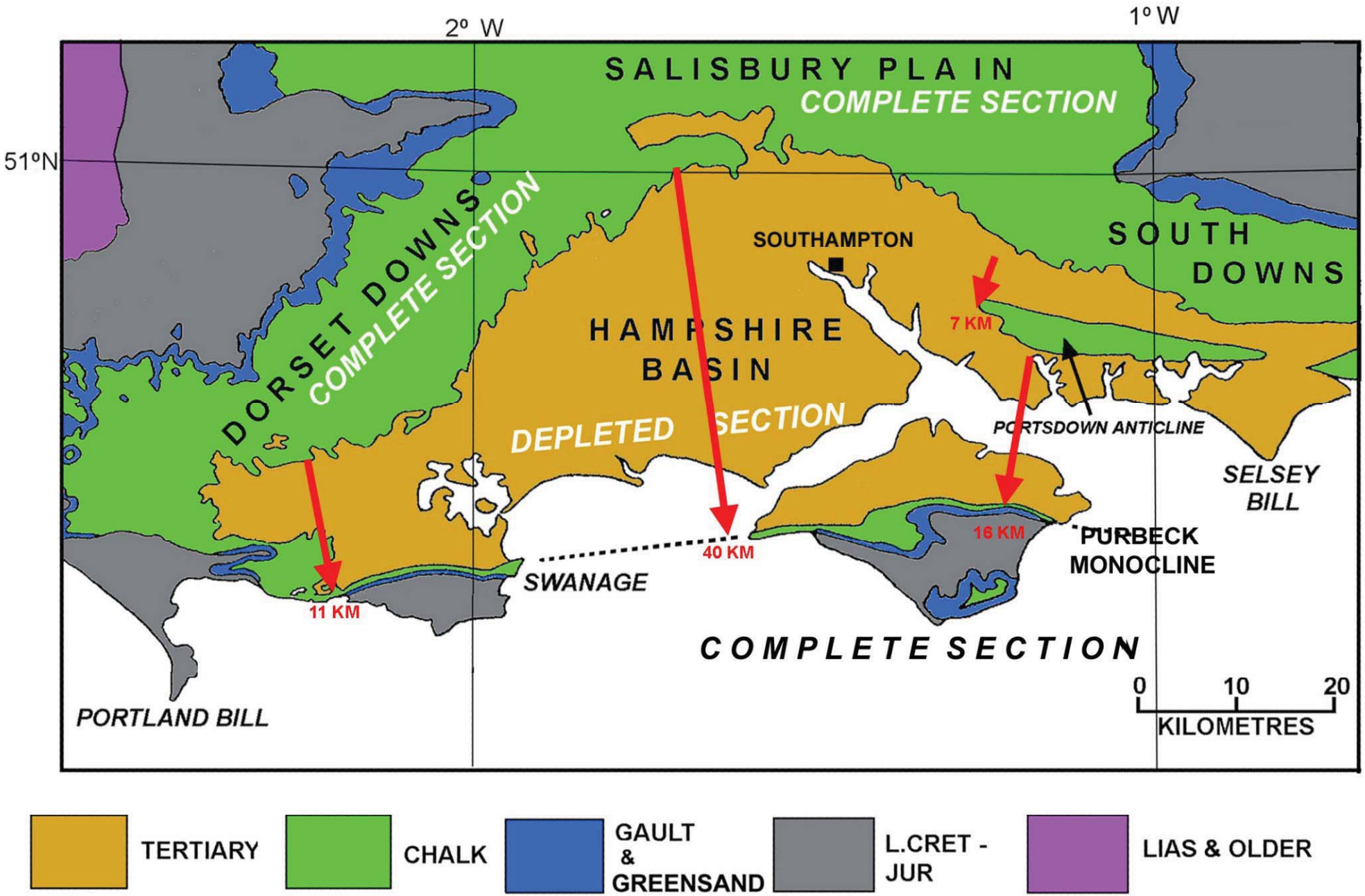


Hamp basin, classic localities, Jan 2008.jpg

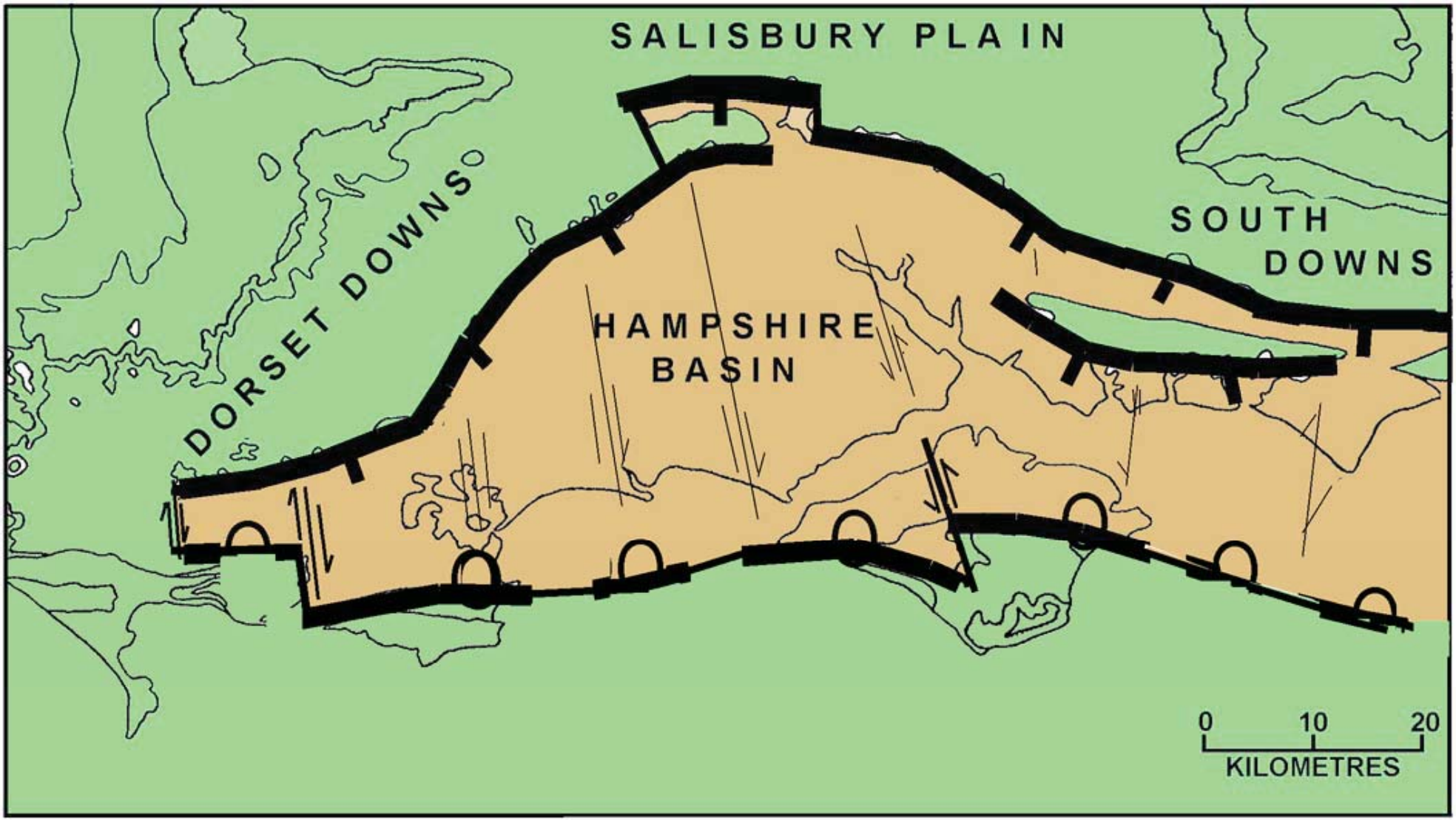


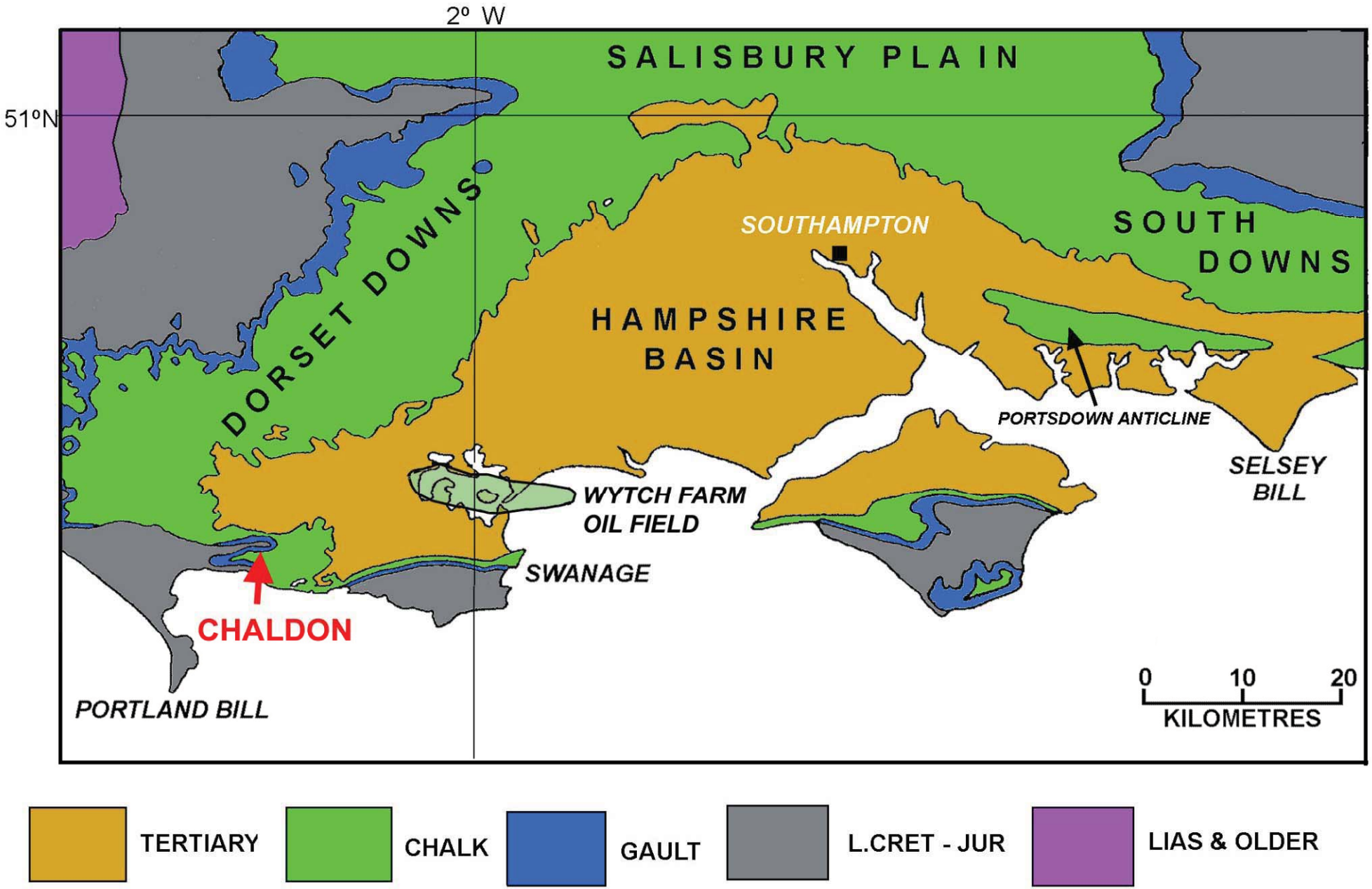
Modified from Wernicke & Burchfiel, 1982

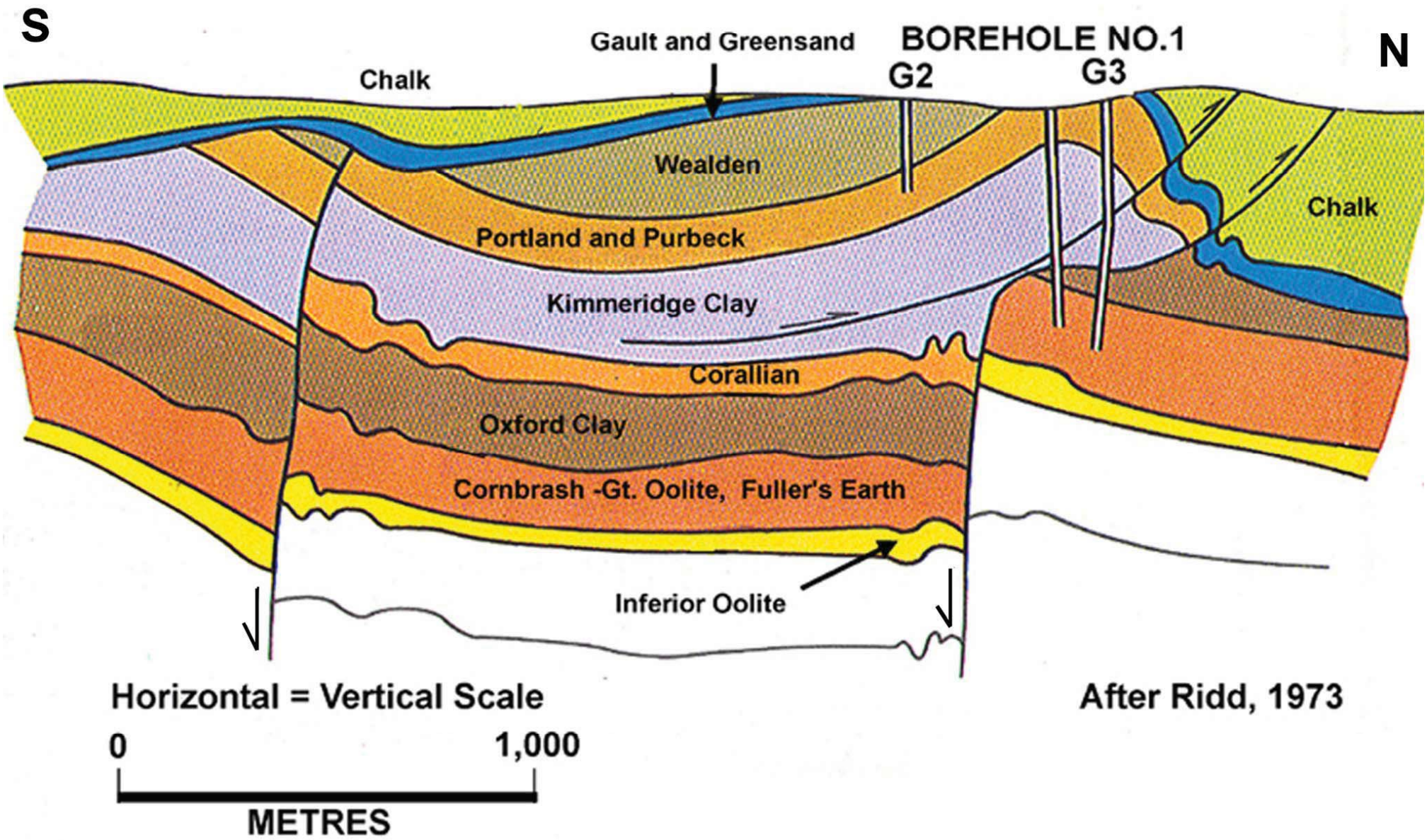

SOUTH
HAMPSHIRE (WESSEX) BASIN
NORTH
PURBECK MONOCLINE
PORTSDOWN ANTICLINE
10 - 35 KM
SMALL THRUSTS
IN KIMMERIDGE BAY
WEALDEN
KIMMERIDGE
LONDON CLAY
CHALK
POOLE GP
S.L.
WYTCH FARM
OIL FIELD
MID-JURASSIC
LOWER JURASSIC
TRIASSIC
LONDON CLAY DETACHMENT
GAULT DETACHMENT
KIMMERIDGE DETACHMENT

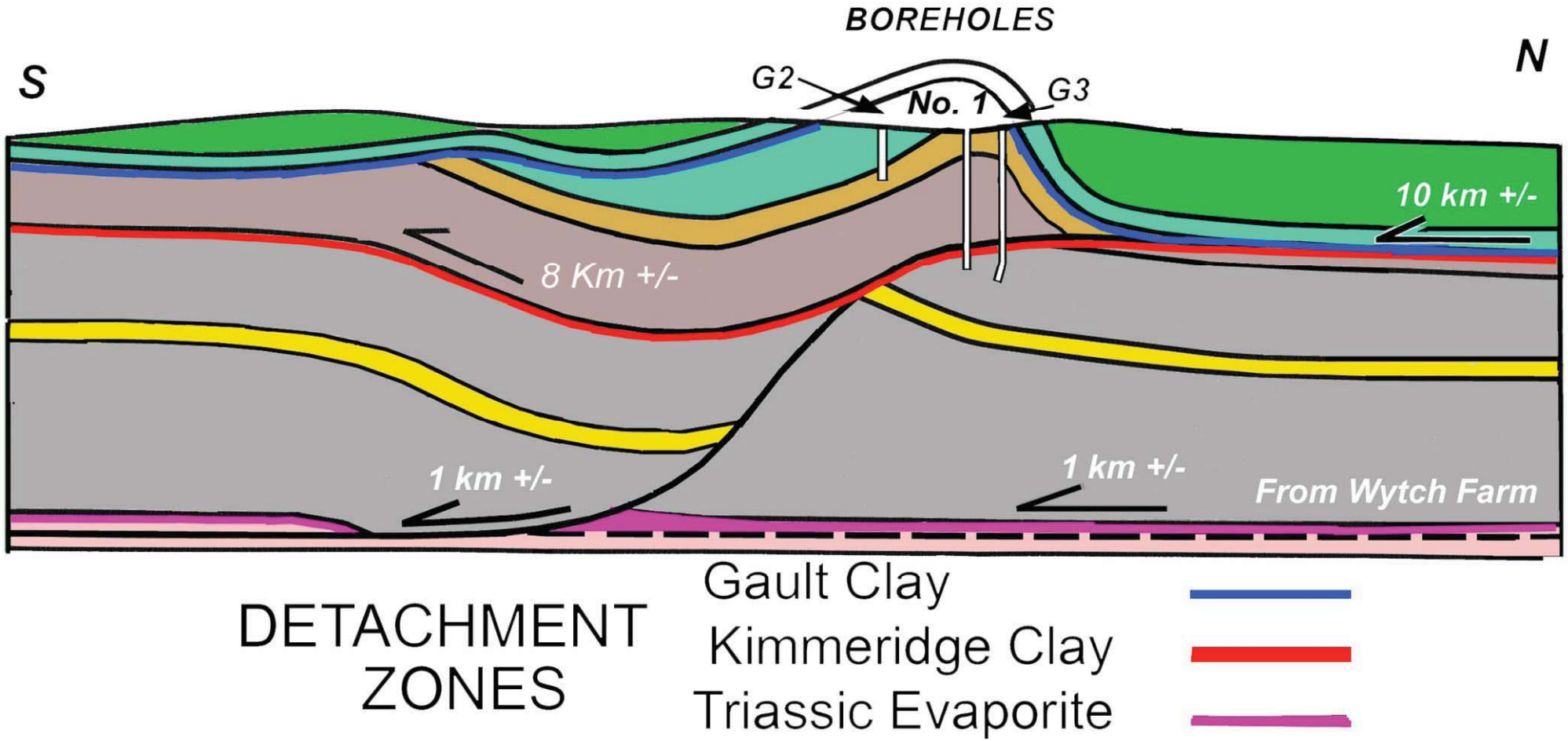


REMOVAL PATHS OF MISSING SUB-BASIN SECTION

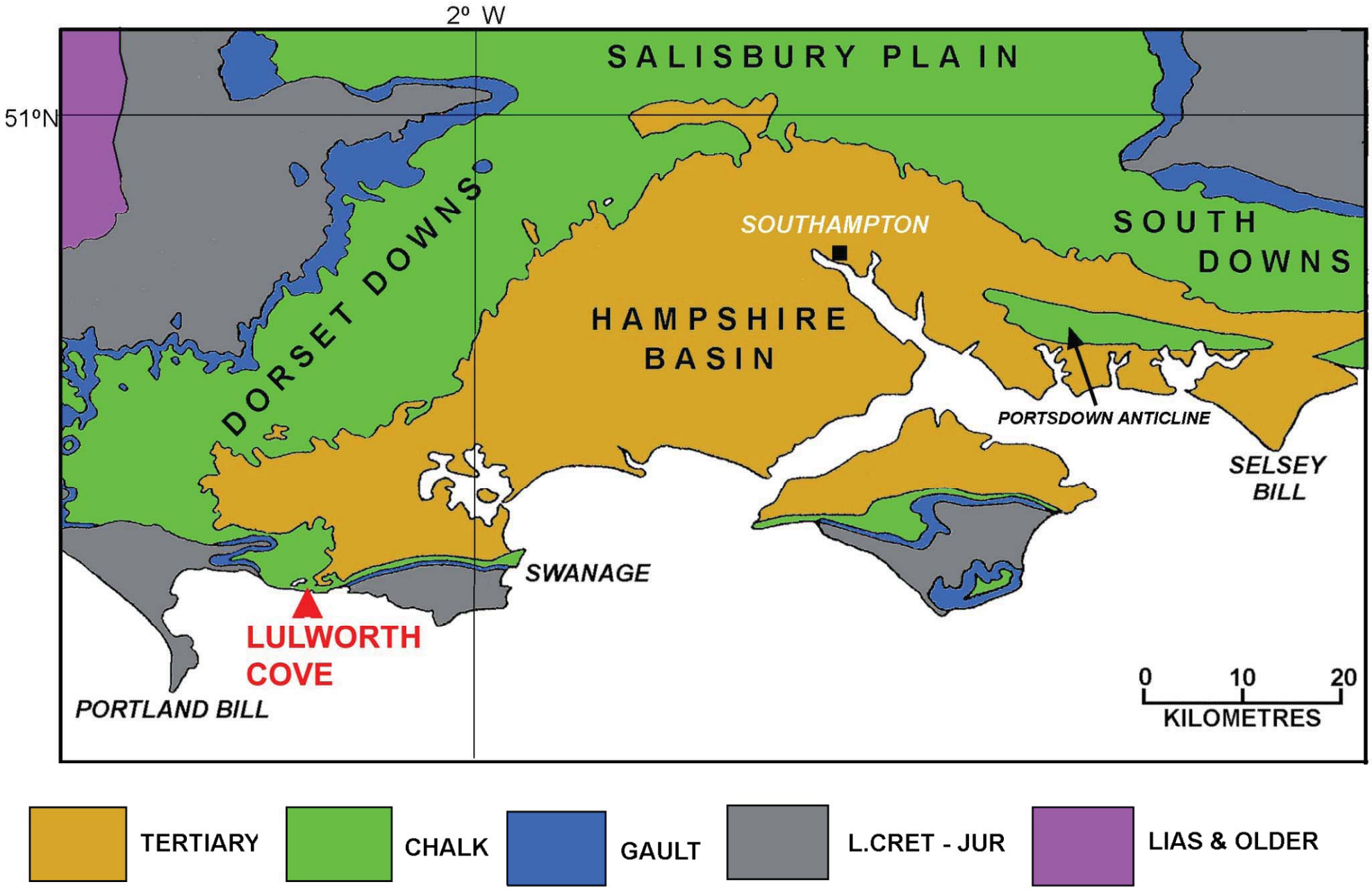

SALISBURY PLAIN
DORSET DOWNS
SOUTH DOWNS
HAMPSHIRE BASIN
0 10 20
KILOMETRES


2º W
51ºN
SALISBURY PLAIN
DORSET DOWNS
SOUTHAMPTON
SOUTH DOWNS
HAMPSHIRE BASIN
PORTSDOWN ANTICLINE
SELSEY BILL
WYTCH FARM OIL FIELD
SWANAGE
CHALDON
PORTLAND BILL
0 10 20
KILOMETRES
TERTIARY
CHALK
GAULT
L.CRET - JUR
LIAS & OLDER

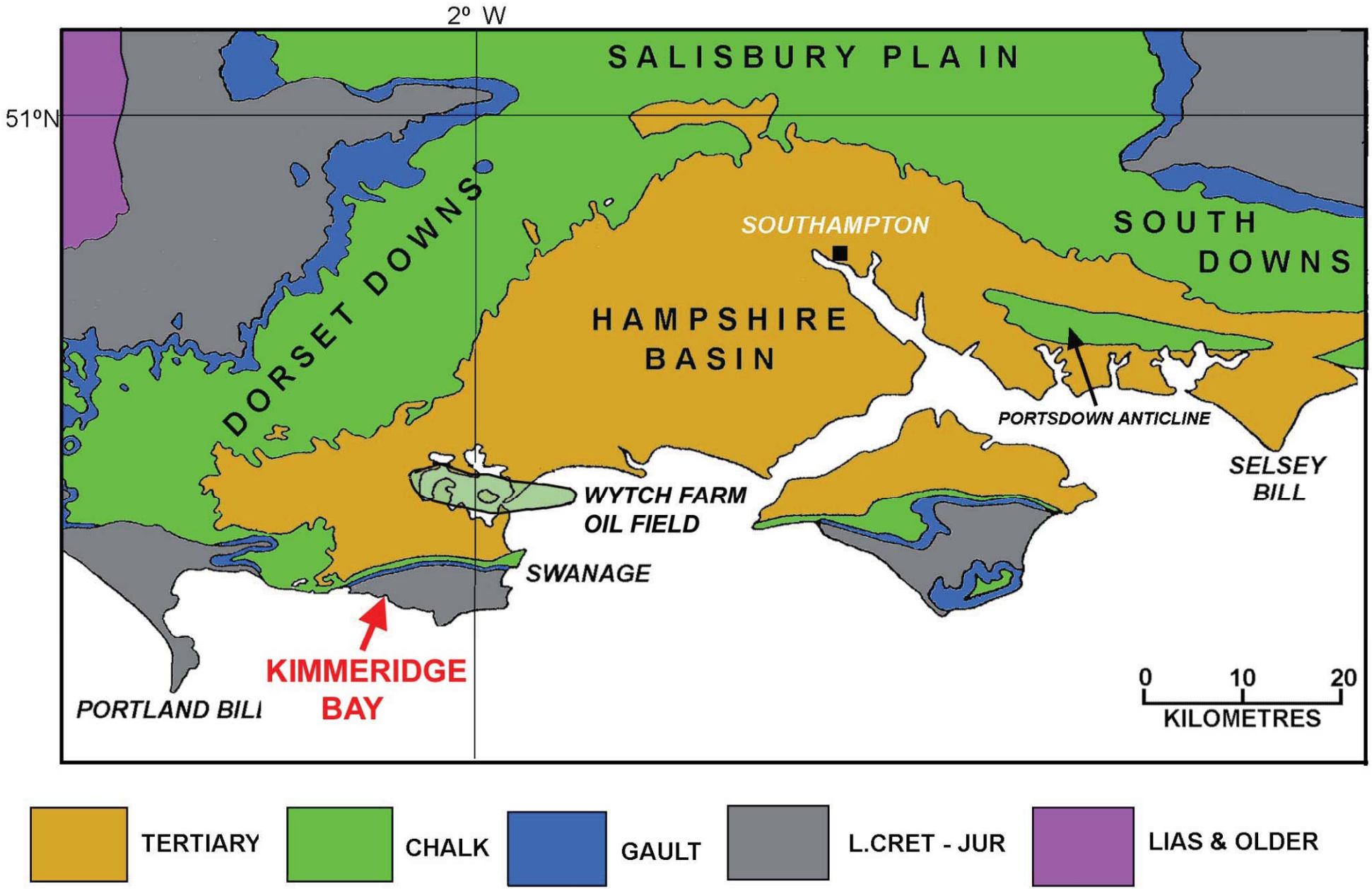

S
N
Gault and Greensand
BOREHOLE NO.1
G2
G3
Chalk
Wealden
Portland and Purbeck
Kimmeridge Clay
Corallian
Oxford Clay
Cornbrash -Gt. Oolite, Fuller's Earth
Inferior Oolite
Chalk
Horizontal = Vertical Scale
0
1,000
METRES
After Ridd, 1973

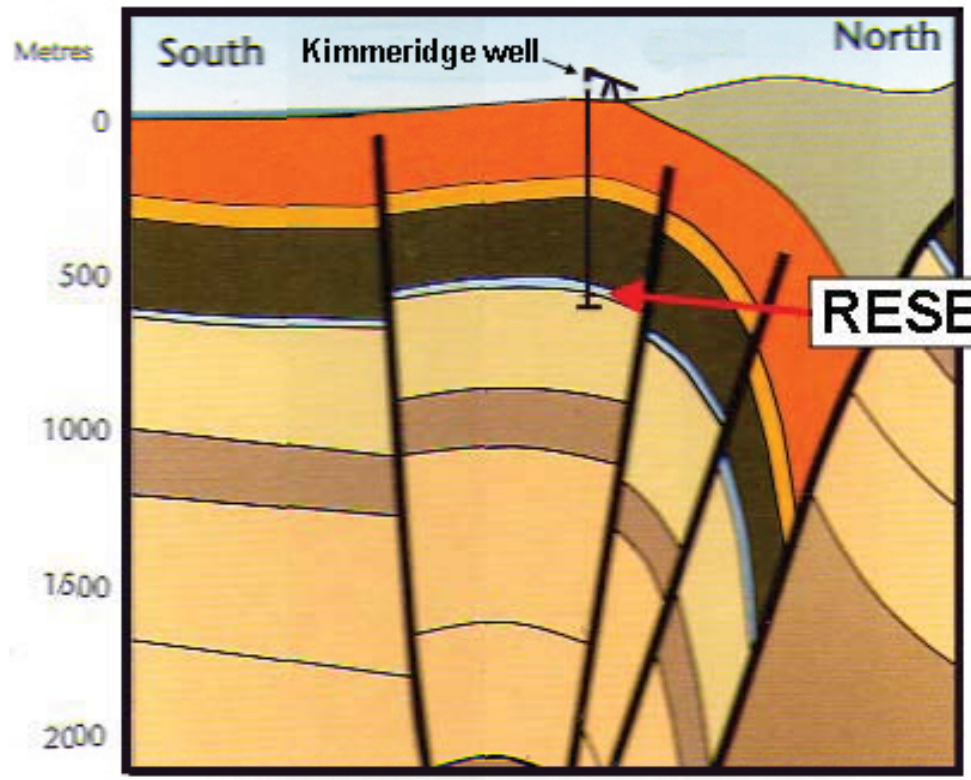


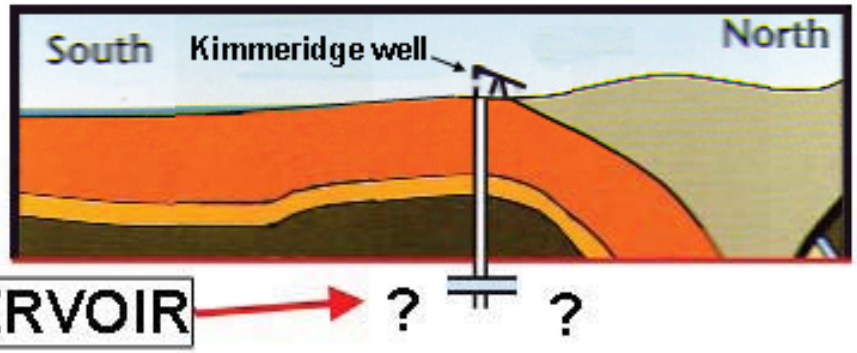
Modified after Ridd, 1973


2º W
51ºN
SALISBURY PLAIN
DORSET DOWNS
SOUTHAMPTON
SOUTH DOWNS
HAMPSHIRE BASIN
PORTSDOWN ANTICLINE
SELSEY BILL
SWANAGE
LULWORTH COVE
PORTLAND BILL
0 10 20
KILOMETRES
TERTIARY
CHALK
GAULT
L.CRET - JUR
LIAS & OLDER

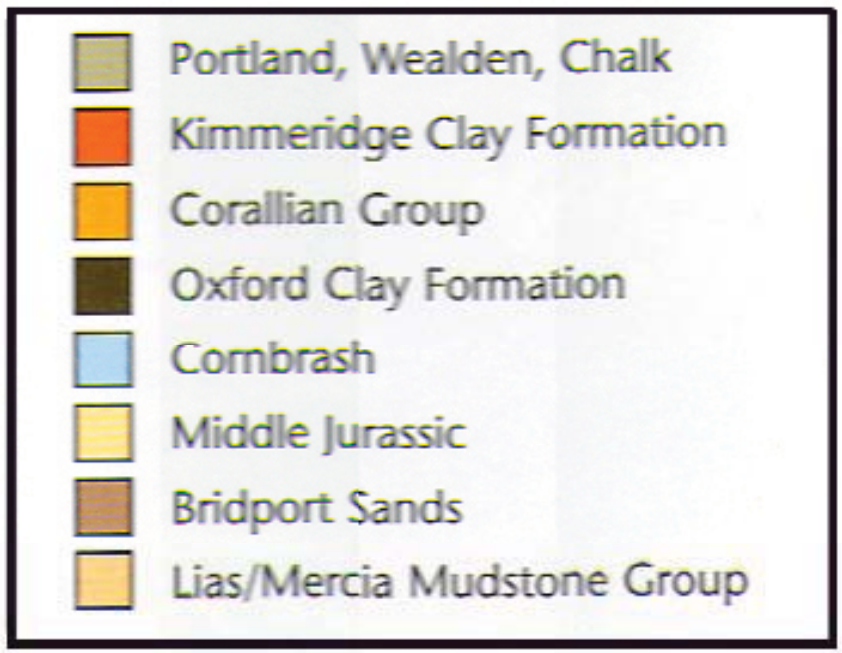
VERTICAL LIMB OF THE PURBECK MONOCLINE


2° W
51°N
SALISBURY PLAIN
DORSET DOWNS
SOUTHAMPTON
SOUTH DOWNS
HAMPSHIRE BASIN
PORTSDOWN ANTICLINE
SELSEY BILL
WYTCH FARM OIL FIELD
SWANAGE
KIMMERIDGE BAY
PORTLAND BILL
0 10 20
KILOMETRES
TERTIARY
CHALK
GAULT
L.CRET - JUR
LIAS & OLDER





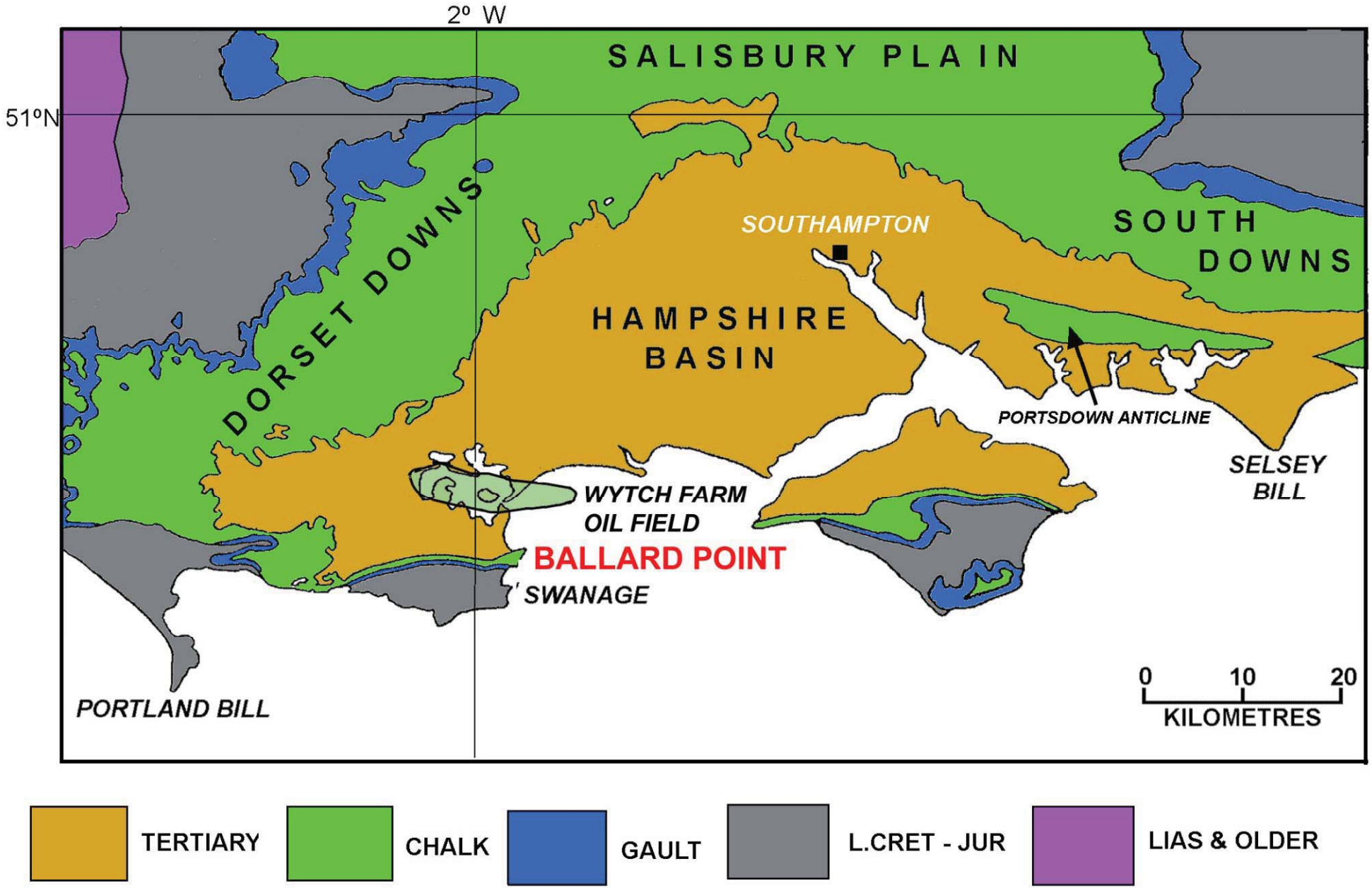
STRUCTURE UNKNOWN



Q. Why did the Kimmeridge Well produce more than expected?

A. Because the geology beneath the Kimmeridge detatchment is different from the surface geology.

From: JURASSIC COAST. D. Brunsden, ed. 2005


2º W
51ºN
SALISBURY PLAIN
DORSET DOWNS
SOUTHAMPTON
SOUTH DOWNS
HAMPSHIRE BASIN
PORTSDOWN ANTICLINE
SELSEY BILL
WYTCH FARM OIL FIELD
BALLARD POINT
SWANAGE
PORTLAND BILL
0 10 20
KILOMETRES
TERTIARY
CHALK
GAULT
L.CRET - JUR
LIAS & OLDER

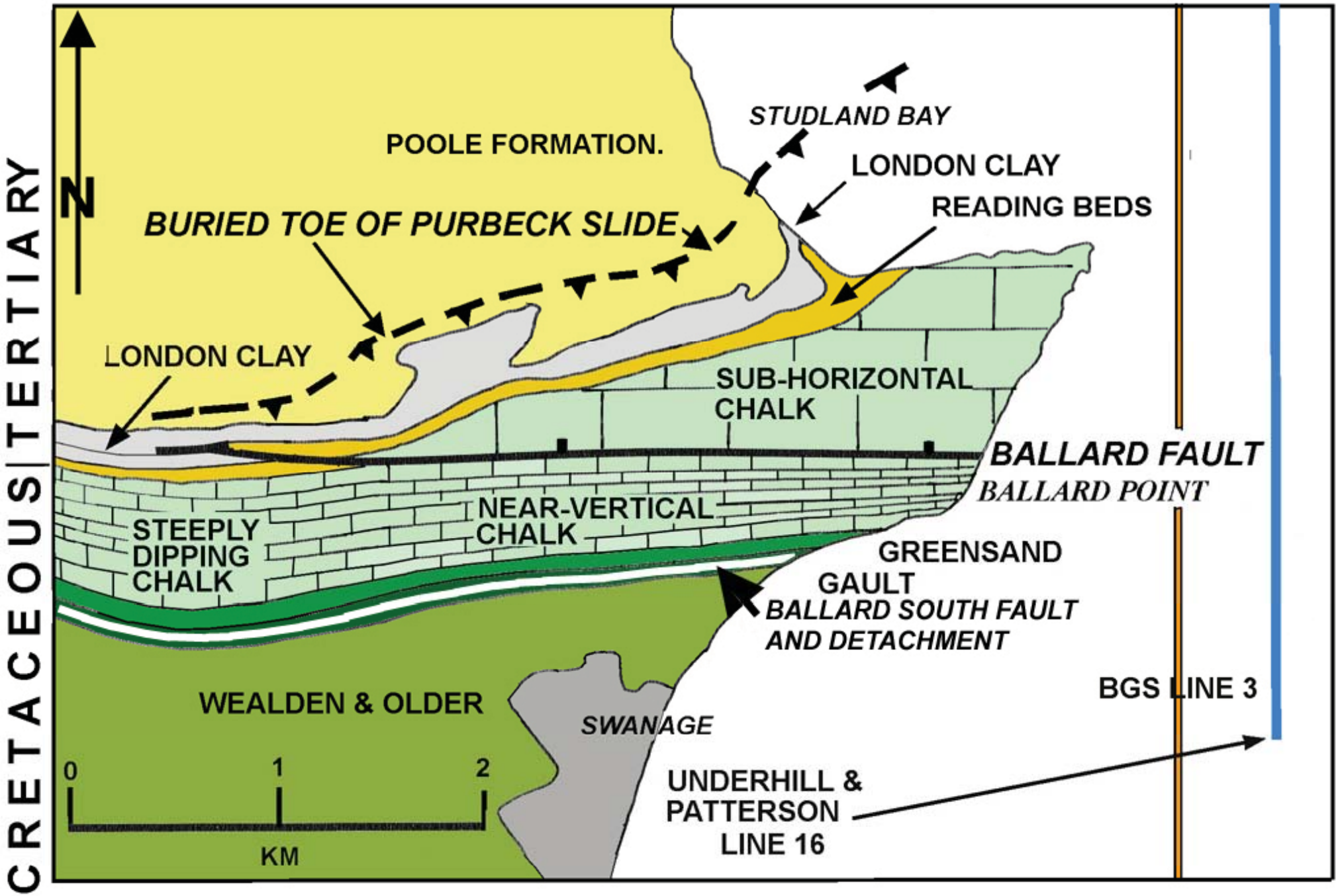
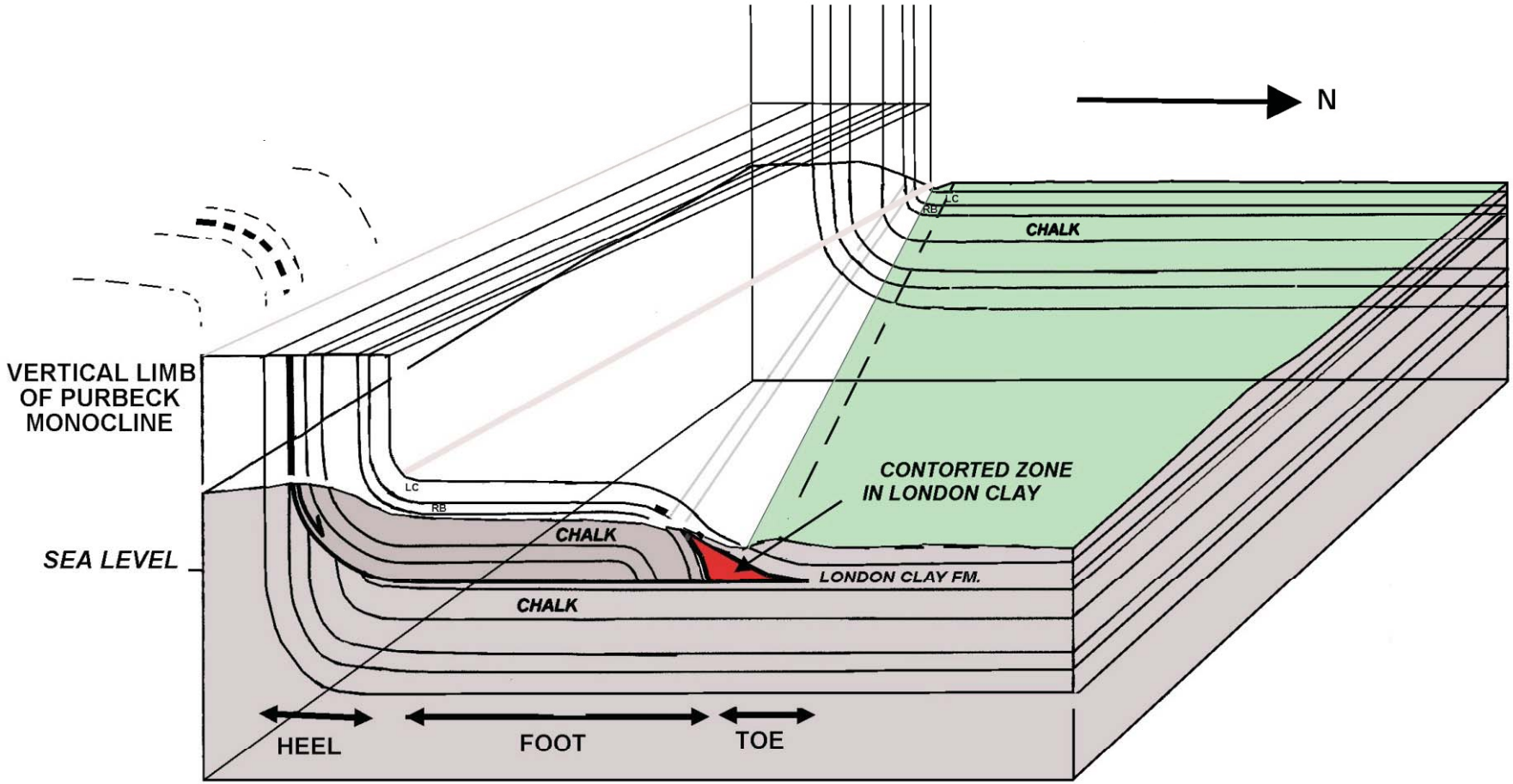
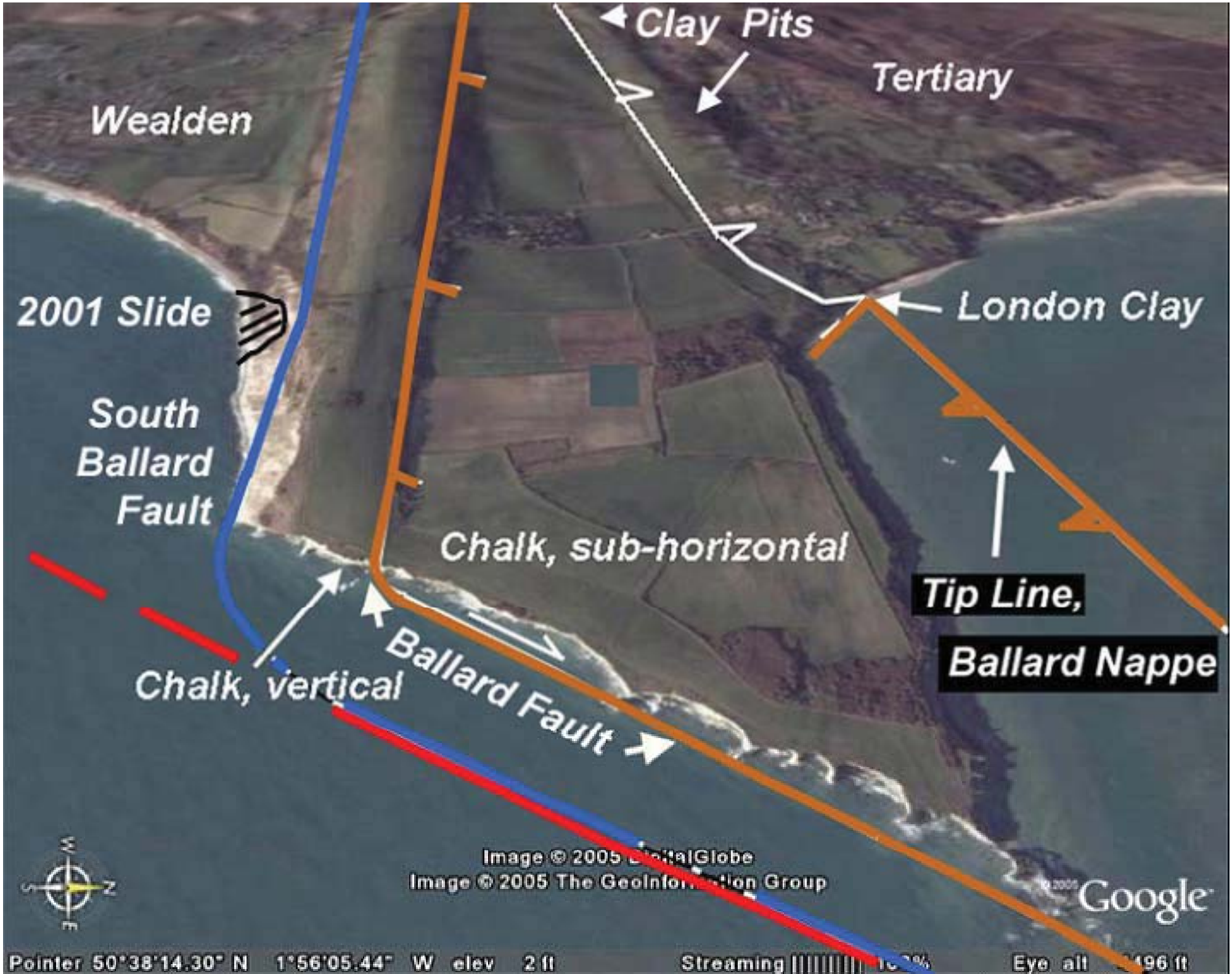

CRETACEOUS|TERTIARY
N
POOLE FORMATION.
STUDLAND BAY
LONDON CLAY
READING BEDS
BURIED TOE OF PURBECK SLIDE
LONDON CLAY
SUB-HORIZONTAL CHALK
BALLARD FAULT
BALLARD POINT
NEAR-VERTICAL CHALK
STEEPLY DIPPING CHALK
GREENSAND
GAULT
BALLARD SOUTH FAULT AND DETACHMENT
WEALDEN & OLDER
SWANAGE
BGS LINE 3
0
1
2
KM
UNDERHILL & PATTERSON LINE 16


Image © 2005 DigitalGlobe
Image © 2005 The GeoInformation Group
© 2005 Google
Pointer 50°38'14.30" N 1°56'05.44" W elev 2 ft
Streaming 100%
Eye alt 4496 ft


BALLARD DOWN FAULT



THE BALLARD DOWN FAULT- SOLE FAULT OF A REGIONAL-SCALE GRAVITY SLIDE, THE BALLARD NAPPE

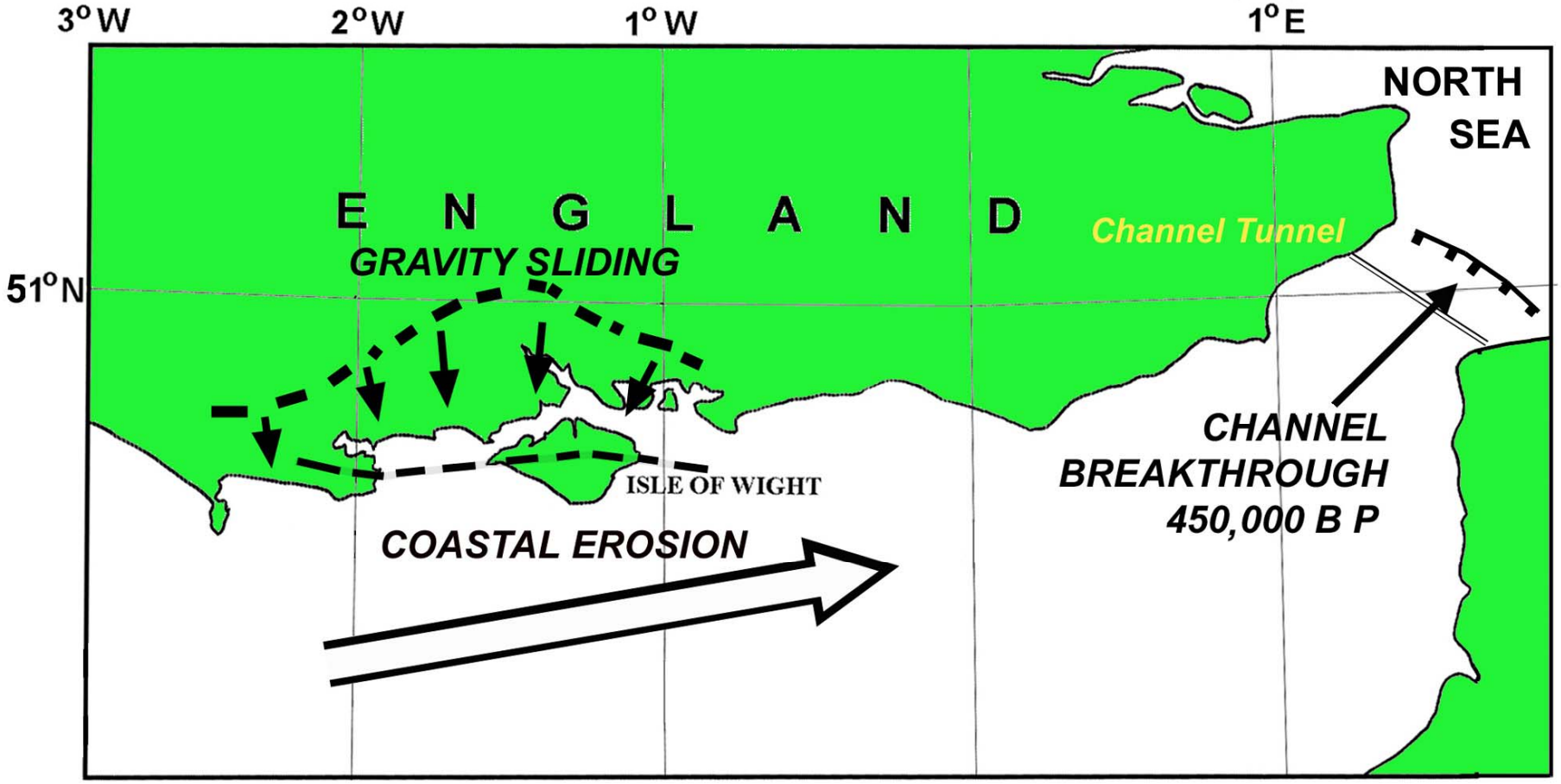

Clay Pits
Tertiary
Wealden
2001 Slide
London Clay
South
Ballard
Fault
Chalk, sub-horizontal
Tip Line,
Ballard Nappe
Chalk, vertical
Ballard Fault
Image © 2005 DigitalGlobe
Image © 2005 The GeoInformation Group
Google
Pointer 50°38'14.30" N 1°56'05.44" W elev 2 ft
Streaming
Eye alt 496 ft

CONSEQUENCES FOR OIL & GAS

- Stratigraphy and sedimentation are all affected because it had been assumed that all sediments were autochthonous, moved little or not at all from their sites of deposition and movements were predominantly vertical.
- All critical localities, outcrops and wells, need to be restored to their sites of deposition to construct usable isopach, facies, and other paleogeographic maps.
- Removal of the mid-Cretaceous unconformity means that sedimentation was continuous through the Mesozoic and Tertiary until the Plio-Pleistocene resulting in increased maturation of section - in particular - the Kimmeridge clay falls within the oil window.
- Prospects for the area are dramatically improved. It is now a new frontier!

GEOLOGICAL CONCLUSIONS

- The Hampshire basin is a half-graben formed through gravity sliding southward along blind, sub-horizontal and overpressured bedding-plane detachment faults at both shallow and deeper levels. Since all movements were extensional, no inversion was involved.
- Significant movement did not occur until latest Tertiary or Pleistocene, synchronous with eastward encroachment of the English Channel, which finally connected with the North Sea around 450,000 years BP.
- There is no connection to alpine tectonics in time and space.
- There is no need to include tectonic inversion to connect shallow and deep structures since they are all extensional.



Eastward advance of the future English Channel with coastal erosion of contemporaneous gravity sliding in the Hampshire Basin.