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Boris Choubert: The forgotten fit of the circum-Atlantic continents

Jacques Kornprobst

Laboratoire Magmas et Volcans, université Blaise-Pascal de Clermont-Ferrand, campus universitaire des Cézeaux, 6, avenue Blaise-Pascal, 63170 Aubière, France

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ABSTRACT

Boris Choubert was a strong supporter of Wegener's continental drift theory. In 1935, he published a very accurate fit of the circum-Atlantic continents, which was based on continental edges instead of coastlines; in the same paper, he interpreted the Palaeozoic belts as the result of horizontal movements of the Precambrian blocks; so, he greatly expanded the role of continental drift through time. This original and very prophetic work was almost completely ignored by his contemporaries. Thirty years later (1965), Bullard, Everett and Smith published in turn a similar but more sophisticated fit; they did not acknowledge Choubert's initial work. Bullard's fit was met with immediate and tremendous success. The present paper analyses the reasons why Boris Choubert was frustrated of his pioneering role. This lack of recognition is related to: (1) a great evolution in the geological concepts between 1935 and 1965, and (2) a poor choice of Choubert, regarding the title of his 1935 article.

1. Boris Choubert: a busy life

Boris Schuberth (Fig. 1), also known as Choubert, is a French geologist of Russian origins (see Barruol, 1984). He was born in Saint Petersburg in 1906 and left Russia for Finland in 1917. He came to France in 1927 and studied geology for two years at the Sorbonne in Paris with Léon Luteaud and Albert Michel-Levy. In 1929, he entered the Applied Geology Institute in Nancy. Having his engineer degree in hand, he was appointed, from 1933, by the general government of Gabon ("French Equatorial Africa" or AEF). He defended his thesis in 1937 ("Étude géologique des terrains anciens du Gabon"/"Geological study of the old units in Gabon"). He stayed in Africa until the end of the war. In 1946, he was recruited by the "*Office de la recherche scientifique d'Outre-Mer*" (ORSOM, future ORSTOM) and left for a geological expedition in French Guyana. In 1949, he established in Guyana a multidisciplinary research organisation that became in 1954 the "French Tropical America Institute" (IFAT) and, ten years later, the ORSTOM Centre of Cayenne. In 1960, while general inspector of the ORSTOM and head of the French Guyana geological survey, he came back to France. In 1961, he entered the CNRS ("*Centre national de la recherche scientifique*"/National Centre for Scientific Research) as Research Director; he joined the School of Mines of Paris, Fontainebleau Centre, and remained there until his retirement at the age of 70. Pr. René Dars then offered him a room in the geological laboratory at Nice University. Boris Choubert died in Nice on 3 December 1983.

2. Scientific work

Boris Choubert focused his research on three main topics: prospecting and mining; geological mapping and

Email address: J.Kornprobst@opgc.fr.

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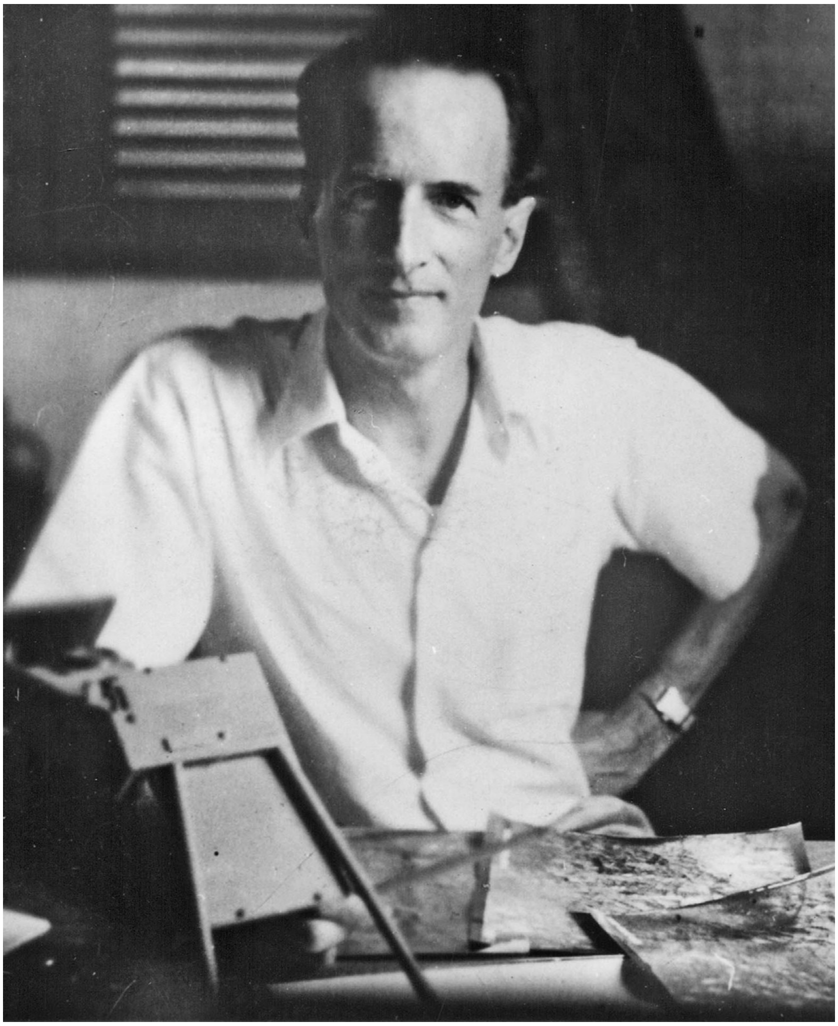

Fig. 1. Boris Choubert in Guyana (around 1950). In front of him is a stereoscope, the main tool of the cartographer together with his hammer Photo courtesy of Georges Choubert.

structural geology; theoretical petrology of igneous rocks. The first two directions brought rather significant results that are summarized below.

2.1. Mining geology

In 1934, he discovered (Okanga-Guay, 1998) in the Moanda district in Gabon (Upper Ogooué Valley), the first mineral occurrences (manganite and rhodochrosite) of a huge manganese deposit. An industrial exploitation started in 1962, currently producing 4 Mt of ore per year; this deposit accounts for 25% of the earth global reserves of Mn. In Gabon again, in 1939, Choubert discovered the first alluvial diamonds in the River Ikoy basin, near Lambaréné (where he met Doctor Schweitzer); he showed later (Choubert, 1946) that these placers are related to kimberlites, which are the primary origin of diamond like in South Africa. In Guyana, Boris Choubert was especially interested in gold; he carefully described the gold mines of Saint-Élie and Adieu-Vat (Choubert, 1952) and already emphasized the problem of gold panning in this area.

2.2. Geological mapping

It was Boris Choubert's favourite activity. He signed, or jointly signed, a large number of geological maps at any scale, from mining plans on a 1/4000 scale to a world tectonic map on a 1/10,000,000 scale. He was particularly interested in old units and especially in igneous and metamorphic rocks. He especially liked to achieve regional, continental and even intercontinental geological syntheses on very small scale. As far back as 1935, just before his thesis, he published an important paper (Choubert, 1935) on "The Genesis of the Palaeozoic and Precambrian Belts", which will be discussed in the next section. Just arriving in Guyana, he started to draw the geological map on a 1/500,000 scale of the whole territory (88,000 km^2); a preliminary version was printed in 1949; a more elaborate sheet was published in 1960.

3. Boris Choubert and continental drift

When working on his thesis on old rocks in Gabon, Boris Choubert obviously knew the work of the South African geologist Alexander Du Toit. Du Toit believed in Alfred Wegener's continental drift theory and showed (Du Toit, 1926; Du Toit and Reed, 1927) the great geological similarities between South America and West and South Africa. Boris Choubert further compared the rock units between Gabon, Congo and Brazil, and thus became a strong supporter of continental drift as well.

3.1. The continental drift concept at the beginning of the 1930s

In the successive editions of his book (*Die Enstehung der Kontinente*, five editions from 1912 to 1929), Alfred Wegener brought truly compelling arguments to defend the continental drift hypothesis. To the morphological arguments based on the nesting of continents into each other, were added paleontological, geodesic, climatic, and structural arguments. The opponents to that theory nevertheless regarded Wegener's continental fit as extremely approximate; they also emphasized the occurrence of a significant mountain range just in the middle of the Atlantic (so called "Atlantic Threshold" and today known as the "Mid-Atlantic Ridge"), not compatible with a former jointing between America, Africa and Europa, they thought. They also denied paleontological evidences by arguing for the past existence of "land bridges", as well as the climatic arguments, which they considered unrelated to any continental motion. On the other hand, the British geophysicist Harold Jeffreys (1924) emphasized what he saw as the chief defect of the continental drift theory: the total lack of a credible force to drive the continents on the Earth's surface.

3.2. Boris Choubert's contribution to continental drift theory

In his extensive article (1935), Boris Choubert brought a new vision on the mobility of continents over time. Two main points emerge from this paper.

3.2.1. The circum-Atlantic continents fit

The reconstitution of the ante-Triassic mutual position of America, Africa and Europa, as published by Choubert (1935, Fig. 2), is much more accurate than the fits previously published by Wegener (1929) and Du Toit and Reed (1927). Effectively, Choubert has taken into consideration the "bathymetric map of the ocean". In order to define the relevant continental boundaries, he chose the isobath "–1000 metres", i.e. the continental edge instead of the coastline (Choubert, 1935, Fig. 1). Wegener himself had indicated (1929) the need to do so: "space for their platform must be left between continents", he had written. For their part, Du Toit and Reed (1927) have effectively left empty a large space between Africa and South America. Choubert gave no explanation as to how his document was made: no detail about the choice of the projection; no justification of the rotations imposed on South America (22° anticlockwise) and Africa (22° clockwise). It is likely that Boris merely found directly what seemed to him to be the best fit on the world map, like a jigsaw puzzle fan would have. Although it is not perfect, this fit is excellent, demonstrating with further accuracy that the continental masses were closely joined together in the past. Some important points, such as the post-Triassic rotation of Iberia, appear for the first time in this work. However, a few areas failed to reach a coherent fit, for instance the Caribbean Sea, which was strongly affected by Cenozoic tectonics. As soon as the evidence of a close fit was acquired, the problem of the Atlantic threshold was no longer relevant: this belt simply did not exist before continental breakup; it is most likely a consequence of the latter. From this point of view, Choubert went further than Wegener, who thought that the Atlantic threshold should find its place in an initial interval in between the continental blocks. Boris specified that "the Atlantic threshold is a witness to the huge crack that occurred between continents before their final separation, witness made of solidified sima and sial remains". Obviously, this concept is quite far from the way the mid-Atlantic ridge actually works; but, in 1935, Choubert's hypothesis was nevertheless a very great progress!

3.2.2. Continental drift: a general process through time

Wegener's continental drift exclusively deals with post-Triassic motions of continental masses. By contrast, Choubert's paper (1935) was mostly devoted to the tectonic interpretation of the Palaeozoic belts, stressing again their correspondences on both sides of the Atlantic. It shows that the Caledonian, Hercynian and Appalachian belts resulted from constant motions, during the Palaeozoic, of the three major Precambrian cratons: the Laurentian and Baltic "masses" to the north and Gondwana to the south: *"It is between these three bodies, already formed before the Cambrian, that the Palaeozoic chains have been compressed."* (Choubert, 1935, p. 10). Choubert adds this very important sentence: "*If, after having removed successively all Palaeozoic chains, we try to juxtapose these three bodies, we find that they fit together perfectly... This necessarily leads one to think that these three masses once formed a single block*" (Choubert, 1935, p. 11). Boris Choubert thus arrived at the following concept: in the Late Precambrian, there was a supercontinent made of folded and metamorphic rocks; during the Palaeozoic, this continent was fragmented by large trenches where Cambrian, Ordovician, Silurian, Devonian and Carboniferous sediments were successively deposited. The successive collisions between moving Precambrian cratonic blocks were the cause of the folded mountain belts that were formed in succession in time. From this point of view, Choubert went much further than Wegener in the concept of continental drift; he wrote: "*Indeed, it seems illogical to admit, as Wegener did, that Pangea could remain unchanged throughout the primary era*" (Choubert, 1935, p. 10).

Thus, as early as 1935, by applying Wegener's ideas, Boris Choubert was the first scientist in the world to reconstruct the fit of the circum-Atlantic continents on the basis of continental edges instead of coastlines, strongly reinforcing Wegener's hypothesis on continental drift. Moreover, Choubert showed that continental drift is not just about the post-Triassic evolution of the Earth, but also concerns at least the whole Palaeozoic time as well as the edification of all the Palaeozoic mountain belts. Boris Choubert's work (1935) therefore gave a very modern

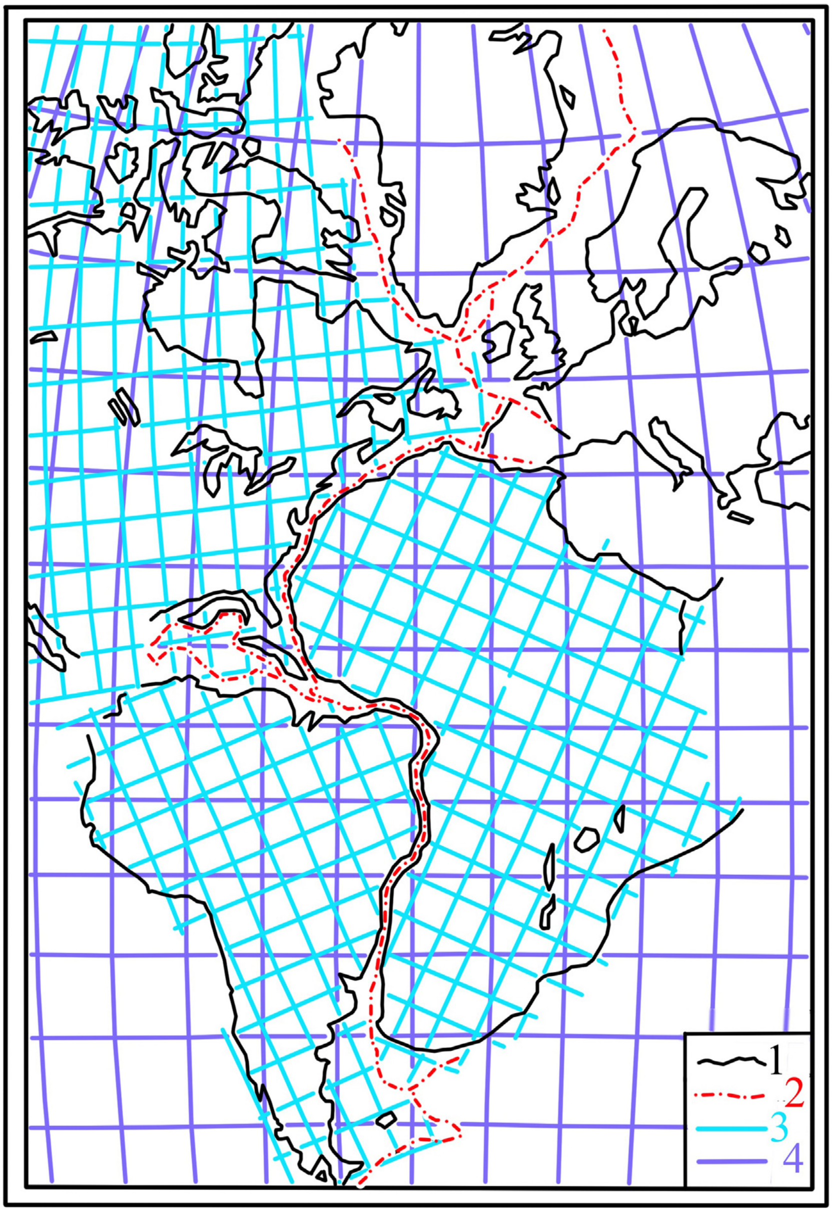

Fig. 2. Choubert's fit drawn on the basis of continental edges. 1: Shorelines; 2: continental edges; 3: longitude and latitude grid before continental drift; 4: present time longitude and latitude grid.
Redesigned after Choubert (1935).

vision of the Earth's dynamics, close enough to the present conceptions of global tectonics. Of course, he did not invent plate tectonics, because, in particular, the concept of lithospheric plunging was unknown to him [although the "Verschluckung" – or "swallowing" had already been discussed by Ampferer (1906)], but he brought arguments strong enough to silence the opponents to the continental drift theory. Furthermore, answering Jeffreys' critics (1924), he discreetly implied that the motion of the continents could be related to "telluric currents" within the "sima" (i.e. in the mantle); on this particular point, Choubert quoted Pierre Dive's work (1933), however sketchy, but missed to quote Arthur Holmes's (1929) prophetic paper on convection currents in the mantle. Anyway, Boris's strong arguments were ignored by his contemporaries.

4. Bullard's fit (1965)

At the beginning of the 1960s and with the help of the young Jim Everett and Gilbert Smith, Sir Edward Bullard, a famous geophysicist, undertook to search for the best fit of the circum-Atlantic continents by numerical modelling, with an EDSAC2 computer (still working with punched paper tapes and almost as powerful as an Apple 2). The publication of this model in 1965, immediately won great and very well deserved success. Indeed, this work is of high quality; the bibliography is nevertheless incomplete because, despite its relevance, Choubert's work is ignored!

4.1. The scientific context at the beginning of the sixties

When Boris Choubert published his fit of the circum-Atlantic Continents (1935), great scepticism was prevailing in the scientific world about Wegener's hypotheses. Seismologists did not really accept the idea of a slip of the "sial" on the "sima" (i.e. of the granitic continental masses on the ultramafic upper mantle) without the generation of seismic signals at the Mohorovicic discontinuity. Indeed, such signals have never been recorded, although Wegener (1929) announced displacements of 32 cm per year (ten times too much, actually!) between Washington and Paris over the period 1913–1927. Furthermore, the driving force of the drift was not identified. The gravitational energy associated with the moon and the sun's attraction was considered by Wegener as a determining factor in the continents' motion, but would not be a credible driving force, according to Harold Jeffreys (1924). On the other hand, when Bullard, Everett and Smith, in 1962, undertook to check the consistency of the circum-Atlantic continents fit, new data gradually led the scientific community to consider the mobilistic theory much less critically and then, continental drift gradually became plate tectonics, particularly through the considerable extension of seafloor studies during and after World War II. Already in 1929, Arthur Holmes suggested the existence of convection currents within the Earth's mantle, which provided an extremely powerful engine for continental drift. The detection of the seismic zones – or planes – of Wadati (1935)/Benioff (1949), was a strong argument supporting the latter hypothesis. At the end of the 1940s, Maurice Ewing and his team from the Lamont laboratory effectively showed that the sea floor is mainly made of basalts covered by Mesozoic and Cenozoic sediments of varying thickness. As a result, the mid-oceanic ridges were soon regarded as sites of important current volcanic eruptions and the sea floor as made of basalts, which were outpoured in the past along the ridges, as suggested by Harry Hess (1962). The accurate mapping of the oceanic floor (Heezen et al., 1959) showed the continuity of mid-oceanic ridges, and a morphology more complex than expected; a number of faults, parallel or transversal to the ridges, cut across basalts and sediments, which suggested rather significant tectonic activity. This was in agreement with the active seismicity along these ridges, first reported by Nicholas Heck (1935), then fully confirmed by Beno Gutenberg and Charles Richter (1949), and finally by Jean-Pierre Rothé (1954). A very important step was taken, again by Beno Gutenberg (1959), who discovered the presence of a seismic low-velocity zone (LVZ) within the upper mantle, which allows smooth sliding, i.e. without seismic activity, of the rigid lithosphere on the underlying soft asthenosphere. Runcorn (1956) absolutely wanted to demonstrate the wandering over time of the Earth's magnetic poles; actually, he brought the contrary evidence that the continents are moving and not the magnetic poles (Collinson and Runcorn, 1960). Finally, Vine and Matthews (1963) interpreted the "zebra skin" of the Atlantic magnetic anomalies south of Iceland as the result of sea floor spreading from the mid-oceanic ridge; Morley and Larochelle (1964) simultaneously and independently put forward this very important concept. Thus, at that time, everything was in place to enable the development of the theoretical syntheses of Dan McKenzie and Parker (1967), Jason Morgan (1968), and Xavier Le Pichon (1968). In this context, Bullard, Everett and Smith's aim was not to try to demonstrate that America had moved with respect to Africa and Europa, which had become absolutely obvious, but rather to judge the actual quality of the initial fit: "*mathematically, just how good is the fit between South America and Africa? Or what is the degree of misfit?*" (Everett and Smith, 2008).

4.2. Bullard's fit: universal success of a magisterial study

Unlike previous authors, including Choubert, Bullard et al. have described in great detail the method they have used to reconstruct the circum-Atlantic continents fit before the Trias (Fig. 3). That method is based on the Eulerian geometry, which requires a vertical axis of rotation for any shifting of objects over the surface of a sphere. The problem consists of researching, through iterating, the best position of the rotation axis (latitude and longitude) corresponding to the best fit between two edges now located on either side of the ocean (Bullard et al., 1965, fig. 1). The misfits (determined by a least-square method) have been calculated for several depths, and the "best fit" was obtained at 500 fathoms (about 1000 m) in depth, i.e. near the top of the continental slope. Actually, this Bullard's fit shows many imperfections or misfits, gaps and overlaps. The deviations measured in several sections are in some cases very large – several tenths of km and up to 140 km – but are minimized when recent geological structures (such as the Niger Delta or the Walvis Ridge) are left out of the calculation. Such large misfits are not surprising. They even seem rather small when taking into consideration that, according to a classical passive margin model, the continental break up has mainly worked in extension with a crustal thinning characterized by a number of tilted blocks (Fig. 4). Therefore, the Bullard, Everett and Smith fit is of course a quite remarkable document, very important in the body of evidence of the circum-Atlantic continents separation over Secondary and Tertiary times.

4.3. Why did Bullard and co-authors not acknowledge Choubert's previous work?

The historical section of Bullard's paper is rather small. About continental drift, only Wegener is really highlighted. In particular, the authors point out that, according to him, the continental fit had to be built from the continental shelf edges, which was actually done by Choubert. However, Bullard et al. specified (1965, p. 6) that Carey (1958) was the first to show that the fit of Africa and South America is much closer at the continental edges than it is at the

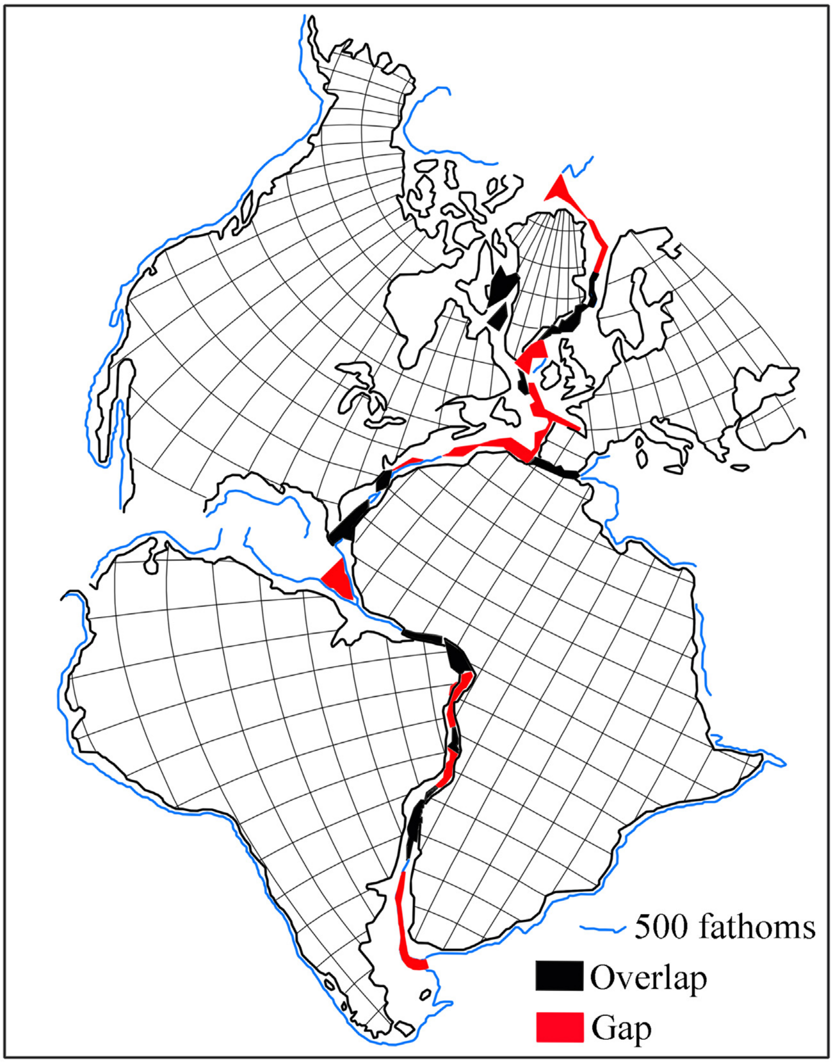

Fig. 3. Bullard's 1965 fit; note that this assemblage highlighted the misfits, overlaps or gaps, which are not identified in Choubert's fit. Redesigned after Bullard et al. (1965).

coastlines. It is true that Sam Carey, a strong supporter of the Earth expansion and a tireless disparager of continental drift, provided a consistent fit of South America and Africa, but he was just 23 years late with respect to Choubert's! Why was Choubert's fit ignored by Edward Bullard (1965), Sam Carey (1958), Harold Jeffreys (1924), and even more recently, by Jim Everett and Gilbert Smith (2008), Eliza Richardson (2014), and John Dewey (2015)?

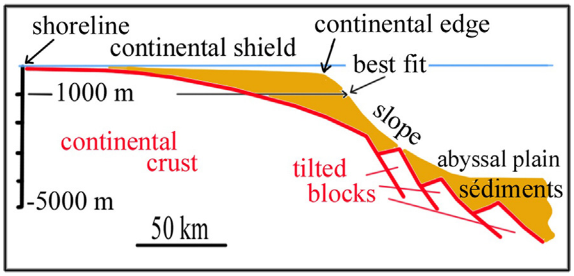

Fig. 4. Sketch of a continental passive margin (modified after Boillot, 1979). The collapse of the tilted blocks at the beginning of the extension stage makes the reconstruction of a perfect fit impossible; this accounts for the large misfits observed by Bullard et al. (1965).

At the end of the sixties, Boris Choubert kept a very strong bitterness for having been an unsung precursor. He was indeed convinced of having been the victim of a conspiracy. Much later, Jean Gaudant (1995) supported this interpretation, as well as Michel Durand-Delga (2006). There is nothing actually believable in this conspiracy theory. Choubert's paper was published in French in a French Journal, which had some fame in 1935, but much less, internationally speaking, in the early 1960s. The title of Choubert's paper ("Research on the Genesis of Palaeozoic and Precambrian Belts") was extremely broad, and did not let anybody imagine that it might have concerned the fit of the circum-Atlantic continents and a generalisation of continental drift to Palaeozoic time. This was probably enough for Choubert's paper to remain unnoticed in 1965.

5. The "Bullard–Choubert fit"

Boris Choubert benefited from a long geological career in his life, during which he distinguished himself by his cartographic documents, mining discoveries and ability to organize multidisciplinary research. He collected the fruits of that work. However, he was scientifically wronged by the indifference with which his contemporaries received his accurate fit of circum-Atlantic continents and innovative concept on continental drift. He was shocked by the almost complete lack of recognition of his work, especially by his happy successors whose paper (Bullard et al., 1965) was acknowledged more than 1500 times in international journals. Aware of this unfairness, Xavier Le Pichon once proposed, during a scientific meeting at the beginning of the 1970s, that the circum-Atlantic continents fit would now be called the "Bullard–Choubert fit", as we now talk of "Wadati–Benioff zones". This proposal was not acted upon. The present paper was written to stress Boris Choubert's part in the history of the continental drift and plate tectonics theories.

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References

Ampferer, O., 1906. Uber das Bewegungsbild von Faltengebirgen. Jb. Geol. Reichsanstalt. Wien 56, 539–622.
Barruol, J., 1984. Boris Choubert. Géochronique 9, 23.
Benioff, H., 1949. Seismic evidence for fault origin of ocean deeps. Bull. Geol. Soc. Am. 60, 1837–1856.
Boillot, G., 1979. Géologie des marges continentales. Paris, Masson.
Bullard, E., Everett, J.E., Smith, A.G., 1965. The fit of the continents around the Atlantic. Phil. Trans. Roy. Soc. A258 (1088), 41–51.
Carey, S., 1958. The tectonic approach to continental drift. In: Continental Drift – A symposium. University of Tasmania, Hobart177–355.
Choubert, B., 1935. Recherches sur la genèse des chaînes paléozoïques et antécambriennes. Rev. Géogr. Phys. Géol. Dyn. VIII (1), 50–51.
Choubert, B., 1946. Sur la présence du diamant au Gabon (A.E.F.), en relation avec des kimberlites et des roches carbonatées métamorphiques. C. R. Acad. Sci. Paris 223, 638–640.
Choubert, B., 1952. La mine d'or de Saint-Élie et Adieu-Vat en Guyane française. Écho Mines & Métallurgie 2, 99–116.
Collinson, D.W., Runcorn, S.K., 1960. Polar wandering and continental drift: evidence from paleomagnetic observations in the United States. Bull. Geol. Soc. Am. 71, 915–958.
Dewey, J.F., 2015. A harbinger of plate tectonics: a commentary on Bullard, Everett and Smith (1965) "the fit of the continents around the Atlantic". Phil. Trans. Roy. Soc., A 373, 239.
Dive, P., 1933. La dérive des continents et les mouvements intratelluriques. Dunod.
Du Toit, A.L., 1926. The Geology of South Africa. Oliver and Boyd, London.
Du Toit, A.L., Reed, F.R.C., 1927. A geological comparison of South America with South Africa. Carnegie Inst. Washington Pub. 381.
Durand-Delga, M., 2006. Trois essais de tectonique globale avant la lettre, par Léonce Élie de Beaumont, Eduard Suess et Alfred Wegener. Travaux COFRHIGEO, 3, pp. XX.
Everett, J.E., Smith, A.G., 2008. Genesis of a geophysical icon: The Bullard, Everett and Smith reconstruction of the circum-Atlantic continents. Earth Sci. Hist. 27, 1–12.
Gaudant, J., 1995. La réception de l'idée de dérive des continents en France et en Suisse romande: les enseignements d'une enquête. Mém. Soc. geol. France 168, 129–138.
Gutenberg, B., 1959. Physics of the Earth's Interior. Academic Press.
Gutenberg, B., Richter, C.F., 1949. Seismicity of the Earth and associated phenomena. University Press, Princeton, NJ, USA.
Heck, N., 1936. Distribution of earthquakes. Trans. Am. Geophys. Union 93.
Heezen, B., Tharp, M., Ewing, M., 1959. The floors of the oceans. I. The North Atlantic. Text to accompany the physiographic diagram of the North Atlantic. In: Geological Society of America, Special paper 65. .
Hess, H.H., 1962. History of ocean basins. In: Engel, A.E.J., James, H.L., Leonard, B.F., (Eds.), Petrologic studies: a volume in honor of A. F. Buddington, Geological Society of America. pp. 599–620.
Holmes, A., 1929. Radioactivity and earth movements. Trans. Geol. Soc. Glasgow 18 (3), 559–606.
Jeffreys, H., 1924. The Earth. Its origin, history and physical constitution. Cambridge University Press.
Le Pichon, X., 1968. Sea-floor spreading and continental drift. J. Geophys. Res. 73 (12), 3661–3697.
McKenzie, D.P., Parker, R.L., 1967. The North Pacific: an example of tectonics on a sphere. Nature 216, 1276–1280.
Morgan, W.J., 1968. Rises, trenches, Great Faults and Crustal Blocks. J. Geophys. Res. 73 (6), 1959–1982.
Morley, L.W., Larochelle, A., 1964. Paleomagnetism as a means of dating geological events. Geochronology in Canada. R. Soc. Canada Spec. Publ. 8, 39–51.
Okanga-Guay, M., 1998. Moanda, Gabon: ville minière ou ville régionale (Mém. MSC Géographie). University of Sherbrooke, Canada.
Richardson, E., 2014. Biographical Information for Teddy Bullard, PennState. Earth 520 Plate Tectonics and People. .
Rothé, J.P., 1954. La zone sismique médiane indo-atlantique. Proc. Roy. Soc. A222, 337–397.
Runcorn, S.K., 1956. Paleomagnetic survey in Arizona and Utah: preliminary results. Bull. Geol. Soc. Am. 67, 301–316.
Vine, F.J., Matthews, D.H., 1963. Magnetic anomalies over oceanic ridges. Nature 199 (4897), 947–949.
Wadati, K., 1935. On the activity of deep focus earthquakes in the Japan Islands and neighbourhoods. Geophys. Mag. 8, 305–325.
Wegener, A., 1929. Die Entstehung der Kontinente und Ozeane, 5[e] ed. Nizet et Bastard, Paris (Trad. française Armand Lerner, 1937).