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Comparison of Sedimentary Processes in Twenty-Two Modern Submarine Canyons along the Northern California Margin*

Esther J. Sumner[1] and Charles K. Paull[2]

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Abstract

Sedimentary processes and resultant facies in submarine canyons are poorly understood because canyons are bathymetrically complex and sedimentologically heterogeneous environments. Thus, it has proven difficult to study submarine canyons using traditional wire-line coring techniques. This study uses a novel vibracoring system deployed using a remotely operated vehicle that enables precise core location (latitude, longitude and altitude above thalweg) and can capture coarse-grained sediments. Whilst previous studies have focused on individual canyons, this study makes use of 127 cores from 22 canyons along a 600 km stretch of the California margin enabling recognition of different canyon types and identification of the processes that control them. Canyons can be divided into two types: coarse-grained canyons and fine-grained canyons. Coarse-grained canyons have a sharply defined thalweg-channel filled with chaotic sands and gravels, episodic movement of these coarse sediments maintains and probably actively erodes the thalweg-channel; finer grained sands and silts drape the canyon walls. Fine-grained canyons have a poorly defined thalweg-channel and are filled with fine-grained sands and silts that anneal preexisting channel topography and drape the canyon walls. Coarse-grained canyons are formed where the canyon head intersects the local littoral cell, whereas fine-grained canyons have heads on the continental shelf. Facies type, grain size and composition (% sand) are strongly constrained by altitude above the thalweg and much less by distance down canyon. Whereas the grain size of fine-grained facies comprising sands and silts fines slightly down canyon, the sands and gravels in the canyon axis show no such fining. This lack of fining may reflect episodic remobilization of material during numerous sediment transport events. Infilling of canyons by frequent small events and flushing by occasional large events has been inferred for many decades. Two of the canyons studied have areas devoid of canyon fill, where bedrock is exposed. High-resolution bathymetry within one of these canyons reveals that scouring of the previous canyon fill, presumably by exceptionally high-energy flow events, has exposed the bedrock. This study reveals the spectrum of processes operating in modern canyons are controlled by the type and volume of sediment available and whether the canyon can tap these supplies, which is strongly dependent on the position of the canyon head.

Comparison of Sedimentary Processes in Twenty-Two Modern Submarine Canyons Along the Northern California Margin

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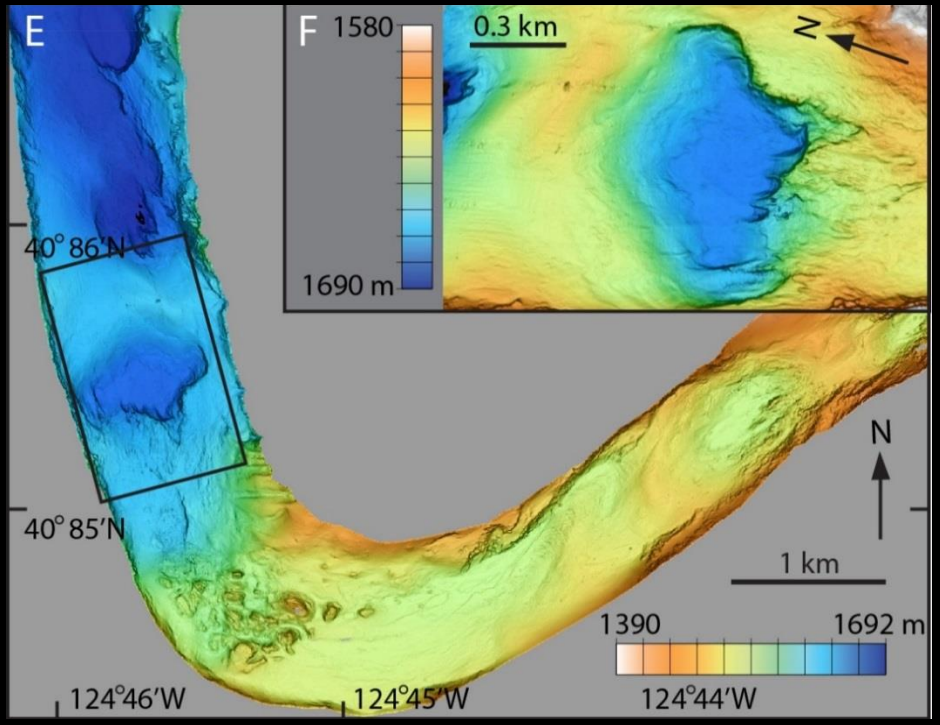
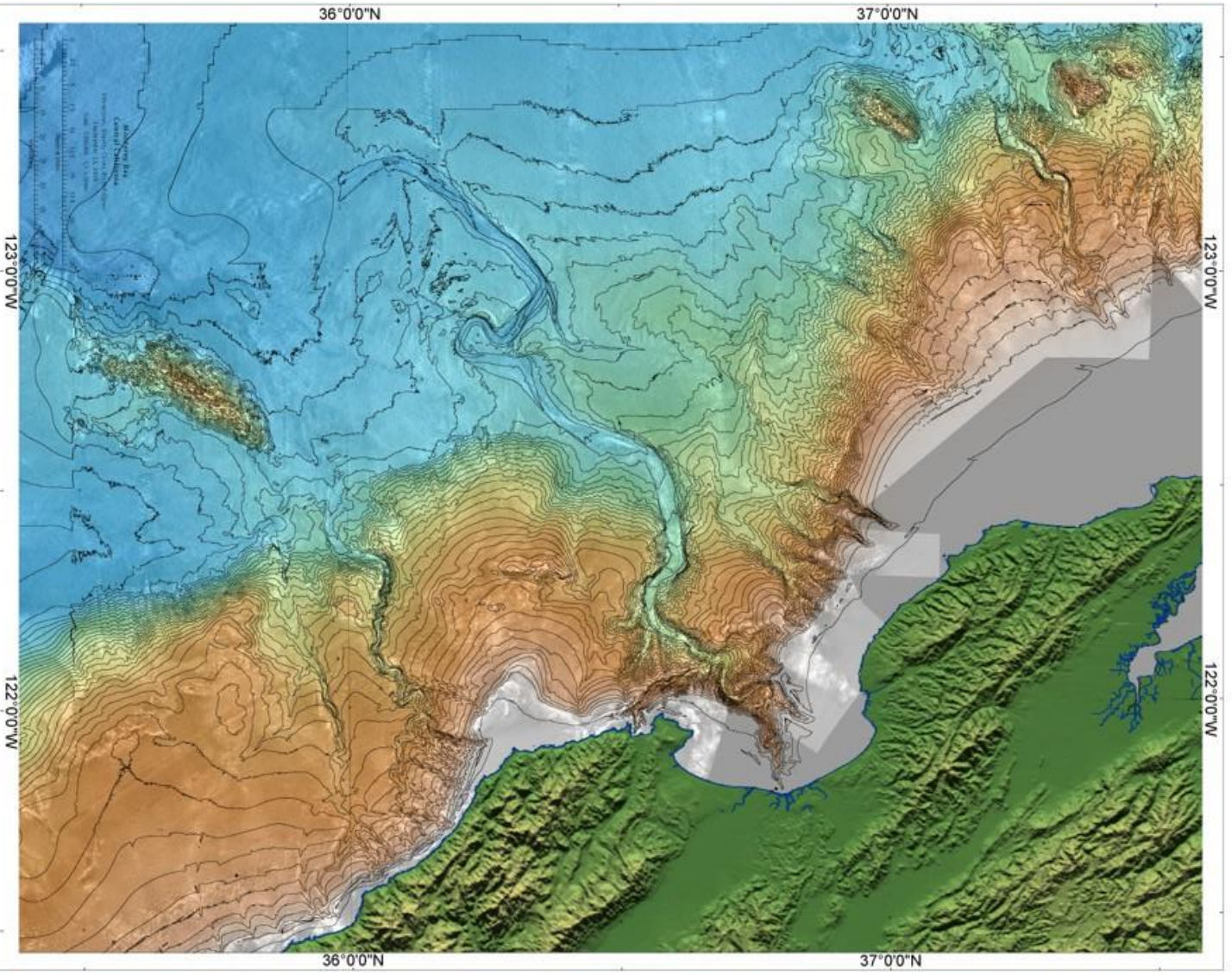
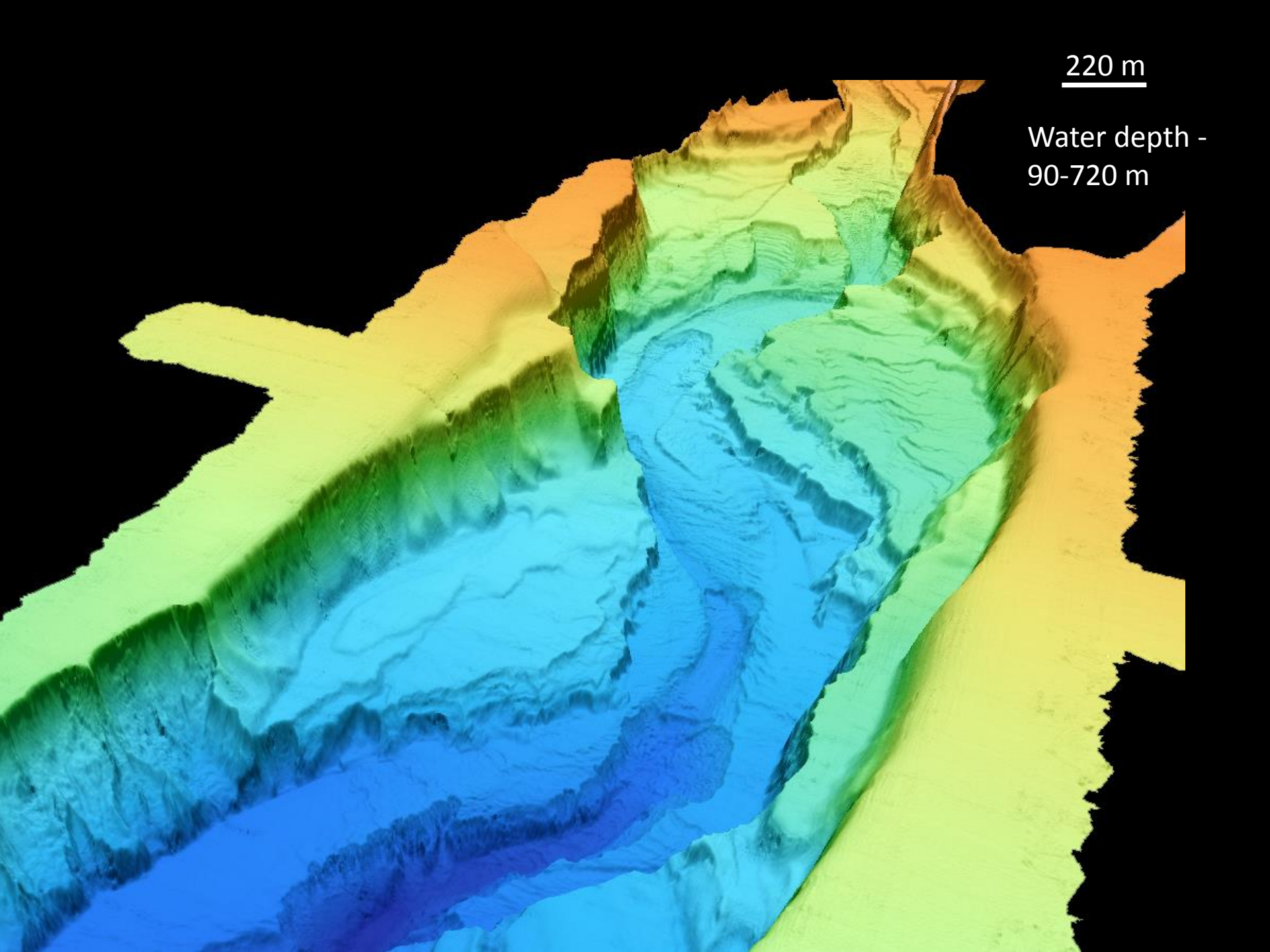
1. University of Southampton, UK. 2. Monterey Bay Aquarium Research Institute, USA.




36°0'0"N
37°0'0"N
123°0'0"W
122°0'0"W


LLOYTRON
Rechargeable
ACCU POWER
LLOYTRON
Rechargeable
ACCU POWER
LLOYTRON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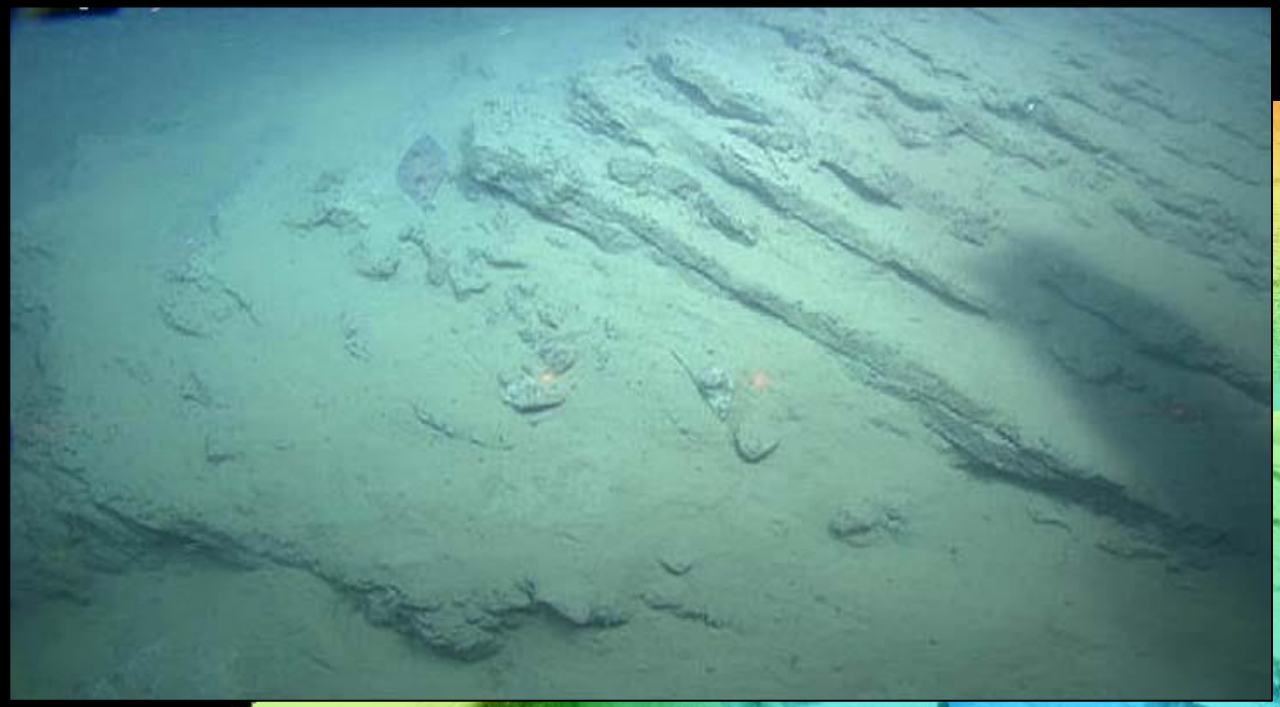
Water depth -
90-720 m

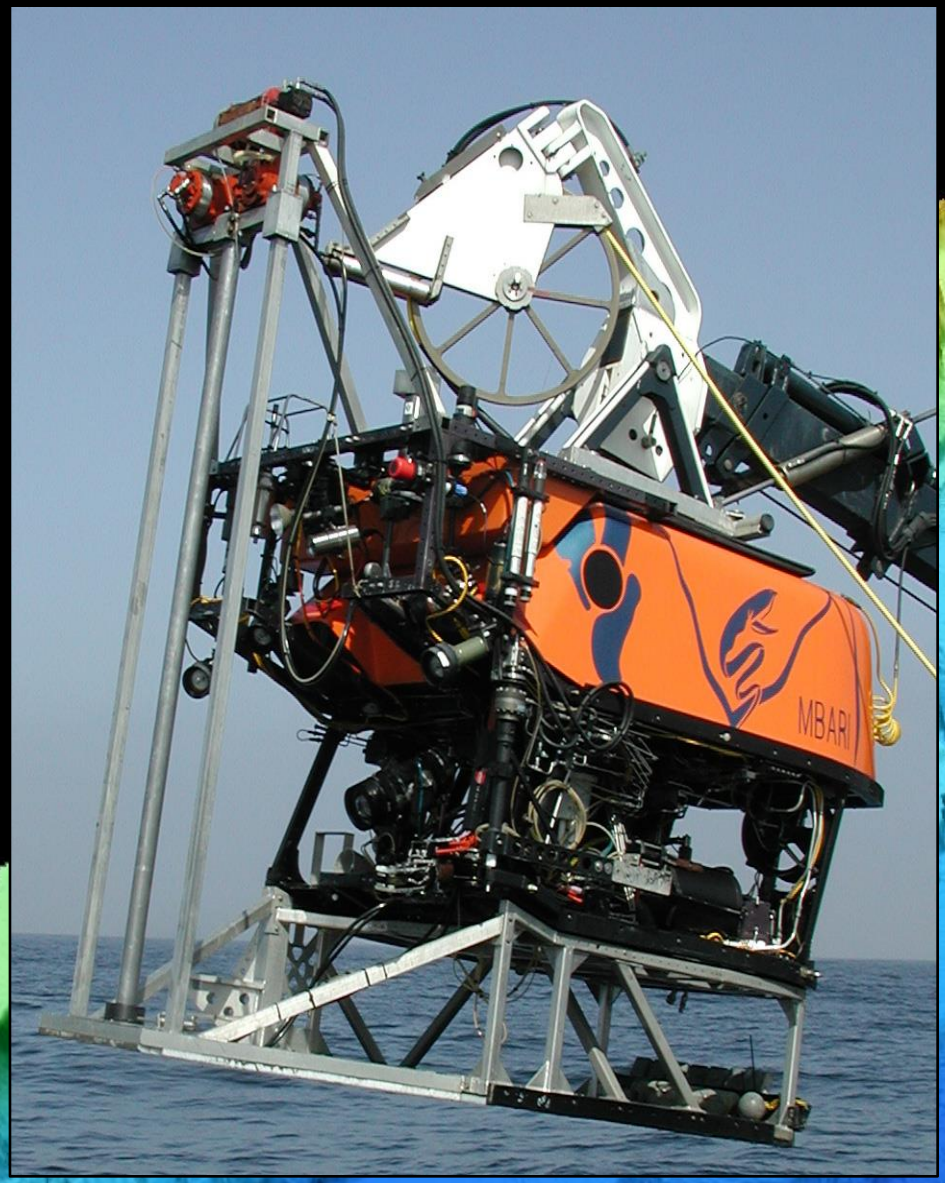


220 m

Water depth -
90-720 m

220 m

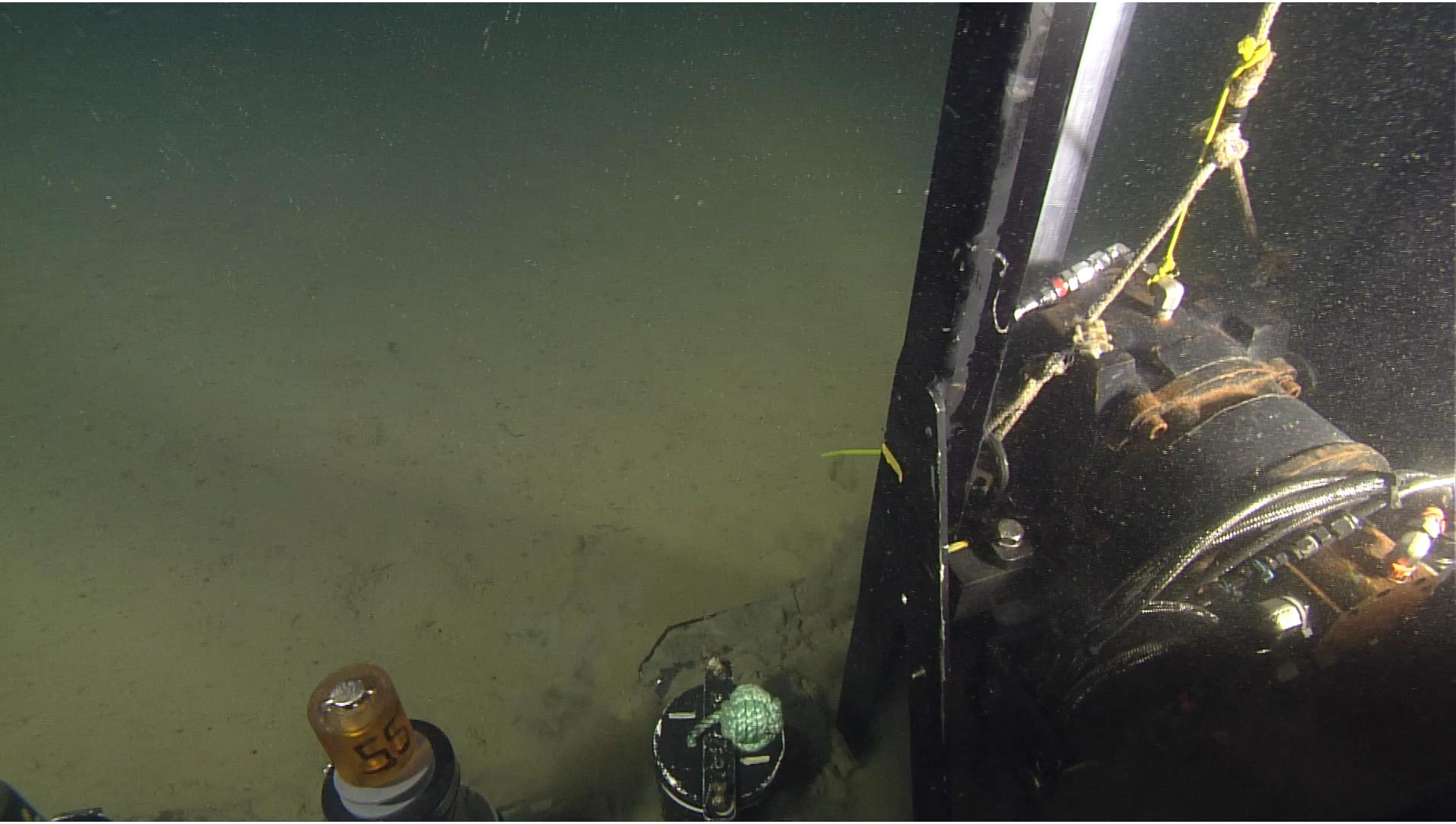
Water depth -
90-720 m



220 m

Water depth -
90-720 m

Access video from page 1



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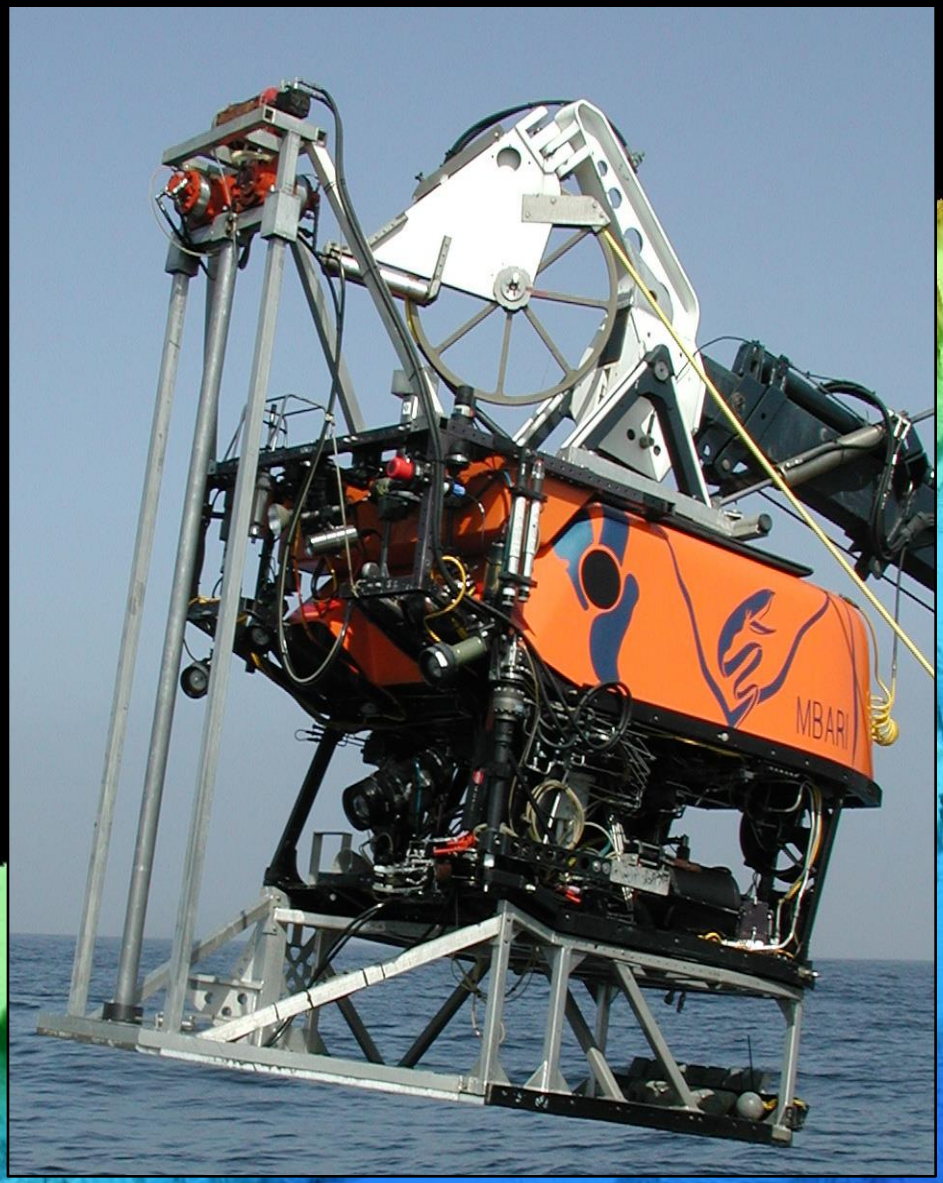
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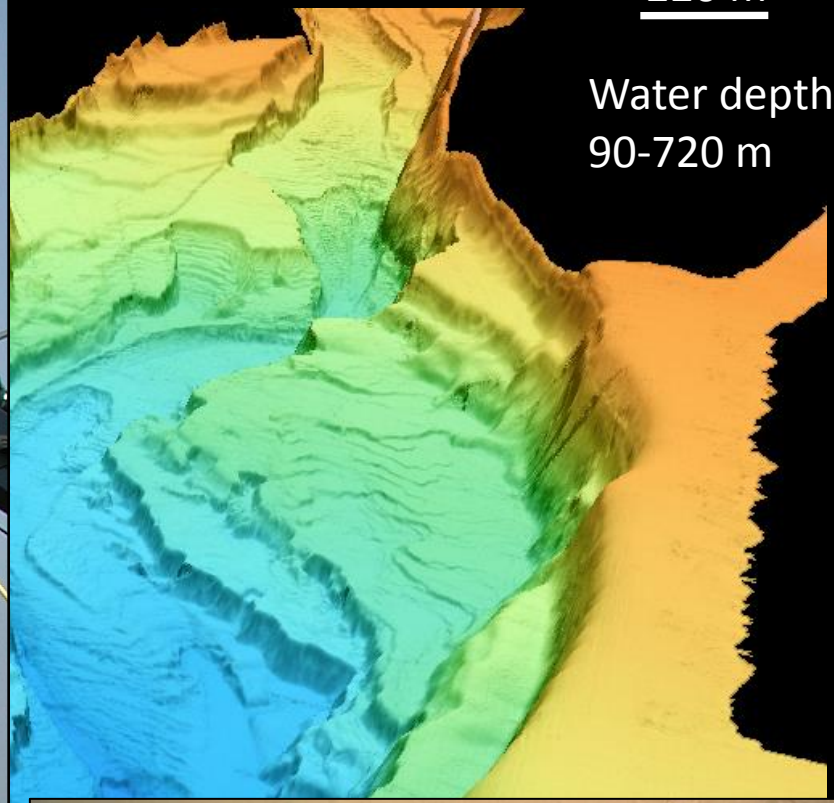
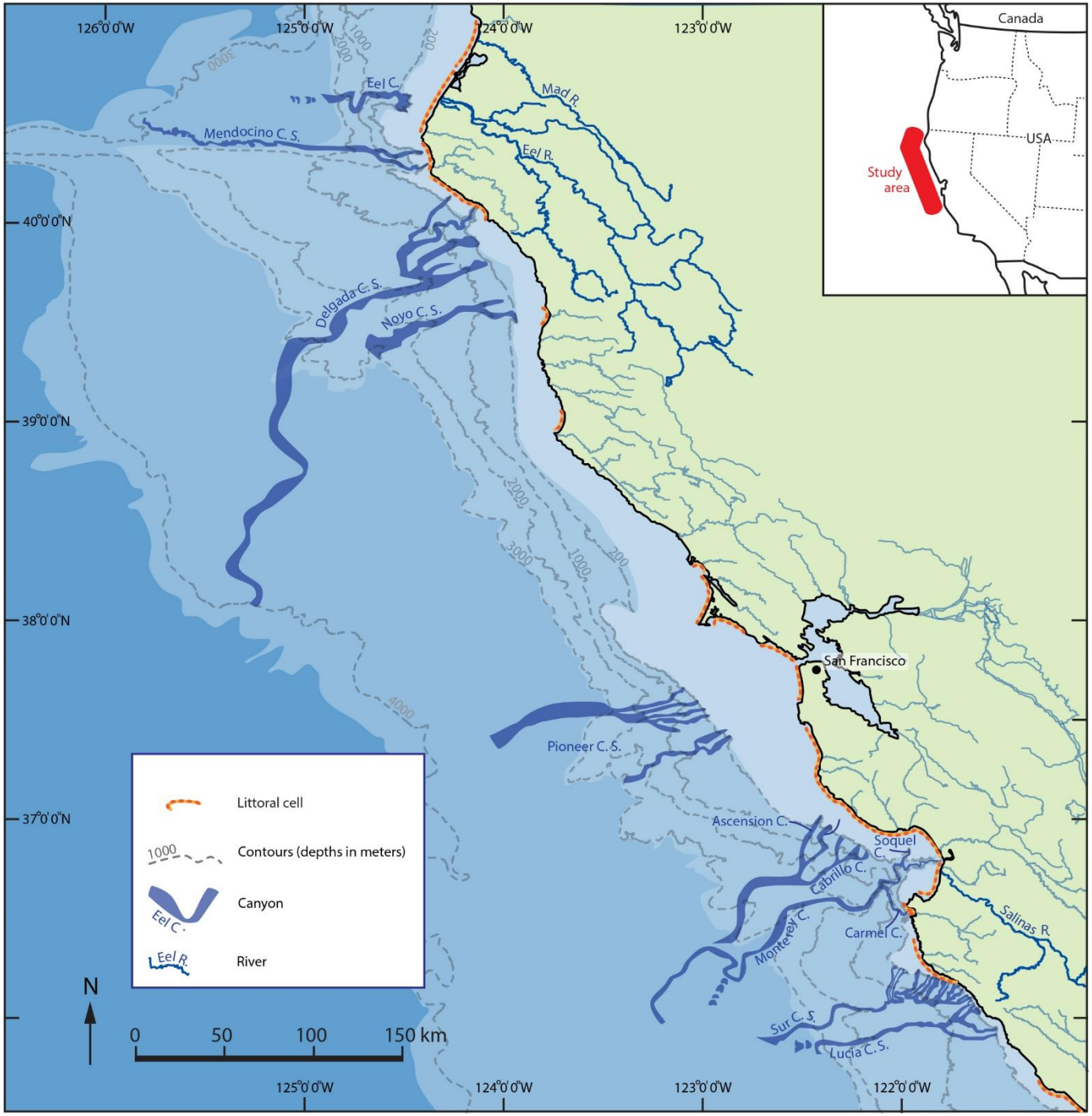
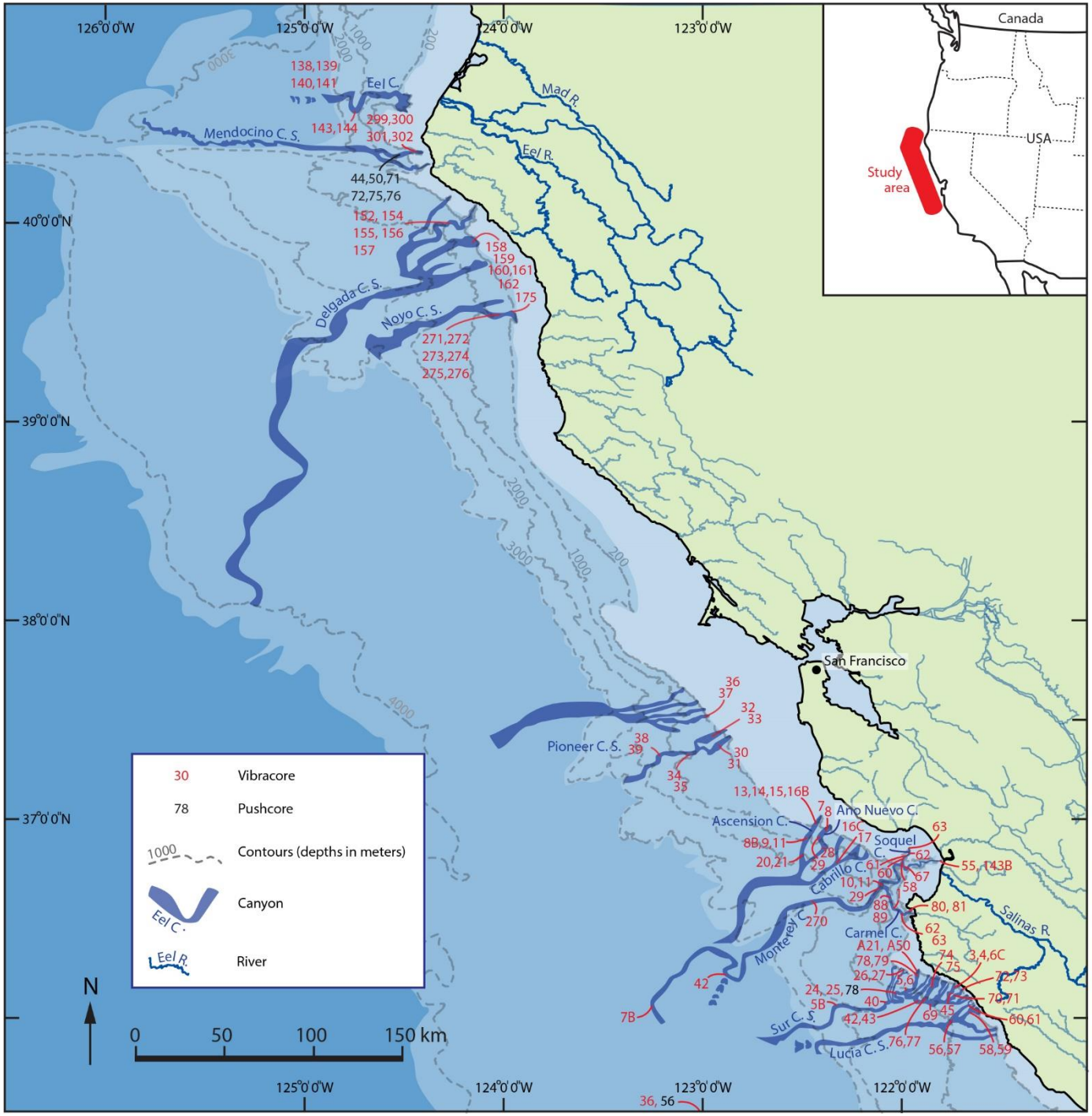
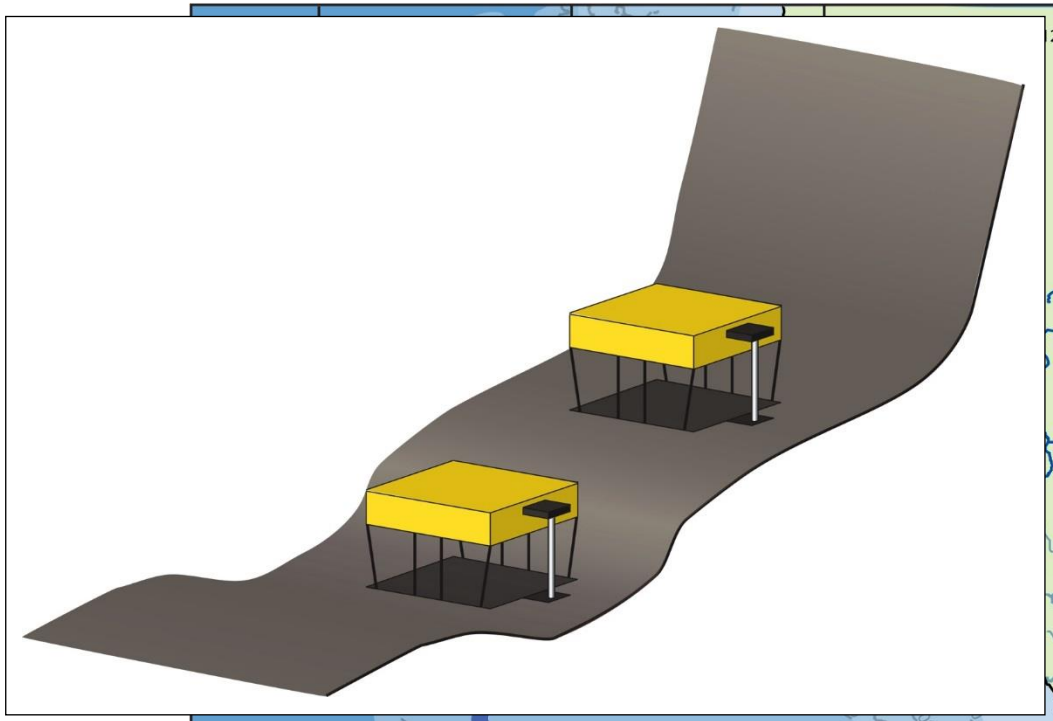

220 m
Water depth -
90-720 m

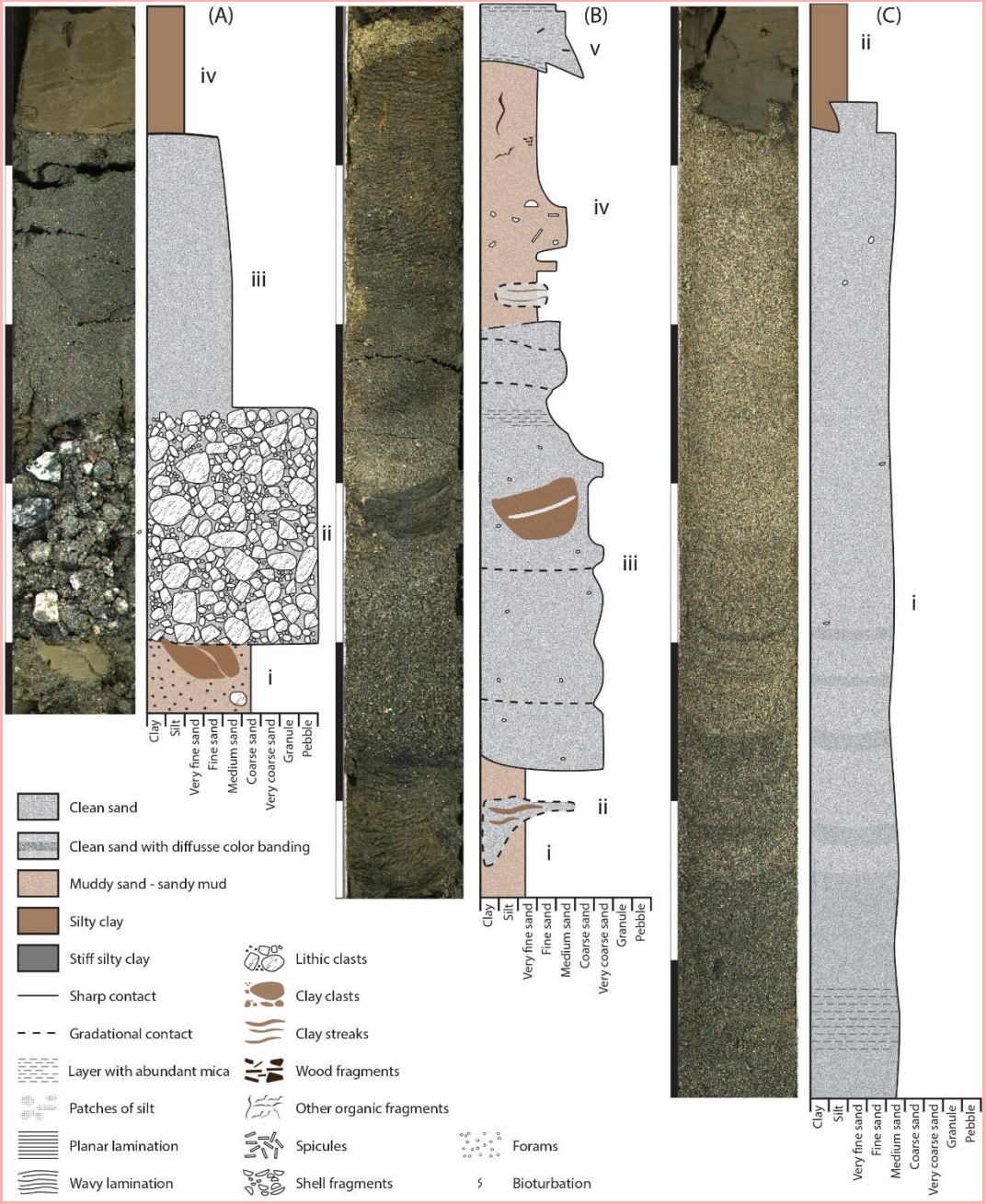

126°0'0"W
125°0'0"W
124°0'0"W
123°0'0"W
122°0'0"W
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
Canada
USA
Study area
Eel C.
Mendocino C. S.
Mad R.
Eel R.
Delgada C. S.
Noyo C. S.
Pioneer C. S.
San Francisco
Ascension C.
Soquel C.
Cabrillo C.
Monterey C.
Carmel C.
Salinas R.
Sur C. S.
Lucia C. S.
200
1000
2000
3000
4000
Littoral cell
Contours (depths in meters)
Canyon
River
N
0
50
100
150 km


126°0'0"W
125°0'0"W
124°0'0"W
123°0'0"W
122°0'0"W
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
1000
2000
3000
200
4000
Eel C.
Mendocino C. S.
Mad R.
Eel R.
Delgada C. S.
Noyo C. S.
Pioneer C. S.
Ascension C.
Año Nuevo C.
Soquel C.
Cabrillo C.
Monterey C.
Carmel C.
Sur C. S.
Lucia C. S.
Salinas R.
San Francisco
138,139
140,141
143,144
299,300
301,302
44,50,71
72,75,76
152, 154
155, 156
157
158
159
160,161
162
175
271,272
273,274
275,276
36
37
32
33
38
39
30
31
34
35
13,14,15,16B
7
8
16C
17
8D,9,11
20,21
28
29
63
62
55, 143B
61
60
67
58
10,11
29
88
89
80, 81
270
62
63
74
75
3,4,6C
A21, A50
78,79
26,27
5,6
72,73
24, 25, 78
5B
40
70,71
42,43
69
45
60,61
7B
42
76,77
56,57
58,59
36, 56
Canada
USA
Study area
30 Vibracore
78 Pushcore
1000 Contours (depths in meters)
Eel C. Canyon
Eel R. River
N
0 50 100 150 km

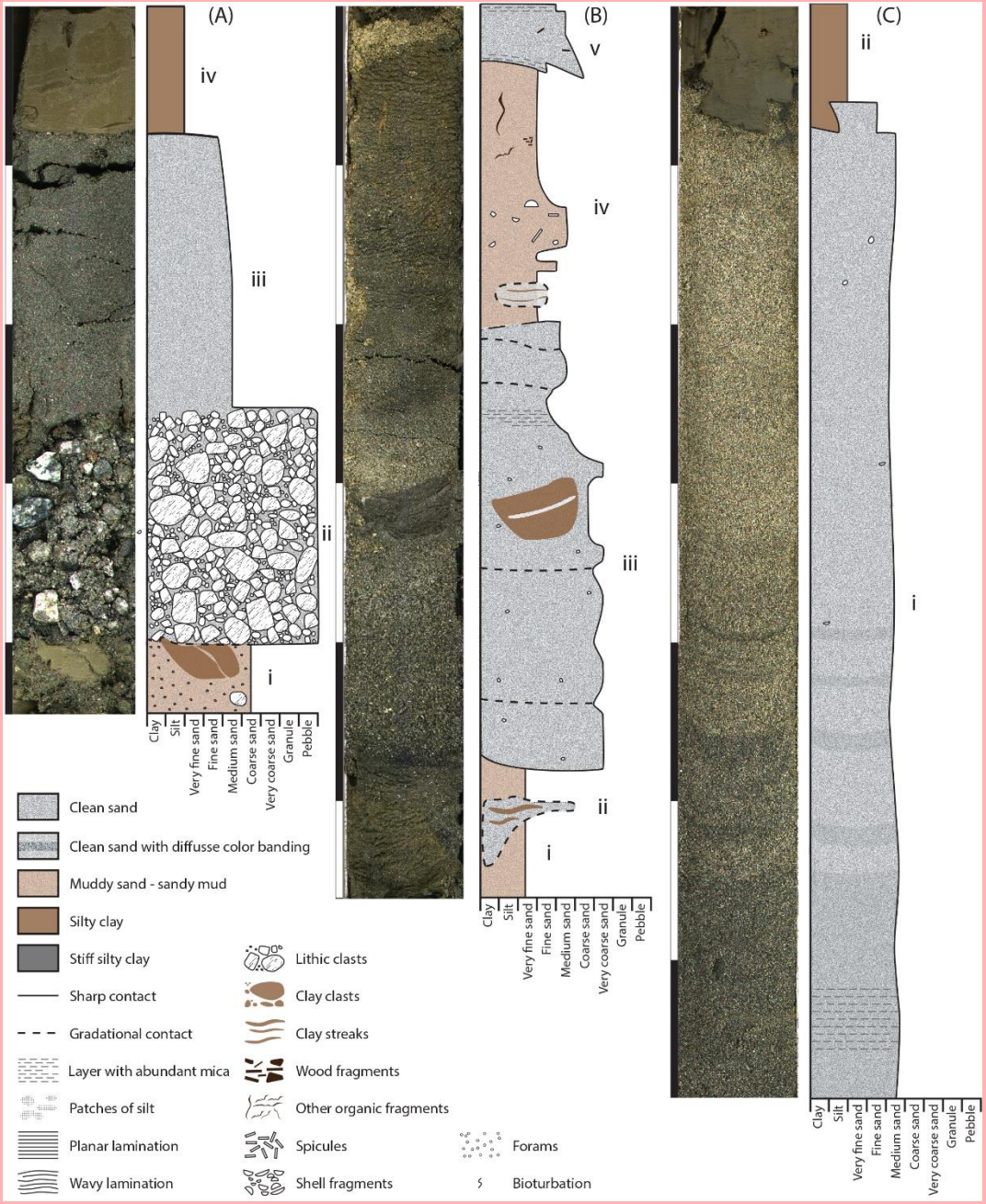


Canada
USA
Study area
123°0'0"W
38°0'0"N
37°0'0"N
San Francisco
Pioneer C.S.
Ascension C.
Año Nuevo C.
Soquel C.
Cabrillo C.
Monterey C.
Carmel C.
Salinas R.
Sur C.S.
Lucia C.S.
Eel C.
Eel R.
30 Vibracore
78 Pushcore
1000 Contours (depths in meters)
Canyon
River
N
0 50 100 150 km
125°0'0"W
124°0'0"W
123°0'0"W
122°0'0"W

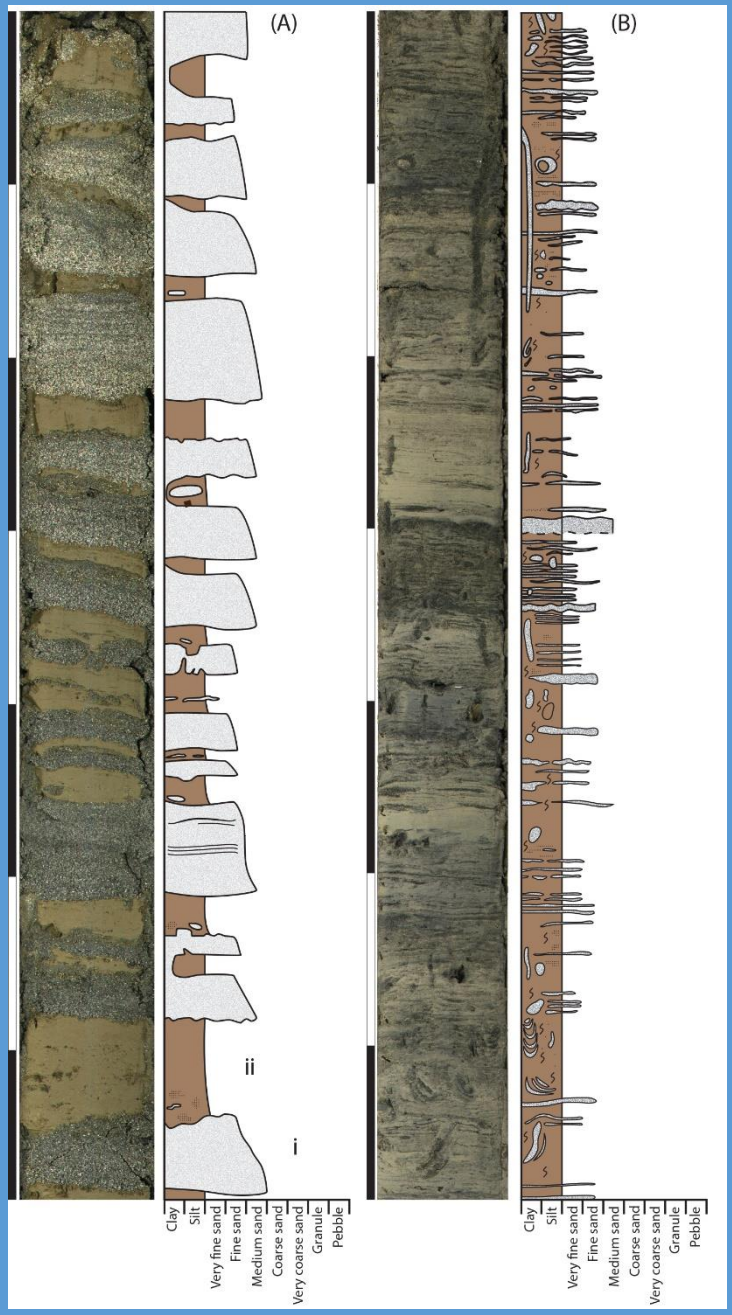
Coarse-grained axial channel deposits

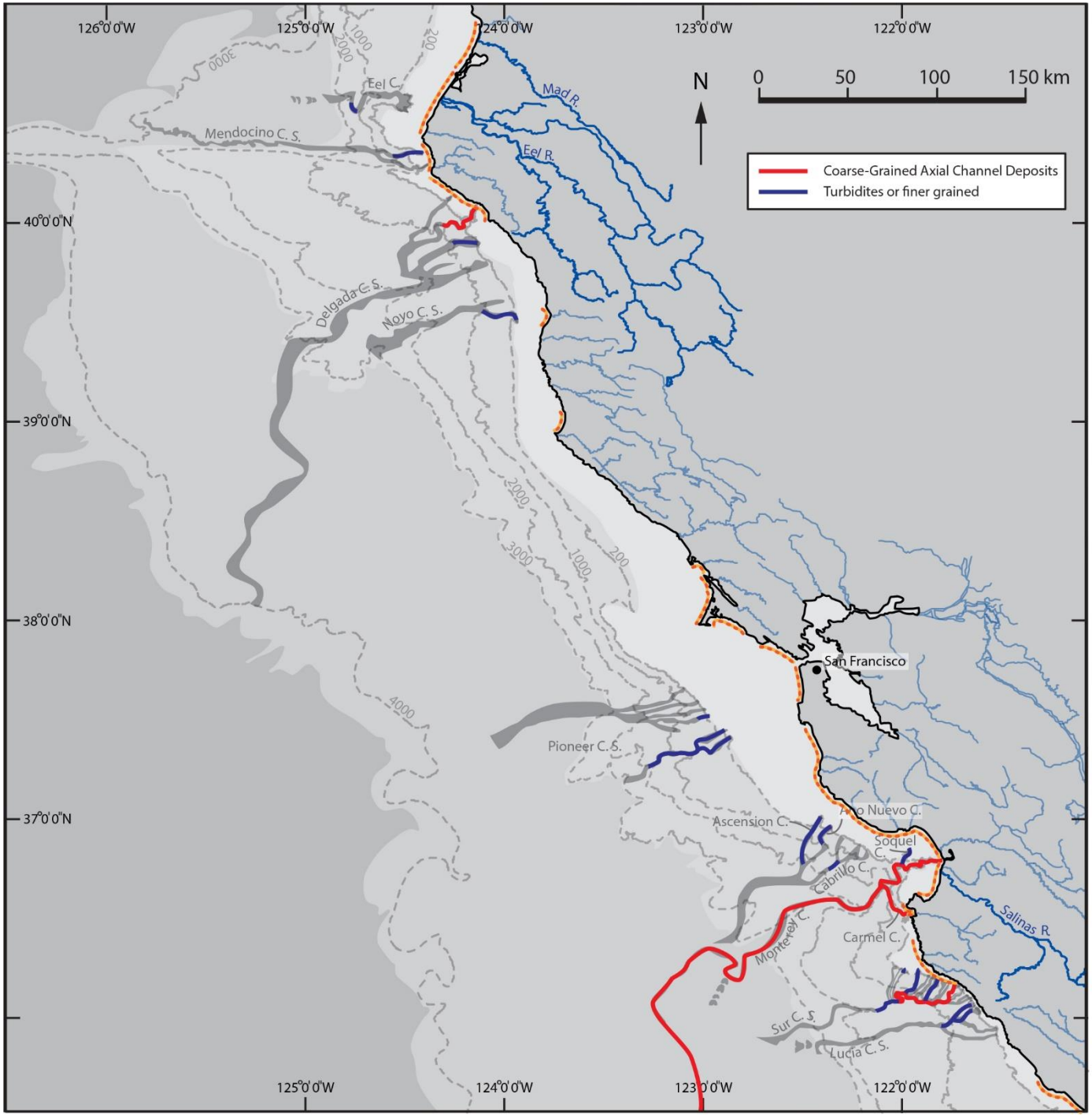


Coarse-grained axial channel deposits



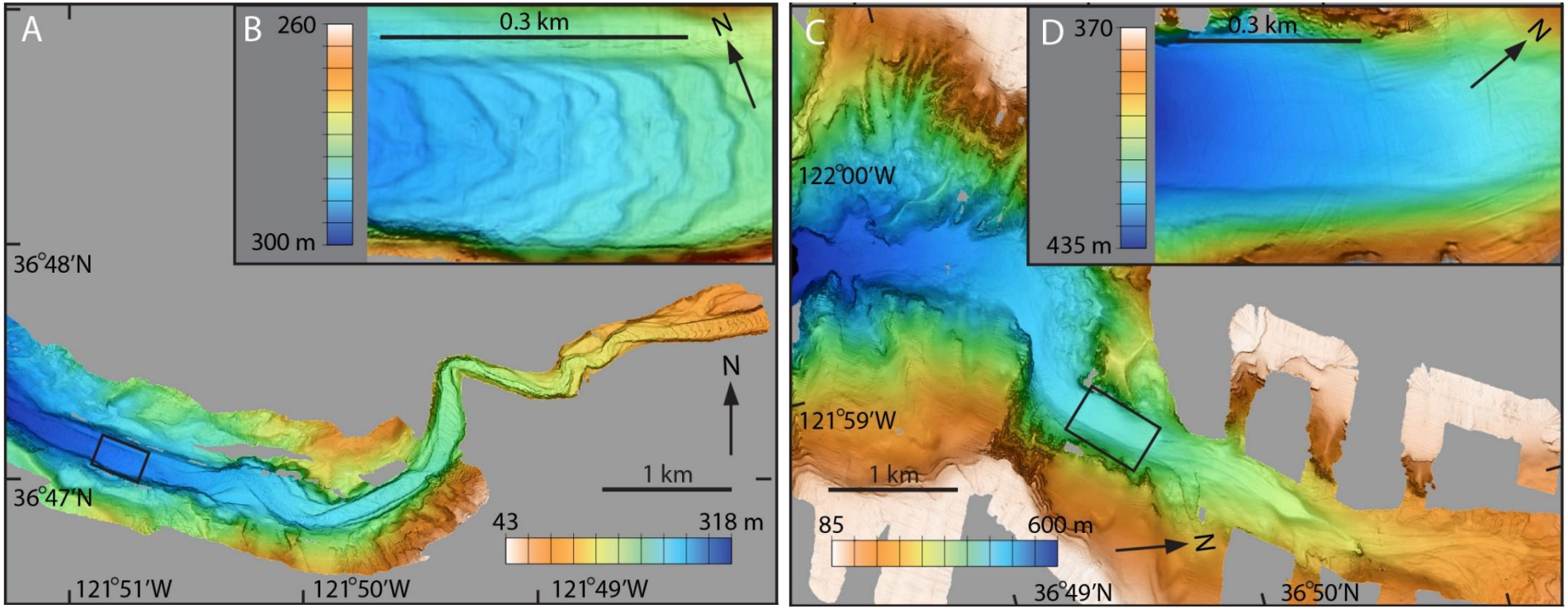
Turbidites

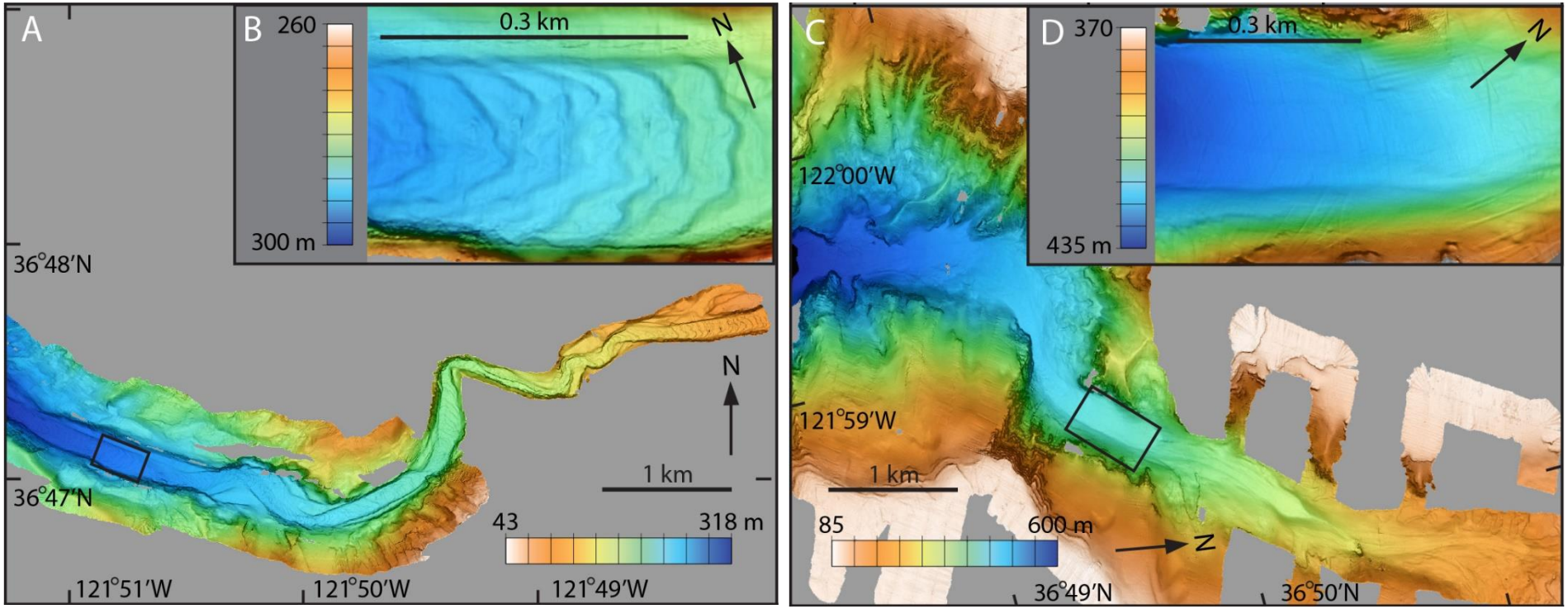


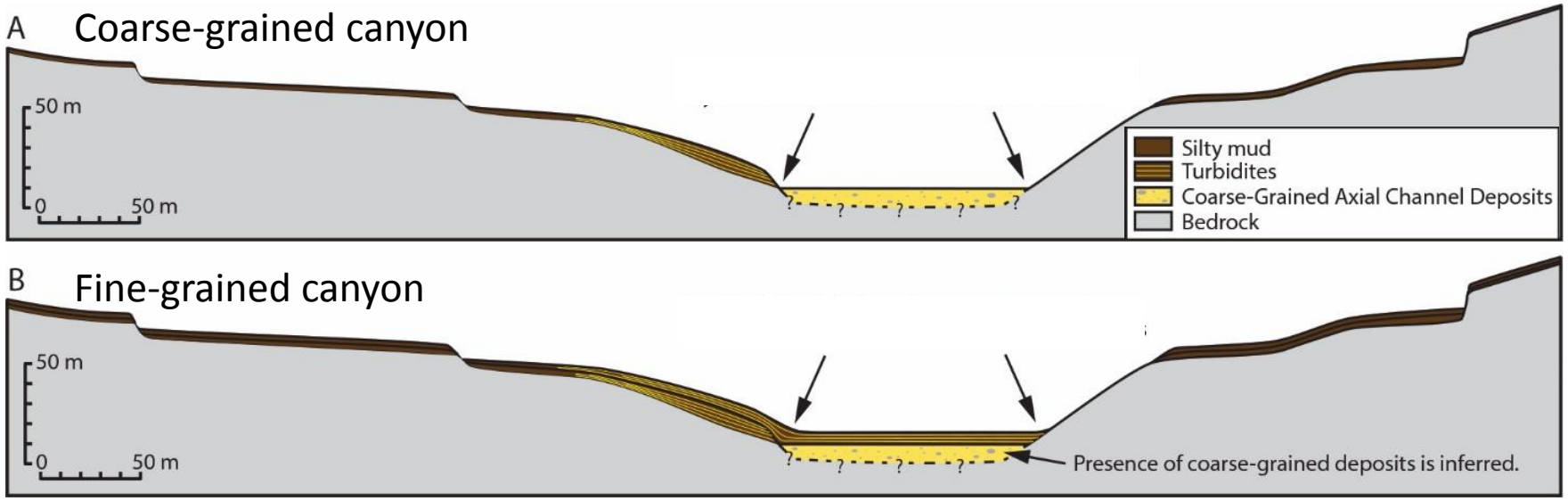

126°0'0"W
125°0'0"W
124°0'0"W
123°0'0"W
122°0'0"W
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
N
0
50
100
150 km
Coarse-Grained Axial Channel Deposits
Turbidites or finer grained
Eel C.
Mendocino C. S.
Mad R.
Eel R.
Delgada C. S.
Noyo C. S.
Pioneer C. S.
San Francisco
Ascension C.
Año Nuevo C.
Soquel C.
Cabrillo C.
Monterey C.
Carmel C.
Salinas R.
Sur C. S.
Lucia C. S.
200
1000
2000
3000
4000

Coarse-grained canyon

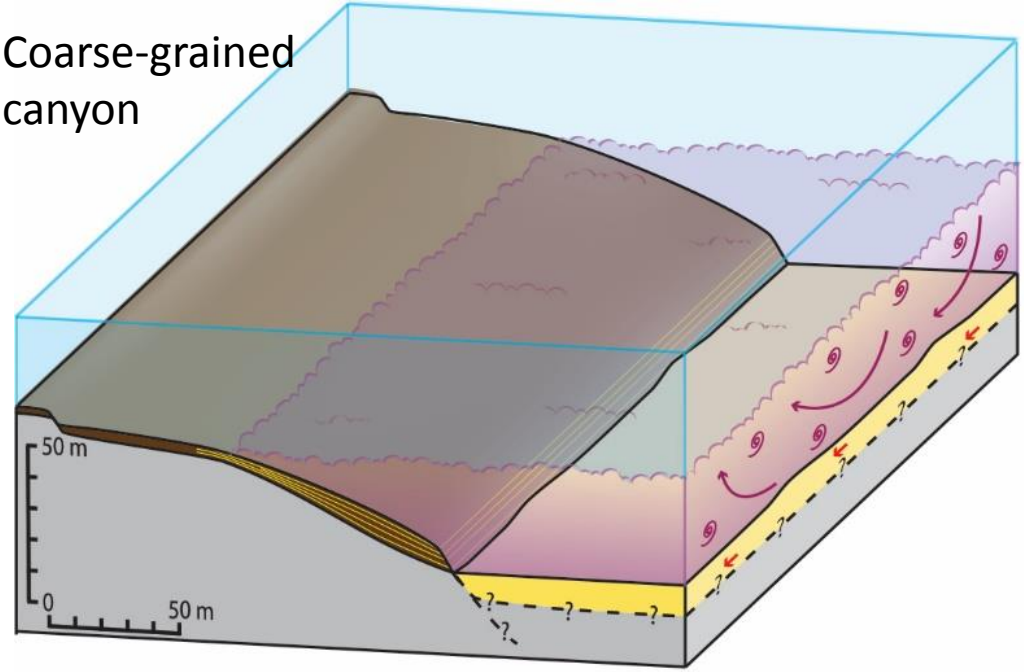
Fine-grained canyon



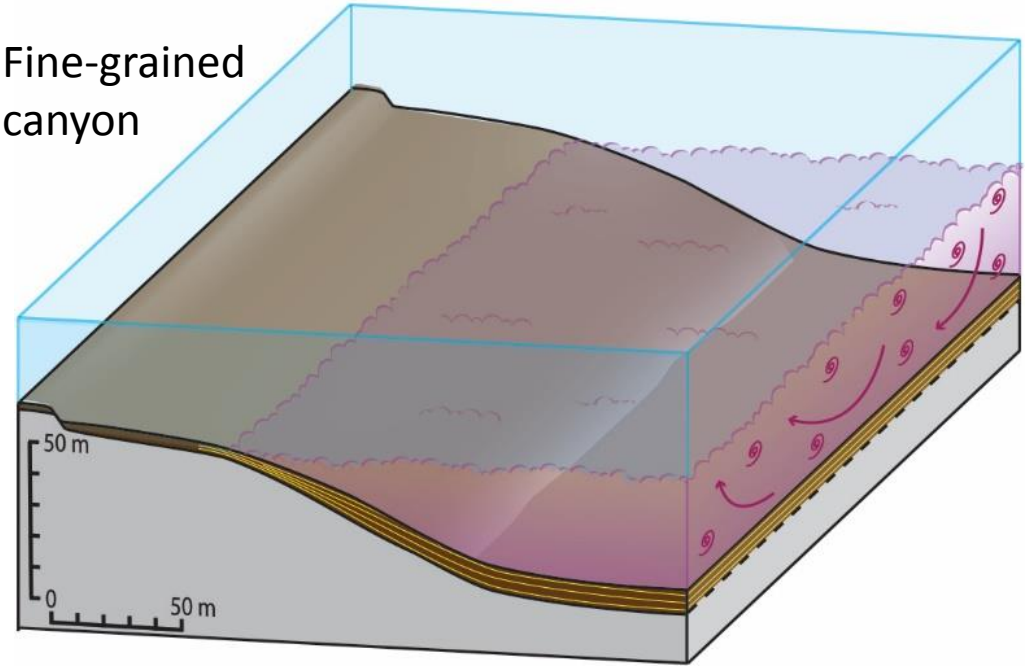

Coarse-grained canyon
Fine-grained canyon
A
B
260
300 m
0.3 km
N
36°48′N
36°47′N
121°51′W
121°50′W
121°49′W
1 km
43
318 m
C
D
370
435 m
122°00′W
121°59′W
85
600 m
36°49′N
36°50′N

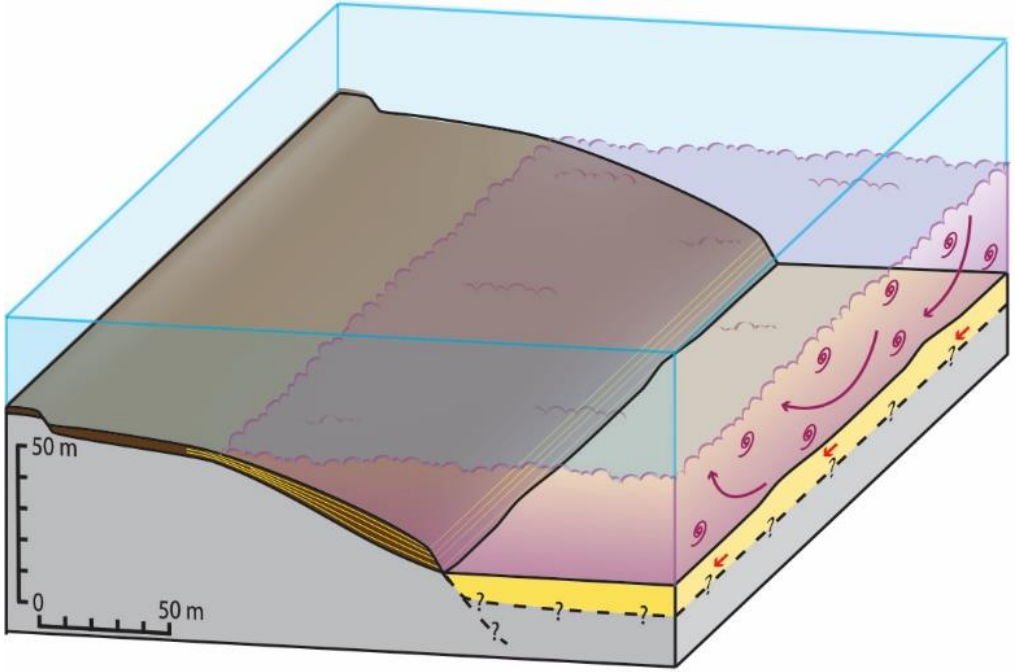

A Coarse-grained canyon
50 m
0
50 m
Silty mud
Turbidites
Coarse-Grained Axial Channel Deposits
Bedrock
B Fine-grained canyon
50 m
0
50 m
Presence of coarse-grained deposits is inferred.

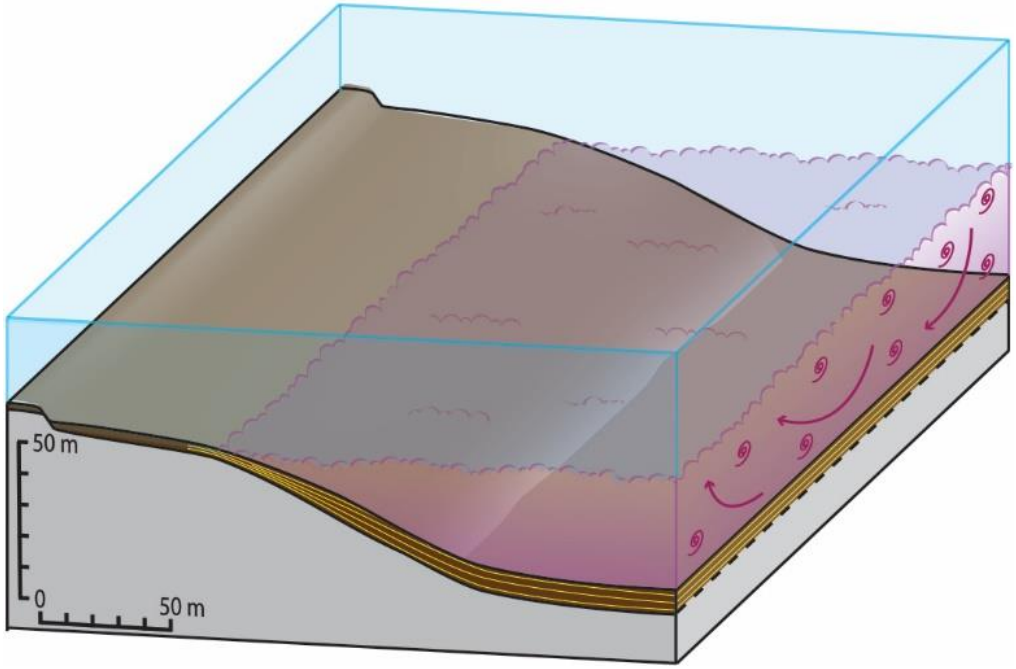
Coarse-grained canyon

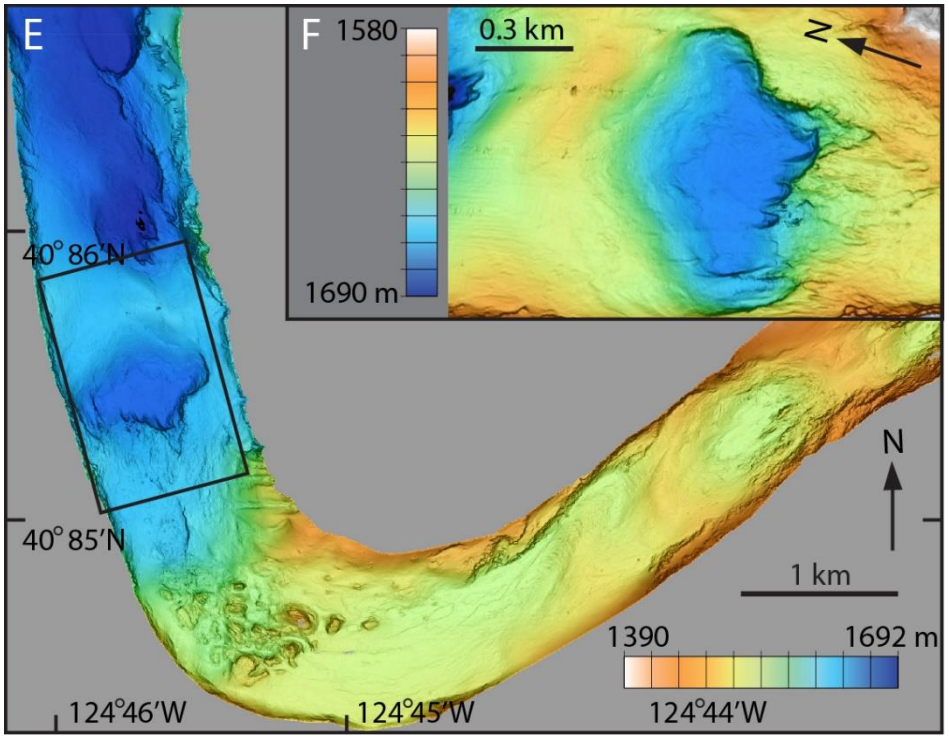


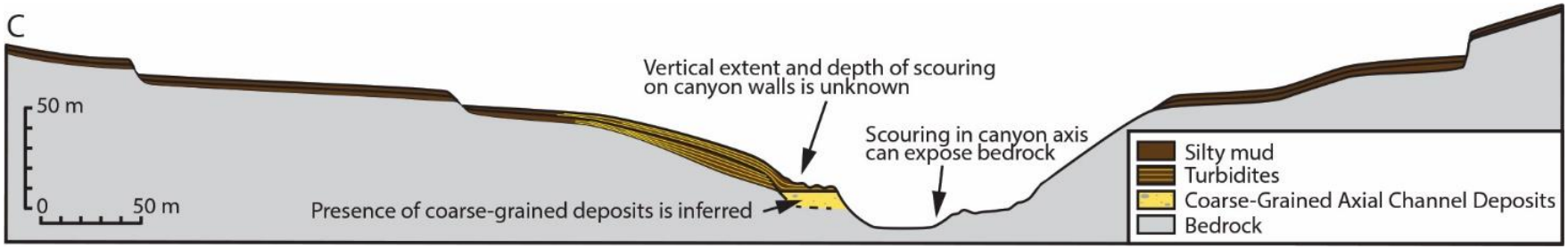
Fine-grained canyon

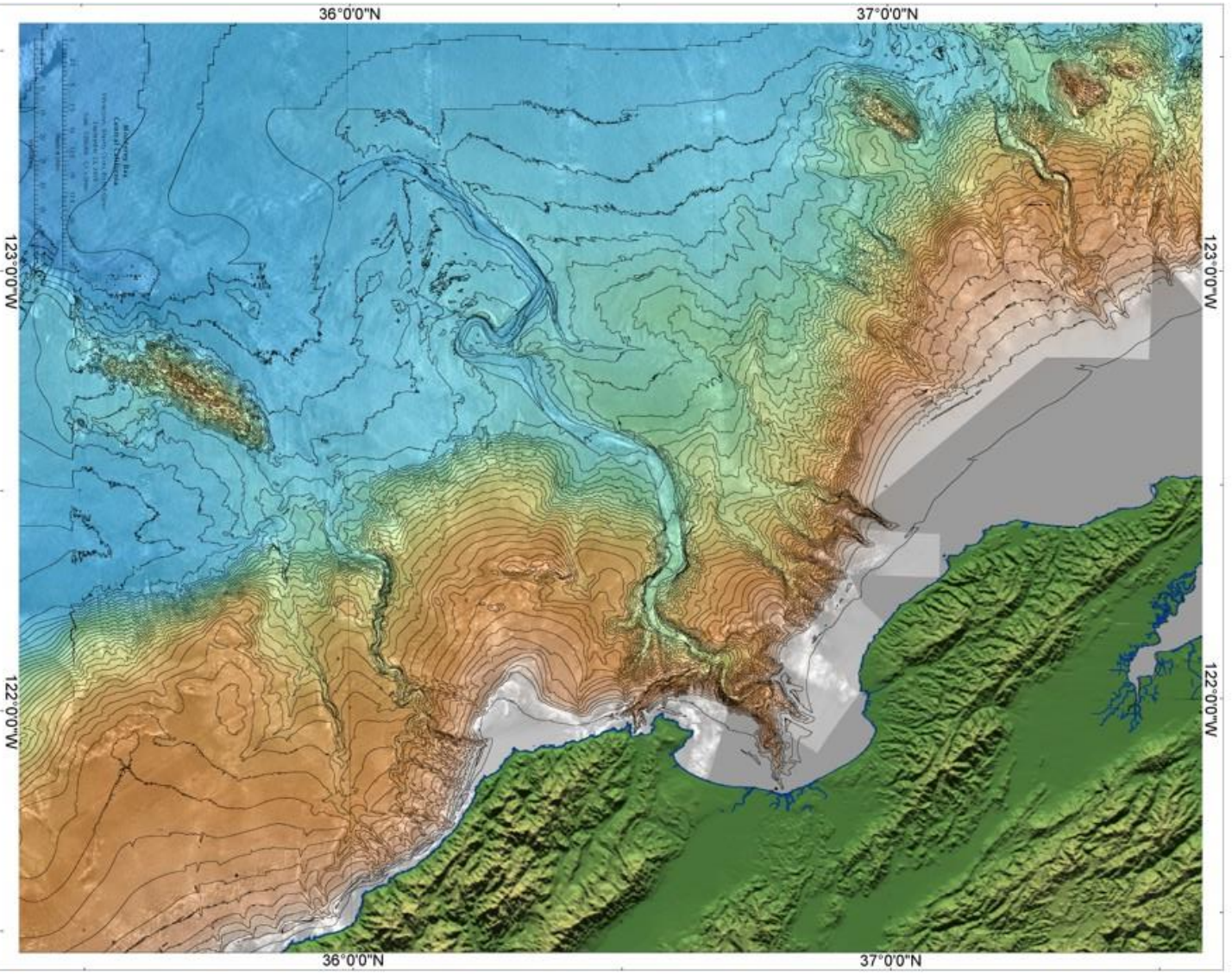



50 m
0
50 m


50 m
0
50 m


E
F
1580
1690 m
0.3 km
N
40° 86'N
40° 85'N
N
1 km
1390
1692 m
124°46'W
124°45'W
124°44'W


C
50 m
0
50 m
Vertical extent and depth of scouring on canyon walls is unknown
Scouring in canyon axis can expose bedrock
Presence of coarse-grained deposits is inferred
Silty mud
Turbidites
Coarse-Grained Axial Channel Deposits
Bedrock


36°0'0"N
37°0'0"N
123°0'0"W
122°0'0"W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LLOYTRON

Conclusions

- Two types of canyons exist on the northern California Margin: coarse-grained canyons and fine-grained canyons.
  - Coarse-grained canyons have a well-defined axial channel that contains sand and gravel.
  - Fine-grained canyons have a poorly-defined axial channel draped by turbidites.

- Coarse-grained canyons occur if the canyon head intersects the local littoral cell, whereas fine-grained canyons occur if the canyon head is on the shelf or at the shelf break.

- Coarse-grained canyons continuously shunt clean sands and gravels from the canyon head to the submarine fan.

- Axial deposits and canyon wall deposits provide profoundly different sedimentary records: axial deposits are transient, whereas wall deposits have a greater potential of preserving an enduring record of at least some of the flows that have passed through the canyon.