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Variable Radius Cartography – Birth and Perspectives of a New Experimental Discipline
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Variable Radius Cartography

Birth and Perspectives of a New Experimental Discipline

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Abstract. It is an aim of the present paper to show that in the last century cartography was used in a way more or less complex, more or less intertwined with other disciplines and databases, not as pure representation or in the spirit of the simple 'fits' that supported continental displacements, but as experiments of greater complexity with a value of proof in favor of the planet expansion and full of suggestions for Physics, Astronomy, Cosmology.

Key words. Variable radius cartography – History of cartography – Expanding Earth

1. Introduction

The expanding Earth conception is today considered the major alternative to the plate tectonics, and is going to overcome the rival theory on the basis of a larger number of interconnected explanations of phenomena, not only in the field of Geology and Geophysics, but also in more general fields (Scalera, 2012). Its main merit is that it has freed the Earth sciences from subordination to Physics and Cosmology. The expanding Earth suggests strongly that our knowledge of the physical world must be based starting from the only celestial body be experienced directly, taking as a "test-body" what lies beneath our feet, and not viceversa boxing the properties of the planet so that does not contradict the still uncertain cosmological principles.

The typical experiments that it was necessary to perform under this conception were of a new kind, namely cartographical experiments. It can be said that the expanding Earth transformed the cartography in experimental science.

The idea of significant changes in the size of our planet has no placed stable roots in the scientific-philosophical culture before the second half of the 19th century with the rise of the first ideas on the expansion of the Earth. Previously, only hints in pure academic disputes, or unaware realization of world maps – with Earth radius less than real – were proposed without any practical follow-up in the technical field of cartography. As to why in the antiquity there has been not a discussion about the constant or variable size of our planet is not easy to say, and on the subject and I believe that no literature exists.

Nicholas Oresme (1323 - 1382)

One of the few statements that I was able to find relevant to the possibility of change in the radius of the Earth over time is of Nicholas Oresme (1323 - 1382).

> *From the above it follows that if by tomorrow the world would become hundreds or thousands of times larger or smaller than it is now, since all its parts grow or diminish in proportion, all things would appear tomorrow just like now, as if nothing had changed. [.....]*
>
> *Similarly, if the center of the Earth was a concavity filled with air, about the size of an apple, [... ...] If such a concavity become a little bigger and growing up to become greatest, you could not find a limit at which this growth can be said that the Earth is to be out of its natural place, precisely be-*

cause, as mentioned above, large and small are relative terms.

Oresme envisaged an increase in size for quite different reasons – pure geometrical case – and he does not seem at all interested in the possibility that the case be actual and geological (Scalera, 1999). Before him I have a total lack of references. The ancient Greeks do not treated this possibility in any of their philosophical systems. Why they have not seen the global change in volume as feasible problem can have several causes. One of these may be the presence of different ideas about the shape of the Earth holding the debate at a lower level: still needed to be discussed and ascertained the sphericity of our planet (Scalera, 1999).

Avesta-Vendidad

A first mythological concept of expanding land or Earth (but it is questionable whether in global or topographic sense only) can be read in the text about the origins, the Avesta-Vendidad, belonging to the people of Parsi Zoroastrians. In Fargard (Chapter) 2 – verses 8 to 19 – the god Yima (Jamshed) fulfills three times, at different times, the prayers of his people and expands the land available to men and herds:

8. – Thus, under the sway of Yima, three hundred winters passed away, and the earth was replenished with flocks and herds, with men and dogs and birds and with red blazing fires, and there was room no more for flocks, herds, and men.

9. – Then I warned the fair Yima, saying: 'O fair Yima, son of Vivanghat, the earth has become full of flocks and herds, of men and dogs and birds and of red blazing fires, and there is room no more for flocks, herds, and men.'

10. – Then Yima stepped forward, in light, southwards, on the way of the sun, and (afterwards) he pressed the earth with the golden seal, and bored it with the poniard, speaking thus: 'O Spenta Armaiti, kindly open asunder and stretch thyself afar, to bear flocks and herds and men.'

11. – And Yima made the earth grow larger by one-third than it was before, and there came flocks and herds and men, at their will and wish, as many as he wished.

12. – Thus, under the sway of Yima, six hundred winters passed away, and the earth was replenished with flocks and herds, with men and dogs and birds and with red blazing fires, and there was room no more for flocks, herds, and men.

13. – And I warned the fair Yima, saying: 'O fair Yima, son of Vivanghat, the earth has become full of flocks and herds, of men and dogs and birds and of red blazing fires, and there is room no more for flocks, herds, and men.'

14. – Then Yima stepped forward, in light, southwards, on the way of the sun, and (afterwards) he pressed the earth with the golden seal, and bored it with the poniard, speaking thus: 'O Spenta Armaiti, kindly open asunder and stretch thyself afar, to bear flocks and herds and men.'

15. – And Yima made the earth grow larger by two-thirds than it was before, and there came flocks and herds and men, at their will and wish, as many as he wished.

16. – Thus, under the sway of Yima, nine hundred winters passed away, and the earth was replenished with flocks and herds, with men and dogs and birds and with red blazing fires, and there was room no more for flocks, herds, and men.

17. – And I warned the fair Yima, saying: 'O fair Yima, son of Vivanghat, the earth has become full of flocks and herds, of men and dogs and birds and of red blazing fires, and there is room no more for flocks, herds, and men.'

18. – Then Yima stepped forward, in light, southwards, on the way of the sun, and (afterwards) he pressed the earth with the golden seal, and bored it with the poniard, speaking thus: 'O Spenta Armaiti, kindly open asunder and stretch thyself afar, to bear flocks and herds and men.'

19. – And Yima made the earth grow larger by two-thirds than it was before, and there came flocks and herds and men, at their will and wish, as many as he wished.

In total, Yima made the land larger (eventually in radius) of about 3.7 times the original size.

Something like that is in the Arabic fables (www.arab.it, 2012), where Allah inflicts to the men the punishment of the falling from the sky of a grain of sand for every bad deed committed.

So, the deserts are created quickly in a way that is reminiscent of a marginal version of the expanding Earth (Myer, 2012). But ironically you may be wondering why today the Earth

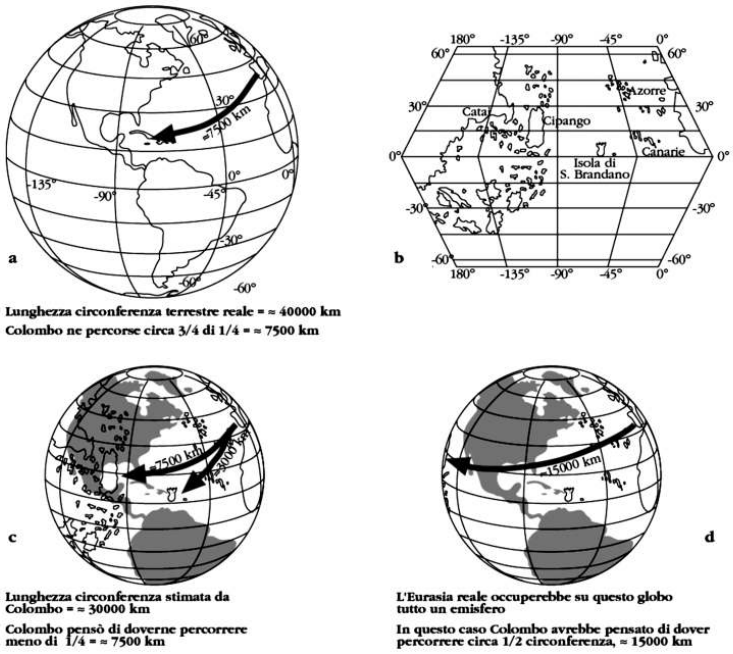

Fig. 1. a) The actual size of the planet and its distribution of the land is represented. b) An explanatory reconstruction of the map of Toscanelli by Kretschmer. c) Resetting the profiles of the coast of this map on a globe of size 3/4 of the actual, we see that the Asia of Toscanelli extends throughout the hemisphere Pacific and beyond. d) If the longitudinal length of Eurasia had been assessed correctly, the distance that Columbus should have expected to travel without a stop would be 15000 km.

is not a whole ball of sand with radius much greater than Jupiter or the Sun.

Francesco Patrizio da Cherso (1529-1597)

However, we must not fell in the error to consider only increasing of the Earth's size. We have to look for traces more generally of volume changes. The idea of expansion is evidently symmetric to that of contraction, once it is accepted that we can speak of variations in size. A rare reports of conceptions in which it is told of strong changes in the volume of the Earth comes in 1562 from the book *The Rhetoric - Ten Dialogues*, by Francesco Patrizio da Cherso (1529-1597) – Dalmatian philosopher and writer of Renaissance –, which contains facts and tales collected by Baldassare Castiglione (1478-1529; famous for his book in four dialogues The Book of the Courtier). This time we deal with a decrease in volume of Earth, like a catastrophic implosion. Here is a selection of the text of Patrizio contained in the first dialogue of The Rhetoric:

> *And I, therefore, will tell [the story ...] as it was reported by [...] Baldassare Castiglione [...] which heard it by some wise men of Ethiopia [...]. In the first centuries [...] this Earth that we live was not of this form, nor of so small size, as it is at present; but by far the greatest and perfect roundness. Indeed, between the sky and the Earth there was transposed nothing but the purest fire [...]. And in its inner body, and on the floor above, it was cavernous of extremely broad caves. [...]*
>
> *Therefore the Earth was in the form of a sponge, and men lived there by the manner [...]of a thousand worms. But it was their life then, happy and without ills. [...] Hence they had knowledge of all things, and celestial, and elemental, and knew the virtues and powers of all: and all they were worth for their wisdom. By means of which they operated many wonders [...]. [...] They were pleased of this, too beyond that it was not lawful. [...]People became proud, and began to believe each other to be gods. And then to compare them with Saturn.. [...]*
>
> *Which seeing Saturn, [...] gave the government in the hands of Jupiter, [...] which [...] in league with Pluto [...] one began to shake from below, [...] and the other to shoot lightning from above. With this horrible crash, and lightning, [...] it [the Earth] fell all in*

its caves below that were filled with its own matter. Since that happened, the Earth became smaller, going away for infinite space from heaven, and buried itself in itself, with all the things that were in it.

It is clear the analogy with the Christian legend of the fall of the rebel angels to Hell, in which, however, the relationship is lost both with mankind and with the Earth, which in the Christian story does not appear.

Paolo del Pozzo Toscanelli (1397-1482)

Instead, the map that Paolo del Pozzo Toscanelli sent to Christopher Columbus (Fig. 1) was an unaware application of mapping on radius less than the real (Chiarelli et al., 1992). There were two errors in it, which favored the enterprise of Columbus. The first was produced by a confusion between Arab and European units. The Arab mile of 1973 meters, was longer than the European one, 1481 meters. The correct estimation of the length of the meridian in Arab degrees was decreased in Europe by about a quarter, because given in European miles. Consequently, radius and circumference of the Earth were decreased by a quarter. As a second error, caused by the difficulty of estimating longitude, Toscanelli strongly overestimated the longitudinal length of Asia. Without this error – common to many other cartographers (see Figure 4 in Scalera, 2000) – the distance Portugal-Asia (going towards west) would be assessed from Colombo still prohibitive. If the width in longitude of Eurasia had been assessed correctly, the distance that Columbus should have expected to travel without a stop (d) would be 15,000 km, perhaps beyond the technical possibilities of the time and beyond the possibility of obtaining trust and support from the sovereigns and the papacy. The wrong evaluation of Toscanelli constituted the driving force for what happened – the discovery of the New World – and the indirect cause of all that was right and wrong ensued.

2. The Progresses Few Centuries Ago

The XIXth century perfects and leads to a higher level of awareness the first insights of Abraham Ortels (Ortelius, 1527-1598), Francis Bacon (1561-1626), René Descartes (1596-1650), François Placet (1666), Thomas Burnet (1635-1715), Theodor Christoph Lilienthal (1717-1781), about possible continental matches of shape and displacements. In full XIXth century began to circulate ideas far more precise on a possible ancient closeness between the continents today facing on the Atlantic. In 1838 Thomas Dick (1774-1857) – American theologian and philosopher – wrote on the "*striking correspondence between two sides of the two continents to which we have adverted*" [Africa, South America], and that the "*prominent parts of the one corresponding to the indentings of the other.*" (pag. 93).

Also Alexander von Humboldt (1769-1859) – in 1801 and 1845 – wrote on the geometrical and geological similarity between the coasts of America and Africa, hypothesizing that the Atlantic had been flooded by a catastrophic event. Until to the famous book of 1858 by Antonio Snider-Pellegrini (1802-1885) Italian-American traveler, essayist, Biblical commentator, in which successive decreasing in the Earth's size were proposed in synchronism with periods of the biblical sequence of events. Often reproduced in texts of the history of science was also the cartographic exercise by Snider-Pellegrini, who in two engravings represented the globe before and after the fracturing and separation of the continents.

It is not difficult to imagine how much influence all these ideas of changes in the Earth's size and movement of continental fragments had to have for the birth of ideas about significant expansions of the planet.

Richard Owen (1810-1890)

In this fertile and uninhibited cultural climate of the nineteenth century a first book saw the light, accompanied by a map, which defended a particular version of the idea of expanding Earth. Richard Owen (1810-1890, American chemist and geologist who studied in Hofwyl on the Swiss Alps) in this book proposed the principles of what him-self called (p. 22) Anatomical Geology:

Our planet, perhaps, typifies an ovule from the solar matrix: in its earlier igneous, chaotic state, it bore analogy to the yet undeveloped amorphous structure of vegetable ovules and the animal ovum. Like them it had at an early period a nucleus, on which, after a time, air and moisture deposited additional ma-terials, derived from the matrix. At a yet later period, a part of these same materials were carried in mechanical mixture, partly in chemical solution, to promote the development of later formations, forming new continents, etc.; just as a portion of the seed (the albumen) and the food-yolk of

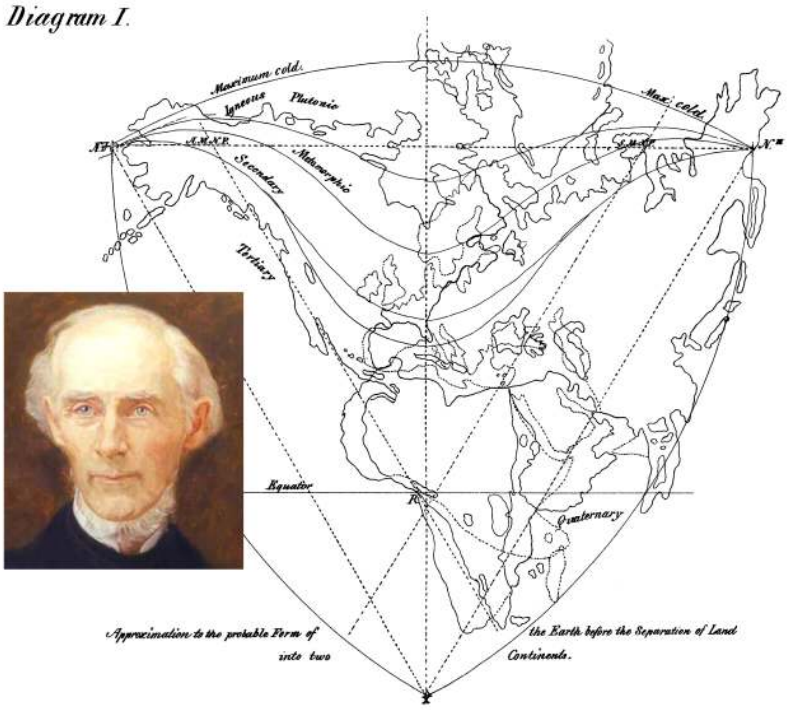

Fig. 2. Left: the portrait of Richard Owen, the son of the English utopian Robert Owen founder in the U.S. of the community of New Harmony. Richard became rector of Indiana University. Right: The position of the continents proposed by Owen in 1856. The original caption of the map reads: *Approximation to the probable Form of the Earth before the Separation of Land into two Continents. The land is supposed to be replaced somewhat as it was before the separation into the present continents: the dotted lines indicating those portions supposed farthest submerged, and covered by the parts drawn in full lines. Thus, the layers composing the South American Continent are supposed once to have rested on the layers of submerged Africa, particularly in the region of its Sahara. So also Australia is imagined, in some of the earth's early phases, to have been superposed on Arabia, while the points of Cape Comorin and of Cape Horn dove-tailed into its sinuses. Perhaps New Guinea occupied the region of the depressed Caspian Sea* [p. 254].

> *the egg go to nourish the expanding germ.* [p. 84]

It is very interesting to read the description, written in his own hand, how from the geological mapping available in 800 sprang his idea of a global solution, from which it will be born the first example of mapping of an expanding Earth (reproduced in Fig. 2):

> *[... ...] placed on the floor of a vacant room all the geological maps which he possessed, in their correct relative position. These are chiefly from the surveys made in the United States. Alongside of them he had Lyell's Map of the Geology of the United States, and Professor Hitchcock's map appended to his Geology of the Globe. While contemplating the latter, (compiled chiefly, Hitchcock remarks, from Johnston's Physical Atlas,) there suddenly flashed upon him the idea that the formations in the Western Continent corresponded in many respects to those in the Eastern; and he fitted, adjusted, and moved them apart and together, until it appeared to him that they must have been detached at some period from each other. The longer he examined the subject, the more this fist conviction was confirmed into a certainty. The next point was to find the law according to which they had separated; and, after much deep and perplexing investigation, he thought he perceived the great truth.* [p. 14]

> *[... ...] The earth, in some of its former geological epochs, occupied a smaller volume than before the whole of the present superficies emerged from the ocean, and than it did before some of the later successive layers were deposited on the earlier formations.* [p. 20]

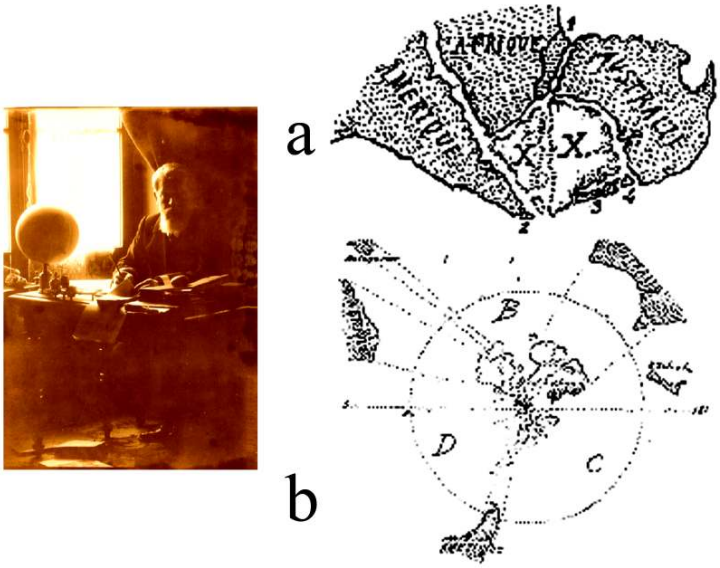

Fig. 3. Left: A portrait of Roberto Mantovani. already an old man, at his desk probably in his apartment in Paris Rue Marcadet 151 bis, 18th arrondissment. Right: the paleogeographic evolution of the southern continents that he traced in the work printed in 1909 and that was quoted by Alfred Wegener. a) Before the supercontinent break-up. b) After the break-up, with the tapered shapes of the continents faced towards their zone of primeval location.

> *[... ...] If we examine Johnston's geological maps of the globe, or Professor Hitchcock's, we see that, in order to bring the hypogene rocks of America and those of northern Europe to form a regular curve; or in order to make the palaeozoic and mesozoic rocks correspond, and finally the tertiary, in each continent, we must not only bring the two continents in actual contact, but we must slide a portion of North America into western Europe, the northern mass of South America on to the great Sandy Desert of Sahara, when sunk, as already remarked, beneath the waters of the ocean, Eastern Asia on to the great Sandy Deserts of Tartary, and Australia on to the submerged Sandy Desert of Arabia.* [p. 75]

No other work on the expanding Earth of 800 will contain a mapping practice of such significance. The work on the expansion of the Earth of the Russian-Polish engineer Ivan Osipovich Yarkowsky (1844-1902) (1888, 1889, 1912; Beekman, 2005, 2006) did not contain paleogeographic maps. Neither there are maps in the early writings of the French-Italian expansionist Roberto Mantovani (1854-1933) (1888, 1889; Scalera, 2009). Until further possible new historical findings, it must be agreed priority in the expanding Earth palaeogeography to the cartographic exercise – as unacceptable as it sounds today – of Richard Owen (Fig. 2). Considering the closure of the Atlantic and the overlap of South America on Africa, his Earth was to have a radius of not more than 4000 kilometers. After him no more until the next century.

3. Experiments of First Decades of XXth Century

Albeit the focus of this paper is to deal with variable radius carthography, it have to be stressed that a burst of interest in the paleogeographic aspect of the Earth was raised by the publication of the papers and the book of Alfred Wegener (1880-1930) (1912a, 1912b, 1915-1936). His ideas and the three global maps – Early Carboniferous, Eocene, Late Quaternary, reproduced in many papers and books of history of geology – influenced deeply the next generations of Earth scientists. Also the different authors of variable radius globes were inspired explicitly or implicitly by him, who posed the foundation of the mobilism.

However, a proficuous cultural exchange occurred between Wegener and the nascent expansionists group. Some maps are contained in the works printed at the beginning of 900, and

Fig. 4. On the left: the cover of the book of J.A.H. Kerkhoff (1928) that summarizes the author's conception: a comet colliding with Earth into a small Pacific hemisphere causing consequent expansion of the planet after the expulsion of the lunar mass. The five photographic poses show the early Earth globe with a single continental crust, without oceans, Europe is in contact with Africa, without the Mediterranean interposed. On the right: in the small insert five-steps are shown of the expansion of the Earth (the equator is vertical). The original caption reads (my translation): *Schema of the transformation of the early Earth with respect to the actual Earth and of the flood (Pacific hemisphere). - From I to IV, asymmetrical growth at the margins, with the progress of the flood. – I-III The increase in water. - IV, decreasing. - V, the current state.*

they assume a sense of real paleogeographic reconstruction.

Roberto Mantovani (1854-1933)

The maps drawn in 1909 by Roberto Mantovani (1854-1933) to illustrate his idea of the expansion of the Earth were a first example. The global map centered on Pacific hemisphere contains the first drawing of hypothetical lines of journey, which ideally join opposite points of the Pacific coast (e.g. between Asia and North America; Australia-New Zealand and South America) that the author assumed to have been initially in contact on a smaller Earth without oceans, covered by only continental crust (Scalera, 2003; Scalera, 2009). We shall find similar representations only at the dawn of the plate tectonics, for example in the work of Morgan (1968). In the same short article published in 1909 in the French magazine of Popular Science *Je m'instruis*, Mantovani drew a southern supercontinent before and after the separation of the fragments (Fig. 3).

The mapping is not rigorous (and indeed could't: the Italian was a talented musician, a professional violinist) but nevertheless very effective in depicting the idea. As a result of an exchange of letters, Alfred Wegener in a later edition of his book (Wegener, 1929; Scalera, 2009) recognized the priority of Mantovani in the reconstruction of the southern continents and in the continental displacements concept.

The realization of these early maps of Richard Owen and Roberto Mantovani – as well as the most famous ones of the continental drift of Wegener (1912, 1915, 1936) – was somewhat rough and this inaccuracy had to help in speed up the need to model the palaeogeography of the expanding Earth on spherical globes, avoiding the cartographic distortions of the projections on flat maps. This is a need similar to that which historically led to the

transition from world geographical flat maps to wooden globes (which existed already in Greek and Roman antiquity) and their apotheosis operated by Vincenzo Coronelli (1650-1718).

Joh. A.H. Kerkhoff

So it was that in 1928 the book of the Dutch Joh. A.H. Kerkhoff (under the nik-name Aero-Dilettant) appeared. Along with an original hypothesis on the origin of the Moon for ejecting of a fragment of Earth by a collision with a comet, the book contained photos of a paleogeographic globe – the early Earth – with a radius slightly more than half of the current one, completely covered by a mosaic of the present continents, without interposed oceans.

The author describes the experiment in which he traces the outlines of the continents from a globe and, levelling the fold belts to estimate the original size of the continents, shows that the continents make a good fit on a globe wit $R \approx 0.6$ of the actual radius.

The reconstruction was not performed with rigorous methods, and the prejudice of the expulsion of a large fragment of Pacific hemisphere must have forced the position attributed to the continents. The Mediterranean is – as it should be – closed, with the Italian peninsula Tyrrhenian margins faced to Libya.

The presence of 'Maan-Land' which will coalesce into a Moon does not allow Kerkhoff to solve what today remains a problem (see discussion in Scalera, 2007): the position of the North American Pacific margin joined to Asia or to New Guinea.

Erroneously, in some booksellers catalogue, the book is also today often judged as crank astronomy, crank science. Instead, it contains the first important example of a global paleogeographical reconstruction on a smaller globe. The way opened by Kerkhoff was followed by many others.

Ott Christofer Hilgenberg (1896-1976)

We do not know if the book of Kerkhoff has been part of the library of Ott Christopher Hilgenberg, but it should be noted that the publication of the German paleogeographic globes occurred a few years later, in 1933. The period of intellectual and material processing is compatible with the Dutch influence on his work, and moreover it is possible that the book by Richard Owen was among the readings of Hilgenberg during his early involvement in oil exploration in the U.S. (Scalera & Braun, 2003). However, he dedicated the book of 1933 to Alfred Wegener as the origin of inspiration for the ideas that he had developed in a yet more general scheme, including the expansion concept.

Hilgenberg's approach is more aware and more complete than the one set up by Kerkhoff globe. In the pamphlet of 1933, a photo shows his work table with the methodology, rough but efficient, adopted in the construction of the three paleogeographic globes (Fig. 5). Bringing the outlines of the modern continents on spherical caps of paper and then cutting them out and finally fitting the caps on globes of smaller radius, is equivalent to apply a cartographic equidistant transformation.

Hilgenberg was not only a globe-maker but also a scientist that continuosly progressed in his field. Never fully coopted by Berlin University, during his long life he persevered in refining the investigations about Earth's expansion by using all the new data was available in the after-war periond. The paleopoles published by Irving were collected and plotted on a paleogeographic reconstruction of Carboniferous (Fig. 5; Hilgenberg, 1965). A more complete biography of Hilgenberg can be found in Scalera & Jacob (2003).

Ivan Vasilievic Kirillov (1909-2004)

A major supporter of the concept of expanding Earth was Ivan Vasilievic Kirillov (17 February 1909 - 13 Mar 2004) in Russia. Kirillov worked on the expanding Earth theory starting from 1949, but the first publication of him came out in 1958. The Russian scientific community does not thought opportune to publish immediately his models of variable radius paleogeography, and only after nine years the Academy of Sciences of URSS, become interested in the Kirillov theses and invited him to hold a public conference. An extended abstract of the conference '*The hypothesis of the growing Earth and continents*', held in January 14, 1958, was then published, and the Kirillov work aroused interest in URSS and abroad (Kirillov, 1958, 1961).

Kirillov was not part of a staff of scientific or academic institutions. He worked professionally at aircraft and naval modelling, and for many years, before retirement, he was Director of a Naval Modelling Laboratory. The great ability to model allowed him to build without difficulty variable radius paleogeographic globes (Fig. 6) based on the data coming from paleogeography and paleomagnetism.

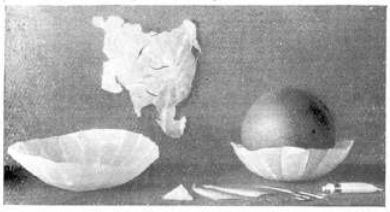

Abb. 1. Schelfkugel im Vergleich zu Kugelschalen aus Pauspapier, die sich dem zugehörigen, entsprechend größeren Globus anschmiegen, und Papierschelf von Eurasien mit Schlitzen in der Gegend der Hauptgebirge.

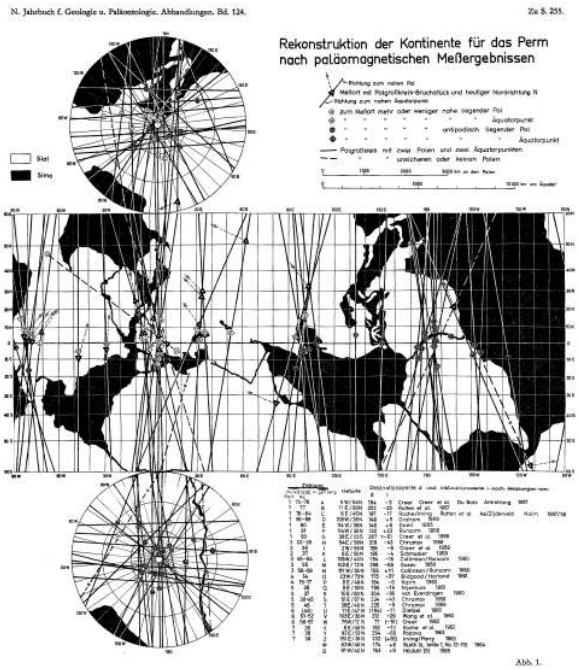

Fig. 5. Above left: photo of the work table of O.C. Hilgenberg published in his pamphlet of 1933. Stand out drawing paper, scissors, glue. The original caption reads (my translation): *Continental outlines on spherical parchment paper in comparison with larger spherical shells that wrap around a globe. The shape of Eurasia has slits at the main mountain ranges*. The slits are for Hilgenberg an attempt to take into account the expansion associated to orogenetic belts. Above right: photo of the paleogeographic globes (photographic plate by Bernd Kleeberg). Reproductions of the four globes were made in INGV (Migotto and Ferracci, 2003) and are in exhibition in the Observatory of Rocca di Papa, near Rome. Below: a portrait of Hilgenberg working to a wooden globe, besides his paleogeographic reconstruction of Carboniferous performed with the help of the paleopoles. India is not detached from Eurasia, and the block Australia-Antarctica is correctly joined. Because of the equatorial position of this block and of the interchangeability of North and South paleopoles, the block can be rotated of 180° assuming a position similar to the position in Scalera (2001).

The solution of Kirillov for the Pacific is very different from the Hilgenberg solution, and from the solution of others that worked and work today on the expanding Earth paleogeography, and this great variety of interpretation is testimony of how hard it is to reconstruct the past on the basis of the data and clues collected in the present. From seventieth, Kirillov's interest focused on the nature and effects of the gravitation and some papers of him were about these topics. He follows the way opened by Yarkovsky (1888, 1889) and anticipated themes that still today are under investi-

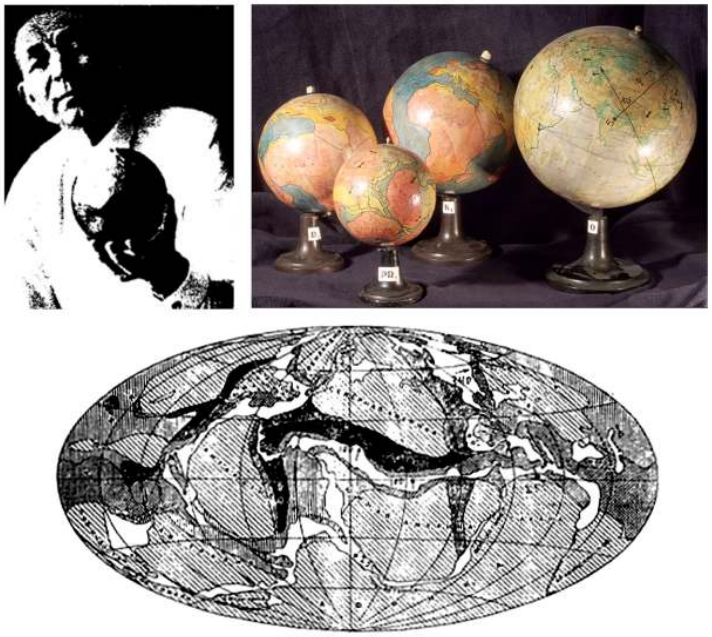

Fig. 6. Upper left: Ivan Vasilievic Kirillov portrait. Top right: the paleogeographic globes – diameters 14, 18, 22 and 25 cm – exposed for a few years starting in 2003 at the Museum of Geology "VV Ershov" in Moscow (photo by gentle permission of Ershov Museum). Below: The world map of the Earth covered by one sialic continental crust, with the current Pacific margins of North and South America in contact, according to Kirillov's interpretation. On the two intermediate size globes the Mediterranean is in closure, which is the opposite of all other reconstructions due to followers of the expansion.

gation by the followers of the 'Pushing gravity' (Edwards, 2002; Kirillov, 2003).

Ludwig Brösske

In 1952 it was published (at the expense of the author) a booklet of Ludwig Brösske that illustrated with several maps the global palaeogeography of an expanding Earth. The maps are not very accurate, it is not stated whether the method and projection used (if any), but the solutions are sometimes very original. For example, the configuration of the Mediterranean shows the Italian peninsula with Sicily, Sardinia and Corsica lying along a meridian and closed – without sea interposed – between Spain on the west and Yugoslavia and Albania on the east (Fig. 7a). The Mediterranean and its peninsulas in the Mesozoic and Paleozoic have always been a very challenging problem for paleogeographers (see Fig. 7abcd).

Brösske in 1962 published a more complete book in which four photographic poses of a paleogeographic globe were shown. In this last booklet it is explicit that before the opening of the Mediterranean the Iberian peninsula is located in the Sirte gulf of Libya (Fig. 7). The four poses (in an elegant version in India ink) had the honour to be published in the books of the physicist Pascual Jordan (1966, 1971) *Die expansion der Erde* and *The Expanding Earth: Some Consequences of Dirac's Gravitation Hypothesis*.

Rhodes Fairbridge (1914-2006)

A great name of Australian geology was the geomorphologist and climate change expert Rhodes Fairbridge. He was professor at the University of Western Australia and then at the Columbia University and acted as advisors for the Hydroelectric Commission of Tasmania (among many other activities). It may be that in Tasmania he knew personally Sam Carey, gaining a favorable disposition toward expanding Earth.

In a paper of 1964 (Fairbridge, 1964), *Thoughts about an expanding globe*, he wrote of an experience of carthography performed with inflated rubber balls, and published the results of this test as four sketches of globes of increasing size – Cambrian, Triassic, Miocene, Present. Fairbridge was a prolific editor of geosciences encyclopaedias – credited to be *The King* of the Earth science encyclopaedia – and

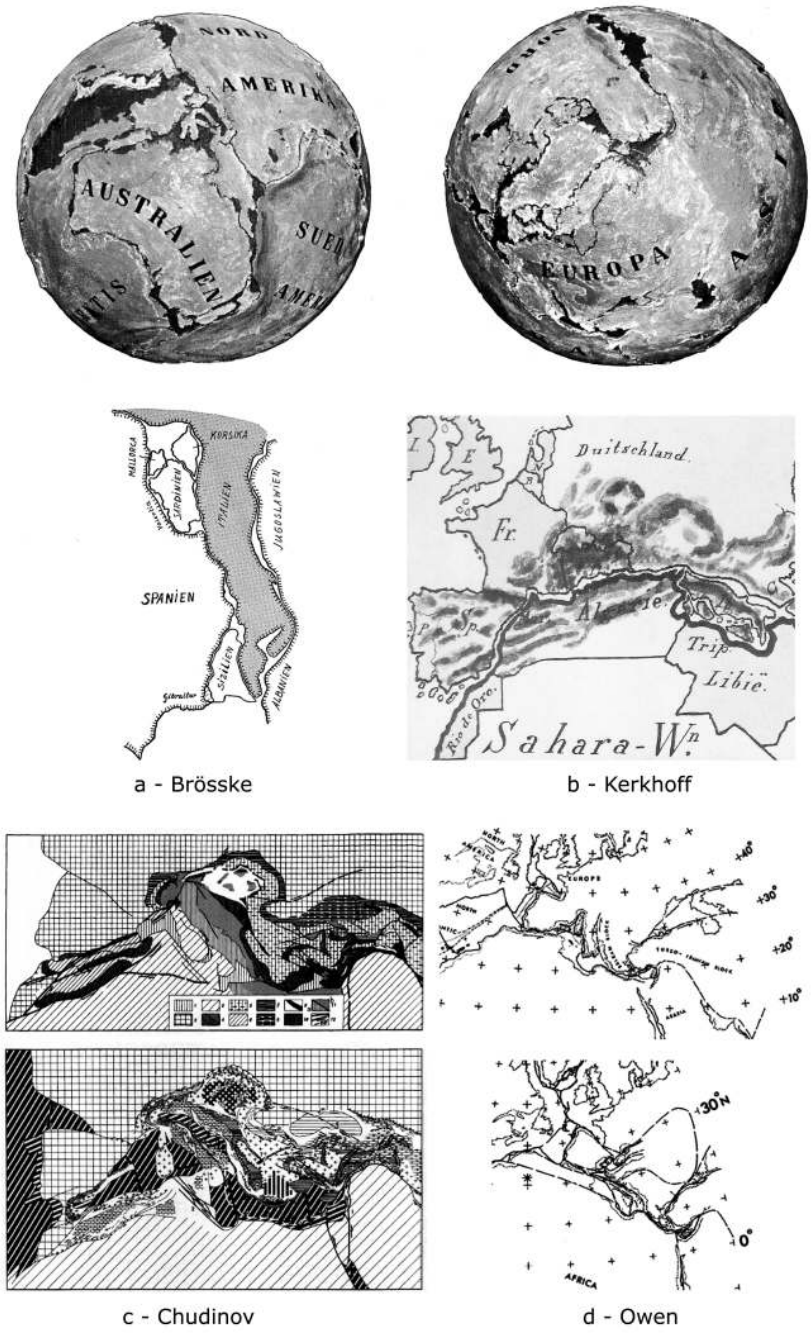

Fig. 7. Above: Two poses of the Brösske globes (1962). Below: Mediterranean reconstructions. a) Paleogeographic map of the Mediterranean by Brösske (1952). b) The same region by Kerkhoff (1928). c) The region according to the Russian Chudinov (1980), with rotation of the Iberian peninsula and the opening of the Bay of Biscay. d) Hugh Owen (1976, 1983) has drawn various positions of the land interposed between Africa and Eurasia, on the basis of data that continue to improve. In 1976 the Italian peninsula protrudes into the Gulf of Sirte, while in his atlas of 1983 is rotated towards the Iberian peninsula.

benefited from his connections with many editorial houses and in this case with the publishing house of Life. His sketches in black and white were supplied to the famous American illustrator and artist Ken Fagg (1901-1980), who elaborated them in color for a page on the

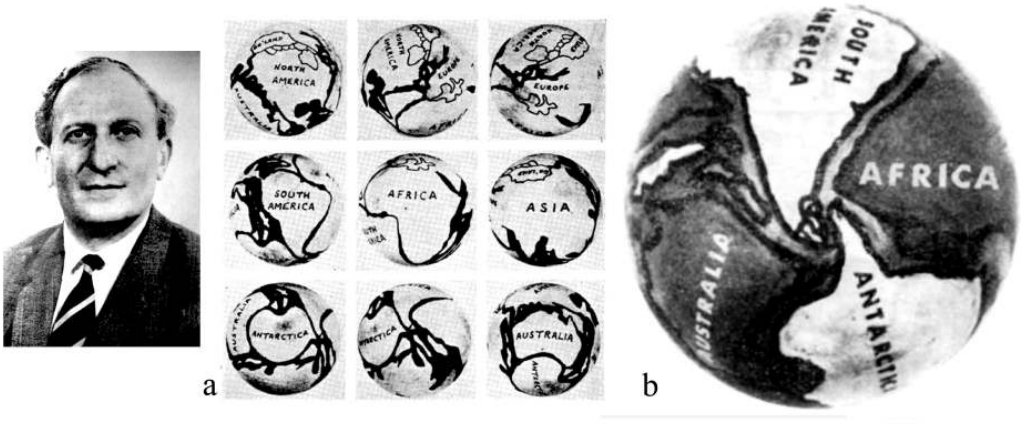

Fig. 8. The portrait of Cyril Barnett besides his globes. a) The wooden globe in nine poses in the first article on Nature (Barnett, 1962). b) The globe reproduced in the second paper (Barnett, 1969) where the author argues about the acuminate shapes of the continents, whose cusps were brought to coincidence on his reconstruction on a Earth's radius less than three quarters of the present one. The region of the cusps meeting was proposed as the zone of first opening of the supercontinent.

evolution of the Earth published on the great 'Life Pictorial Atlas' of 1961.

The caption of the paper of 1964 says:

> *Paleogeographic sketches of an expanding globe prepared from an experimental rubber model by the writer. Note that the orientation has been adjusted to the data on polar migration based on paleomagnetism, and that the coastlines have been drawn to the latest paleogeographic data. Particularly striking is the small amount of dry land actually exposed about the Cambro-Ordovician time. (From sketches prepared for the "LIFE PICTORIAL ATLAS").*

The caption of the Ken Fagg (McNally, 1961) elaboration of the globes says:

> *The globes on thls page illustrate one theory of the evolutlon of the continents. Graduated in size (from top to bottom) and dated from about 500 million years ago to the present, they also illustrate the theory that the earth itself has grown in slze since the very beginning of its existence. The expanding globe theory suggests that the earth began as a mass of cold radioactive dust whlch gradually warmed up over aeons. It began to expand, fracturing its relatively light crust and creating thousand-mile-long ridges that sundered existìng land masses. The present-day shape of the continents seems to suggest that some af them were once joined together.* (pag. 16)

The paleogeographic reconstructions on the Life Pictorial Atlas were printed without indication of the author's name, and – in my opinion – Fairbridge in his paper of 1964 was willing also to leave a witness of his contribution to the Atlas. At the end of the 60th decades, plate tectonics was adopted as the new Earth Science paradigm, and Fairbridges does not continued to work about this subject, and his ideas on expanding Earth were not know by most colleagues and scholars of him.

Albeit in anonymous form, the concepts of an expanding Earth were diffused worldwide in the Life Atlas, that had a number of translations in Europe and other countries, and continued to pass and evolve from mind to mind like a *meme* among people of any cultural background.

Cyril Barnett (1919-1970)

In 1962 Cyril Barnett – Department of Anatomy, School of Medicine, St. Thomas Hospital in London – cited the results of Carey and built a wooden globe of 7.6 cm on which moved thin rubber continental outlines cutted following the isobath of 1000 m on a modern Earth globe of 11.4 cm. He wrote:

> *The outline of each continent was transferred from such a globe [of 4.5 in. in diameter] to thin sheets of rubber and cut*

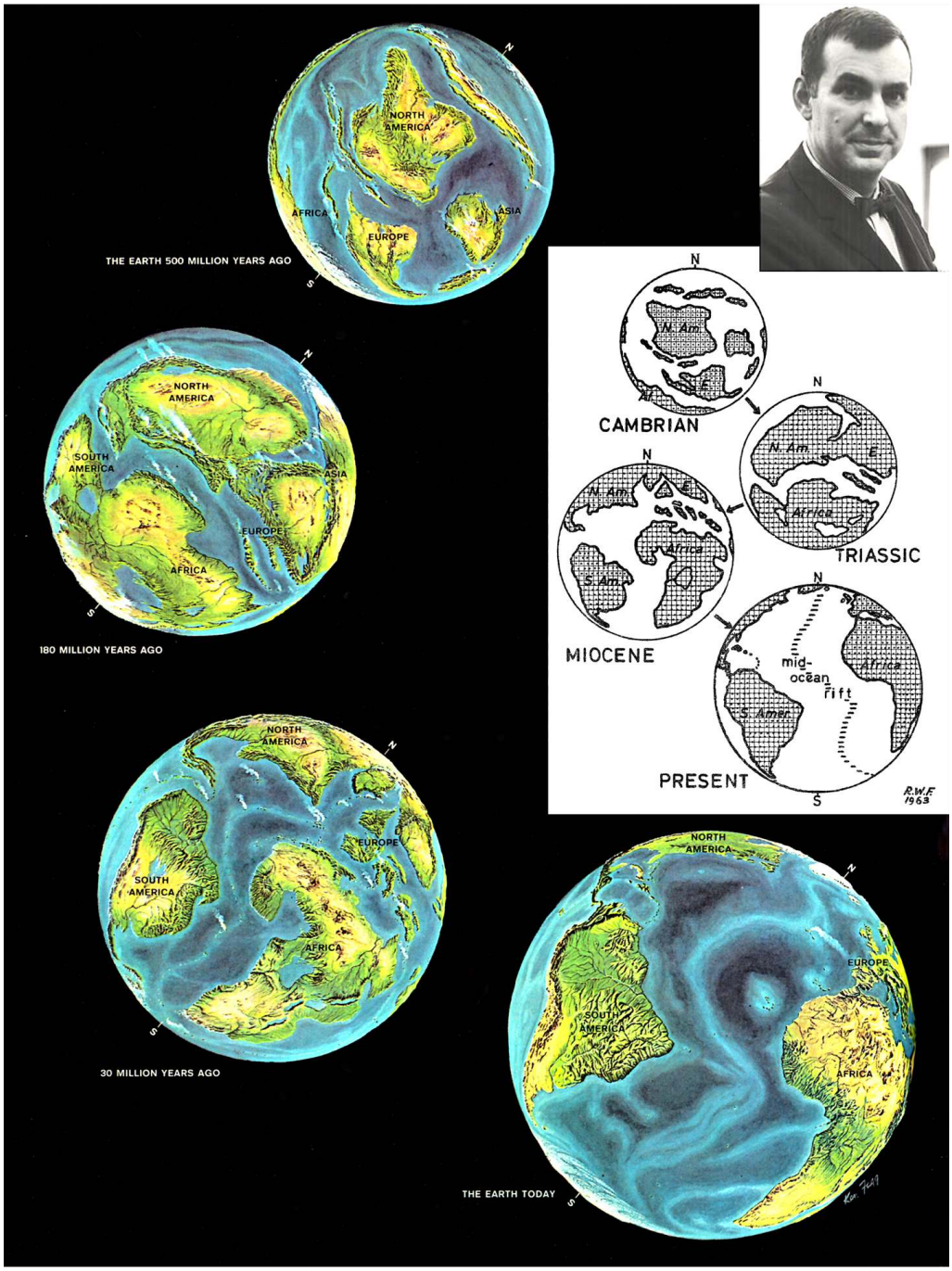

Fig. 9. The paleogeographic reconstructions of Rhodes Fairbridge printed on the Life Pictorial Atlas (McNally, 1961), besides his photo-portrait and the original B/W sketches (Fairbridge, 1964). The author performed an experiment using inflated rubber ball, and the final four B/W sketches – oriented following paleopole data – were provided to the american painter Kenneth Fagg, who elaborated them in full color.

out. The separate pieces of rubber were then placed on a wooden ball 3 in. in diameter and their outlines marked on the wood, to represent the appearance of the Earth soon after the hypothetical splitting of the crust. Despite the crude method used, the land masses fitted together reasonably well, though there was some distorsion of certain regions and there was a triangular gap in the North Atlantic ocean.

Queued to the article by Barnett (1962), once again Harold Jeffreys commented on the possibility that the rubber sheets could have suffered significant distortions in the transition from one globe to another.

The reason why Barnett was interested in the expanding Earth concept resides in his period of working in Australia, before to came back in London (and to die before his time). He probably knew Sam Carey for a medical consultation or surgery – he was interested in the anatomy of orthopaedic conditions and Carey was bearer of a knee metal prosthesis. The obituary of Cyril (Anonimous, 1970) says:

[. . .] In 1956 a grant from the Nuffield Foundation enabled him to take a temporary appointment in the anatomy department of the University of Melbourne under Professor Sydney Sutherland. In 1964, with permission from the University of London, he was seconded to Hobart, Tasmania, to act as foundation professor of anatomy and dean of the new Medical School. [. . .]

[. . .] Professor Barnett's scientific interests ranged widely from the interpretation of Aboriginal bark paintings to the formation of the earth's continents. [. . .]

Samuel Warren Carey (1911-2002)

One of the most important formulators of the ideas of the expansion tectonics was the Australian geologist Samuel Warren Carey, also considered one of the greatest thinkers of the last century in the field of earth sciences. Carey did not know the rudiments of mathematical cartography and never performed paleogeographic reconstructions of Terrelle of smaller radius. His only achievement was the cover of the Proceedings Book of the symposium "The Expanding Earth" held in Sydney on February 1981, which was a general concept-cartoon of a series of eight globes – from the primordial meteoritic bombardment to the opening of Pacific.

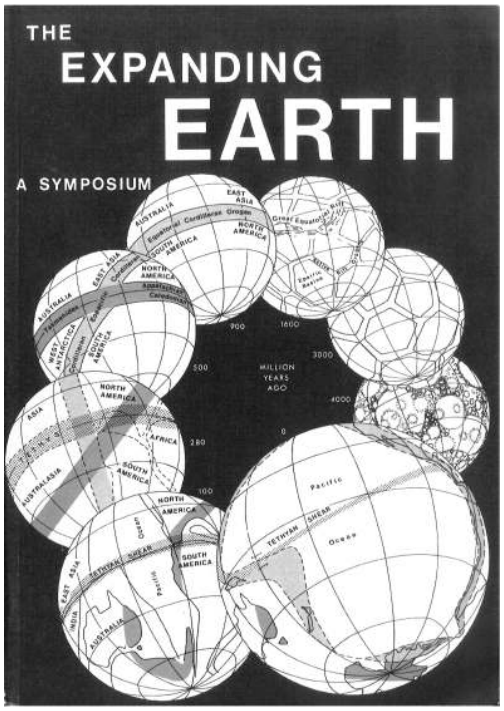

Fig. 10. The cover of the Proceedings of The Expanding Earth Symposium convened by Carey in Sydney on 1981.

Instead, he was captured by the problem of cartographical distortions and prompted to action by the criticisms that Sir Harold Jeffreys addressed to the computerized reconstructions by Bullard et al. (1965) (criticisms of bad agreement between the continental profiles brought into contact) and Barnett (1962).

Carey decided to demonstrate the goodness of 'fit' of the continents Atlantic eliminating any distortion possibly coming from the map projections. So he set up in the laboratories of the University of Tasmania in Hobart all that was necessary for the production of sheets of translucent spherical paper, and with these caps lying on a globe of equal radius, he could move the continent outlines without distorting their shapes. He showed that this fit of Africa and the Americas, to the isobath of 2000 m, was better than the computer fit of Bullard and that the criticisms of Jeffreys were unfounded. Carey provided an independent test of the mobilism, although then he fought for his more extreme version: a not only tangential mobil-

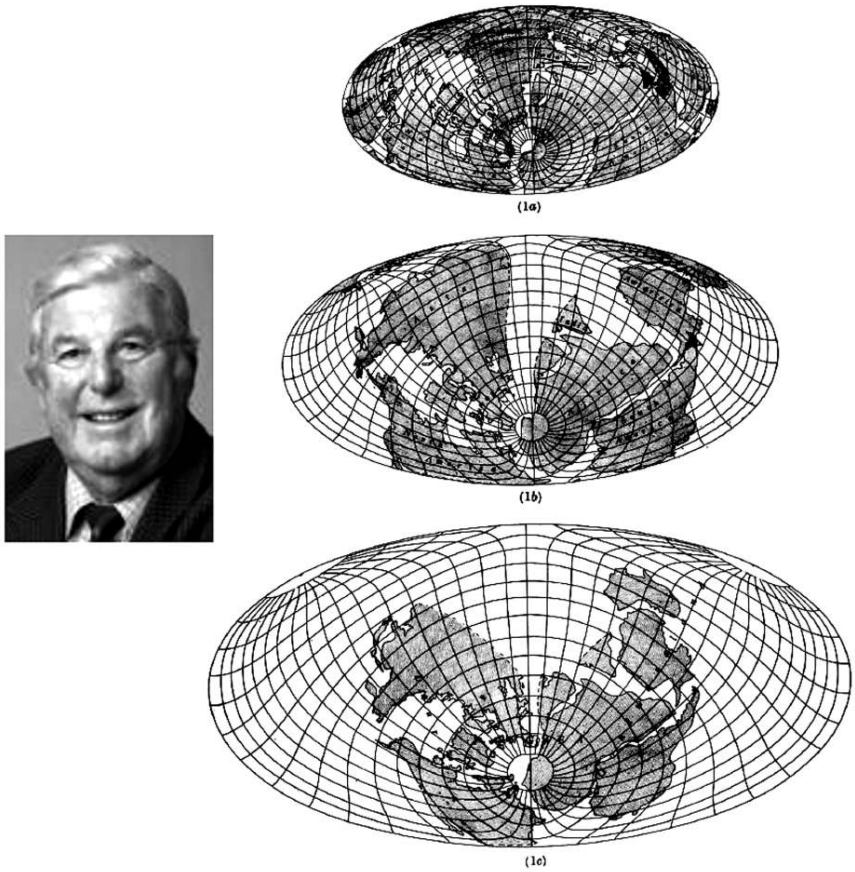

Fig. 11. The three paleogeographic reconstructions published by Creer on 1965. The original caption reads: *To illustrate how the shapes of the continents are consistent with evolution on an expanding Earth. Radius of Earth in (a) is 0.55, in (b) and 0.77 in (c) 1.0 of the present radius.*

ism, but also a radial one, with neat expansion of the planet.

Kenneth Medworth Creer

Kenneth M. Creer (born on the Isle of Man on 1925) has been one of the major paleomagnetists of the last century, brought up in the talent pool of Keith Runcorn (1922-1995). He, too, was fascinated by the possibility of an expansion of the Earth and performed an important cartographic experiment in the 60s (Fig. 9). In the paper on Nature (1965) Creer wrote:

> *I have formed the impression that the fit of the continents on a smaller Earth illustrated in Figs. 1a and 2a appears too good to be due to coincidence and hence requires explaining. The simplest explanation appears to be expansion of the Earth, and one purpose of this article is to suggest that this hypothesis should be taken seriously.*

Creer reconstructed the palaeogeography on perspex globes referring to the isobath of 500 fathoms (about 914 m). Starting with a perspex sphere of diameter 50 cm, continental fragments would have to be adapted to the greater curvature of a globe of 27 cm (radius 0.55 of the actual Earth), which would have been completely covered by the continental sialic crust (Fig. 10). The easiest way

was chosen to always use the sphere of 50 cm and to build spherical continental outline of glass fiber with the same curvature but of proportions increased by a factor of 1/0.55 = 1.82. Also in this case the effective cartographic projection was the equidistant one. Creer (1967) published the same 'experiment' on the sumptuous Runcorn's International Dictionary of Geophysics, which greatly contributed to legitimate and promote the ideas of the expanding Earth, and the new wave of publications appeared from the seventies onwards (Carey, 1975, 1976; Hilgenberg, 1974; Chudinov, 1976, 1980; Owen, 1976, 1983; and many others).

Raymond Dearnley

A more geological approach was proposed in the same years by Raymond Dearnley at the Geological Survey and Museum in London. After having reconstructed the supercontinent on the actual radius globe using a modified stereographic projection (Dearnley, 1965a, 1966), he made the progress to reconstruct the Earth's paleogeography at a radius $R = 4400$ km at the age 2750-1950 My (Dearnley, 1965b, 1966). He transferred the continental outlines ad data from a 34.3 cm globe to a 23.6 cm one, with a declared awareness of the criticism of Jeffreys (in Barnett, 1962) and Dennis (1962). The aim of this experiment was to try to prove that the ancient fold belts prolong from a continent to the adjacent ones, when the Earth's crust was nearly completely sialic (Fig. 10).

This experimental approach to cartography was republished on the special volume edited by Runcorn in 1969, after a Conference in Newcastle Upon Tyne, confirming the role of great open-mind organizer of cultural events of Keith Runcorn. In the same Conference Proceedings the base maps of Dearnley was used by Henri Termier (1897-1989) and Geneviéve Termier (1917-2005) to plot the results of their paleontological researches. It may be useful to remember that the Geological Survey & Museum merged in the Natural History Museum, where perhaps Dearnley inspired the more complete cartographic work of Hugh Owen, which will be discussed below.

Bruce Heezen & Marie Tharp

In this panorama of the 'experimental cartography' a special case are the physiographic maps of the ocean floor relief built with the data collected from Bruce Heezen (1924-1977) between the fifties and sixties and perfected with the help of Marie Tharp (1920-2006) (Heezen et al., 1959; Heezen, 1962; Heezen & Tharp , 1977). Many expansionists would have no difficulty in admitting that in the planisphere of Heezen & Tharp painted by the Austrian artist Heinrich Caesar Berann (1915-1999) is written the history of an expanding Earth (Fig. 11). This rare blend of art and science, despite the fact that it is not variable radius cartography, has greatly contributed to strengthen and passing down the ideas of the expanding Earth concepts.

Heezen was initially a follower of the expansive view (Heezen, 1959) and this planisphere can be considered his scientific legacy to the community of Earth Sciences. The maps produced by H&T are also an example of how a restriction imposed on cartographic methods caused by the cold war (it was not possible to publish bathymetric charts of the seabeds) and the subsequent retreat of the cartography on more qualitative methods, made it possible to produce maps never more reached on that what concerns their evocative and synthesis power. Copies of the maps were exposed in large numbers and great evidence in the corridors that we graduates of the Institute of Physics of the University of Bari traveling along every day, and often they caught our attention and were admired as an example of what of new the modern science had produced in geology.

The physiographic map of the world (Heezen & Tharp, 1977) was for me more than just a simple depiction source of meditations, but also and especially a test ground. Already familiar as a boy to similar activities using the more incomplete introductory physiographic maps of the Atlas of Readers Digest (when I reflected on the possibility that the Arctic Ocean was a large circular crater remnant of an impact that would inflate the Earth – an idea that later I abandoned), it is cutting out continental outlines from photocopies of the map of Heezen, Tharp and Beramm that I could, with great emotion, recognize the similarities of shapes in the Pacific between continents and ocean basins, the first in the south between South America and the Coral Sea, then between the margin of western North America and the lineament to the north of New Guinea (Manus, Salomon, Vityaz), with the added value of the similarity between the shape and position of the small Juan de Fuca plate and the oval of New Britain.

Cartographic distortions manifested with undoubted evidence in this 'experiments' on

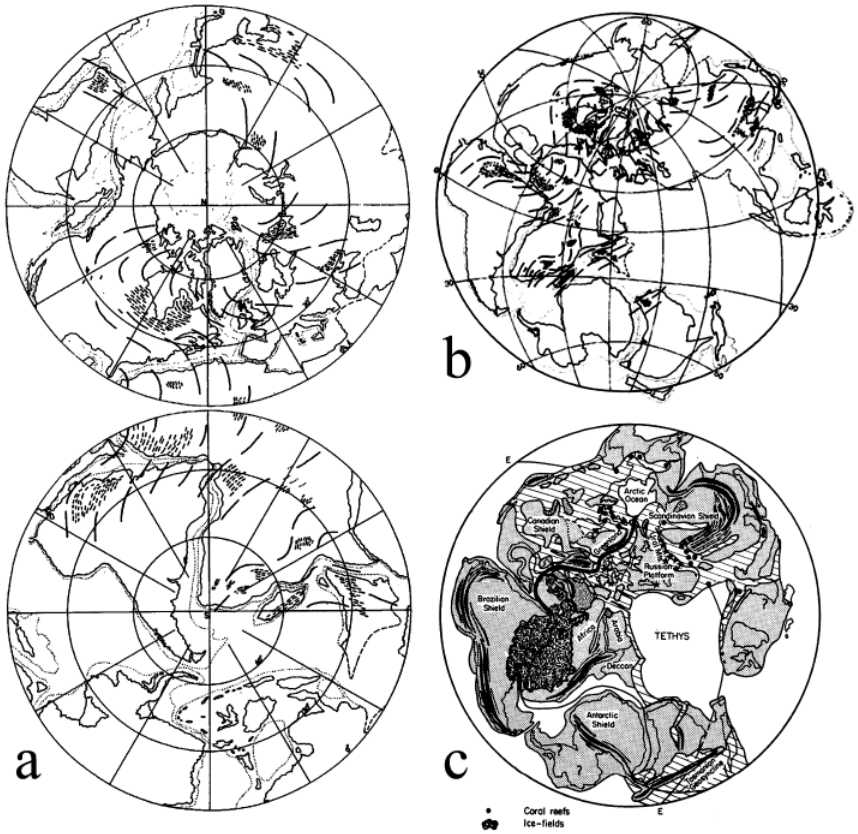

Fig. 12. The Raymond Dearnley's experiment. a) – The two polar stereographic projection of the Arctic and Antarctic regions at a radius $R = 4400$ km. The prolongations over two or more continents of the orogenic belts are drawn. b) – The paleogeographic reconstruction in a modified stereographic projection of the supercontinent at 2750-1950 My. c) – A plot of paleogeographic indicators on the base map of Dearnley performed by Termier & Termier.

the North Pacific. It was necessary to avoid them, building a Fortran program that allowed to see that the outline of the North American continent was well matched to the profile of the basin of the North West Pacific.

4. Old and New Ganged in Recent Decades

What made different the experimental cartography of the last decades of XXth century is the availability of the ocean floor magnetic survey data and interrelated geochronological data. All these information on the linear magnetic anomalies and on the ages of the seafloor constituted soon the subject of important works of synthesis like the map Identified Magnetic Sea-Floor Spreading Anomalies by Roeser & Rilat (1982; and many sub-sequent others) and the map The Bedrock Geology of the World (sea floor age), by Larson et al. (1985; and many subsequent others).

Hugh Owen

In London, U.K., Hugh Owen at the British Museum of Natural History felt the duty to implement the Creer and Dearnley experiments in a more complex way, with the methods that classical cartography used to build globes. To reproduce on the map large areas of the Earth's surface one uses special interrupted projections that divide the land into segments (gores). An interrupted projection is a way of reducing the distortion inherent in representing the surface of a sphere on a flat piece of paper. Within a gore, distortions due to the projection remain contained within acceptable limits. The inverse procedure is used to build geographic Earth's globes. The factories of globes – to cover a

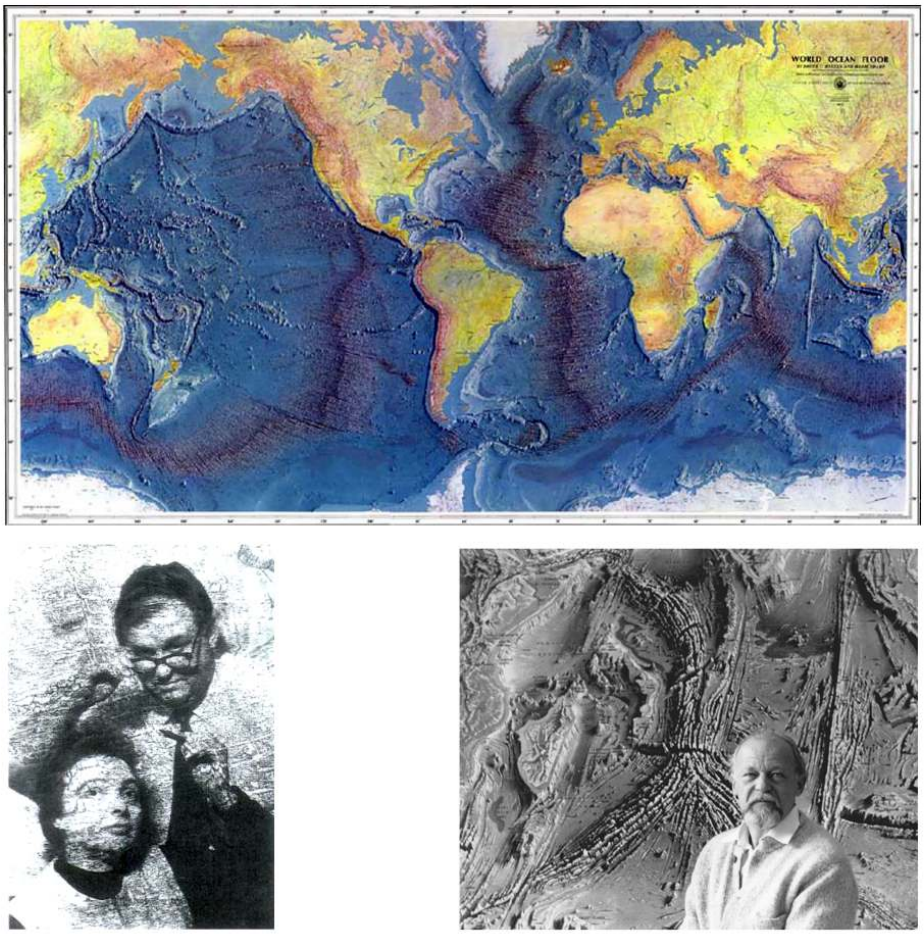

Fig. 13. Above: The Map of The World Ocean Floor by Bruce Heezen & Marie Tharp (1977) painted by the Austrian artist Heinrich Caesar Berann. Below: Tharp and Heezen working on a transparent physiographic map at the Lamont Geological Laboratory (now Lamont-Doherty Earth Observatory) and a portrait of Berann.

heavy cardboard or plastic material globe (in the past gypsum or wood) – split the world into 12 gores, each one 30 degrees of longitude wide, suitable for applying onto the surface of a physical globe.

Owen used 36 gores of 10° and each gore was split also latitudinally every 10°. He had then $36 \times 18 = 648$ trapezoidal fragments of nearly free from distortions Earth's geography. With a complex procedure he computed the deformation to apply to each fragment when located on the 10×10 reticulate of a new planisphere (eventually with radius less than the actual). The first challenging publication by Owen – nearly 70 pages – went out in the Philosophic Transaction of the Royal Society of London in 1976. The five regions studied in details were the Artic Ocean, Atlantic Ocean, Mediterranean, Indian Ocean, Pacific Ocean. The investigation of the author covers the Recent, Tertiary and Mesozoic.

In the preliminary steps of this experiment, inflatable rubber spheres was used and continental outlines cut in polystyrene sheets, referring to the 1000 m isobaths of a 38 cm diameter globe. Owen in this preparatory phase concluded that the continental fragments undergone unpleasant mutual overlapping at radiuses lesser than $R = 80\%$ of the actual RE, and at this limit he stopped the investigation,

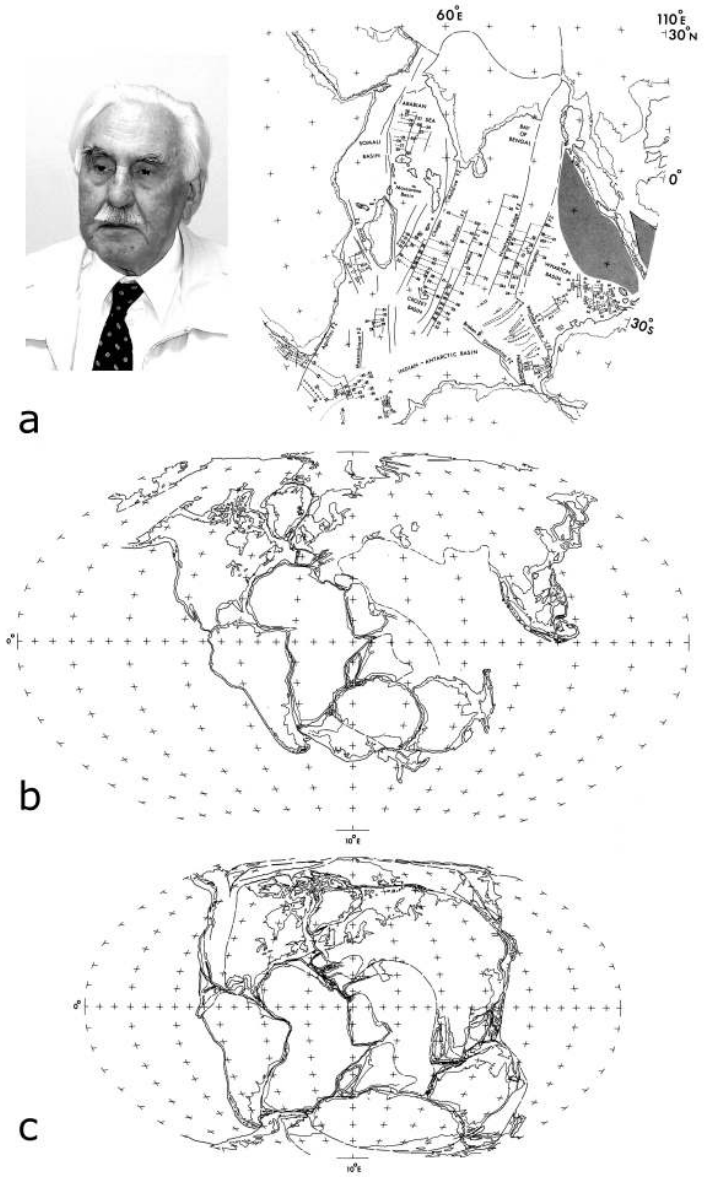

Fig. 14. a) A portrait of Hugh Owen besides the reconstruction of the Indian Ocean in Paleocene at 94% of actual radius, with the ocean floor magnetic anomalies. b) Pangea at actual Earth radius with the open Tethyan fictitious gore. c) Pangea at 80% Earths radius with Tethys closed.

but being aware that a complete sialic crust would be possible only at about 50%.

He divided the Jurassic to Recent interval in five sub-intervals, assigning the intermediate radiuses. The epochs mapped in his study were lower Jurassic (180 Ma, $R = 0.80 \times RE$), early Cretaceous (Hauterivian, 120 Ma, $R = 0.87 \times RE$), mid-Upper Cretaceous (Turonian, 90 Ma, $R = 0.90 \times RE$), early Tertiary (Palaeocene, 60 Ma, $R = 0.93 \times RE$), middle Tertiary (Oligocene, 30 Ma, $R = 0.97 \times RE$) and Recent. The linear magnetic anomalies of the ocean floors were for the first time used in the expanding Earth paleogeographic reconstructions to evaluate the amount of ocean floor to be eliminated because younger than the age of the map.

Owen's Pacific Region reconstructions do not show the Pacific completely closed, because he was convinced of the reality of the

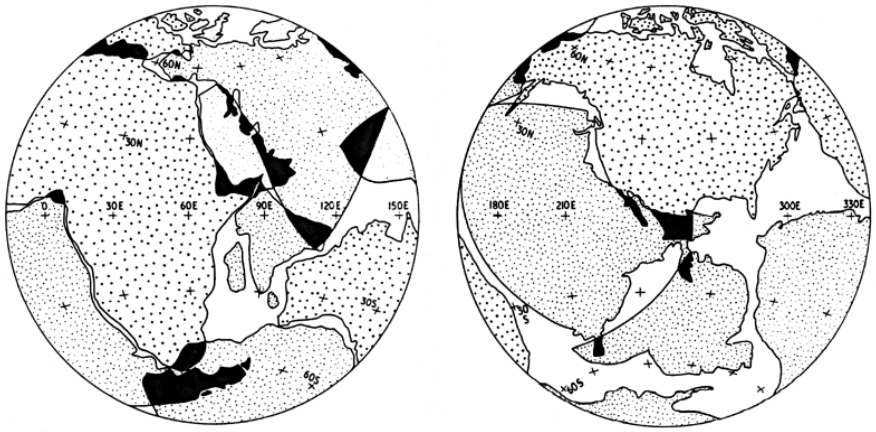

Fig. 15. The reconstruction of Schmidt & Embleton (1981). The continental outlines and paleopoles have been recalculated and fitted for a small Earth of 0.55 present radius by using an adaptation of Ward's (1963) method – which is the analytical equivalent of the numerical geometric one (Scalera, 1995).

subduction process. He adopted in this first 'Atlas' the zenithal equidistant projection, but a new projection – the Triazimuthal projection, explained in an appendix – was elaborated for the regional planispheres (Atlantic, Indian, etc.), getting a fair representation of equatorial and polar zones on the same map.

The second more complex and accurate effort of Owen was the famous Atlas of continental displacement, 200 million years to the present published on 1983 for the types of Cambridge University Press. The same limit of $R = 0.8 \times RE$ was adopted, and the epochs become seven: late Triassic to lower Jurassic (180-200 Ma, $R = 0.80 \times RE$), Oxfordian (146 Ma, $R = 0.84 \times RE$), early Cretaceous (Hauterivian, 120 Ma, $R = 0.87 \times RE$), mid-Upper Cretaceous (Turonian, 90 Ma, $R = 0.90 \times RE$), early Tertiary (Palaeocene, 56 Ma, $R = 0.94 \times RE$), middle Tertiary (Oligocene, 29 Ma, $R = 0.97 \times RE$) and Recent. A profusion of cartographic projections were adopted according to the different requirements of the sections in which the atlas was divided. Besides the Mercator, the Azimuthal equidistant and the Tripel Winkel, a modification of the Azimuthal equidistant projection devised by Brigadier Guy Bomford (1899-1996; renowned geodesist and paleontologist) was adopted, in order to reduce distorsions on the peripheral regions of the Pacific hemispheric maps.

Owen's non secondary aim was to provide a series of base-maps to paleontologists, in order to cheek the goodness and eventual continuity of fossil distributions on an expanding

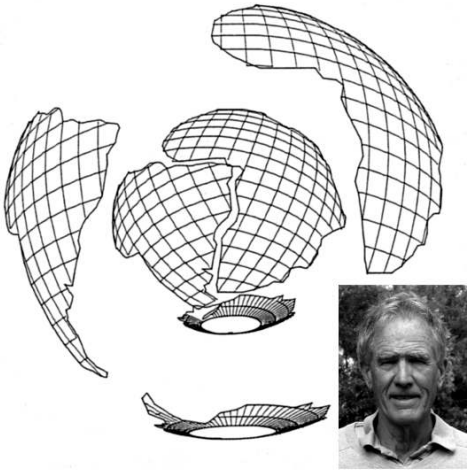

Fig. 16. A portrait of Ken Perry besides his globe-in-globe (from his unpublished paper of 1986) representing the opening of the Atlantic.

Earth. So, to allow a comparison between rival theories, the paleogeographic reconstruction adopting the actual radius was drawn, besides the lesser radius one. Despite the polite approach, not extremist and possibilist with respect to important aspects of the ideas of the main stream, the influence of the Owen Atlas was very large. He achieved the milestone of making you feel not incompatible two different concepts. However, the two kernels – philosophical and cosmological – remained distant, if the origin of the expansion process was located in a super-dense core at the center of

the Earth remnant of a supernova explosion (the primordial Sun). Even today a current of 'expanding Earth' considers to be justified the concept of subduction, trying to reconcile the two theories that, in fact, in the sixties had already run along common way: the expansion of the ocean floor and the expansion of the Earth were considered almost synonymous.

Embleton & Schmidt

After the Second World War, not only the geomagnetism of the seabeds developed, but also a new impulse to paleomagnetic investigations was provided by Blackett, Runcorn and their pupils Irving, Tarling and many others. The new paleopole data allowed Embleton and Schmidt in Australia to repeat and to perfect an experiment already performed many years before by Hilgenberg (1962) (Embleton & Schmidt, 1979; Schmidt & Embleton, 1981; Embleton et al., 1983). The recognition of common apparent polar-wander paths for Africa, Australia, Greenland, and North America in the Proterozoic, indicated that today these continents are in the same relative locations on the globe as they did in the early Proterozoic. The compatibility of this fact with the expanding Earth view was proved, and they concluded that an *Earth of about half the present radius accommodates the present continents in such a manner that this paradox can be satisfactorily resolved* (Schmidt & Embleton, 1981).

After them, a growing need to made paleogeographic reconstructions based on paleopole data leads to the assembling of paleopole catalogues, like those of Khramov (1984), Piper (1988), Westphal (1989), Irving et al. (1990), Lock & McElhinny (1991). Especially the catalogue of McElhinny – The Global Paleomagnetic Database (GPMDB) – and the extraction of data facilities maintained by different institutions (NOAA – National Geophysical Data Center; Norges Geologiske Undersokelse – Geological Survey of Norway) was sub-sequently used by the researchers involved in the expanding Earth cartography (Maxlow, Scalera). After McElhinny and Lock the database was maintained and updated by Sergei Pisarevskiy, but the funding by NSF stopped and unfortunately the data are available up to 2005. It is hoped that this impasse is overcome, considering the great importance of GPMDB for anyone involved in paleogeography.

Ken Perry

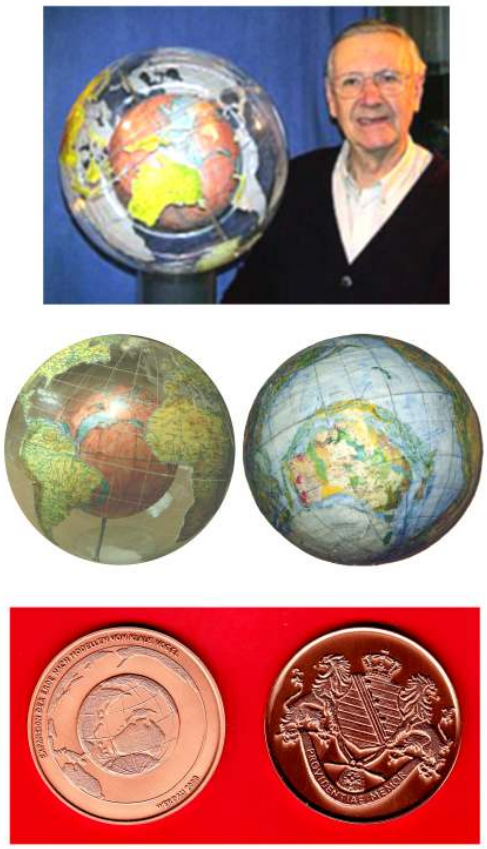

Fig. 17. Above: a portrait of Klaus Vogel besides his globe-in-globe. Below: an Atlantic view of the globe-in-globe donated to INGV in Rome, and a early Pacific view of a paleogeographic globe where Vogel has used a map of the World Geology. The medal that the Municipality of Werdau has conied in honour of Klaus is also shown.

Kenneth Perry was born in 1932 in New York City. As a graduate student involved in rock chemistry at Yale University, in the academic year 1959 to 60 he attended a seminar given by Sam Carey. In 1980's he developed an interest in digital mapmaking, and with the aim to investigate the possibility of earth expansion he created a computer model which, assuming continents are rigid bodies, attempted to close present day ocean basins on a smaller globe. On this subject he wrote two manuscripts that do not overcomed the referees scrutiny (Perry, 1984, 1986). Carey was in touch with him and two figures of Perry (1984) were printed in Theories Of The Earth And Universe (Carey, 1988; and in other publications of the Australian).

The two unpublished papers deal essentially with the Atlantic side of the Earth, leaving unresolved the problems of the Pacific closure. Discouraged from the difficulty to publish his works and probably from the isulation that the academic world reserves to researchers not adopting main stream ideas, Perry abandoned the scientific investigations and created a small business of services and mapping software (Chalk Butte Inc, Boulder, WY). He developed a didactical cartographical software – on Macintosh platform – to illustrate to high school students the principles of plate tectonics. It is his belief that available observations fail to conclusively support either plate tectonic or expanding earth models.

Klaus Vogel

The civil engineer Klaus Vogel lives in Werdau (Sachsen), with his wife Eva-Maria, in a nice house full of paleo-globes, and have worked as entrepreneur having a factory of building materials. Vogel is fond of Geology, and – assisted by geologists – have made experiments with concrete to demonstrate the types of fractures similar to those that can be found in all continents. Expansion of the Earth is his hobby, taking many conference on this topic in Germany and abroad. About 1977 he started with his first globe models that illustrate the various stages of the expansion of the Earth (Vogel, 1979, 1983, 1984). He adopted the method of Hilgenberg, and can be considered his heir. The paleogeography was reconstructed by cutting various geological mapping and also the Geological Map of the World (CGMW, 1990, 2000).

Klaus nicer realization has been the so called globe-in-globe, namely a transparent actual globe containing a coaxial terrella covered only by continental sialic crust. After attending the conference ”100 years after Tunguska 1908-2008” the University of Moscow begged him to give one of the paleo-globe to be exhibited in the hall of the Geology Institute of Mining En-gineering. Recently the municipality of Werdau coined a medal in honor of his laboriousness as paleogeographer. Globes of Klaus are also in Wrocaw and in Rome at INGV. He was invited to have a stage in the University of Tasmania of Hobart by Carey in the eighty, and I found a sample of his globes in the office of Sam Carey that I visited a little after him. The passionate and continuous work of Klaus Vogel in Germany as ’globe-maker’ constitutes a true junction between old and new.

James Maxlow

A similar work was made in Australia by the geologist James Maxlow that wrote a doctoral thesis about the expansion of the Earth at the Curtin University. His method is more elaborated with respect to predecessors and consists in a sort of mixing between physical and digital globe-making.

The starting map is the Geological Map of the World (CGMW, 1990, 2000), which was digitized and colored using MapInfo GIS software. The native Mercator projection was converted, using a software code into a twenty-four-gore sinusoidal projection map to get undistorted, true-to-scale printed geological information.

The map was printed to a series of scales greater than the physical globe to simulate a smaller terrella (like Creer’s method), and the printed outputs were cut and pasted onto each of the spherical small Earth models (all on 30cm diameter high-density polystyrene foam spheres). Maxlow (2013) says:

> *For each small Earth model, plate assemblage was established and maintained by removing each coloured seafloor stripe in turn and manually cutting the continental and oceanic geological information from the sinusoidal base map and pinning and pasting to polystyrene foam spheres as required. The varying radius of each small Earth model constructed was allowed for by varying the output scale of the printed sinusoidal base maps and once each model was completed it was digitally rescaled to the correct size using Photoshop. Geographical grids were established for each model by using published palaeomagnetic data to locate the magnetic poles.*

In the final steps of perfecting the globes, taking photos of them, retouching using a graphic software and their virtual rescaling, Maxlow was assisted by his wife Anita, a professional in fine art and graphics.

The cartographical results of Maxlow were published in a number of thesis, papers and a book (Maxlow, 1995, 2001, 2003, 2005, 2012; Scalera & Jacob, 2003; Scalera et al., 2012). The globes have been used to plot on their surface different paleogeographical indicators (geological, paleontological, paleomagnetical), and some of the James spheres was in exhibition in several occasions and conferences.

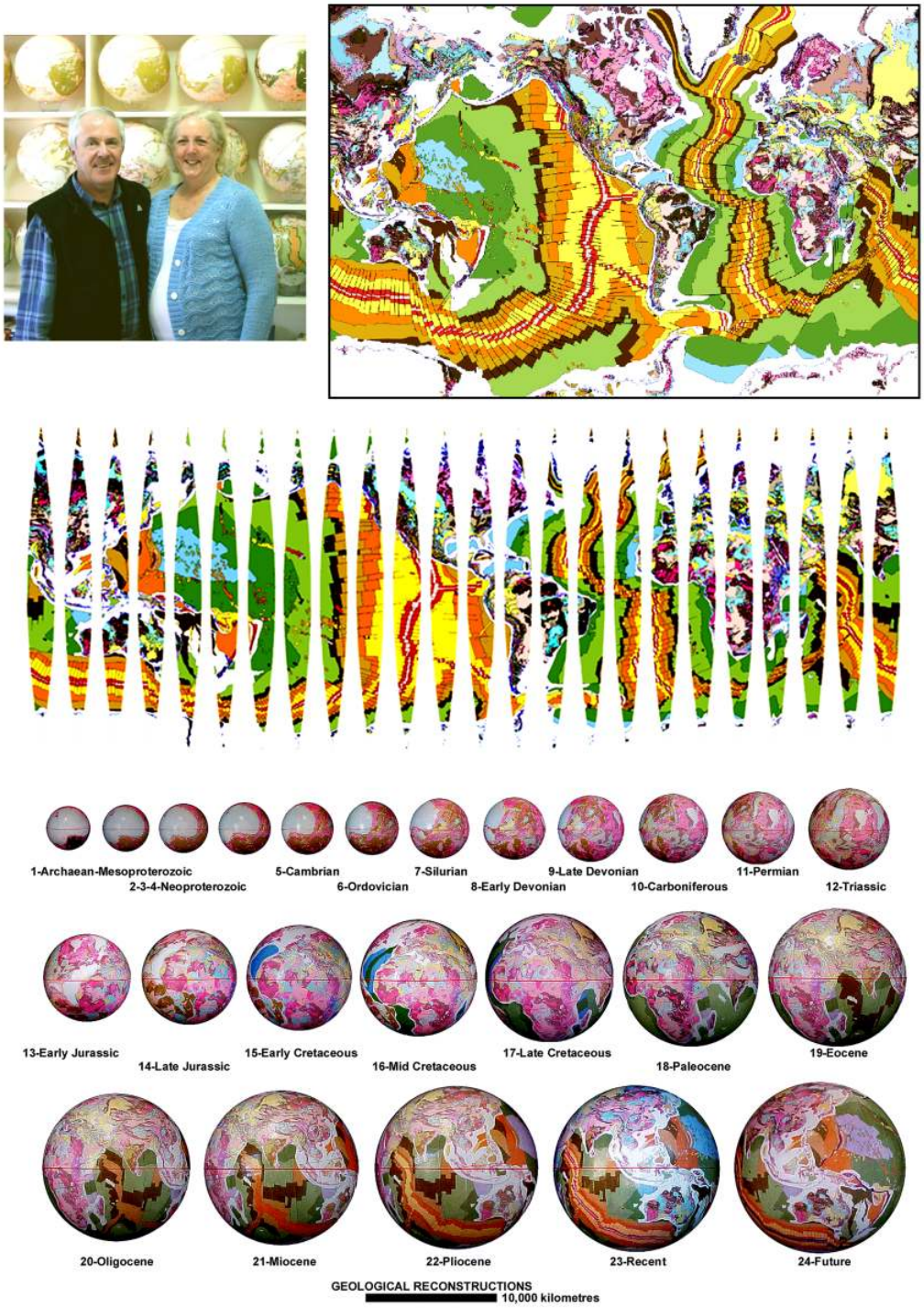

Fig. 18. Above: The portrait of James and Anita Maxlow besides The World Geology Map of CGMW (1990, 2000) transformed in an interrupted sinusoidal projection with 24 gores. Below: The series of globes of James Maxlow photographically scaled to the old size of Earth. The original series of 30cm diameter high-density polystyrene foam spheres can be seen on the background of the portrait of the authors.

5. Cartographical Experiments at INGV

My involvement in variable radius cartography began in the early eighties, when I was hired at Istituto Nazionale di Geofisica at the Geophysical Observatory of Monteporzio Catone. I was fascinated by the book of Samuel Warren Carey The expanding Earth and immediately I noted that the book does not contained precise paleogeographic mapping. The decision to ask for an initial help to Hugh Owen in building a computer code was taken and a letter to him was delivered (I belied that a digital method was used for his Atlas). Hugh was very gentle and completely collaborative and soon delivered to me the materials he had used: the complete set of 648 trapezoidal fragments of Earth's geography, providing detailed instruction about how to deform them on different projections reticulate. This material was not what I expected, because I need to plot also paleopole data. In my project I would have to reproduce, but with variable radius, the method of compter-mapping by Bullard, Everett & Smith (1965) and Smith & Hallam (1970).

Another attempt was to write on the advice of SW Carey to K. Perry in the U.S. to ask the computer code used for a depiction of the opening of the Atlantic on a land expansion (reproduced in Carey, 1996). I received the print of a short code (in Basic language that I don't know) and I was unable to determine the projection used by Perry and the overall method to transfer outlines from a radius to another. Carey when visited Rome assured me on the goodness of the Perry work but I decided to build a personal code to have the complete control of the method.

A FORTRAN code was then developed step by step, allowing the first experiments to be performed (Scalera, 1988, 1990). In the first paper the tentative reconstruction of Pangea on an half-radius Earth was checked – without use of geomagnetic or paleomagnetic data – and a first partial recognition of the existence of conformities among continental outlines and oceanic lineaments was described. In the second paper the paleopole data were handled and plotted passing from a radius to a lesser one.

Plotting paleopoles on smaller globes

My culture in cartography was extracted from classical book like Richardus & Adler (1972) and Pearson (1984), but in this phase,

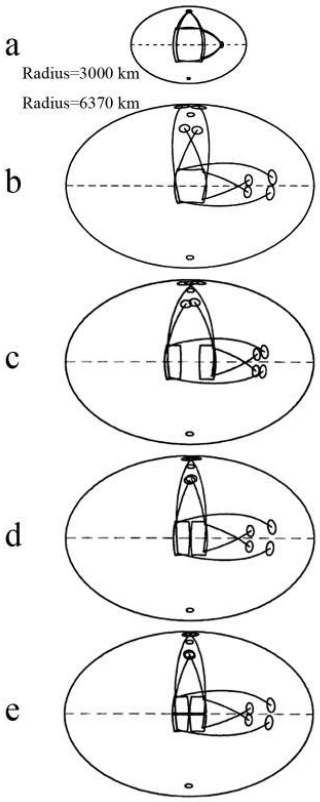

Fig. 19. Trasferring a plate and its paleopoles from a globe of 3000 km radius (a) to one with a radius of 6370 km (b,c,d,e), using the equivalent law of projection. b) The plate conserves its size (the area), while the site-pole angular distance must be conserved. The effect is the typical dispersion of the paleopoles, which is greater along the meridians (referred to the paleopoles). The ellipses of confidence mantain their size in degrees, appearing greater in linear size on the actual globe. In c) ,d), e) the effect of plate fragmentation and rifting on the paleopoles distribution is shown. c) As soon as the expansion starts, the plate is broken and rifted: the two fragments centroid are displaced purely radially This is equivalent to the application of a pure operation of radius increase to the globe without imposing any condition on the mutual position of the plates. The dispersion of the paleopoles is reduced along a direction perpendicular to the rift. d) The plate is broken but not rifted. The conservation of a contact between the two fragments is imposed. The dispersion of the paleopoles is reduced along the longitude, for poles located along the direction of the fracture. e) A further fragmentation without rifting produces a further attenuation of the paleopoles dispersion. This experiment teaches that the possibility of applying the method of Egyed (1961) to reveal the terrestrial expansion is affected by the presence of rift, graben and orogenesis interposed between the detection sites of the paleopoles.

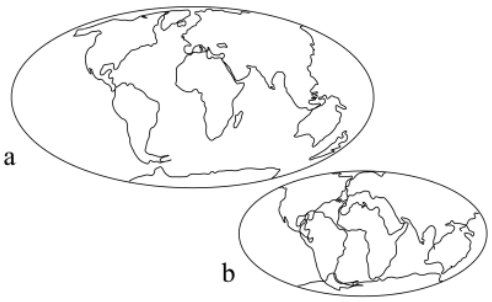

Fig. 20. In this experience the computerized cartography is used to apply the pure operation of decreasing the Earth's radius, maintaining fixed the geographical coordinates of the continents' centroids. The radius of the globe in a) is decreased to about 60% and the globe b) is obtained, showing that the continents do not match in a Pangea without mutual roto-translations. The expansion was not simply radial but complex and asymmetrical – more pronounced on the Pacific, and less pronounced on the Mediterranean, where a strong superimposition is evident.

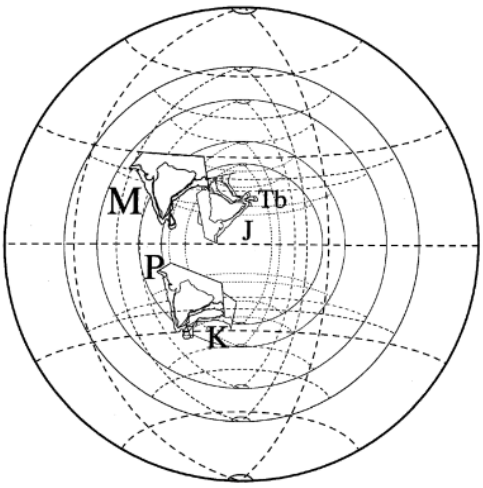

Fig. 21. The path of the Indian plate in the expanding Earth is plotted in a pseudo hyperspheric perspective. India performs a strong clock-wise rotation (more than 150") from Jurassic to Cretaceous. The kilometric amplitude of the Indian oscillation, from north to south and north again, is only of nearly 4000 km (less than the 8000 km of plate tectonics) that is easier to explain as containing a component of global reorientation of the lithosphere, namely a component of True Polar Wander. Geological contact with Eurasia is never lost. The projection used is the Lambert azimuthal equivalent, and a perspective effect has been applied.

besides the learning of the know-how in projecting a continent on a plane, reprojecting on a different radius sphere, changing the reference meridian-parallel system and other operations, I had to excogitate a method to plot paleopoles. The problem was not banal because the transformation laws followed by a plate and its paleopoles when the radius varies are different. While the continent has to conserve its area (or, in other possible choice, the distance in kilometers of each point from the projection center), a paleopole has to conserve its distance in degrees from the sampling site. Paleopoles have then to be projected following a different procedure (Scalera, 1995):

i) The pairs of geographical coordinates of the sampling site are added to the file of the plate perimeters and then pro-jected and rotated on a sphere whose radius can be different from the initial one (Scalera 1988, 1990) using the azimutal equivalent or equidistant projection and the equations of the transformation of the meridian-parallel system.

ii) A set of test points are added and projected, which are distant 5×10^{-4} degrees from the sampling sites, in the same direction of the paleopoles. These points have the function to follow the local deformation around the sampling site as soon as the curvature changes passing from a globe to a different size one. Each test point is – with a recurrence procedure – progressively approached to the point of the site, until the position of the pole does not vary more than a predetermined little with respect to the previous.

iii) The paleopoles are projected starting from the transformed site positions toward the directions of their test point, maintaining constant the site-pole distance in degrees.

In this way, for a distribution of sites, it is obtained the same paleopoles convergence or divergence effects on variable radius, which have already been described in classical works on the argument (Egyed, 1961; Ward, 1963; Van Hilten, 1963, 1967; Hospers e Van Handel, 1967).

Need for a new cartographic projection

After these preliminary papers (Scalera, 1988, 1990, 1995) I was aware that I have the quick and handy tool to perform true experiments. In view to go ahead, the complete digitization was performed of the Maps of Larson

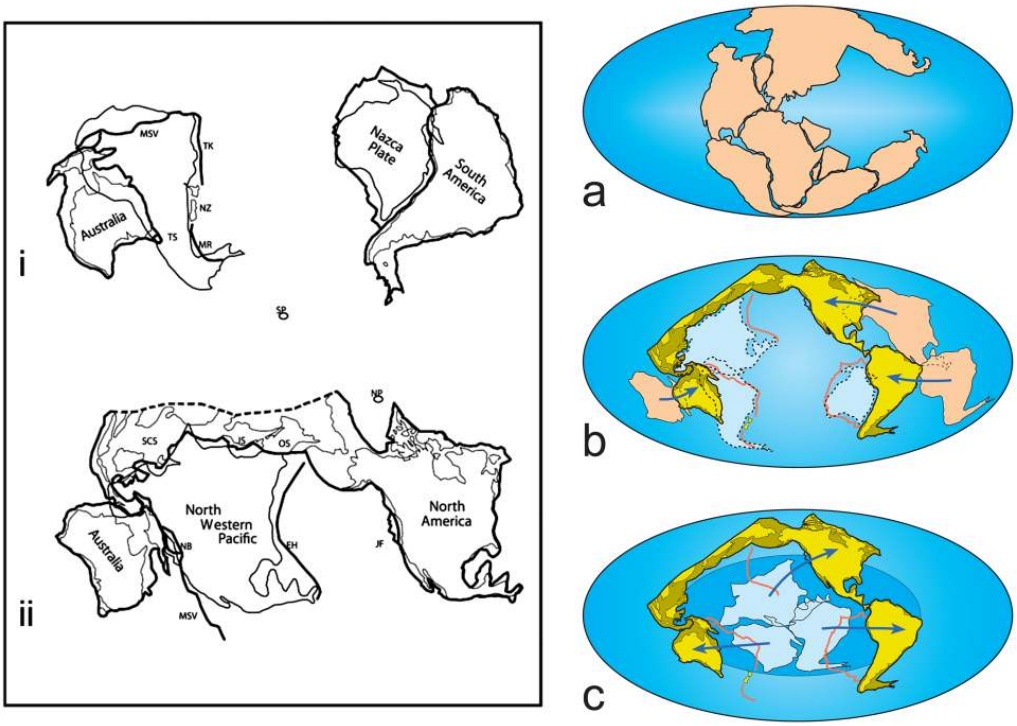

Fig. 22. Conformities in the Pacific hemisphere and their meaning. On the left: i) – Conformities and symmetry continent-basin and viceversa in Southern Hemisphere. South America corresponds in shape to Tasman and Coral sea basin, and Australia corresponds in shape to Nazca plate. Solid lines represent coast contour. Bold lines represent major tectonic discontinuities as continental shelves margins, trenches and spreading ridges. The computer aided rotations of Australian and South American continental shelves contours on the Nazca and Coral sea is shown. ii) – Conformities and symmetry continent-basin and viceversa in Northern Hemisphere. North America corresponds in shape to North Western Pacific. Juan de Fuca plate corresponds in shape to New Britain ovoidal plate. Solid lines represent coast contours. Bold lines represent major tectonic discontinuities as continental shelves margins, trenches and spreading ridges. The broken bold line is an arbitrary boundary between Asia (not represented in figure) and East Asiatic trench arc back-arc zones. The computer aided rotations of the North American continental shelves and Juan de Fuca plate contours has been performed. SCS = South China Sea; JS = Japan Sea; OS = Ochotsk Sea; ZF = Zodiac Fan; EH = Emperor Hawaii volcanic chain; JF = Juan de Fuca plate; NB = The little New Britain ovoidal plate; MSV = Manus, Salomon, Vityaz trenches; TK = Tonga Kermadec trench; NZ = New Zealand; MR = Macquarie ridge; CS = Coral Sea; TS = Tasman Sea; NP = North Pole; SP = South Pole. On the right: a) – Reference Pangea. The supercontinent has been reconstructed following the classic work of Bullard, Everett and Smith (1965) and Smith & Hallam (1970). b) – All the conformities among continents and basins together with the (dotted) outlines of Australia, Laurentia and South America in the positions which they assume in the reference Pangea. It is truly impossible for this pairs of similarities to have been created if the path of the continents have followed the arrows connecting in b) the Pangea positions (pink) of the continents and their Recent positions (yellow). The basin conformities of the continents are on the opposite side of the destination hemisphere! c) – It is more easy to appreciate that if the Earth was once – before the Pangea break-up – smaller than the modern Earth (the darker blue ellipse; approximately an half radius Earth), the displacements of the continents from Pangea (which covered all the planet) towards the modern positions is mostly radial (with rotations), from starting positions which are mere overimpositions and juxtapositions of all the conformities.

et al. (1985) of the Ages of the seafloors and of the magnetic anomalies from the map of Roeser & Rilat (1982). I found was simpler and perceptively easier to plot in the paleogeographic reconstruction the isochronal areas of the seafloor, leaving to the linear magnetic anomalies the role of eventual support – the anomalies were used as further check in problematic regions, like e.g. Indian ocean.

Finally, to increment the velocity of my computer assisted variable radius cartography, I needed on my maps a complete observability of the two opposite polar regions, on which were plotted Paleopoles and their antipoles, to allow a quick judgment of the goodness and reliability of the reconstructions and to immediately evaluate the roto-translations to be applied to the crustal fragments to improve the map. The global projections like Mollweide – that I initially used – and similar ones did not have this feature. I know that this is a common problem for cartographers: Hugh Owen created an hybrid projection in his paper of 1976 to show both equatorial and polar zones, and a Transverse Hammer-Aitoff equal area projections was used by Weijermars (1986, 1990) in his supercontinents representation. Both were unpleasant to the eye. The Lambert azimuthal equivalent have the requested characteristics but is greatly deformed out of a circle of 90° from the projection center.

In this period I was delighted by the equilibrium and beauty of the Robinson projection, and soon I understood that was an arbitrary projection that did not conserve area, distance or angle, but made a reasonable compromise getting a right aspect. Under the Robinson influence I realized to be not excessively worried of using an existing projecting method but that I could have created the one suitable to my needs. Starting then from the Lambert azimuthal equivalent, I preserved exactly the Lambert projection into a 90° circle around the projection center but a progressively strong deformation was applied going more far outside from the 90° circle. By polynomials factors, the circular appearance of the Lambert map was transformed in an elliptical one, which has a less pronounced deformation up to intermediate latitudes and a complete visibility of the regions enclosed into the 60°N and 60°S parallels, were most paleopoles distributions should be plotted. As a last significant dowry, the projection was good-looking, and perhaps attributable to the group of orthophanic projection (which means ”right appearing”).

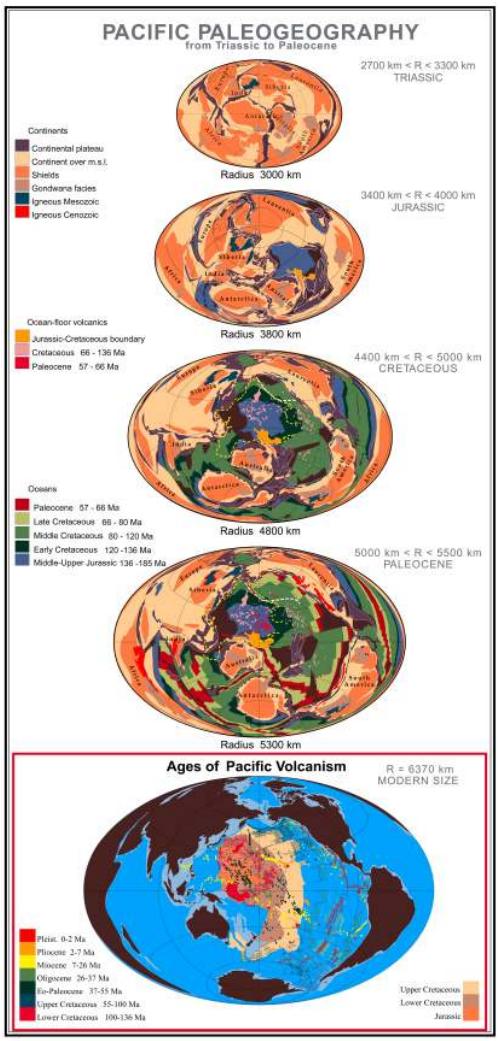

Fig. 23. The digitization has been performed of all the ocean floor fragments of same age and continental shields from the map ”Bedrock Geology of the World” (Larson et al. 1985), and of all the magnetic anomalies from the map ”Identified magnetic seafloor spreading anomalies” of Roeser & Rilat (1982) and the paper of Nakanishi et al.(1992). The projection was the modified Lambert azimuthal equivalent, a good-looking orthophanic projection (which means ”right appearing”). The image is extracted from an unpublished poster of the Birmingham 1999 IUGG Conference.

From Paleogeography to TPW and PM

With this perfected software I could run fast numerous re-constructions and developments, including better recognition of the conformity of the Pacific and a series of reconstructions of global increasing radius pa-

leogeography (Scalera, 1993, 1995b, 1995c, 1998) although the conventional position of the Indian fragment always leave me unsatisfied, because of inconsistencies of paleomagnetic data. Only later, after a large number of retries, did a plausible solution for the paleo-position of India on an expanding Earth became clear in my mind, making obsolete my old reconstructions (Scalera, 2001). India, because a series of paleontologic, geologic and geophysical clues, appeared in Triassic with its west margin flanked to Antarctica (not with its east margin as conventionally believed) (Scalera, 2001).

Finally, I was ever more involved in global geodynamics, especially in searching for links among expanding Earth long-term processes and astrogeodetic and paleomagnetic data (Scalera, 2001, 2002, 2013). I soon found out that very strangely Polar Motion (PM) and True Polar Wander (TPW) were explained in two different ways, while they had to be the same phenomenon, with the same causes. An expanding Earth can offer a common explanation to both PM and TPW simply by hypothesizing a region of prevailing upwelling of inner dense materials. This region is today the Nazca region, where an ocen floor symmetric expansion several times greater than the other oceans has been detected.

Indeed the actual PM (in the last 100 years of available reliable astrogeodetic data) shows a secular path directed toward nazca, and can be prolonged into the TPW's path back in the geologic time at least up to about 50 million years ago. Going even further back in time, beyond the 50My, the path of the TPW reverses its direction (Besse & Courtillot, 1991, 2002). The wonderful link of all this with variable radius cartography was soon recognized: The already performed paleogeographic reconstructions provided indication of a shift during geological time of the region of prevailing upwelling of inner materials. The Pacific started to open in the northern hemisphere, where probably a proto-Nazca triple point existed. Then this region of maximum expansion migrated towards south crossing the equator around 50 My ago and finally shifted toward the actual location. The time of crossing the equator can easily be put in relation to the inversion of the path of TPW and his next move towards Nazca.

This experiment has the same value as the inversion of the seismic data, which allows to argue about density and/or seismic waves anomalies of mantle regions and layers. Indeed, the expanding Earth paleogeography has been successfully inverted to argue the rough TPW and PM path from Jurassic to Recent and Present time. Experimental cartography and paleomagnetism (that can be called paleo-astrogeodesy) were worked by independent research programs but finally converged upon a common explanation based on a typical behavior of an expanding selfgravitating planet, namely an asymmetrical expansion with a region of prevailing slow extrusion of deep materials.

6. Geodetic Problems on Expanding Globes

Geodesy and cartography are interrelated, with a link similar to that which exists between paleogeodesy (namely paleomagnetic poles) and paleogeography. But no try has been made to use a radius different from the actual for surveys of geodetic data performed in different years.

Although a large amount of evidence coming from various fields is in favor of an expanding Earth, a clear result supporting an expanding globe has not been found by geodetic methods (Gerasimenko, 2003; Shen et al., 2011). The little eventual rates of expansion (Heki et al., 1989; Kostelecký & Zeman A. 2000; Gerasimenko, 2003, Shen et al., 2011; Wu et al., 2011; Devoti et al., 2012; Sarti, 2012) are too small in comparison to the error-bars and then they cannot be considered as supporting or not the Earth expansion. However, the *scale factor D* provided by IERS as the size of the geodetic network in different years of updating of the ITRF (see Table 1 in Scalera ERICE) seems in favor of an increase of the Earth's radius of $\approx$ 3 cm in the twenty years time lapse 1988-2008 (Fig. 2ab). This value is one order of magnitude less than the expected value of about 1.5 cm/y that can be deduced by paleogeographic reconstructions (Scalera, 2001, 2003; Maxlow, 2005; and others) from Triassic to Recent.

A possible solution – not excluded by other solutions – is a slowdown of the Earth's expansion in the Recent and in other paricular geologic periods. Albeit no final evidence of this possibility exsists, some real support is provided by the *Half Spreading Map of the Oceans* (Müller et al., 1997; McElhinny & McFadden, 2000) and related arguments (see Scalera, xxxx, 2012). In the *Half Spreading Map of the Oceans* at least three periods

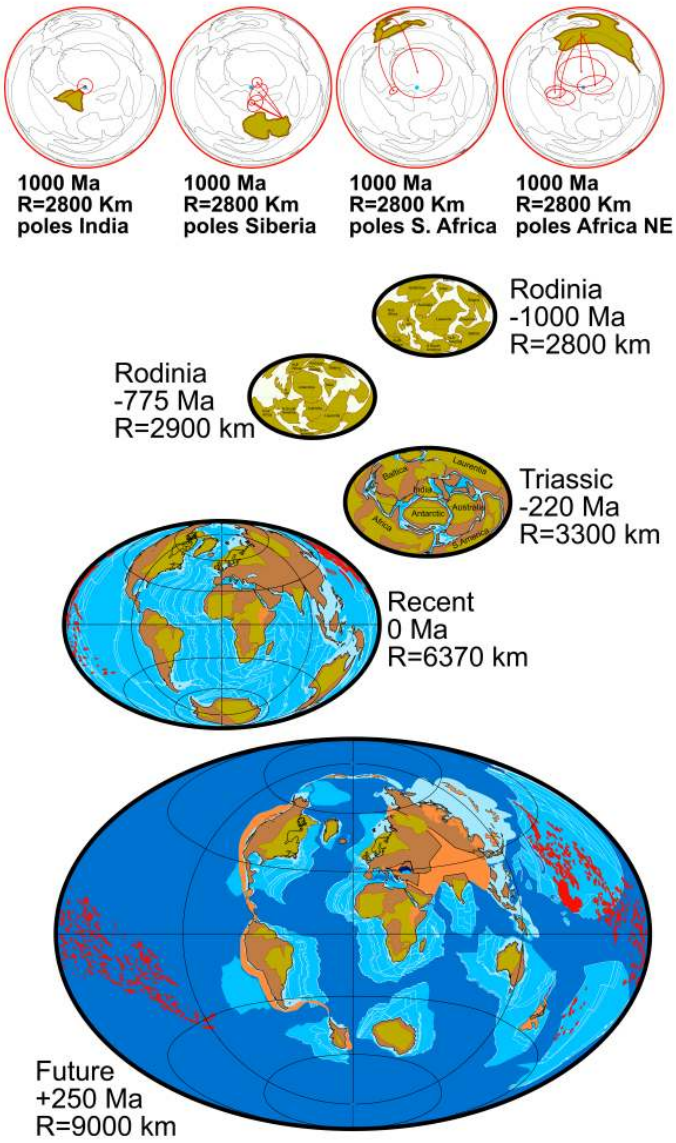

Fig. 24. Using paleopoles to check deep geologic time paleogeography. Software has been created to extract and to use the data from the updated version of the Global Paleomagnetic Database (Lock and McElhinny, 1991, McElhinny & Lock 1990a,1990b) filtering the paleopole on the basis of their quality (Florindo et al., 1994; Scalera, et al., 1993). Above: four examples of plotting paleopoles of age around 1000Ma for shields of India, Siberia, Africa N and NE. Below: Five reconstructions at 2800km, 2900km, 3300km, 6370km and 9000km. The modified Lambert azimuthal equivalent (orthophanic) projection is used. In a formerly performed Triassic reconstruction at radius of 3300 km, a new paleoposition of India was found – with western margin of India in contact with Antarctica – India being in northern hemisphere. Then, a check has been performed about the existence of the supercontinent called Rodinia. The results have been that palaeopoles of 750Ma and 1000Ma age indicate continuity of the northern position of India and of its neighbouring fragments, and that all the continents continue to reside in the same mutual position they are today. Rodinia was nothing but the Pangea at radiuses lesser than 3300km. No need at all of ancient drifting supercontinents and of their breakup and dispersal is present on these variable radius reconstructions. A picture of the Future time at 250Ma is proposed, with a more open Mediterranean, new terranes in continental Asia, and a prolongation of the Pacific ocean floor volcanic chains (reddish dots) towards the future position of the Nazca triple point. The images are extracted from a poster presented to the 2003 EGU Conference of Nice, France.

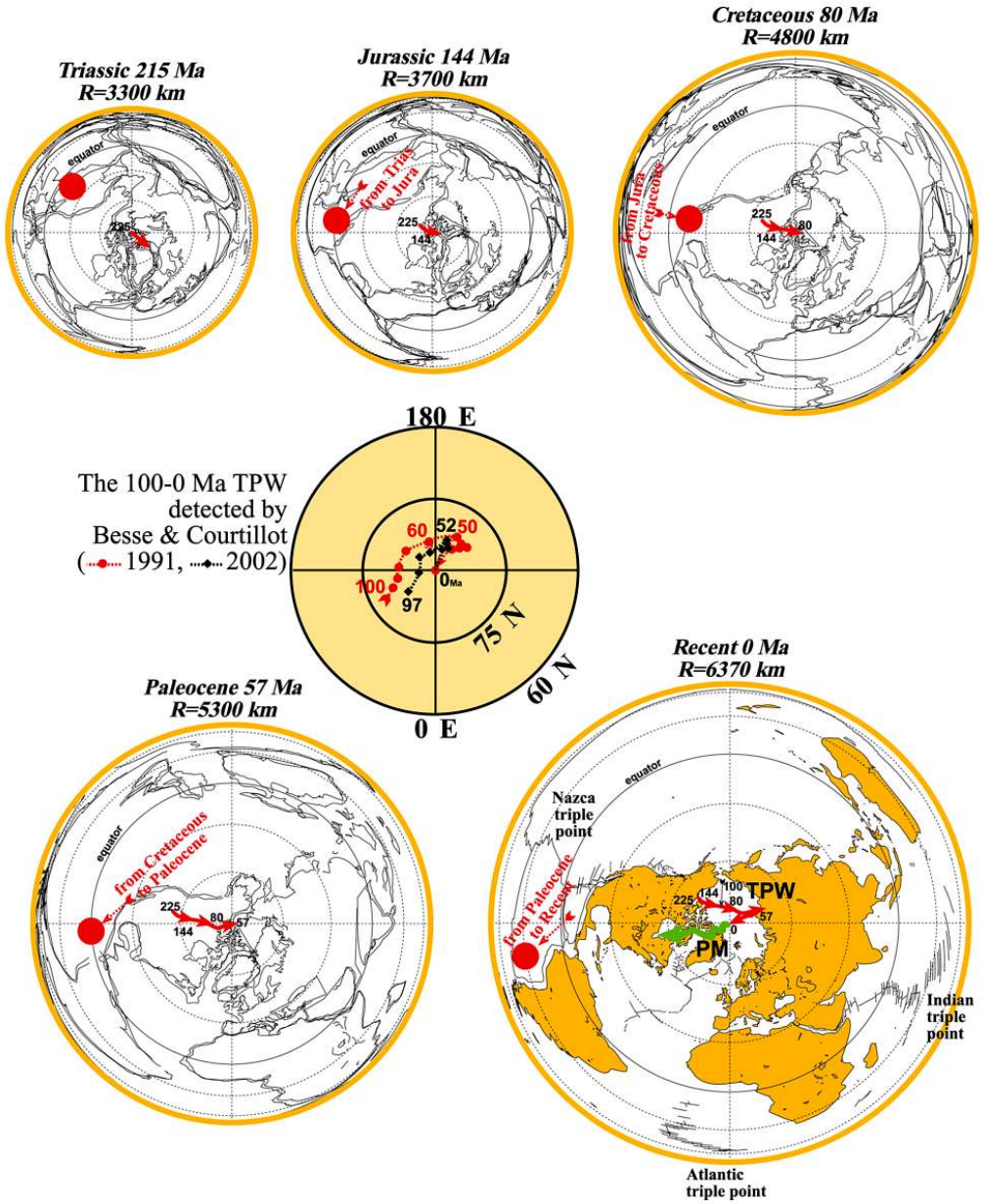

Fig. 25. Reconstruction of the probable TPW during an asymmetric expansion of the Earth. The red circles represent the regions of maximum expansion through geological time. It is possible to roughly reproduce the TPW path from Canada to Asia, the "stasis" at ≈50 Ma and the coming back toward Canada as revealed by Besse & Courtillot (1991, 2002) (box in the center) by a simple migration of the point of maximum expansion from the northern hemisphere to the southern one, as easily deducible from the evolution of the opening of the Pacific ocean in the expanding Earth paleogeography. Stasis occurs when the region of maximum expansion crosses the equator. The TPW is then a prolongation of the current secular PM (drawn in green, not to scale).

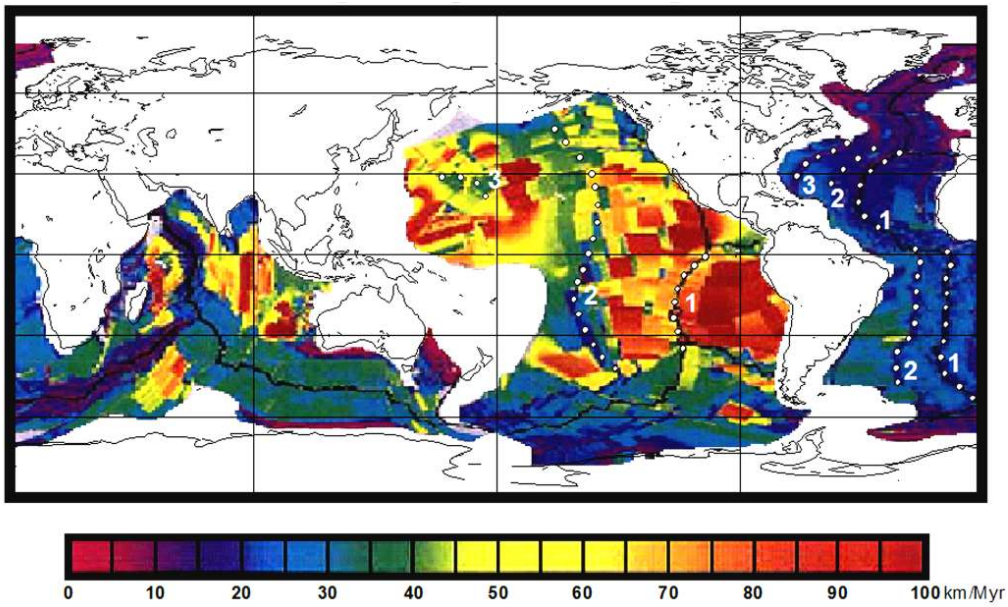

Fig. 26. In the *Half Spreading Map of the Oceans* at least three periods of slowdown are present: the Recent, the Cretaceous-Cenozoic boundary and Jurassic-Cretaceous boundary, indicated by white circles and the numbers 1, 2 and 3 respectively.

of slowdown are present: the Recent, the Cretaceous-Cenozoic boundary and Jurassic-Cretaceous boundary (see Fig. 25). Then we are today in a long period of *stasis* of the expansion, which presumably is difficult to detect by geodetic methods.

Obviously a multeplicity of causes can be superimposed in making really or fictitiously low the expansion rate, and the second important branch to be investigated is the existence of some hidden vicious circle in the geodetic methodology, eventually linked to the presence of the parameterized constant Earth's radius in some point of the complex methods. Geodesists are convinced to operate in a Cartesian reference system, without use of the Earth's radius: but is this really true? The possibility exists that the reduction of the data on the adopted international ellipsoid can produce subtle problems, and other sources of systematic errors have been treated by Sarti et al. (2011) and Sarti (2012). Finally, in geodetic techniques making use of artificial satellites (GPS, DORIS, ...) the possibility that a less than centimetric expansion may be hidden in the satellites orbital decay should not be forgot (Scalera, 2006).

The expanding globe appears as an object of great complexity of behaviour that still lacks for a complete and unambiguous theoretical treatment in Geodesy. It is my opinion that the introduction of a variable radius $R = R(t)$ in the geodetic software could be a new ground of fertile investigations and experiments.

7. Concluding remarks

I have tried to provide a historical panorama of the variable radius cartography, without presumption to reach completeness (some minor realizations have not been included). The present paper has shown that in the last century cartography was used in a way more or less complex, more or less intertwined with other disciplines and databases, not as pure representation or in the spirit of the simple 'fits' that supported continental displacements, but as experiments of greater complexity with a value of proof in favor of the planet expansion.

The old way to use the cartography as simple scaled plotting of the existing things of the Earth was slowly overcome by the need to represent the same objects (continents, rivers, terranes, mountains etc.) in different positions than the actual, as soon as the paleogeography took in consideration not only regressions and transgressions of the seas but also the mobilistic concepts of displacements of large fragments of the Earth's crust. The shrinking Earth lead initially to the palinspastic restorations of

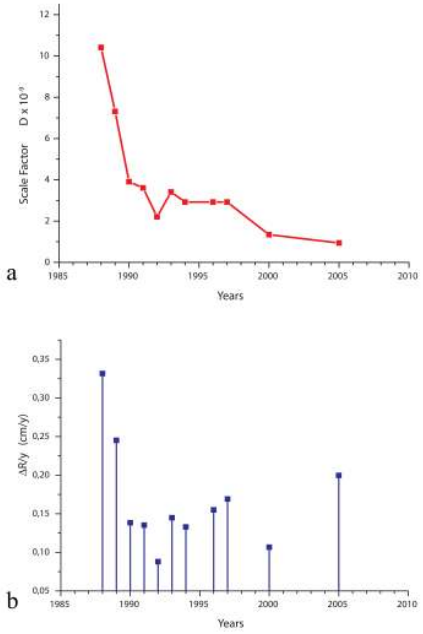

Fig. 27. The scale factor D and its consequences. – a) Values of the scale factor D at different years, with respect to the ITRF-2008. – b) The values of the radius variations annual rate $\Delta R/y$, averaged on the time lapses from the indicated year to 2008. With the exception of the probably spurious values of 1988 and 1989, the series seems to indicate a value around 0.15 cm/y. This means a total expansion of ≈3.0 cm on about 20 years.

single orogenic belts and this is not so different from the restoring of the ancient mutual position of the continents in the continental drift view. But this new way of mapping was not fully experimental, because the more advanced aim was to provide proof of the goodness of the fit of continental outlines. Nothing of new was suggested to physical sciences.

Instead, a new and deep aim was defined with the use of cartography in the expanding Earth framework. In this case the success of the paleogeographical reconstructions on lesser radius globes is not only a good geological experiments but take on a new and more general significance. This time the fields involved are not only geology, geodynamics, tectonics, but unavoidable suggestions are provided to physics, astronomy, cosmology – leading all these disciplines toward perspectives of a more dynamic, extremely "mobilistic" view, showing the inadequacy of many current conceptions. With the advent of the variable radius cartography a two step revolution has been then made, which still has to be fully transferred to the physical sciences. The experiments in cartography are surely "lowest cost" nevertheless the results should be considered "heavy", like those coming from the "great physics" of the giant particle accelerators (Scalera et al., 2012).

The hope of the author is to rise interest about the variable radius cartography in the new generations of professionals of the field, looking forward to the creation of a series of options of mapping with a different radius in the presently available codes of computer assisted mapping like GMT (General Mapping Tool) today diffusely used in Universities and Research Institutions.

The possibility to perform cartographycal tests – with the help of precise computer assisted variable radius mapping tools – would avoid the flimsiness both of some researches and of the critical comments addressed to them (Scalera, 2007). To assign the proper Earth's radius $R = R(t)$ to each geodetic data can become a more correct procedure in geodesy, as it already is in paleogeodesy. But finally a so advanced mapping tool would become an "experimental tool" patrimony of all the scientific community, eventually opening new unexpected or today unimaginable ways of research in geosciences, planetology and astrogeodesy.

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References

Aëro-Dilettant (pseudonym of JAH Kerkhoff) (1928) Het Maanproblem: Opgelost. Het Vraagstuk der oceanen en continenten onzer "tegenwoordige" Aarde: Verklaard (in Dutch). Uitgave Electrische Drukkerij "Luctor et Emergo" S. Gravenhage, 126 pp

Anonymous (H.B.) (1970) C. H. Barnett M.A., M.B., B.CHIR., F.R.C.S. (Obituary), British Medical Journal, 31 October 1970, 309

Barnett CH (1962) A suggested reconstruction of the land masses of the Earth as a complete crust. Nature, 195 (4840), 447-448

Barnett CH (1969) Oceanic rises in relation to the expanding Earth hypothesis. Nature, 221 (5185), 1043-1044

Beekman G (2005) The nearly forgotten scientist Ivan Osipovich Yarkovsky. J. Br. Astron. Assoc., 115 (4), 207-212

Besse J and Courtillot V (1991) Revised and synthetic apparent polar wander paths of the

African, Eurasian, North American and Indian plates, and true polar wander since 200 Myr., J. Geophys. Res., 96, 4029-4050

Besse J and Courtillot V (2002) Apparent and true polar wander and the geometry of the geomagnetic field over the last 200 Myr., J. Geophys. Res., 107 (B11), 2300, doi:l0.1029/2000JB000050.

Beekman G (2006) I. O. Yarkovsky and the discovery of 'his' effect. Jour. for the History of Astronomy, 37, 71-86

Bogolepow M (1930) Die Dehnung der Lithosphäre. Zeitschrift der Deutschen Geologischen Gesellschaft, 82, 206-228

Brösske L (1952) Das Schicksal unserer Erde in Vergangenheit und Zukunft. Verlag SANUS, Dusseldorf-Benrath, 16 pp

Brösske L (1962) Wachst die Erde mit Naturkatastrophen? Die "Expansions- Theorie" (Does the Earth grow with natural catastrophes? The expansion theory). "Sanus" Brösske Abtig. Verlag, Dusseldorf-Benrath 41, 105 pp

Bullard E, Everett JE, Smith AG (1965) The fit of the Continents around the Atlantic. Phil. Trans. Roy. Soc. London, Series A, 258 (1088), A Symposium on Continental Drift (Oct. 28, 1965), 41-51

Carey SW (1975) The expanding Earth: an Essay Review. Earth Science Reviews, 11 (2), 105-143

Carey SW (1976) The Expanding Earth. Elsevier, Amsterdam, 488 pp

Carey SW (1996) Earth, Universe, Cosmos. School of Earth Sciences – University of Tasmania, 258 pp

CGMW (1990, 2000) Geological map of the world (first and second edition). Commission for the Geological Map of theWorld (CGMW) & UNESCO Publishing, Paris.

Chiarelli B, Rombai L, Ammannati F, Cardini F, Calzolari S, Castagna CA (1992) La carta perduta – Paolo dal Pozzo Toscanelli e la cartografia delle grandi scoperte. Con una Presentazione di Paolo Blasi e Lapo Mazzei, Cassa di Risparmio di Firenze, Alinari, Firenze, 118 pp

Chudinov YV (1976) Razsirenije zemli kak alternativa 'novoj globalnoj tektoniki' (The expanding Earth as an alternative to the 'new global tectonics') Geotektonika, 1976 (4), 16-36

Chudinov YV (1980) Proiskhozhdeniye Al'piyskogo skladchatogo poyasa stochki zreniya gipotezy rasshireniya Zemli (Origin of the Alpine folding belt from the viewpoint of the Expanding Earth hypothesis) (in Russian). In: Muratov MV & Yanshin AL (eds.) Tectonics of the Mediterranean belt. Nauka Publ. (MS), 223-237

Creer KM (1964) Palaeomagnetic data and Du Toit's reconstruction of Gondwanaland. Nature, 204 (4956), 369-370

Creer KM (1964) A reconstruction of the continents for the Upper Palaeozoic from palaeomagnetic data. Nature, 203 (4950), 1115-1120

Creer KM (1965) An expanding Earth? Nature, 205 (4971), 539-544

Creer KM (1967) Earth, possible expansion of. In: Runcorn, S.K. (ed.) International Dictionary of Geophysics. Pergamon, London, 383-389

Dearnley R (1965a) Orogenic fold-belts and continental drift. Nature, 206 (4989), 1083-1087

Dearnley R (1965b) Orogenic fold-belts, convection and expansion of the Earth. Nature, 206 (4991), 1284-1290

Dearnley R (1966) Orogenic belts and a hypothesis of Earth evolution. In: Ahrens LA, Press F, Rankama K, Runcorn SK (eds.) Physics and Chemistry of the Earth, Vol.7, Pergamon Press, Oxford, 1-118.

Dearnley R (1969) Crustal tectonic evidence for Earth expansion. In:. Runcorn, S.K (ed.): The Application of Modern Physics to the Earth and Planetary Interiors. Wiley, London, 103-110.

Dennis JG (1962) Fitting the continents. Nature, 196 (October 27), 364

Dick T (1838) Celestial Scenery – Or, the Wonders of the Planetary System Displayed – Illustrating the Perfections of Deity and a Plurality of Worlds. E. & L. Merriam, Brookfield, 390 pp

Edwards MR (ed.) (2002) Pushing Gravity. Roy Key Inc., Montreal. 316 pp

Egyed L (1961) Palaeomagnetism and the ancient radii of the Earth. Nature, 190, 1097-1098

Embleton BJJ and Schmidt PW (1979) Recognition of common Precambrian polar wandering reveals a conflict with plate tectonics. Nature, 282, 705-707

Embleton BJJ, Schmidt PW and Fisher NI (1983) Precambrian palaeomagnetism. In: Carey SW (ed.) Expanding Earth Symposium. Sydney 1981, University of Tasmania, Impact Printing Ltd. Brunswick, 87

Fairbridge RW (1964) Thoughts about an expanding globe. In: Subramanion AP and Balakrishna S (eds.) Advancing Frontiers in Geology and Geophysics. Osmania University Press, Hyderabad, 59-88.

Florindo F, Sagnotti L, Scalera G (1994) Using the ASCII Version of the Global Paleomagnetic Database, EOS, 75 (21), May 24, 236-237

Migotto L and Ferracci S (2003) The restoration of the Hilgenberg palaeogeographic globes. In: Scalera G. and Jacob K-H (eds.) Why Expanding Earth? – A book in Honour of Ott Christoph Hilgenberg. Proceedings of the 3rd Lautenthaler Montanistisches Colloquium, Mining Industry Museum, Lautenthal (Germany), 26 May 2001, INGV, Rome, 65-69

Heezen BC (1959) Géologie sous-marine et déplacements des continents. In: La topographie et la géologie des profondeurs océaniques, 295-304

Heezen BC (1962) The Deep-Sea Floor. In K. Runcorn (ed.) Continental Drift, International Geophysical Series, Vol.3, Academic Press, New York & London, 235-288

Heezen BC, Tharp M (1977) World Ocean Floor (a map). U.S. Navy Office of Naval Research, Washington, DC

Heezen BC, Tharp M, Ewing M. (1949) The Floors of the Oceans. Geol. Soc. of America, New York.

Hilgenberg OC (1933) Vom wachsenden Erdball (The Expanding Earth). Berlin, Giessmann & Bartsch, 56 pp

Hilgenberg OC (1962) Paläopollagen der Erde (Earth's palaeopoles) N. Jb. Geol. Paläont., 116 (1), 1-56

Hilgenberg OC (1965) Die Paläogeographie der expandierenden Erde vom Karbon bis zum Tertiär nach paläomagnetischen Messungen (The Paleography of the Expanding Earth from the Carboniferous to the Tertiary Period, according to Paleomagnetic Measurements). Geologischen Rundschau, Bd. 55, 878-924

Hilgenberg OC (1974) Geotektonik, neuartig gesehen (Geotectonics, seen in a new way). Geotektonische Forshungen, 45 (1-2), 194 pp

Hospers J and Van Handel SI (1967) Palaeomagnetism and the Hypothesis of an expanding Earth,Tectonophysics, 5, 5-24

Irving E, Wheadon P, Horel G (1990) Catalogue of Paleomagnetic Directions and Paleopoles, Geological Survey of Canada, 93 pp

Jordan P (1966) Die expansion der Erde (The expansion of the Earth) (in German). Sammlung 'Die Wissenschaft', Braunschweig, Federal Republic of Germany, Friedr. Viehweg and Sohn, 182 pp

Jordan P (1971) The Expanding Earth: Some Consequences of Dirac's Gravitation Hypothesis (translated by A. Beer from the original 1966 German edition). International Series of Monographs in Natural Philosophy, vol.37, Pergamon Press, Oxford, New York, Toronto, Sydney, 202 pp

Kirillov IV (1958) Hypothesis on the growing of the Earth, of the matter and of the oceanic basins. Autoreferata conference, MOIP, Geology, 2, 142

Kirillov IV (1961) The growing Earth's globe. Tecnica-Molodescji, n.3, 33

Kirillov IV (1968) A proof in favour of the expanding Earth hypothesis with the help of reconstructions on spherical models of the oceanic basins based on paleomagnetic data. 6th Conference on Planetology, 1, 32

Kirillov IV (2003) Kinetic gravitation of the Earth. Maks Press, Moscow, 68 pp

Khramov AN (1984) Palaeomagnetic directions and pole positions, summary catalogue No. 1. Soviet Geophysical Committee of the Academy of Sciences of the USSR, World Data Center B, Moscow, 94 pp

Larson RL, Pitman III WC, Golovchenkso X, Cande SC, Dewey JF, Haxby WF and. La Brecque JL (map's compilers) (1985) The bedrock geology of the world, Freeman and Co. Inc., New York

Lilienthal TC (1756) Die gute Sache der Göttlichen Offenbarung. vol.VII, Har-tung, Königsberg, 247 pp

Lock J, McElhinny MW (1991) The Global paleomagnetic database: design, installation, and use with ORACLE, Kluwer Academic Publishers, 188 pp

McNally R. (ed.) (1961) Life Pictorial Atlas of the World. Life & McNally, New York, 600 pp

Mantovani R (1888) Réforme du calendrier, Bulletin de la Société des Sciences et Arts de La Réunion, 13, 39

Mantovani R (1889) Les fractures de l'écorce terrestre et la théorie de Laplace, Bulletin de la Société des Sciences et Arts de La Réunion, 41-53

Mantovani R (1909) L'Antarctide, Je m'instruis – La science pour tous, 38, 19 september, 595-597

Mantovani R (1927) L'Atlantide et la découverte de la dilatation planétaire. C.R. somm. Soc. géol. France, (4), XXVII, 153-155

Maxlow J (1995) Global Expansion Tectonics: the geological implications of an expanding Earth. Unpublished thesis, Curtin University of Technology, Perth, Western Australia

Maxlow J (2001) Quantification of an Archaean to Recent Earth Expansion Process Using Global Geological and Geophysical Data Sets. Unpublished PhD thesis, Curtin University of Technology, Perth, Western Australia, 438 pp

Maxlow J (2005) Terra non Firma Earth: Plate Tectonics is a Myth

Maxlow J (2013) Private communication.

Morello N (1979) La macchina della Terra: Teorie geologiche dal seicento all'ottocento. Torino, Loescher

Morgan JW (1968) Rises, Trenches, Great Faults, and Crustal Blocks. Journal of Geophysical Research, 73 (6), 1959-1982

Nakanishi M, Tamaki K, Kobayashi K (1992) Magnetic anomaly lineations from Late Jurassic to Early Cretaceous in the west-central Pacific Ocean. Geophys. J. Int., 109 (3), 701-719

Oresme N (1377) Le livre du ciel et du monde. I, 24. Cit.in Massimo Parodi (cura, traduzioni, introduzioni): Tempo e spazio nel medioevo. Antologia. Sez.III, documento 14, Loescher Editore, Torino, 1981, 256 pp

Owen HG (1976) Continental displacements and expansion of the Earth during the Mesozoic and Cenozoic. Phil. Trans. of the R. Soc. of London, Series A: 281 (1303), 223-291

Owen HG (1983) Atlas of continental displacement, 200 million years to the present. Cambridge University Press, Cambridge, 159 pp

Owen R (1857) Key to the geology of the globe: An essay, designed to show that the present geographical, hydrographical, and geological structures, observed on the Earth's crust, were the re-

sult of forces acting according to fixed, demonstrable laws, analogous to those governing the development of organic bodies. Nashville, Tennessee, Stevenson & Owen, W.T. Berry & Co., viii, 256 pp

Patrizio (da Cherso) F (1562). Della Retorica – Dieci Dialoghi. I° dialogo. In Venezia, appresso Francesco Senese, 5-7

Pearson F (1984) Map projection methods, Sigma Scientific, 292 pp

Perry K. 1984. A geometrical test of plate tectonics. Unpublished manuscript, 33 pp.

Perry K. 1986. The fit of South America, Africa and Antarctica on a globe whose paleoradius is 54% present. Unpublished manuscript, 11 pp.

Piper JDA (1988) Palaeomagnetic database, Open University Press, 264 pp

Placet F (1666) La corruption du grand et petit monde. Paris, Alliot & Alliot

Reynaud J (1840). Discours sur la condition physique de la terre. Un extrait de l'Encyclopédie nouvelle

Reynaud J (1854) Terre et ciel. (2nd edition) Paris, Furne, 460 pp

Richardus P and Adler RK (1972) Map Projection for Geodesists, Cartographers and Geographers, North-Holland, Amsterdam, 174 pp

Roeser HA and Rilat M (1982) Identified magnetic sea-floor spreading anomalies, Federal Institute for Geosciences and Natural Resources, Hannover, Gemany, Geol. Jahrb. E, 23, 71-80

Romm J (1994) A new forerunner for continental drift. Nature, 367, 6462

Runcorn K (ed.) (1969) The Application of Modern Physics to the Earth and Planetary Interiors. Proceedings of the Conference of the NATO Advanced Study Institute held on 29 March - 4 April 1967 at the School of Physics of the University of Newcastle Upon Tyne (UK), Wiley-Interscience, London, 692 pp

Scalera G (1988) Nonconventional Pangea reconstructions: new evidence for an expanding Earth. In: Wezel, FC (ed.): The Origin and evolution of arcs. Special Issue of Tectonophysics, 146, 365-383

Scalera G (1990) Palaeopoles on an expanding Earth: a comparison between synthetic and real data sets. Phys. Earth Planet. Inter., 62, 126-140

Scalera G (1993) Non-chaotic emplacements of trench-arc zones in the Pacific Hemisphere, Annali di Geofisica XXXVI (5-6), 47-53

Scalera G (1995a) Relocation of paleopoles on variable radius Earth models. In: Barone M and Selleri F (eds.) Advances in Fundamental Physics. Hadronic Press, Palm Harbor (FL, U.S.A.), 463-474

Scalera G (1995b) Ricostruzioni paleogeografiche e cinematica delle placche su una Terra in espansione. Atti del 13° Convegno GNGTS, Roma 28-30 novembre 1994, Esagrafica, Roma, 257-262

Scalera G (1995) Terra in espansione (Earth in expansion). Voce per la Enciclopedia delle Scienze Fisiche, Istituto per la Enciclopedia Italiana Treccani, Roma, VI, 228-231

Scalera G (1998) Paleogeographical reconstructions compatible with Earth dilatation. Annali di Geofisica, 41 (5-6), 819-825

Scalera G (1999) I moti e la forma della Terra. INGV, Roma, 195 pp

Scalera G (2001) The Global paleogeographical reconstruction of the Triassic in the Earth's dilatation framework and the paleoposition of India. Annali di Geofisica, 44 (1), 13-32

Scalera G (2001) Relations among expanding Earth, TPW and Polar Motion, Proceedings 20th Annual Meeting GNGTS, Roma, on CDrom, 15 pp

Scalera G (2002) Possible relations among expanding Earth, TPW and Polar Motion. In: Maslov L (ed.) Proceedings Int. Symposium on New Concepts in Global Tectonics, held in May 2002 in La Junta, Colorado, Otero Junior College Press, La Junta, 37-50

Scalera G (2003) La Terra tra mito e realtà. Giornale di Astronomia, 29 (1), 36-46

Scalera G (2003) Roberto Mantovani an Italian defender of the continental drift and planetary expansion. In: Scalera G & Jacob KH. (eds.) Why expand-ing Earth? – A book in honour of OC Hilgenberg. INGV, Rome, 71-74

Scalera G (2007) Fossils, frogs, floating islands and expanding Earth in changing-radius cartography – A comment to a discussion on Journal of Biogeography. Annals of Geophysics, 50 (6), 789-798

Scalera G (2009) Roberto Mantovani (1854-1933) and his ideas on the expand-ing Earth, as revealed by his correspondence and manuscripts. Annals of Geophysics, 52 (6), 615-648

Scalera G (2012) Distensional Mediterranean and World Orogens – Their Possible Bearing to Mega-Dykes Active Rising. In: Scalera G, Boschi E, Cwojdzinski S (eds.) The Earth Expansion Evidence – A Challenge for Geology, Geophysics and Astronomy Selected Contributions to the Interdisciplinary Workshop of the 37th International School of Geophysics held in Erice, Sicily, Italy, 4-9 October 2011 at the Ettore Majorana Foundation and Centre for Scientific Culture (EMFCSC), Aracne editrice, Roma, 115-160.

Scalera G (2013). The variable radius cartography - history and perspectives of a new discipline. In: Pisano R, Capecchi D, Lukeová A (eds). Physics, Astronomy and Engineering. Critical Problems in The History of Science and Society. Proceedings of the 32th International Congress of the Italian Society of Historians of Physics and Astronomy (SISFA), Rome27-29 September 2012. The Scientia Socialis Press, Siauliai, XXXX YYYY ZZZZ ???? pp

Scalera G, Boschi E, Cwojdzinski S (eds.) (2012) The Earth Expansion Evidence – A Challenge for Geology, Geophysics and Astronomy. Selected contributions to the Workshop held in Erice, Sicily, Italy, 4-9 October 2011 at the Ettore Majorana Foundation and Centre for Scientific Culture, Aracne editrice, Roma, xiv + 493 pp

Scalera G, Braun T (2003) Ott Christoph Hilgenberg in twentieth-century Geophysics. In: Scalera G and Jacob K-H (eds.) Why Expanding Earth? – A book in Honour of Ott Christoph Hilgenberg. Proceedings of the 3rd Lautenthaler Montanistisches Colloquium, Mining Industry Museum, Lautenthal (Germany) May 26, 2001, INGV, Rome, 25-41

Scalera G, Favali P, Florindo F (1993) Use of the paleomagnetic database for geodynamic studies: some example from the Mediterranean region. In: Boschi E, Mantovani E, Morelli A (eds.) Recent Evolution and Seismicity of the Mediterranean Region. Kluver Ac. Publ., N.A.T.O. ASI Series, Series C, Mathematical and Physical Sciences, Netherlands, 403-422

Schmeling Harro (2004) GEODYNAMIK. Goethe-Universität Frankfurt, Institut für Meteorologie und Geophysik, 22 pp

Schmidt PW and Embleton BJJ (1981) A geotectonic paradox: has the Earth expanded? Journal of Geophysics – Zeitschrift für Geophysik, 49 (1), 20-25

Smith AG, and Hallam A (1970) The Fit of the Southern Continents. Nature, 225, 139-144

Snider-Pellegrini A (1858) La Création et ses mystères dévoilés – Ouvrage ou l'on expose clairement la nature de tous les étres, les éléments dont ils sont composés et leurs rapports avec le globe et les astres, la nature et la situation du feu du soleil, l'origine de l'Amérique et de ses habitants primitifs, la formation forcée de nouvelles planètes, l'origine des langues et les causes de la variété des physionomies, le compte courant de l'Homme avec la Terre, etc. Paris, Frank e Dentu, 487 pp

Spencer N (2013) Web site: http:// www. normanspencer. co.nz

Termier H and Termier G (1969) Global palaeogeography and Earth expansion. In: Runcorn SK (ed.) The Application of Modern Physics to the Earth and Planetary Interiors, Wiley, London, 87-101

Termier H and Termier G (1983) Reflections about an expanding Earth. In: Carey SW (ed.) Expanding Earth Symposium. Sydney 1981, University of Tasmania, Impact Printing Ltd. Brunswick, 101-103

Van Hilten D (1963) Palaeomagnetic indications of an increase in the Earth's radius, Nature, 200 (491 3), 1277- 1279

Van Hilten D (1967) Global expansion and palaeomagnetic data, Tectonophysics, 5 (3), 191-210

Vogel K (1983) Global models and Earth expansion. In: Carey SW (ed) Expand-ing Earth Symposium, Sydney 1981, University of Tasmania, 17-27

Vogel K (1984) Beitrage zur Frage der Expansion der Erde auf der Grundlage von Globenmodellen (Contributions to the Question of Earth Expansion Based on Globe-Models) (in German). Zeitschrift für Geologische Wissenschaften, 12 (5), 563-573; translated to English in: Scalera G, Boschi E, Cwojdzinski S (eds.) The Earth Expansion Evidence – A Challenge for Geology, Geophysics and Astronomy. Aracne editrice, Roma, 161-170

Vogel K (1990) Die Entwiclung der Randmeere und Ozeane aus der Sicht der Erdexpansion, dargestellt an Globenmodellen. Nachr. Dt. Ges. H. 43, p. 154 Nachrichten Deutsche Geologische Gesellschaft

Ward MA (1963) On Detecting Changes in the Earth's Radius, Geophys. J.R. astr. Soc., 8, 2 17-225

Wegener A (1912a) Die Entstehung der Kontinente. Geologische Rundschau 3: 276-292

Wegener A (1912b) Die Entstehung der Kontinente. Petermanns Geographische Mitteilungen 58: 185-195: 253-256: 305-309

Wegener A (1915-1936) Die Entstehung der Kontinente und Ozeane. Fiedr. Vieweg & Sohn. Braunschweig. 5a ed. Italian Translation by Clara Giua, Boringhieri, Torino, 1976, 313 pp

Weijermars R (1986) Slow but not fast global expansion may explain the surface dichotomy of the Earth. Physics of the Earth and Planetary Interiors, 43, 67-89

Weijermars R (1990) New fit Gondwana. Journal of African Earth Sciences, 11 (3-4), 421-436

Westphal M (1989) The Strasbourg palaeomagnetic database, Geophys. J., 97, 361-363 www.arab.it (2012) La creazione dei deserti. http:// www.arab.it/ favole/ lacrea-zione.htm

Yarkovsky IO (1888) Hypothèse cinétique de la gravitation universelle en connexion avec la formation des éléments chimiques (Kinetic theory of universal gravitation in relation with the generation of ponderable matter within celestial bodies). Published by the author in Moscow

Yarkovsky IO (1889) Universal gravitation as a consequence of the formation of ponderable matter inside celestial bodies (in Russian). Moscow, 1889, 388 pp.; S. Peterb., 1912, 269 pp

Zarathustra (1916) L'avesta. Il Venidad [legge contro i demoni] reso in italiano sul testo zendico di C.F. Geldner da F.A. Cannizzaro, corredato da intr. e note del prof. I. Pizzi. Messina, 235 pp

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