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Alfred Wegener's Hypothesis on Continental Drift and Its Discussion in Petermanns Geographische Mitteilungen (1912 – 1942)

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Abstract: Certainly not the first to notice the obvious key-and-lock shape of Brazil and Africa, in 1911 the meteorologist Alfred Wegener was nevertheless among the first scientists to link hitherto isolated scientific arguments to these empirical observation and develop a hypothesis conclusively explaining the architecture of the Earth's surface which over the years evolved into an intense debate with his adversaries. Although cautioned by his colleague and father-in-law Wladimir Köppen not to interfere with the discussion of geological matters as a meteorologist – and therefore as an outsider – he presented his thoughts to the "Geologische Vereinigung" in Frankfurt am Main on 6 January 1912 and first published them in 'Petermanns Geographische Mitteilungen', one of the leading geographical monthlies of international reputation, in April 1912 in a paper entitled "Die Entstehung der Kontinente" (The Origin of the Continents). In the, at times, highly controversial debate sparked by Wegener's paper in 'Petermanns Geographische Mitteilungen', which for obvious reasons soon after shifted to geological platforms of discussion, it is a lesser known fact that 'Petermanns Geographische Mitteilungen' too mirrored this heated debate over a period of thirty years in eleven major articles of which four (ANDRÉE 1917, NÖLKE 1922, KOBER 1926, SCHUMANN 1936) opposed Wegener's hypothesis and seven defended his benchmark paper. Interestingly Alfred Wegener himself never defended his concept in this journal, but, except for one supportive paper (RUUD 1930), the others defending his interpretation were some sort of 'family backlash' vigorously conducted by Wladimir KÖPPEN (1921a, 1921b, 1925) and Kurt WEGENER (*brother,* 1925, 1941, 1942).

Zusammenfassung: Obwohl dem Meteorologen Alfred Wegener sicherlich nicht als Erstem das Zusammenpassen von Brasilien und Afrika aufgefallen war, entwarf er doch 1911 als einer der Ersten aus dieser empirischen Beobachtung gerade durch die Verknüpfung bislang unabhängig voneinander gesehener wissenschaftlicher Argumente eine über die Jahre in Auseinandersetzung mit seinen Widersachern weiter entwickelte schlüssige Hypothese zur Erklärung der gegenwärtigen Gestaltbildung. Obwohl von seinem Kollegen und späteren Schwiegervater Wladimir Köppen gewarnt, sich als fachlicher Außenseiter nicht in geologische Streitfragen einzumischen, trug er seine Gedanken am 6. Januar 1912 vor der Geologischen Vereinigung in Frankfurt am Main vor und veröffentlichte diese unter dem Titel „Die Entstehung der Kontinente" im April-Heft 1912 von 'Petermanns Geographische Mitteilungen', einer der international führenden geographischen Fachzeitschriften. Bei Verfolgung der zeitweise sehr kontrovers geführten Diskussion seines Konzepts, die sich naturgemäß bald vor allem in geologischen Fachorganen fortsetzte, ist kaum bekannt, dass sich der losgetretene hitzige argumentative Schlagabtausch auch in der Zeitschrift der Erstveröffentlichung widerspiegelte. Diese enthält über einen Zeitraum von drei Jahrzehnten elf größere Aufsätze, von denen vier (ANDRÉE 1917, NÖLKE 1922, KOBER 1926, SCHUMANN 1936) gegen Wegeners grundlegenden Aufsatz Stellung beziehen und sieben zustimmende Beiträge. Interessanter Weise verteidigte Alfred Wegener seine Hypothesen niemals in dieser Zeitschrift, jedoch sind alle unterstützenden Aufsätze bis auf einen (RUUD 1930) eindringliche Zeugnisse familiären Zusammenhalts, da diese von Wladimir KÖPPEN (1921a, 1921b, 1925) und Kurt WEGENER (*Bruder,* 1925, 1941, 1942) stammen.

The year 2005 not only commemorated the 75th anniversary of Alfred Wegener's death on the inland ice of Greenland but also the 150th anniversary of "Petermanns Geographische Mitteilungen" (hereafter PGM). The paths of both these "celebrities" crossed when the famous first publication of Wegener's hypothesis on continental drift appeared in the April and May issues of PGM 1912. Given this double anniversary, it might be timely to recall some of the circumstances, which led to this publication and to shed some light on probably little known aspects of the debate it triggered in the columns of this leading geographical journal in the three decades thereafter.

Alfred Wegener (1880-1930, Fig. 1) was definitively not the first scientist to notice the eye-catching jigsaw-puzzle-fit of Brazil with the west coast of Africa. In fact, the contiguity of these continents had already made other scientists think along similar lines. The scientist whose ideas came closest to the concept of the German meteorologist was the US-American geologist Frank B. Taylor (1860-1939) who presented his ideas in a lecture already in 1908. However, his predecessors ideas only came to Wegener's attention after he had formulated his idea as explained in the introduction to his paper in PGM (A. WEGENER 1912: 185).

In January 1911 he wrote his bride Else Köppen (1892-1992) whom Wegener married in 1913 about an observation made after browsing for hours through the splendidly elaborated map pages of the "Andree Handatlas": *"Doesn't the east coast of South America fit precisely into the west coast of Africa so as if they had been connected in the past. This seems even more true, when one looks at a bathygraphical map of the Atlantic Ocean and compares not the rims of continental dry lands but the edges of the continental shelves to the deep sea. I have to follow up this thought."* (E. WEGENER 1960: 75). It did not take Wegener long to think seriously about this "discovery" because in autumn 1911 he, by accident, read a summary review on similar palaeontological discoveries in Africa and Brazil, suggesting that at times there has been a land bridge between these two continents. This review led the young scientist to conceptualize a hypothesis which conclusively explains these somewhat puzzling observations.

The core of the emerging concept, the break up of the palaeocontinent Gondwana, was already sketched in a letter dated 6 November 1911 to his future father-in-law, the well-known meteorologist Wladimir Köppen (1846-1940): *"One can imagine this process in two ways: 1.) by the foundering of the connecting continent 'Archhelenis' or 2.) by the drifting apart of a giant rift. Until now one has always considered 1.) and ignored 2.) because it has been common opinion that the position of all land is invariable. Despite this 1.) contradicts the modern concept of isostasy and generally our physical imaginations. A continent cannot sink because it is lighter than that*

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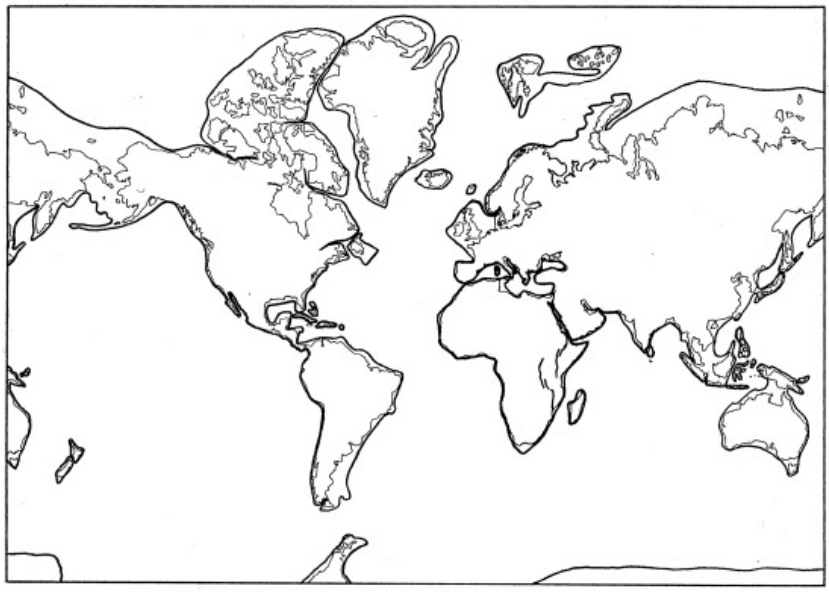
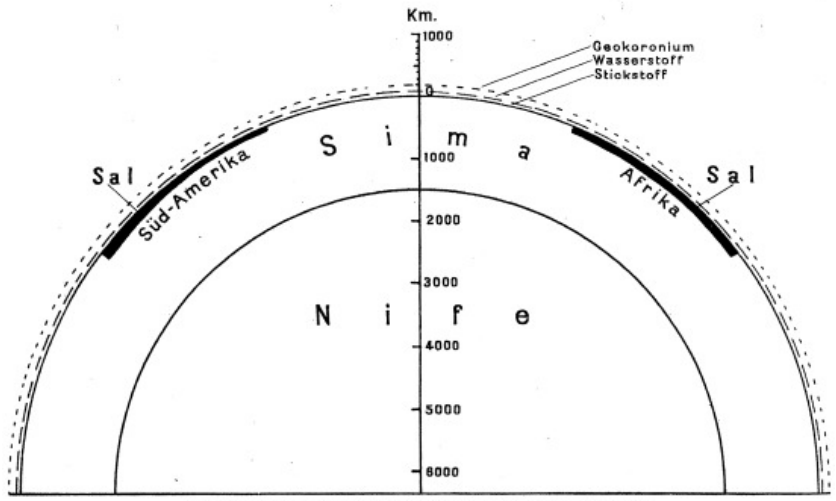
Fig. 1: Alfred Wegener in the winter hut Borg in northeast Greenland during his second expedition to Greenland, 1912-1913; Source: E. WEGENER 1960: Plate 5 follwing p. 80.

Abb. 1: Alfred Wegener in der nordostgrönländischen Überwinterungshütte Borg auf seiner zweiten Grönland-Expedition 1912-13; Quelle: E. WEGENER 1960: Tafel 5 nach Seite 80.



1. Kartenskizze der Kontinentalschollen



2. Schnitt im größten Kreise durch Südamerika und Afrika
in getreuen Größenverhältnissen

Fig. 2: Continents floating on the viscous crust (Source: A. WEGENER 1912: Plate 36, extract). The upper sketch (1.) maps in a rough manner the submarine edges of the continental shelves while the lower one (2.) provides a schematic view of a section from the earth's surface to its core in true proportions indicating that the Sal-continents float on the Sima called outer viscous crust.

Abb. 2: Kontinente schwimmen auf dem zähflüssigen Erdmantel (Quelle: A. WEGENER 1912: Tafel 36, Ausschnitt). Das obere Schema (1.) zeigt eine rohe Kartenskizze der untermeerischen Kontinenträndern, während die untere Skizze (2.) einen schematischen Schnitt durch die Erdkugel von der Oberfläche zum Kern in den tatsächlichen Proportionen darstellt und verdeutlicht, dass die Sal-Kontinente auf dem Sima genannten zähflüssigen Erdmantel schwimmen.

on which it floats … so why should we hesitate to throw overboard the old opinion?" (Closs et al. 1985: 42).

Foreseeing at least some of the heated disputes that would arise out of the articulation of such views, Köppen warned Wegener, in vain, not to drift away into realms interfering with the discussion of geological matters as a meteorologist and therefore as an outsider. Ignoring this well-intended advice already on 6 January 1912 a committed Wegener gave a lecture entitled "Development of the Main Features of the Earths Crust (Continents and Oceans) on a Geo-Physical Base" at the annual general meeting of the Geologische Vereinigung in Frankfurt a.M., thereby making his hypothesis of continental drift public for the first time (E. Wegener 1960: 75-76, A. Wegener 1929: 1).

Shortly afterwards Wegener completed two manuscripts of which he sent the minor, a brief summary, to the journal Geologische Rundschau. The major one being a typoscript consisting of 69 pages he submitted to PGM anticipating the verdict that it would be too long. However, PGM did not demand any shortening but published the lengthy paper straightaway (E. Wegener 1960: 77) in three consecutive monthly issues with the laconic but appropriate title "The Origin of Continents" beginning in its April issue (A. Wegener 1912) – before the publication of the summary in Geologische Rundschau. Therefore, one of the leading geographical journals of the time could claim the honour of being the first to publish the much disputed geological hypothesis of continental drift.

As indicated in his letter to Köppen, the fundamental assumption in both Wegener's concept and its description in the PGM paper, centred around a hypothesis already formulated in the 19th century. According to this the continents consist of a lighter assemblage of elements called Sial (Wegener in the inaugural paper calls it Sal) – an acronym of Silicon and Aluminium with a density ranging between 2.5 and 2.7 g cm^{-3} – which isostatically float on a heavier assemblage of elements of the outer mantle of the globe called Sima – an acronym of Silicon and Magnesium with a density ranging between 3 and 4 g cm^{-3} (Fig. 2).

Thinking conclusively the geological, palaeontological, palaeo-climatological and biological concurrences between Brazil and Africa could not possibly be explained by the physical foundering of a land bridge extending over thousands of kilometres. The only remaining second option as described in Wegener's letter to Köppen was the gradual disintegration and/or collision of continents. Furthermore, the picture of drifting ice-floats also offered a strikingly simple explanation for the observation that Scandinavia had been steadily rising above sea level ever since the melting of its burdening Pleistocene glaciers (A. Wegener 1912: 191).

Like other revolutionary hypotheses Wegener's proposal contained some initial errors and omissions. One of these errors – although not in the process but in its extent – was his assumption *"that the salic crust once covered the entire surface of the whole earth"* which only by the process *"of tearing up and merging, of which the single phases we perceive as orogenesis, gradually lost surface and coherence but instead gained [vertical] thickness"* (A. Wegener 1912: 194). Among the more prominent omissions, one has to mention Wegener's inability to name the mighty engine needed to drive the proposed drift of the continents. Apart from initially retreating to effects of the *"lunar tide onto the globe",* he somewhat helplessly suggested to consider preliminarily *"the movements of the continents as results of accidental currents in the globe"* (A. Wegener 1912: 194-195). It was primarily this failure to name the driving force necessary to substantiate his hypothesis that seemingly presented Wegener's adversaries an Achilles' tendon – at least until the discoveries of palaeo-magnetic stripes on the ocean floor and the spreading of the oceanic crust around mid-ocean ridges (Vogel 1981: 353-358) made just before the Second World War (Fig. 3).

Apart from the above Wegener also announced right at the beginning of his PGM paper in a footnote that due to his participation in Johan Peter Koch's (1870-1928) expedition to Greenland, leaving in June 1912, he would be forced *"to postpone the envisaged detailed treatment and provisionally publish this preliminary notice only"* (A. Wegener 1912: 185). This expedition to Greenland, the waiting for new evidence in favour of his hypothesis and, finally, the outbreak of the First World War with Wegener initially in active service delayed the promised more extensive treatise. It was only in 1915 that a small book of only 94 pages appeared under almost the same title as the PGM paper: "The Origin of Continents and Oceans". The fact that this booklet was published during the Great War delayed the international reception of the first impression; a situation which later changed dramatically when its fourth and ever-extended as well as revised impression appeared in 1929.

Sadly for PGM, the originator of the soon emerging debate on the pros and cons of the proposed continental drift never again submitted a paper in defence of his concept from this geographical rostrum. This unfortunate fact possibly contributed to a judgement by Albrecht Penck (1858-1945) characteristic of many contemporary geographers. After attending a lecture given by Wegener to the Berlin Geographical Society on 21 February 1921, Penck, a leading geomorphologist of the time, only conceded that such a reconstruction of continents had *"something seductive"* about it. However, the geomorphologist, like most contemporary geo-scientists, remained firm in the belief that the shape of the continents in principal was achieved by processes of contraction and vertical crustal movements (E. Wegener 1960: 163, Stäblein 1980: 28).

The decades-long and at times highly controversial debate sparked by Wegener's paper in PGM understandably soon shifted to geological platforms of discussion. However, what is not commonly known fact is that this geographical journal, apart from being the first to publish the hypothesis, also mirrored the controversy around it over a period of thirty years. Due to adversary circumstances at the time, which led to its initial slow reception, a total of eleven major articles appeared (Tab. 1) until the end of the Second World War – not considering marginal remarks in papers focussing on other topics. Of these eleven papers, surprisingly only four (Andrée 1917, Nölke 1922, Kober 1926, Schumann 1936) opposed the gradually developed hypothesis while a majority of seven defended the epochal concept inaugurated in PGM in 1912. While Alfred Wegener himself never defended his idea in that

Figuren zu W. Köppen: Polwanderungen, Verschiebungen der Kontinente und Klimageschichte.

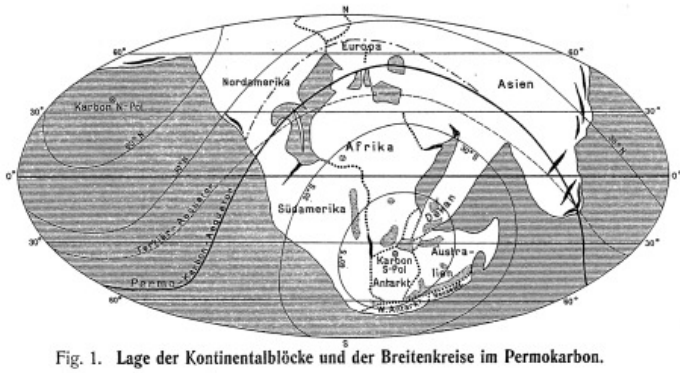


Fig. 1. **Lage der Kontinentalblöcke und der Breitenkreise im Permokarbon.**

Beginnende ..... Zukünftige Spaltungen .-.-.-. Aequator im älteren Karbon
Nachgewiesene Glazialspuren aus dem Permokarbon
Mollweide-Gradnetz das jetzige von Afrika.

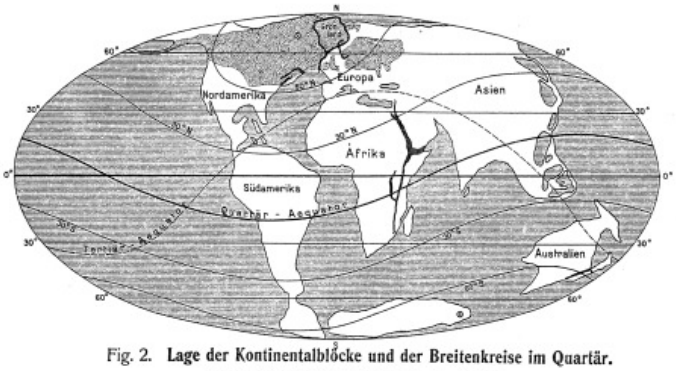


Fig. 2. **Lage der Kontinentalblöcke und der Breitenkreise im Quartär.**

Für Spalten, Glazialspuren und Gradnetz vgl. Fig. 1.
(Flachmeer in beiden Figuren nicht berücksichtigt.)

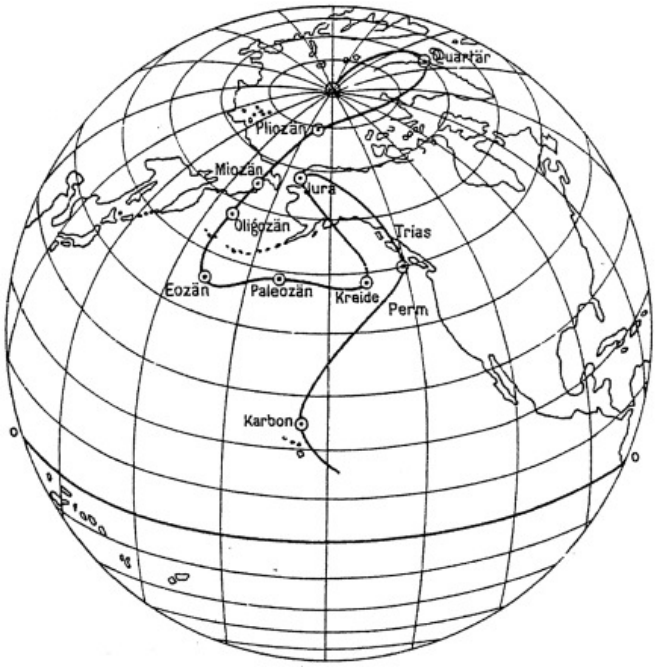


Fig. 6.

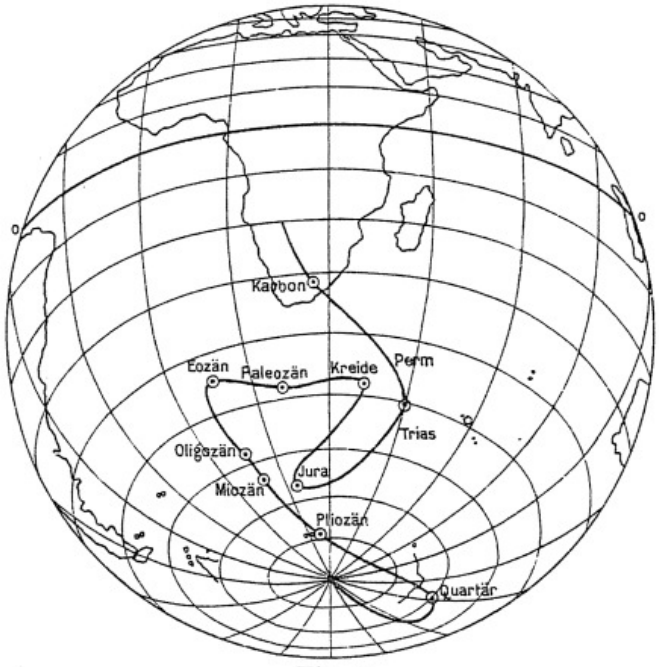


Fig. 7.

Wanderungen des Nordpols und Südpols.

Kontinente in jetziger Lage. Gradnetz das jetzige von Afrika. Fig. 3, 5 u. 8 s. im Text.

Fig. 3: Palaeomagnetic and palaeoglacial observations supporting the theory of continental drift (Source: KÖPPEN 1921a: Plate1 [extract]). A paper by KÖPPEN (1921a) contains the best early illustrations published in PGM both on the effect of the drift on the continents and its geomagnetic evidence. The upper two sketch maps (Figs. 1 and 2) indicate the global land distribution and palaeo-equatorial lines in the Carboniferous–Permian period – with proved widespread glaciations in today tropical regions – and in the Quaternary period. The lower two three-dimensional drawings of the globe (Figs. 6 and 7) with the recent position of the continents indicate the palaeo-wandering paths of the north and south poles from the Carboniferous to the Quaternary.

Abb. 3: Paläomagnetische und paläoglaziale Beobachtungen zur Untermauerung der Theorie der Kontinentaldrift (Quelle: KÖPPEN 1921a: Tafel 1 [Ausschnitt]). Ein Aufsatz von KÖPPEN (1921a) enthält die besten frühen Illustrationen in PGM sowohl zum Ausmaß der Kontinentaldrift als auch zu den erdmagnetischen Belegen. Die beiden oberen Skizzen (Fig. 1 und Fig. 2) verdeutlichen die erdweite Landverteilung and verschiedenen vorzeitlichen Äquatorlagen im Permokarbon – mit nachgewiesenen Spuren der Vereisung in gegenwärtig tropischen Erdteilen – und in Quartärzeiten. Die unteren beiden dreidimensionalen Erdkugeln (Fig. 6 und 7) mit der heutigen Lage der Kontinente deuten die erdgeschichtlichen Wanderungen von Nord- und Südpol vom Karbon bis zum Quartär an.

Author and Date: KARL ANDRÉE (1917: 50-53, 77-81)
Title: *Alfred Wegeners Hypothese von der Horizontalverschiebung der Kontinentalschollen und das Permanenzproblem im Lichte der Paläogeographie und dynamischen Geologie*
Position: CONTRA
Summary: 1) Consents that "*a major part of Wegener's geophysical presentation might explain the real circumstances and live expressions of the earth*" (p. 50);
2) Inability to name the driving force behind the theory is "*missing of a plausible interpretation of the drifts*" (pp. 50-51);
3) Although consenting that currents within the globe are responsible for forming the earths surface the "*supposed far reaching horizontal drifts of continents in their enormous thickness might prove as impossible*" (p. 51);
4) Cites Eduard Suess (1831-1914) and Carl Diener (1862-1928) and palaeo-geographic research which contradicts that South America and Africa were connected until Tertiary and that there are no stratigraphic boundaries between shelves of Eurasia and Gondwana (p. 53);
5) Rejects supposed wandering of poles as an explanation for paleo-glacification in Southern Africa because this does not explain palaeo-glacifications in West Africa and Australia (p. 53);
6) Rejects the split of North America and Europe as the origin of the Atlantic Ocean because if so, the proved land bridge between Alaska and Sibiria must, until the Tertiary, have stretched over a width of 35 degrees of longitude (p. 77);
7) Joins Diener in assuming that since the Triassic drifts of continents and ocean basins were restricted and because of this semi-permanence there is neither space nor need for far reaching horizontal drifts (p. 79);
8) The "*long stretched double rift form of the Atlantic Ocean*" deems it not plausible that North America and South America should have moved westward in different times (p. 79);
9) Deep sea sediments in South Atlantic Ocean are to be explained by vertical and not by horizontal movements (p. 80);
10) Palaeogeography contradicts the genetic interpretation of the Indian Ocean and "*a correlation between the folding of the Himalaya or the Andes and the supposed continental drifts seems impossible*" (p. 80);
11) However: "*Taking Wegener's hypothesis totally ad acta would mean turning a blind eye towards the challenges of modern geophysics and dynamic geology*" (p. 80).

Author and Date: WLADIMIR KÖPPEN (1921a: 1-8, 57-63)
Title: *Polwanderungen, Verschiebungen der Kontinente und Klimageschichte*
Position: PRO
Summary: 1) Communicates Wegener's latest observations, amendments and corrections as well as provides maps drafted by him on the supposed wandering of the polar axis since the Carboniferous [see Fig. 3] (p. 1);
2) In listing extensively palaeo-landbridges between the continents he argues that the shape of the continents has a certain permanence but not their or deep sea basins placement (p. 5);
3) Split of South America and Africa started in Jurassic times by rifts (p. 7);
4) Carboniferous-Permian glacification in the range of 40° to 50° southern latitude suggests a contemporary position of the South Pole and could explain plausible hard coal deposits stretching from Texas via Germany to China which would all have been around the equator of that time (p. 8);
5) Discusses wide range of climatological details up to the observation of recent climatic changes (pp. 57-60).

Author and Date: WLADIMIR KÖPPEN (1921b: 145-149, 191-194)
Title: *Ursachen und Wirkungen der Kontinentalverschiebungen und Polwanderungen*
Position: PRO
Summary: 1) Wegener's reason to only hint at a driving force of the supposed continental drift was desire not to come up with a solely deductive construction but also empirical observations (p.145);
2) Identifies – in conjunction with others – a major driving force: "*But the movement of whole continents und the folding of whole mountain ranges apparent in conjunction with it may find its main cause in the* 'Polflucht' *due to the uneven bottom sides of the continental plates at depth in the Earth.*" That contra-polar driving force (= 'Polflucht') aims at a mass symmetrical position of the rotational axis by masses drifting away from the poles by a centrifugal "*force towards the equator we* (= Alfred Wegener and Köppen) *in short have named* 'Polflucht' *of the continental plates*" (pp. 148-149);
3) Additional tendency of westward movements of continents may be explained by tidal friction (p. 149).

Author and Date: FRIEDRICH NÖLKE (1922: 79-81, 114-115)
Title: *Physikalische Bedenken gegen A. Wegeners Hypothese der Entstehung der Kontinente und Ozeane*
Position: CONTRA
Summary: 1) Argues physically neither geological mass transfers like sedimentation and building up of inland ice, nor viscous currents in outer mantle, had sufficient effects on polar circulation axis stability to result in the supposed far reaching palaeo-movements of poles (p. 79);
2) Questions missing out on the immense source of energy for drift of continents and folding of mountain ranges which will force Wegener to accept the old concept of global contraction for folding up and foundering of land bridges (p. 114);
3) Argues that centrifugal forces are too weak to dominate the supposed 'Polflucht' (p. 114);
4) Criticises that an ongoing westward tidal movement of North America up to 20 m per year is impossible with yet unnoticed crustal frictions (p. 115).

Author and Date: KURT WEGENER (1925: 51-53)
Title: *Die Kontinentalschollen*
Position: PRO
Summary: Identifies three "*proofs*" for the existence of continental plates although concedes these "*by means of descriptive science neither could be confirmed nor falsified*":
- seismic indication of different viscous layers in mantle giving possibility to vertical and horizontal currents,
- gravity observations being conclusive with the concept of floating continental plates,
- geophysical double maximum heights on continental clods and deep sea floors.

Author and Date:	WLADIMIR KÖPPEN (1925: 160-162)
Title:	*Muß man neben der Kontinentalverschiebung noch eine Polwanderung in der Erdgeschichte annehmen?*
Position:	PRO
Summary:	1) Citing Rudolf Staub (1890-1961) on the northward drift of Europe, he discusses a proposal to give up the concept of contra-polar movement in favour of continental drift only (p. 160); 2) Explains Wegener's concept of drawing maps of palaeo-geographical positions of continents as a mean to prove supposed drift (pp. 160-161); 3) Concedes that preliminarily there are "*only hints from a few areas of the world*" supporting the theory of continental drift (pp. 161-162); 4) Defends the possibility of major wandering of polar rotation axis (p. 162).
Author and Date:	MARIA KOBER (1926: 9-11)
Title:	*Zur Frage der Kontinentalverschiebungen*
Position:	CONTRA
Summary:	1) Cites recent geological field research publications rejecting palaeo connection of North America and Eurasia due to a lack of petrographic similarities in both coastal areas except fo the basalts in South Africa and central South America (pp. 9-10); 2) Cites Evans that Wegener's map of South America is a simplified version of his own and therefore no evidence for supposed continental drift (p. 10); 3) Concedes that palaeo-botanical observations support drift theory (p. 10); 4) Cites recent geological objections concerning supposed drift of continental plates on viscous outer mantle (p. 10).
Author and Date:	INGOLF RUUD (1930: 119-124, 174-180)
Title:	*Die Ursache der Kontinentalverschiebung und der Gebirgsbildung*
Position:	PRO
Summary:	1) States variety of research has demonstrated continental drift while conceding that driving force of the process still is missing (p. 119); 2) Concedes in reflecting recent researches that the supposed 'Polflucht' for continental drift and tidal frictions for westward tendencies are insufficient models (p. 119); 3) Argues convectional currents in viscous outer mantle (R. SCHWINNER 1919, G. KIRSCH 1928) support the hypothesis of continental drift (pp. 119-120); 4) Discusses connection between continental drift and folding of Tertiary mountain ranges and identifies horizontal contraction theory as origin of folded mountain ranges either primarily or secundarily by continental drift (pp. 120-124, 174-176); 5) States geotectonic break-up of a single super continent in Tertiary due to general crustal cooling, which triggered continental drift (pp. 176-179).
Author and Date:	RICHARD SCHUMANN (1936: 11-12)
Title:	*Stützen neuzeitliche astronomisch-geodätische Messungen die Hypothese einer Kontinentalverschiebung?*
Position:	CONTRA
Summary:	Rejects supposed continental drift by citing astronomic-geodetic observations of various stations indicating – if at all – an annual drift of less than 0.2 m – and still within the sphere of technical measuring errors – in contrast to formerly assumed 20 m per annum and more.
Author and Date:	KURT WEGENER (1941: 98-100)
Title:	*Geophysik und Geographie*
Position:	PRO
Summary:	1) States difference between continents made up of sediments resting on granite with basalt intrusions and deep-sea beds consisting of basalt (p. 98); 2) Maintains supposed thickness of continental plates of 100-120 km (p. 99); 3) Argues that gravity observations and axiom of equilibrium support supposed floating of continental plates on viscous crust by, inter alia, citing the uplift of Scandinavia relieved of its glacial cover load (pp. 99-100).
Author and Date:	KURT WEGENER (1942: 178-182)
Title:	*Die Theorie Alfred Wegeners über die Entstehung der Kontinente und Ozeane*
Position:	PRO
Summary:	1) Summarises the basics of theory on continental drift which his brother in 1929 believed impossible to develop further because of the sheer quantity of ever more specialised research publications (p. 178); 2) Repeats statements 1.-3. of his paper in PGM 1941 (pp. 178-179); 3) Describes as core of supposed continental drift that by unfolding mountain ranges and matching the continents one can build the original single super continent (p. 180); 4) States origin of folded mountain ranges by horizontal drifts is undisputed and is balanced statistically by the same degree of separations (p. 180); 5) Explains the tropical hard coal deposits from Texas via Germany to China by palaeo-ecliptic changes (pp. 180-181); 6) Rejects simultaneous drift of all continents by referring to palaeo-botanical differences (p. 181); 7) Gives reasons for the palaeo connection of the Americas and Eurasia-Africa by naming palaeontological similarities, parallelism of coastal forms and the recently researched submarine Atlantic mountain range as ideal seam of continental splits (p. 181); 8) Draws on the theory of the moon being a global split off to fill remaining continental 'gap' in the Pacific Ocean (p. 182).

Tab. 1: Chronological content review of major articles pro and contra Wegener's theory of continental drift in PGM 1917-1942.

Tab. 1: Chronologische Inhaltsübersicht der Hauptaufsätze für und gegen Wegeners Theorie der Kontinentaldrift in PGM 1917-1942.

journal except for one supportive paper (RUUD 1930) the others were some sort of "family backlash" vigorously written by Köppen (KÖPPEN 1921a, 1921b, 1925) and his brother Kurt Wegener (1878-1964) (K. WEGENER 1925, 1941, 1942).

Although Köppen initially warned his son-in-law about the implications of publishing his hypothesis, Köppen became by far its most important early advocate in the PGM columns. According to the biography written by his daughter Else Wegener, Köppen *"always carried a small globe in his coat"* to check on suddenly conceived ideas (WEGENER-KÖPPEN 1955: 136). The actual reasons for most of the PGM-papers discussing the arguments for and against Alfred Wegener's hypothesis remain uncertain, but generally rather echoed the current discussion outside than pertaining contributions within that journal as well as introducing recent research results. On the whole, two main periods of submission clusters can be identified: The papers of KÖPPEN 1921a,b and NÖLKE 1922 seem to be triggered by the geographical peak of the controversy when Wegener presented the above-mentioned talk to the Berlin Geographical Society and published a paper in their journal in 1921. During the international dispute in the 1920s, with the majority of geo-scientists strongly declining the possibility of horizontal continental drifts, the two meteorologists Wegener and Köppen came up with their most important joint publication in which they drew on recent palaeo-climatic observations suggesting wanderings of the polar rotational axis and subsequent palaeo glaciations and, thereby, ironically supporting Wegener's concept with evidence they derived from the scientific fields of their strongest adversaries (KÖPPEN & WEGENER 1924). The impact of this major publication is mirrored clearly by the other cluster of publications by K. WEGENER (1925), KÖPPEN (1925) and KOBER (1926).

But it was only decades later that the hypothesis on continental drift would be widely accepted. Although already hinted at in the supportive PGM paper by RUUD 1930 that convection cells and currents within the Earth might be the sought-after engine behind continental drift, it would require the technical auxiliary means of a further generation to successfully follow up this suggestion. By the 1960s, submarine ridges discovered shortly before the Second World War – and already postulated by Kurt Wegener as plate sutures for the continental drift in his final PGM paper 1942 – were found to be sites of permanent sea-floor spreading. This process is thought to be fuelled by constantly emerging lava and corresponding subduction trenches that would consume or "swallow" the surplus of such created ocean floors. The latter led to the concept of plate tectonics in which plate movement is driven by steady convectional currents within the viscous mantle of the Earth, which changed but basically also confirmed Wegener's epochal publication in PGM 1912.

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