Depositional Model of the Marcellus Shale in West Virginia Based on Facies Analysis*

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Abstract

A lithologic analysis of well exposed Marcellus outcrops has identified six different facies in West Virginia and neighboring states: (1) light gray calcareous shale, (2) fossiliferous limestone, (3) black calcareous shale, (4) black noncalcareous shale, (5) dark gray noncalcareous shale, and (6) K-bentonite. Close interbedding of these rock types attests to a complex, ever-changing environment on the eastern foreland ramp of the Appalachian Basin. The environmental setting was clearly not a deep trough, permanently anoxic, salinity stratified, sediment starved, and populated exclusively by phytoplankton—the traditional depositional model. To the contrary, our sedimentary data suggest a rather shallow water depth, intermittent anoxia, normal-marine salinity, a fluctuating input of siliciclastic mud, and faunal communities of low and moderate diversity.

Interbedding of the shale and limestone lithofacies as well as the vertical stacking of facies associations is explained most simply by fluctuations in water depth coupled with fluctuations in sediment supply. The sea floor was, at times, immediately below wave base (Facies 1 and 2), around the depth of the thermocline (Facies 2 and 3), or below the thermocline (Facies 4 and 5), relative sea level changing through two sequences of lowstand, transgression, and highstand. Simultaneously the supply of siliciclastic mud was greater at times of lowstand (increased erosion) and highstand (prograding shoreline), and the supply smaller during transgression (sediment stored in distant coastal plain).

Selected References

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NATIONAL ENERGY TECHNOLOGY LABORATORY

DEPOSITIONAL MODEL OF THE MARCELLUS SHALE IN WEST VIRGINIA BASED ON FACIES ANALYSIS

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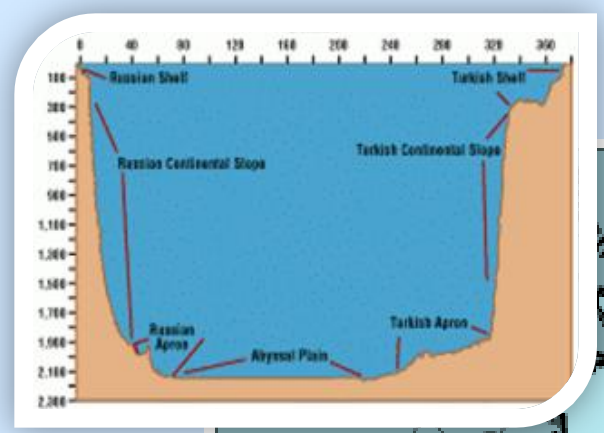
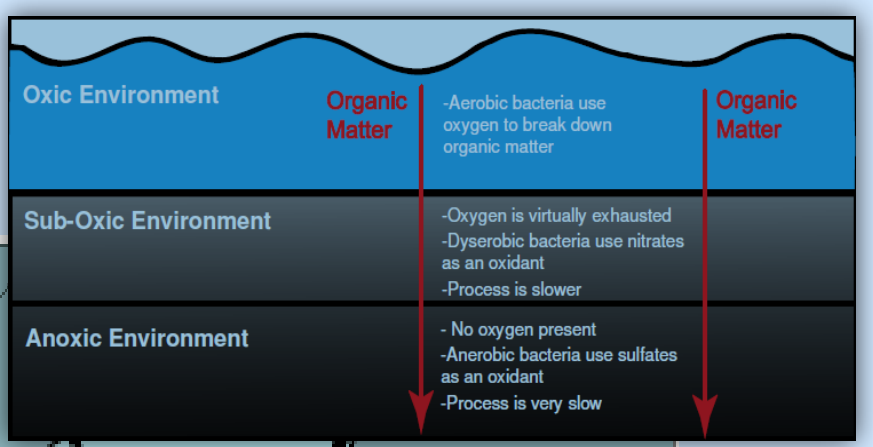
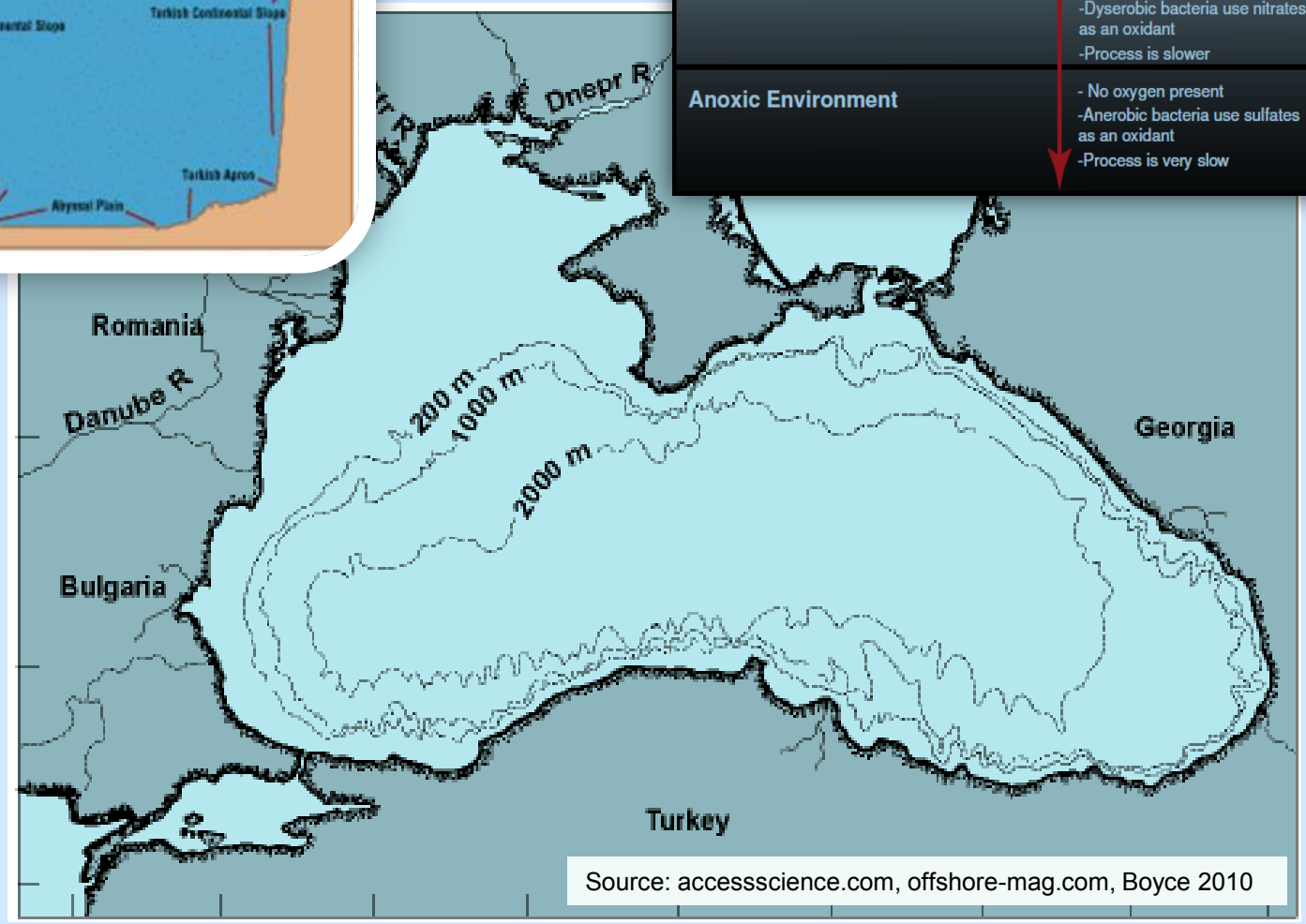
National Energy Technology Laboratory, URS Corporation, and West Virginia University

U.S. DEPARTMENT OF ENERGY

MODERN ANALOG







Source: accessscience.com, offshore-mag.com, Boyce 2010

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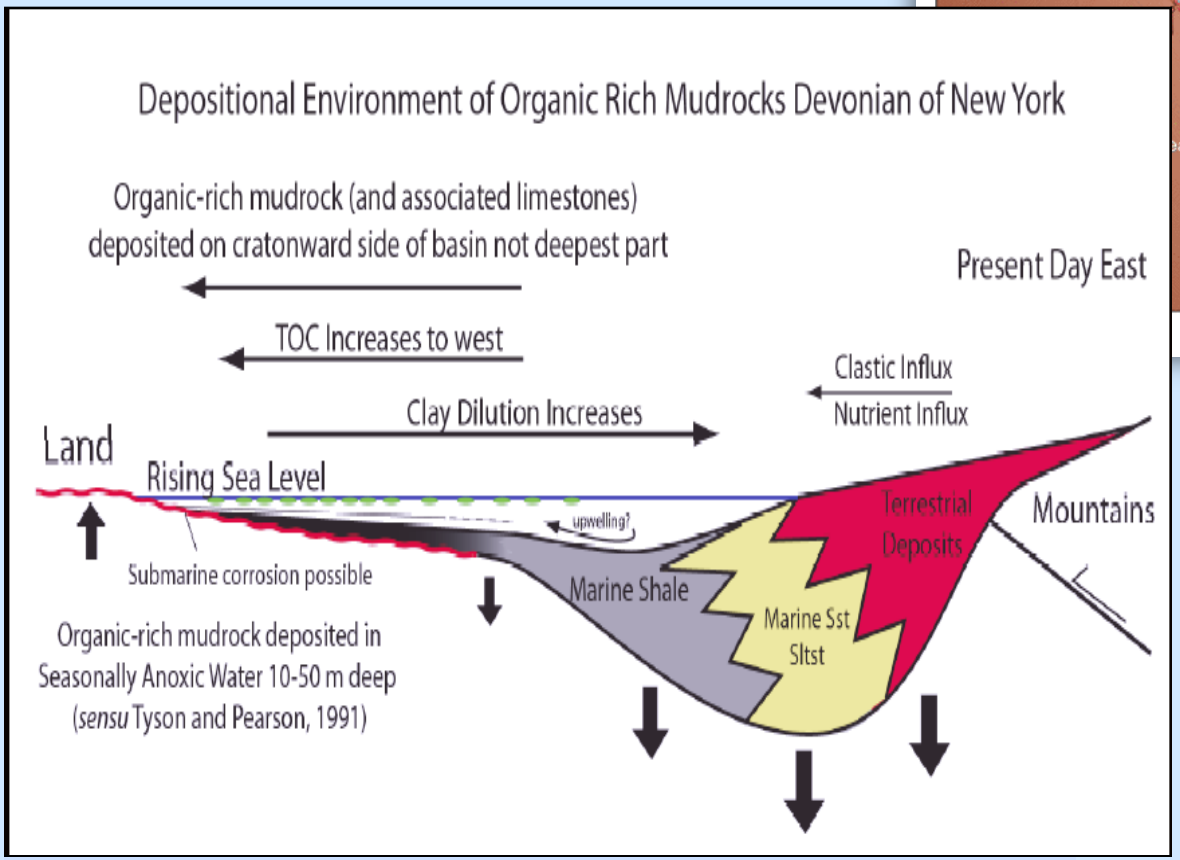

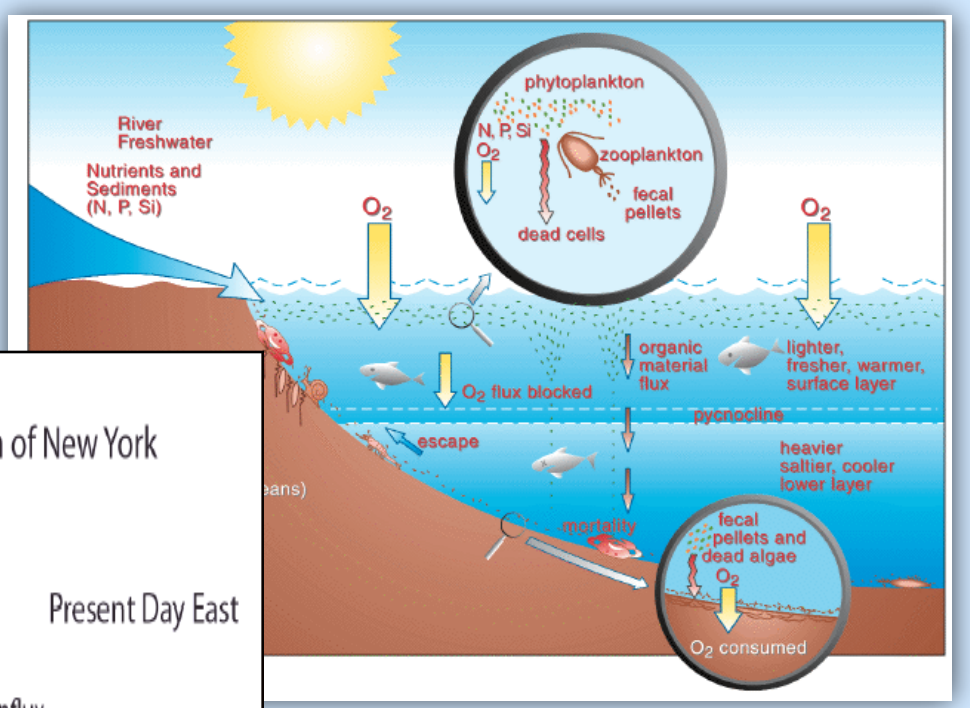

Source: Smith and Leone; 2010, Schweitering, 1981, ehp.niehs.nih.gov

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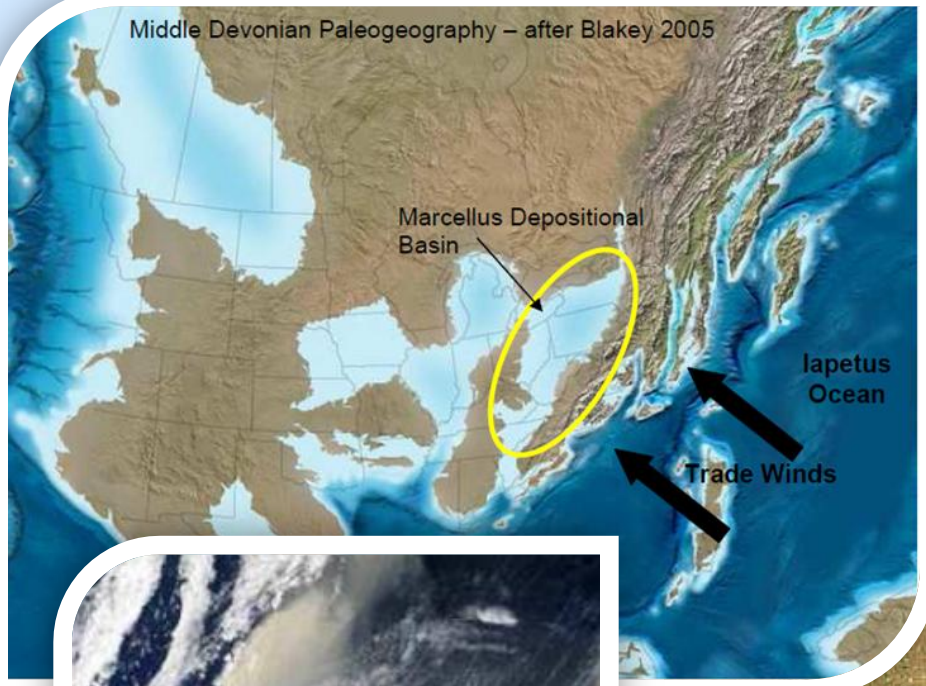
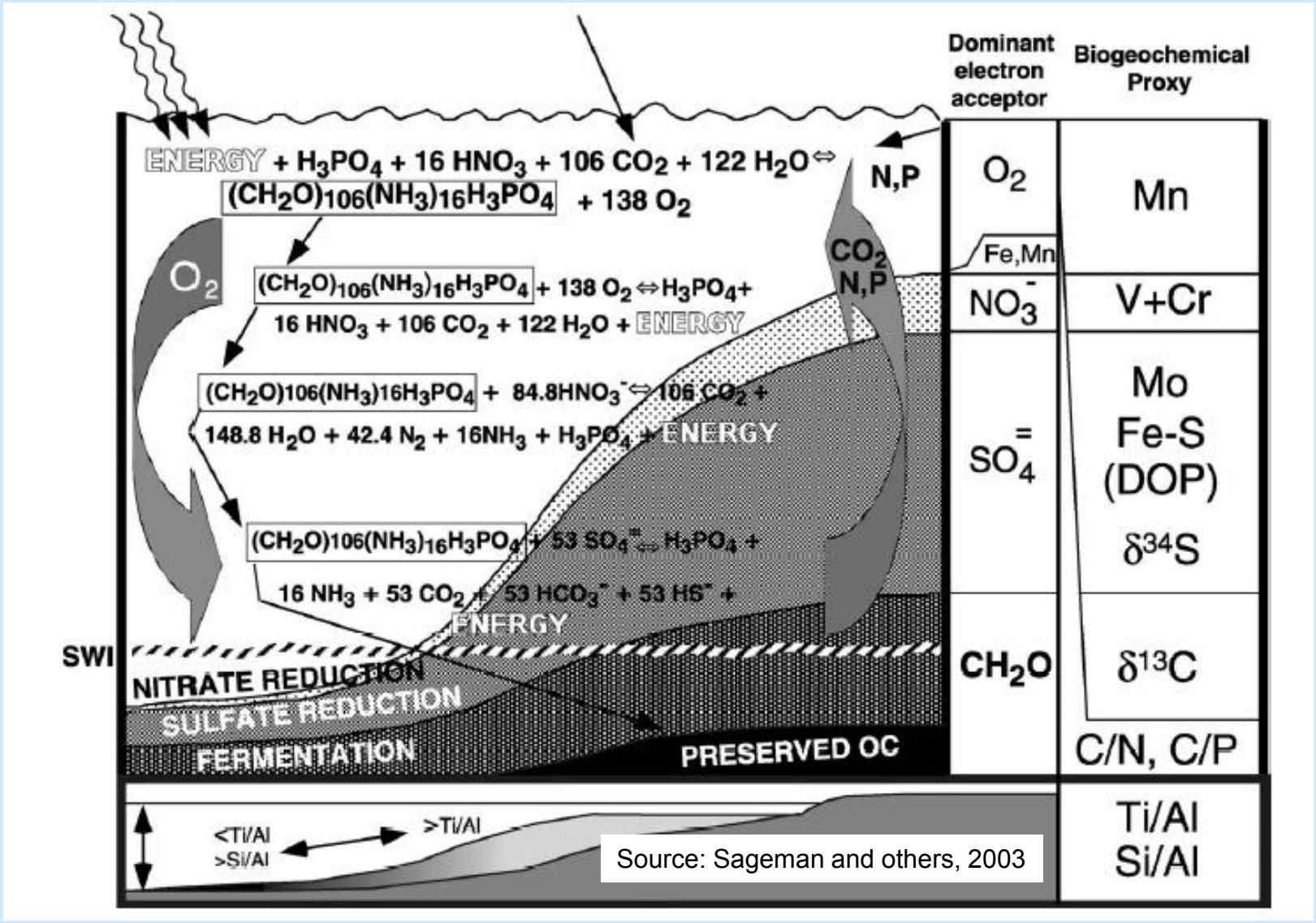


Source: feww.wordpress.com, flickr.com, Wrightstone 2008, Blakey 2005

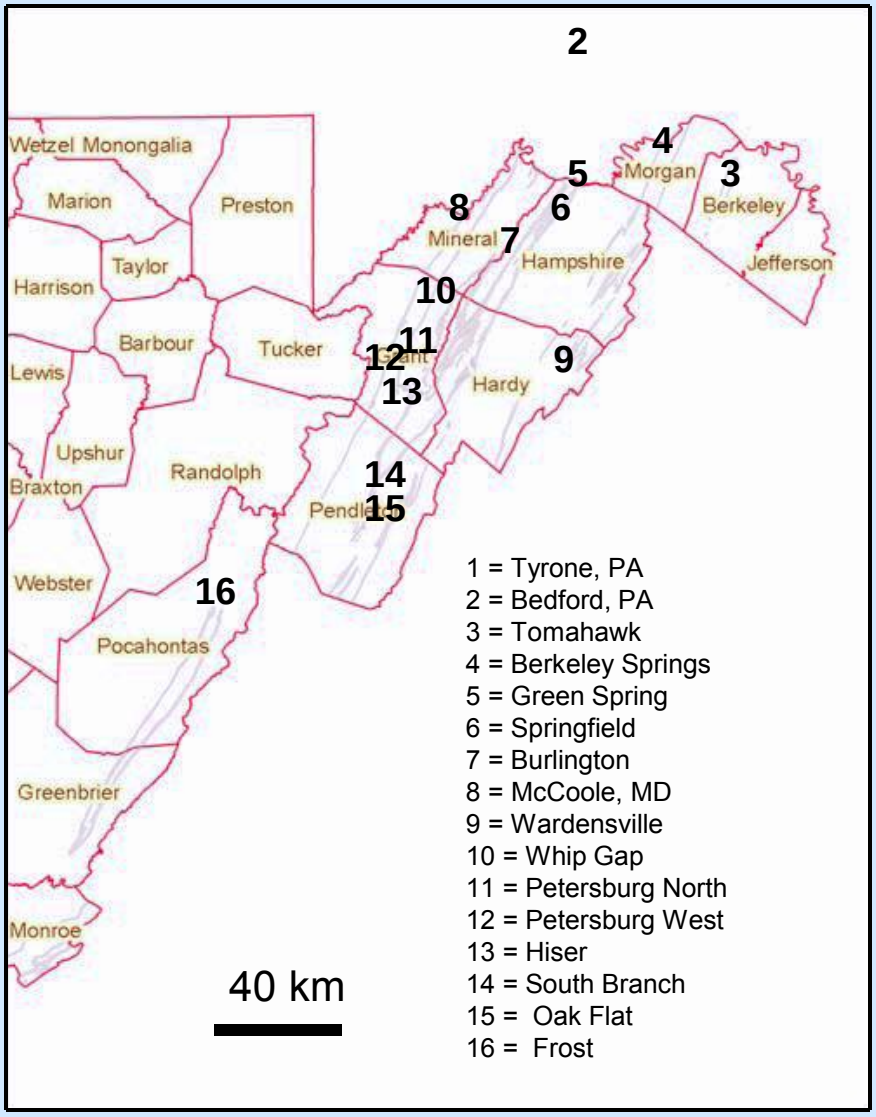
CHEMICAL PROXY

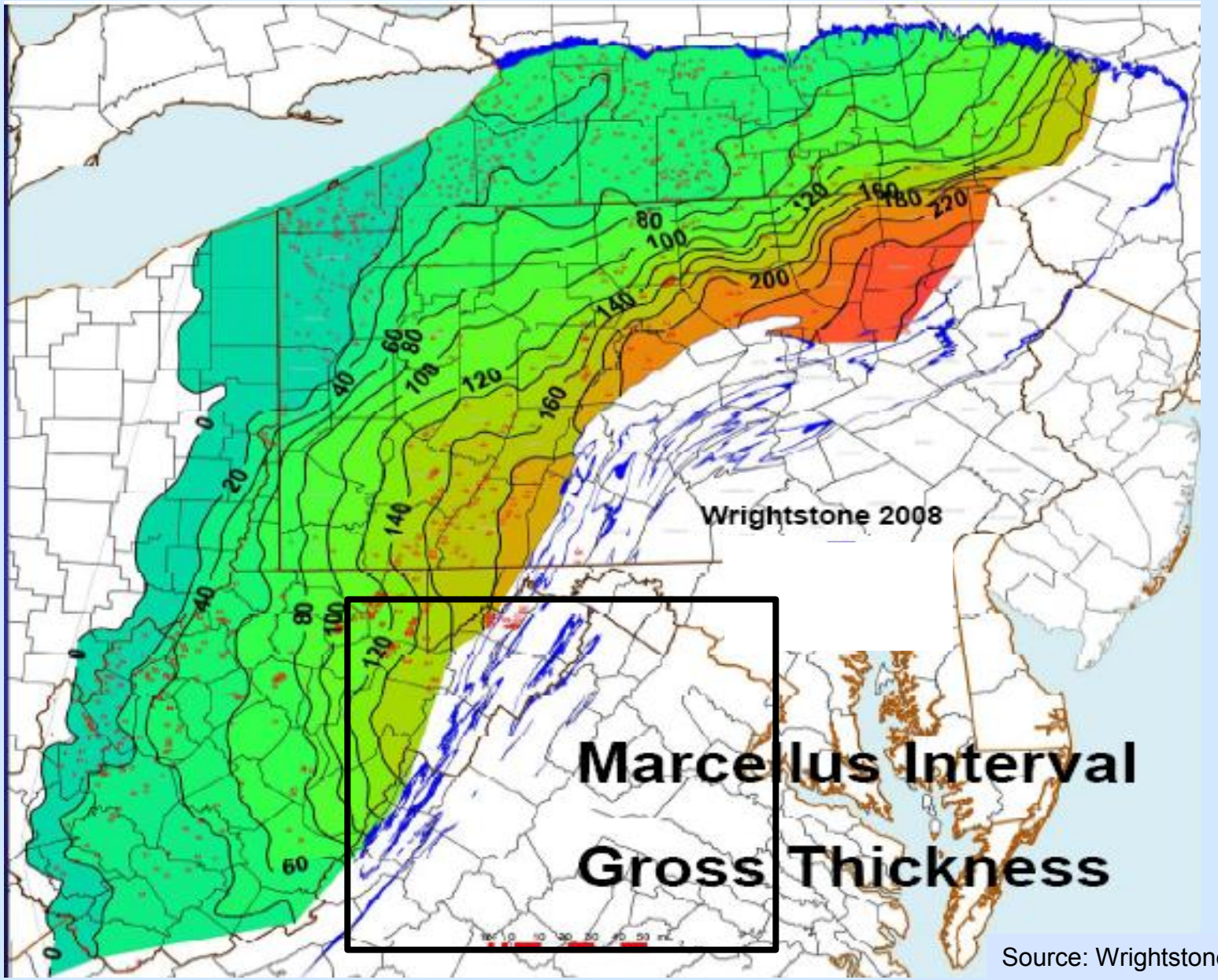


BURLINGTON, WV

PETERSBURG NORTH, WV

OUTCROP LOCATIONS





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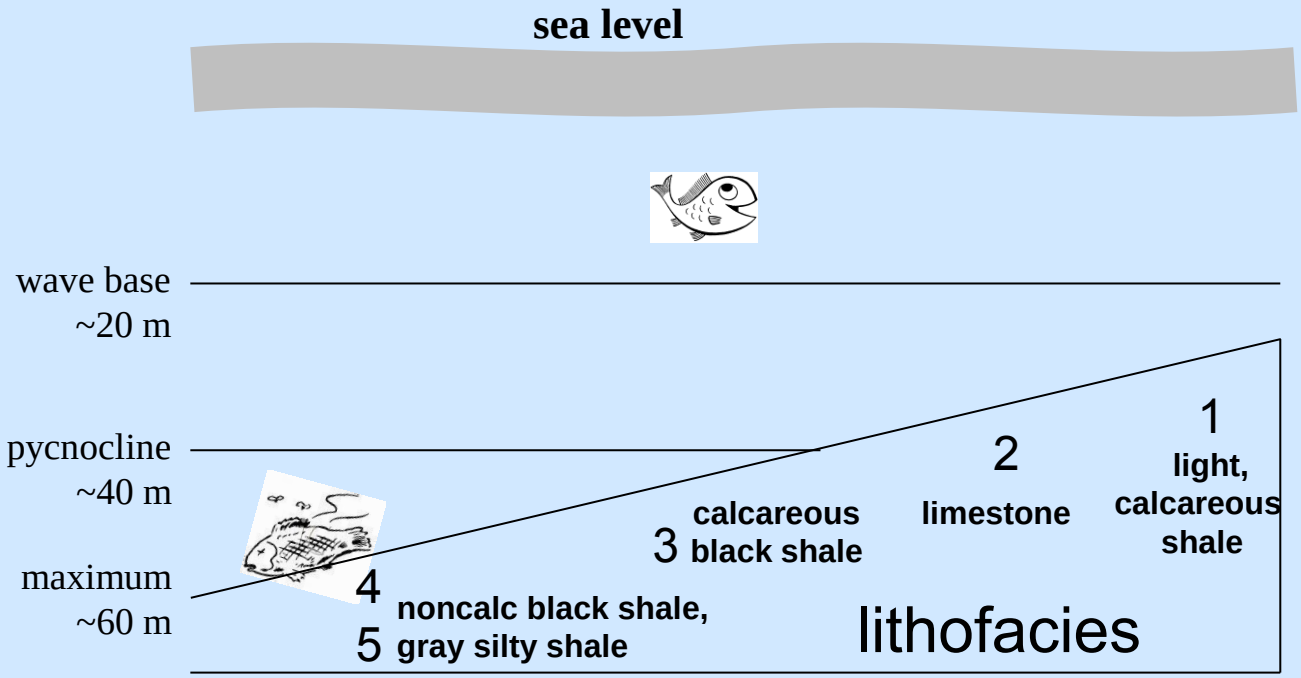


rock type—color—texture—bedding character—fossils

FACIES 1: light-colored calcareous shale

PETERSBURG WEST

FACIES 1: light-colored calcareous shale

PETERSBURG WEST

FACIES 1: light-colored calcareous shale

BURLINGTON

FACIES 2: limestone

BURLINGTON

FACIES 2: limestone

PETERSBURG WEST

FACIES 2: limestone

PETERSBURG NORTH

FACIES 2: limestone

GREEN SPRING

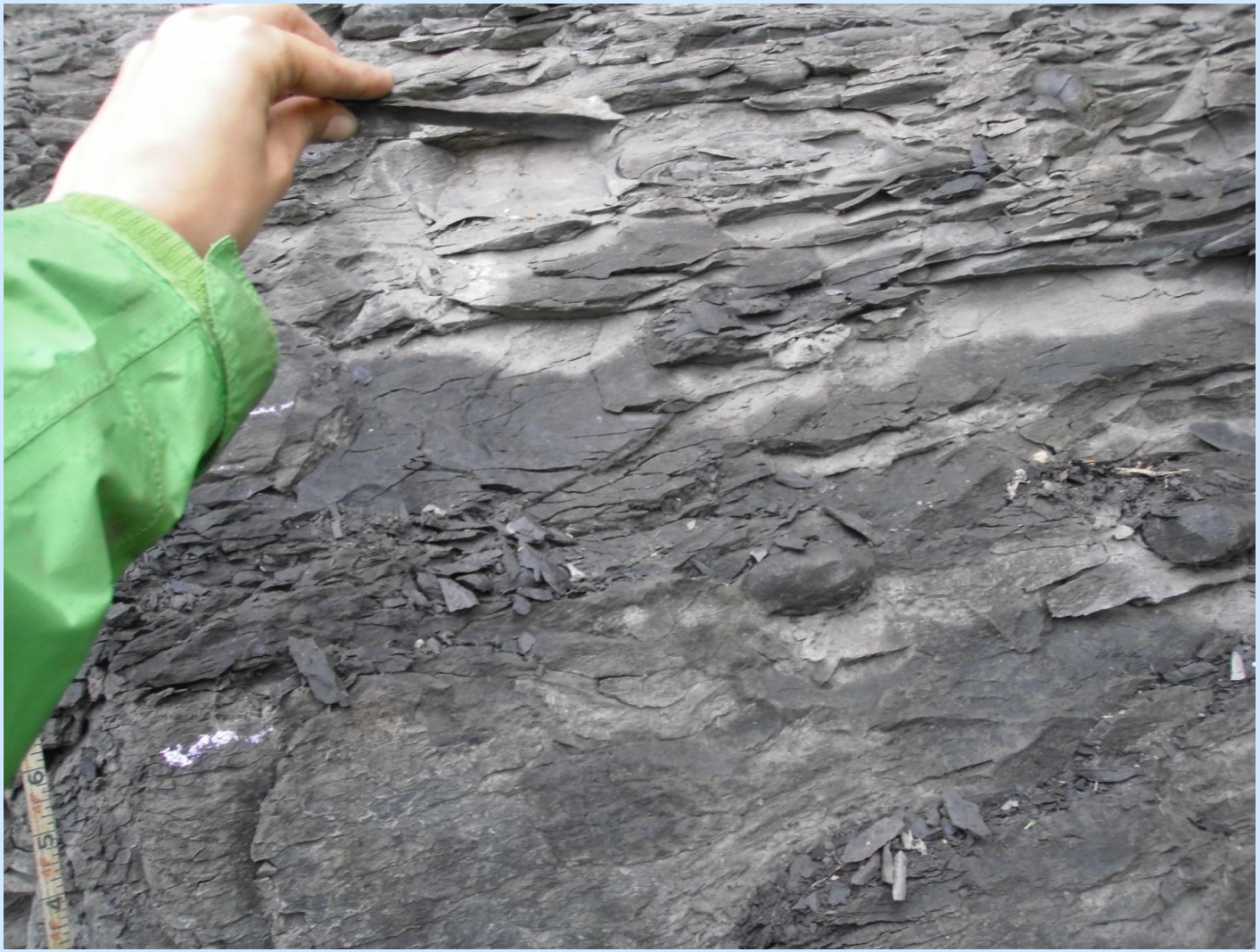
FACIES 3: black calcareous shale

OAK FLAT

FACIES 3: black calcareous shale

BEDFORD

FACIES 3: black calcareous shale

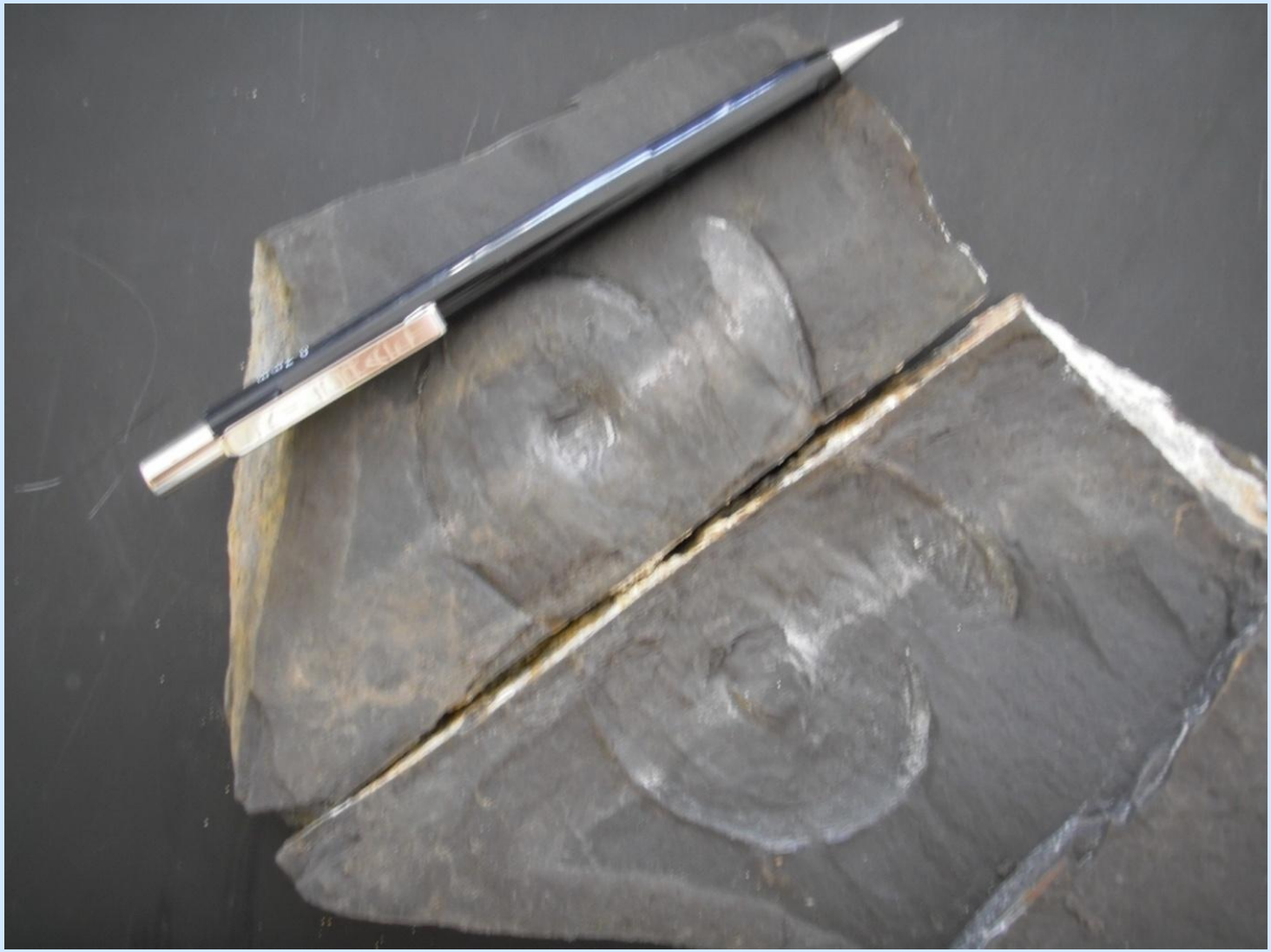


PETERSBURG NORTH

FACIES 3: black calcareous shale

TYRONE

FACIES 3: black calcareous shale



TYRONE

FACIES 3: black calcareous shale

BEDFORD

FACIES 4: black noncalcareous shale

PETERSBURG NORTH

FACIES 4: black noncalcareous shale

TOMAHAWK

FACIES 4: black noncalcareous shale

SOUTH BRANCH

FACIES 4: black noncalcareous shale

WHIP GAP

FACIES 4: black noncalcareous shale

OAK FLAT

FACIES 5: gray noncalcareous shale

SOUTH BRANCH

FACIES 5: gray noncalcareous shale

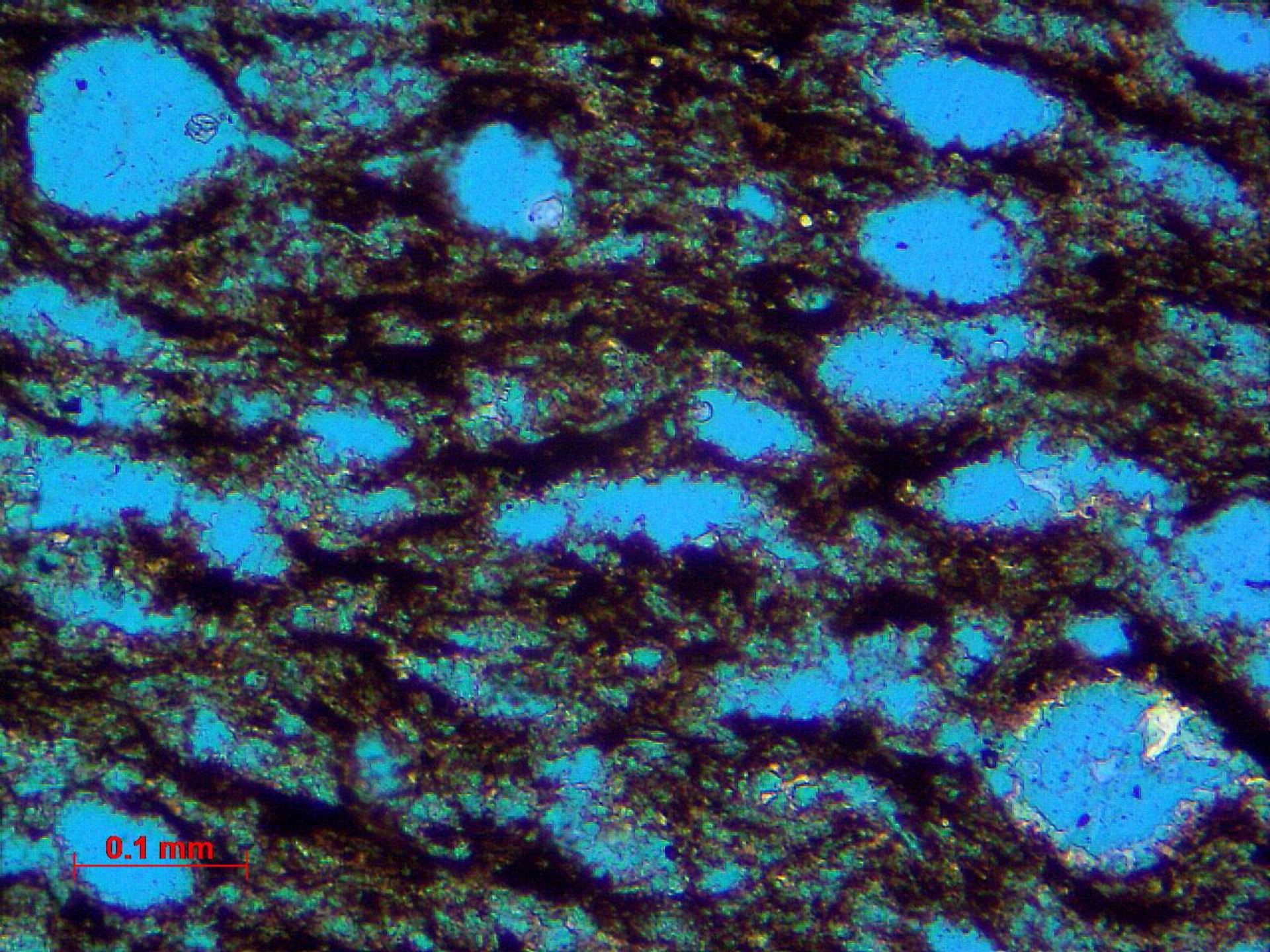
MCCOOLE

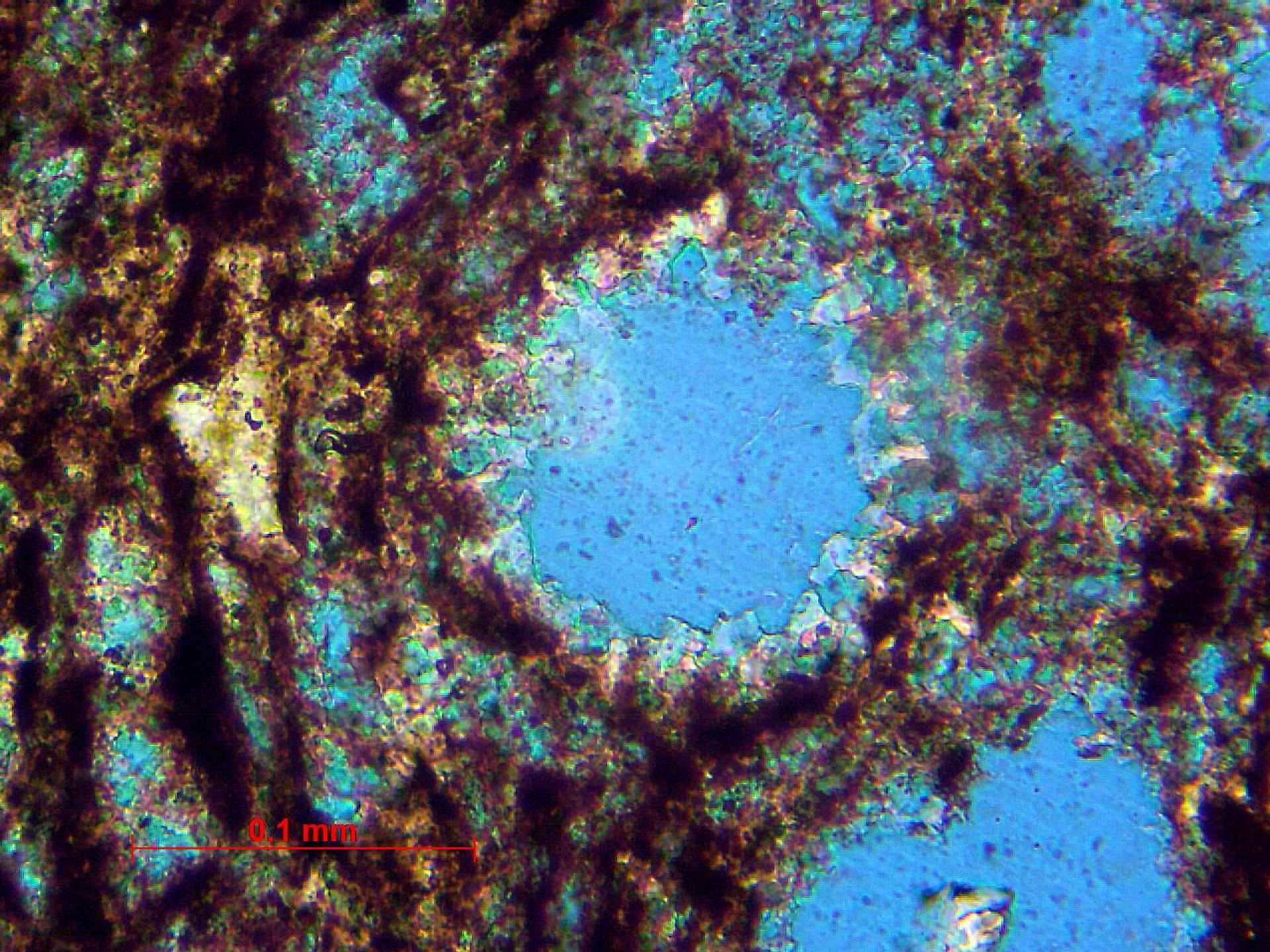
FACIES 5: gray noncalcareous shale

MCCOOLE

FACIES 6: K-bentonite

TOMAHAWK


0.1 mm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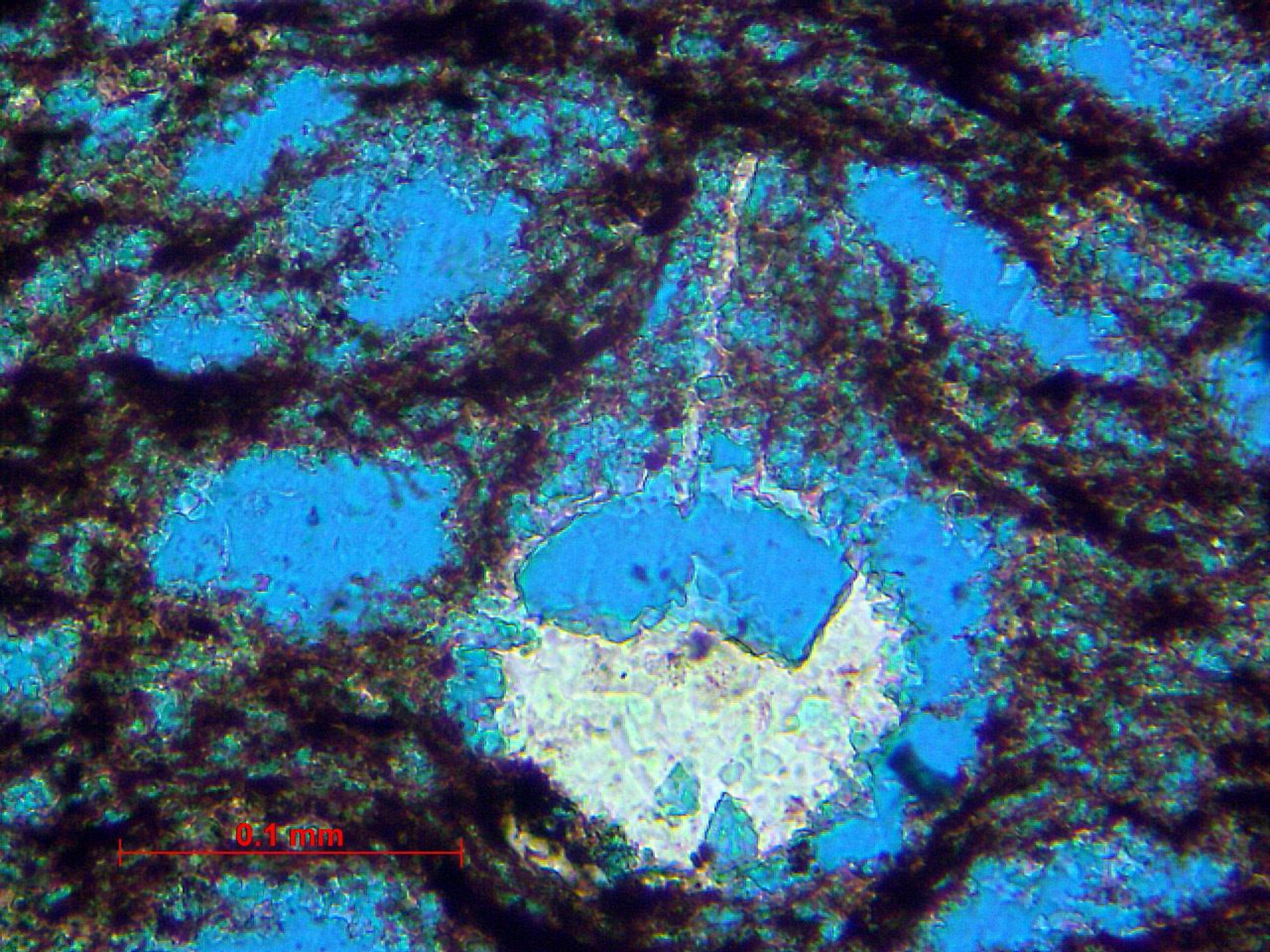
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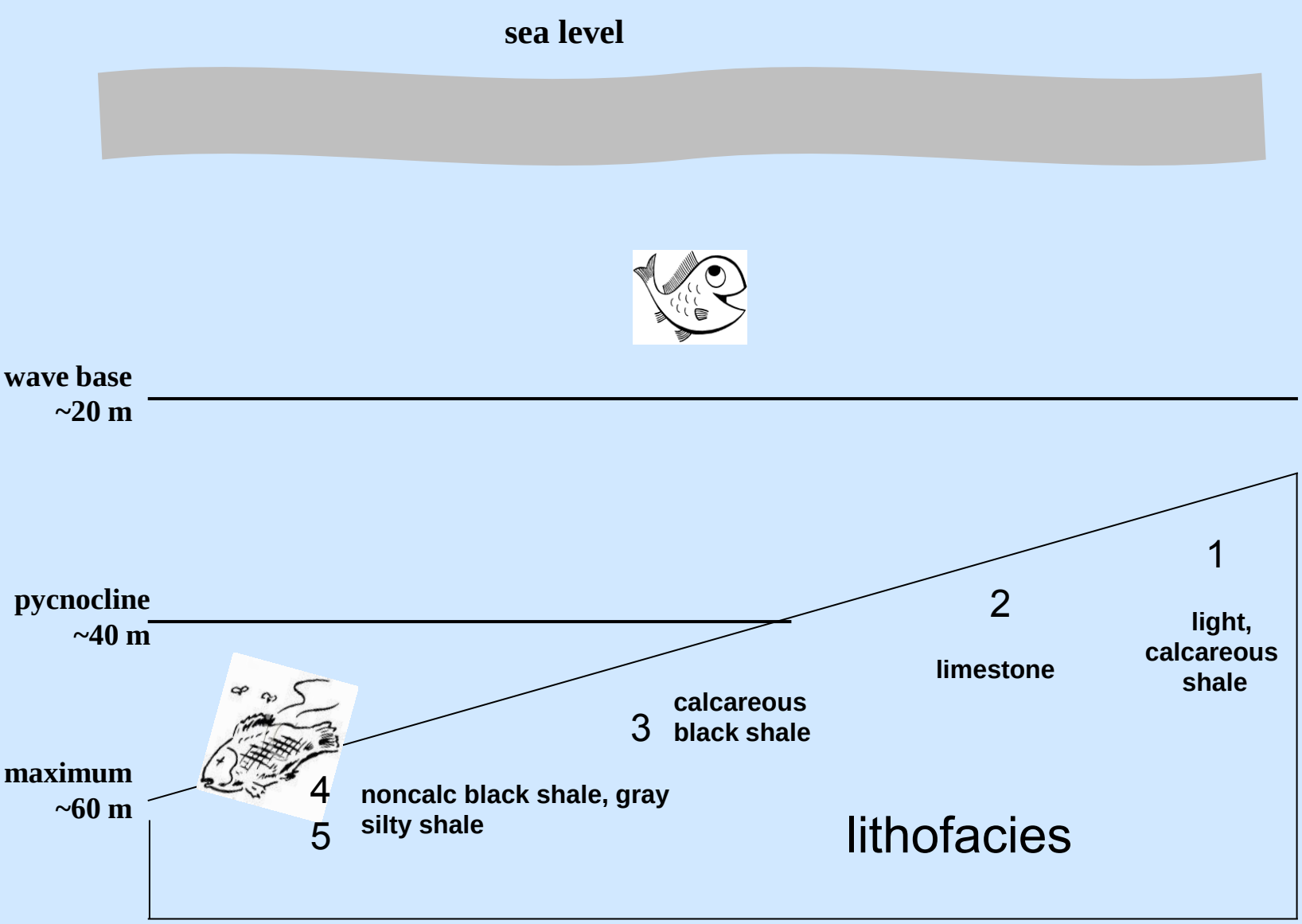
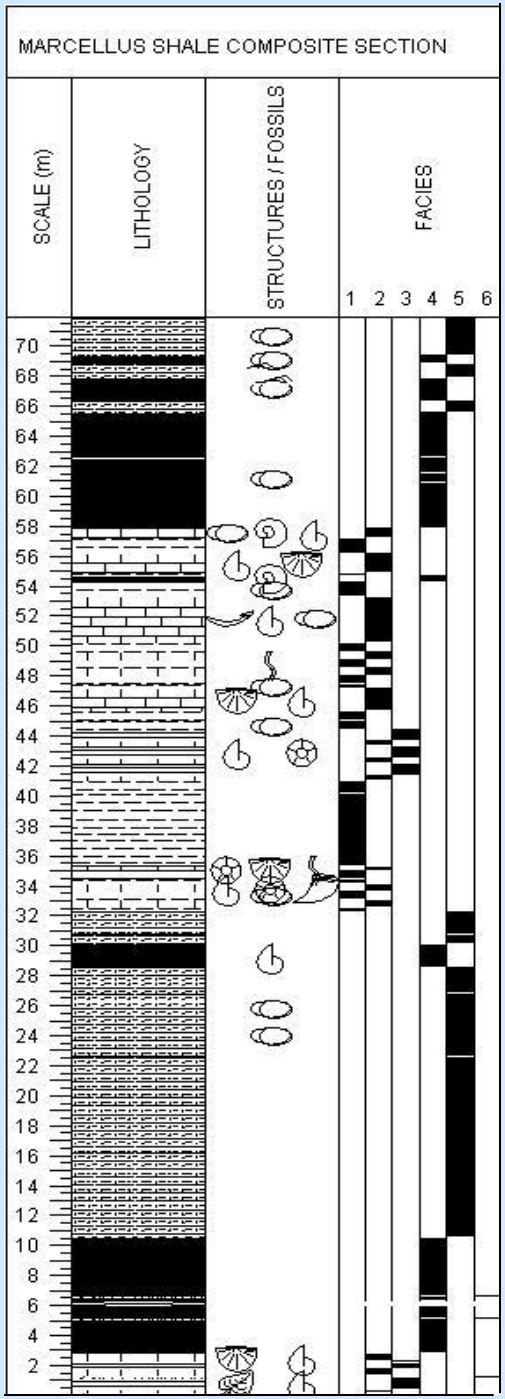
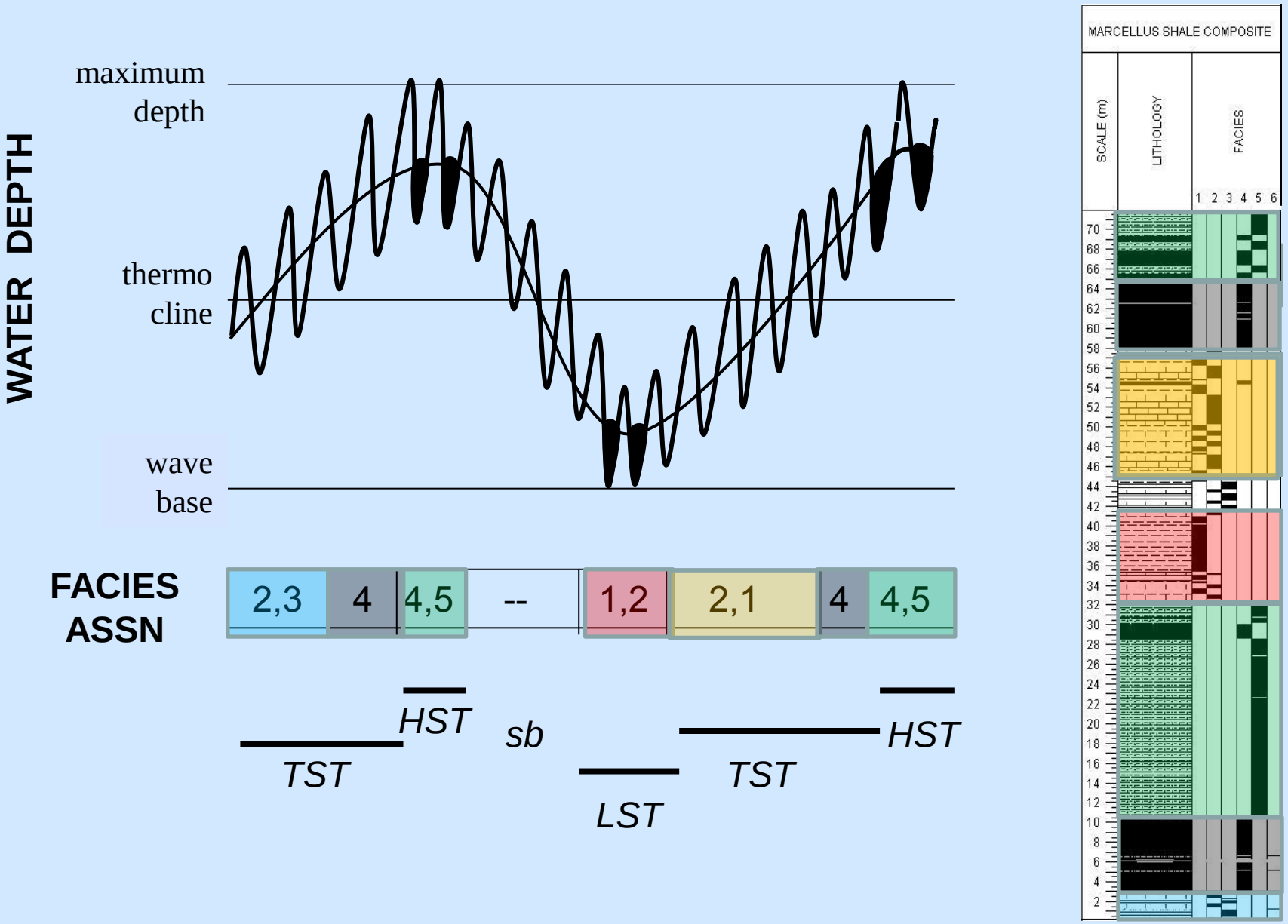
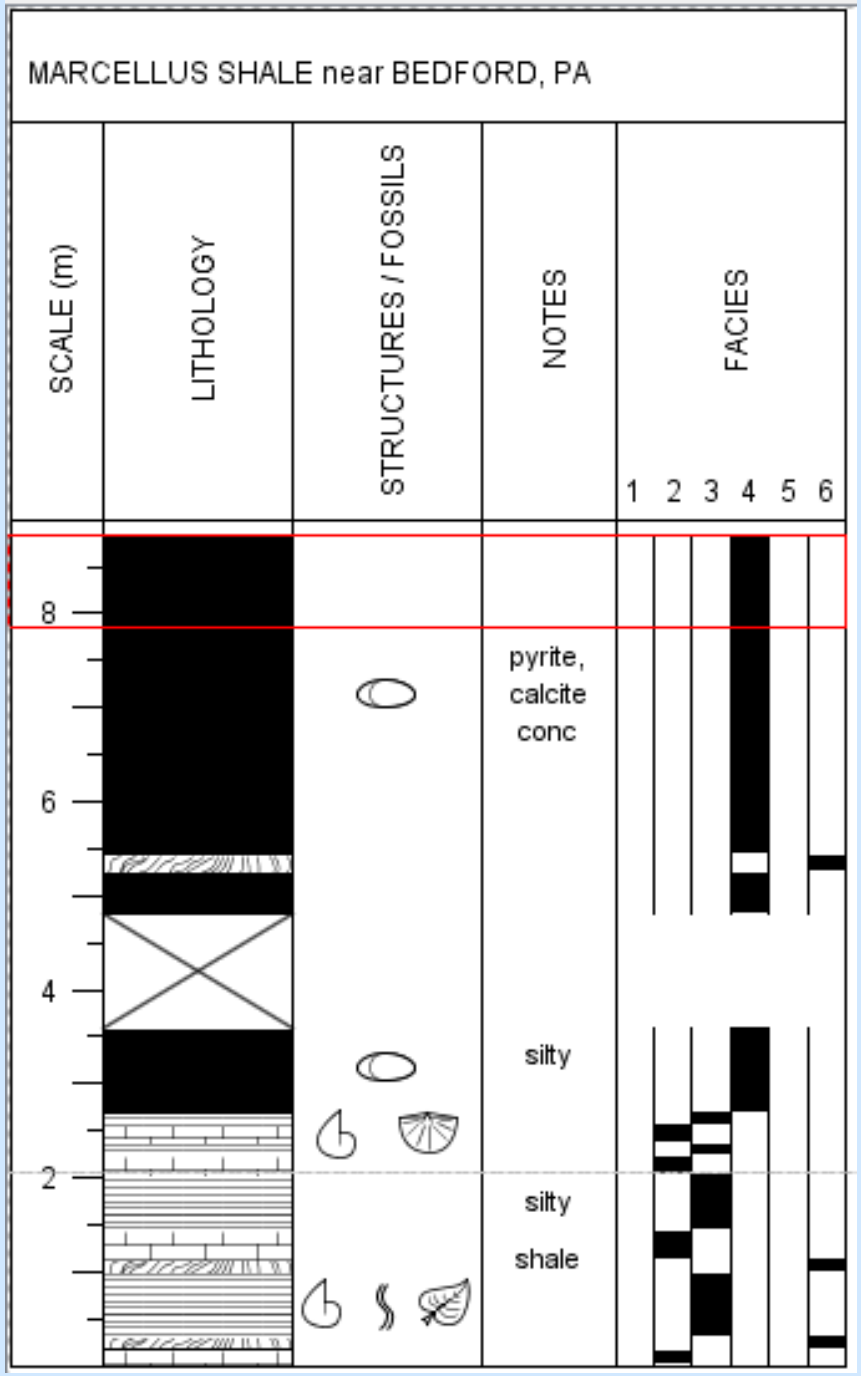
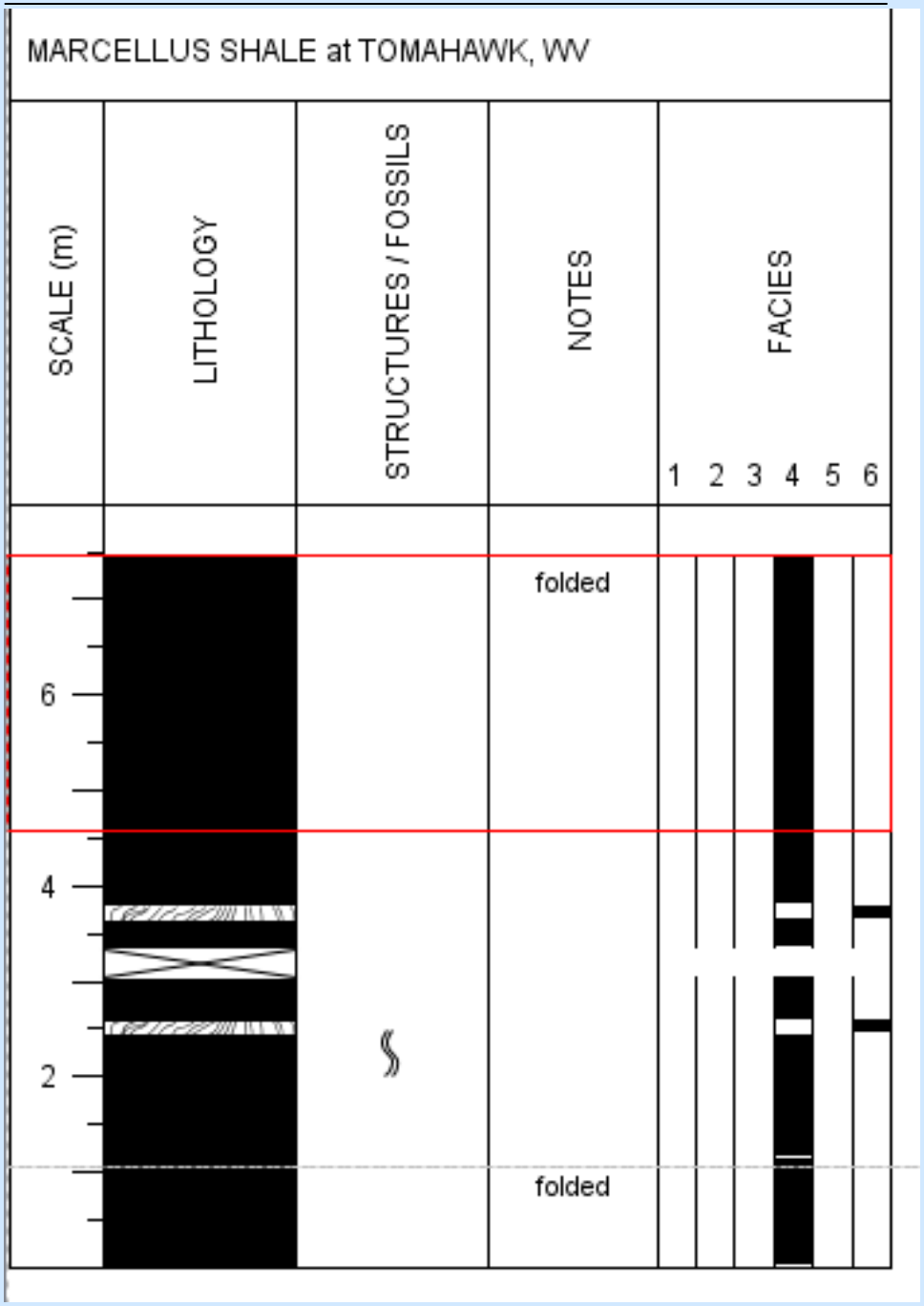
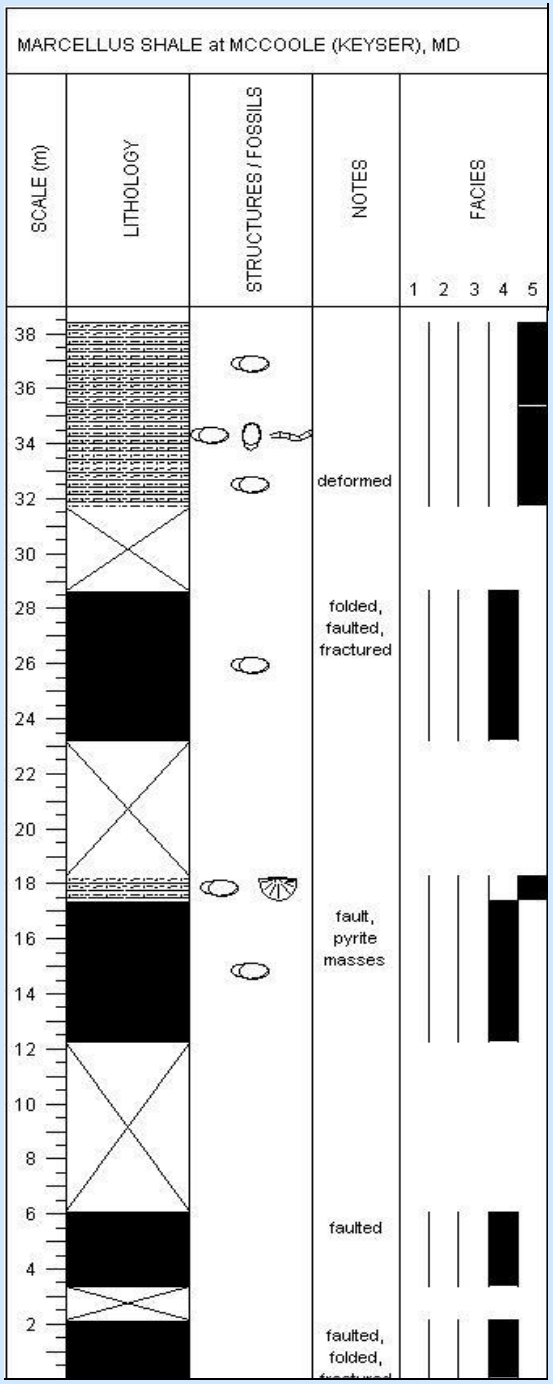

sea level
wave base
~20 m
pycnocline
~40 m
maximum
~60 m
1
light, calcareous shale
2
limestone
3
calcareous black shale
4
5
noncalc black shale, gray silty shale
lithofacies

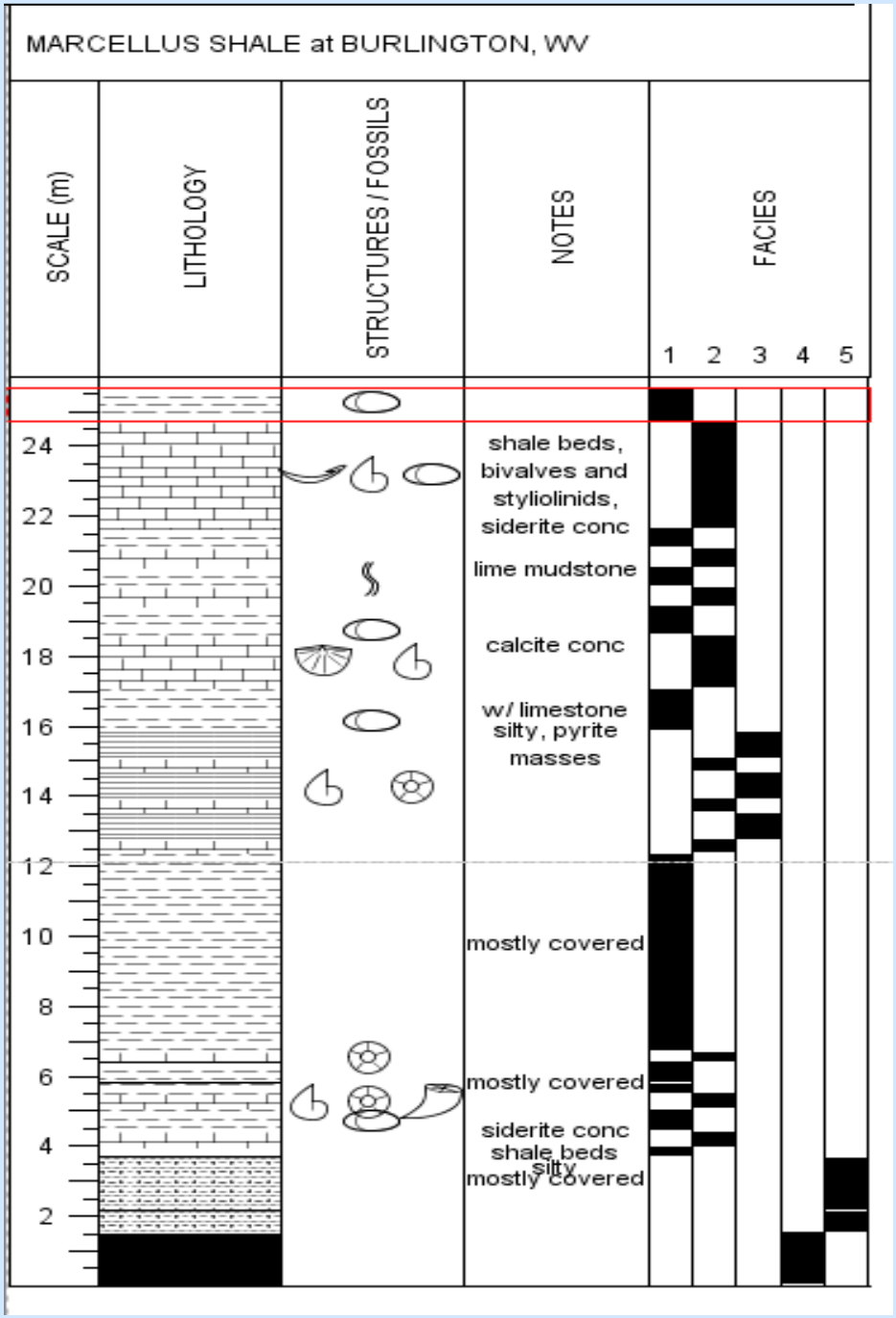

MARCELLUS SHALE COMPOSITE SECTION
SCALE (m)
LITHOLOGY
STRUCTURES / FOSSILS
FACIES
1 2 3 4 5 6
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2

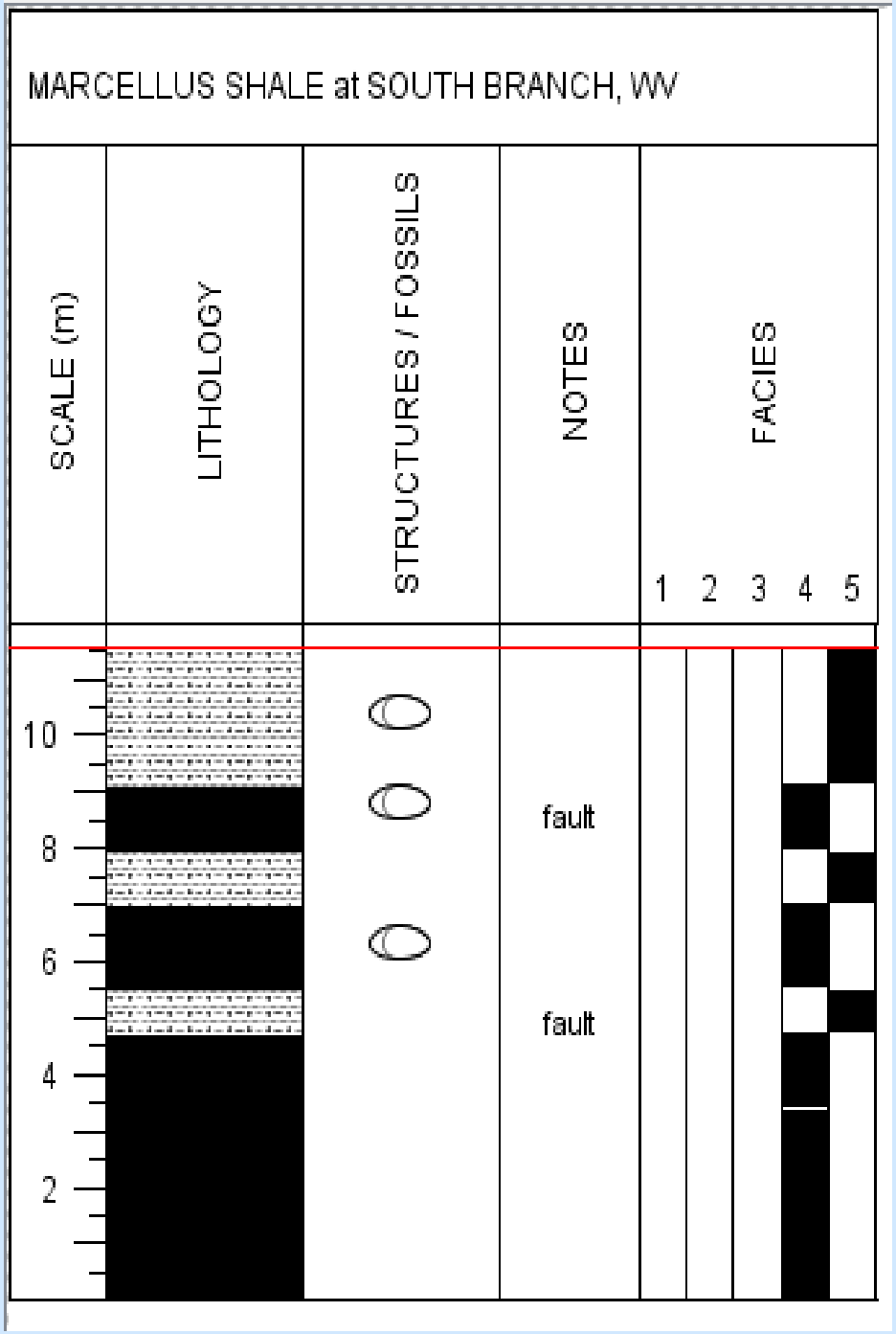

WATER DEPTH
maximum depth
thermo cline
wave base
FACIES ASSN
2,3
4
4,5
--
1,2
2,1
4
4,5
HST
sb
HST
TST
LST
TST
MARCELLUS SHALE COMPOSITE
SCALE (m)
LITHOLOGY
FACIES
1 2 3 4 5 6
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2


MARCELLUS SHALE near BEDFORD, PA
SCALE (m)
LITHOLOGY
STRUCTURES / FOSSILS
NOTES
FACIES
1 2 3 4 5 6
8
6
4
2
pyrite, calcite conc
silty
silty shale


MARCELLUS SHALE at TOMAHAWK, WV
SCALE (m)
LITHOLOGY
STRUCTURES / FOSSILS
NOTES
FACIES
1 2 3 4 5 6
6
4
2
folded
folded


MARCELLUS SHALE at MCCOOLE (KEYSER), MD
SCALE (m)
LITHOLOGY
STRUCTURES / FOSSILS
NOTES
FACIES
1 2 3 4 5
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
deformed
folded, faulted, fractured
fault, pyrite masses
faulted
faulted, folded,


MARCELLUS SHALE at BURLINGTON, WV
SCALE (m)
LITHOLOGY
STRUCTURES / FOSSILS
NOTES
FACIES
1
2
3
4
5
24
22
20
18
16
14
12
10
8
6
4
2
shale beds, bivalves and styliolinids, siderite conc
lime mudstone
calcite conc
w/ limestone silty, pyrite masses
mostly covered
mostly covered
siderite conc shale beds
silty
mostly covered


MARCELLUS SHALE at SOUTH BRANCH, WV
SCALE (m)
LITHOLOGY
STRUCTURES / FOSSILS
NOTES
FACIES
1
2
3
4
5
10
8
6
4
2
fault
fault