GSA Data Repository item 2019051

FIGURE CAPTIONS

Figure S1. Locations of Scientific Ocean Drilling (SOD) Drill Sites Leg 1 to Expedition 371. (A) Location of all SOD sites. Colors indicate the program under which the site was cored. (B) Deep Sea Drilling Project (DSDP) Legs 1–96, Sites 1–624 (http://iodp.tamu.edu/scienceops/maps/dsdpmap.pdf). (C) Ocean Drilling Program: Legs 100–203, Sites 625–1243 (http://iodp.tamu.edu/scienceops/maps/odpmap.pdf). (D) IODP [Integrated Ocean Drilling Program] Expeditions 301–348, Sites U1301–U1430 (*JOIDES Resolution*), C0001–C0022 (*Chikyu*), and M0001–M0067 (mission specific) http://iodp.tamu.edu/scienceops/maps/iodpmap.pdf. (E) IODP [International Ocean Discovery Program] Expeditions 349–371, Sites U1431–U1516 (*JOIDES Resolution*), C0023 (*Chikyu*), and M0068–M0077 (mission specific) (http://iodp.tamu.edu/scienceops/maps/iodpmap2.pdf). (F) ODP/DSDP Special Holes: K/Pg boundary, reentry cones, and long-term observatories (http://iodp.tamu.edu/scienceops/maps/vip_holes.pdf).

Figure S2. Example of difference in soft sediment cored with a rotary drill (left) and hydraulic piston core (HPC, right). The HPC was first deployed in 1979 (Leg 64, Guymas Basin). With the undisturbed sediment recovered with the HPC, it became possible to create detailed stratigraphy of paleoceanographic changes. The high resolution stratigraphy is further enhanced by drilling multiple offset cores at the same site and creating a composite depth scale (see Fig. 2).

Figure S3. Schematic representation of creation of Composite Core Depth below Seafloor (CCSF-A) to generate a complete stratigraphic section. Here three offset Holes were cored at the same site. In this hypothetical example from Expedition 361 (Hall, Hemming, LeVay et al., 2017) five cores from three Holes are shown. The depth of the cores in each hole is staggered to recover a complete undisturbed sedimentary sequence. The CSF-A scale (core depth below seafloor) is established by adding the curated core length to the core top depth (DSF). Core expansion, during decompression, can create apparent overlaps and stratigraphic reversals when data are plotted on the CSF-A scale. In addition, tops and bottoms of cores tend to be disturbed so, if possible, they are avoided in the CCSFA. To accommodate this, the CCSF-A is constructed using sequential identification of distinct horizons (dashed red lines) identified from multiple holes using whole core measurements such as magnetic susceptibility and natural gamma ray, and/or color and lithology change in the split core. The primary splice (CCSF-D) (complete splice) is constructed by combining selected intervals between tie points (yellow). This way coring gaps and disturbed section are excluded producing a complete stratigraphic section. CCSF-A depth designations are not necessarily equivalent to CCSF-D depth designations. For example, Horizon Q, green dashed lines, occurs at different CCSF-A depths in the three Holes. Brown intervals = recovered core, yellow intervals = recovered core that will become part of the splice, dashed and dotted lines = equivalent horizons, red dashed lines = tie points aligning specific, easily recognized features.

Figure S4. Digital line scan of cores from Site U1337, eastern, equatorial Pacific. These cores are more colorful than many SOD cores allowing hole to hole correlation using color. Numbers are core numbers (from Pälike, H., Lyle, M., Nishi, H., Raffi, I., Gamage, K., Klaus, A., and the Expedition 320/321 Scientists, 2010). A. Cores from the upper 50 m of the Site where the softer sediment tends to be well recovered. Red lines = base of a splice interval (tie point), yellow lines = top of the next splice interval (tie point). The composite core (splice) is shown at the bottom. B. Deeper in the section, where there is more lithification, core recovery is more challenging. When there are core gaps a complete composite splice cannot be constructed.

Figure S5. CCSF-A construction by aligning whole core natural gamma radiation (NGR) measurements from Expedition 346, Northwestern Pacific. Line colors are measurements from different Holes; Hole U1424A (orange), Hole U1424B (blue), U1424C (red). The spliced section (CCSF-A) is shown in black. Red triangles identify tie points (Tada, R., Murray, R.W., Alvarez Zarikian, C.A., and the Expedition 346 Scientists, 2015).

Figure S6. Map of the location of multiple SOD Legs (38, 81, 104, 152, 163) cored along the high magma rifted margins between Greenland and Europe (Storey et al., 2007), north of the Charlie-Gibbs Fracture Zone.

Figure S7. A. Location map of the Juan de Fuca flank drilling where the Expeditions 301 and 327 emplaced CORKs for hydrogeological, geochemical, and microbiological studies. B. Seismic cross section running WNW to ESE across the area of Fig. 3, showing the locations of ODP and IODP drill holes. The colorful surface shows the interpreted top of the volcanic crust, based on additional seismic lines, acquired as part of the site survey for drilling expeditions. Depths are plotted in units of two-way travel time (after Becker et al., 2013).

REFERENCES CITED

Becker, K., Fisher, A.T., and Tsuji, T., 2013, New packer experiments and borehole logs in upper oceanic crust: evidence for ridge-parallel consistency in crustal hydrogeologic properties: Geochemistry Geophysics Geosystems, v. 14, https://doi.org/10.1002/ggge.20201.

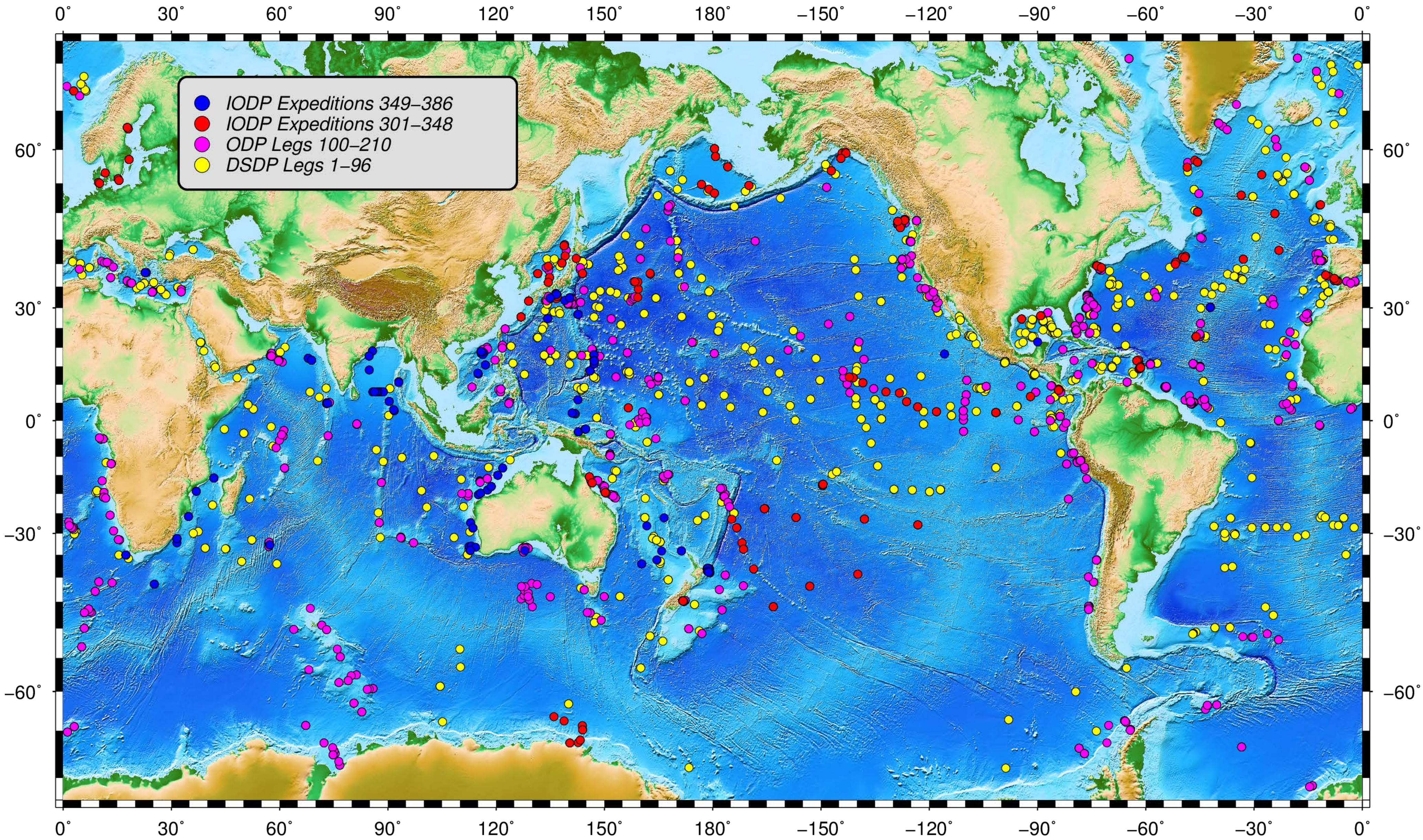
Hall, I.R., Hemming, S.R., LeVay, L.J., and the Expedition 361 Scientists, 2017, IODP Proceedings of the International Ocean Discovery Program, v. 361: https://doi.org/10.14379/iodp.proc.361.102.2017.

Pälike, H., Lyle, M., Nishi, H., Raffi, I., Gamage, K., Klaus, A., and the Expedition 320/321 Scientists, 2010, Proc. IODP, 320/321: Tokyo, IODP Management International, Inc., doi:10.2204/iodp.proc.320321.2010.

Storey, M., Duncan, R.A., and Tegner, C., 2007, Timing and duration of volcanism in the North Atlantic Igneous Province: Implications for geodynamics and links to the Iceland hotspot: Chemical Geology, v. 241, p. 264–281, https://doi.org/10.1016/j.chemgeo.2007.01.016.

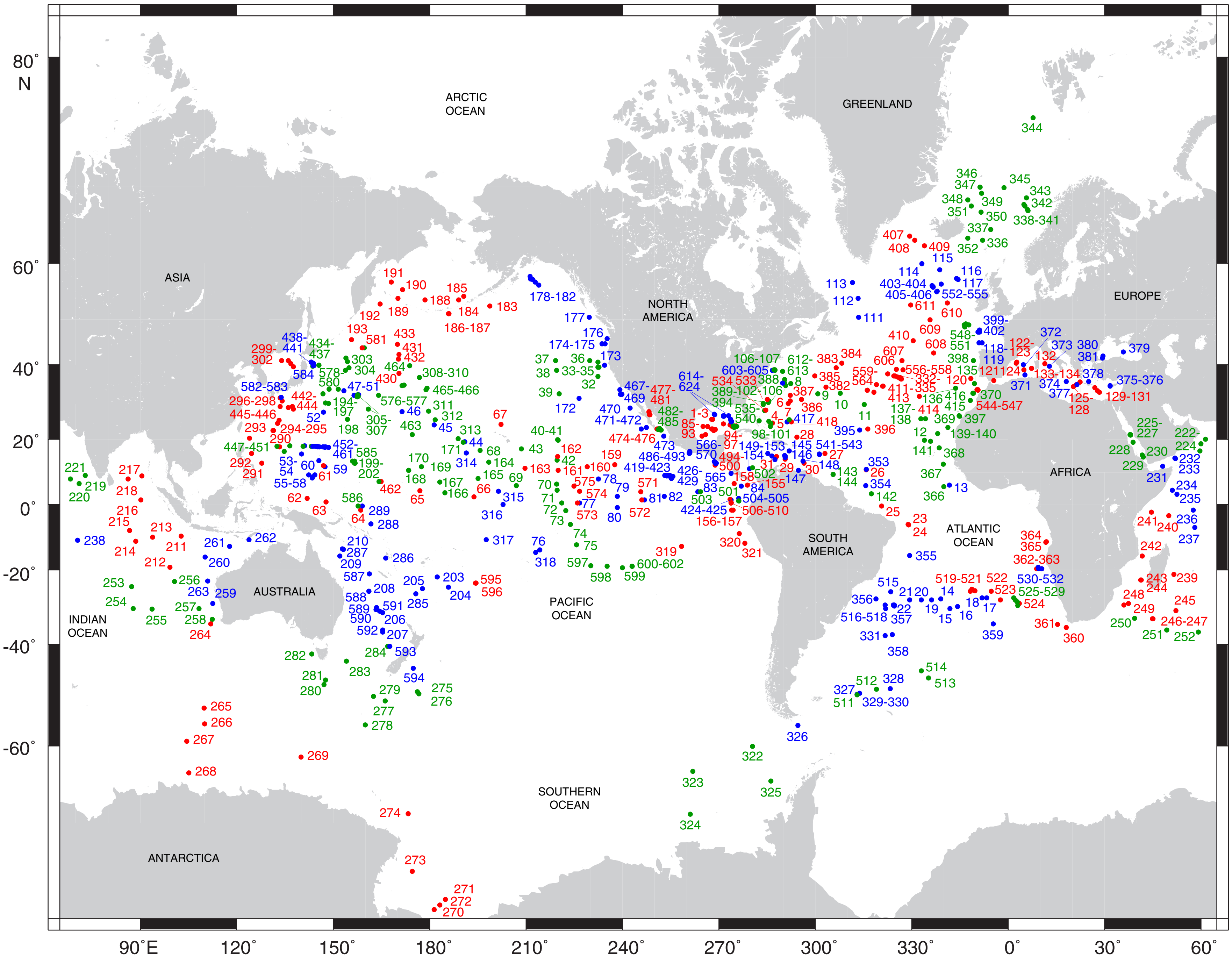
Tada, R., Murray, R.W., and Alvarez Zarikian, C.A., and the Expedition 346 Scientists, 2015, Proc. IODP, v. 346: Tokyo, IODP Management International, Inc., https://10.2204/iodp.proc.346.101.2015.

Figure S1A



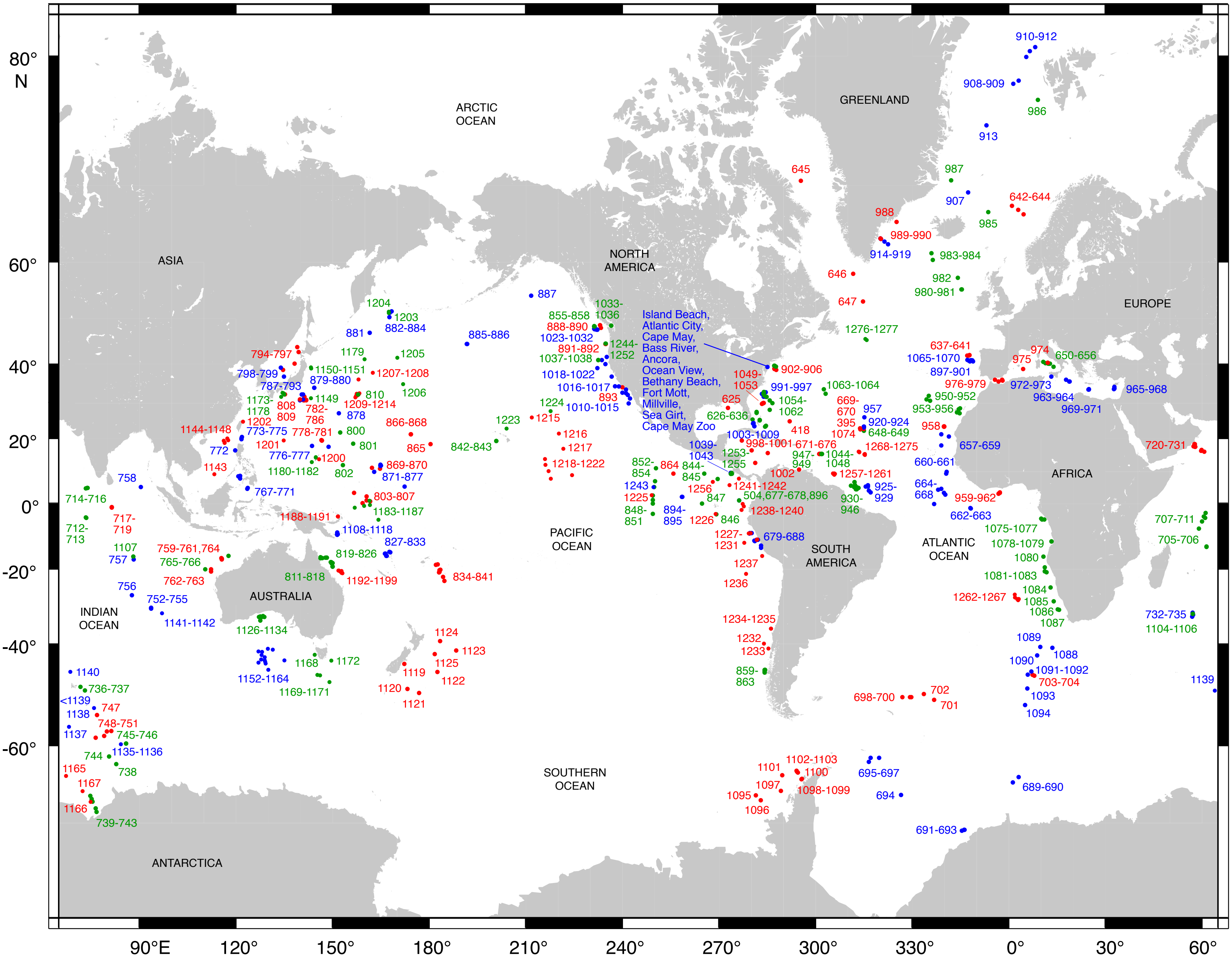
IODP Expeditions 349–386
IODP Expeditions 301–348
ODP Legs 100–210
DSDP Legs 1–96
0˚
30˚
60˚
90˚
120˚
150˚
180˚
−150˚
−120˚
−90˚
−60˚
−30˚
0˚
60˚
30˚
0˚
−30˚
−60˚

Figure S1B



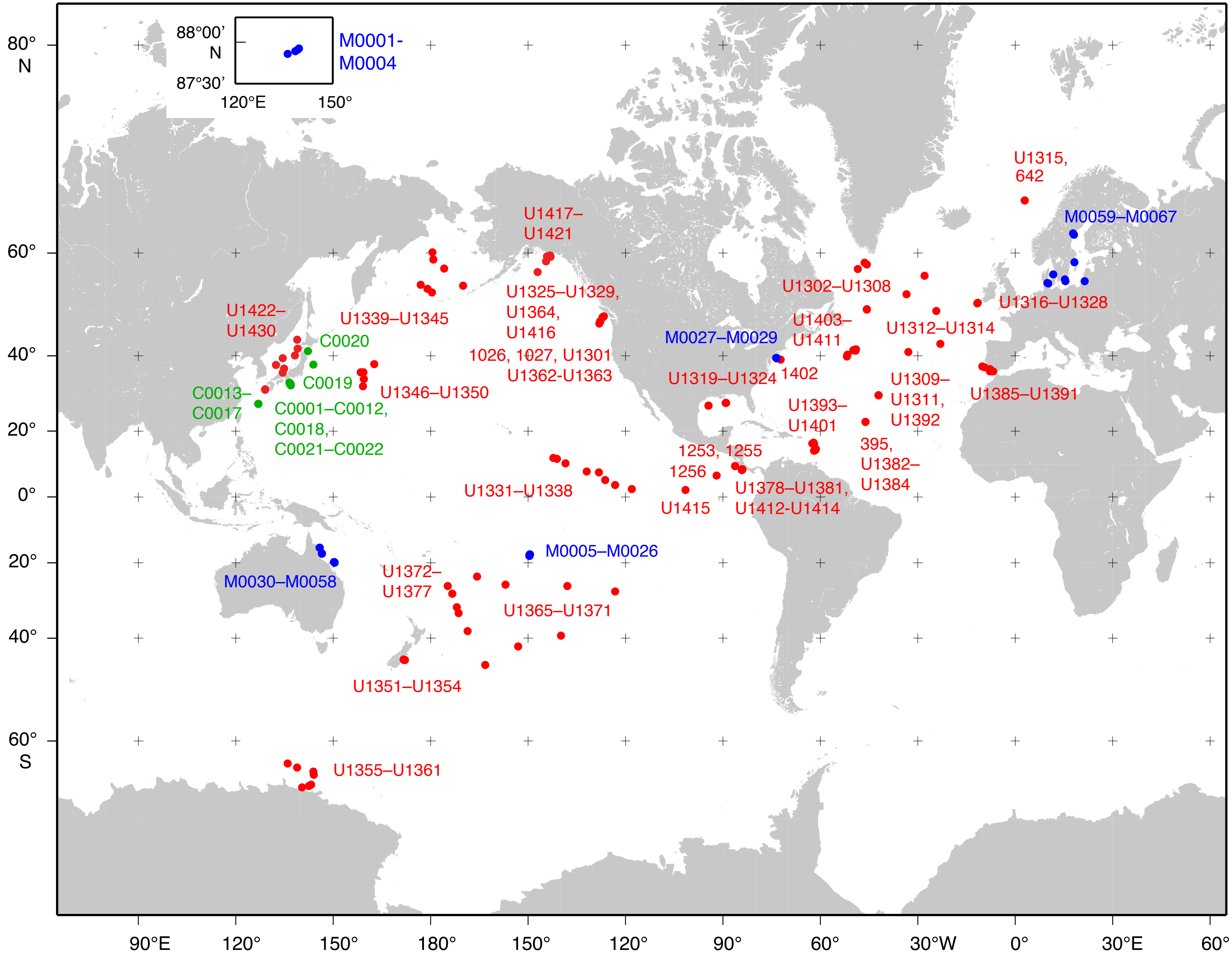
DSDP Legs 1-96, Sites 1-624

Figure S1C



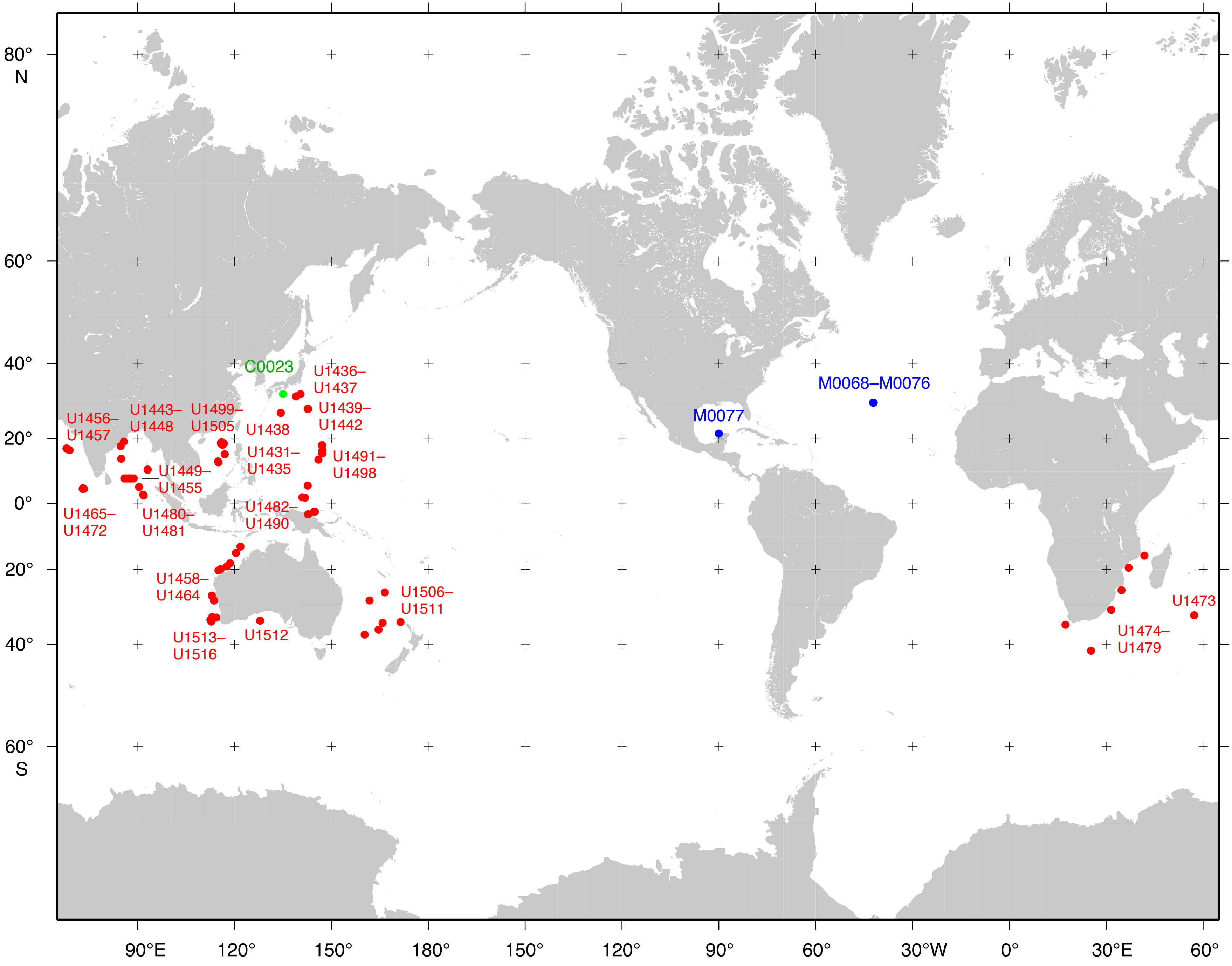
Ocean Drilling Program (1985–2003): Legs 100–210, Sites 625–1277

Figure S1D



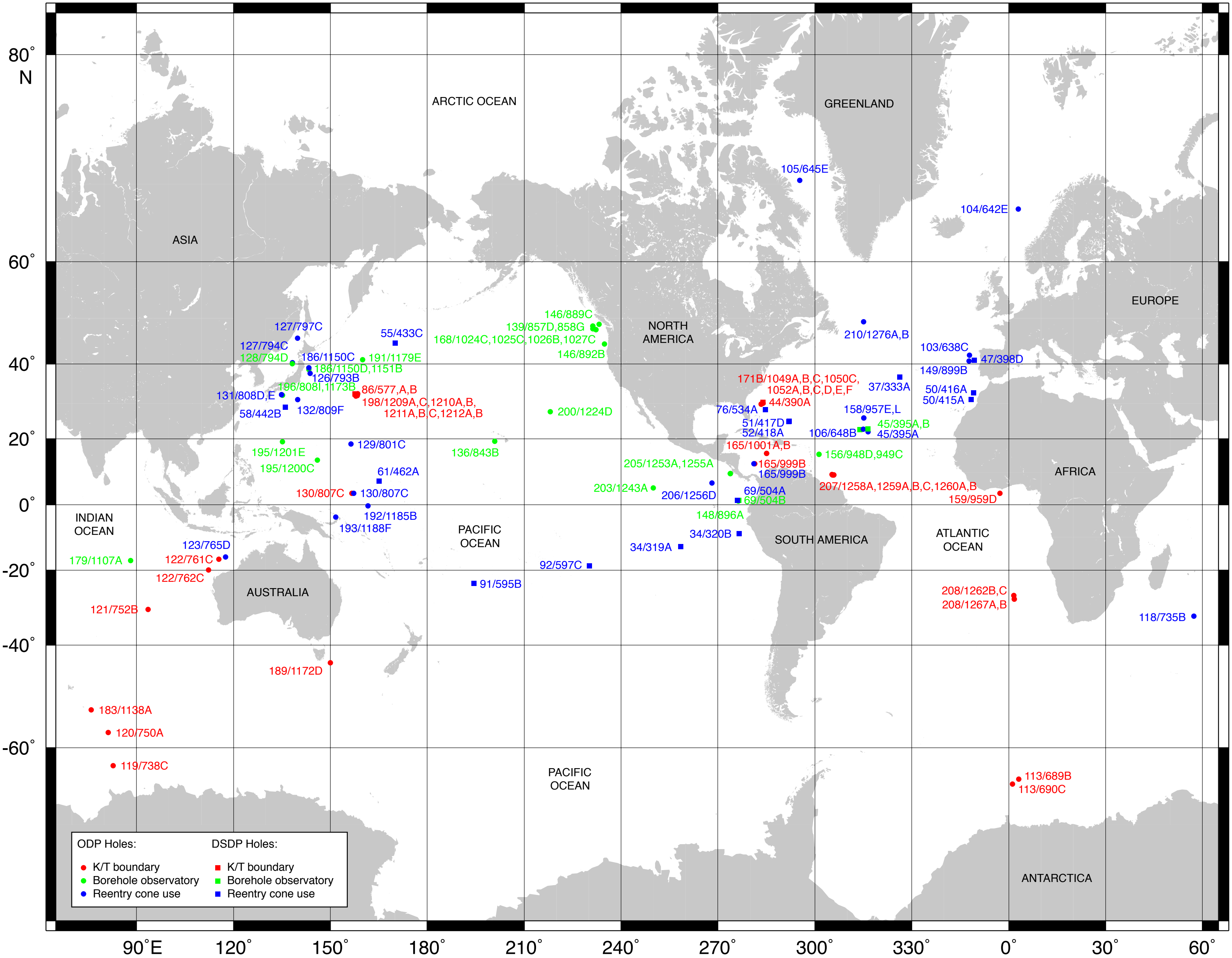
IODP Expeditions 301–348, Sites C0001–C0022 (●), M0001–M0067 (●), U1301–U1430 (●)

Figure S1E



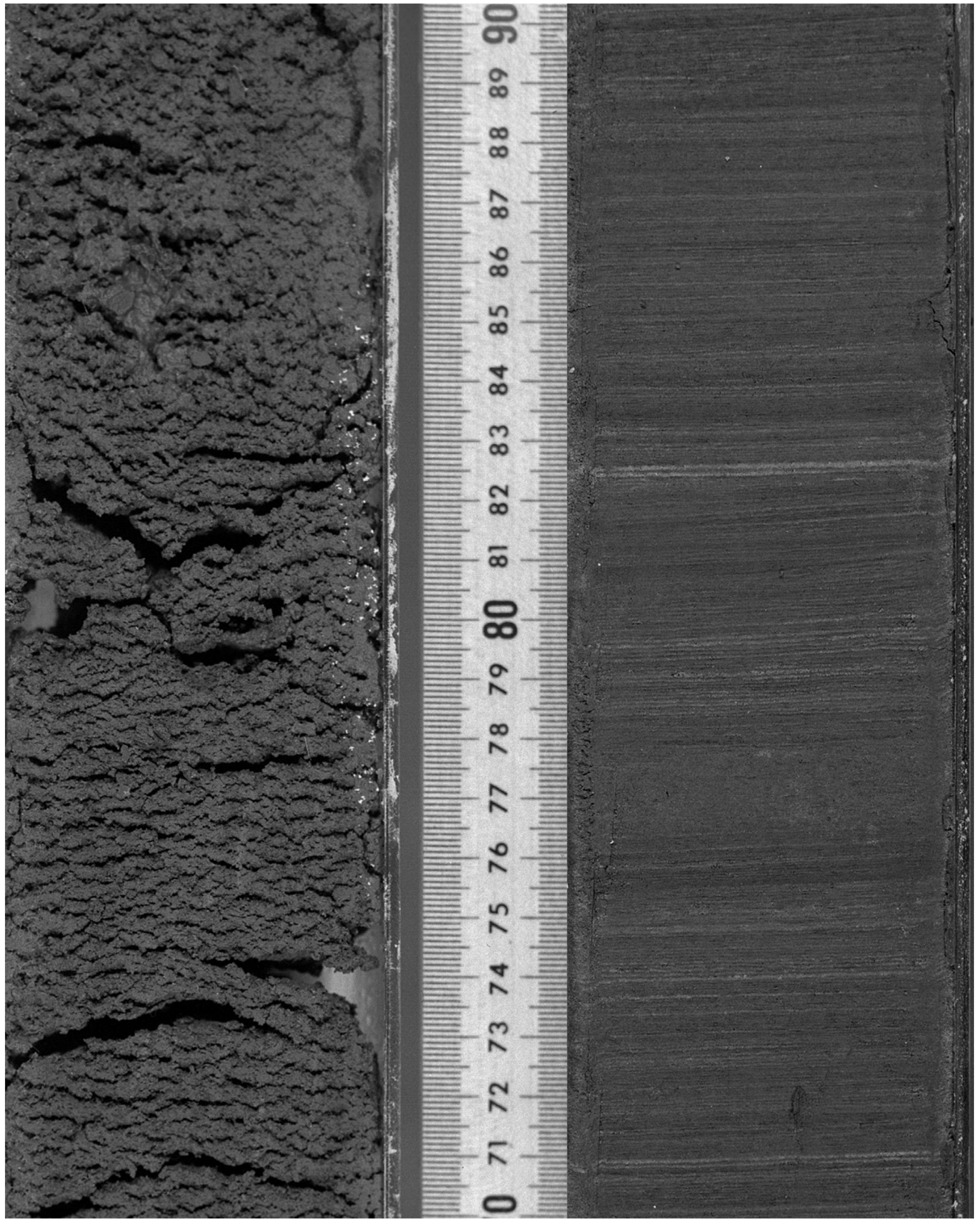
IODP Expeditions 349–371, Sites C0023 (●), M0068–M0077 (●), U1431–U1516 (●)

Figure S1F



80° N
60°
40°
20°
0°
-20°
-40°
-60°
90°E
120°
150°
180°
210°
240°
270°
300°
330°
0°
30°
60°
ARCTIC OCEAN
GREENLAND
ASIA
EUROPE
NORTH AMERICA
AFRICA
SOUTH AMERICA
AUSTRALIA
ANTARCTICA
INDIAN OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
105/645E
104/642E
146/889C
139/857D,858G
168/1024C,1025C,1026B,1027C
146/892B
210/1276A,B
103/638C
47/398D
149/899B
127/797C
55/433C
127/794C
128/794D
186/1150C
191/1179E
186/1150D,1151B
126/793B
196/808I,1173B
86/577,A,B
198/1209A,C,1210A,B,
1211A,B,C,1212A,B
131/808D,E
58/442B
132/809F
200/1224D
171B/1049A,B,C,1050C,
1052A,B,C,D,E,F
44/390A
37/333A
50/416A
50/415A
76/534A
51/417D
52/418A
158/957E,L
106/648B
45/395A,B
45/395A
195/1201E
129/801C
136/843B
165/1001A,B
156/948D,949C
195/1200C
61/462A
205/1253A,1255A
165/999B
165/999B
130/807C
130/807C
203/1243A
206/1256D
69/504A
69/504B
207/1258A,1259A,B,C,1260A,B
159/959D
192/1185B
193/1188F
148/896A
34/320B
34/319A
123/765D
179/1107A
122/761C
122/762C
92/597C
91/595B
208/1262B,C
208/1267A,B
121/752B
118/735B
189/1172D
183/1138A
120/750A
119/738C
113/689B
113/690C
ODP Holes:
K/T boundary
Borehole observatory
Reentry cone use
DSDP Holes:
K/T boundary
Borehole observatory
Reentry cone use

Figure S2



Rotary cored

Piston cored

Figure S3

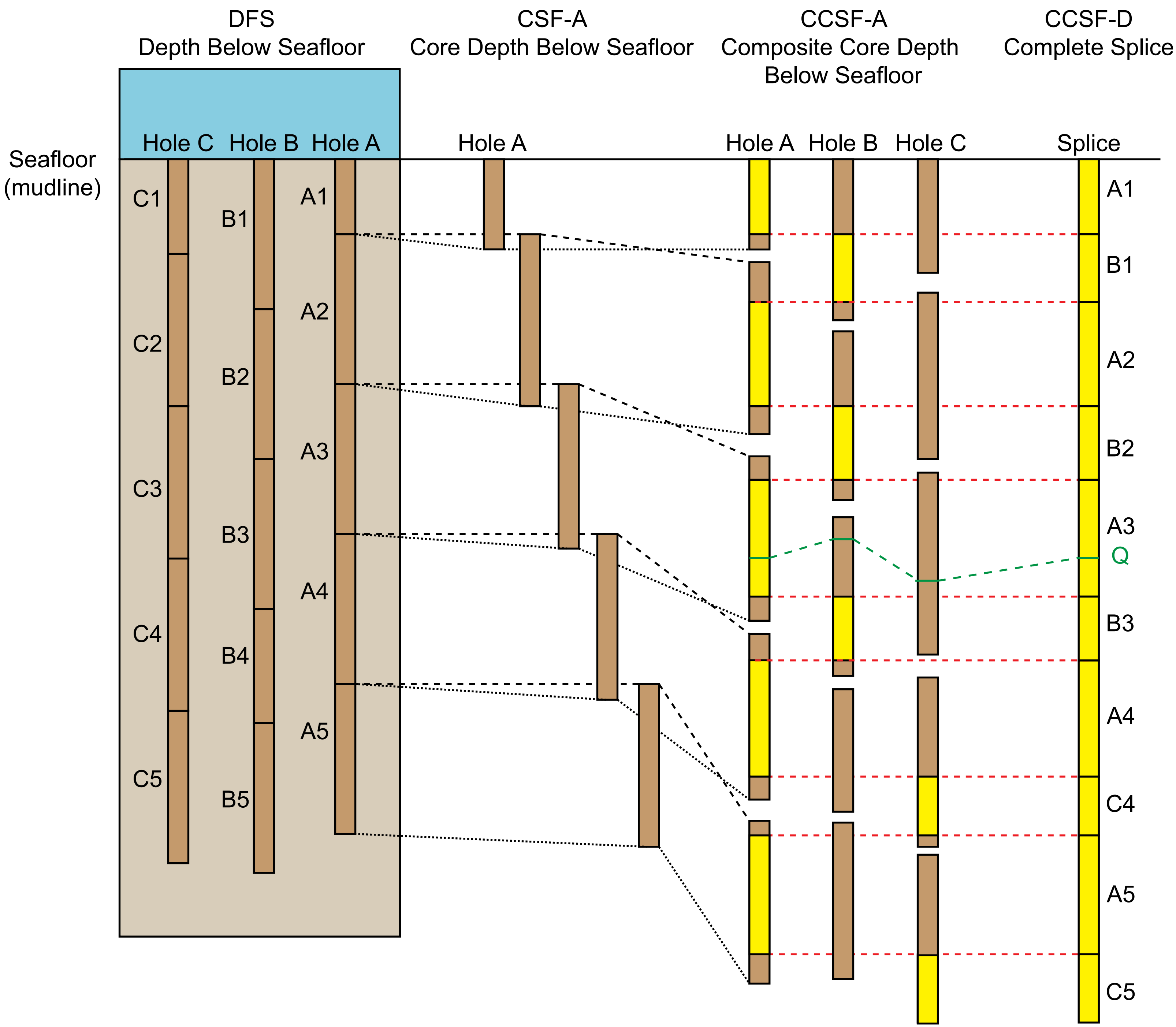

DFS
Depth Below Seafloor
CSF-A
Core Depth Below Seafloor
CCSF-A
Composite Core Depth
Below Seafloor
CCSF-D
Complete Splice
Hole C
Hole B
Hole A
Hole A
Hole A
Hole B
Hole C
Splice
Seafloor
(mudline)
C1
C2
C3
C4
C5
B1
B2
B3
B4
B5
A1
A2
A3
A4
A5
A1
B1
A2
B2
A3
Q
B3
A4
C4
A5
C5

Figure S4A

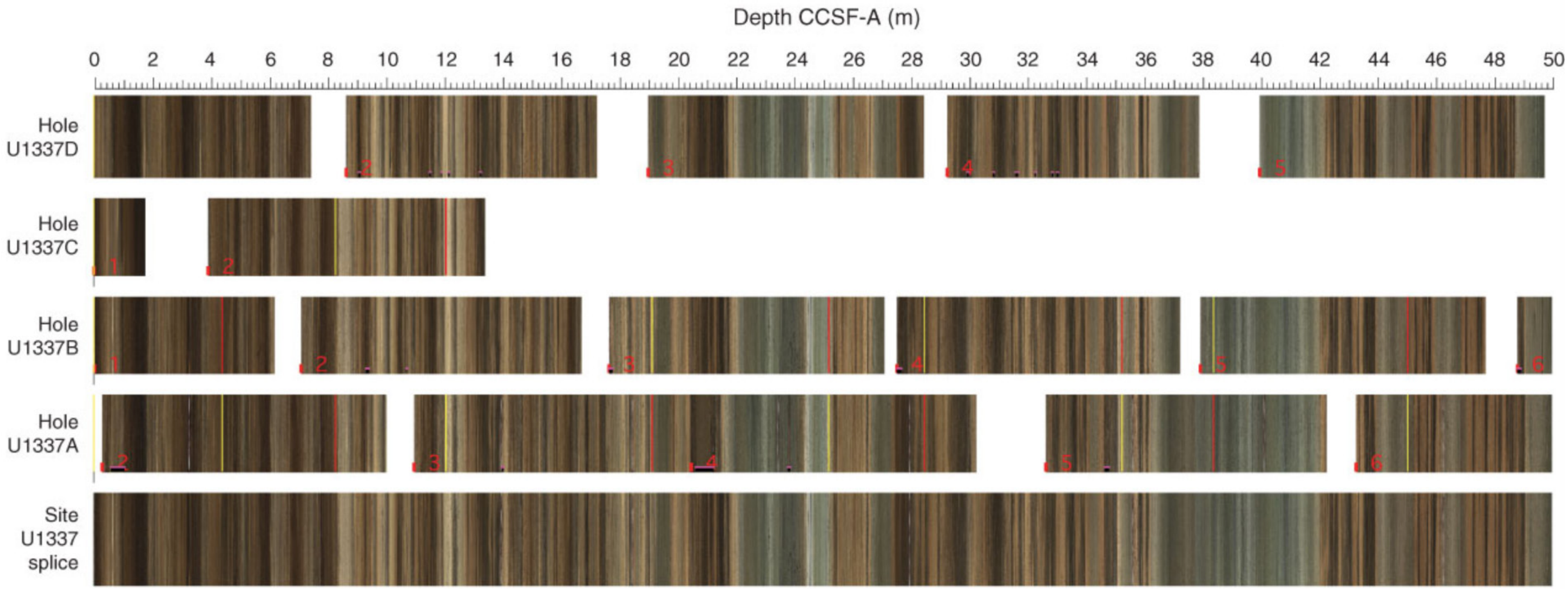
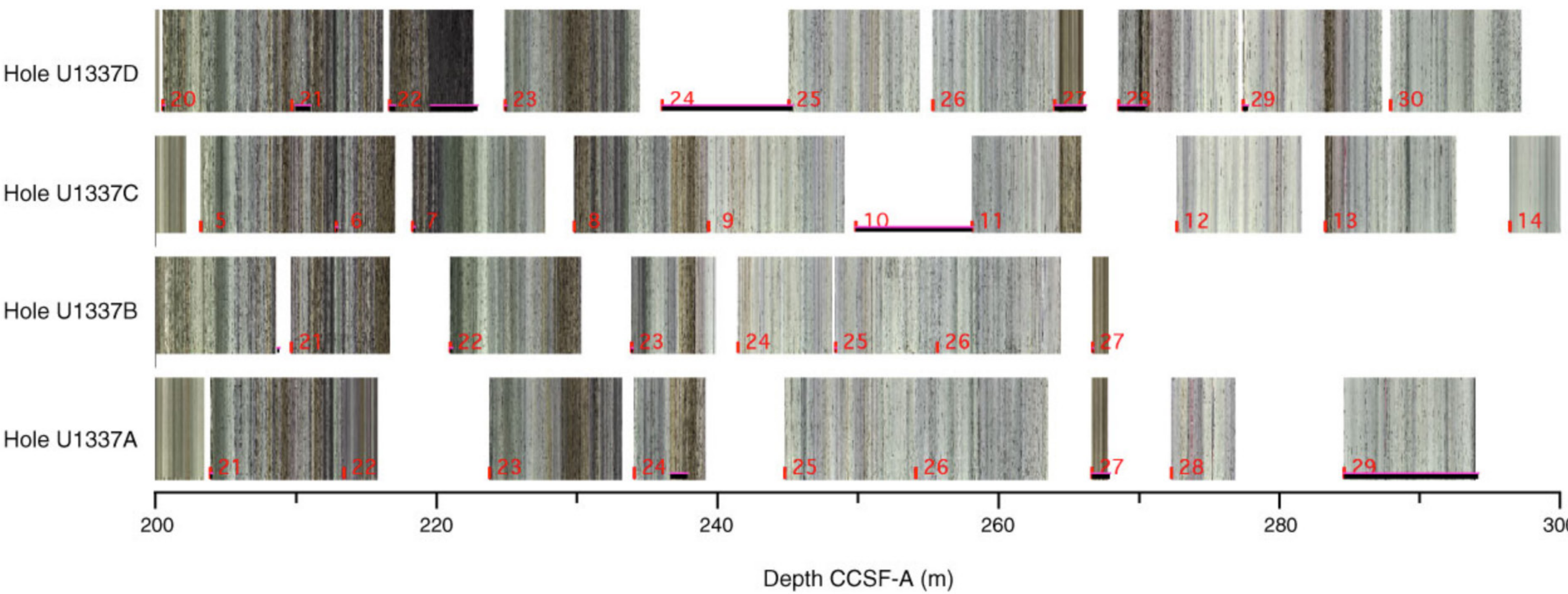
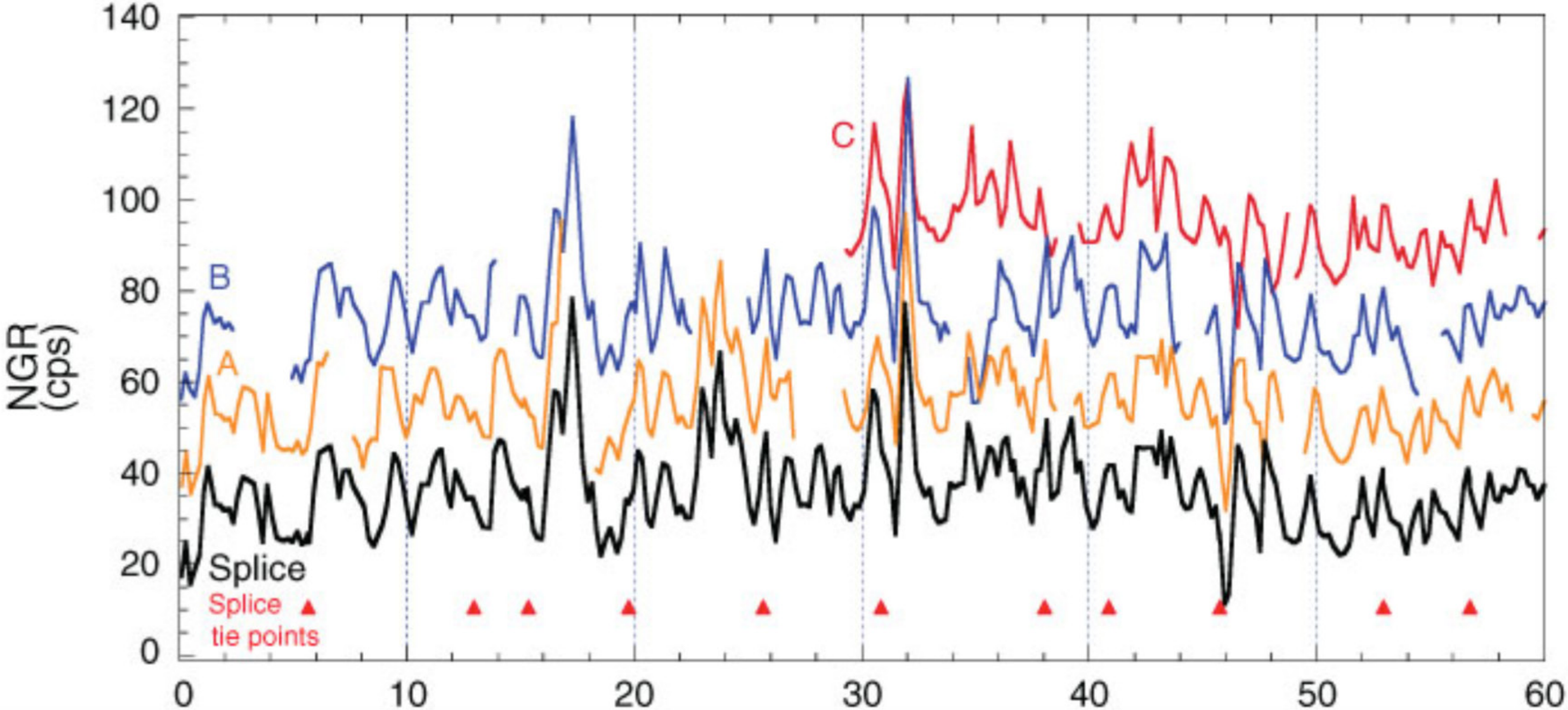

Depth CCSF-A (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
Hole U1337D
Hole U1337C
Hole U1337B
Hole U1337A
Site U1337 splice

Figure S4B



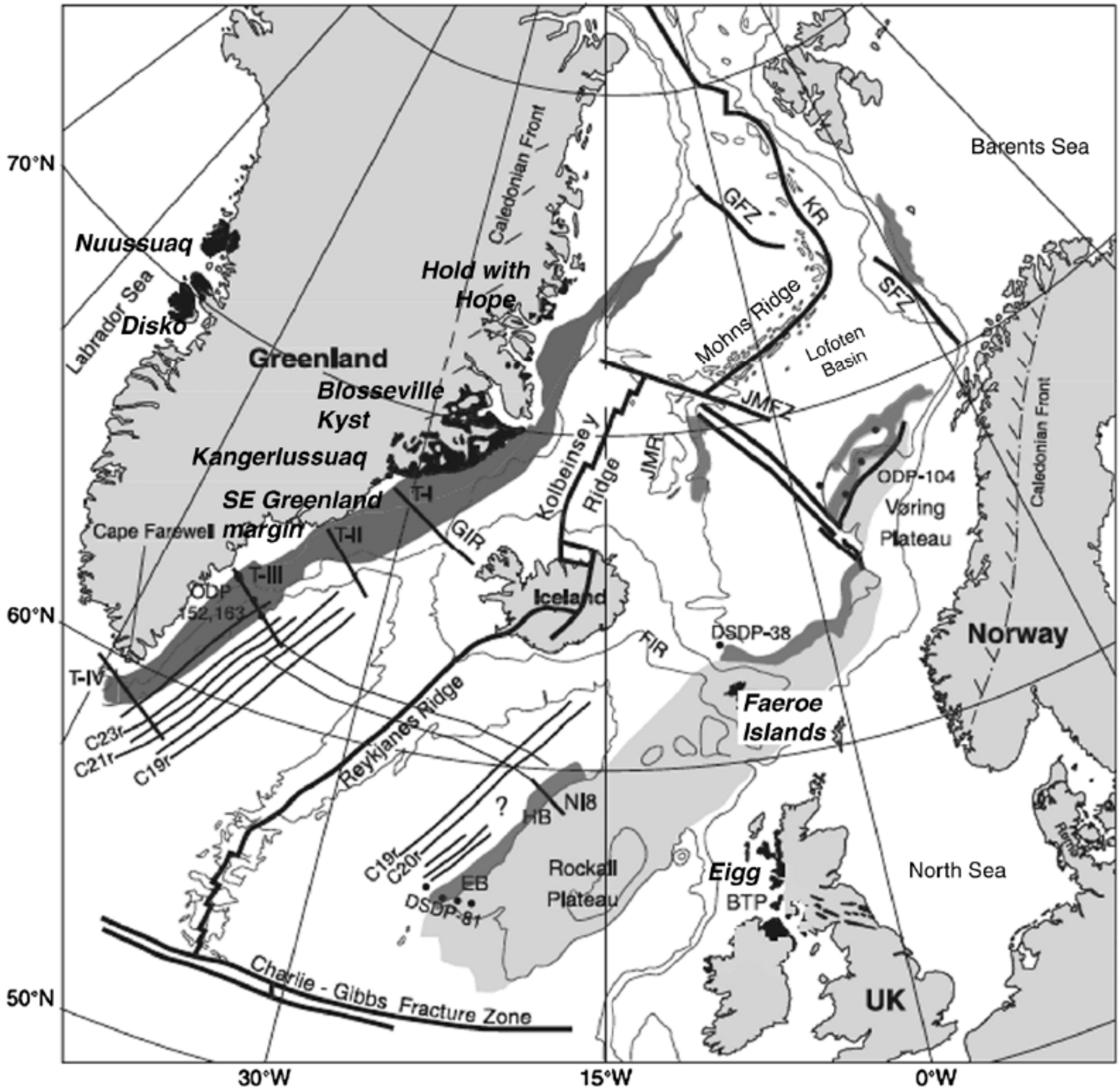
Hole U1337D
20
21
22
23
24
25
26
27
28
29
30
Hole U1337C
5
6
7
8
9
10
11
12
13
14
Hole U1337B
21
22
23
24
25
26
27
Hole U1337A
21
22
23
24
25
26
27
28
29
200
220
240
260
280
300
Depth CCSF-A (m)

Figure S5



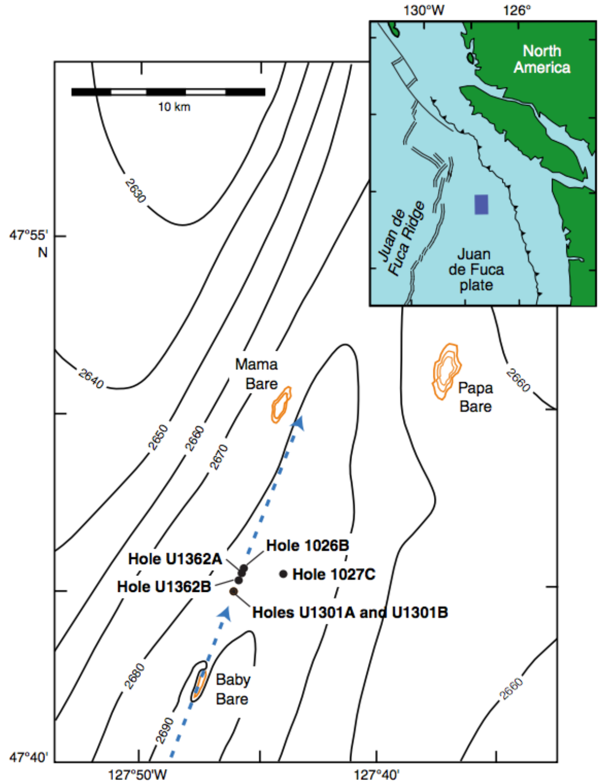
140
120
100
80
60
40
20
0
NGR (cps)
B
A
C
Splice
Splice tie points
0
10
20
30
40
50
60

Figure S6

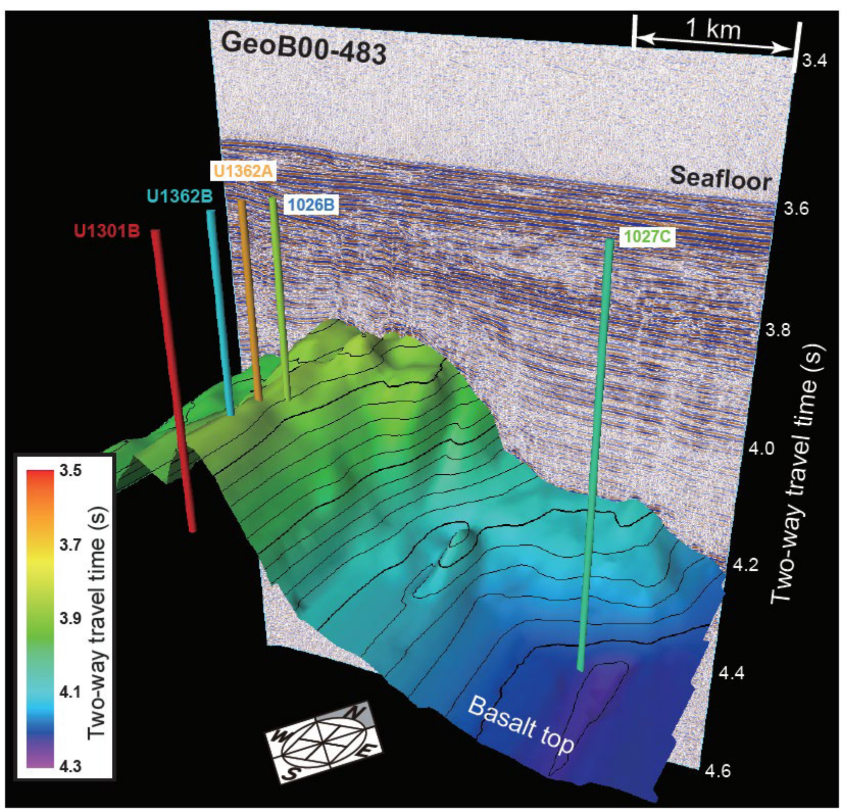


70°N
60°N
50°N
30°W
15°W
0°W
Nuussuaq
Disko
Labrador Sea
Greenland
Hold with Hope
Caledonian Front
Blosseville Kyst
Kangerlussuaq
SE Greenland margin
Cape Farewell
ODP 152,163
T-I
T-II
T-III
T-IV
GIR
C23r
C21r
C19r
Reykjanes Ridge
Kolbeinsey Ridge
Iceland
JMR
JMFZ
Mohns Ridge
GFZ
KR
SFZ
Lofoten Basin
Barents Sea
ODP-104
Vøring Plateau
Caledonian Front
Norway
DSDP-38
FIR
Faeroe Islands
NI8
HB
?
C19r
C20r
EB
DSDP-81
Rockall Plateau
Eigg
BTP
North Sea
UK
Charlie - Gibbs Fracture Zone

Figure S7


10 km
130°W
126°
52° N
50°
48°
46°
North America
Juan de Fuca Ridge
Juan de Fuca plate
47°55' N
47°40'
127°50'W
127°40'
2630
2640
2650
2660
2670
2680
2690
Mama Bare
Papa Bare
Baby Bare
Hole U1362A
Hole U1362B
Hole 1026B
Hole 1027C
Holes U1301A and U1301B

A.


GeoB00-483
1 km
Seafloor
U1362A
U1362B
U1301B
1026B
1027C
Basalt top
3.4
3.6
3.8
4.0
4.2
4.4
4.6
Two-way travel time (s)
3.5
3.7
3.9
4.1
4.3
Two-way travel time (s)
N
E
S
W

B.

TABLE S1. LINKS TO A COMPLETE LISTING OF LEGS AND EXPEDITIONS

url	Data available
http://www.deepseadrilling.org/	Complete listing and documents for the Initial Results, Technical Notes, Technical Reports and a brief history of DSDP. Included in the Initial Results are site descriptions, when they were drilled and their location, and initial post-leg, peer-reviewed science results.
http://www-odp.tamu.edu/publications/pubs.htm	Complete listing and documents for scientific prospectus, preliminary report, the Initial Results (written onboard the ship), Scientific Results (peer-reviewed, shore-based studies, usually written within 2 years after the leg), for Legs 101-210, cumulative index and citations.
http://publications.iodp.org/	Complete listing and documents for scientific prospectus, preliminary report, Proceedings (written onboard the ship), and citations to peer-reviewed, shore-based studies, for Expeditions since Expedition 301.