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1 **Contourite depositional systems along the Mozambique Channel: the interplay between bottom currents**
2 **and sedimentary processes**

3

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12

13 **Abstract**

14 We present a combined study of the geomorphology, sedimentology, and physical oceanography of
15 the Mozambique Channel to evaluate the role of bottom currents in shaping the Mozambican continental
16 margin and adjacent Durban basin. Analysis of 2D multichannel seismic reflection profiles and bathymetric
17 features revealed major contourite deposits with erosive (abraded surfaces, contourite channels, moats,
18 furrows and scours), depositional (plastered and elongated-mounded drifts, sedimentary waves), and mixed
19 (terraces) features, which were then used to construct a morpho-sedimentary map of the study area.
20 Hydrographic data and hydrodynamic modelling provide new insights into the distribution of water masses,
21 bottom current circulation and associated processes (e.g., eddies, internal waves, etc.) occurring along the
22 Mozambican slope, base-of-slope and basin floor. Results from this work represent a novel deep-sea
23 sedimentation model for the Mozambican continental margin and adjacent Durban basin. This model shows 1)
24 how bottom circulation of water masses and associated sedimentary processes shape the continental margin,
25 2) how interface positions of water-masses with contrasting densities (i.e., internal waves) sculpt terraces
26 along the slope at a regional scale, and 3) how morphologic obstacles (seamounts, Mozambique Ridge, etc.)
27 play an essential role in local water mass behaviours and dynamics. Further analysis of similar areas can
28 expand understanding of the global role of bottom currents in deep-sea sedimentation.

29 **Keywords:** Contourites; Bottom currents; Sedimentary processes; Water mass interfaces; Continental margin;
30 Mozambique Channel

31

32 **1. Introduction**

33 Contour-following currents generated by thermohaline circulation are common processes that affect
34 continental margins and abyssal plains of the world's oceans (e.g., Stow, 1994; Faugères et al., 1999; Stow et
35 al., 2002, 2009; Rebesco and Camerlenghi, 2008; Rebesco et al., 2014). Deposits generated by along-slope
36 currents are known as 'contourites' or 'contourite drifts' (see McCave and Tucholke, 1986; Rebesco and Stow,

2001). *'Erosional features'* (e.g., abraded surfaces, contourite channels, contourite moats) are locally developed in association with contourite drifts in areas traversed by higher velocity current cores (e.g., García et al., 2009; Cattaneo et al., 2017). In some settings, *'mixed features'* develop due to long-term depositional and erosional phases that form contourite terraces (e.g., Viana et al., 2007; Hernández-Molina et al., 2009, 2017a). Other settings host interactions between along-slope (contourites) and across-slope gravity-driven processes (turbidity currents and mass transport deposits). These processes may form *'hybrid features'* (e.g., Creaser et al., 2017; Hernández-Molina et al., 2017b; Sansom, 2018). The range of depositional, erosional and mixed (erosional-depositional) features associated with a particular water mass can be interpreted as a *'Contourite Depositional System'* (CDS). Continental margins host a number of CDSs associate to a water mass within a given depth range.

Recent studies have demonstrated the effectiveness of combining oceanographic analysis and geomorphologic approaches in interpreting CDSs (e.g., western South Atlantic margin: Preu et al., 2013; Hernández-Molina et al., 2016a; Gulf of Cadiz: Hernández-Molina et al., 2016b; Mediterranean Sea: Cattaneo et al., 2017). However, CDSs can become difficult to decipher (e.g., Hernández-Molina et al., 2006a) in the case of interactions of several different water masses, intermittent oceanographic processes (e.g., eddies, internal waves), and / or complex physiography. These special cases remain less understood due to lack of direct observations (Rebesco et al., 2014).

Since initial publication of studies on current-controlled sedimentation along the southern Mozambique basin (e.g., Kolla et al., 1980; 6, **Fig. 1A**), the southwestern region of the Indian Ocean and its CDSs have enjoyed growing scientific interest (**Fig. 1A**). To date, deposits directly linked to bottom current action have been described from at least eight different locations (**Fig. 1A**). The largest features are associated with water masses formed from Antarctic and sub-Antarctic sources. These include features along the north-eastern Agulhas Ridge and Cape Rise seamounts (Gruetzner and Uenzelmann-Neben, 2015; 1, **Fig. 1A**), contourite drifts of the Transkei, which include the Oribi drift, M-drift (Niemi et al., 2000; 3, **Fig. 1A**), and Agulhas drift (Schlüter and Uenzelmann-Neben, 2008; 3, **Fig. 1A**), features along the southern Mozambique Ridge (Uenzelmann-Neben et al., 2011; 7, **Fig. 1A**), features along the Agulhas Plateau and Passage (Uenzelmann-Neben, 2001; Uenzelmann-Neben and Huhn, 2009; 2 and 8, **Fig. 1A**), and features along the continental margin of Mozambique off the Limpopo River (Preu et al., 2011; 5, **Fig. 1A**). In summary, these

65 studies link the development of contourite features to particular water masses and water depth ranges.
66 Despite the strong influence that circulation exerts on sedimentary processes (e.g., Wiles et al., 2014, 2017;
67 Breitzke et al., 2017), long stretches of the East African continental margin have not been interpreted in terms
68 of their depositional processes. This paper presents novel analysis of water mass influence on seafloor
69 morphology to interpret CDSs along the East African continental margin between the latitudes of 15° S and 30°
70 S (hereafter the Mozambique Channel). The primary aims of this work are 1) to identify the main regional
71 sedimentary features related to bottom current action, 2) to generate a regional morpho-sedimentary map of
72 the Mozambique Channel and 3) to interpret the interplay between sedimentary and oceanographic
73 processes.

74 **2. Regional setting**

75 *2.1. Geologic setting*

76 The Mozambique Channel is located in the southwest Indian Ocean between the East African
77 continental margin of Mozambique and Madagascar (**Fig. 1A**). It developed during the break-up of East
78 Gondwana (i.e., Madagascar, India, Antarctica, and Australia) and West Gondwana (i.e., Africa and South
79 America) (McElhinny, 1970; McKenzie and Sclater, 1971). Rifting began in the Early-Middle Jurassic (183 - 177
80 Ma; Eagles and König, 2008) with the opening of the northern Mozambique basin (159 Ma to 124 Ma; Jokat et
81 al., 2003; König and Jokat, 2010; Leinweber and Jokat, 2012; Leinweber et al., 2013) and persisted to the Early
82 Cretaceous opening of the southern Mozambique Basin (124 Ma to 84 Ma; Gradstein et al., 2012) and the
83 Natal Valley (135 Ma to 115 / 90 Ma; Goodlad et al., 1982; Watkeys and Sokoutis, 1998). Currently, the
84 Mozambique Channel consists of three major basins: the northern Mozambique basin, the southern
85 Mozambique basin, and the Durban basin (**Fig. 1B**). The northern Mozambique basin is bounded by the East
86 African continental margin of Mozambique to the west and by the Davie Fracture Zone (DFZ) to the east. The
87 DFZ developed during southerly movement of East Gondwana (including Madagascar) (Coffin and Rabinowitz,
88 1987, 1992) and was later reactivated by extensional deformation (e.g., Lacerda Graben) since the late
89 Miocene (Mougenot et al., 1986). A group of isolated carbonate platforms (e.g., Bassas Da India) formed in the
90 middle of the northern Mozambique basin from the Paleocene to early Miocene (Courgeon et al., 2016). Late
91 Miocene-early Pliocene cessation of carbonate deposition and initiation of graben formation along the DFZ

92 appears to be coeval and spatially linked with the development and propagation of the East African Rift System
93 (Franke et al., 2015). The southern Mozambique basin is bounded to the west by the Mozambique Ridge
94 (MozR), which occurs about 100 km off the coast, and to the east by the Madagascar Ridge (MdgR) (**Fig. 1B**).
95 Both ridges are interpreted to represent a large igneous province of oceanic origin (Sinha et al., 1981; Fischer
96 et al., 2017) forming between 140 and 122 Ma for the Mozambique Ridge (König and Jokat, 2010). Finally, the
97 Durban basin represents the eastern termination of a major east-west trending fault system, the Agulhas-
98 Falkland Fracture Zone (Broad et al., 2006).

99 Open marine sedimentation began in the Early Cretaceous for the northern and southern
100 Mozambique basins and in the Late Cretaceous for the Durban basin (Davison and Steel, 2017). Over the past
101 30 Ma, the areas of interest have experienced significant periods of middle Oligocene, middle Miocene, and
102 late Pliocene hinterland uplift (Castelino et al., 2015). Periods of uplift are associated with increase in sediment
103 transport to the adjacent basins along the southwestern Indian Ocean (Walford et al., 2005; Wiles et al., 2014;
104 Castelino et al., 2015; Hicks and Green, 2016). Sediment delivery to the Mozambique Channel is complex and
105 related to global eustatic changes and hinterland tectonics (Walford et al., 2005; Castelino et al., 2015; Hicks
106 and Green, 2016; Wiles et al., 2017). Sediments are primarily sourced from the adjacent Zambezi river
107 (present-day catchment of $1.39 \cdot 10^6$ km²), Limpopo river (present-day catchment of $4.15 \cdot 10^5$ km²), and Tugela
108 river (present-day catchment of $2.91 \cdot 10^4$ km²) (**Fig. 1A**). These control the general sediment type and flux
109 delivered to the Mozambique Channel over time.

110 2.2. Oceanographic framework

111 The south Indian Ocean hosts a variety of water masses characterized by different hydrographic
112 properties as summarized in **Table I**. At present, oceanic circulation along the Mozambique Channel consists
113 primarily of the southward flowing Mozambique current and the northward flowing Mozambique
114 undercurrent (De Ruijter et al., 2002). The Mozambique current is part of the Agulhas current system
115 (Lutjeharms, 2006) and is characterized by anticyclonic eddies with diameters of ~300 km (**Fig. 2**). Four to six
116 anticyclonic eddies per year occur in the Channel, and propagate southwards at ~3 - 6 km/day (de Ruijter et
117 al., 2002; Schouten et al., 2003; Halo et al., 2014). The Mozambique current carries Tropical Surface Water,
118 Subtropical Surface Water (TSW and STSW, < 200 m water depth, wd), the South Indian Central Water (SICW,

119 between 200 and 600 m wd) (De Ruijter et al., 2002), and the northwest Indian-origin Red Sea Water (RSW,
120 900 - 1200 m wd) (Donohue et al., 2000; Beal et al., 2000; Swart et al., 2010). The Mozambique and Agulhas
121 undercurrents flow northward along the Mozambican continental slope (**Fig. 2**) carrying Antarctic Intermediate
122 Water (AAIW, 800 - 1500 m wd) after its westward flow over the Madagascar ridge (Fine, 1993) and the North
123 Atlantic Deep Water (NADW, 2200 - 3500 m wd), which flows into the Natal Valley (Toole and Warren, 1993)
124 towards the southern Mozambique basin, south of the Mozambique Ridge. A portion of the NADW flows into
125 the southern Mozambique basin across deep corridors within the Mozambique Ridge (Wiles et al., 2014). The
126 upper volume of the NADW crosses a sill in the northern Mozambique basin to enter the Somali Basin, while
127 the remaining NADW flows along the eastern boundary of the northern Mozambique basin with a southerly
128 returning current (van Aken et al., 2004; Ullgren et al., 2012). The Antarctic Bottom Water (AABW) circulates
129 below 4000 m wd (**Fig. 2**). It flows northward as a western boundary current along the southern Mozambique
130 basin (Tucholke and Embley, 1984; Read and Pollard, 1999). Because the basin is closed in the north, the
131 AABW is deflected to form a southerly flowing boundary current along the east flank of the southern
132 Mozambique basin (Kolla et al., 1980).

133 **3. Data and methods**

134 This study utilizes bathymetry, multichannel 2D seismic reflection profiles, hydrographic data, and
135 hydrodynamic modelling. A slope gradient map was generated using GEBCO 2014 (Weatherall et al., 2015).
136 The bathymetric base map included data from previous works of Wiles et al. (2014, 2017) and Breitzke et al.
137 (2017), which were used to generate the morpho-sedimentary map.

138 Profiles interpreted derive from a regional 2D multichannel seismic reflection (MCSs) dataset (**Fig. 1**)
139 acquired for the Mozambique basin during 2013 / 2014 geophysical cruises by WesternGeco. This primary
140 dataset represents a regional grid of linear, 36179 km MCSs spaced at approximately 10 to 70 km intervals.
141 Profiles were migrated in time. A second dataset was acquired for the Durban basin in 2013 - 2014 by CGG.
142 The secondary dataset consists of widely spaced arrays spanning 6920 km and including 17 strike lines and 25
143 dip lines. The data were processed with Kirchhoff pre-stack time migration. Major morpho-sedimentary
144 features were identified and mapped using bathymetry and seismic profiles.

145 Oceanographic analysis was performed using hydrographic data from the World Ocean Database 2013
146 (WOD13; <https://www.nodc.noaa.gov/OC5/WOD13/>) and a Regional Oceanic Modelling System (ROMS,
147 version CROCO: <https://www.croco-ocean.org/>).

148 Hydrographic data from WOD13 was used to create combined hydrographic and seismic cross sections.
149 Due to the lack of hydrographic sections, we constructed cross-slope sections by combining all available
150 conductivity, temperature, salinity, and depth (CTD) stations and then projecting water sample stations onto
151 the seismic cross-section at distances of up to 50 km. The cross-sections were created using Ocean Data View
152 (Schlitzer, 2013). CTD data were also used for generating potential temperature-salinity diagrams in order to
153 identify water masses present along the Mozambique Channel.

154 The Regional Oceanic Modelling System (ROMS, CROCO version), a three dimensional ocean model
155 described by Shchepetkin and McWilliams (2005), was used to simulate the bottom currents in the
156 Mozambique Channel. ROMS is a primitive equation model that can estimate basin-scale, regional and coastal
157 oceanic processes at high resolution (Shchepetkin and McWilliams, 2005). ROMS uses a topography following
158 vertical grid allowing explicit resolution of interactions between bottom topography and ocean dynamics. The
159 model used the GEBCO 2014 (Weatherall et al., 2015) bathymetric base map smoothed for numeric
160 constraints. The model simulation ran for 21 years (from 1993 to 2014). The model surface conditions are
161 derived from the ERA Interim atmospheric reanalysis (Dee et al., 2011) using a bulk formulation (Fairall et al.,
162 1996). The lateral boundary conditions are drawn from a global ocean reanalysis GLORYS (Ferry et al., 2012).
163 To reach a high resolution $1/36^\circ$ (~ 3 km) in the Mozambique Channel, three levels of embedded grids are
164 used, based on the AGRIF two-way nesting method (Debreu et al., 2012). Since the mean kinematic bottom-
165 shear-stress induced by tides affects only the shelf (i.e., Bight of Sofala; Chevane et al., 2016), barotropic tides
166 were not introduced in the model for this simulation.

167 Three cross-slope hydrographic sections based on CTD stations from northern, central, and southern
168 sector water columns were used to interpret relations between water mass stratification and sedimentary
169 features along the continental margin. Combining these sections with potential salinity-temperature-oxygen
170 diagrams from the same dataset allowed us to identify the main water masses in each physiographic domain.
171 This approach also revealed lateral variation in water mass dynamics along the Mozambique Channel. Accurate

172 identification of water masses and their spatial correlation with seafloor morphology can elucidate longer-
173 term oceanographic and sedimentary processes (Hernández-Molina et al., 2016a). Calculated as the oscillation
174 frequency of a parcel displaced vertically in a statically stable environment, the buoyancy or Brunt-Väisälä
175 frequency (N) provides information on water column stratification (Da Silva et al., 2009). It is calculated
176 from hydrographic data (World Ocean Database 2013) as:

$$177 \quad N = \sqrt{\frac{g}{\rho} \frac{\partial \rho}{\partial z}} \quad (1)$$

178 where g is the gravitational acceleration, ρ is the density, and $\frac{\partial \rho}{\partial z}$ is the vertical density gradient.

179 This analytical approach identified numerous bottom current-controlled depositional and erosional
180 features. We use the term '*contourites*' for sediments deposited or substantially reworked by the persistent
181 action of bottom currents (Faugères and Stow, 2008). This term includes a large variety of sediments affected
182 by different types of currents (Rebesco et al., 2014). Thick, extensive sedimentary accumulations are defined
183 as '*contourite drifts*' or '*drifts*'. Interpretation of features followed criteria for drift morphology and internal
184 configuration detailed in McCave and Tucholke (1986), Faugères et al. (1999), Rebesco and Stow (2001),
185 Rebesco (2005), and Rebesco et al. (2014).

186 4. Results

187 4.1. Physiography of the study area

188 The Mozambique Channel includes three major physiographic provinces, as defined by IHO and IOC
189 (1983): the continental shelf, the continental slope and the abyssal plain (**Fig. 3**). All three margin provinces
190 were interpreted from southern, central, and northern sectors of the study area. These represent the Tugela,
191 Limpopo, and Zambezi Rivers discharge areas, respectively (**Fig. 1A**).

192 The continental shelf exhibits an average gradient of 0.4° . It is particularly narrow ($\sim 2 - 15$ km in
193 width) compared to the global average of ~ 50 km (Shepard, 1963), except in the regions in front of the Tugela,
194 Limpopo and Zambezi rivers (i.e., 51 km, 80 km and 130 km respectively) (**Fig. 3**). The continental slope is
195 bordered to the west by the shelf-break, which is around 50 - 120 m water depths (set at ~ 200 m wd in this
196 study). In the study area, the continental slope exhibits a relatively gentle gradient (1.1° on average) relative to

197 the global average slope (3°, Kennett, 1982). The slope divides into upper, middle, and lower subdomains. Each
198 subdomain was defined to highlight zones of abrupt changes in seabed gradient (**Fig. 3 and Table II**); the
199 upper, middle and lower slope, respectively, have an average gradient of: 1.6°, 1.1° and 0.9°, and occur
200 between isobaths of: 200 to 1000 m, 1000 to 1600 m, and 1600 to 2400 m. The morphological seafloor
201 changes that determine the upper, middle and lower slope subdomains roughly coincide with the distribution
202 of large-scale flatter areas or terraces. These terraces have been described and locally characterized by Martin
203 (1981) in the central sector: the Inharrime terrace (< 800 m wd) and the Central terrace (~1400 - 2000 m wd),
204 which are separated by the SW-NE rough topography of the Almirante Leite Bank. Furthermore, a broad (~90
205 km) gently seaward dipping (0.3°) terrace occurs around 21° S (1300 - 1600 m wd) that has been described by
206 Wiles et al. (2017) (**Fig. 3**). In this study, the base-of-slope is set at 2400 m water depth (wd). In areas where
207 the buried Beira High and the Mozambique Ridge abut the continental slope (i.e., 21° S to 29° S), a steep
208 surface (2 - 10°) develops at the foot of the lower slope (from ~2400 m wd) (**Fig. 3**). In this study, this feature
209 belongs to the abyssal plain province.

210 The abyssal plain of the southern sector (i.e., Natal Valley) lies between 2400 m (uppermost,
211 narrowest part) and ~3000 m wd (southward at ~31° S). This feature is bounded to the east by the
212 Mozambique Ridge, which rises to a depth of 1800 m (**Fig. 3**). The Mozambique Ridge deepens along E-W
213 oriented pathways (at depths of ~2000 - 3000 m wd) connecting the abyssal plain regions of the Natal Valley
214 and the southern Mozambique basin. The abyssal plain depth of the Mozambique basin in the northern and
215 central sector increases from ~2400 m to ~4000 m wd southward at ~27° S. The large-scale morphology of
216 the abyssal plain includes numerous seamounts (i.e., Bassas Da India and Boucart) (**Fig. 3**).

217 *4.2. Gravitational features*

218 The continental slope of the southern sector hosts numerous submarine canyons extending from the
219 upper slope to the distal limit of the lower slope. Northward (and south of the Tugela canyon), submarine
220 canyons only occur within the lower slope (**Fig. 4**). Tugela canyon obliquely crosscuts the continental slope and
221 feeds the Tugela Cone, a deep-water fan complex (**Fig. 4**). The canyon reaches widths of up to 19 km and
222 incision depths of up to 1000 m in the middle slope. The canyon lacks any form of connection with the modern
223 fluvial system. A second, unnamed canyon originates at 1400 m wd north of the Tugela canyon. It widens and

224 deepens downslope to 2320 m wd with incision depths of up to 250 m around a prominent basement high, the
225 Naudé Ridge (Dingle et al., 1987) (**Figs. 4 and 5A**). The continental slope of the central sector is dominated by
226 along-slope sedimentary processes (**Figs. 4 and 5B**), except south of 27° S, where the upper slope is dissected
227 by several submarine canyons of varying size (from 50 - 300 m wide and 10 - 40 m deep to 750 - 2000 m wide
228 and > 400 m deep) (**Fig. 4**). Evidence of down-slope sedimentary processes is common along the slope of the
229 northern sector. Large Mass Transport Deposits (MTDs) appear in the middle to lower slope, where huge
230 deposits gather on the seafloor (**Fig. 4**) or appear as buried features in seismic profiles (**Fig. 5C**). This sector
231 also hosts many submarine canyon systems (SCSs). Wiles et al. (2017) identified three different SCSs of this
232 area. From north to south, these include the Angoche SCS, the Middle Zambezi SCS, and the Lower Zambezi
233 SCS (**Fig. 4**). In the Angoche SCS, the margin consists of a series of canyons that extend across the shelf towards
234 the lower slope and from the shelf to the middle slope (**Fig. 4**). These canyons reach widths of up to 4 km (**Fig.**
235 **5D**). The Lower Zambezi SCS consists of canyons mostly initiating in the middle slope at around 1000 m wd. A
236 few of these canyons appear at around 300 m wd. These canyons can reach 12 km in width (**Fig. 5C**). Along the
237 abyssal plain, sedimentary lobes form at the distal limit of the lower slope of the Angoche SCS and the Lower
238 Zambezi SCS (**Figs. 4, 5C, and 5D**). The Middle Zambezi SCS consists of canyons mostly initiating in the middle
239 slope (**Fig. 4**). The present-day canyons lack any form of connection either with modern continental drainage
240 channels or with incisional canyons on the shelf. These canyons reach widths of up to 7 km and incision depths
241 of up to 200 m at around 2500 m wd. Along the abyssal plain, the Middle Zambezi SCS converges at about 19°
242 S to join the Zambezi Valley. The combined feature then flows towards the south confined by the western
243 flank of the Davie Fracture Zone (DFZ) until about 25° S where a large sedimentary lobe develops (**Fig. 4**).

244 *4.3. Contourite features*

245 Our analysis identified a wide range of contourite features, including depositional (drifts and
246 sedimentary waves), erosional (abraded surfaces, moats, channels, scours, and furrows), and mixed
247 (contourite terraces) features occurring from the shelf break to the abyssal plain (**Fig. 4**). Contourite drifts
248 represent important along-slope accumulations of sediment that appear as continuous, layered seismic
249 reflections with internal, regional-scale unconformities (**Fig. 6**). Erosional features are mainly characterized by
250 truncated reflections underlying stratified and / or chaotic facies. These generally show relatively high
251 amplitude reflections (HARs) relative to those representing associated drifts (**Fig. 6**). The mixed features

252 (contourite terraces) display similar seismic facies defined by continuous to discontinuous, subparallel, and
253 occasionally truncated seismic reflections (**Fig. 6**). High amplitude reflections are generally found along these
254 terraces with a number of 2D sedimentary waves (e.g., Flemming, 1978; Green, 2011).

255 4.3.1. Depositional contourite features

256 Drifts are the dominant depositional features observed. The largest of these features are '*plastered*
257 *drifts*' and '*elongated-mounded drifts*'. Large, plastered drifts of the Mozambique continental slope show a
258 prominent along-slope trend (**Fig. 4**). Elongated-mounded drifts are dispersed throughout the continental
259 slope and abyssal plain of Mozambique's central sector (**Fig. 4**). In addition to large-scale plastered and
260 elongated-mounded drifts, other minor depositional features include large '*sedimentary waves*' previously
261 described by Breitzke et al. (2017). These exhibit a wavy geometry (**Fig. 5B**) and occur throughout the abyssal
262 plain, particularly south of the Bassas Da India seamounts in the centre of the Mozambique Channel (**Fig. 4**).

263 The three plastered drifts recognized in this study were informally referred to as D1 to D3 based on
264 their water depth range along the slope (D1 being the shallowest and D3 the deepest; **Fig. 4**). '*Plastered drifts*
265 *1 and 2*' (D1 and D2) are located between ~300 and 600 m wd along the upper slope and between ~900 and
266 1300 m wd along the middle slope, respectively (**Fig. 4**). These show aggradational and progradational internal
267 reflection configurations with thickness variations that indicate depocenters parallel to the slope (**Figs. 5E, 6A,**
268 **6B, and 6I**). In the southern sector, the 10 - 40 km wide D1 developed between 30° S and the Tugela Cone (**Fig.**
269 **4**). In the central sector, D1 spans about 20 km width and extends ~56 km along the Inharrime Terrace (**Fig. 4**).
270 In the northern sector, D1 is about 7 km wide and disappears near 18° S (**Fig. 4**). In the southern sector, the 15
271 km wide D2 developed between 30° S and the Tugela Cone (**Fig. 4**). In the central sector, between 29° S and
272 25° S, D2 spans about 10 km in width (**Fig. 4**), and extends ~116 km near 27° S before it disappears in the
273 vicinity of topographic highs associated with the Almirante Leite Bank (**Fig. 4**). North of the Almirante Leite
274 Bank, D2 is about 6 - 30 km wide and disappears in the vicinity of the southeastern limb of the Beira High, near
275 the northern sector (**Fig. 4**). The deeper '*plastered drift 3*' (D3) occurs in the lower slope of the central sector
276 (between ~27° S and 29° S) at ~1500 - 2200 m wd (**Fig. 4**). Between the Tugela Cone and the abraded surface,
277 D3 extends to 88 km width (**Fig. 4**). In this area, D3 exhibits aggradational to progradational internal reflections
278 with a more pronounced upslope progradational stacking pattern than those exhibited by drifts D1 and D2

279 (Fig. 6C). North of the abraded surface, D3 extends to a width of about 110 km along the Central Terrace (Fig.
280 4) and exhibits predominantly progradational and seaward internal reflections (Fig. 6E).

281 Apart of the aforementioned plastered drifts D1 to D3, the central sector hosts other '*elongated-*
282 *mounded drifts*' (Fig. 4). Along the distal limit of the middle slope, elongated-mounded drifts occur east of the
283 Almirante Leite Bank, near 24° S (Fig. 4), where they reach about 12 km in width (Fig. 6B). Along the lower
284 slope, elongated-mounded drifts are widespread from 22° S to 26° S, ranging 1 - 20 km in width (Fig. 4). From
285 the distal limit of the lower slope to about 3200 m wd, elongated-mounded drifts occur in association with
286 steep surfaces of the Mozambique Ridge (29° S to 22° S) and the south-eastern limb of the Beira High (21° S).
287 These drifts reach widths of about 6 - 60 km (Figs. 4, 5B, 6F, and 6G).

288 '*Sedimentary waves*' occur along most of the basin floor of the central sector (Figs. 4, and 5B). At
289 water depths of ~3500 to 4500 m, sedimentary waves can reach 60 - 80 m in height and up to 5 km in length,
290 with wavelengths around 2.5 - 3 km. These features generally orient in a NE-SW direction, but then shift to
291 WSW-ENE and WNW-ESE orientations to the north (Fig. 4). For water depths between ~3000 and 3400 m,
292 sedimentary waves reach heights of 35 - 60 m, wavelengths around 1 - 2 km, and lengths of up to 10 km. These
293 shallower features strike NW-SE, but shift into W-E and NE-SW orientations to the east (Fig. 4).

294 4.3.2. Erosional contourite features

295 Erosive contourite features occur locally along the Mozambican continental margin and basin floor.
296 Erosional features include moats / contourite channels, abraded surfaces, and lineations (i.e., scours and
297 furrows) (Fig. 4). '*Abraded surfaces*' occur along the lower slope of the central sector (Figs. 4, 5B, 6B, 6G, and
298 6H), and north of the Naudé Ridge (~50 km wide, ~100 km long, and deepening from ~1900 to 2300 m wd)
299 (Figs. 4, and 6D). They also appear as steep surfaces related to the Mozambique Ridge (29° S to 22° S) and the
300 southeastern limb of the Beira High (21° S) at the base of the slope (Figs. 4, 5B, 6G, and 6H). '*Moats*' are
301 associated with elongated-mounded drifts and exhibit U-shaped cross sections (Figs. 4, 5B, 6B, 6F, and 6G).
302 These features can span up to 3 km in width and incise to depths of up to 100 m. '*Contourite channels*' develop
303 in the vicinity of the large topographic highs of the Almirante Leite Bank and within the deeper corridor of the
304 Mozambique Ridge (Fig. 4). '*Lineations*' (i.e., scours and furrows) occur along the abyssal plain near 26° S (Fig.
305 4). '*Scours*' form between 3500 - 4500 m wd. often exhibiting a crescent-like shape (Breitzke et al. 2017), these

306 can reach 20 km in length, 3 - 7 km in width and incisional depths of up to 450 m. Several large 'furrows' (i.e.,
307 60 - 100 m deep, 2 - 3 km wide, and 8 - 15 km long) are located east of the giant erosional scours between
308 3600 - 4300 m wd. Furrows generally assume a NW-SE or E-W orientation and a smooth V-shape morphology
309 as described in Breitzke et al. (2017).

310 4.3.3. Mixed features

311 'Contourite terraces' represent mixed features that appear as sub-horizontal elements developed during long-
312 term depositional and erosional phases of the continental slope (Hernández-Molina et al., 2016a). These form
313 erosive features in proximal domains and mostly depositional features in distal domains. Terraces are
314 morphological features that extend to distinct depth intervals above large plastered drifts to produce long
315 flatter areas with subtle ($< 1^\circ$) seaward dips along the Mozambican margin (T1 to T4) (Figs. 5B, and 6).
316 Terraces develop along the upper slope (T1 at ~300 m wd) near the transition between upper and middle
317 slopes (T2 at ~800 m wd), near the transition between middle and lower slopes (T3 at ~1500 m wd), and
318 along the lower slope (T4 at ~2200 m wd) (Figs. 4, and 5B).

319 'Terrace 1' (T1) is associated with the upper surface and landward proximal domain of the D1 drift
320 (Fig. 6A). In the southern sector, T1 develops between 30° S and the Tugela Cone to reach a width of ~4 km. In
321 the central sector, T1 reaches ~4 - 5 km in width and extends ~50 km along the Inharrime Terrace. In the
322 northern sector, T1 reaches about ~2.5 km in width and disappears near 18° S (Fig. 4). 'Terrace 2' (T2) is
323 associated with the top surface and landward proximal domain of the D2 drift (Fig. 6A). In the southern sector,
324 T2 forms between 30° S and the Tugela Cone to reach widths of ~15 km. In the central sector between 29° and
325 25° S, T2 spans less than 1 km in width. It extends up to ~30 km near 27° S (Limpopo Cone) before it
326 disappears in the vicinity of the topographic highs of the Almirante Leite Bank. North of the Almirante Leite
327 Bank, T2 reaches widths of about ~20 - 30 km and extends 80 km near the Beira High. T2 disappears in the
328 vicinity of the large MTDs occurring in the northern sector (Fig. 4). 'Terrace 3' (T3) is associated with the top
329 surface and landward proximal domain of the D3 drift (Figs. 6C, and 6E). In the central sector, T3 is about ~4 -
330 25 km wide, extending ~60 km and disappearing in the vicinity of the topographic highs of the Almirante Leite
331 Bank. North of the Almirante Leite Bank, T3 is about ~4 km wide but poorly developed relative to T1 and T2.
332 T3 disappears in the vicinity of the southeastern limb of the Beira High (21° S) (Fig. 4). 'Terrace 4' (T4) only

333 appears from 21° to 25° S where it spans about ~60 km in width (**Fig. 6H**). Toward the northern sector, T4 is
334 about ~2 km wide and disappears in the vicinity of the southeastern limb of the Beira High (21° S) (**Fig. 4**).
335 Unlike T1-T3, which exhibit mostly a depositional character in their distal domain (i.e., plastered drifts D1 to
336 D3), T4 exhibits a steep surface with an erosive character along its seaward flank (**Figs. 4, and 6H**).

337 *4.4. Identification of water masses and associated oceanographic processes*

338 Temperature and salinity profiles indicate seven major water masses operating the Mozambique
339 Channel of the southwest Indian Ocean (**Fig. 7 and table I**). These include three of Indian origin (TSW, Tropical
340 Surface Water; STSW, Subtropical Surface Water; and SICW, South Indian Central Water), one of North Atlantic
341 origin (NADW, North Atlantic Deep Water), one of Red Sea origin (RSW, Red Sea Water), and two of Antarctic
342 origin (AAIW, Antarctic Intermediate Water; AABW, Antarctic Bottom Water). An eighth water mass lies below
343 the TSW, the Tropical Thermocline Water, which differs from STSW (same temperature) according to the
344 former's much lower oxygen content (Lutjeharms, 2006) (**Figs. 7D, and 7E**). The TSW, STSW, Tropical
345 Thermocline Water, and SICW make up the upper water column, while the AAIW and RSW constitute the
346 intermediate water column, and the NADW and AABW form the base of the water column (Ullgren et al.,
347 2012). Select neutral density profiles in this region showed that $\gamma^n = \sim 26.4 \text{ kg/m}^3$ for the Subtropical Surface
348 Water (STSW) – South Indian Central Water (SICW) transition, $\gamma^n = 27 \text{ kg/m}^3$ for the SICW – Antarctic
349 Intermediate Water (AAIW) transition, $\gamma^n = 27.8 \text{ kg/m}^3$ for the AAIW – North Atlantic Deep Water (NADW), and
350 $\gamma^n = 28.2 \text{ kg/m}^3$ for the NADW – Antarctic Bottom Water (AABW) (Toole and Warren, 1993; Talley, 1996;
351 Ullgren et al., 2012) (**Fig. 7**). Identification of present water masses and their correlation with seafloor
352 morphology can help elucidate longer-term oceanographic and sedimentary processes. The present oceanic
353 circulation offshore of Mozambique is relatively complex and composed of various water masses interacting at
354 different depths. These are briefly described below.

355 *4.4.1. Identification of water masses along the Southern Sector*

356 At shallow water depths (< 200 m), the Tropical Surface Water (TSW; above 24° C) covers the Sub-
357 Tropical Surface Water (STSW), which exhibits a maximum in salinity of 35.7 psu and temperature of around
358 17° C (**Fig. 7A**). Both are saturated in dissolved oxygen (**Fig. 7D**). Tropical Thermocline Water can be
359 distinguished from STSW (same temperature) by the former's much lower dissolved oxygen concentrations (<

360 4 ml/l) (**Fig. 7D**). Directly below the STSW, within a neutral density range of 26.4 kg/m^3 to 26.8 kg/m^3 and a
361 water depth range of about 200 - 600 m, temperature-salinity properties declined down to values of $8 - 14^\circ \text{ C}$
362 and $34.8 - 35.5 \text{ psu}$, respectively. These parameters are characteristic of the South Indian Central Water (SICW)
363 (**Fig. 7A**). The relatively fresh Antarctic Intermediate Water (AAIW) and relatively saline Red Sea Water (RSW)
364 with neutral densities ranging from $27.0 - 27.8 \text{ kg/m}^3$ occupy intermediate depths below the thermocline (**Fig.**
365 **7A**). The AAIW forms a salinity minimum of $< 34.5 \text{ psu}$, while the RSW modifies this minimum by interleaving
366 the water column with relatively saline layers ($> 34.6 \text{ psu}$) (**Fig. 7A**). Further downslope, at neutral densities
367 greater than 27.8 kg/m^3 , a cold ($\sim 2^\circ \text{ C}$) and high salinity ($> 34.8 \text{ psu}$) bottom layer is interpreted as the North
368 Atlantic Deep Water (NADW) (**Fig. 7A**).

369 4.4.2. Identification of water masses along the Central Sector

370 Along this hydrographic section, the TSW, STSW, and Tropical Thermocline Water occupy the upper
371 water column ($< 200 \text{ m wd}$, $\gamma^n < 25.8 \text{ kg/m}^3$) (**Figs. 7B, and 7E**). The TSW forms surface water, which is
372 warmer than 24° C . Directly beneath, the STSW exhibits a maximum in salinity of 35.8 psu at temperatures of
373 around 17° C (**Fig. 7B**). TSW and STSW are saturated with dissolved oxygen while Tropical Thermocline Water,
374 at the same depth as the STSW salinity maximum, exhibits lower dissolved oxygen concentrations ($< 4 \text{ ml/l}$)
375 (**Fig. 7E**). At water depths of 200 to 600 m, temperature-salinity properties ($8 - 14^\circ \text{ C}$ and 34.8 to 35.5 psu ,
376 respectively) are characteristic of the SICW (26.4 kg/m^3 to 26.8 kg/m^3) (**Fig. 7B**). The AAIW appears at water
377 depths of $\sim 800 \text{ m}$ near the neutral density of the SICW-AAIW transition (27 kg/m^3) (**Fig. 7B**). The AAIW layer at
378 this section exhibits low salinities (~ 34.5). AAIW combines high salinities ($> 34.6 \text{ psu}$) and low dissolved
379 oxygen ($< 3.5 \text{ ml/l}$) layers of the RSW at water depths of 800 and 1500 m (**Figs. 7B, and 7E**). Below, as neutral
380 densities surpass 27.8 kg/m^3 , the NADW ($< 4^\circ \text{ C}$, $\sim 34.8 \text{ psu}$) appears at around 2200 m wd (**Fig. 7B**). At water
381 depths around 3500 - 4000 m, cold ($\sim 1.5^\circ \text{ C}$), low salinity ($< 34.7 \text{ psu}$) bottom waters approach the neutral
382 density of the NADW-AABW transition (28.2 kg/m^3) (**Fig. 7B**).

383 4.4.3. Identification of water masses along the Northern Sector

384 The hydrographic section located in the northern part of the margin intersects the 2000 m isobath.
385 Dissolved oxygen data for this part of the basin was not available. The surface water column is characterized by
386 warm temperatures ($> 24^\circ \text{ C}$) and high salinity ($\sim 35.2 \text{ psu}$) of the TSW (**Fig. 7C**). Beneath this water mass lies

387 the STSW, which exhibits a maximum salinity of ~ 35.5 psu and temperature of 15°C to give a neutral density
388 of $< 25.8\text{ kg/m}^3$ for its upper layers ($< 200\text{ m wd}$) (**Fig. 7C**). Below the STSW salinity maximum, temperature-
389 salinity properties increase to values characteristic of the SICW, which exhibits a neutral density range of 26.4
390 kg/m^3 to 26.8 kg/m^3 in the $200 - 600\text{ m}$ depth range (**Fig. 7C**). The base of the SICW reaches a local salinity
391 minimum and neutral density of 27 kg/m^3 , which marks the transition to properties associated with
392 intermediate water masses (**Fig. 7C**). The intermediate water masses exhibit a neutral density range of 27
393 kg/m^3 to 27.8 kg/m^3 and flow at depths of 800 to 1500 m wd . The water masses are relatively salty and
394 salinities greater than 34.9 psu in the middle of the density range indicate the presence of the RSW (**Fig. 7C**).
395 Below the RSW, salinities decrease (< 34.7 psu) to another local minimum around 1500 m wd and 27.6 kg/m^3
396 density indicating a deeper AAIW core (**Fig. 7C**). For deeper water approaching 27.8 kg/m^3 neutral density,
397 salinities increase to about 34.8 psu at temperatures of around 2°C . These parameters indicate the presence
398 of the NADW in contact with the seafloor at around 2200 m wd (**Fig. 7C**).

399 4.4.4. Associated interface processes

400 Near-bottom layers for the water masses described above indicate that TSW, STSW and SICW traverse
401 the continental shelf and upper slope of the Mozambican margin while the AAIW and RSW traverse the middle
402 and lower slopes, and the NADW and AABW occupy the Mozambican base-of-slope and deep basins (**Figs. 2,**
403 **and 8**). Interfaces between the TSW + STSW / SICW and SICW / AAIW (and RSW) thus interact with the
404 Mozambican slope (**Fig. 8**), whereas interfaces between AAIW (and RSW) / NADW and NADW / AABW affect
405 the Mozambican base-of-slope and basin floor. The interfaces (pycnoclines) between the TSW + STSW / SICW
406 and SICW / AAIW are characterized by sharp density gradients while the interface between AAIW / NADW is
407 characterized by a diffuse density gradient with a gradual transition from one water mass to the other (**Fig.**
408 **9C**). High values of buoyancy (Brunt-Väisälä) frequency ($> 2\text{ cycl/h}$) is observed at around 800 m wd and above
409 $\sim 300\text{ m wd}$ (**Fig. 9A**), matching the TSW + STSW / SICW and SICW / AAIW interfaces. Above $\sim 300\text{ m wd}$, the
410 buoyancy (Brunt-Väisälä) frequency reaches maximum values around $50 - 100\text{ m wd}$ ($> 6\text{ cycl/h}$) (**Fig. 9B**).
411 Internal waves (solitons) were observed propagating from the shelf of the Bight of Sofala into the Indian Ocean
412 (20°S to 21°S ; **Figs. 10D, and 10E**). **Figs. 10 (A, B, and C)** also illustrates internal wave propagation towards the
413 coast in the Bay of Maputo.

414 4.5. Circulation model results

415 Bottom current simulations carried out with the Regional Oceanic Modelling System (ROMS) indicated
416 that currents often flow parallel to the isobaths but exhibit some degree of variation in direction and velocities
417 depending on location (**Fig. 11**). Along the upper slope, the simulated bottom currents show southward
418 movement with mean velocities of > 12.5 cm/s (**Figs. 11A, and 11B**). The upper slope along the Inharrime
419 Terrace and Limpopo Cone experienced W-NW transport near the shelf break (200 m wd) with inversions
420 towards the W-SW, especially along the distal limit of the upper slope (~ 1000 m wd) (**Fig. 11C**). Flow directions
421 corresponded to a local cyclonic eddy previously described by Lamont et al. (2010). Along the middle slope,
422 simulated bottom currents showed greater variability in current direction. Current direction was less
423 rectilinear and flowed northward with at relatively low current velocities (< 12.5 cm/s). By contrast, current
424 direction indicated southward transport deflected E-SE associated with the highest estimated current
425 velocities (> 12.5 cm/s) (**Figs. 11A, 11C, and 11D**). Higher current speeds correspond to periods of southward
426 moving anticyclonic eddies as documented by Schouten et al. (2003). Slope morphology constrains current
427 direction near the Almirante Leite Bank. Steeper slope flanks in this area intensify circulation (> 25 cm/s) (**Fig.**
428 **11C**). Along the lower slope, simulated currents showed predominantly northward transport with mean
429 velocities reaching > 25 cm/s (**Fig. 11**). Faster currents occur along steep surfaces around 1800 m (**Fig. 11B**),
430 2500 m (**Fig. 11A**) and 3000 m wd (**Figs. 11D, and 11E**) with mean velocities of ~ 12.5 cm/s but locally reaching
431 as much 25 cm/s. Along the abyssal plain, simulated bottom currents intensify along the Mozambique Ridge
432 with mean velocities oscillating between 12.5 - 25 cm/s (**Fig. 11D**) and around Mt. Boucart, especially along its
433 western flank, where mean velocities can exceed 25 cm/s (**Fig. 11B**). Current directions indicate predominantly
434 northward transport along the western side of the margin and eastward deflection in the middle of the abyssal
435 plain (**Figs. 11A, and 11E**).

436 5. Discussion

437 The morpho-sedimentary map and oceanographic features described above enable interpretation of
438 sedimentary processes operating within the Mozambique Channel. Interpretation indeed suggests that bottom
439 currents adequately explain the formation and variability of observed contourite features (depositional,

440 erosive and mixed). Matching contourite types with the relevant bottom water masses allows us to propose a
441 depositional model for the Mozambique Channel.

442 5.1. Water-mass interfaces sculpt contourite terraces

443 Contourite terraces 1 and 2 represent regional scale features formed along the Mozambique Channel
444 while contourite terraces T3 and T4 show much more variation in their spatial distribution (**Fig. 4**). The terraces
445 occur in water depths of ~300 m for T1, ~800 m for T2, ~1500 m for T3 and ~2200 m for T4. Hydrographic
446 Sections A and B (**Fig. 8**) cover T1, T2, T3 and T4. These show that terraces occur close to the present water
447 depth range of various water mass interfaces. For example, terrace T1 with Tropical + Subtropical Surface
448 Water (TSW + STSW) / South Indian Central Water (SICW) interface, terrace T2 with SICW / Antarctic
449 Intermediate Water (AAIW) interface, and terraces T3 and T4 with AAIW / North Atlantic Deep Water (NADW)
450 interface. The interfaces (pycnoclines) for T1 and T2 represent sharp and well-defined density gradients (**Fig.**
451 **9C**). A 700 m thick transition zone marks the interface for T3 and T4 between AAIW (800 - 1500 m wd) and
452 NADW (2200 - 3500 m wd). The transition zone is marked by a diffuse density gradient with a gradual
453 transition from one water mass to the other (**Fig. 9C**). These interfaces can be affected by different
454 oceanographic processes, which are described below.

455 5.1.1. The effect of internal tides

456 According to both in situ measurements (tidal gauges) and numerical models, the most important
457 harmonic affecting the Mozambique Channel is semi-diurnal (M_2 tidal constituent; 12.42 h) tides (sea-level
458 amplitudes up to 2 m) (Chevane et al., 2016). Manders et al. (2004) demonstrated that the barotropic tidal
459 current (with the dominant M_2 component) velocity oscillates within $\pm 2 - 5$ cm/s in north-south direction. The
460 east-west oriented tidal current oscillates within ± 1 cm/s and is thus negligible, except along the shelf (30 - 70
461 cm/s; Chevane et al., 2016). Interaction between the barotropic tidal current with the bottom topography, in
462 regions where it changes more or less abruptly, as ridges, banks, slopes, shelf breaks, etc., may often result in
463 the generation of large internal waves of tidal period, known as internal (baroclinic) tides (Shanmugam, 2013;
464 Hernández-Molina et al., 2016b). According to Manders et al. (2004), internal semi-diurnal tidal current
465 oscillates within $\pm 3 - 4$ cm/s, with peaks exceeded 12 cm/s (~250 m wd). Internal waves of tidal period (M_2)
466 are also a major driving force for vertical displacements of the isopycnals (Maas et al., 2018). Isopycnal

467 displacement (~100 m) produced by internal waves propagation can be observed directly from Envisat
468 advanced synthetic aperture radar (ASAR) images (**Fig. 10**). It shows clear evidence of internal waves travelling
469 oceanward away from the shelf break (**Figs. 10E, and 10D**) and toward the continental shelf (**Figs. 10A, 10B,**
470 **and 10C**). In **Fig. 9**, higher buoyancy (Brunt-Väisälä) frequency is observed on the proximal and / or nearly flat
471 sector of terrace T1. It coincides with the water depth range of the interface between TSW + STSW / SICW
472 (~200 m wd). DaSilva et al. (2009) observed internal waves travelling at 1.4 m/s with wavelengths of 0.5 km
473 along the pycnocline near the surface (~60 - 100 m). It leads to oscillation around 10 cycl/h which is consistent
474 with values observed along T1 at ~100 m wd (**Fig. 9B**). For T2, high values of buoyancy (Brunt-Väisälä)
475 frequency along the water depth range of the interface between SICW / AAIW (~800 m wd) (**Fig. 9A**) indicate a
476 stably-stratified boundary layer, allowing for internal waves to propagate (Maas et al., 2018). Lastly, Maas et
477 al. (2018) indicated that the fluctuation of the isopycnal (displacements of 80 m) at 1500 wd was in general
478 dominated by the internal tides, as reported for internal waves above. This fact point to a probable
479 propagation of internal waves in the water depth range of T3. However, the study of Maas et al. (2018) is
480 located along the narrowest part of the Mozambique Channel (17° S) while T3 occurs at around 22° S (**Fig. 4**).
481 This assumption remains nevertheless to be confirmed by further studies. Hence, we suggest that internal
482 waves of tidal period may act as the primary mechanism in the erosion or non-deposition of contourite
483 terraces T1, T2 and T3 as have been proposed along the south Atlantic continental slopes (e.g., Hernández-
484 Molina et al., 2009; Preu et al., 2013). These can mobilize and re-suspend bottom sediments (e.g., Cacchione et
485 al., 2002; McCave, 2009; Pomar et al., 2012; Shanmugam, 2013).

486 *5.1.2. The effect of eddies*

487 Mesoscale eddies (either cyclonic or anticyclonic) can be considered as a further mechanism (e.g.,
488 García et al., 2015). Such eddies are well described along the Mozambique Channel (de Ruijter et al., 2002).
489 These eddies have a large barotropic component, affecting the whole water column with current velocities
490 ~50 - 25 cm/s at ~200 - 300 m wd, respectively (Ternon et al., 2014). Current velocities are, however, greatly
491 weakened near the bottom (~10 cm/s at depths > 2000 m) (Schouten et al., 2003). Consequently, these
492 eddies were able to induce erosion or non-deposition along the contourite terraces. This finding is consistent
493 with the area of erosion or non-deposition of T1 along the Inharrime Terrace (Martin, 1981) (**Fig. 4**) maintained
494 by strong bottom currents due to eddies (Lamont et al., 2010; Preu et al., 2011). As a final remark, internal

495 waves are also likely to be amplified by interaction with mesoscale eddies (Magalhaes et al., 2014; Xie et al.,
496 2015). Beal et al. (2006) also suggested eddy-induced generation of internal waves along the upper boundary
497 of the NADW (~2200 m wd) in the water depth range of T4 (e.g., Clément et al., 2017).

498 5.1.3. *The effect of along-slope bottom currents*

499 Another possible mechanism controlling sediment dynamics originates from the along-slope bottom
500 currents. **Fig. 11** shows clear evidence for high current velocities influencing T3 and T4 (> 25 cm/s). For T3,
501 Beal (2009) reported northward flow velocities of 25 cm/s with peak speed over 95 cm/s at ~1400 m wd
502 within the Agulhas undercurrent (1000 - 2900 m wd). Ridderinkhof and de Ruijter (2003) interpreted
503 northward flow velocities of 4.5 cm/s with peak speed around 40 cm/s at 1500 - 2400 m wd within the
504 Mozambique undercurrent. However, it should be noted that geostrophic flows have periods of intense,
505 reduce or even revert circulation modulated by periodic or a-periodic processes (eddies, deep water tidal
506 currents, etc.). Additionally, internal waves may be generated when the along-slope bottom currents flow over
507 rough topography (Liang and Thurnherr 2012).

508 5.2. *Along-slope bottom current circulation governs the formation of plastered drifts*

509 Large-scale plastered drifts (D1 and D2) occur on a regional scale along the Mozambican margin while
510 plastered drift D3 occurs on a more local scale (**Fig. 4**). These occur in basinward areas and in distal areas of
511 contourite terraces T1, T2 and T3, respectively (**Figs. 6A, 6C, and 6E**). Plastered drift water depths range from
512 ~300 to 600 m for D1, ~900 to 1300 m for D2 and ~1600 to ~2200 m for D3. Their distribution determines
513 morphological seafloor changes that roughly coincide with the major physiographic provinces (D1, upper
514 slope; D2, middle slope; and D3, lower slope; **Figs. 5, and 6**). Thus, these have significant effect in the shaping
515 of the continental margin (e.g., Mosher et al., 2017). Hydrographic sections indicate that D1 and D2 match the
516 near-bottom layer distribution of water masses bounded by the most pronounced density contrasts
517 (pycnoclines) (**Fig. 9**). We therefore interpret large plastered drifts D1 and D2 along the Mozambican slope as
518 influenced by the SICW (200 - 600 m wd) and AAIW (800 - 1500 m wd), respectively (**Figs. 8A, and 8B**). In
519 contrast, plastered drift D3 occurs in the transition zone between AAIW (800 - 1500 m wd) and NADW (2200 -
520 3500 m wd). Along-slope bottom currents move relatively slowly in the water depth range occupied by the
521 plastered drifts (~5 - 10 cm/s) (**Fig. 11**). These currents exhibit generally southward direction over D1 (**Fig.**

522 **11A**), and northward direction over D2 and D3 (**Figs. 11B, and 11D**). This hypothesis is further confirmed by
523 other studies: Martin (1981) demonstrated that rapid sediment accumulation of D1 along the Inharrime
524 Terrace occurs under weak southward flow conditions; and Beal (2009) reported weak northward flow
525 velocities of 10 cm/s at 1100 m wd in the water depth range of D2.

526 These morpho-sedimentary and hydrographic coincidences lead us to propose that the regional
527 physiographic configuration of the Mozambican margin is most likely related to along-slope bottom currents.
528 Seismic profiles indicate that the present-day physiographic configuration and the sub-bottom architecture of
529 the plastered drifts have a stable behaviour on geological timescales, as reported by Dingle et al. (1978) and
530 Preu et al. (2011) for D1 along the Inharrime Terrace. It allows us to suggest a long-term, stable behaviour of
531 the water masses (e.g., Rebesco et al., 2014; Ercilla et al., 2016). Thus, the observed variability of geostrophic
532 flows in the region (eddies, deep water tidal currents, etc.) appears to have no significant effect in the long-
533 term shaping of the continental margin. Although their apparent not significant effect may simply reflect poor
534 interpretation because their importance cannot be resolved in our seismic profiles. This point was mentioned
535 in the study of Ercilla et al. (2016). Lastly, the actual oceanographic model and all observed variability (eddies,
536 deep water tidal currents, etc.) might differ over the geological time span of plastered drifts formation. This
537 scenario might explain the present-day unusual location of D3 in the water depth range of the transition zone
538 between two water masses (AAIW and NADW).

539 *5.3. Influence of bottom topography on bottom current processes*

540 The AAIW and NADW encounter obstacles such as seamounts (i.e., Almirante Leite Bank, Naudé
541 Ridge), the Beira High and the Mozambique Ridge. These obstacles produce streamline distortions, creating
542 current cores that can winnow, distribute, erode, and rework near-surface sediment (e.g., Kennett, 1982;
543 Faugères et al., 1999; García et al., 2009). The AAIW and NADW usually have main current cores that run
544 northward, parallel to isobaths along the walls of the obstacles (e.g., Dingle et al., 1987) (**Fig. 11**). The velocity
545 of these cores manifests in erosive features (moats, contourite channels, abraded surfaces, and lineations;
546 scours and furrows) (**Fig. 4**). Moats are associated with elongated-mounded drifts at the foot of high walls, as
547 well as the abraded surfaces along their walls (e.g., Kennett, 1982; Hernández-Molina et al., 2006b) (**Figs. 4, 5,**
548 **and 6**). These features suggest helicoidal flows around the cores of the current, referred to as 'horizontal

549 eddies' (Rebesco et al., 2014). It result from Coriolis effect directing the cores of the current against the
550 adjacent slope eroding the left side of the moat and depositing sediment on the right side where the current
551 velocity is lower (e.g., Llave et al., 2001; Faugères and Mulder, 2011). The currents then form the abraded
552 surfaces north of the Naudé Ridge (**Fig. 6D**) and along the steep lower-slopes of the Mozambique margin (**Figs.**
553 **5B, 6G, and 6H**). They also influence contourite channels and moats along the Almirante Leite Bank (**Fig. 4**), on
554 the Mozambican lower-slope (**Figs. 5B, and 6B**), at the foot of the Mozambique Ridge (**Figs. 5B, 6F, and 6G**),
555 and eastern-limb of the Beira High (**Fig. 6G**), and across deep, E-W corridors within the Mozambique Ridge
556 (**Fig. 4**; described in Wiles et al., 2014). Finally, they form elongated-mounded drifts immediately seaward of
557 moats (**Figs. 5B, 6B, 6F, and 6G**). As shown in **Fig. 11**, bands of high bottom current velocities (> 25 cm/s)
558 correspond either to the presence of moats / contourite channels or abraded surfaces, while elongated-
559 mounded drifts experience the lowest bottom current velocities (< 12.5 cm/s). Both are associated with
560 northward flowing water masses of the AAIW and NADW within the Mozambique and Agulhas undercurrents.
561 However, **Fig. 11C** shows the complexity of AAIW circulation, a large part of which is diverted southward.
562 Observations of Dingle et al. (1978) and Martin (1981) support the interpretation given here by emphasizing
563 that the deepest moats lie along upstream (NE) flanks of topographic highs centered on the Almirante Leite
564 Bank between ~ 900 and 1300 m wd. This suggests southward flow of the AAIW following the model of
565 Faugères et al. (1999), Llave et al. (2001), and Hernández-Molina et al. (2006b). Re-circulation of the AAIW may
566 be due to the occurrence of passing moving anticyclonic eddies that also carry the RSW southward at a depth
567 of $\sim 900 - 1200$ m (Gründlingh, 1985; Ridderinkhof and de Ruijter, 2003). Beal (2009) also defined the core of
568 the Agulhas undercurrent at $1000 - 2900$ m wd, where it carries both AAIW and NADW northward. For the
569 northern part of the Mozambique Channel near 17° S, Ridderinkhof and de Ruijter (2003) interpreted the core
570 of the Mozambique undercurrent at $1500 - 2400$ m wd and suggested entrainment of the AAIW southward
571 where it exits the local undercurrent.

572 Sedimentary waves at water depths of 2500 to 3500 m along the abyssal plain are linked to the
573 presence of the NADW, which would be locally guided by seafloor irregularities and incisions created by the
574 Zambezi Valley and seamounts (i.e., Bassas Da India, Mt. Boucart) (**Figs. 4, and 11**). Breitzke et al. (2017)
575 demonstrated that these sedimentary waves are draped with sediments, indicating that present-day velocities
576 cannot erode sediments along this part of the abyssal plain. At water depths greater than ~ 3500 m, Breitzke et

577 al. (2017) described bedforms as consisting mainly of large sedimentary waves, giant erosional scours, and
578 furrows. These occur in the transition zone (~500 m) between the NADW (< 3500 m) and the AABW (> 4000
579 m) and within the AABW. Crests tend to be aligned oblique to the current direction in the case of sedimentary
580 waves associated with geostrophic bottom currents (Fox et al., 1968; Manley and Flood, 1993). Simulation
581 results (**Fig. 11E**) demonstrate that bottom currents direction is consistent with the oblique alignments of the
582 sediment wave crests (**Fig. 4**). Here, the shallow bathymetry (< 4000 m wd) of the northern part of the margin
583 topographically blocks the AABW to the north and deflects it eastward. Thus, we can infer that these features
584 likely result from the geostrophic flows (~12.5 cm/s), being aided by internal waves in the transition zone of
585 NADW and AABW (3500 - 4000 m wd) (Kolla et al., 1980). Furrows, observed to run oblique relative to the
586 main bottom currents, and scours point toward the northward flowing AABW (**Figs. 4, and 11E**). Furthermore,
587 high northward flow velocities (> 25 cm/s) at the foot of the Mozambique Ridge (along 37° E, **Fig. 11E**) suggest
588 the role of 'horizontal eddies' in generating these features (e.g., Hernández-Molina et al., 2014).

589 *5.4. A model for deep-sea sedimentation in the Mozambique Channel*

590 We present a new model for deep-sea sedimentation within the Mozambique Channel (**Fig. 12**).
591 Sediments from the continent are mainly transported by the Zambezi, Limpopo, and Tugela rivers. When these
592 rivers reach coastal areas, the Mozambique Current and Agulhas Current quickly disperse the suspended
593 sediment over large areas along the continental shelf and upper slope. The Mozambique Undercurrent and
594 Agulhas Undercurrent subsequently transport and deposit the sediment along the middle-lower slopes, base-
595 of-slope, seamount flanks, and abyssal plain. The TSW + STSW (+ Tropical Thermocline Water) / SICW, SICW /
596 AAIW (+ RSW), AAIW (+ RSW) / NADW, and NADW / AABW interfaces along the Mozambican margin form
597 superimposed nepheloid layers by settling processes (McCave, 1986; Preu et al., 2013). For example, fine-
598 grained sediments arriving as turbidity currents from the continent are remobilized by the NADW / AABW
599 interface and subsequently concentrated into a dense nepheloid layer between 3500 and 4500 m wd (Kolla et
600 al., 1980). These layers represent a major regional / basin scale transport mechanism for fine-grained
601 sediments at different water depths. They deposit sediments laterally and basinward with a dominant along-
602 slope component. Material in the Mozambique Channel can thus experience significant transport over long
603 distances prior to deposition. Turbulent processes generated at the interfaces (e.g., internal waves) interacting
604 with the continental slope / shelf may induce bottom current erosion, re-suspension, and redistribution of

605 sediment (e.g., Dickson and McCave, 1986; Cacchione et al., 2002; Pomar et al., 2012; Shanmugam, 2013,
606 2014). These mechanisms change slope morphology by steepening upslope and developing a terrace-like
607 feature along the water mass interface (Hernández-Molina et al., 2009; Preu et al., 2013). This sweep and
608 winnow of the seafloor may also supply the nepheloid layers with sediment at the seaward limit of the terrace
609 (Dickson and McCave, 1986; Puig et al., 2004; Wislon et al., 2015). Kolla et al. (1980) suggested that
610 sedimentary waves on the Mozambican abyssal plain can result from very deep internal waves (e.g., van Haren
611 and Gostiaux, 2011) focused on the nepheloid layer at the NADW / AABW interface between 3500 and 4500 m
612 wd. Deposition occurs mainly in areas experiencing relatively low current velocities where settling of
613 suspended particles can form contourite drifts (Miramontes et al., 2016; Cattaneo et al., 2017). Large-scale
614 velocity variation in current pathways may reflect strong rotational current velocities (>70 cm/s) due to
615 southward moving anticyclonic eddies (Ridderinkhof and de Ruijter, 2003) interacting with the Mozambican
616 margin morphology (Dingle et al., 1987). Contourite drifts can also form from local reworking of the seafloor
617 by bottom currents (e.g., 'horizontal eddies'). In this case, topography influences the velocity of the impinging
618 water-mass and sediments deposit near the eroded source area (Rebesco and Camerlenghi, 2008). Coriolis
619 forcing of northward currents towards the Mozambican margin (e.g., Faugères and Mulder, 2011) can amplify
620 this effect. In the depositional model for the Mozambique Channel described here, most present-day
621 sedimentary processes and their morpho-sedimentary products result from bottom current processes.
622 Observations from similar European and South American margins (Hernández-Molina et al., 2011, 2016a;
623 Ercilla et al., 2016; Preu et al., 2013) support this interpretation.

624 Based on our results, two important aspects should be considered for improving this sedimentary
625 model in the future. First, we show a dominance of across-slope gravity-driven processes operating along the
626 northern sector of the Mozambican margin (**Fig. 4**). Slope and shelf areas associated with the northern sector
627 experienced high rates of sediment than those located in the central and southern sectors (e.g., estimated
628 present annual sedimentary input: $100 \cdot 10^6$ t from the Zambezi River; $4.8 \cdot 10^6$ t from the Limpopo River,
629 Milliman, 1981). In the northern sector, high rates of sediment delivery beginning in the Pliocene and
630 continuing up to present (Dingle et al., 1983; Walford et al., 2005; Franke et al., 2015) may have conditioned
631 large MTDs and maintained turbidity currents through time. In the central and southern sectors, limited
632 sediment supply between the Pliocene and present (Green et al., 2008; Green, 2011; Said et al., 2015; Hicks

633 and Green, 2016) led to a predominance of along-slope (contourite) processes. The northern sector, however
634 reveals a combination of along-slope (i.e., T1 and D1) and across-slope (i.e., MTDs, turbidity currents)
635 processes that may be related to sea-level fluctuations during glacial and inter-glacial periods (Wiles et al.,
636 2017). During interglacial periods, sediments in front of the Zambezi River (*'inner mud belt'*) are transported
637 northward along the *'inner'* shelf. Much of these sediments transfer through upper slope canyons of the
638 Angoche SCS, few of these sediments are transported southward along the *'outer'* shelf (*'outer mud belt'*)
639 toward the Middle and Lower Zambezi SCSs (Schulz et al., 2011; Wiles et al., 2017) (**Fig. 4**). This flux can be
640 expected to have resulted in greater downslope transport (i.e., MTDs and turbidity currents) in front of the
641 Angoche SCS than in front of the Middle and Lower Zambezi SCSs as it reached the shelf edge (Wiles et al.,
642 2017) and may inhibit along-slope processes and their sedimentary features. Furthermore, shelf morphology
643 (depth of the shelf-break, width of the shelf, etc.) during interglacial periods (such as in present-day, Wiles et
644 al., 2017) is suitable for internal waves to propagate along the shelf edge, especially in front of the Middle and
645 Lower Zambezi SCSs (DaSilva et al., 2009). Internal waves contributed to erosion, re-suspension, and
646 redistribution of sediments along the upper slope, forming contourite terrace T1 and plastered drift D1 (e.g.,
647 Preu et al., 2013). During glacial periods, greater sediments supply and variation of the shelf morphology in
648 front of the Middle and Lower Zambezi SCSs probably facilitate downslope sediment transport (Wiles et al.,
649 2017) along the continental slope as well as preclude generation of internal waves. Further research can
650 confirm or refute this hypothesis.

651 Second, a particular deep plastered drift (D3) occurs over a specific water depth range in the
652 transition zone between two water masses (AAIW and NADW) while upper plastered drifts (D2 and D3) match
653 water depth ranges of water masses (SICW and AAIW) between density interfaces (pycnoclines) (e.g., Preu et
654 al., 2013; Rebesco et al., 2014). However, the interpretation of D3 being generated in the transition zone
655 between two water masses is questionable and it could be related to vertical movement of interfaces. The
656 plastered drift formation is the result of processes acting on longer geological times. During the Quaternary,
657 the Atlantic and Southwest Indian water-mass circulation and spatial fluctuations in water-mass interfaces may
658 have been controlled by the Agulhas leakage (Hall et al., 2017) with less leakage during full glacial times than
659 interglacial times (Peeters et al., 2004; Caley et al., 2012; Petrick et al., 2015). Variations of the Agulhas leakage
660 have led to a weakening of the NADW flow during glacial stages, allowing the deep Antarctic water masses

661 (CDW and AABW) to extend farther north than it does today (Bickert and Wefer, 1996; Pena and Goldstein,
662 2014). During cold (glacial) periods under this scenario, the oceanographic setting would differ from the
663 present one and may have potentially provoked vertical and lateral variations of the interfaces and the
664 associated oceanographic processes (e.g., internal waves), displacing drift D3 under the influence of deep
665 Antarctic water masses. This interpretation is supported by Breitzke et al. (2017) suggesting that sedimentary
666 waves under the water depth range of the NADW along the abyssal plain (**Fig. 4**) are draped with sediments.
667 Thus, sedimentary waves might be related to strong bottom currents during cold periods, potentially under
668 the AABW flow. While the discussion given above is somewhat speculative, and open a discussion proposed by
669 Preu et al. (2013) in Argentine / Uruguay and Hernández-Molina et al. (2017b) in the Pacific margin of the
670 Antarctic Peninsula about if some deep water features in the ocean are functional or relict. Are observed drifts
671 and contourite terraces identify in deep-environments (lower slope and basin floor) relate to the same water
672 masses structure than observed today? The conditions and timing of their formation, remain still unresolved
673 but future research should address these questions.

674 **6. Conclusion**

675 This work interpreted a number of large contourite deposits along the Mozambique Channel and their
676 associated bottom currents and oceanographic processes. The oceanographic processes described act in
677 combination to determine the bottom current's local direction and velocity. Although many of these processes
678 and their effects on deep-water sedimentation are not fully understood, local or regional interaction of these
679 processes with the seafloor influences morphology and sediment distribution along the Mozambican
680 continental margin and adjacent Durban basin. This study came to fourth major conclusions:

- 681 a) The first and most important finding is that internal waves originate from instabilities in the
682 transition zone (interfaces / pycnoclines) between two water masses, caused by eddies, tidal and
683 geostrophic currents being aided by topography. It provides the most plausible mechanism for
684 sculpting contourite terraces (T1 to T4 in this study), facilitating erosion, re-suspension and
685 redistribution of sediments (e.g., nepheloid layers).
- 686 b) Second, weak along-slope bottom currents on the plastered drifts (D1 to D3) rarely exceed 12.5
687 cm/s and thus promote the settling of suspended particles. Growth of plastered drifts D1 and D2

688 is facilitated by weak along-slope bottom currents of two major water-masses circulating in the
689 Mozambique Channel (i.e., SICW and AAIW) or a counteraction of such currents with periodic or
690 a-periodic processes (e.g., eddies, deep water tidal currents), reducing current velocities.

691 c) Third, the strengthening of along-slope bottom currents (e.g., Coriolis Effect, eddies, deep water
692 tidal currents), being aided by seafloor irregularities would result in 'horizontal eddies'. Hence,
693 these currents lead to erosion inside the moat and deposition on the elongated-mounded drift.
694 Our study show that these drifts can develop inside the transition zone. Nevertheless, the finding
695 in our study and limitations in the hydrodynamic modelling (e.g., secondary processes) point out
696 a need for further studies, not only based on numerical simulations but also by field
697 measurements (i.e., sedimentary cores and mooring scheme) to better quantify the impact of
698 instabilities on contouritic depositional systems.

699 d) The fourth finding is that the specific plastered drift D3 in our study area occurs in the transition
700 zone between two water masses (AAIW and NADW), and forms on a much smaller lateral scale.
701 This marks a major difference between the plastered drift investigated here and the existing
702 paradigm that plastered drifts are often formed below water mass interfaces (such as D1 and D2).
703 A possible explanation for that could be related to the fact that, through geological times, vertical
704 movements of water masses and associated interfaces occurred, as reported in the south Atlantic
705 by Preu et al. (2013), where the AABW was thicker, more vigorous and its top quite shallower
706 during glacial stages compared with interglacial stages, as the present one. This hypothesis
707 highlight new and important considerations: are all present morphologies in deep marine
708 environment functional? Can some depositional and erosional features, especially in the deepest
709 oceans, be relicts, being active under different oceanographic processes than the present ones?

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1198 FIGURE CAPTIONS

- 1199 **Fig. 1.** Location of study area and data collection sites. (A) Bathymetric map (ETOPO1 1 arc-minute global relief model;
 1200 Amante and Eakins, 2009) of the southwest Indian Ocean indicating catchment areas of the Zambezi, Limpopo, and Tugela
 1201 rivers basins. Yellow dots indicate examples with large contourite deposits in present-day (or recent) ocean basins and in

1202 the ancient sedimentary record generated by bottom currents. 1: Gruetzner and Uenzelmann-Neben, 2015; 2:
1203 Uenzelmann-Neben, 2001; 3: Schlüter and Uenzelmann-Neben, 2008; Niemi et al., 2000; 4: Flemming, 1978; 5: Preu et al.,
1204 2011; 6: Breitzke et al., 2017; Kolla et al., 1980; 7: Uenzelmann-Neben et al., 2011; 8: Uenzelmann-Neben and Huhn, 2009;
1205 (B) Bathymetric map (ETOPO1 1 arc-minute global relief model; Amante and Eakins, 2009) of the Mozambique Channel
1206 indicating position of the dataset interpreted and the main bathymetric features. The study area covered by high-
1207 resolution multibeam data was interpreted based on Breitzke et al. (2017) and Wiles et al. (2017). Yellow dots show the
1208 location of the IODP Expedition 361 and DSDP Leg 25. Abbreviations: MozR = Mozambique Ridge; MdgR = Madagascar
1209 Ridge; and FZ = Fracture Zone.

1210 **Fig. 2.** Bathymetric map (ETOPO1 1 arc-minute global relief model; Amante and Eakins, 2009) of the Mozambique Channel
1211 indicating schematic position of present-day water masses.

1212 **Fig. 3.** Slope gradient map for surfaces dipping $\geq 2^\circ$ along the Mozambican continental margin. Bathymetric map includes
1213 the main physiographic domains (continental shelf; upper, middle, and lower continental slopes; and abyssal plain) and
1214 morphological features superimposed (ETOPO1 1 arc-minute global relief model; Amante and Eakins, 2009). The white line
1215 indicates the location of the buried Beira High. Abbreviations: ALB = Almirante Leite Bank; CT = Central Terrace; IT =
1216 Inharrime Terrace; LC = Limpopo Cone; MozR = Mozambique Ridge; NR = Naudé Ridge; and TC = Tugela Cone. (A) to (F)
1217 Bathymetric profiles showing seafloor morphology for the three different sectors: (A) and (B) are the northern sector, (C)
1218 and (D) the central sector, and (E) and (F) the southern sector.

1219 **Fig. 4.** Morpho-sedimentary map of the Mozambique Channel. This map illustrates the complex morphology of the
1220 Mozambique Channel as well as the interplay between down- and along-slope processes. Contourite depositional,
1221 erosional, and mixed erosive-depositional features are indicated. Lineations based on Breitzke et al. (2017) and submarine
1222 canyons based on Wiles et al. (2017). Abbreviations: DFZ = Davie Fracture Zone and SCS = Submarine Canyon Systems.

1223 **Fig. 5.** Examples of four multichannel seismic reflection profiles of the Mozambican continental margin from south (A) to
1224 north (D), showing the major morpho-sedimentary features. Horizontal scale is the same for all the profiles. (E) Inlay
1225 illustrating the D1 drift and the T1 terrace, as well as high amplitude reflection patterns (HARs) of contourite terrace T1.
1226 Location in **Figs. 1 and 4** (section (A) courtesy of CGG Multi-client and New Ventures and sections (B, C), and (D) courtesy of
1227 INP and WesternGeco Multiclient).

1228 **Fig. 6.** Examples of depositional, erosional, and mixed contourite features from multichannel seismic reflection profiles.
1229 Details of contourite terraces T1 and T2 in (A), T3 in (C), (D), and (E), and T4 in (G) and (H). Examples of plastered drift D1
1230 are illustrated in (A), D2 in (A), (B), and (E), and D3 in (C) and (E). Moats and elongated-mounded drifts are shown in (B), (F),

1231 and (G). Abraded surfaces and steep surfaces are illustrated in (B), (D), (G), and (H). (I) Inlay illustrating the sedimentary
1232 stacking pattern of plastered drift D2. Locations in **Fig. 4** for (A-H), in **Fig. 11** for (A, B, E, F, G) and (H). Abbreviation: HARs =
1233 High Amplitude Reflections. Profiles (A, B, F, G) and (H) courtesy of INP and WesternGeco Multiclient. Profiles (C-E)
1234 courtesy of CGG Multi-client and New Ventures.

1235 **Fig. 7.** (A-C) Temperature ($^{\circ}\text{C}$) vs. salinity (psu) diagrams for southern, central, and northern sectors respectively. (D-E)
1236 Panel plots with neutral densities (kg/m^3) vs. oxygen content (ml/l) along the Mozambican continental margin for data
1237 collected from hydrographic sections of the southern (D) and central (E) sectors. Deep water mass circulation denoted as:
1238 AABW = Antarctic Bottom Water; NADW = North Atlantic Deep Water; AAIW = Antarctic Intermediate Water; RSW = Red
1239 Sea Water; SICW = South Indian Central Water; TSW-STSW = Tropical Surface Water – Subtropical Surface Water.

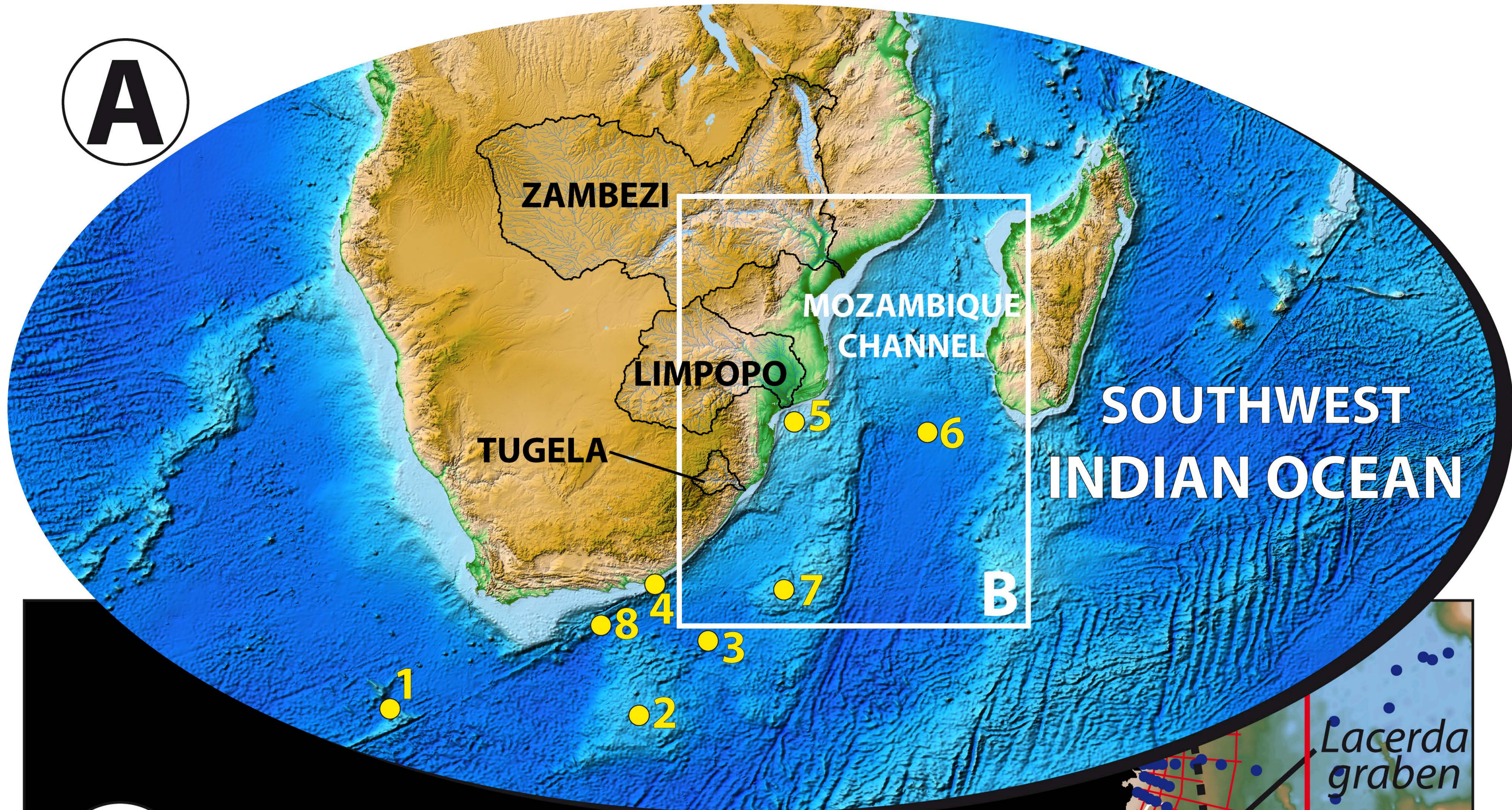
1240 **Fig. 8.** Seismic and hydrographic vertical sections for the Mozambican continental margin. The water column colour ranges
1241 indicate salinity (psu), temperature ($^{\circ}\text{C}$) and oxygen content (ml/l). These profiles are located in **Fig. 1**. Water mass
1242 interpretations and major contourite features are indicated on the sections. Profile (A) courtesy of TOTAL and partners and
1243 Profiles (B, C) courtesy of INP and WesternGeco Multiclient.

1244 **Fig. 9.** (A) Seismic and hydrographic vertical section for the Mozambican continental margin. Water column colour range
1245 indicates the buoyancy (Brunt-Väisälä) frequency (cycl/h). This profile is denoted as **Fig. 6A** located in **Fig. 4**. (B) Inlay
1246 illustrating the buoyancy (Brunt-Väisälä) frequency (cycl/h) along contourite terrace T1. Seismic line courtesy of INP and
1247 WesternGeco Multiclient. (C) Panel plots with Depth from pressure (m) vs. neutral densities (kg/m^3) and buoyancy (Brunt-
1248 Väisälä) frequency (cycl/h) at station 17802 (WOD13) located in **Fig. 1**. The yellow stripes indicate areas potentially
1249 correlated with internal wave generation at interfaces between Subtropical Surface Water (STSW) and South Indian Central
1250 Water (SICW), and between SICW and Antarctic Intermediate Water (AAIW).

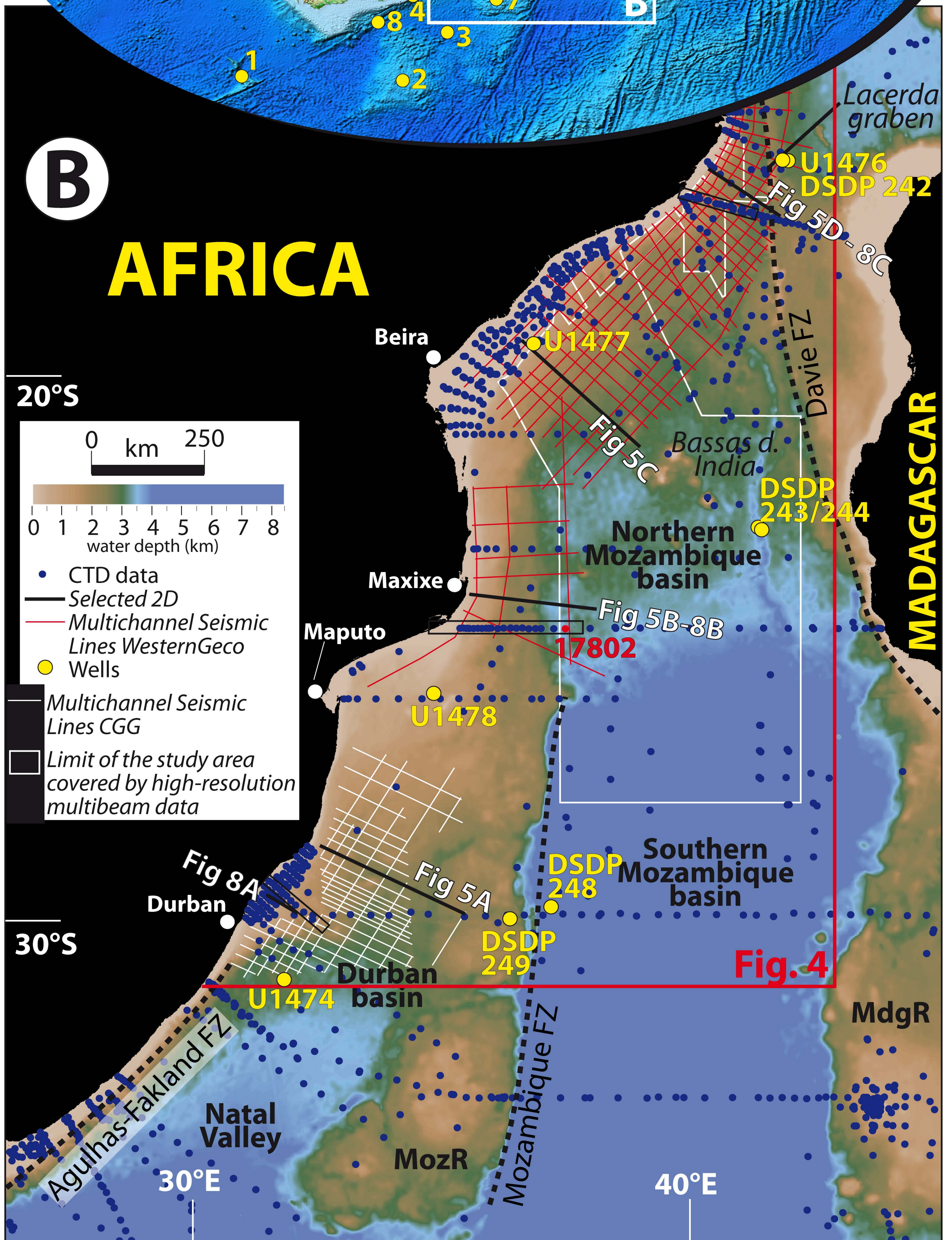
1251 **Fig. 10.** Select examples of internal waves (solitons) propagating along the Mozambique Channel. Images (A-C) are located
1252 along the Bay of Maputo (from Jackson, 2004) and (D-E) are along the Bight of Sofala (from Magalhaes et al., 2014).
1253 Abbreviations: NMB = Northern Mozambique Basin; SMB = Southern Mozambique Basin; NV = Natal Valley; MozR =
1254 Mozambique Ridge; IWS = Internal waves.

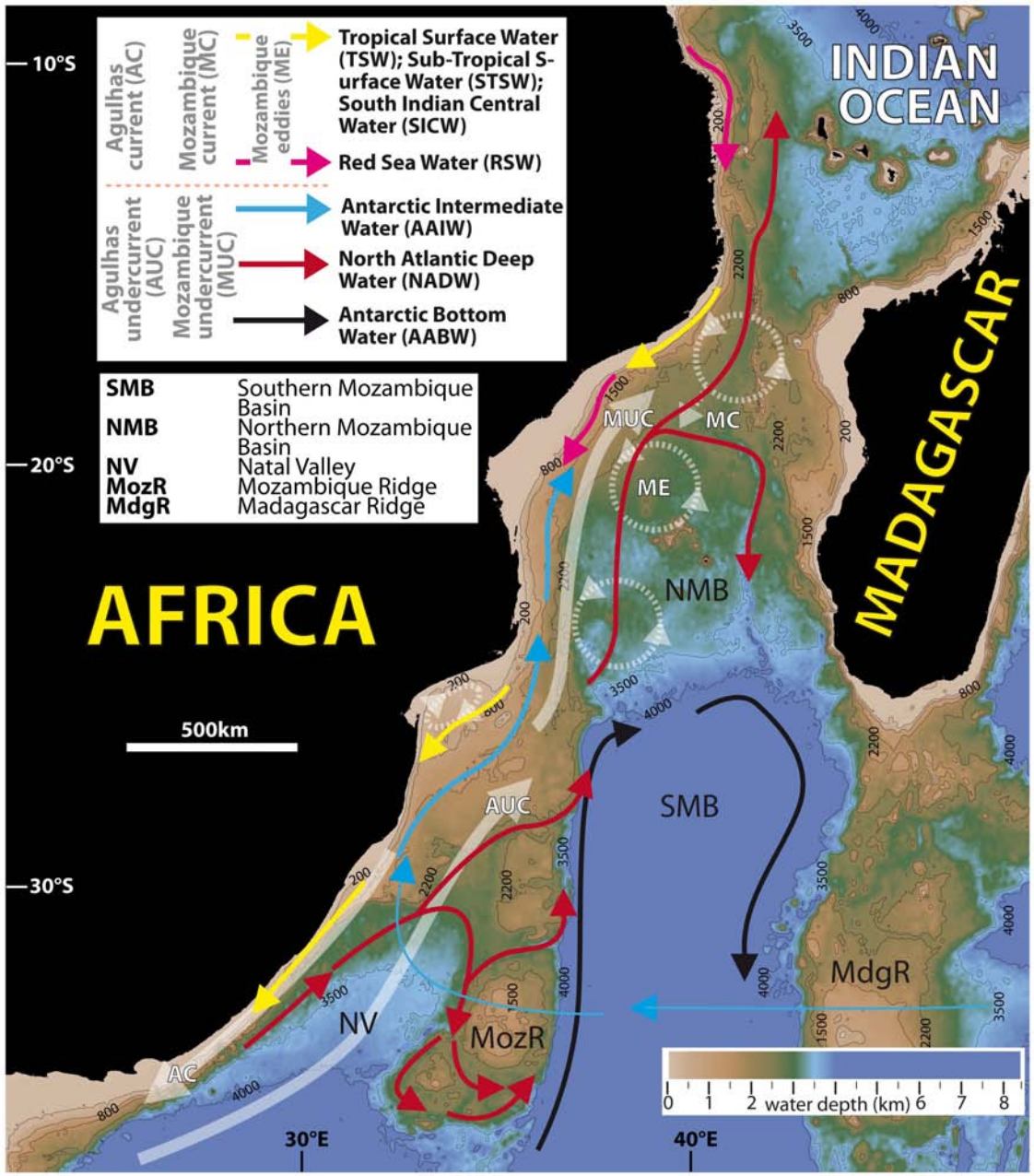
1255 **Fig. 11.** Results from the Regional Oceanic Modelling System (ROMS) showing mean bottom current velocities along the
1256 seafloor of five different sectors indicated in **Fig. 4**.

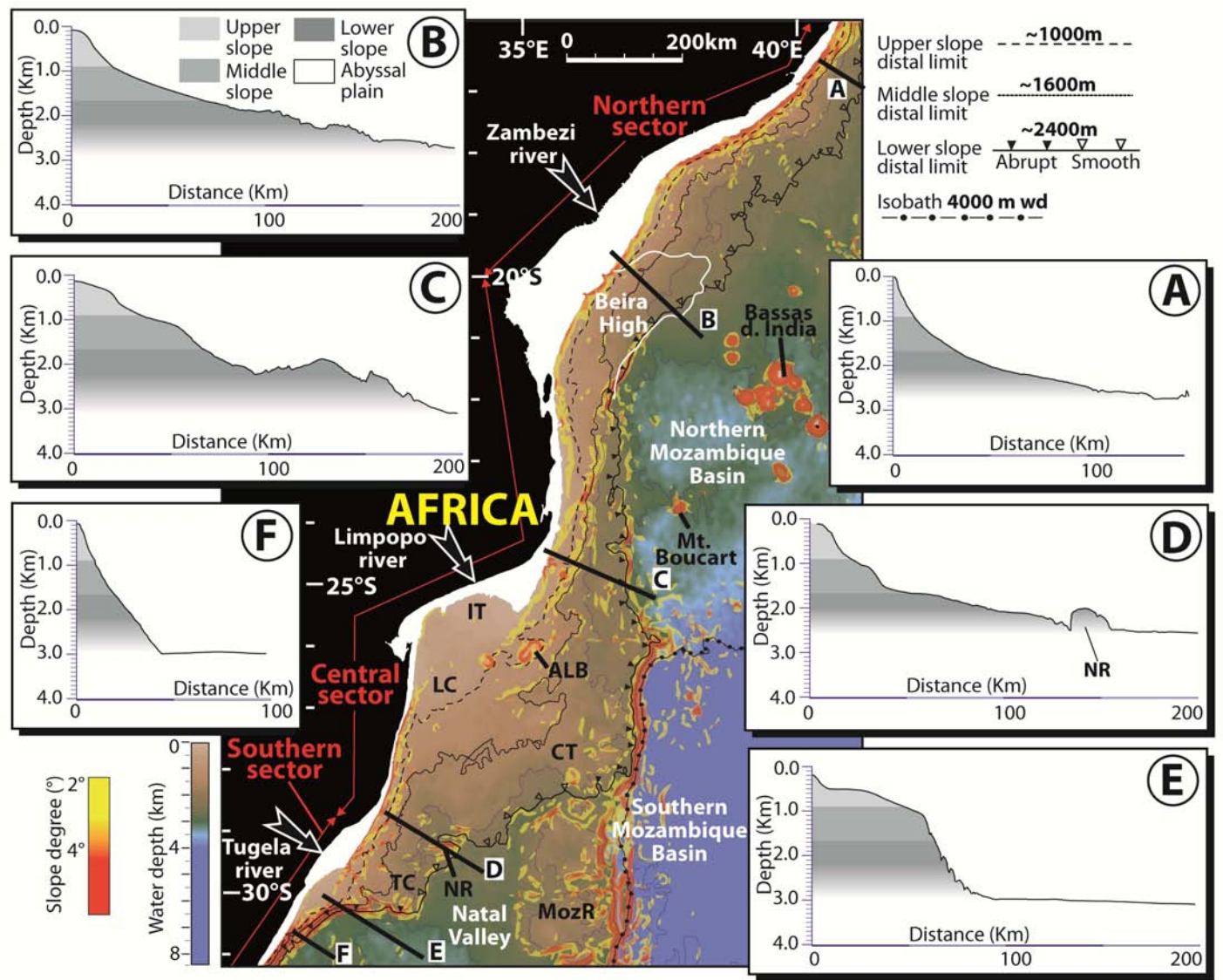
1257 **Fig. 12.** (A) 3D sketch summarizing the conceptual model of the effect of bottom current processes on deep-water
1258 sedimentation along the Mozambique Channel. Simplified morpho-sedimentary and hydrographic features are shown. (B)
1259 Schematic model for the Mozambique Channel explaining water mass interface processes.

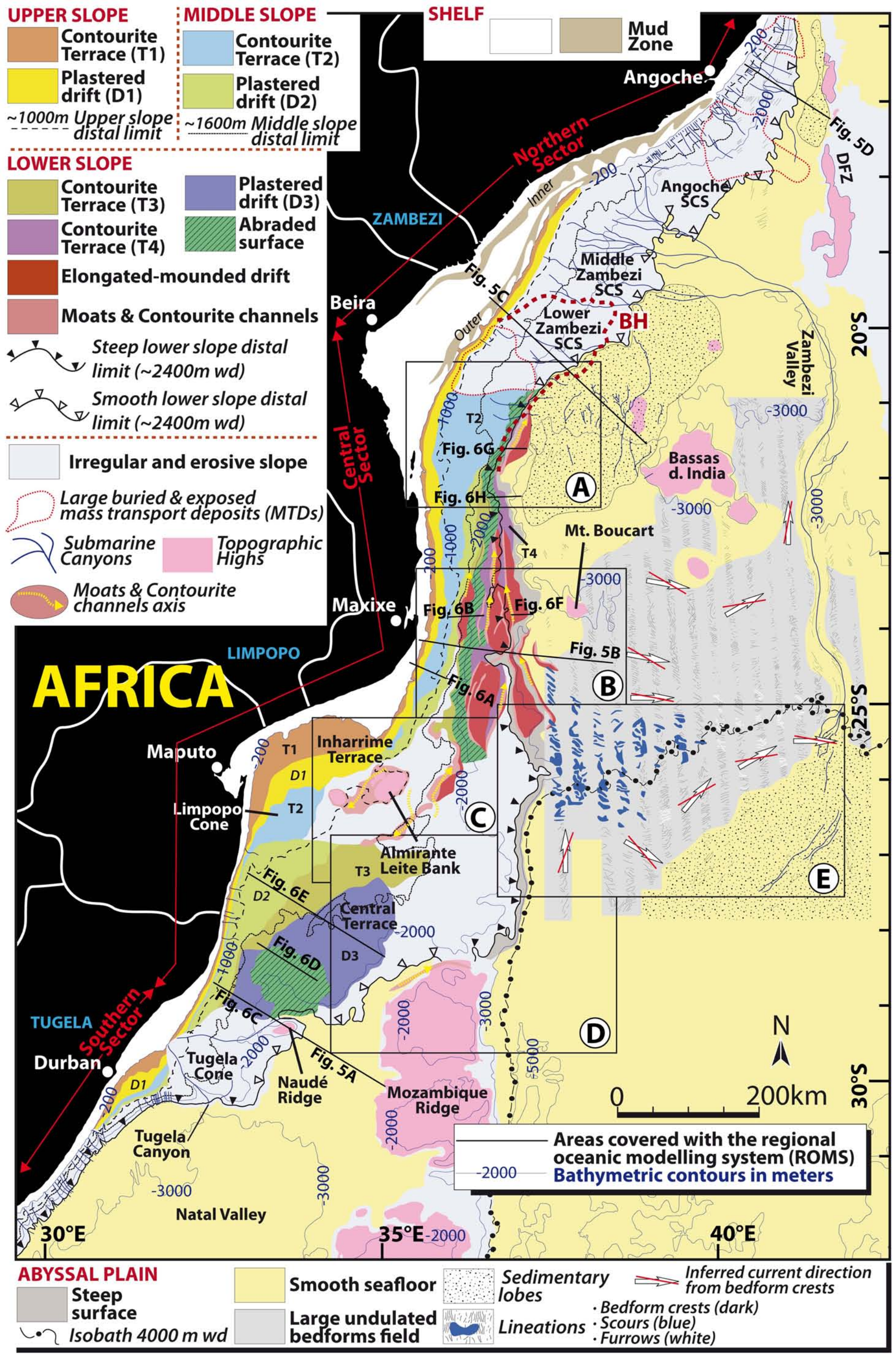


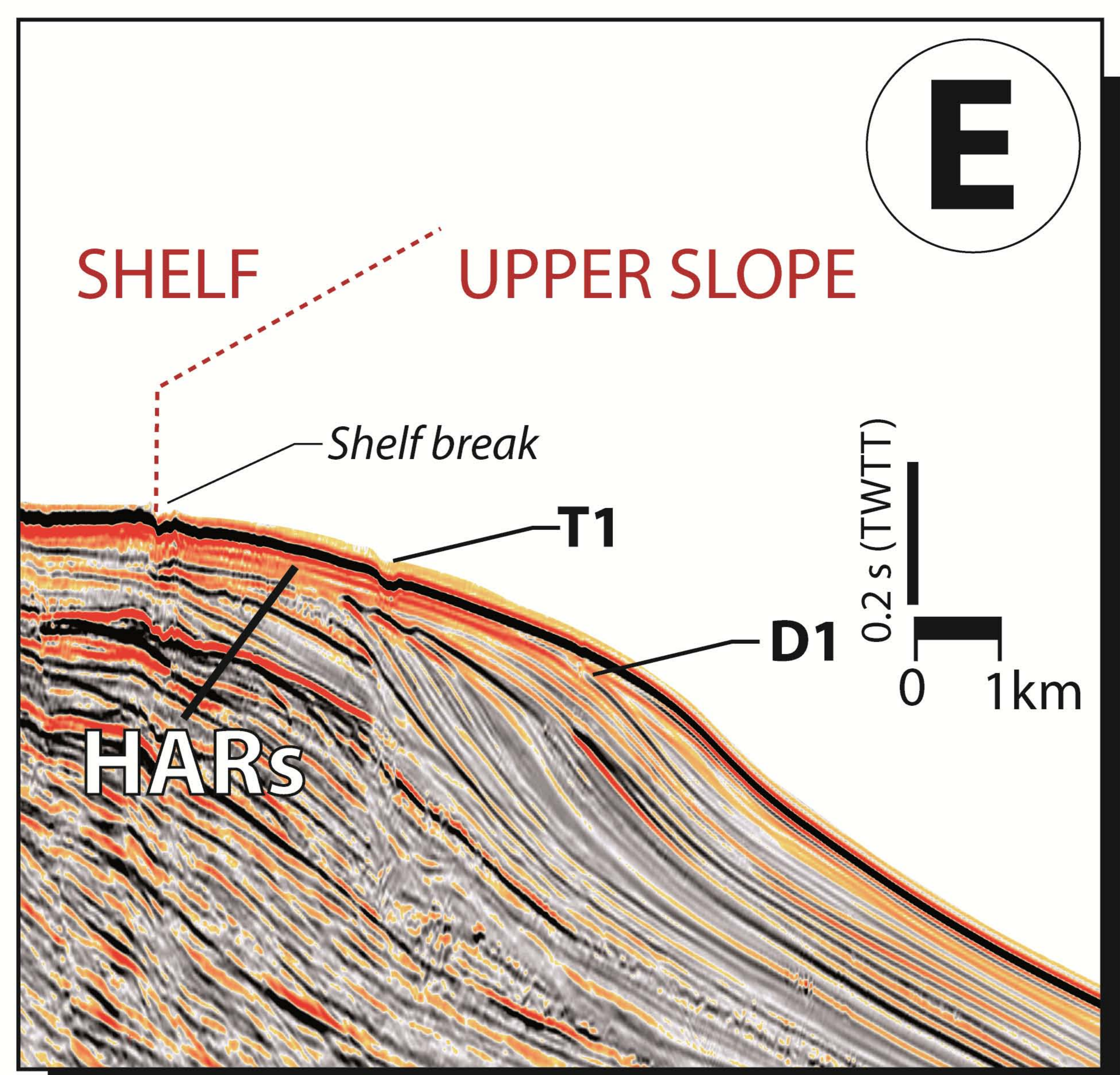
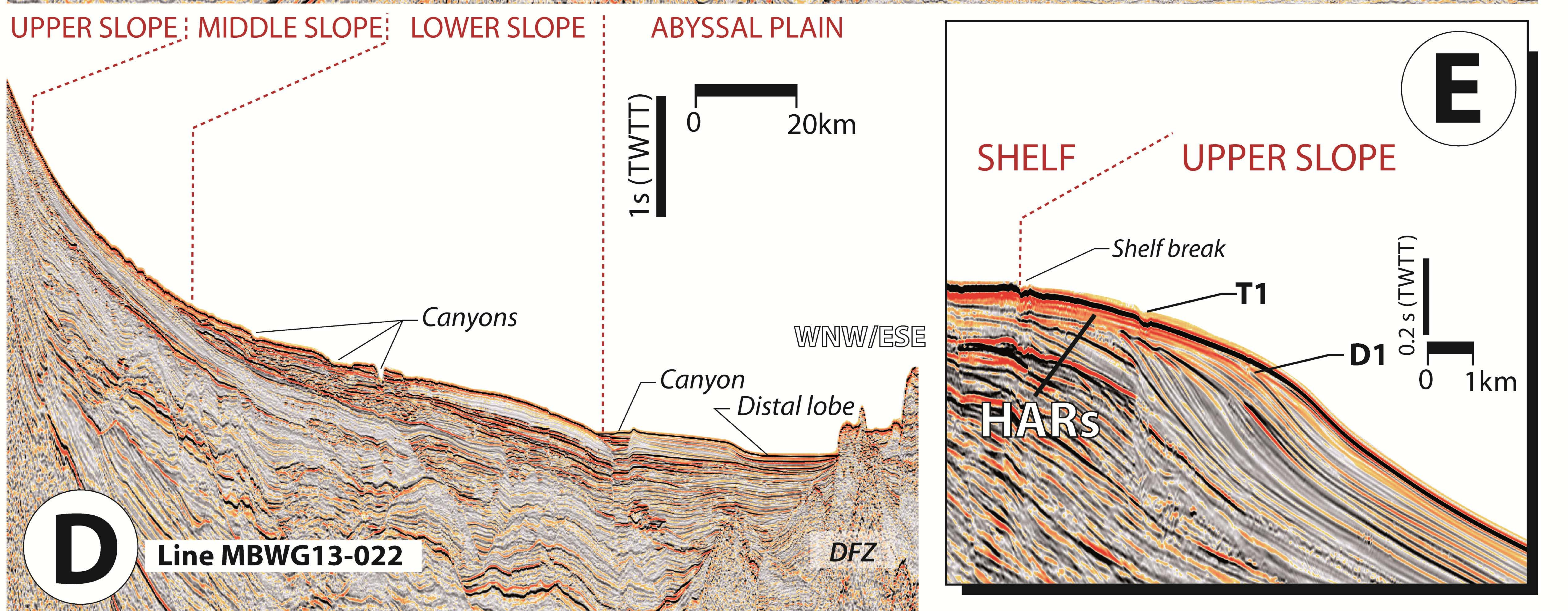
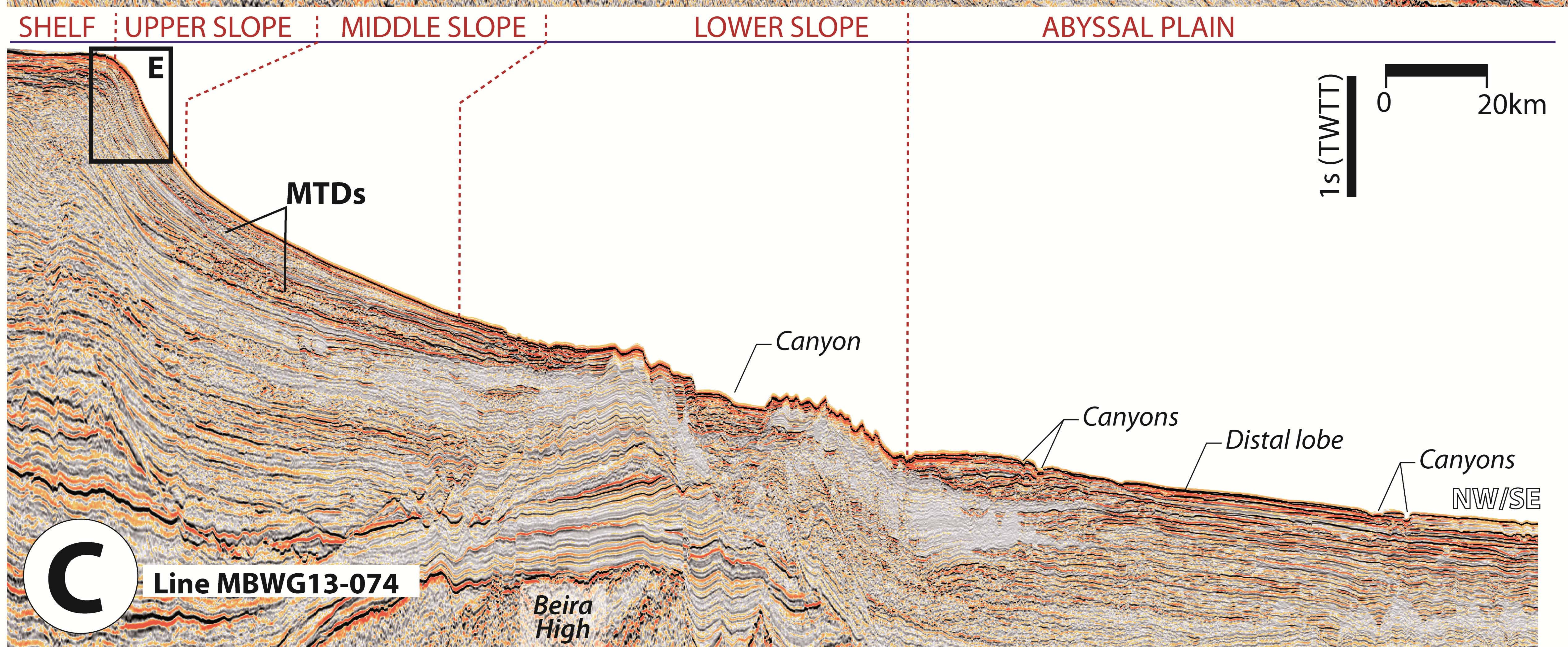
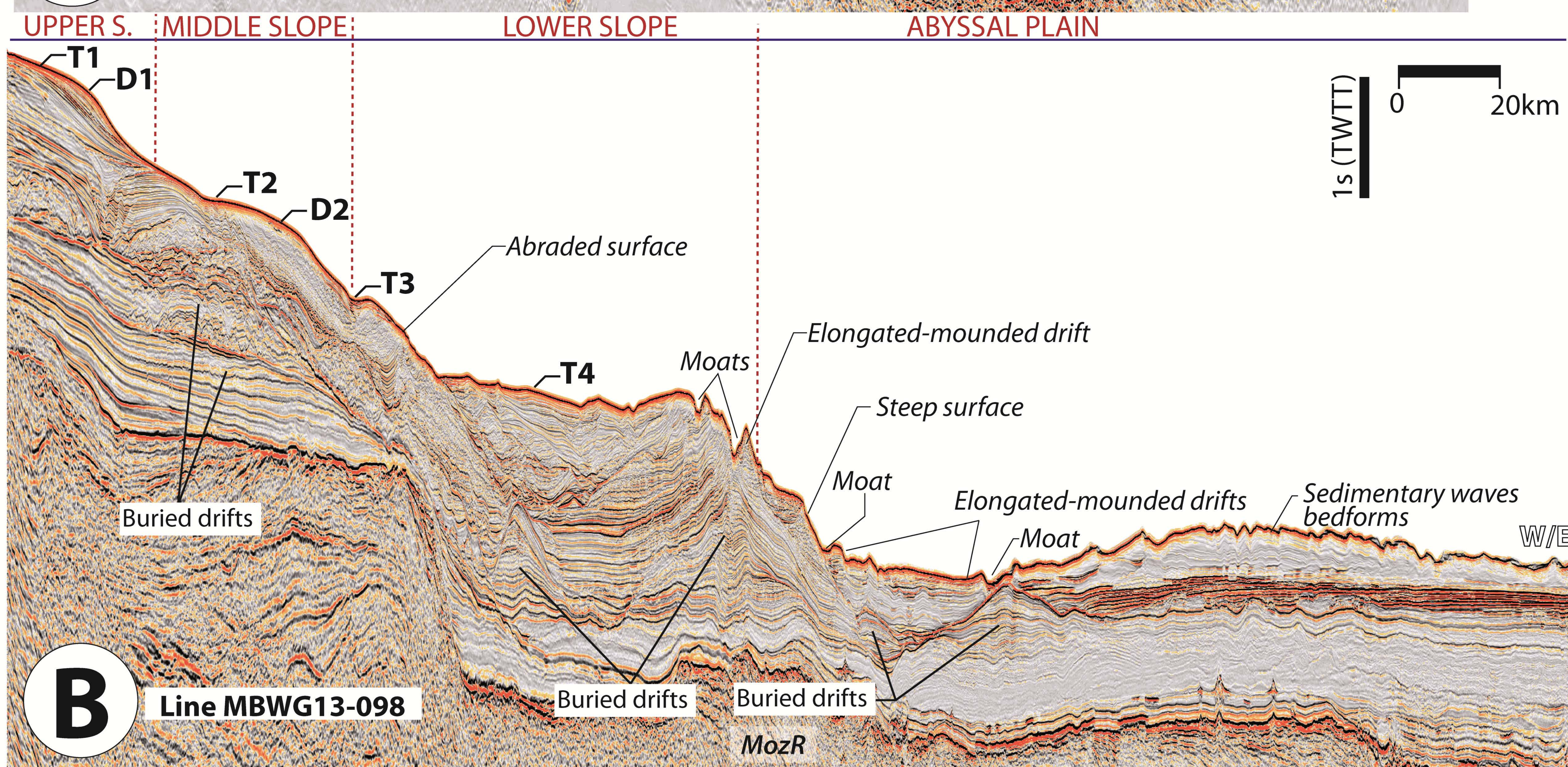
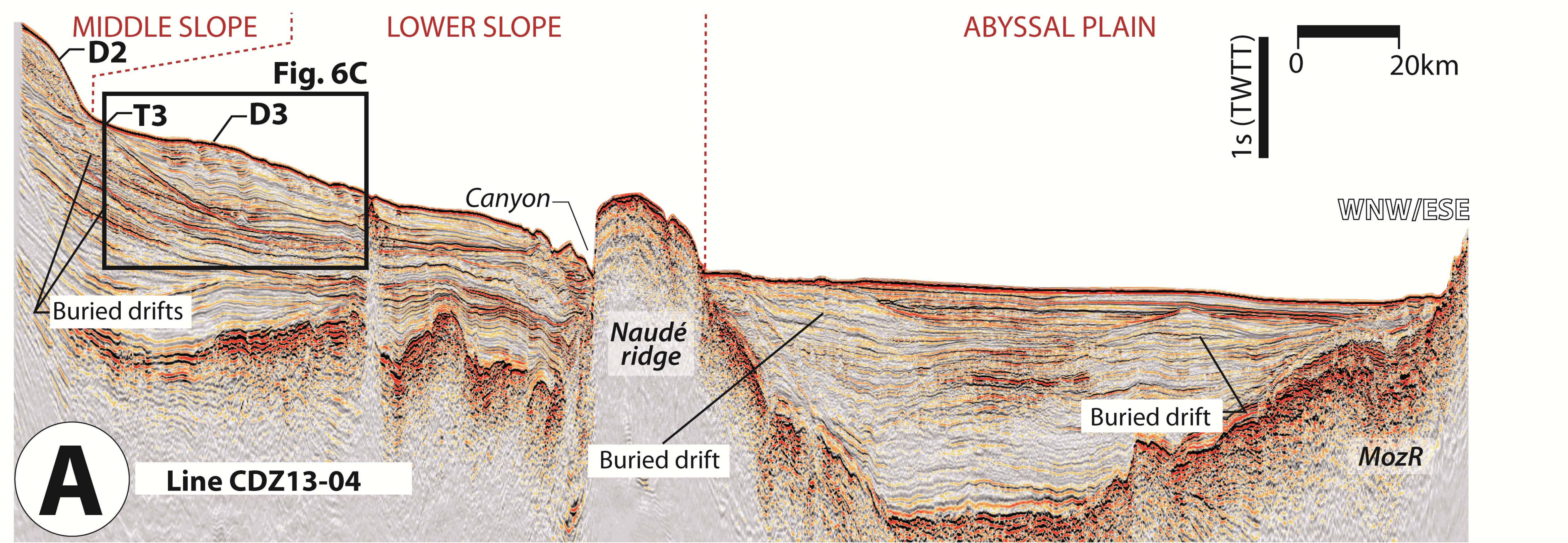
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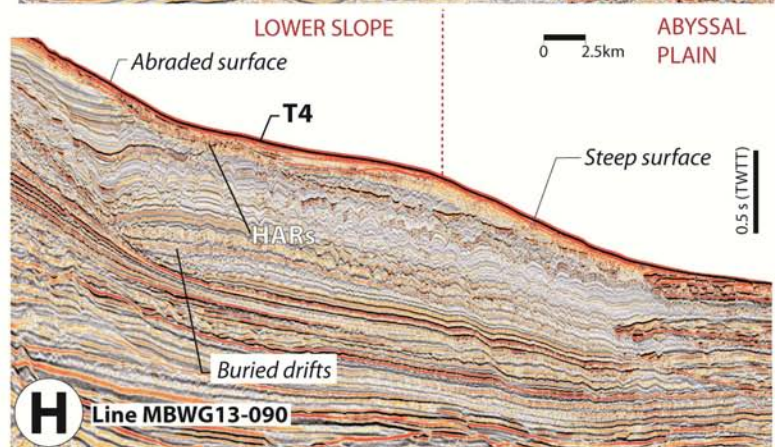
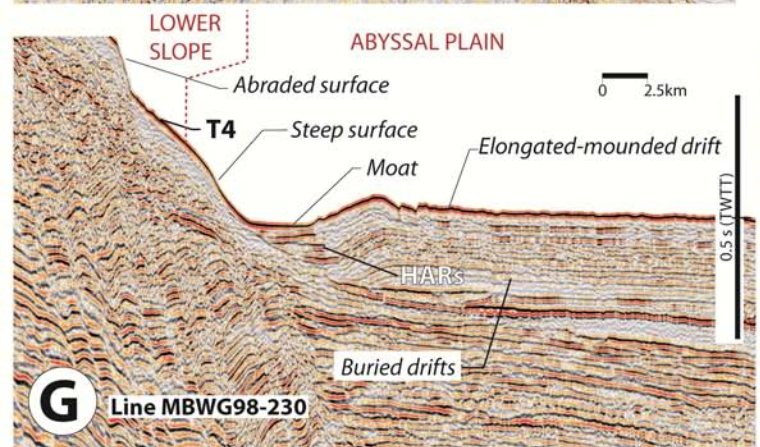
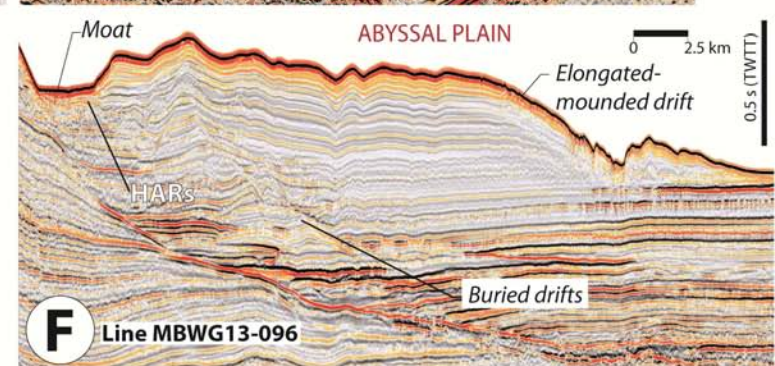
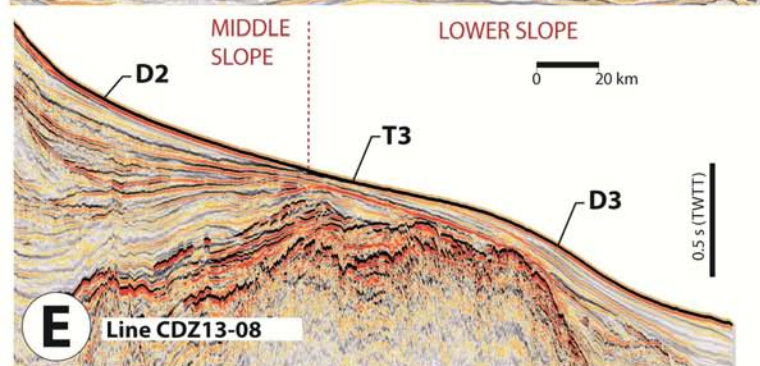
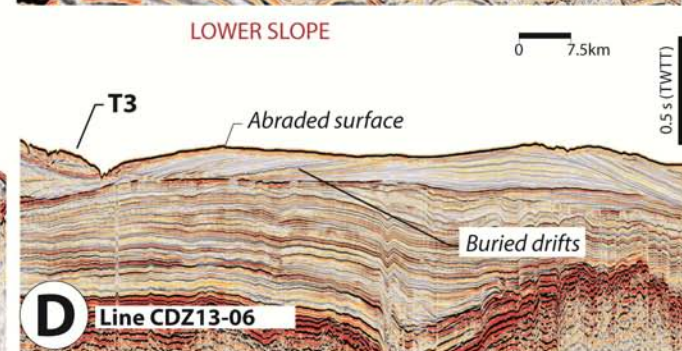
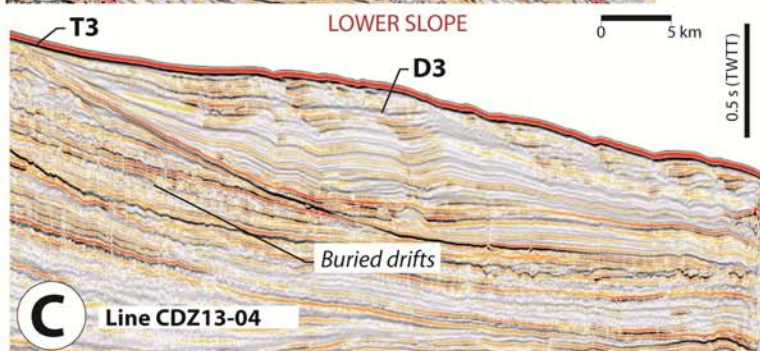
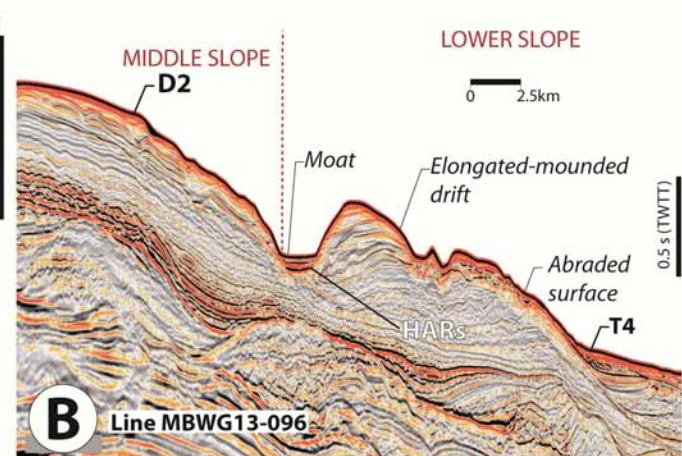
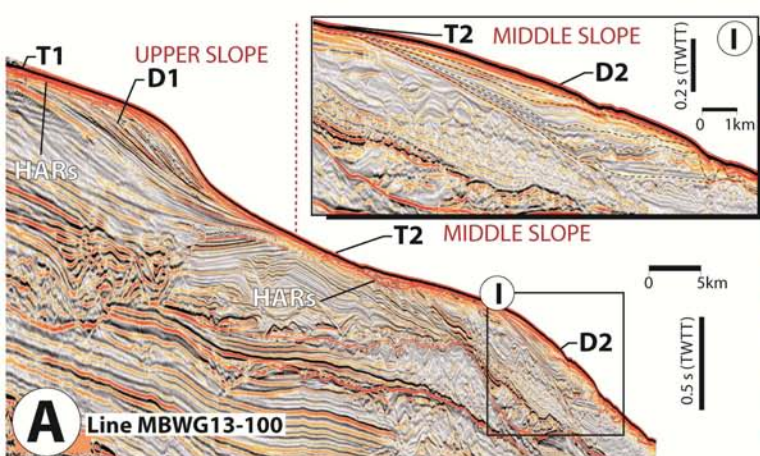


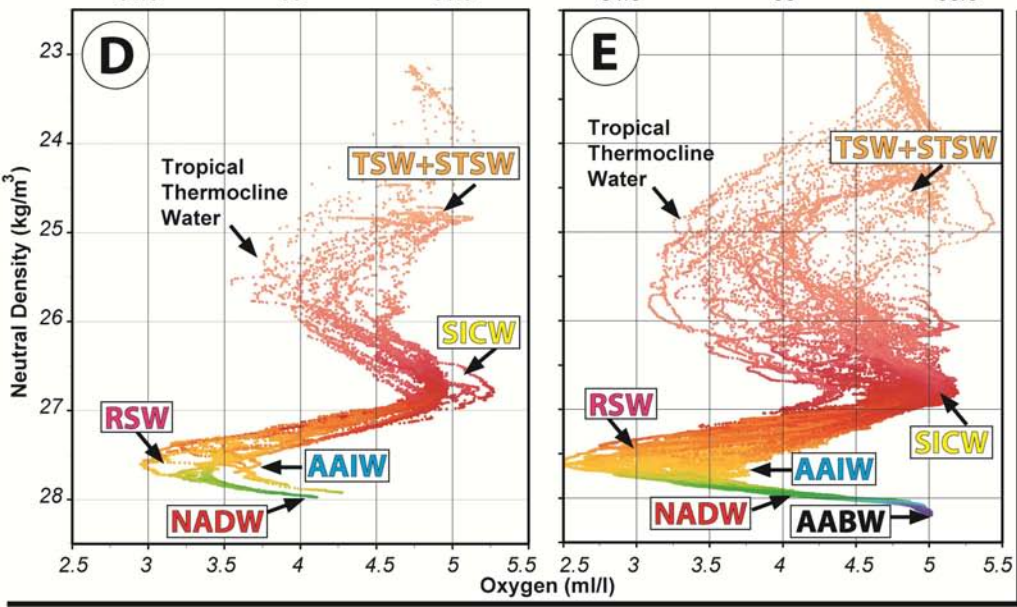
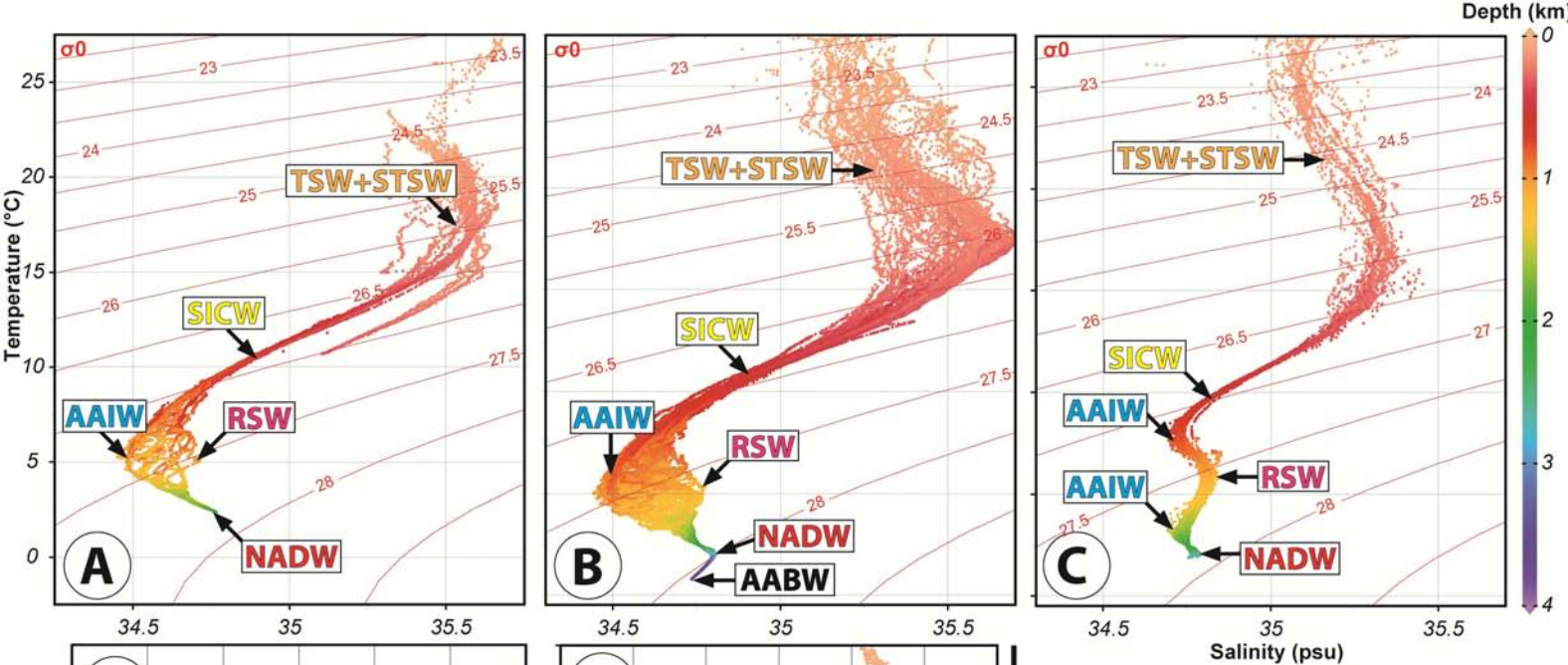


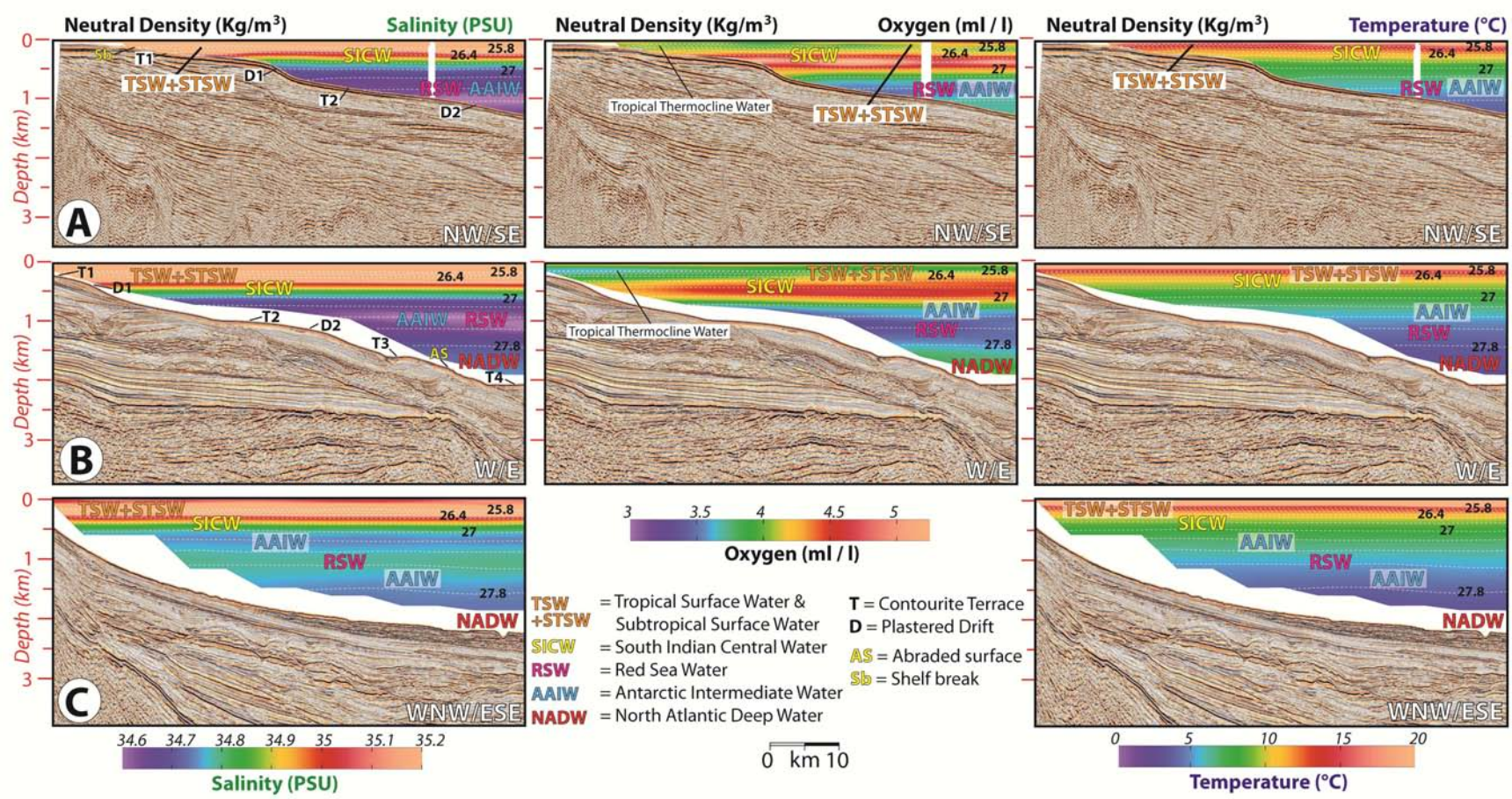




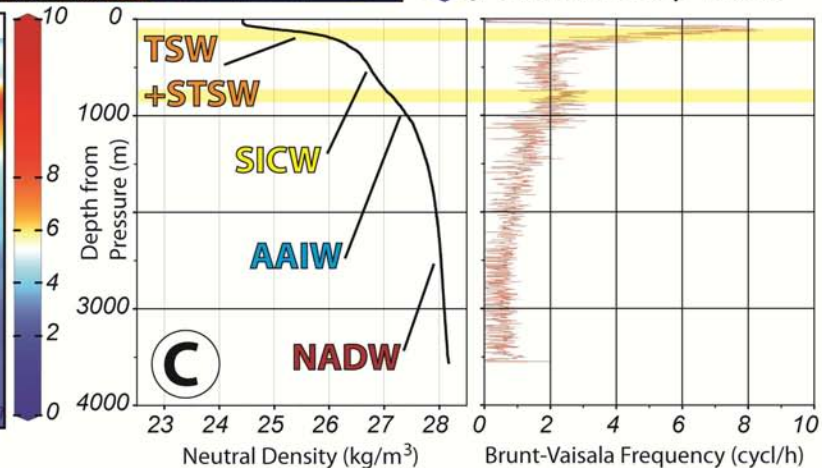
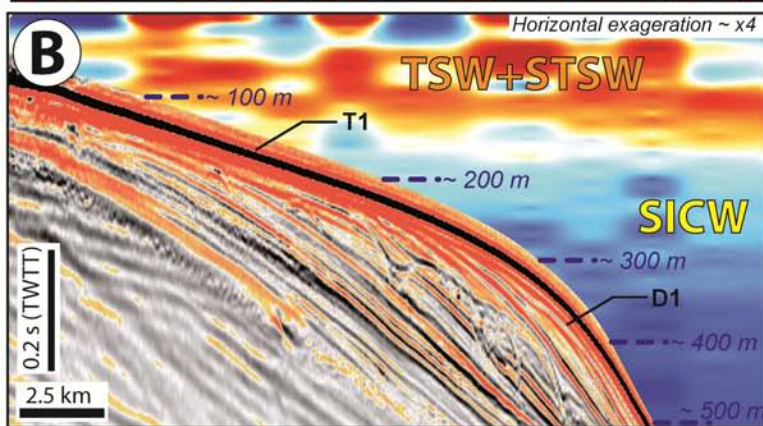
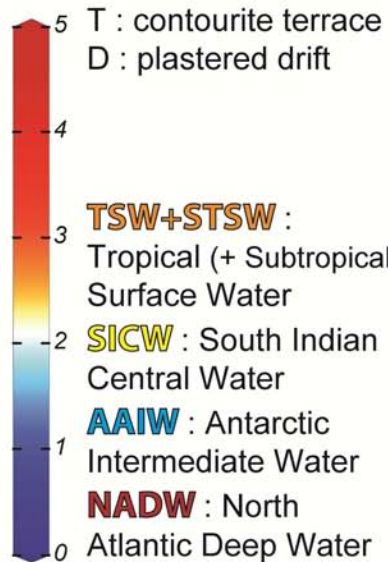
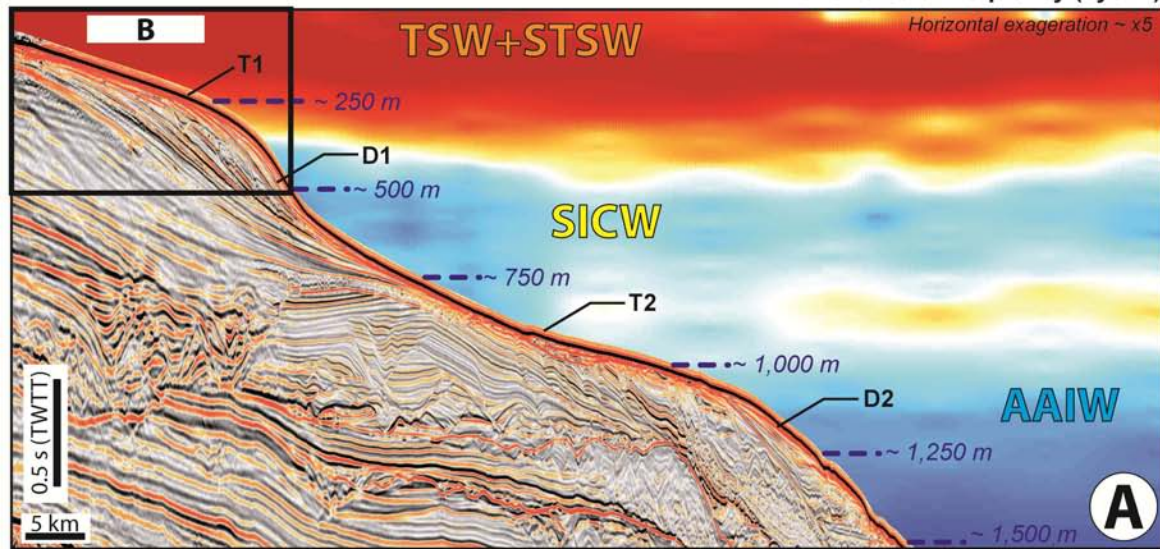


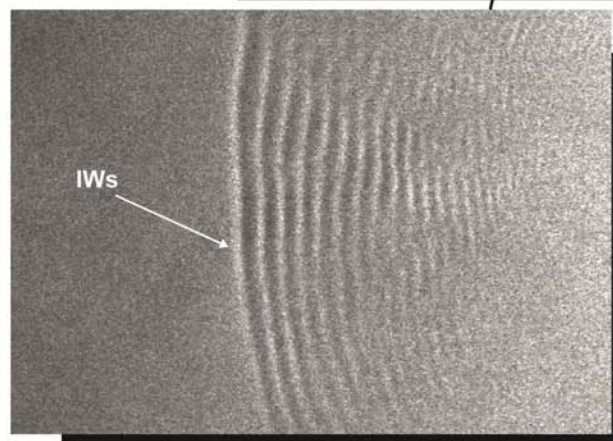
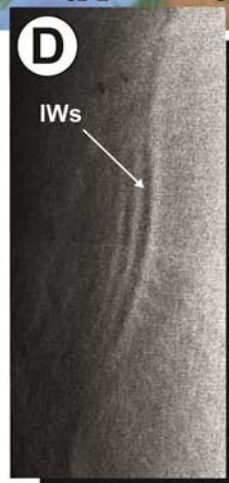
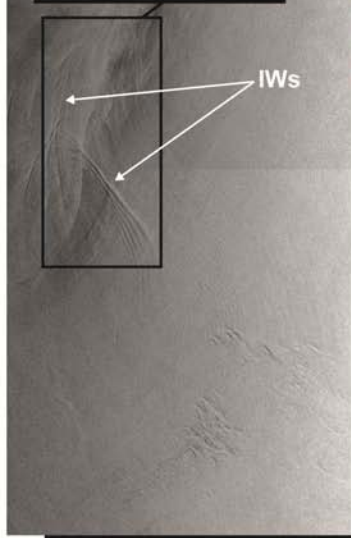
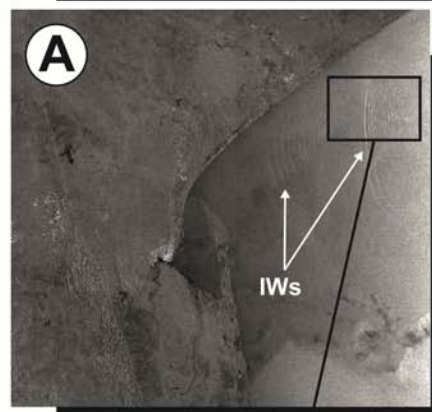
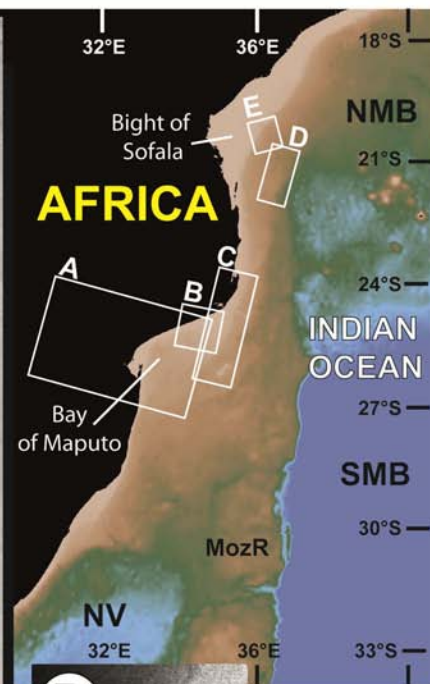
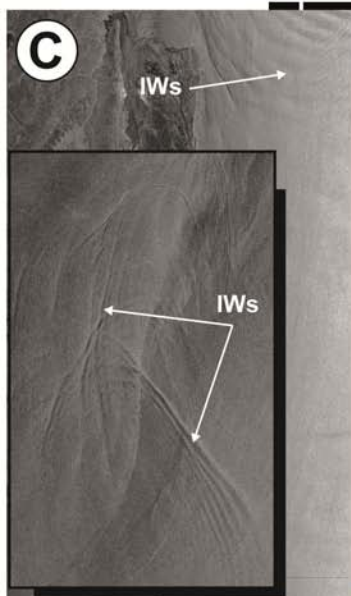
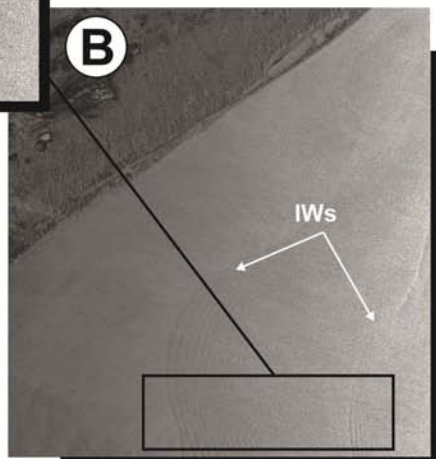
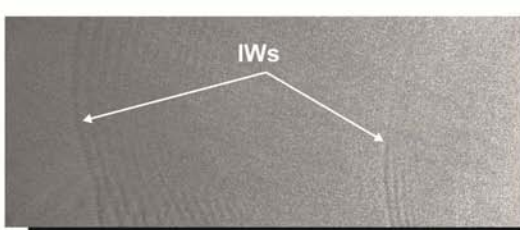
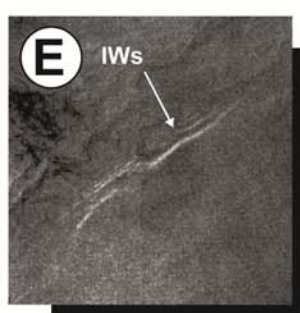


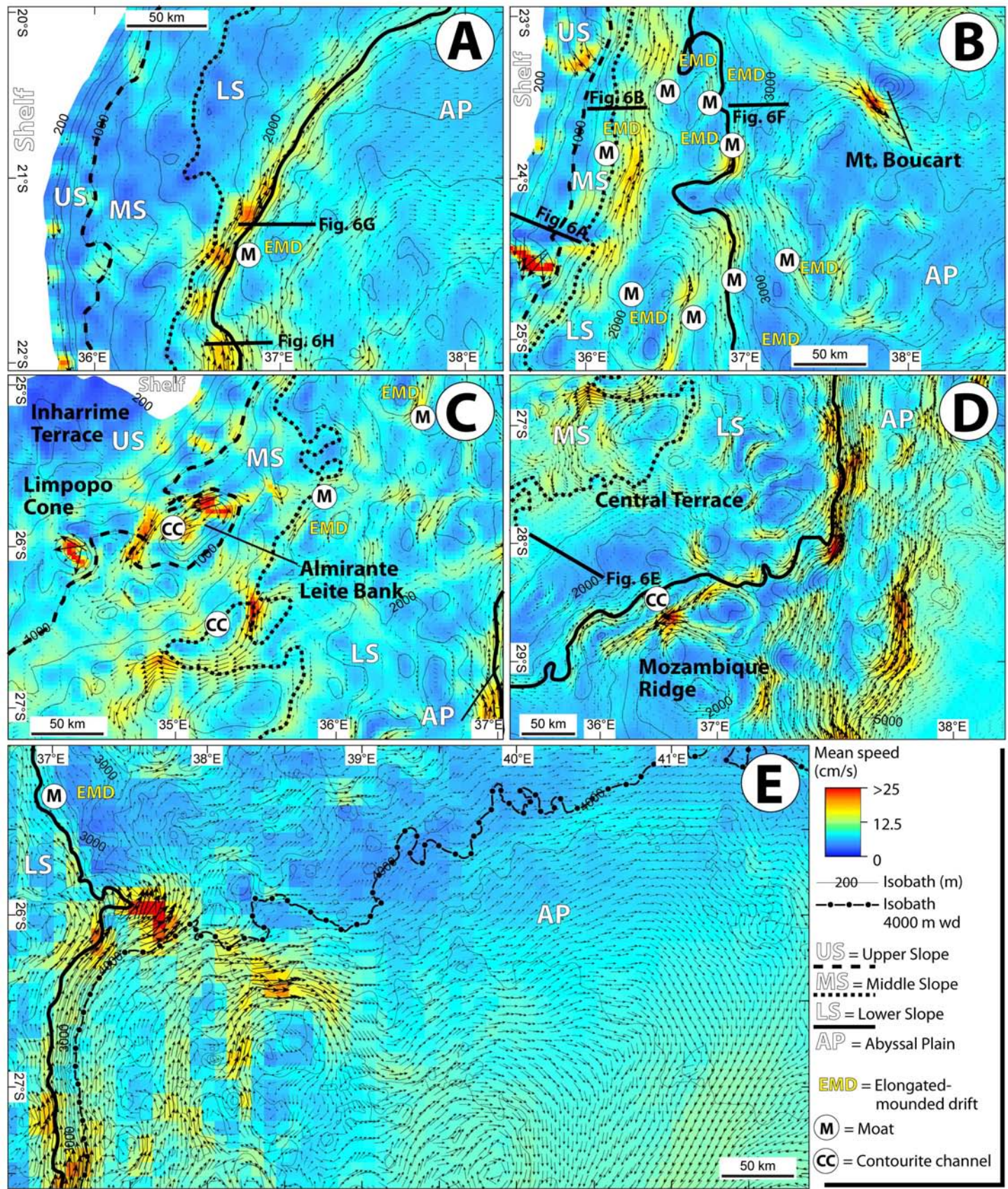


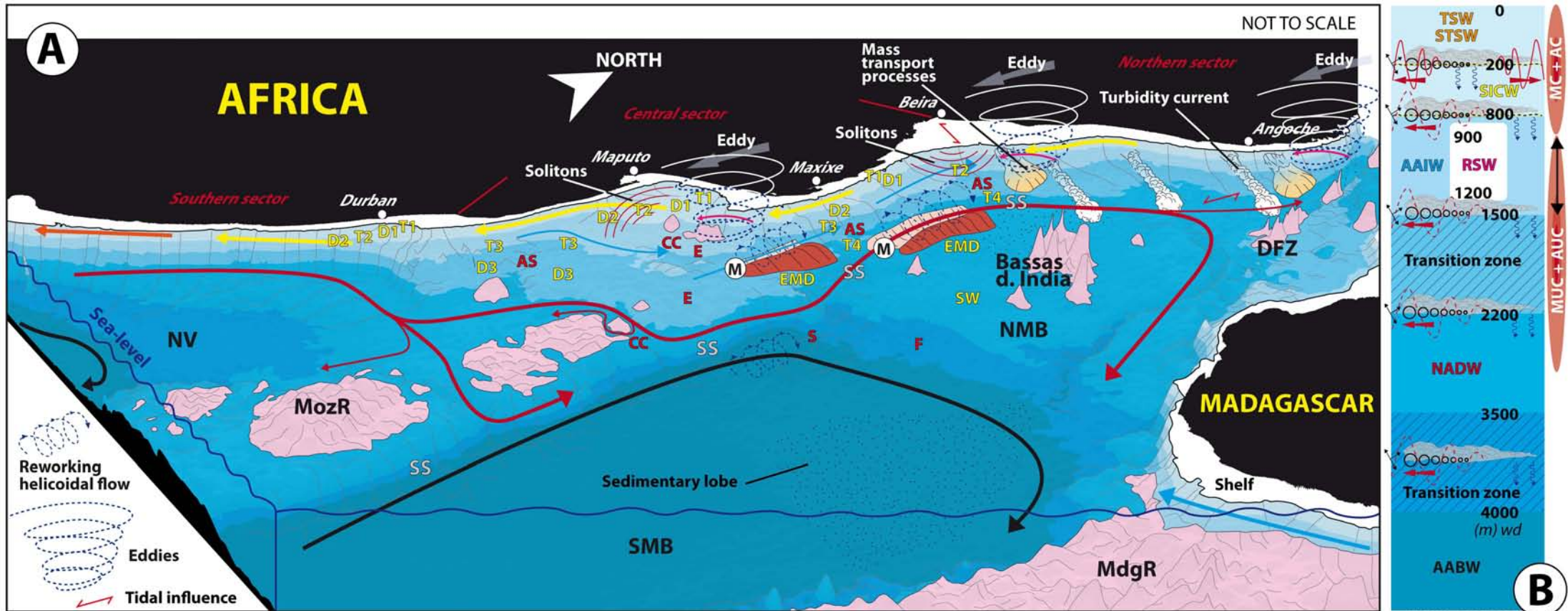


Brunt-Vaisala Frequency (cycl/h)









- Tropical Surface Water (TSW); Sub-Tropical Surface Water (STSW)
- South Indian Central Water (SICW)
- Red Sea Water (RSW)
- Antarctic Intermediate Water (AAIW)
- North Atlantic Deep Water (NADW)
- Antarctic Bottom Water (AABW)
- Seamounts & Ridge > 2200m wd
- MozR: Mozambique Ridge
- MdgR: Madagascar Ridge
- DFZ: Davie Fracture Zone
- SMB: Southern Mozambique Basin
- NMB: Northern Mozambique Basin
- NV: Natal Valley

- Depositional features:*
- D** : Plastered drifts
 - EMD** : Elongated-mounded drifts
 - SW** : Sediment waves
- Erosional features:*
- AS** : Abraded surfaces
 - E** : Erosion
 - S** : Scours
 - F** : Furrows
 - CC** : Contourite channels
 - (M)** : Moats
- Mixed features:*
- T** : Contourite terraces
 - SS** : Steep surface

- Main core** MC + AC: Mozambique + Agulhas Currents
- MUC + AUC:** Mozambique + Agulhas Undercurrents
- Interfaces between water masses / nepheloid layers
- Gradient sediment concentration
- Internal waves observed / inferred (dashed line)
- Sediment settling
- Reworking & Resuspension
- Moving current core

B

Highlights:

- Combined study of the geomorphology, sedimentology, and physical oceanography of the Mozambique Channel.
- Bottom circulation of water masses and associated sedimentary processes shape the continental margin.
- Interface positions of water-masses with contrasting densities (i.e., internal waves) sculpt terraces along the slope at a regional scale.
- Morphologic obstacles play an essential role in local water mass behaviours and dynamics.