ORIGINS OF CONTINENTAL DRIFT THEORY AND THE INFLUENCE OF RHETORIC

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The fact that South America and Africa seem to fit together like puzzle pieces has been evident to anyone who has ever seen a map drawn after the 16th century. Further, the observation that identical species lived on continents separated by thousands of miles of water has been evident for centuries. However, before 1910, there was no reasonable geological explanation for either observation. Geologists explained the existence of continents through the idea of "cooling and contracting": present-day continents are the shriveled remains of what was once a single, all encompassing continent that covered the planet. The quandary of identical species was explained through the use of land bridges, but these had no plausible origin and left no identifiable remains.

Robert Taylor's "Bearing of the Tertiary Mountain Belt on the Origin of the Earth's Plan," published in 1910 in the *Bulletin of the Geological Society of America*, built on the work of a number of eminent geologists, most notably Eduard Suess, to address these and other geological questions. His theory offered a credible solution to the existence of the continents, creating a geological history where common species would finally share a common location. Taylor proposed that two large land masses, each centered upon one of the two poles, broke apart and migrated to their present locations. Although Taylor's work did not explain the entire picture as it is currently understood, his ideas were well ahead of their time. Nonetheless, Taylor's ideas were largely ignored.

Five years later, Alfred Wegener made a similar claim in *The Origin of Continents and Oceans*, a book which would become one of the most influential scientific works of the twentieth century. Wegener proposed the existence of Pangaea, a super continent comprised of all present-day continents. Pangaea, located in the present day Indian Ocean, explained the quandary of matching species. It also resolved the problems of why the continents seemed to fit together so well and why many of the world's mountain belts appeared to be continuous. Like Taylor, Wegener proposed a situation where the continents had split apart and flowed to their present location, a process he called "continental drift." Like Taylor, Wegener had no viable explanation for continental drift.

It was not until the late 1960's when the implications of the Mid-Atlantic Ridge were realized that Wegener was "discovered" and recognized for the validity of his theory. For fifty years after Taylor's and Wegener's publications, geologists cited empirical evidence like gravitational field strength variance and measurement of heat flow rates around the edges of continents to cling to their presumption that the continents were, are, and always will be static. Finally, however, the

spreading of the crust at the ridge was evidence of the geothermal power needed to explain Wegener's otherwise mysterious continental drift. Wegener's continental drift has since evolved into plate tectonics—a more advanced science, yet still the same at heart. Plate tectonics has become so prominent as to be a household term and is taught to most junior high students.

Although *Origin* and "Bearing of the Tertiary Mountain Belt" suggested the same basic concept, that the continents are in motion and have moved large distances over vast periods of time, Wegener has enjoyed international fame and prestige, while Taylor has effectively disappeared from popular science texts. In this article, I address this seeming incongruity by building on Thomas Kuhn's notion of "scientific revolutions." Specifically, I argue that the rhetorical construction of a scientific idea plays as much a part in causing a revolution as the idea itself. Applied to continental drift, Wegener has succeeded and Taylor failed due to the manner in which they presented their ideas.

"Scientific Revolutions" and the Rhetoric of Science

In his revolutionary text, *The Structure of Scientific Revolutions*, Thomas Kuhn discusses the origins of revolutionary scientific ideas. Kuhn's ideas have significantly influenced those studying the rhetorical implications of science. Although the book expands on the idea in a number of directions and possibilities, Kuhn's primary argument is as follows:

> And when it does—when, that is, the profession can no longer evade anomalies that subvert the existing tradition of scientific practice—then begin the extraordinary investigations that lead the profession at last to a new set of commitments, a new basis for the practice of science. The extraordinary episodes in which that shift of professional commitment occurs are the ones known in this essay as scientific revolutions. (6)

Thus, scientific revolutions, according to Kuhn, occur when a scientist presents a shift of ideas, a proposal that is so different, so contrary to the established belief that the only way for the scientific community to accept it is to undergo a complete revolution of belief.

I suggest that a new, potentially transformative, scientific idea succeeds in spawning a revolution only if it is *written in a revolutionary manner*. That is, rhetorical devices that have been identified and utilized in virtually all societal endeavors—for example, the author's attitude toward his audience, the goals in the communication, decisions regarding specific information, and presentation of information—play as critical a role in causing an upheaval of scientific belief as scientific content.

Since its origins with Sir Francis Bacon in the sixteenth century, experimental science has prided itself on being above or outside of base human motivations and influences. The traditional scientific community contends that their discipline is the pursuit of laws and theories that describe the concrete, repeatable observations seen in the laboratory. Motivations for research are

found not in social pressures but in the logical progression of the scientific body of knowledge; the influence of their work stays within the bounds of its scientific implications.

However, this purist viewpoint is not held by all members of the scientific community. Increasing numbers of scientists believe that no process that exists in the framework of society can maintain separation from the influences of that society. Many, including Alan Gross (*The Rhetoric of Science* and "Does Rhetoric of Science Matter? The Case of the Floppy-Eared Rabbits"), John Campbell ("Scientific Revolution and the Grammar of Culture: The Case of Darwin's *Origin*"), Michael Halloran ("Technical Writing and the Rhetoric of Science") and R. Allen Harris ("Rhetoric of Science") have expanded on this perspective. They contend that scientists engaging in communication with other scientists (lecture, article, or textbook) use both consciously and unconsciously the ideas and tools of contemporary rhetoric to gain acceptance for their ideas. This new culture of rhetorical science asserts that all human communication serves the base, Sophistic purpose of persuading others to the beliefs or ideas of the speaker. Part of the growing acceptance of rhetorical science stems from the discipline's ability to explain the success or failure of certain publications, results that could not be understood solely on the merit of the publication.

For example, John Campbell's "Scientific Revolution and the Grammar of Culture: The Case of Darwin's *Origin*" details the important role that rhetoric played in the acceptance of Darwin's *Origin of Species*. Campbell illustrates Darwin's various rhetorical techniques. Stephen Hawking, another well-known scientist, notes that *The Universe in a Nutshell* has been much more successful at explaining current issues in physics to the common reader than his other texts, including the widely known *A Brief History of Time*. Hawking's observation is based upon his own assertion that he conscientiously wrote *Universe* in a more rhetorically aware and effective manner (*Universe in a Nutshell* vii).

Methods of Rhetoric in Origin and "Bearing"

From the combined strengths of scientific might and rhetorical style, Wegener's *The Origin of Continents and Oceans* was poised to cause a scientific revolution, while Taylor's text, lacking rhetorical punch, led him to geological anonymity.

Attitudes Toward Peers

The attitude an author presents toward his academic peers can play a crucial role in determining the rhetorically revolutionary might of a scientific writing. A consenting attitude, though initially desirable, has far less rhetorical power than a dissenting attitude, which creates a certain state of mind in the reader that lends itself to acceptance of new, drastically different ideas.

When it was published in 1915, *Origin* made a loud, dissenting splash in the geological pool. Its revolutionary attitude and content did not sit well with the vast majority of Wegener's

contemporaries, a fact which may explain why it took several decades for geologists to come to terms with his ideas and accept continental drift. Wegener separated himself from conventional geological thinking by establishing himself as the foremost geological expert; he built up his own image and tore down the images of others through rhetorically strong statements as evidenced by the following:

- If one surveys the results of this chapter, *it is impossible to escape the impression that drift theory can today be regarded as well founded geologically*, even in the detailed pronouncements. (95, emphasis added).
- [I]t is undeniable that all early attempts to determine the position of the poles and the equator at all points of time have led to *absurdities so grotesque that it is no surprise that the concept was suspected to be erroneous*. (129, emphasis added)
- "We shall refrain here from citing the literature in support of our statements. The obvious needs no backing by outside opinion, and the willfully blind cannot be helped by any means." (133)

Separating himself from other geologists had the dual effect of alienating traditional geologists and building his image of a scientist with a new, different, better philosophy— a rebel with new, wild ideas. The rhetorical separation from traditional geology, through image and attitude, creates a figure of an outsider. This outsider figure sets the stage in the reader's mind for a new concept outside of and contrary to traditional geology that may not have been achieved through a more submissive attitude. Moreover, to provide his new theories with the foundation they would need to withstand the imminent attacks, he branched out to other natural sciences. Substantial portions of *Origin* are based on interdisciplinary sciences like biology, paleontology, and climatology. Wegener's work lasted through its trial by fire because of this breadth in support.

In contrast, Taylor placed his authority in the hands of those before and above him. In 1910, Eduard Suess was recognized as one of the leaders of traditional geology. He was well known and respected for his beliefs in the popular theories of land bridges and "cooling and shrinking." Taylor recognized others' respect for this geologist and so included him profusely in "Bearing." By relying on Suess throughout his text, Taylor avoided the image of rebel. This rhetorical inclusion of the prominent scientist kept the tone of "Bearing" amenable and affable to traditional geologists as he developed the image of simply reinforcing ideas from the past. While this strategy saved Taylor from the vicious attacks of other geologists, it also condemned his work to anonymity.

In "Bearing," Taylor takes a committed stance of noncommittally saying anything. Instead of stating his ideas in powerful words, he qualifies all new or controversial thoughts with weak descriptors. Examples of this practice are hard to miss in "Bearing." Two characteristic ones follow:

- *It is probably much nearer the truth* to suppose that the mid-Atlantic ridge has remained unmoved. (218, emphasis added).
- If we contemplate the plan of the trend-lines, as shown in figure 2 for these two features, *it seems apparent* that it was the obstructing action of the Indian peninsula which produced the great Himalaya re-entrant. (191, emphasis added)
- These qualifications allow Taylor to avoid stepping on toes but doom "Bearing" to leave no mark, despite its scientific potential.

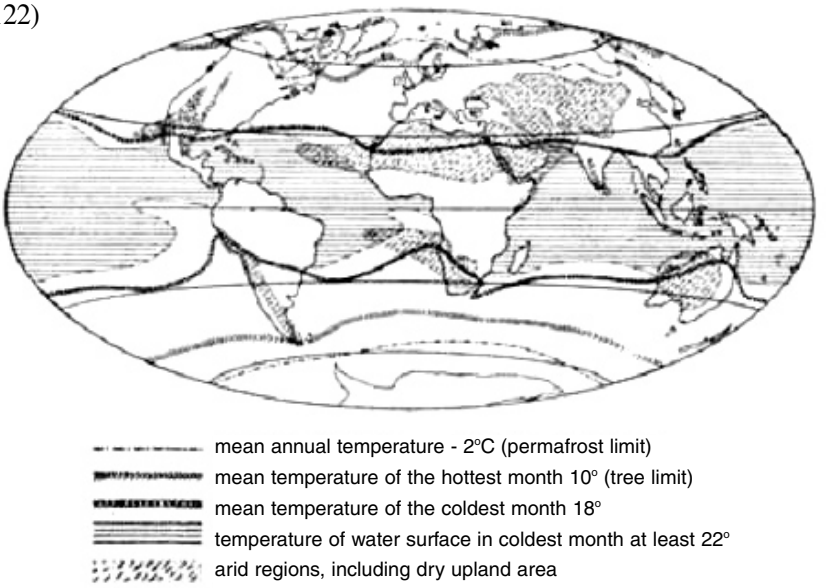
Graphics and Figures

Second in my consideration of Wegener and Taylor is their use of graphics and figures, a technique that is both scientifically and rhetorically sound. Scientists find it an easy and accessible method to display facts and figures without trying to struggle through the process of tedious description. Rhetoricians realize the advantage inherent in appealing to the powers of visual interpretation of the audience. Both disciplines rely heavily on the practice, and both disciplines have benefited immensely from it. Again, Wegener's strength as a scientist and rhetorician is complemented by his skills in this technique, while Taylor's weakness is highlighted by his poor application.

Throughout *Origin*, Wegener includes graphics copiously. The calculated pages per graphic ratio is a quantitative testament to that fact. At one graphic or figure every 3.4 pages, Wegener provides his readers a visual reference to coincide with his complex narrative. It provides a different perspective or demonstration of Wegener's arguments and justifications that would otherwise be hard to grasp.

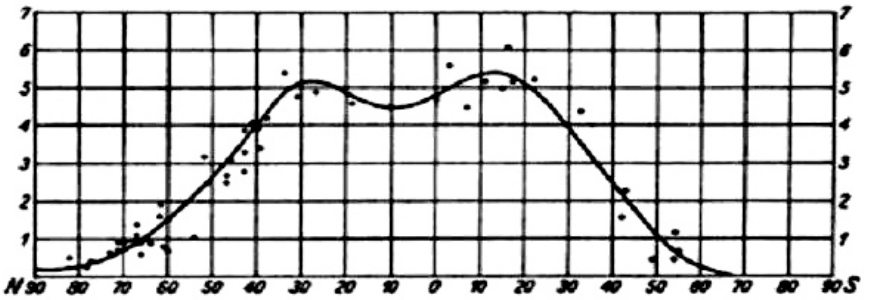
Wegener's graphics are clear and effective, as Figures 1 and 2 below indicate. Each presents a large amount of complex data and ideas and does so in a simple, easy-to-grasp method. Sometimes Wegener diagrams the tectonic motions of South America. Sometimes he illustrates the water depth of the Drake Passage. No matter what specific concept he may be presenting, the graphic is appropriate, accurate, and complete.

Figure 1 (122)



Chief present-day isotherms (at sea level) and arid regions.

Figure 2 (123)



Present-day altitude of the snow limit in the different latitudes (heights in km).

While Wegener had a knack for developing and employing good graphics, the same cannot be said for Taylor. As previously mentioned, Taylor's average of 5.2 pages for each graphic is substantially higher than Wegener's 3.4. The implications of these ratios are far-reaching. Taylor's limited number of figures leaves him with a very small pool from which to draw. Amazingly, he doesn't even make effective use of these. His first figure does a wonderful job depicting his theory on a global scale, yet references to it throughout his article are rare. Instead, time and time again Taylor refers to Figure 3, a graphic with limited range and utility.

Figure 3 (187)

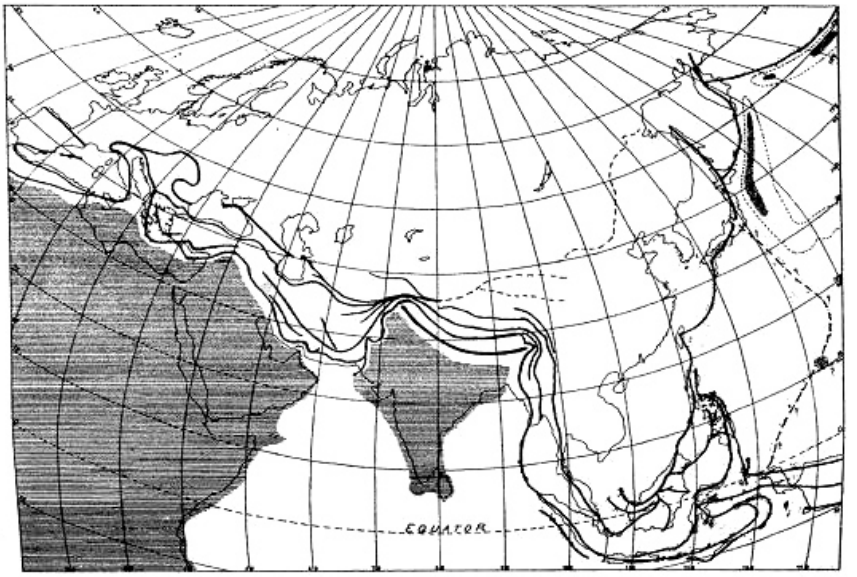


FIGURE 2 – EURASIO
Showing the mountain knot, part of the Aleutian Island arc, and part of the Corilleran ranges of British Columbia and Alaska. The arrows show the supposed direction of crustal movements.

Taylor's graphics have a recurring problem of ambiguity and irrelevance. His figures are a mess of information and take considerable effort to understand. Some, like Figures 4 and 5, are designed to show continental movement. The arrows inserted to illustrate that point are hard to find and even harder to understand. Figure 4 also includes extraneous information. The lower portion of Alaska is shaded, though no explanation is given. Other graphics, such as the figure and map on page 216, have no immediate reference and serve more to take up space in the article than add any real substance.

Figure 4 (203)

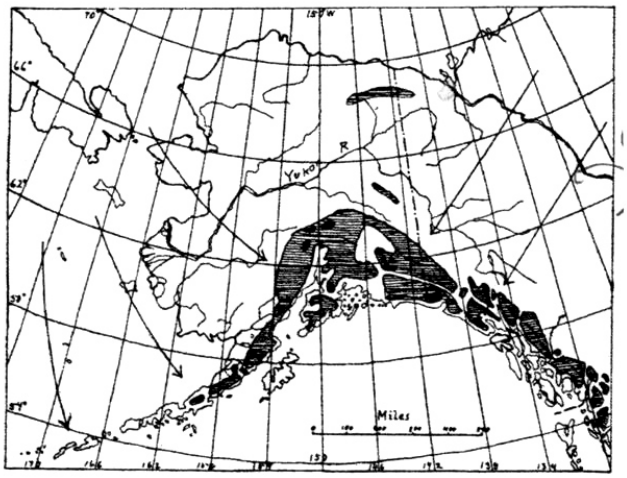


FIGURE – ALASKA
Showing the mountian knot, part of the Aleutian Island arc. and part of the Cordilleran ranges of British Columbia and Alaska. The arrows show the supposed direction of crustal movements.

Figure 5 (206)

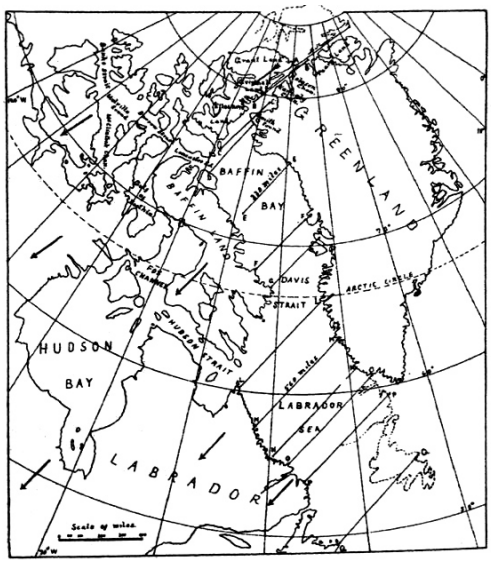


FIGURE 4 – GREENLAND AND THE ARTIC ARCHIPEIAGO
Showing the rift valleys on the northwestern and western sides of Greenland. The arrows show the supposed direction of crustal creep and the lines AA, BB, etceters, show the supposed distance of movement.

In total, "Bearing" is fundamentally flawed regarding the effective use of figures and, therefore, fails to monopolize on a powerful rhetorical technique.

Specific Measurements and Calculations

Finally, I consider the use of precise figures. The obvious advantage for including specific measurements and calculations is to detail to those who can understand or interpret them the exact

facts that led the author to her conclusions. There is, however, a more subtle rhetorical advantage. The in-depth, complex calculations and measurements create something of a state of awe in those readers who cannot begin to understand them.

When authoring *Origin*, Wegener included specific, highly exact calculations, measurements, and formulas in his tables, figures, and narrative. Sometimes he measured the precise distance between Greenland and Europe, and sometimes he derived complex physics equations for calculating polar wandering. Wegener's detailed specifics, such as the measured oscillations in the planet's rotation, create an aura of professionalism, intelligence, and expertise for his readers. Readers are subtly persuaded to believe he knows more than they do and, as such, they should believe him. This rhetorical device serves the broader purpose of creating legitimacy for the rhetorician, one of the staples of successful persuasion.

Wegener practices this rhetorical technique time and time again through the course of *Origin*. He lists species duplication over the various geological periods (100) and diagrams the wandering of the South Pole from 1900 to 1925 (151). He tracks the changes in latitude for the European continent through the geological periods (162) and even specifies the measured gravitational fluctuations of the Himalayas (40). These measurements and many like them give the entire book a feeling of precision and exactitude that could not have been achieved through generalities alone.

The final insight into Taylor involves his use of precise measurements. Taylor's efforts in this area are easy to note—there are none. At no point in the course of "Bearing" does Taylor ever present a measurement more specific than the approximate, highly rounded height of a mountain or depth of a gorge. This opportunity for rhetorical persuasion is completely lost on Taylor.

Conclusion

Wegener's reader is wooed to accept his theories on an emotional level in addition to a scientific or factual one. His techniques are evident, if unconscious, applications of Aristotle's technique of pathetic arguments. The ideas behind Wegener's *Origin* were revolutionary; that is, they were so new and so different that they required an extreme paradigm shift in the way in which scientists and the public viewed the continents and their beginnings. We see in his portrayal of these ideas Aristotle's *logos*. Wegener was able to succeed in turning his revolutionary ideas into a revolutionary text and finally a scientific revolution because he successfully applied techniques from the rhetorical discipline, including the rhetorical rock of Aristotle. Be it structure, attitude, or content, Wegener was a master at the application of rhetoric.

Taylor's failure in "Bearing of the Tertiary Mountain Belt on the Origin of the Earth's Plan" should be credited to lackluster rhetorical persuasion rather than to the flaws in theory. Be it an acquiescent personality, cryptic pictures and figures, or lack of specificity, the motivations of the piece are difficult for the reader to understand. "Bearing's" failure to cause a scientific revolution

results from his apologetic attitude and pedantic presentation of his material.

The implications of Wegener's rhetorical success and Taylor's failure go beyond continents and oceans. This lesson can and should be applied to all scientific texts. The survival of scientific ideas relies as much on the rhetoric used to present the theory as it does on the theory itself. Be it continental drift, biological evolution, or contemporary physics, rhetoric plays a critical role in winning acceptance for a scientist's theories.

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