

A revised position for the rotated Falkland Islands microplate

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ABSTRACT: The early stages of transform margin formation are associated with crustal fragmentation and block rotation. The restricted size of the resultant microcontinental blocks precludes palaeogeographic reconstructions and reliable estimations of the amount of rotation they can undergo. An example considered here is the Falkland Plateau. This is located adjacent to the Agulhas-Falkland Fracture Zone/Transform and its westernmost province is the Falkland Islands microcontinent. The position of the plateau and the islands prior to Gondwana break-up remains contentious. This study integrates seismic reflection and gravity data to propose a revised position of the Falkland Islands microcontinent constrained by: (a) the presence of a mega-décollement, controlling the Gondwanide Orogen, described north of the Falkland Islands and underneath South Africa and Outeniqua Basin, and (b) the similar architecture of fault networks mapped north of the islands and in the northernmost Outeniqua Basin. This revised position requires a re-evaluation of the timing and rate of rotation of the Falkland Islands microcontinent and impacts the expected crustal architecture adjacent to the islands. Our model yields rotation rates between 5.5° and 8° Myr⁻¹, two potential times for rotation and predicts more unstretched crust beneath the basin east of the Falkland Islands than previous models.

22 Transform margins are associated with a complicated tectono-stratigraphy (Scrutton 1979;
23 Basile & Allemand 2002; Mercier de Lépinay *et al.* 2016) and a unified model for their evolution
24 is yet to be established. Commonly, their incipient development stages can be associated with
25 crustal fragmentation and block rotation (Masclé & Blarez 1987). Typically, the resultant
26 microcontinental blocks have a limited outcrop extent. This paucity of information hinders
27 palaeogeographic reconstructions of these blocks which are crucial for understanding the pre-
28 break-up configuration of transform margins. A more reliably constrained palaeoposition of the
29 transform-related microcontinental blocks can also bring insights into the amount of rotation that
30 can affect these blocks and also on the architecture of the continental crust adjacent to them.

31 A pertinent example considered here is the Falkland Plateau transform margin (Fig. 1). Its
32 position prior to Gondwana break-up is highly dependent on the position of the Falkland Islands
33 microcontinent.

34 Reaching a consensus on reconstructions of the southern Gondwanan margin prior to the opening
35 of the South Atlantic Ocean has been hampered by conflicting models that try to account for the
36 position and orientation of the Falkland Plateau. Palaeogeographic reconstructions of Gondwana
37 during the Permo-Triassic recognize a Gondwanide fold and thrust belt that extended from South
38 America through South Africa to Antarctica (Du Toit 1937; Trouw & De Wit 1999; Dalziel *et al.*
39 2000). The first to recognize a link between this fold and thrust belt and the Falkland Islands was
40 Du Toit (1927) while Adie (1952a) further argued for a positioning of the islands east of South
41 Africa in a rotated position as an extension of the Cape Fold Belt. Subsequent studies (Mitchell *et al.*
42 1986; Marshall 1994; Mussett & Taylor 1994; Curtis & Hyam 1998; Thistlewood & Randall
43 1998 in Stone 2016; Thomson 1998; Trewin *et al.* 2002) favoured this reconstruction but the
44 associated uncertainties in interpretation and drawbacks of the model led also to the emergence
45 of a rigid model (Richards *et al.* 1996; Lawrence *et al.* 1999; Ramos *et al.* 2017) with the islands
46 and the Falkland Plateau fixed to the South American plate.

47 Extensive work has been carried across the Falkland Islands (Curtis & Hyam 1998; Aldiss &
48 Edwards 1999) and their adjacent sedimentary basins (Ludwig *et al.* 1979; Lorenzo & Mutter
49 1988; Platt & Philip 1995; Richards *et al.* 1996; Richards & Fannin 1997; Thomson 1998; Del Ben
50 & Mallardi 2004; Baristead *et al.* 2013; Lohr & Underhill 2015). However, deep crustal studies in
51 the offshore region have not been equally widespread, being mainly focused on the Falkland
52 Plateau Basin (Ewing *et al.* 1971; Lorenzo & Mutter 1988; Lorenzo & Wessel 1997; Schreider *et al.*
53 2011; Kimbell & Richards 2008; Schimschal & Jokat 2017). There is, nonetheless, a well
54 constrained crustal model for the southern South African margin and its offshore basins
55 (Dürrheim 1987; Hälbich 1993; Paton & Underhill 2004; Paton *et al.* 2006). The offshore North
56 Falkland Basin is well known only at the scale of its sedimentary infill. Therefore, a direct
57 comparison between the Falkland Islands microplate and the southern South African margin, at
58 a crustal scale, is hard to accomplish. This scarcity of information regarding the deep structure
59 also precludes a more accurate positioning of the islands prior to the break-up of Gondwana.

60 In this study, we aim to integrate offshore seismic reflection and gravity data from the Southern
61 North Falkland Basin (SNFB) to bring new insights into the crustal architecture of the Falkland
62 Islands microplate and better constrain its palaeoposition. The specific objectives are as follows:
63 (a) to map the major tectonic features across the North Falkland Basin, (b) to compare the
64 structural architecture of the SNFB and the Outeniqua Basin offshore South Africa, (c) to constrain
65 the pre-break-up position of the Falkland Islands, and (d) to discuss the implications of the
66 results.

67 **GEOLOGICAL BACKGROUND**

68 **General tectonic setting of south-western Gondwana**

69 The crustal evolution of the southern margin of Gondwana was characterised by repeated
70 reactivation of older structural features in an extensional or compressional regime (Paton &
71 Underhill 2004). After passive margin conditions (1600–1200 Ma), compression ensued between
72 1200 and 900 Ma (Hälbich 1993; Thomas *et al.* 1993). This was accompanied by subduction either
73 on a north-dipping (Tankard *et al.* 2009) or south-dipping (Lindeque *et al.* 2011) plane, leading
74 to the obduction of oceanic crust and the generation of the Gondwana suture during the
75 Namaqua-Natal Orogeny (Hälbich 1993; Thomas *et al.* 1993). Reworking of this suture zone
76 material resulted in the deposition of the Pre-Cape Group in basins that opened parallel to this
77 suture from 900 to 600 Ma (Tankard *et al.* 1982; Hälbich 1993; Paton & Underhill 2004). Between
78 600 and 450 Ma, the Pan African Orogeny led to basin inversion, north-verging thrusts and a
79 south dipping mega-décollement (Tankard *et al.* 1982; Shone *et al.* 1990; Hälbich 1993). During
80 the Ordovician to Carboniferous (450–300 Ma) the Cape Supergroup was deposited, followed by
81 the Cape Orogeny (280–235 Ma) (Tankard *et al.* 1982; Hälbich 1993; Paton & Underhill 2004);
82 the latter was accompanied by the deposition of the Karoo foreland sequence (Hälbich 1993;
83 Veevers *et al.* 1994). This later collisional episode led to the formation of the Gondwanide orogen
84 which extended through the Sierra de la Ventana (South Argentina), Cape Mountains (South
85 Africa), Falkland Islands, Ellsworth Mountains and Pensacola Mountains (Antarctica) (Du Toit
86 1937; Thomas *et al.* 1993; Trouw & De Wit 1999; Dalziel *et al.* 2000).

87 Evidence of an up-dip continuation of the mega-décollement interpreted by Hälbich (1993) is
88 presented by Lindeque *et al.* (2011). Their study documents a south dipping interface beneath
89 the Karoo Basin, lying between ~5 and 11 km depth and separating the deformed Karoo and Cape
90 supergroup sequences from the Mesoproterozoic basement (Lindeque *et al.* 2011). This interface
91 has been interpreted as an angular unconformity by Lindeque *et al.* (2011) but the fact that
92 thrusts coalesce onto it suggests that it acted as a decoupling plane and its depth correlates with
93 the depth of the mega-décollement interpreted by Hälbich (1993); this décollement is believed to
94 have had been partially reactivated during the Cape Orogeny (Hälbich 1993).

95 During the Middle Jurassic to Early Cretaceous break-up of Gondwana many Cape Fold Belt
96 structures were reactivated in an extensional regime (Paton & Underhill 2004; Paton 2006).
97 During this time, there were high rates of exhumation across southern South Africa (Richardson
98 *et al.* 2017), with sediment supplied to offshore extensional basins such as the Outeniqua and
99 Southern Outeniqua Basins (Fig. 2) (Tinker *et al.* 2008). At the same time, offshore the Falkland
100 Islands, the North Falkland Basin, the Falkland Plateau Basin, the South Falkland Basin and the
101 Malvinas Basin developed (Figs 1&3) (Richards *et al.* 1996; Macdonald *et al.* 2003). The extension
102 was the result of the westward drift of South America along the dextral Agulhas-Falkland Fracture
103 Zone (AFFZ), away from Africa, and the opening of the South Atlantic (Ben-Avraham *et al.* 1997;
104 Macdonald *et al.* 2003).

105 **Outeniqua Basin**

106 Rifting in the broader Outeniqua Basin is thought to have occurred between Middle Jurassic and
107 Valanginian with sedimentation into four depocentres: Bredasdorp, Pletmos, Gamtoos and Algoa
108 (McMillan *et al.* 1997). These are bounded by west-dipping normal faults (from west to east
109 respectively: Plettenberg Fault, Gamtoos Fault, Port Elizabeth Fault and St. Croix Fault) with
110 displacements in excess of 10 km or by basement highs (Agulhas and Infanta Arches) (McMillan

111 *et al.* 1997) (Fig. 2). The dip angles of the controlling faults consistently increase towards the
112 south-west from 24° across the St. Croix Fault to 60° across the Plettenburg Fault (Paton *et al.*
113 2006) and coalesce onto a south-dipping mega-décollement (Hälbich 1993; Paton *et al.* 2006).
114 This configuration results in a southward change in structural style from thin-skinned to thick-
115 skinned (Paton *et al.* 2006). These depocentres are bounded to the south by the Southern
116 Outeniqua Basin which is in turn separated from the AFFZ by the Diaz Marginal Ridge (DMR)
117 (Parsiegla *et al.* 2009) (Fig. 2).

118 The basin-fill of each of these depocentres consists of Middle Jurassic to Early Cretaceous
119 terrestrial and shallow marine sediments that unconformably overlie the Ordovician-Devonian
120 Cape Supergroup onshore and offshore in the early rift stages, and transit to deep-water deposits
121 offshore in the late rift stages (McMillan *et al.* 1997; Paton & Underhill 2004; Paton 2006). The
122 post-rift sequence is represented by shallow marine deposits (McMillan *et al.* 1997).

123 **North Falkland Basin**

124 The structure of the North Falkland Basin (NFB) is controlled by the superimposition of two rift
125 systems: the Late Jurassic Southern North Falkland Basin (SNFB), which is overlain by the Early
126 Cretaceous North Falkland Graben (Lohr & Underhill 2015) (Figs 1&3). The SNFB is bounded by
127 NW-SE striking normal faults which are overprinted to the north by the N-S striking normal faults
128 of the younger North Falkland Graben and its secondary half-grabens (Richards & Fannin 1997;
129 Thomson & Underhill 1999; Lohr & Underhill 2015). The Jurassic normal faults have low dip
130 angles, thought to suggest that they originated as thrust faults (Richards *et al.* 1996; Richards &
131 Fannin 1997; Thomson & Underhill 1999). Their strike is similar to the onshore structures
132 associated with the Gondwanide orogeny (Richards & Fannin 1997; Brandsen *et al.* 1999).

133 The onset of post-rift sedimentation in the SNFB is interpreted as coeval with the deposition of
134 syn-rift in the North Falkland Graben and its subsidiary basins (Lohr & Underhill 2015). The infill
135 of the basins is considered to comprise Jurassic to Valanginian fluvio-lacustrine deposits
136 transitioning to lacustrine and deltaic during the post-rift of the North Falkland Graben and
137 overlain by fluvial to marine mudstones of Late Cretaceous to Cenozoic age (Richards & Hillier
138 2000; Richards *et al.* 2006; Lohr & Underhill 2015).

139 **Falkland Islands within Gondwana**

140 Du Toit (1927) first suggested that the Falkland Islands might represent a displaced segment of
141 the Cape Fold Belt (CFB) and placed the islands between South America and South Africa. Adie
142 (1952a) built upon that hypothesis and suggested that the islands rotated ~180° having
143 originated from offshore east South Africa (Fig. 4a). This assertion was based on stratigraphic
144 correlations, fossil assemblages, ice flow directions and structural similarities between the
145 Falkland Islands and the South African margin. This hypothesis is further supported by more
146 recent palaeomagnetic, aeromagnetic, stratigraphic, palaeontological and structural data analysis
147 (Mitchell *et al.* 1986; Mussett & Taylor 1994; Marshall 1994; Curtis & Hyam 1998; Trewin *et al.*
148 2002; Stone *et al.* 2009). The palaeomagnetic measurements were carried out on dykes identified
149 onshore the Falkland Islands (Mitchell *et al.* 1986; Taylor & Shaw 1989; Stone *et al.* 2008) and on
150 Permian sediments (Thistlewood & Randall 1998 in Stone 2016). The dykes trend E-W to NE-SW
151 and N-S and are of Early Jurassic to Early Cretaceous age, respectively (Mussett & Taylor, 1994;
152 Thistlewood *et al.* 1997; Stone *et al.* 2008; Richards *et al.* 2013). Their emplacement is related to
153 the Karoo-Ferrar magmatism in South Africa and Antarctica for the Jurassic dykes (Mitchell *et al.*
154 1999) and the opening of the South Atlantic for the Cretaceous swarm (Richards *et al.* 2013). Five

155 deformation phases (D1 to D5) were identified by Aldiss & Edwards (1999) onshore the Falkland
156 Islands; the first four were interpreted as being synchronous to the Permo-Triassic CFB in South
157 Africa (Curtis & Hyam 1998; Stone 2016). The West Falkland Group, which crops out on the West
158 Falkland, the northern part of the East Falkland and the Beauchêne Island (Aldiss & Edwards
159 1999; Stone 2015), has been correlated with the Table Mountain, Bokkeveld and Witteberg
160 groups in South Africa (Adie 1952b in Marshall 1994), whereas the Fitzroy Tillite Formation from
161 the Falkland Islands is considered coeval with the Dwyka Group (Fig. 5) from South Africa (Curtis
162 & Hyam 1998) based on ice flow directions (Frakes & Crowell 1967; Crowell & Frakes 1972) and
163 fossil assemblages from erratic clasts from the glacial diamictites (Stone & Thompson 2005; Stone
164 *et al.* 2012). The overlying Permian deposits of the Upper Lafonian Group have been correlated
165 with the Ecca and Beaufort groups in South Africa based on stratigraphy, trace fossils and
166 sediment provenance (Trewin *et al.* 2002) (Fig. 5).

167 These correlations led to the positioning of the Falkland Islands east of the south-eastern coast of
168 South Africa (Curtis & Hyam 1998; Trewin *et al.* 2002) (Fig. 4a) with the Maurice Ewing Bank,
169 now located at the eastern end of the Falkland Plateau (Fig. 1), adjacent to the Durban Basin
170 (Marshall 1994). In this model, the Falkland Islands underwent a clockwise rotation of up to 180°
171 during the break-up of Gondwana (120° prior to the opening of the South Atlantic and 60° during
172 the drifting of the South American plate) (Mitchell *et al.* 1986).

173 As part of the rotational model, the Falkland Islands are considered to be part of a microplate that
174 underwent vertical-axis rotation during the break-up of Gondwana. However, the northern and
175 western boundaries of this microplate remain uncertain, while the southern and eastern
176 boundaries are considered to coincide with the present-day North Scotia Ridge and the NE-SW
177 striking fault bounding the Falkland Plateau Basin, respectively (Marshall 1994; Richards *et al.*
178 1996; Storey *et al.* 1999) (Fig. 1).

179 A further implication of this reconstruction of the islands consists of space issues, which require
180 the presence of a right-lateral fault north of the North Patagonian Massif (Ben-Avraham *et al.*
181 1993) or south of it, along the Gastre Fault System (Rapela & Pankhurst 1992) (Figs 1&4a) to
182 account for a more eastern position of Patagonia prior to the break-up of Gondwana. However,
183 field observations along the Gastre Fault contradict its predicted dextral nature (Franzese &
184 Martino 1998 in Ramos *et al.* 2017; Von Gosen & Loske 2004) and provide an additional argument
185 against the rotational model.

186 Furthermore, no deformation affecting the sedimentary basins offshore the Falkland Islands has
187 been identified in previous studies (Richards *et al.* 1996) which led to the conclusion that the
188 rotation occurred prior to the opening of these basins in the mid-Jurassic (Stone *et al.* 2008).
189 However, there is little movement recorded along the AFFZ at this time (Broad *et al.* 2006 in
190 Tankard *et al.* 2009) in support of this hypothesis. In addition, the uncertainty around
191 palaeomagnetic measurements (Richards *et al.* 1996; Hodgkinson 2002 in Stone 2016) and the
192 absence of a pertinent mechanism to account for the rapid and substantial rotation of the islands
193 resulted in numerous studies advocating for a contrasting rigid evolution of the Falkland Islands,
194 in which the islands are part of a Falkland Plateau fixed to the South American plate (Fig. 4b). In
195 this scenario the Falkland Islands undergo a rotation of only 60° during the opening of the South
196 Atlantic (Lawrence *et al.* 1999; Ramos *et al.* 2017).

197 In the rigid model the opposite vergence of the thrusts and folds onshore the Falkland Islands
198 compared to the Cape Fold Belt is explained through the existence of similar south-verging

199 structures in the north-eastern North Patagonian Massif (Von Gosen 2003; Ramos *et al.* 2017).
200 The West Falkland Group is interpreted as being coeval with same age deposits from northern
201 Patagonia, their common source being the Deseado Massif whereas the equivalent of the
202 diamictite in the Falkland Islands is interpreted as being the Sauce Grande Tillite of the Ventania
203 System, Argentina (Ramos *et al.* 2017). Furthermore, the trend of the Jurassic Southern North
204 Falkland Basin is correlated to basins along the South American margin (Fig. 1), having the same
205 trend and age (Ramos *et al.* 2017), their opening being associated either with back-arc extension
206 along the southern margin of Gondwana or the southward movement of Antarctica and early
207 extension in the Weddell Sea (Uliana *et al.* 1989; Baristead *et al.* 2013; Reeves *et al.* 2016; Ramos
208 *et al.* 2017).

209 DATA AND METHODS

210 The study was based on the analysis of open-source gravity data (Fig. 6) and seismic reflection
211 and well data (Fig. 3) courtesy of the Falkland Islands Government.

212 The gravity data consist of the V24.1 1-minute satellite altimetry free-air gravity anomaly grid of
213 Sandwell *et al.* (2014). The seismic reflection data used for this study comprise 2D lines from
214 seven different vintages acquired between 1980s and 2008 by BIRPS, WesternGeco, Spectrum,
215 Rockhopper Exploration and Desire Petroleum. The shot point interval ranges from 25 m for the
216 more recent datasets to 50 m for the regional traverse east of the islands whereas the fold of cover
217 varies between 120 and 30 respectively. The line spacing ranges from 2 to 30 km and the
218 maximum record lengths between 6.7 to 18 seconds. All seismic sections have a vertical axis in
219 two-way-time (TWT), a depth conversion being undertaken on type-sections post-interpretation.
220 Two wells, 26/6-1 (Rockhopper Exploration) and 14/24-1 (IPC Falklands), were used for this
221 study with formation top markers and were tied to the seismic reflection data. VSP surveys were
222 available for each well and provided velocity information that facilitated the subsequent depth
223 conversion.

224 The total horizontal derivative of the free air gravity anomaly (Cordell & Grauch 1985), first
225 vertical derivative (Evjen 1936) and tilt derivative (Miller & Singh 1994; Verduzco *et al.* 2004;
226 Oruç & Keskinsezzer 2008) were computed (Fig. 6) for edge detection and in order to enhance
227 linear structures. The main gravity lineaments were mapped along the entire NFB (Fig. 6) and
228 show a close correlation with fault trends mapped on the seismic reflection data (Fig. 7).

229 Four key surfaces were mapped across the SNFB based on stratal terminations of reflectors and
230 internal geometries of seismic facies (Mitchum *et al.* 1977; Hubbard *et al.* 1985*a, b*) and used to
231 define four mega-sequences: pre-rift, syn-rift, post-rift 1 and post-rift 2. The latter two are
232 separated by the base Cenozoic regional unconformity. Within the syn-rift two unconformities,
233 described in detail by Lohr & Underhill (2015), were mapped along the extent of the half-grabens
234 basin-fills. The SNFB pre-rift is associated with a semi-transparent seismic facies capped by a high
235 amplitude reflector that is overlapped by wedge-shaped syn-rift deposits. These display a chaotic
236 seismic character in the lower section and sub-parallel to parallel reflectors in the upper part. The
237 post-rift 1 comprises wavy to hummocky deposits overlain by the sub-horizontal post-rift 2 (Fig.
238 8).

239 The oldest sediments penetrated by both wells are represented by Upper (?) Jurassic
240 volcanoclastic deposits. Across the faults, the corresponding reflector is correlated with the top
241 syn-rift of the SNFB. This horizon is not continuous southward across the half-grabens shoulders.

242 The age of the infill of the southernmost half-graben is inferred based on stratal geometries alone
243 assuming coeval deposition across the SNFB.

244 Faults at the SNFB pre-rift level were mapped (Figs 7–9) and superimposed onto the interpreted
245 gravity features shown in Fig. 6 for comparison and correlation. Two deep high amplitude
246 intervals were identified, the shallower (-3.5 s to -8.2 s TWT) being mapped across the entire
247 SNFB (Figs 7&10a, b, c) on two of the vintages whilst the deeper feature (-11 s to -12 s TWT) was
248 interpreted only on the regional traverse east of the islands (Fig. 10c, d).

249 A regional cross-section was constructed perpendicular to the main structural grain of the basin
250 to allow a direct comparison with published sections from onshore Falkland Islands and South
251 Africa. In order to assess the geometry of the faults more reliably, the section was depth converted
252 using velocity information from the borehole seismic surveys available for both wells. Post-rift 1
253 and 2 were depth converted using interval velocities of 1900 and 2600 m/s respectively. A v_0 - k
254 function was used for the syn-rift deposits ($v_0 = 3000$ m/s and $k = 0.6$) whereas the pre-rift down
255 to a depth of 8s TWT was depth converted using a constant velocity of 5200 m/s. The same
256 velocity model was used to depth convert type-section across the major NW-SE faults in order to
257 estimate the thickness of the half-graben infills and the dips of the faults more accurately.

258 RESULTS

259 The deformation in the SNFB was accommodated by three main NW-SE striking reactivated
260 thrust faults (A to C in Fig. 7), up to 150 km long, and with depocentres ~ 3000 ms TWT (~ 5 km)
261 deep. The NW-SE trend of these faults can be tracked on the gravity data derivatives where they
262 are associated with linear anomalies (Fig. 6). Further north, this NW-SE trend of the gravity
263 lineaments is overprinted by WNW-ESE to E-W striking features swinging through NE-SW to N-S
264 on the west of the islands and the N-S trend of the Early Cretaceous main graben (Fig. 6).

265 The NW-SE trending normal faults have low depth converted dips of 20-40° (with the exception
266 of Fault A that steepens up to 60° closer to the surface), dominantly down throw to the NE, and
267 are associated with splay faults and smaller-scale synthetic and antithetic faults within their
268 hanging-walls (Figs 7&8).

269 The syn-rift deposits associated with these faults reach a thickness of ~ 2000 ms TWT but a
270 greater thickness was likely to have existed as the southernmost half-graben infills have since
271 been uplifted and eroded. The syn-rift was deposited in three stages, separated by unconformities
272 interpreted within the package (Fig. 8) and most likely overlies the same formations that crop out
273 onshore (Thomson & Underhill 1999; Lohr & Underhill 2015). The syn-rift was further inverted
274 and deformed into harpoon structures and gentle folds along with the overlying Cretaceous post-
275 rift (Fig. 8). The whole sequence is capped unconformably by Cenozoic deposits.

276 The WNW-ESE to E-W trending features mapped on the gravity data (Fig. 6) correlate with
277 depressions and fractured zones within the seismic reflection data (Fig. 9). A high amplitude
278 reflector correlated with the top SNFB pre-rift (Fig. 9) can be mapped across these structures; the
279 geometry of the strata overlying it shows a slight thickening south-westwards whereas further
280 up the succession strata thicken north-eastwards (grey-shaded packages in Fig. 9a). The infill of
281 these structural lows is unconformably overlain by Cenozoic deposits (Fig. 9).

282 Across the SNFB a high amplitude north dipping set of reflectors was interpreted between -3.5 s
283 and -8.2 s TWT (-8 to -20 km) (Fig. 10a, b, c). The 'surface' can be mapped out to ~ 100 km from
284 the coastline where the imaging becomes poorer and/or its depth exceeds the maximum

285 recorded length of the data. Towards the south, the interface is visible nearshore Stanley where
286 it shallows both southwards and south-eastwards, disappearing around 51°42'S (Fig. 7). This
287 feature has been characterised as an interval of high amplitudes as it appears as a discrete
288 interface only updip (Fig. 10a). Further downdip, the area widens and becomes more convoluted,
289 being characterised by an irregular top and the presence of lenticular features most likely
290 generated through thrusting (Fig. 10b). East and northeast of the islands another set of reflectors
291 was picked between -11 s and -12 s TWT (Fig. 10c, d); the two sets of reflectors seem to converge
292 northeast of the Falkland Islands (Fig. 10d, f).

293 **DISCUSSION**

294 **SNFB fault geometry and formation**

295 The NW-SE normal faults mapped in the SNFB have low dip angles, are downthrown
296 predominantly to the NE and have a similar orientation to the D4 thrust faults described onshore
297 the Falkland Islands by Aldiss & Edwards (1999). This suggests that they exploited pre-existing
298 thrust planes (Richards *et al.* 1996) developed during the Gondwanide orogeny much like the
299 faults on the southern margin of South Africa (Paton *et al.* 2006; Paton 2006). However, unlike its
300 conjugate (Paton *et al.* 2006), the faults in the SNFB do not show a consistent steepening away
301 from the deformation front, their mean depth converted dips being in the 20°–40° range (Fig.
302 11a). The south-westward steepening of the faults in the Outeniqua Basin has been recorded
303 across a wide area of over 200 km, which is in direct contrast with the narrow extent of the
304 analysed SNFB (~60 km). We speculate that this limited extent does not cover the deep rooted,
305 higher angle faults and predict that these may underlie the northernmost part of the NFB.

306 The present-day preserved SNFB is therefore characteristic only of a narrow deformational
307 domain. Its equivalent on the conjugate South African margin based on the range of dips could
308 correspond to the transitional area between the thin-skinned and thick-skinned domains
309 described by Paton *et al.* (2006), namely the area between the St. Croix Fault and the Gamtoos
310 Fault (Fig. 11).

311 There are, however, basins along the South American margin (e.g. Cañadón Asfalto, San Jorge, El
312 Tranquilo, San Julián, Río Mayo basins) that underwent rifting along the same NW-SE trend as the
313 SNFB or have similar infills, suggesting a synchronous opening within the same stress field
314 (Uliana *et al.* 1989; Brandsen *et al.* 1999; Ramos *et al.* 2017). The normal faults bounding the
315 grabens and half grabens in these basins situated along strike from the SNFB are nonetheless
316 steeply dipping (Fitzgerald *et al.* 1990; Soares *et al.* 2000; Echavarría *et al.* 2005) and point
317 towards a different evolution prior to the Jurassic rifting.

318 The similarities in trend between the SNFB and the South American basins have been previously
319 invoked as an argument for the rigid model (Ramos *et al.* 2017), but this does not explain the
320 origin of the crustal anisotropy beneath the Falkland Islands and its northern basin. The south-
321 verging deformation documented by Von Gosen (2003) in the North Patagonian Massif was
322 correlated with the accretion of Patagonia during Late Paleozoic (Ramos 2008) and used to
323 explain the present-day vergence of the Falkland Islands deformation front (Ramos *et al.* 2017).
324 Evidence of south-verging thrusts can be seen up to 150 km away from the western coast of the
325 Falkland Islands (Fig. 10a; McCarthy *et al.* 2017), but there is however no documentation of a
326 south-verging fold and thrust belt further west to support a correlation with Patagonia. The
327 opening of the SNFB due to the same stress regime as the one in the South American NW-SE
328 trending basins is still a pertinent interpretation but does not preclude a rotation of the islands
329 prior to this rifting event.

330 The WNW-ESE to E-W gravity lineaments mapped across the NFB (Fig. 6) are associated with
331 fractured zones interpreted as extensional or transtensional features (Fig. 9). The timing of
332 activity on these faults is difficult to constrain because some of these features are not covered by
333 the available seismic data, their infill was partly eroded and well data cannot be extrapolated
334 across the fault shoulders. The geometry of the strata overlying the interpreted top SNFB pre-rift
335 show a slight thickness variation (grey-shaded packages in Fig. 9) suggesting a diachronous
336 activity of the faults bounding the structures. However, due to the lack of well data on the platform
337 and scarcity of seismic reflection data the timing of activity on these faults along with the sense
338 of movement (dip-slip, strike-slip) remains speculative.

339 The E-W trend of these lineaments changes to a more ENE – WSW orientation westwards (Fig. 6).
340 As this area is not constrained by seismic reflection data, the nature of these gravity lineaments
341 remains unknown. We speculate their formation is either simultaneous with the event that
342 generated the E-W trending features or with the Triassic – Late Jurassic opening of the San Julian
343 Basin (Soares *et al.* 2000) where a NE – SW gravity trend is noticeable parallel to the eastern
344 margin of the basin.

345 **Mega-décollement**

346 We interpret the north dipping high amplitude interval mapped between -3.5 s and -8.2 s TWT (-
347 8 to -20 km after depth conversion) as a mega-décollement onto which the major faults bounding
348 the three half-grabens of the SNFB coalesce (Figs 10e–11a). Further south the interface can be
349 mapped until 51°42'S.

350 Based on previous crustal studies carried out by Kimbell & Richards (2008) and Schimschal &
351 Jokat (2017) on the Falkland Plateau, the Moho discontinuity is located at 34-36 km depth on the
352 continental shelf east of the islands and shallows northwards to 30 km based on gravity
353 modelling. Using the P-wave velocities published by Schimschal & Jokat (2017) for the continental
354 shelf crust, the reflectors we interpreted between 11 – 12 s TWT off the east coast of the Falkland
355 Islands would be situated at a converted depth of 33-36 km; this led us to correlate them with the
356 Moho discontinuity (Fig. 10f).

357 Taking into account the present-day depth distribution of the Moho north of the Falkland Islands
358 as shown by Kimbell & Richards (2008) and the dip of the mega-décollement, it can be deduced
359 that the latter emerges from the Moho between 48°S and 50°S (present-day coordinates) (double
360 line in Fig. 12).

361 The presence of a similar regional décollement dipping south has been inferred by Hälbich (1993)
362 to be controlling the deformation in South Africa. Based on a deep seismic reflection profile along
363 the Agulhas Bank (Dürrheim 1987, (1) in Fig. 12), the depth of this décollement would be -6.5 s
364 or -18 km underneath the Outeniqua Basin (Hälbich 1993) which is in the depth range estimated
365 for the décollement under the SNFB. The interpretation of a more recent seismic reflection
366 transect ((2) in Fig. 12) acquired between Prince Albert and Slingersfontein (South Africa) shows
367 the presence of a crustal interface that dips 3° southwards and separates the shallower thrust
368 sequence of the CFB and Karoo Basin from the Mesoproterozoic basement (Lindeque *et al.* 2011).
369 Extrapolating this plane southwards, we estimate its depth underneath the Agulhas Plateau at
370 ~20 km and correlate it with the mega-décollement of Hälbich (1993). This depth variation of the
371 mega-décollement is also proposed by Paton *et al.* (2006). The detachment is located underneath
372 the Cape Supergroup in the southern part of the Karoo Basin (Lindeque *et al.* 2011) and is thought
373 to displace Proterozoic deposits further south (Paton *et al.* 2006) (Fig. 11b).

374 The Moho for the South African margin shallows southwards from 50 km underneath the Karoo
375 Basin to ~30 km near the coast and 25-26 km beneath the Agulhas Bank (Nguuri *et al.* 2001;

376 Stankiewicz *et al.* 2008; Stankiewicz & de Wit 2013). Taking into account the dip of the
377 décollement ($\sim 3^\circ$ based on Lindeque *et al.* 2011) and the present-day depth of the Moho offshore
378 South Africa, we can estimate a merging of the decoupling plane with the Moho occurring at $\sim 35^\circ\text{S}$
379 (dashed grey double line in Fig. 12) which is in accordance with the interpretation of Hälbig
380 (1993).

381 **South African connections**

382 Cross-sections across both the southern South African onshore to offshore margin and the
383 Falkland Islands and their northern basin exhibit similar deformation styles (Fig. 11). Given the
384 uncertainty in the relative positions during the initial phases of rifting during the break-up of
385 Gondwana, the terms foreland and hinterland will be used to refer to different parts of the cross-
386 sections.

387 The foreland portion in both areas comprises Carboniferous to Permian deposits of the Karoo and
388 Lafonia supergroups exposed onshore South Africa and Eastern Falkland, respectively (Fig. 11).
389 These are affected by open to isoclinal folds with symmetric to highly asymmetric limbs
390 controlled at depth by thrusting (Aldiss & Edwards 1999; Stone 2016; Paton *et al.* 2006).

391 Towards the hinterland, thrusts active during the Cape orogeny underwent negative structural
392 inversion during the Mesozoic rifting event. Closer to the CFB deformation front, the extension
393 resulted in low angle (20° – 40°) listric normal faults that bound half grabens filled with Late
394 Jurassic terrestrial to shallow marine deposits across the SNFB and the South African Algoa and
395 Gamtoos Basins (Fig. 11). Away from the deformation front, the normal faults accommodating the
396 extension steepen (Fig. 11b) and it has been proposed that these originated as normal faults
397 during the Cape Supergroup deposition and were further exploited during the subsequent
398 compressional and extensional regimes (Paton *et al.* 2006; Paton 2006).

399 These steeply dipping faults were not identified offshore the Falkland Islands. The E-W trending
400 features we have mapped north of the SNFB and the subsequent opening of the North Falkland
401 Graben are most likely overprinting their effect.

402 On both margins, at depth, the deformation is controlled by the presence of a mega-décollement
403 onto which the thrusts and normal faults coalesce (Fig. 11).

404 **Palaeogeographic implications**

405 Existing palaeogeographic reconstructions of the Falkland Islands have associated drawbacks
406 from the absence of a mechanism that explains the substantial rotation of the islands in the
407 rotational model to the lack of continuation of a south verging fold and thrust belt east and west
408 of the islands in the rigid model.

409 Given the new observations in this study, we propose that the geometry of the normal faults
410 bounding the SNFB half grabens could correspond to the deformation domain between the St.
411 Croix and Gamtoos Faults suggesting that the reactivated Paleozoic thrusts north of the Falkland
412 Islands were an along strike continuation of the present-day Algoa Basin region. This translates
413 in a change in trend of the Cape Fold Belt from WNW-ESE to NNW-SSE eastwards. This abrupt
414 change in orientation is supported by the strike change of the St. Croix, Port Elizabeth and
415 Gamtoos Faults (Fig. 12) which has been referred to as the Port Elizabeth Antitaxis (Johnston
416 2000). This strike variation has been related to the pre-existing crustal fabric developed during
417 the Cape Orogeny rather than later movements along the AFFZ (Paton & Underhill 2004). Similar
418 oroclinal bends of the Ventana-CFB are seen in western South Africa and Argentina at the Cape
419 and Colorado syntaxes, respectively (De Beer 1992; Pángaro & Ramos 2012; Paton *et al.* 2016).
420 The rotation expected to affect the Falkland Islands microplate would be $\sim 140^\circ$ in this scenario

421 (~80° if we subtract the rotation occurring during the opening of the South Atlantic (Mitchell *et*
422 *al.* 1986)).

423 This repositioning of the Falkland Islands microplate would mean that the points at which the
424 mega-décollement branches off from the Moho are distributed along a trend similar to the trend
425 of the CFB across the restored AFFZ (Fig. 12) and has implications for the extension expected in
426 the Falkland Plateau Basin.

427 The available data do not allow for longitudinal constraints in repositioning the microplate, the
428 extent of the Falkland Plateau Basin fitted between the Eastern Falkland and the AFFZ remaining
429 uncertain. However, the revised position predicts more unstretched crust between the
430 microplate and the Maurice Ewing Bank block, which is thought to have originated south of the
431 Tugela Cone (Marshall 1994). Therefore, less extension is required in order to achieve the
432 present-day relative position of the two continental blocks.

433 Regarding the timing of rotation of the Falkland Islands microplate, two scenarios are available
434 based on the stress regime that led to the opening of the SNFB.

435 Considering a WSW-ENE extension direction during the opening of the SNFB similar to the Late
436 Jurassic extensional episode inferred for the Gamtoos Basin (Paton & Underhill 2004), the
437 SNFB/Falkland Islands microplate should have been in a pre-rotation position in the Late
438 Jurassic. Between the two rifting events that led to the formation of the SNFB and the North
439 Falkland Graben, the microplate underwent a rapid clockwise rotation possibly exploiting the E-
440 W to ENE-WSW lineaments described previously. Based on the detailed study carried out by Lohr
441 & Underhill (2015) in the North Falkland Basin, the time interval between the two extensional
442 episodes is of ~10 Myr, although a longer time-frame is possible due to the extensive Tithonian
443 hiatus marking the end of the SNFB formation. A rotation rate of maximum 12° Myr⁻¹ is estimated
444 for this scenario for a rotation of 120° consistent with the existing rotation model. For the same
445 time interval, the revised model yields a rotation rate of 8° Myr⁻¹. The latter is closer to the range
446 of rates documented for strike-slip-related vertical-axis block rotations (Little & Roberts 1997;
447 Ingersoll & Coffey 2017).

448 If we speculate that the SNFB opened simultaneously with the NW-SE oriented basins along the
449 South American margin (Uliana *et al.* 1989; Baristead *et al.* 2013; Ramos *et al.* 2017), the Falkland
450 Islands microplate should have already been in the rotated position in Late Jurassic when rifting
451 started in the SNFB. Based on the Ar-Ar dating carried out on one of the NE-SW dykes onshore
452 the Falkland Islands, the microplate is thought to have rotated after 178 Ma (Stone *et al.* 2008).
453 This would limit the time interval for the rotation to Middle Jurassic which is in accordance with
454 the time frame suggested by Stone *et al.* (2008), giving rotation rates of ~8.2° Myr⁻¹ and 5.5° Myr⁻¹
455 for the 120° and 80° scenarios, respectively.

456 CONCLUSIONS

457 The North Falkland Basin was affected by two rifting episodes during the break-up of Gondwana,
458 the older of which led to the formation of the Southern North Falkland Basin. Our study reveals
459 that the Paleozoic thrusts exploited during the opening of this basin emerge from a north-dipping
460 mega-décollement, much like the faults in the Outeniqua Basin, offshore South Africa, which
461 coalesce on a south-dipping mega-décollement. Based on the range of fault dips in the SNFB and
462 the inferred latitude at which the mega-décollement merges with the Moho, we propose a
463 repositioning of the Falkland Islands microplate so that the SNFB sat along strike from the Algoa
464 Basin prior to the break-up of Gondwana. The implications of the revised position of the islands
465 are threefold:

- 466 (a) the position is in agreement with the presence of an antitaxis of the CFB at Port Elizabeth;
467 (b) the amount of extension expected to have affected the Falkland Plateau Basin is reduced
468 compared to previous rotational models;
469 (c) the amount of rotation and the estimated rotation rate of the Falkland Islands
470 microcontinental block are reduced, the latter being now comparable to block rotation
471 rates in strike-slip systems.

472 The orientation of the extensional regime that led to the opening of the SNFB can be either WSW-
473 ENE and related to the separation between South America and Africa or NW-SE rifting related to
474 the southward movement of Antarctica or back-arc extension. Based on these two scenarios, the
475 timing of rotation is restricted to Tithonian–Berriasian or Middle-Jurassic, respectively.

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484 **REFERENCES**

- 485 Adie, R. J. 1952a. The Position of the Falkland Islands in a Reconstruction of Gondwanaland.
486 *Geological Magazine*, **89**(6), 401-410. <https://doi.org/10.1017/S0016756800068102>
- 487 Adie, R. J. 1952b. Representatives of the Gondwana system in the Falkland Islands. *In*: Teichert, C.
488 (ed.) *Symposium sur le Sériés de Gondwana*. 19th Intl. Geol. Congr., Algiers, 385-392.
- 489 Aldiss, D. T. & Edwards, E. J. 1999. The geology of the Falkland Islands. *British Geological Survey*
490 *Technical Report WC/99/10*. Retrieved from <http://nora.nerc.ac.uk/507542/>
- 491 Baristead, N., Anka, Z., di Primio, R., Rodriguez, J. F., Marchal, D. & Dominguez, F. 2013. New
492 insights into the tectono-stratigraphic evolution of the Malvinas Basin, offshore of the
493 southernmost Argentinean continental margin. *Tectonophysics*, **604**, 280-295.
494 <https://doi.org/10.1016/j.tecto.2013.06.009>
- 495 Basile, C. & Allemand, P. 2002. Erosion and flexural uplift along transform faults. *Geophysical*
496 *Journal International*, **151**(2), 646-653. <https://doi.org/10.1046/j.1365-246X.2002.01805.x>
- 497 Ben-Avraham, Z., Hartnady, C. J. H. & Malan, J. A. 1993. Early tectonic extension between the
498 Agulhas Bank and the Falkland Plateau due to the rotation of the Lafonia microplate. *Earth and*
499 *Planetary Science Letters*, **117**(1-2), 43-58. [https://doi.org/10.1016/0012-821X\(93\)90116-Q](https://doi.org/10.1016/0012-821X(93)90116-Q)
- 500 Ben-Avraham, Z., Hartnady, C. J. H. & Kitchin, K. A. 1997. Structure and tectonics of the Agulhas-
501 Falkland fracture zone. *Tectonophysics*, **282**, 83-98.
- 502 Bransden, P. J. E., Burges, P., Durham, M. J. & Hall, J. G. 1999. Evidence for multi-phase rifting in
503 the North Falklands Basin. *Geological Society, London, Special Publications*, **153**(1), 425-443.
504 <https://doi.org/10.1144/gsl.sp.1999.153.01.26>

- 505 Broad, D.S., Jungslager, E.H.A., McLachlan, I.R. & Roux, J. 2006. Offshore Mesozoic basins. *In:*
506 Johnson, M.R., Anhaeusser, C.R., Thomas, R.J. (eds.) *The Geology of South Africa*. Geological Society
507 of South Africa and Council for Geoscience, Johannesburg, 553–571.
- 508 Cordell, L. & Grauch, V.J.S. 1985. Mapping Basement Magnetization Zones from Aeromagnetic
509 Data in the San Juan Basin, New Mexico. *In:* Hinze, W.J. (ed.) *The Utility of Regional Gravity and*
510 *Magnetic Anomaly Maps*. Society of Exploration Geophysicists, Tulsa, 181-197.
- 511 Crowell, J. C. & Frakes, L. A. 1972. Late Paleozoic Glaciation: Part V, Karoo Basin, South Africa.
512 *Geological Society of America Bulletin*, **83**, 2887–2912.
- 513 Cunningham, A. P., Barker, P. F. & Tomlinson, J. S. 1998. Tectonics and sedimentary environment
514 of the North Scotia Ridge region revealed by side-scan sonar. *Journal of the Geological Society,*
515 *London*, **155**, 941–956.
- 516 Curtis, M. L. & Hyam, D. M. 1998. Late Palaeozoic to Mesozoic structural evolution of the Falkland
517 Islands: a displaced segment of the Cape Fold Belt. *Journal of the Geological Society*, **155**(1), 115–
518 129. <https://doi.org/10.1144/gsjgs.155.1.0115>
- 519 Dalziel, I. W. D., Lawver, L. A. & Murphy, J. B. 2000. Plumes, orogenesis, and supercontinental
520 fragmentation. *Earth and Planetary Science Letters*, **178**(1–2), 1–11.
521 [https://doi.org/10.1016/S0012-821X\(00\)00061-3](https://doi.org/10.1016/S0012-821X(00)00061-3)
- 522 De Beer, C.H., 1992. Structural evolution of the Cape Fold Belt syntaxis and its influence on
523 syntectonic sedimentation in the SW Daroo Basin. *In:* de Wit, M.J. & Ransome, I.G.D. (eds.)
524 *Inversion Tectonics of the Cape Fold Belt, Karoo and Cretaceous Basins of Southern Africa*. Balkema
525 Publishers, Rotterdam, 197–206.
- 526 Del Ben, A. & Mallardi, A. 2004. Interpretation and chronostratigraphic mapping of multichannel
527 seismic reflection profile I95167, Eastern Falkland Plateau (South Atlantic). *Marine Geology*, **209**,
528 347-361.
- 529 Du Toit, A.L. 1927. *A Geological Comparison of South America and South Africa*. Carnegie
530 Institution of Washington, Washington.
- 531 Du Toit, A.L. 1937. *Our Wandering Continents*. Oliver and Boyd, London.
- 532 Durrheim, R. J. 1987. Seismic reflection and refraction studies of the deep structure of the Agulhas
533 Bank. *Geophysical Journal of the Royal Astronomical Society*, **89**(1), 395–398.
534 <https://doi.org/10.1111/j.1365-246X.1987.tb04437.x>
- 535 Echavarría, L. E., Schalamuk, I. B. & Etcheverry, R. O. 2005. Geologic and tectonic setting of
536 Deseado Massif epithermal deposits, Argentina, based on El Dorado-Monserrat. *Journal of South*
537 *American Earth Sciences*, **19**(4), 415–432. <https://doi.org/10.1016/j.jsames.2005.06.005>
- 538 Evjen, H. M. 1936. The place of the vertical gradient in gravitational interpretations. *Geophysics*,
539 **1**(1), 127-136.
- 540 Ewing, J. I., Ludwig, W. J., Ewing, M. & Eittreim, S. L. 1971. Structure of the Scotia Sea and Falkland
541 Plateau. *Journal of Geophysical Research*, **76**(29), 7118-7137.
- 542 Figari, E. G., Scasso, R. A., Cúneo, R. N. & Escapa, I. 2015. Estratigrafía y evolución geológica de la
543 Cuenca de Cañadón Asfalto, Provincia del Chubut, Argentina. *Latin American Journal of*
544 *Sedimentology and Basin Analysis*, **22**(2), 135–169.

- 545 Fitzgerald, M. G., Mitchum, R. M., Uliana, M. A. & Biddle, K. T. 1990. Evolution of the San Jorge
546 Basin, Argentina. *American Association of Petroleum Geologists Bulletin*, **74**(6), 879-920.
- 547 Frakes, L. A. & Crowell, J. C. 1967. Facies and Paleogeography of Late Paleozoic Diamictite,
548 Falkland Islands. *Geological Society of America Bulletin*, **78**, 37-58.
- 549 Franzese, J., Martino, R. 1998. Aspectos cinemáticos y tectónicos de la zona de cizalla de Gastre en
550 la sierra de Calcatapul, provincia de Chubut, Argentina. *X Congreso Latinoamericano de Geología*
551 *y VI Congreso Nacional de Geología Económica*, Actas II, 3.
- 552 Galeazzi, J. S. 1998. Structural and Stratigraphic Evolution of the Western Malvinas Basin,
553 Argentina. *AAPG Bulletin*, **82**(4), 596-636.
- 554 Hälbich, I. W (ed.). 1993. *The Cape Fold Belt—Agulhas Bank Transect across the Gondwana Suture*
555 *in southern Africa*. American Geophysical Union Special Publication, **202**, AGU Press, Washington.
- 556 Hodgkinson, R. 2002. *Structural studies in the Falkland Islands, South Atlantic*. Unpublished PhD
557 Thesis, University of Birmingham, UK.
- 558 Hubbard, R.J., Pape, J. & Roberts, D.G. 1985a. Depositional sequence mapping as a technique to
559 establish tectonic and stratigraphic framework and evaluate hydrocarbon potential on a passive
560 continental margin. In: Berg, O.R. & Woolverton, D. (eds) *Seismic Stratigraphy II: An Integrated*
561 *Approach to Hydrocarbon Exploration*. Am. Assoc. Petrol. Geol., Mem., **39**, 79-91.
- 562 Hubbard, R.J., Pape, J. & Roberts, D.G. 1985b. Depositional sequence mapping to illustrate the
563 evolution of a passive continental margin. In: Berg, O.R. & Woolverton, D. (eds) *Seismic*
564 *Stratigraphy II: An Integrated Approach to Hydrocarbon Exploration*. Am. Assoc. Petrol. Geol.,
565 Mem., **39**, 93-115.
- 566 Ingersoll, R. V., & Coffey, K. T. 2017. Transrotation Induced by Crustal Blocks Moving through
567 Restraining Double Bends, with Southern California Examples. *The Journal of Geology*, **125**, 551-
568 559. <https://doi.org/10.1086/692654>
- 569 Johnston, S. T. 2000. The Cape Fold Belt and Syntaxis and the rotated Falkland Islands: dextral
570 transpressional tectonics along the southwest margin of Gondwana. *Journal of African Earth*
571 *Sciences*, **31**(1), 51-63.
- 572 Kimbell, G. S. & Richards, P. C. 2008. The three-dimensional lithospheric structure of the Falkland
573 Plateau region based on gravity modelling. *Journal of the Geological Society*, **165**(4), 795-806.
574 <https://doi.org/10.1144/0016-76492007-114>
- 575 Lawrence, S. R., Johnson, M., Tubb, S. R. & Marshallsea, S. J. 1999. Tectono-stratigraphic evolution
576 of the North Falkland region. *Geological Society, London, Special Publications*, **153**(1), 409-424.
577 <https://doi.org/10.1144/GSL.SP.1999.153.01.25>
- 578 Lindeque, A., De Wit, M. J., Ryberg, T., Weber, M. & Chevallier, L. 2011. Deep crustal profile across
579 the Southern Karoo basin and Beattie magnetic anomaly, South Africa: An integrated
580 interpretation with tectonic implications. *South African Journal of Geology*, **114**(3-4), 265-292.
581 <https://doi.org/10.2113/gssaig.114.3-4.265>
- 582 Little, T. A. & Roberts, A. P. 1997. Distribution and magnitude of Neogene to present-day vertical-
583 axis rotations, Pacific-Australia plate boundary zone, South Island, New Zealand. *Journal of*
584 *Geophysical Research*, **102**, 20447-20468.

585 Lohr, T. & Underhill, J. R. 2015. Role of rift transection and punctuated subsidence in the
586 development of the North Falkland Basin. *Petroleum Geoscience*, **21**(2-3), 85-110.
587 <https://doi.org/10.1144/petgeo2014-050>

588 Lorenzo, J. M. & Mutter, J. C. 1988. Seismic stratigraphy and tectonic evolution of the
589 Falkland/Malvinas Plateau. *Revista Brasileira de Geociências*, **18**(2), 191-200.

590 Lorenzo, J. M. & Wessel, P. 1997. Flexure across a continent-ocean fracture zone: the northern
591 Falkland/Malvinas Plateau, South Atlantic. *Geo-Marine Letters*, **17**, 110-118.
592 <https://doi.org/10.1007/s003670050015>

593 Ludwig, W. J., Windisch, C. C., Houtz, R. E. & Ewing, J. I. 1979. Structure of Falkland Plateau and
594 Offshore Tierra del Fuego, Argentina. In: Watkins, J. S., Montadert, L. & Dickerson, P. W. (eds.)
595 *Geological and Geophysical Investigations of Continental Margins*, Am. Assoc. Petrol. Geol., Mem.,
596 **29**, 125-137.

597 Macdonald, D., Gomez-Perez, I., Franzese, J., Spalletti, L., Lawver, L., Gahagan, L., Dalziel, I., Thomas,
598 C., Trewin, N., Hole, M. & Paton, D. 2003. Mesozoic break-up of SW Gondwana: implications for
599 regional hydrocarbon potential of the southern South Atlantic. *Marine and Petroleum Geology*, **20**,
600 287-308.

601 Marshall, J. E. A. 1994. The Falkland Islands: A key element in Gondwana paleogeography.
602 *Tectonics*, **13**(2), 499-514.

603 Mascle, J. & Blarez, E. 1987. Evidence for transform margin evolution from the Ivory Coast-Ghana
604 continental margin. *Nature*, **326**, 378-381.

605 McCarthy, D., Aldiss, D., Arsenikos, S., Stone, P. & Richards, P. 2017. Comment on “Geophysical
606 evidence for a large impact structure on the Falkland (Malvinas) Plateau”. *Terra Nova*, **29**, 411-
607 415.

608 McMillan, I.K., Brink, G.J., Broad, D.S. & Maier, J.J., 1997. Late Mesozoic sedimentary basins off the
609 south coast of South Africa. In: Selly, R.C. (ed.) *Sedimentary Basins of the World*, **3**. Elsevier,
610 Amsterdam, 319-376.

611 Mercier de Lépinay, M., Loncke, L., Basile, C., Roest, W. R., Patriat, M., Maillard, A. & De Clarens, P.
612 2016. Transform continental margins – Part 2: A worldwide review. *Tectonophysics*, **693**, 96-115.
613 <https://doi.org/10.1016/j.tecto.2016.05.038>

614 Miller, H. G. & V. Singh. 1994, Potential field tilt—A new concept for location of potential field
615 sources. *Journal of Applied Geophysics*, **32**, 213-217.

616 Mitchell, C., Taylor, G. K., Cox, K. G. & Shaw, J. 1986. Are the Falkland Islands a rotated microplate?
617 *Nature*, **319** (6049), 131-134. <https://doi.org/10.1038/319131a0>

618 Mitchell, C., Ellam, R. M. & Cox, K. G. 1999. Mesozoic dolerite dykes of the Falkland Islands:
619 petrology, petrogenesis and implications for geochemical provinciality in Gondwanaland low-Ti
620 basaltic rocks. *Journal of the Geological Society*, **156**, 901-916.

621 Mitchum, R.M. Jr., Vail, P.R. & Sangree, J.B. 1977. Seismic stratigraphy and global changes of sea
622 level; part 6, stratigraphic interpretation of seismic reflection patterns in depositional sequences.
623 In: Payton, C. E. (ed.) *Seismic Stratigraphy; Applications to Hydrocarbon Exploration*. Am. Assoc.
624 Petrol. Geol., Mem., **26**, 117-134.

- 625 Moreira, P. & Fernández, R. R. 2015. La Josefina Au-Ag deposit (Patagonia, Argentina): A Jurassic
626 epithermal deposit formed in a hot spring environment. *Ore Geology Reviews*, **67**, 297–313.
- 627 Mussett, A. E. & Taylor, G. K. 1994. ⁴⁰Ar-³⁹Ar ages for dykes from the Falkland Islands with
628 implications for the break-up of southern Gondwanaland. *Journal of the Geological Society*,
629 **151**(1), 79–81. <https://doi.org/10.1144/gsjgs.151.1.0079>
- 630 Nguuri, T. K., Gore, J., James, D. E., Webb, S. J., Wright, C., Zengeni, T. G., Gwavava, O., Snoke, J. A. &
631 Kaapvall Seismic Group. 2001. Crustal structure beneath southern Africa and its implications for
632 the formation and evolution of the Kaapvaal and Zimbabwe cratons. *Geophysical Research Letters*,
633 **28**(13), 2501–2504. <https://doi.org/10.1029/2000GL012587>
- 634 Oruç, B. & Keskinsezer, A. 2008. Structural setting of the northeastern Biga Peninsula (Turkey)
635 from tilt derivatives of gravity gradient tensors and magnitude of horizontal gravity components.
636 *Pure Appl. Geophys.*, **165**, 1913–1927.
- 637 Pángaro, F. & Ramos, V. A. 2012. Paleozoic crustal blocks of onshore and offshore central
638 Argentina: New pieces of the southwestern Gondwana collage and their role in the accretion of
639 Patagonia and the evolution of Mesozoic south Atlantic sedimentary basins. *Marine and Petroleum*
640 *Geology*, **37**, 162–183.
- 641 Parsieglá, N., Stankiewicz, J., Gohl, K., Ryberg, T. & Uenzelmann-Neben, G. 2009. Southern African
642 continental margin: Dynamic processes of a transform margin. *Geochemistry, Geophysics,*
643 *Geosystems*, **10**(3). <https://doi.org/10.1029/2008GC002196>
- 644 Paton, D. A. & Underhill, J. R. 2004. Role of crustal anisotropy in modifying the structural and
645 sedimentological evolution of extensional basins: The Gamtoos Basin, South Africa. *Basin*
646 *Research*, **16**(3), 339–359. <https://doi.org/10.1111/j.1365-2117.2004.00237.x>
- 647 Paton, D. A. 2006. Influence of crustal heterogeneity on normal fault dimensions and evolution:
648 southern South Africa extensional system. *Journal of Structural Geology*, **28**(5), 868–886.
- 649 Paton, D. A., Macdonald, D. I. M. & Underhill, J. R. 2006. Applicability of thin or thick skinned
650 structural models in a region of multiple inversion episodes; southern South Africa. *Journal of*
651 *Structural Geology*, **28**(11), 1933–1947. <https://doi.org/10.1016/j.jsg.2006.07.002>
- 652 Paton, D.A., Mortimer, E.J. & Hodgson, N. 2016. The missing piece of the South Atlantic jigsaw:
653 when continental break-up ignores crustal heterogeneity. *Special Publication of the Geological*
654 *Society London*, **438**, 195–210. doi: 10.1144/SP438.8
- 655 Platt, N. H. & Philip, P. R. 1995. Structure of the southern Falkland Islands continental shelf: initial
656 results from new seismic data. *Marine and Petroleum Geology*, **12**(7), 759–771.
- 657 Ramos, V. A. 2008. Patagonia: A Paleozoic continent adrift? *Journal of South American Earth*
658 *Sciences*, **26**(3), 235–251. <https://doi.org/10.1016/j.jsames.2008.06.002>
- 659 Ramos, V. A., Cingolani, C., Junior, F. C., Naipauer, M. & Rapalini, A. 2017. The Malvinas (Falkland)
660 Islands revisited: The tectonic evolution of southern Gondwana based on U-Pb and Lu-Hf detrital
661 zircon isotopes in the Paleozoic cover. *Journal of South American Earth Sciences*, **76**.
662 <https://doi.org/10.1016/j.jsames.2016.12.013>
- 663 Rapela, C. W. & Pankhurst, R. J. 1992. The granites of northern Patagonia and the Gastre Fault
664 System in relation to the break-up of Gondwana. *Geological Society, London, Special Publications*,
665 **68**(1), 209–220. <https://doi.org/10.1144/GSL.SP.1992.068.01.13>

666 Reeves, C. V., Teasdale, J. P. & Mahanjane, E. S. 2016. Insight into the Eastern Margin of Africa from
667 a new tectonic model of the Indian Ocean. *Geological Society, London, Special Publications*, **431**(1),
668 299–322. <https://doi.org/10.1144/SP431.12>

669 Richards, P. C., Gatliff, R. W., Quinn, M. F., Fannin, N. G. T. & Williamson, J. P. 1996. The geological
670 evolution of the Falkland Islands continental shelf. *Geological Society of London Special
671 Publication*, **108**(1), 105–128. <https://doi.org/10.1144/GSL.SP.1996.108.01.08>

672 Richards, P. C. & Fannin, N. G. T. 1997. Geology of the North Falkland Basin. *Journal of Petroleum
673 Geology*, **20**(2), 165–183. <https://doi.org/10.1111/j.1747-5457.1997.tb00771.x>

674 Richards, P. C. & Hillier, B. V. 2000. Post-drilling analysis of the North Falkland Basin-Part 1:
675 Tectono-stratigraphic framework. *Journal of Petroleum Geology*, **23**(3), 253–272.
676 <https://doi.org/10.1111/j.1747-5457.2000.tb01019.x>

677 Richards, P. C., Duncan, I., Phipps, C., Pickering, G., Grzywacz, J., Hoult, R. & Merritt, J. 2006.
678 Exploring for fan and delta sandstones in the offshore Falklands basins. *Journal of Petroleum
679 Geology*, **29**(3), 199–214.

680 Richards, P. C., Stone, P., Kimbell, G. S., McIntosh, W. C. & Phillips, E. R. 2013. Mesozoic magmatism
681 in the Falkland Islands (South Atlantic) and their offshore sedimentary basins. *Journal of
682 Petroleum Geology*, **36**(1), 61–73.

683 Richardson, J. C., Hodgson, D. M., Paton, D., Craven, B., Rawcliffe, A. & Lang, A. 2017. Where is my
684 sink? Reconstruction of landscape development in southwestern Africa since the Late Jurassic.
685 *Gondwana Research*, **45**, 43–64. <https://doi.org/10.1016/j.gr.2017.01.004>

686 Sandwell, D. T., Müller, R. D., Smith, W. H. F., Garcia, E. & R. Francis. 2014. New global marine
687 gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure. *Science*, **346**(6205),
688 65–67, doi: 10.1126/science.1258213

689 Schimschal, C. M. & Jokat, W. 2017. The crustal structure of the continental margin east of the
690 Falkland Islands. *Tectonophysics*, **724-725**, 234–253.
691 <https://doi.org/10.1016/j.tecto.2017.11.034>

692 Schreider, A. A., Mazo, E. L., Bulychev, A. A., Schreider, A. A., Gilod, D. A. & Kulikova, M. P. 2011. The
693 structure of the Falkland Basin's lithosphere. *Oceanology*, **51**(5), 866–875.
694 <https://doi.org/10.1134/S0001437011050171>

695 Scrutton, R. A. 1979. On sheared passive continental margins. *Tectonophysics*, **59**, 293–305.

696 Shone, R.W., Nolte, C.C. & Booth, P.W.K., 1990. Pre-Cape rocks of the Gamtoos area - a complex
697 tectonostratigraphic package preserved as a horst block. *South African Journal of Geology*, **93**,
698 616–621.

699 Soares F., J. R. S., Miranda, A. P. & de Figueiredo, A. M. F. 2000. Geological and geophysical
700 interpretation of the San Julian basin-offshore Argentina. *Geophysical Monograph Series*, **115**,
701 193–209. <https://doi.org/10.1029/GM115p0193>

702 Stankiewicz, J. & De Wit, M. 2013. 3.5 billion years of reshaped Moho, southern Africa.
703 *Tectonophysics*, **609**, 675–689. <https://doi.org/10.1016/j.tecto.2013.08.033>

704 Stankiewicz, J., Parsieglä, N., Ryberg, T., Gohl, K., Weckmann, U., Trumbull, R. & Weber, M. 2008.
705 Crustal structure of the southern margin of the African continent: Results from geophysical

706 experiments. *Journal of Geophysical Research: Solid Earth*, **113**(10), 1–15.
707 <https://doi.org/10.1029/2008JB005612>

708 Stone, P. & Thomson, M. R. 2005. Archaeocyathan limestone blocks of likely Antarctic origin in
709 Gondwanan tillite from the Falkland Islands. *Geological Society, London, Special Publications*,
710 **246**(1), 347–357. <https://doi.org/10.1144/GSL.SP.2005.246.01.14>

711 Stone, P., Richards, P. C., Kimbell, G. S., Esser, R. P. & Reeves, D. 2008. Cretaceous dykes discovered
712 in the Falkland Islands: implications for regional tectonics in the South Atlantic. *Journal of the*
713 *Geological Society*, **165**(1), 1–4. <https://doi.org/10.1144/0016-76492007-072>

714 Stone, P., Kimbell, G. S. & Richards, P. C. 2009. Rotation of the Falklands microplate reassessed
715 after recognition of discrete Jurassic and Cretaceous dyke swarms. *Petroleum Geosciences*, **15**(3),
716 279–287.

717 Stone, P., Thomson, M. R. A. & Rushton, A. W. A. 2012. An Early Cambrian archaeocyath–trilobite
718 fauna in limestone erratics from the Upper Carboniferous Fitzroy Tillite Formation, Falkland
719 Islands. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, **102**,
720 201–225.

721 Stone, P. 2016. Geology reviewed for the Falkland Islands and their offshore sedimentary basins,
722 South Atlantic Ocean. *Earth and Environmental Science Transactions of the Royal Society of*
723 *Edinburgh*, **106**(2), 115–143. <https://doi.org/10.1017/S1755691016000049>

724 Stone, P. 2015. Geological exploration of South Atlantic islands and its contributions to the
725 continental drift debate of the early 20th century. *Proceedings of the Geologists' Association*,
726 **126**(2), 266–281. <https://doi.org/10.1016/j.pgeola.2015.01.001>

727 Storey, B. C., Curtis, M. L., Ferris, J. K., Hunter, M. A. & Livermore, R. A. 1999. Reconstruction and
728 break-out model for the Falkland Islands within Gondwana. *Journal of African Earth Sciences*,
729 **29**(1), 153–163.

730 Tankard, A.J., Jackson, M.P.A., Eriksson, K.A., Hobday, D.K., Hunter, D.R. & Minter, W.E.L., 1982.
731 *Crustal Evolution of Southern Africa*. Springer-Verlag, New York.

732 Tankard, A., Welsink, H., Aukes, P., Newton, R. & Stettler, E. 2009. Tectonic evolution of the Cape
733 and Karoo basins of South Africa. *Marine and Petroleum Geology*, **26**(8), 1379–1412.
734 <https://doi.org/10.1016/j.marpetgeo.2009.01.022>

735 Tassone, A., Lodolo, E., Menichetti, M., Yagupsky, D., Caffau, M. & Vilas, J. F. 2008.
736 Seismostratigraphic and structural setting of the Malvinas Basin and its southern margin (Tierra
737 del Fuego Atlantic offshore). *Geologica Acta*, **6**(1), 55–67.

738 Taylor, G. K. & Shaw, J. 1989. The Falkland Islands: New palaeomagnetic data and their origin as
739 a displaced terrane from Southern Africa. *Deep Structure and Past Kinematics of Accreted*
740 *Terranes*, **50**, 59–72.

741 Thistlewood, L., Leat, P. T., Millar, I. L., Storey, B. C. & Vaughan, A. P. M. 1997. Basement geology
742 and Palaeozoic-Mesozoic mafic dykes from the Cape Meredith Complex, Falkland Islands: a record
743 of repeated intracontinental extension. *Geol. Mag.*, **134**(3), 355–367.

744 Thistlewood, L. & Randall, D. 1998. Palaeomagnetic studies of West Gondwanan microplates.
745 *Journal of African Earth Sciences*, **27** (1A: Gondwana 10: Event Stratigraphies of Gondwana
746 (abstracts)), 227.

- 747 Thomas, R.J., Von Veh, M.W., McCourt, S., 1993. The tectonic evolution of southern Africa: an
748 overview. *J. Afr. E. Sci.*, **16**, 5-24.
- 749 Thomson, K. 1998. When did the Falklands rotate? *Marine and Petroleum Geology*, **15**(8), 723-736
- 750 Thomson, K. & Underhill, J.R. 1999. Frontier exploration in the South Atlantic: structural
751 prospectivity in the North Falkland Basin. *AAPG bulletin*, **83**(5), 778-797.
- 752 Tinker, J., de Wit, M. & Brown, R. 2008. Mesozoic exhumation of the southern Cape, South Africa,
753 quantified using apatite fission track thermochronology. *Tectonophysics*, **455**(1-4), 77-93.
754 <https://doi.org/10.1016/j.tecto.2007.10.009>
- 755 Trewin, N. H., Macdonald, D. I. M. & Thomas, C. G. C. 2002. Stratigraphy and sedimentology of the
756 Permian of the Falkland Islands; lithostratigraphic and palaeoenvironmental links with South
757 Africa. *Journal of the Geological Society of London*, **159**(1), 5-19. <https://doi.org/10.1144/0016-764900-089>
- 759 Trouw, R. A. J. & De Wit, M. J. 1999. Relation between the Gondwanide Orogen and
760 contemporaneous intracratonic deformation. *Journal of African Earth Sciences*, **28**(1), 203-213.
761 [https://doi.org/10.1016/S0899-5362\(99\)00024-X](https://doi.org/10.1016/S0899-5362(99)00024-X)
- 762 Uliana, M. A., Biddle, K. & Cerdán, J. 1989. Mesozoic extension and the formation of Argentina
763 sedimentary basins. *Extensional Tectonics and Stratigraphy of the North Atlantic Margin, AAPG*
764 *Mem.*, **46**(3), 599-613.
- 765 Veevers, J. J., Cole, D. I. & Cowan, E. J. 1994. Southern Africa: Karoo Basin and Cape Fold Belt.
766 *Geological Society of America (Memoir)*, **184**, 223-279. <https://doi.org/10.1130/MEM184-p223>
- 767 Verduzco, B., J. D. Fairhead, C. M. Green & C. MacKenzie. 2004. The meter reader—New insights
768 into magnetic derivatives for structural mapping. *The Leading Edge*, **23**, 116-119.
- 769 Von Gosen, W. 2003. Thrust tectonics in the North Patagonian Massif (Argentina): Implications
770 for a Patagonia plate. *Tectonics*, **22**(1). <https://doi.org/10.1029/2001TC901039>
- 771 Von Gosen, W. & Loske, W. 2004. Tectonic history of the Calcatapul Formation, Chubut province,
772 Argentina, and the “Gastre fault system.” *Journal of South American Earth Sciences*, **18**(1), 73-88.
773 <https://doi.org/10.1016/j.jsames.2004.08.007>

774 **FIGURE CAPTIONS**

775 **Fig. 1.** Present-day configuration and structural framework of the Falkland Plateau; offshore fault
776 network for the Falkland Plateau compiled after Richards *et al.* (1996), Richards and Fannin
777 (1997), Cunningham *et al.* (1998), Galeazzi (1998), Tassone *et al.* (2008) and Ramos *et al.* (2017);
778 the structure of the San Jorge and El Tranquilo basins and the Deseado Massif redrawn after
779 Fitzgerald *et al.* (1990), Figari *et al.* (2015) and Moreira and Fernández (2015); main fracture and
780 subduction zones in South America drawn after Rapela and Pankhurst (1992)

781 **Fig. 2.** Map of South Africa and its offshore basins (after Paton *et al.* 2006; Parsieglá *et al.* 2009)

782 **Fig. 3.** Map of the Falkland Islands (after Aldiss & Edwards 1999) and their offshore basins (based
783 on Richards *et al.* 1996); black lines - the position of the 2D seismic reflection lines used in this
784 study, white circles - wells used in this study

785 **Fig. 4.** Two models for the palaeogeographic reconstruction of the Falkland Islands - (a)
786 rotational and (b) rigid; (1) - Lawver *et al.* (1999), (2) - Macdonald *et al.* (2003), (3) - Trewin *et*

787 *al.* (2002), (4) – Martin *et al.* (1981), (5) – Lawrence *et al.* (1999), (6) – Ramos (2008), PBOCB –
788 pre-break-up ocean – continent boundary; the stratigraphic correlation and colour code are
789 found in Fig. 5

790 **Fig. 5.** Lithostratigraphy of the Devonian to Permian deposits of the Falkland Islands and South
791 Africa along with the correlations (dashed lines) presented by Trewin *et al.* (2002); ages after
792 Curtis and Hyam (1998) and Paton *et al.* (2006)

793 **Fig. 6.** Open-source gravity data (Sandwell *et al.* 2014) and the 1st vertical, total horizontal and
794 tilt derivatives for offshore Falkland Islands; gravity lineaments (stippled lines) interpreted
795 based on the computed derivatives are superimposed on the free air gravity anomaly; rectangle
796 shows the extent of the map in Fig. 7

797 **Fig. 7.** Normal faults interpreted based on seismic reflection data in the SNFB superimposed on
798 the TWT map of the mega-décollement; the faults are following the same orientation as the NW-
799 SE gravity lineaments mapped across the SNFB; grey line network represent the seismic
800 reflection profiles used for interpretation

801 **Fig. 8.** Compilation of seismic sections across Fault B from west (a) to east (i) showing how the
802 geometry of the syn-rift package varies along the fault; position of the lines is shown in Fig. 7 (8a
803 – 8j)

804 **Fig. 9.** Sections across E-W trending features associated with (a) fracture zones generating
805 structural lows and (b) half-grabens; sedimentary packages showing slight thickening into faults
806 are shaded in grey; position of the lines is shown in Fig. 7

807 **Fig. 10.** Seismic sections showing: (a), (b) the morphology of the shallower set of deep reflectors
808 interpreted as a mega-décollement; (c), (d) the extent of the second set of deep reflectors
809 correlated with Moho; (e) line drawing and interpretation of section in (b) showing the
810 interaction between the reactivated thrust faults mapped across the SNFB and the mega-
811 décollement along with their common sense of vergence; (f) line drawing and interpretation of
812 section in (c) showing a potential merging between the mega-décollement and the Moho
813 discontinuity; location of the profiles is shown in Fig. 7

814 **Fig. 11.** (a) Depth converted section across the SNFB extrapolated onshore based on published
815 data from Aldiss & Edwards (1999) and Stone (2016); (b) section across the South African margin
816 and its offshore basins showing the steepening of the faults south-westwards (after Paton *et al.*
817 2006); stippled rectangle shows the extent of the South African equivalent of the section in (a).
818 Both sections are restored to the top syn-rift

819 **Fig. 12.** Revised position of the Falkland Islands microplate at ~180 Ma. The mega-décollement
820 in South Africa is constrained by two seismic lines: (1) (Dürrheim 1987) and (2) (Lindeque *et al.*
821 2011) and extrapolated until it intersected Moho as modelled by Nguuri *et al.* (2001) and
822 Stankiewicz & de Wit (2013); mega-décollement inferred on profile (3) (Paton *et al.* 2006) is used
823 for comparison and validation. The mega-décollement underneath the SNFB was truncated at
824 depths of 30-35 km (based on this study, Kimbell & Richards (2008) and Schimschal & Jokat
825 (2017)). Faults in the Outeniqua Basin are drawn based on Paton *et al.* (2006) and Parsiegla *et al.*
826 (2009); GF – Gamtoos Fault, PEF – Port Elizabeth Fault, SCF – St. Croix Fault. Faults in the SNFB
827 are drawn based on the seismic reflection (grey lines) and gravity data available for this study;
828 faults onshore Eastern Falkland are based on Aldiss & Edwards (1999); the position of the section
829 in Fig. 11a is shown onshore and offshore the Falkland Islands