Forward – **Volume II: Paleomagnetism and Confirmation of Drift (H.R. Frankel)**

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This is the story of the formative years – the decade of the 1950s – of paleomagnetism as a scientific discipline in conjunction with a focus on the big questions of the day – the origin of the geomagnetic field, polar wander, continental mobility. The exposition is meticulously documented with referral to primary published literature and enlivened by extensive referral to real-time correspondence and retrospective views based on the author's interviews and written exchanges with many of the principals dating back to the early 1980s. Some of the themes that emerge from the account is the ever-importance of serendipidity and the ability of top scientists to identify tractable aspects of a big problem, adjust the scope and direction of the research as needed, and recognize applications to seemingly oblique problems.

Paleomagnetism involved some of the major figures in physics of the post WWII era, like Neel, including the Nobel laureate Blackett (who studied under Rutherford, another Nobelist), who spins up the story with an ingenious experiment to test whether the geomagnetic field is a fundamental property of a rotating body. The results were famously negative yet the theory and experiment had several notable positive outcomes, namely capturing the interest of his PhD student, Keith Runcorn, to test the fundamental theory versus the competing dynamo theory by making measurements of the geomagnetic field in mine shafts, and the deployment of the sensitive magnetometer developed for the experiment for paleomagnetic research on rocks. Runcorn went on to assemble what became the leading group in paleomagnetism research (started at Cambridge but soon moved to Newcastle), whose students would emerge in the vanguard of the subject's most influential practitioners. The enterprise was graced with luck right at the outset with the arrival in late 1949 at Cambridge of Hospers, a student from Holland who came with his own scholarship and wanted to sample young lavas in Iceland hoping to correlate them by their intensity of magnetization. In the process, Hospers produced evidence for a global correlation tool, polarity reversal stratigraphy; for the exquisitely simple geometry for charting polar motions or continental mobility, the field of a geocentric axial dipole; and providing data that motivated the development of statistical methods on a sphere, Fisher statistics. These are pillars of paleomagnetism and they were basically established by 1953. Soon after Hospers arrived, Runcorn recruited Irving with his background in geology to look for evidence of geomagnetic secular variation in the Torridonian, thick sedimentary beds of Precambrian age. This was a wildly optimistic effort that nevertheless developed modern techniques and produced the first magnetic polarity reversal stratigraphy in sediments and oblique directions that indicated magnetic stability, which pointed to such fine-grained redbeds as key sampling targets for studies of the ancient geomagnetic field. The range of research expanded and was conducted at an exhilarating pace in a global network of information flow with sharp attention to publication priority. Creer, Runcorn's second student in paleomagnetism, built a sensitive astatic magnetometer at Cambridge after the design of Blackett's machine and only managed to start sampling and measuring a series of rock units half-way through his three year fellowship; nevertheless, by 1954 he constructed an apparent polar wander path for Britain, the first such path and the conceptual basis for testing continental drift. Irving leaves for Australia in1954, builds a lab from scratch with a new student, Green, and they had new results on Mesozoic dolerites in press within 2 years. And so forth.

By 1958 there were published results from young lavas from four continents in support of a geocentric axial dipole and the reality of polarity reversals, full results from the Deccan of India by the Blackett group, data from Australia by Irving's lab in Canberra, from South America by Creer, and paleoclimate evidence from proxies like Opdyke's analysis of wind directions in full support of the paleomagnetic assumptions: the evidence from the British schools (and from others like Gough in Africa and the brave Khramov in the Soviet Union) was decisively in favor of crustal mobility. In contrast, Graham at the Department of Terrestrial Magnetism at the Carnegie Institute came to very different conclusions. Graham actually had a head start with the availability of a sensitive spinner magnetometer at the Carnegie that allowed him to publish in 1949 a paleomagnetic survey of sedimentary formations from throughout North America and to develop seminal reliability tools like the fold test. Unfortunately, Graham was unable or unwilling to counter what the author describes as the prevailing fixist and anti-field reversal orthodoxy of the American community, and called upon cryptic strain effects and self-reversal (given credence by theoretical work of Nobel laureate Louis Neel**,** followed shortly thereafter by the chance discovery by Nagata's group in Japan of a self-reversing rock, now known to be an exceeding rare occurrence) to explain otherwise straightforward evidence for crustal and/or polar mobility.

By 1959, the author points out that every major paleomagnetist with the notable exception of the American Graham (and Cox and Doell) favored crustal mobility, but despite this level of success, the paleomagnetists who advocated continental mobility were a beleaguered group. For one, the U.S. effort simply lacked a charismatic leader like Blackett to counter the negativism of the geologic community. And to cap this desultory period in the paleomagnetic case for crustal mobility, a lengthy critical review by Cox and Doell that appeared in the GSA Bulletin in 1960 reserved judgment, an opinion that tended to conform with general disbelief in crustal mobility expressed by the pillars of the American geological community (e.g., Bucher, Gilluly) as well as some of the high priests of theoretical geophysics (e.g., expressed in Jeffrey's The Earth and in Munk and MacDonald's The Rotation of the Earth). A great irony is that despite what is appropriately described as one of the greatest flukes in the history of testing continental drift (ranking right up there with the self-reversing rock from Japan) – Cox's report in 1957 of the aberrant direction from the Eocene Siletz volcanics from Oregon falling close to the Deccan pole from India with continents in the present position and ascribed to rapidly varying geomagnetic fields, which turned out to be due to local tectonic rotation of the Siletz – Cox's misjudgements were basically forgotten and his (with Doell's) reputation rested on their subsequent work on the timescale of polarity reversals (motivated in part by the self-reversing fluke), which was the basis of the Vine and Matthews hypothesis.

The decade-long effort to make the case for continental mobility with land-based paleomagnetism was not in vain. It not only helped prepare the community to accept plate tectonics (the topic of the author's next volume), it eventually provided the natural paleogeographic reference frame.