

Magnetic Anomalies Over Oceanic Ridges

In the footsteps of Frederick Vine

Carlo Laj
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&
EGU Committee on Education

GIFT Workshop, April 7 2019, Vienna



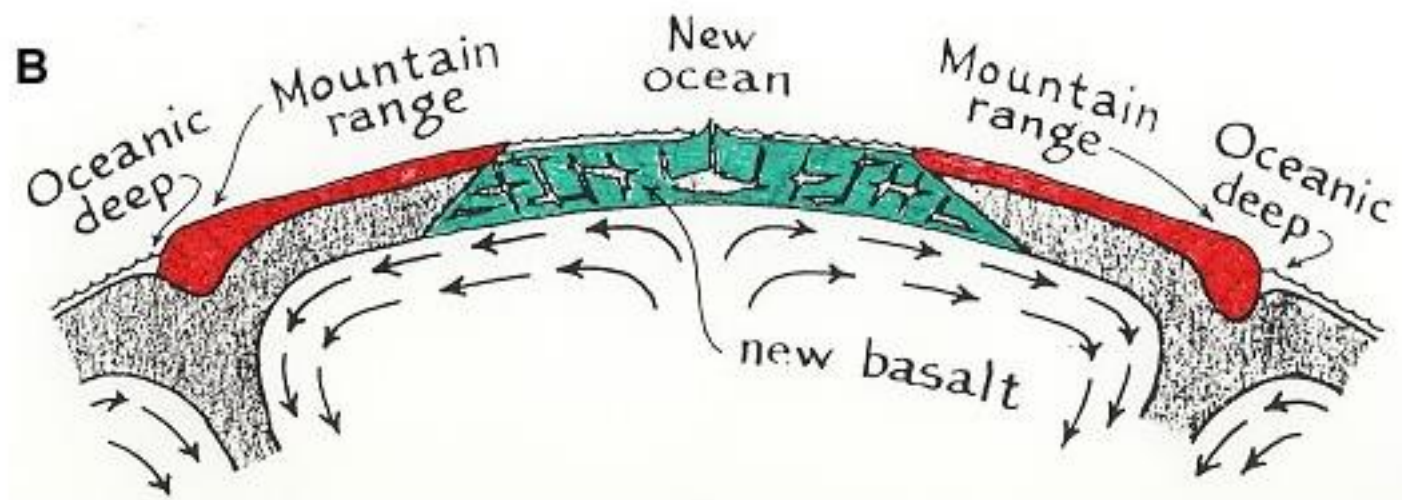
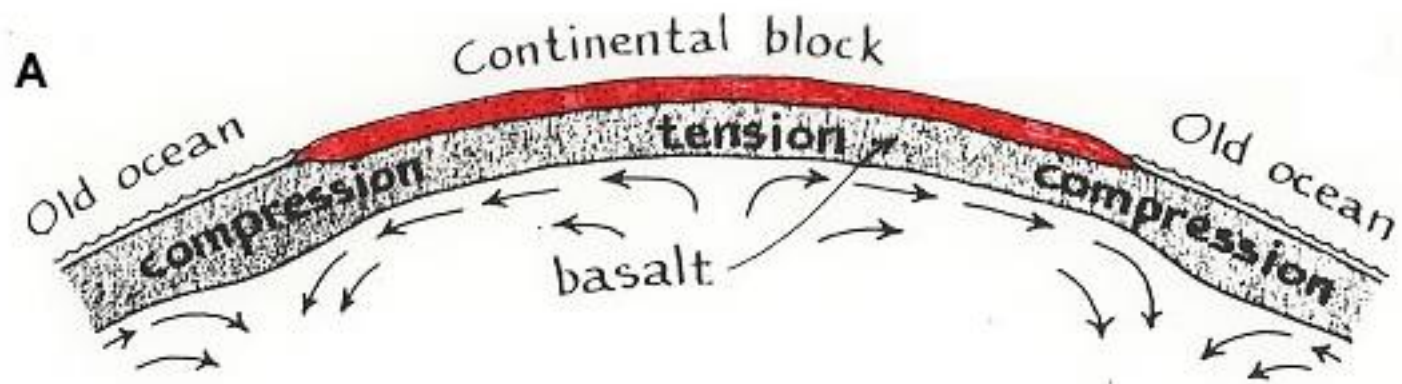
Courtesy: Fred and Sue Vine

State of Art in the '50 early '60..

Alfred Wegener 1912
Proponent of the continental
drift theory/hypothesis
German meteorologist

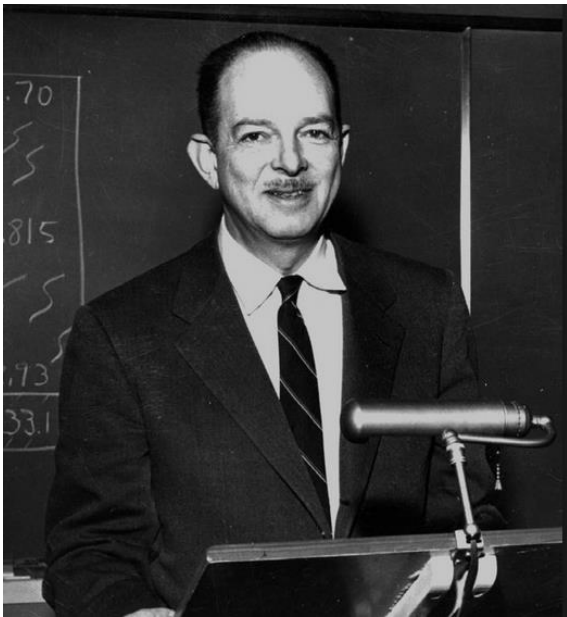


Arthur Holmes, British Geologist, 1890-
1995, father of the geological time scale
(*The age of the Earth*, 1927)





H. Hess was a professor at Princeton, but he had been captain of *U.S.S. Cape Johnson* during the second world war and had done extensive bathymetric exploration of the ocean floors, keeping his sonar always working. He discovered sea floor ridges

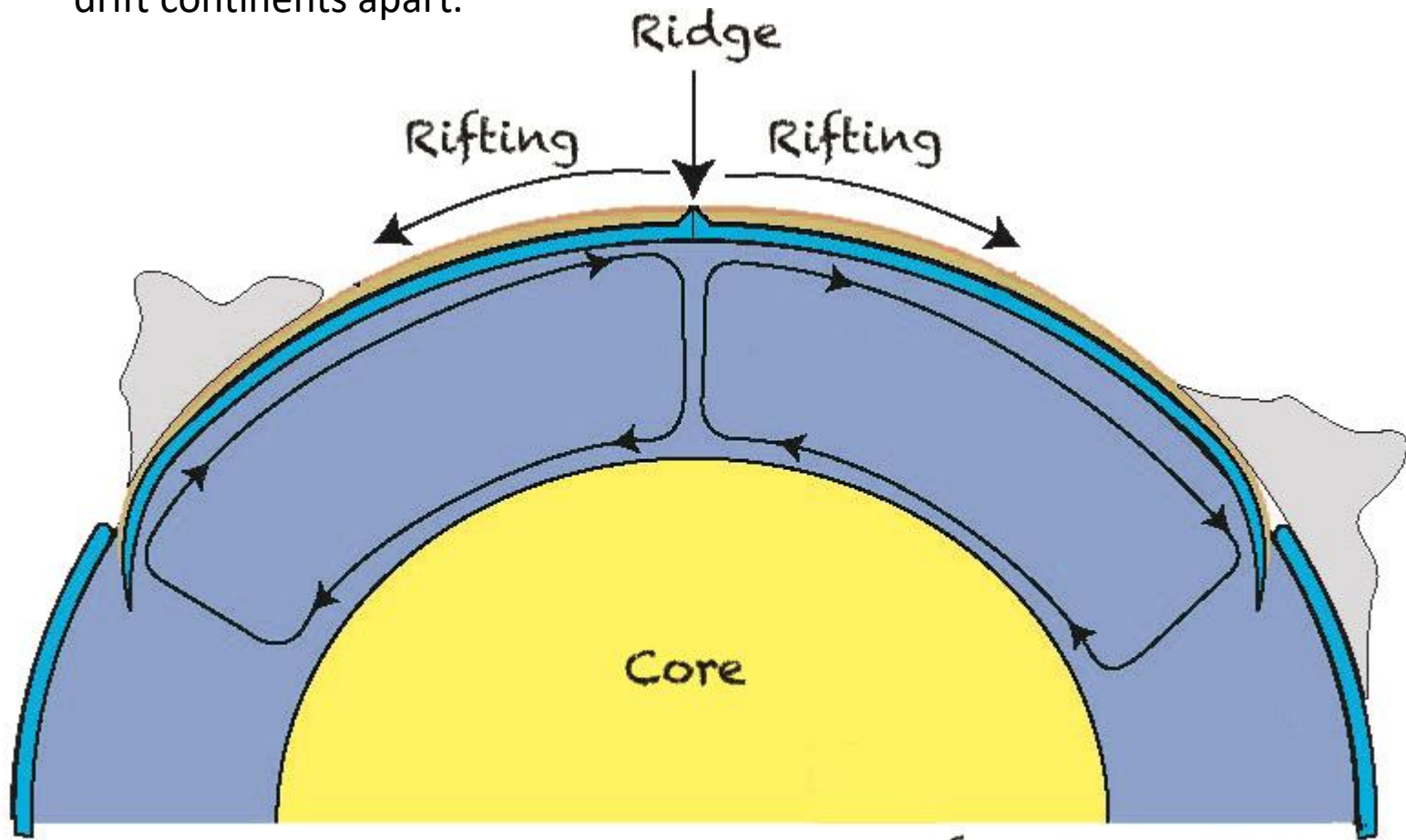


In the 1960's, Harry Hess suggested the theory of seafloor spreading to explain the ridges

The term « sea floor spreading » is due to Robert Dietz, 1961



According to Harry Hess of Princeton University, “conveyor belts” of crust and upper mantle move symmetrically away from mid-ocean ridges and passively drift continents apart.



After Hess, 1962

« I shall consider this paper an essay in geopoetry. »

Harry H. Hess,

History of Ocean Basins, 1962

in Petrologic Studies, a volume to honor A.F. Buddington

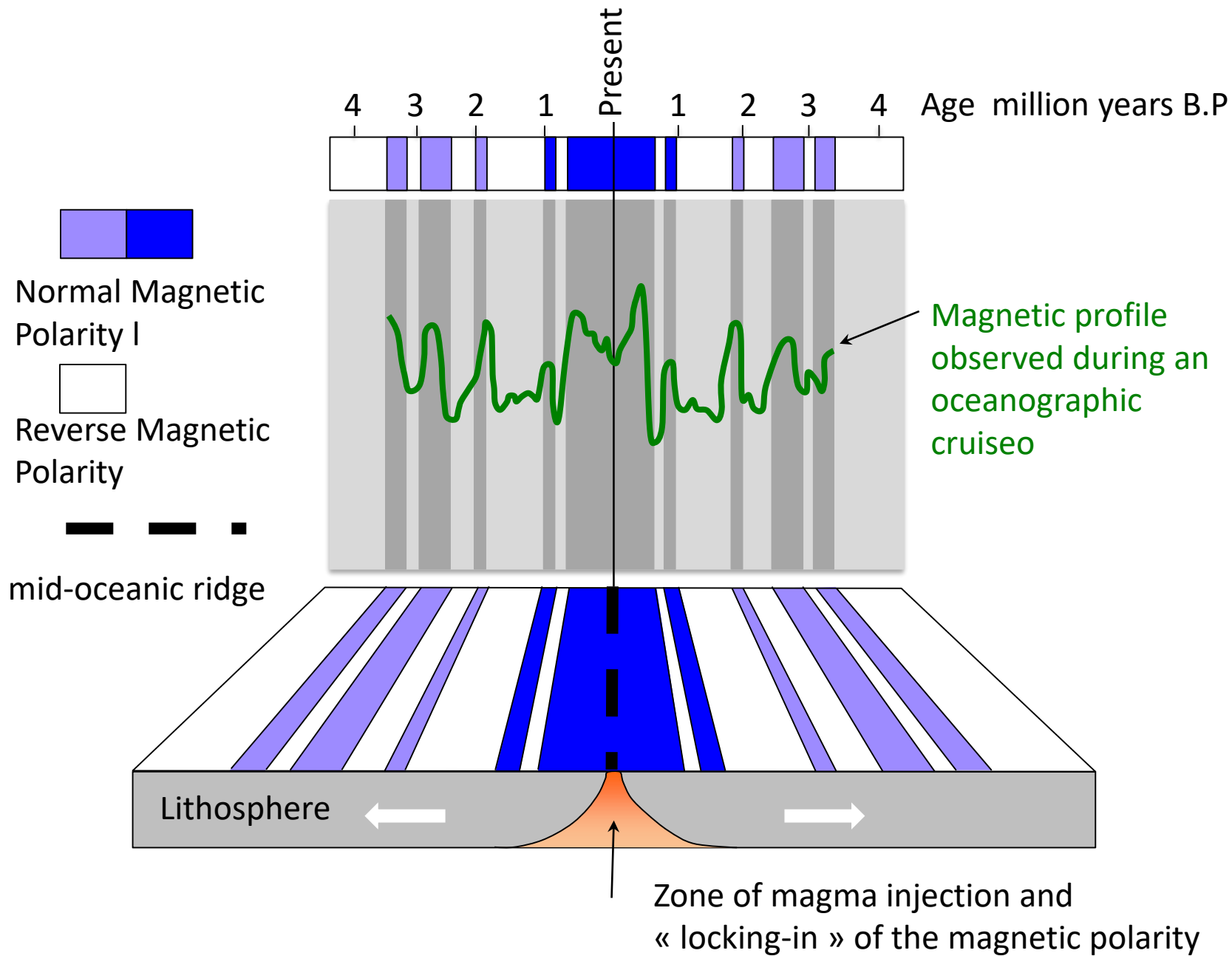
Magnetic Anomalies Over Oceanic Ridges

Frederick Vine and Drummond Matthews

Nature, 7 September 1963

In this landmark paper Vine and Matthews proposed:

« ...that the conveyor belts might also act as tape recorders that record reversals in the polarity of the earth's magnetic field in the 'fossil' (i.e., remanent) magnetism of the oceanic crust. »..





Lawrence Morley

*Chief of the Geophysics
Division/Geological Survey of
Canada;
staff >100 persons*

Laurence Morley submitted his original paper to Nature and, after rejection, to the Journal of Geophysical research with the same fate.

... that the idea may be interesting for "talk at cocktail parties, but it is not the sort of thing that ought to be published under serious scientific aegis."

(Reviewer's comment on Morley's paper!)

Because of his responsibilities he had virtually no time to write further papers and press forward his new ideas.

« ...probably the most significant paper in the Earth sciences ever to be denied publication »

(comment by Norman D. Watkins, 1974)



Lawrence Morley

Fred Vine &
Drummond Matthews

Vine – Matthews – Morley hypothesis



CHAPTER 3

REVERSALS OF FORTUNE

Frederick J. Vine

*Naomi Oreskes' Plate Tectonics: An Insider's
History of the Modern Theory of the Earth
2003*

Earth Ref.org Digital Archive (ERDA)

Initial reaction to the paper was, to say the least, muted.

Frederick Vine, in Reversals of fortune

And there were significant reasons for this!

- The idea of sea floor spreading was far from being universally accepted

- The geomagnetic field reversal scale was at its infancy and the only available one was the Cox, Doell and Dalrymple June 15, 1963

- The importance of remanent (oppose to induced) magnetization of the sea floor was not universally accepted

- Finally, from the limited magnetic data available at the time from the North Atlantic and Indian Oceans, the record was not clearly interpretable (although it clearly appeared completely different from almost any pattern observed by aeromagnetic surveys over the continents)

Progress in the knowledge of the magnetic properties of submarine basalts

Developing the Potassium-Argon method



Evolution of the geomagnetic time scale

The concept of transform faults

Progress in the knowledge of the magnetic properties of submarine basalts

➡ oceanic magnetic anomalies had been generally interpreted in terms of induced magnetizations

➡ problems to explain the observed magnetic anomalies gradients without having improbable petrological contrasts

But, Girdler and Peters, 1957; Mason, 1958, 1967, Bullard and Mason 1963, reported strong magnetizations from dredged oceanic rocks

➡ high ratios of remanent to induced magnetizations

With reversals, the observed magnetization contrasts can exist in perfectly laterally homogenous crust ...

... and this was the whole essence of the Vine-Matthew-Morley idea!

Progress in the knowledge of the magnetic properties of submarine basalts

Developing the Potassium-Argon method



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The concept of transform faults

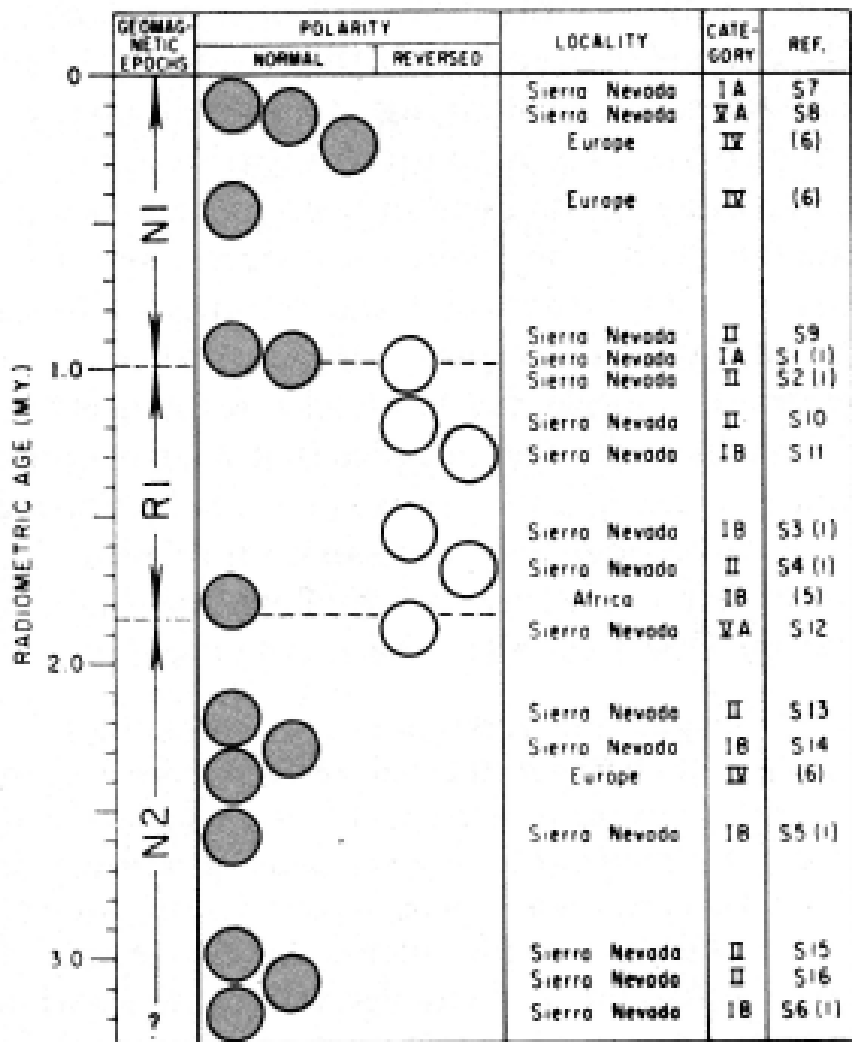
The development of the K-Ar dating technique

December 1954: first mass spectrometer built by John Reynolds, soon followed by Garniss Curtis and John Evernden

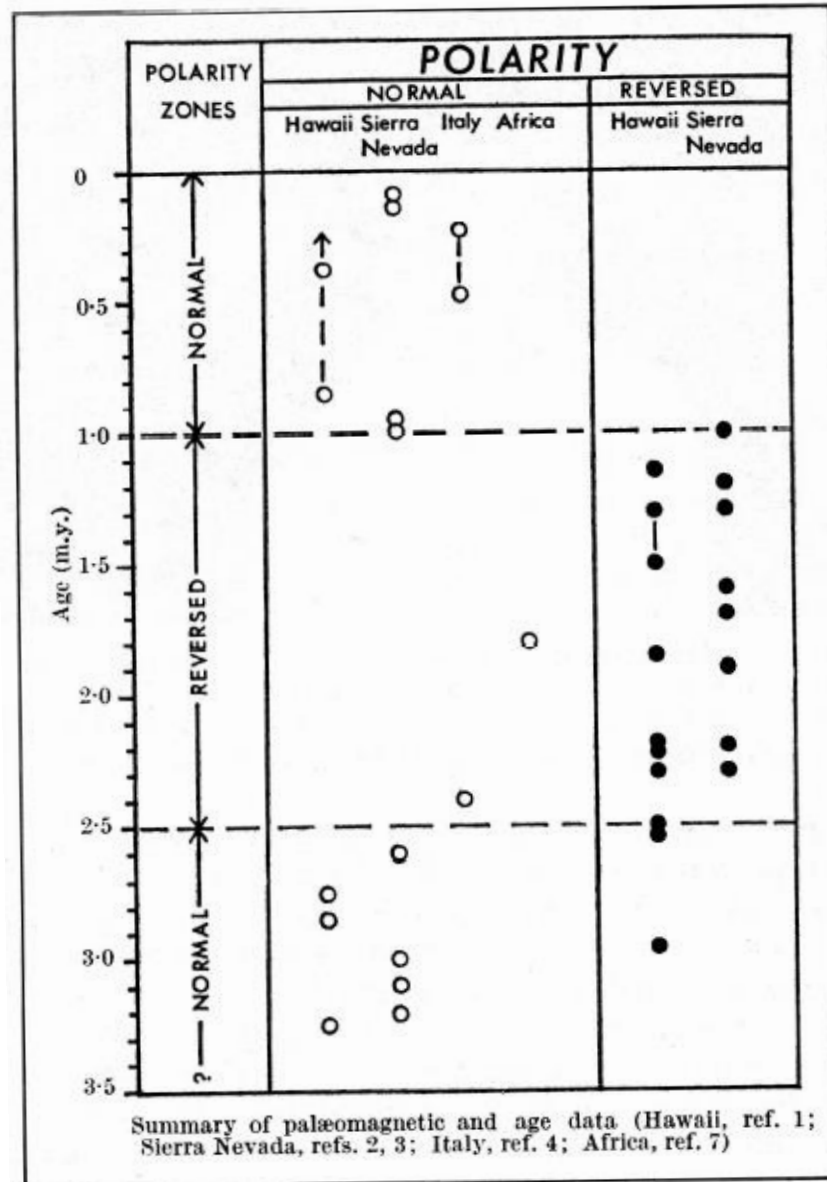
1954: at the USGS in Menlo Park, Allan Cox and Richard Doell (later joined by Brent Dalrymple) started a program specifically aimed at resolving the question: field reversals or self-reversal?

1963 – first polarity scale published by the Menlo Park group

1964 – improved polarity scale published by Ian McDougall and Don Tarling the National Australian University in Canberra



Cox, Doell, Dalrymple, 1963



McDougall and Tarling, April 1964

1964 - improvements by Cox, Doell and Darlymple (*Science*)

Scale 7 : Recognition of the Olduvai event (around 2 my)

Suggestion for the Mammoth Event (around 3 my)

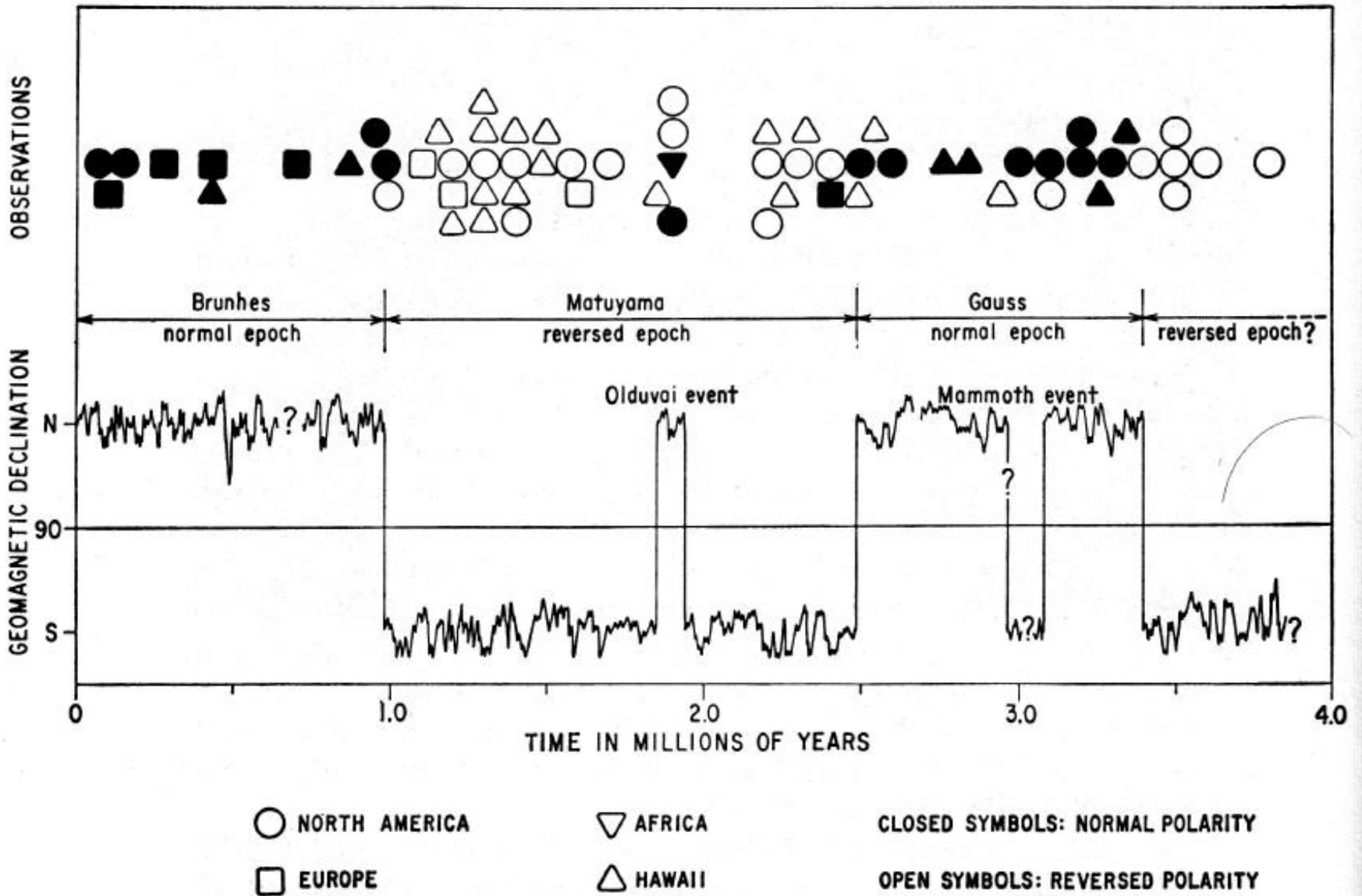


Fig. 3. Magnetic polarities of 64 volcanic rocks and their potassium-argon ages (16). Geomagnetic declination for moderate latitudes is indicated schematically.

1964 - improvements by Cox, Doell and Dalrymple (*Science*)

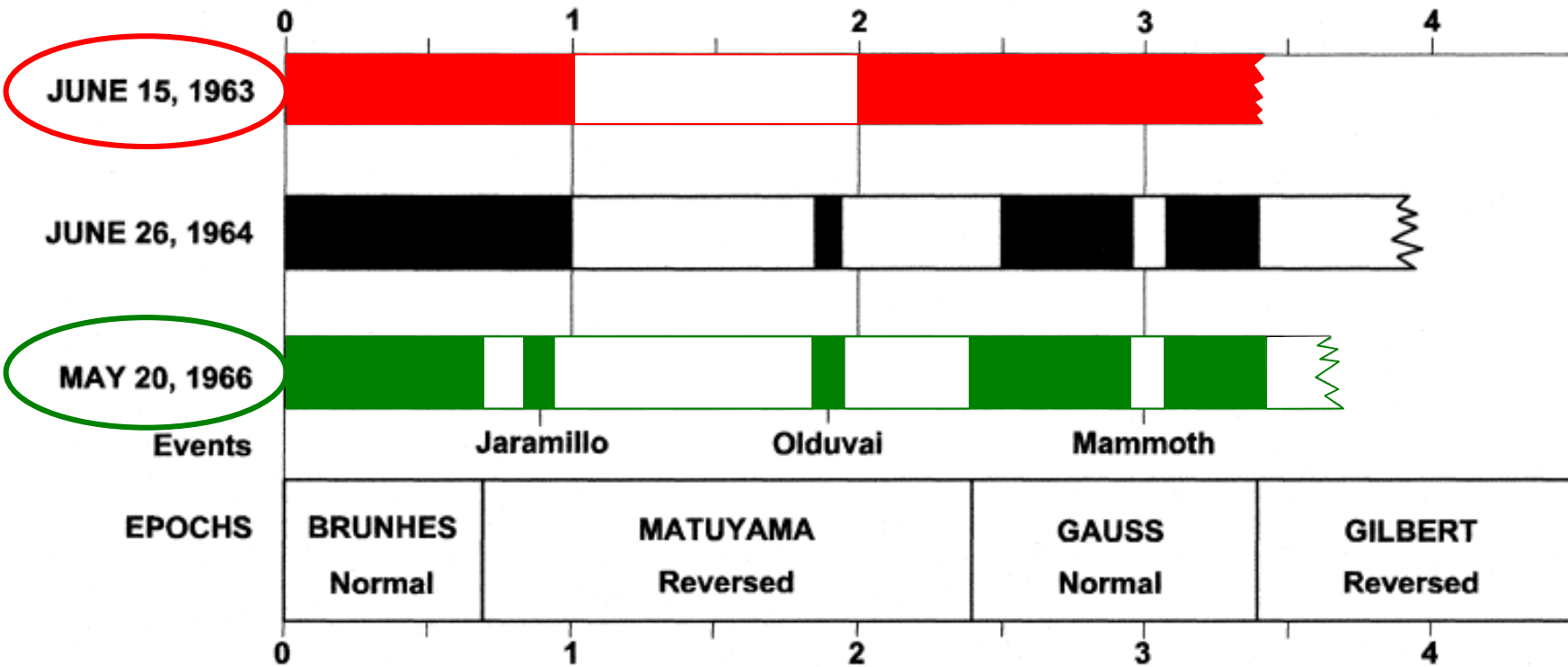
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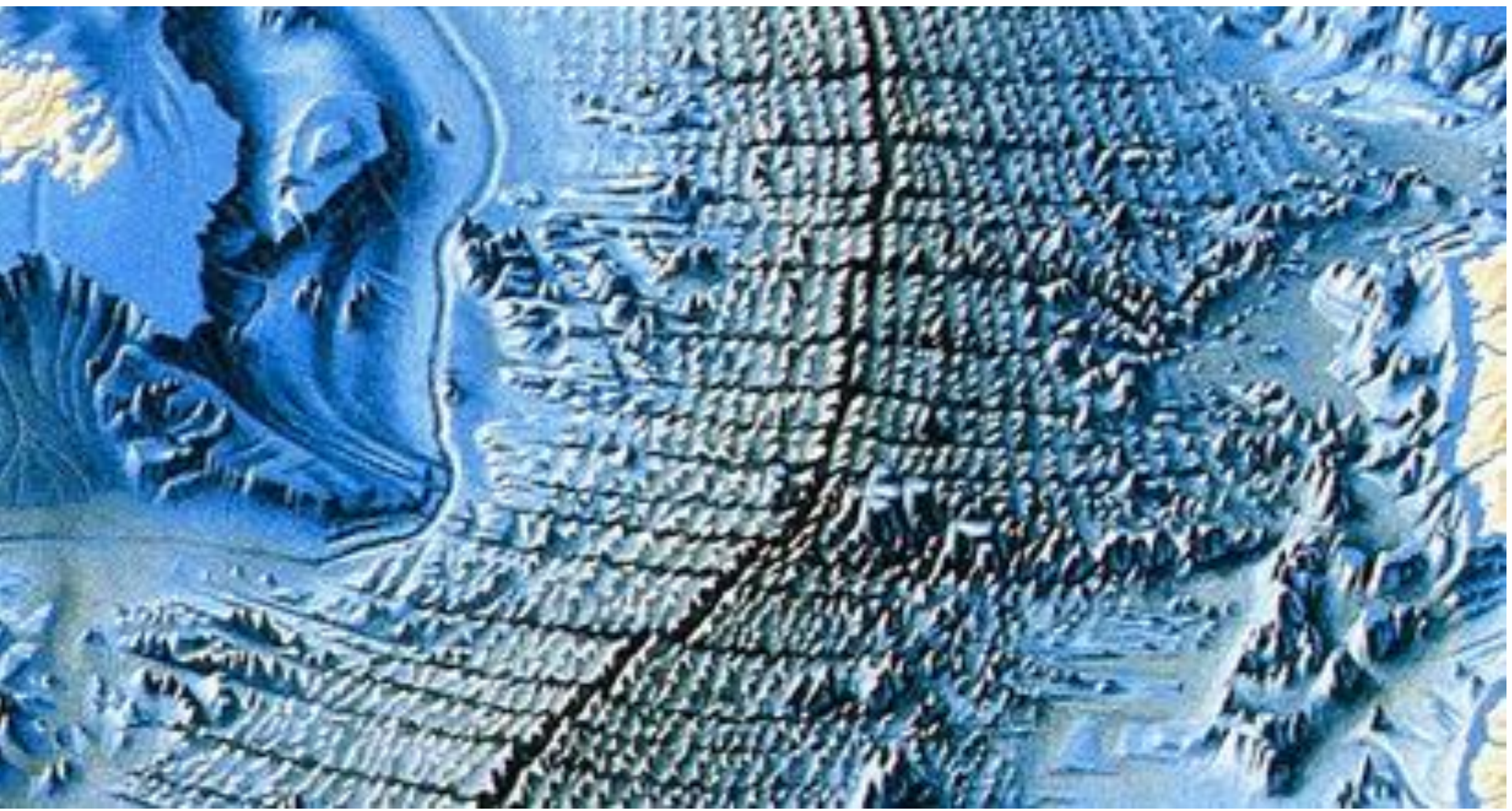
1966 - Scale 11 Doell and Dalrymple

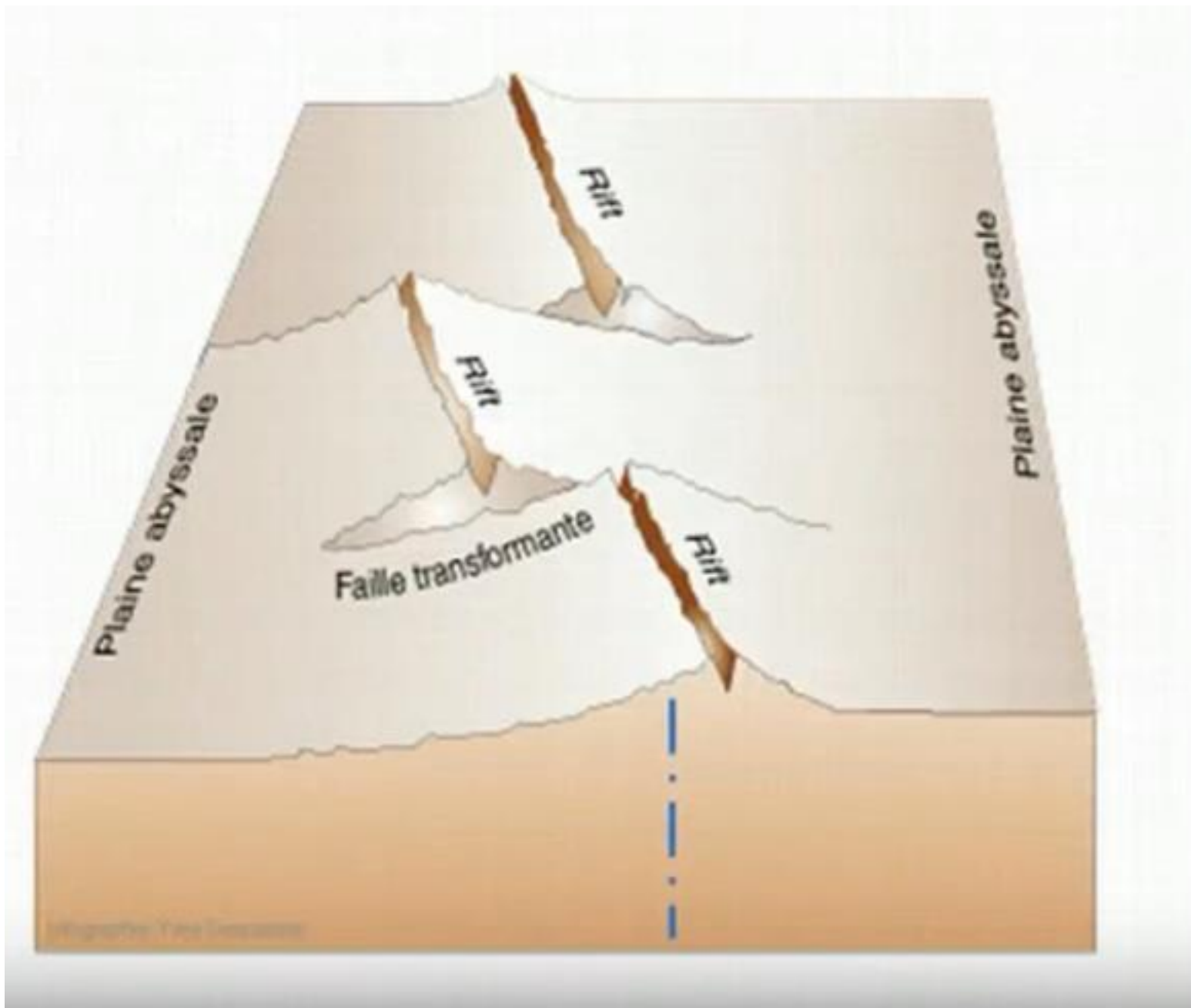
Containing the « Jaramillo Event » also discovered almost simultaneously by Neil Odyke in deep sea sediments.

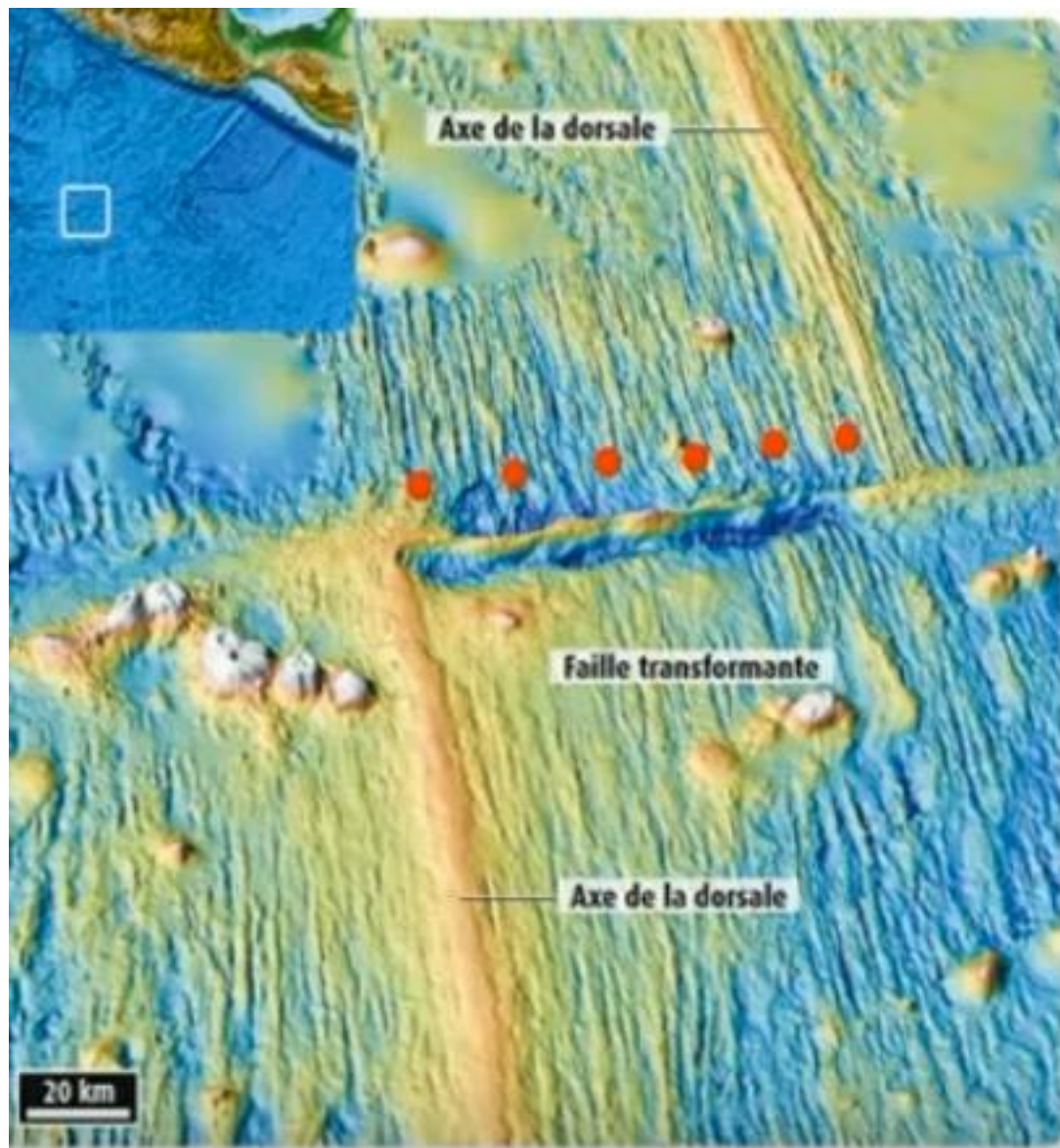
The Jaramillo event : a crucial role in establishing the linearity of sea floor spreading

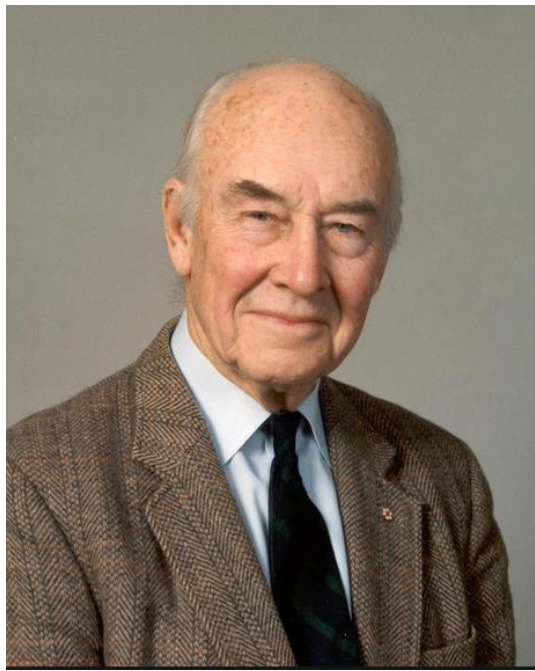
AGE, in millions of years









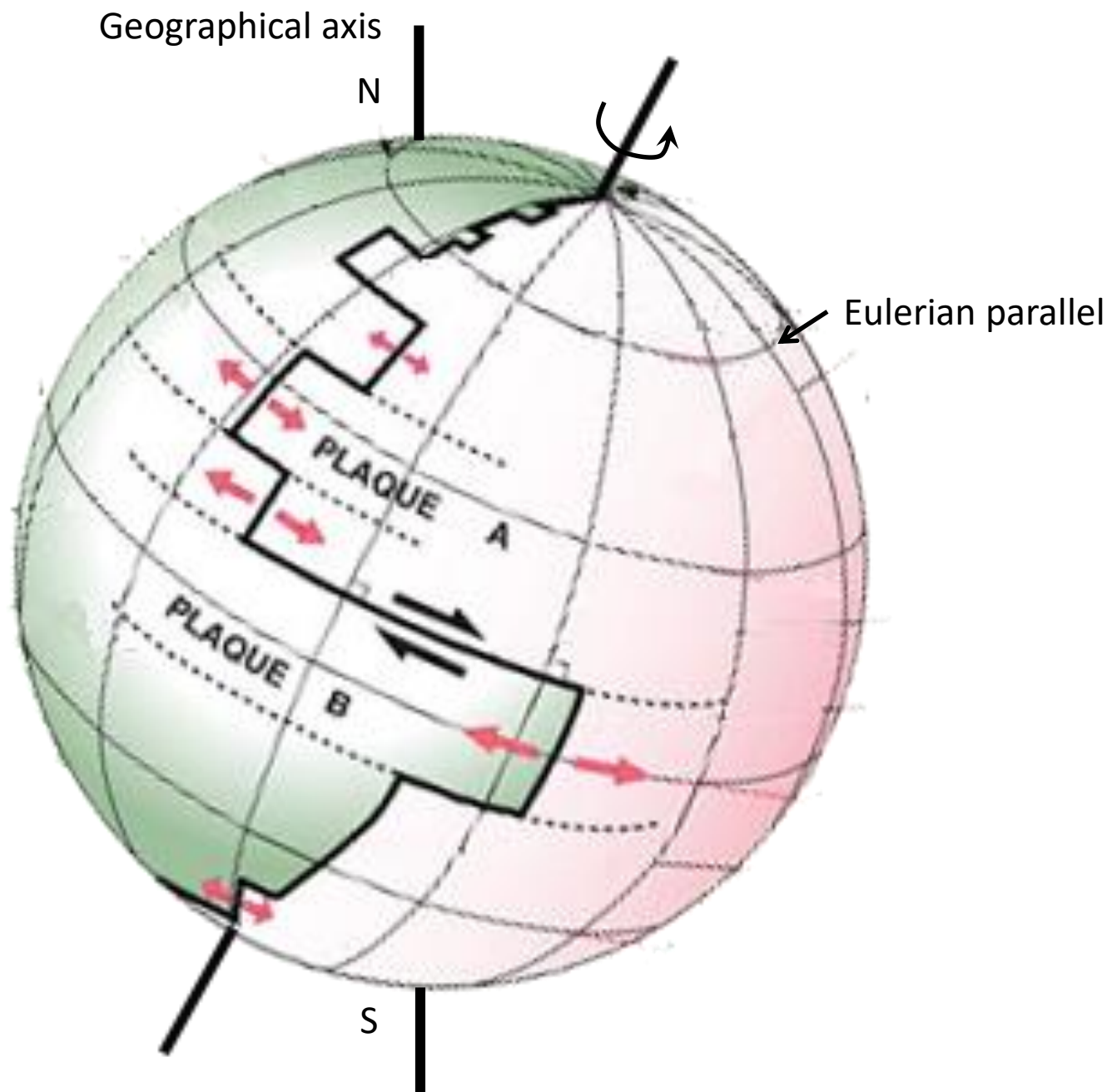


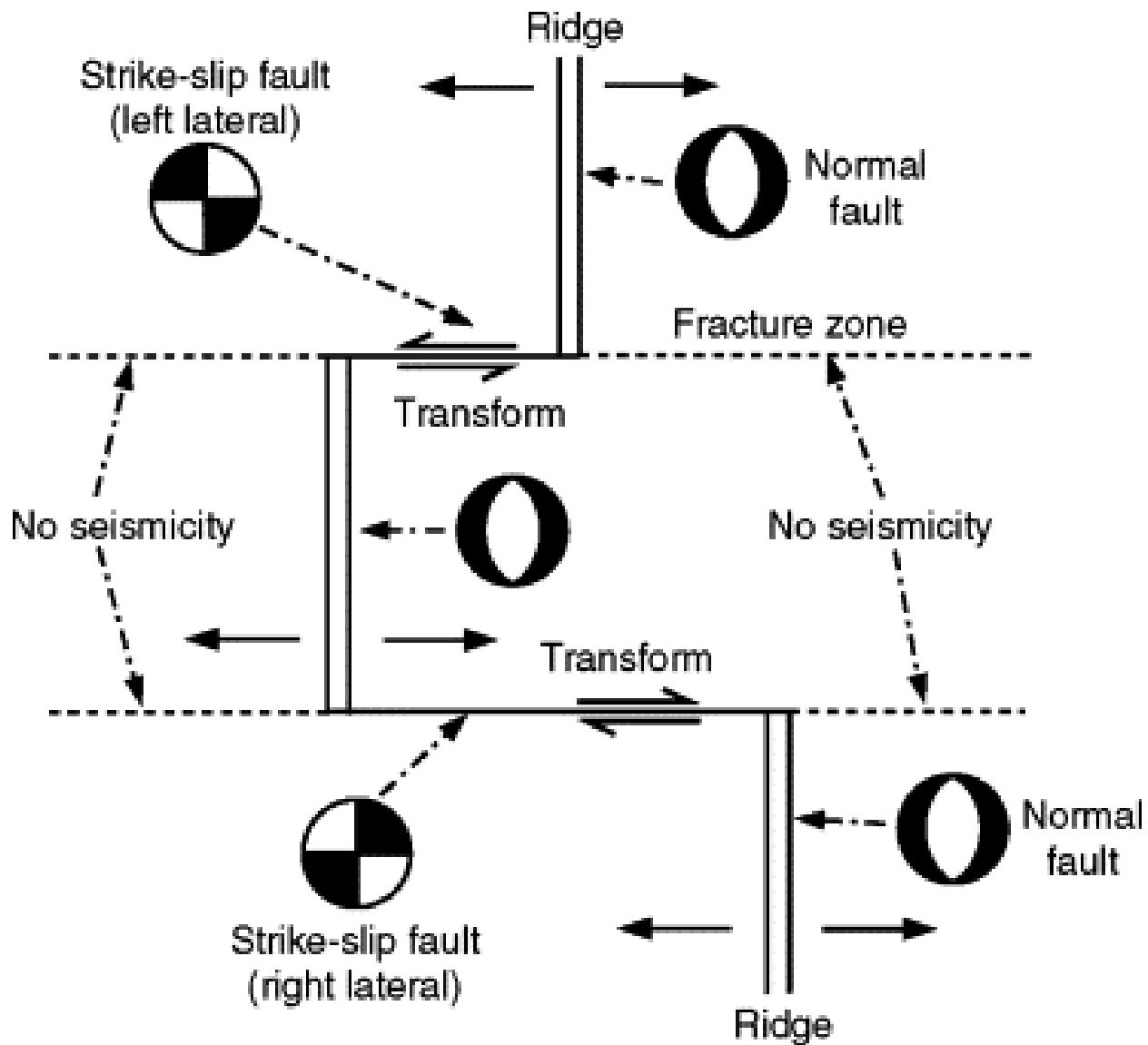
July 24, 1965

NATURE

A NEW CLASS OF FAULTS AND THEIR BEARING ON
CONTINENTAL DRIFT

By PROF. J. TUZO WILSON, O.B.E.
Institute of Earth Sciences, University of Toronto





A conversation among Vine, Hess and Wilson about the Juan de Fuca Ridge in 1965 (reported by Vine):

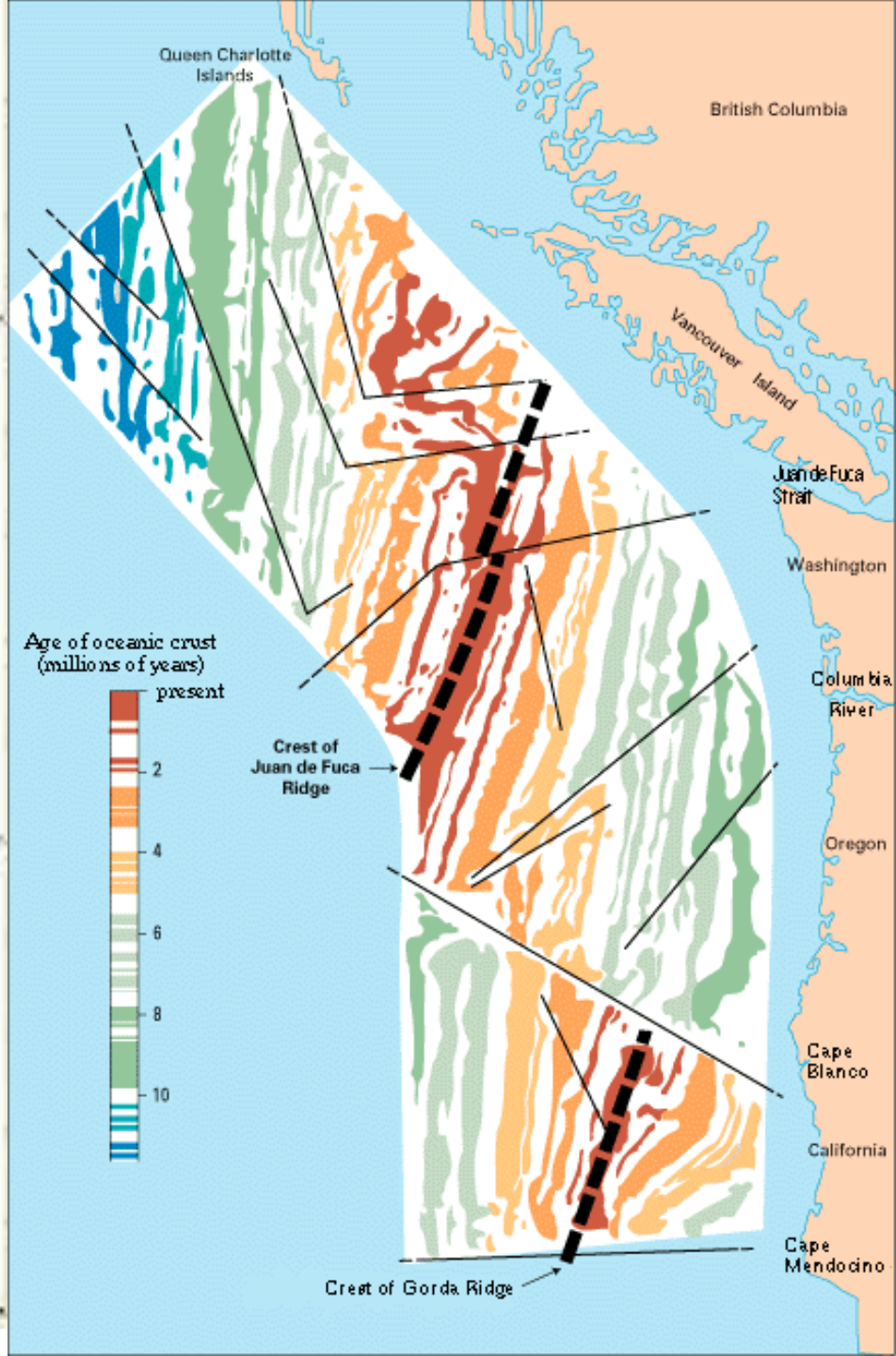
Wilson: « Look, there should be a ridge here »

Hess: Well, if you are going to put a ridge there, then there ought to be some magnetic expression of it in the Raff and Mason map »

Vine rushed to the library and got out the Raff and Mason map: the magnetic stripes were clearly apparent!

Mason and Raff, 1961, Magnetic survey of the West Coast of North America, Bull. Geol. Soc of America

Modified by Vine



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1953—1965

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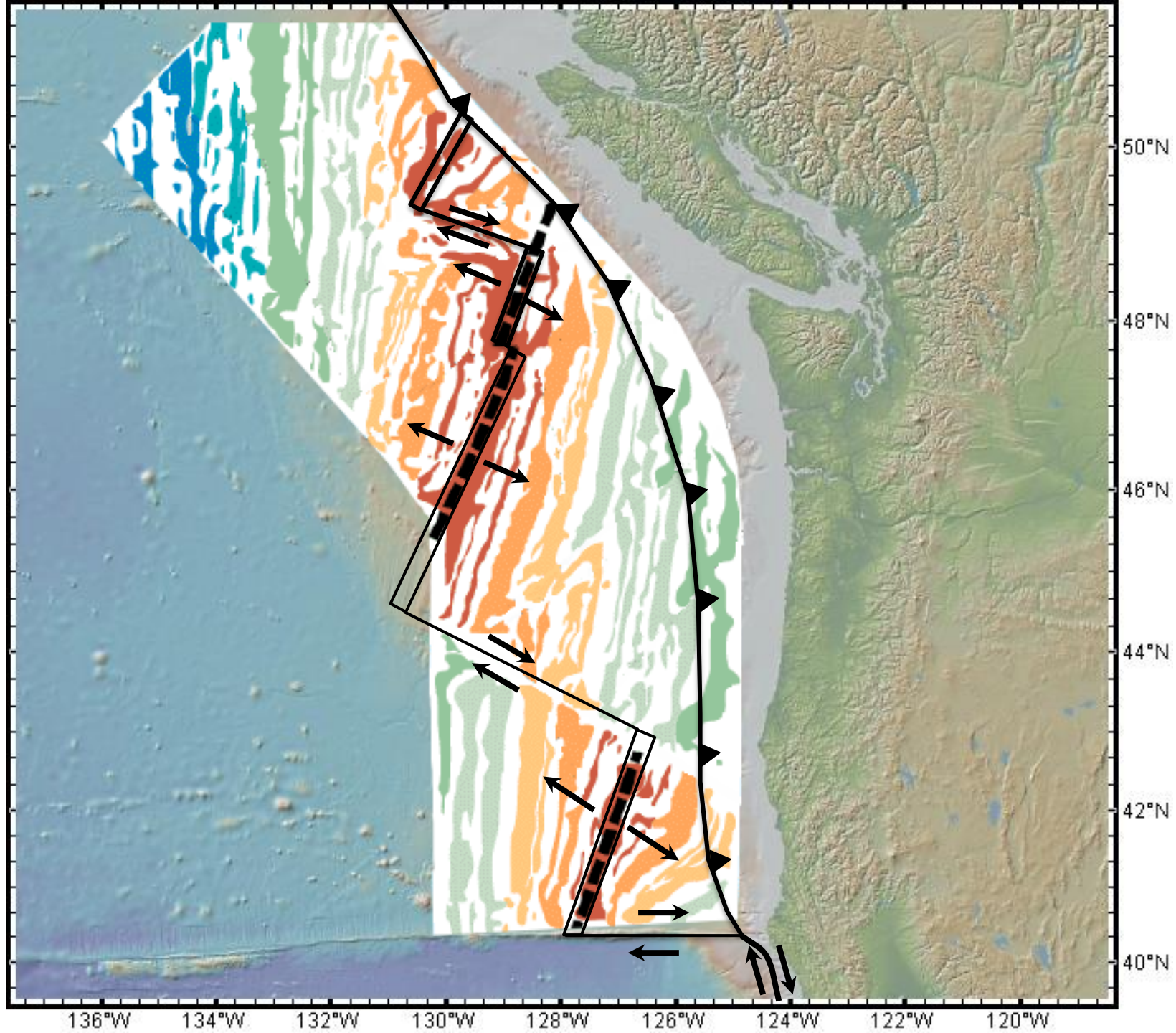
1966

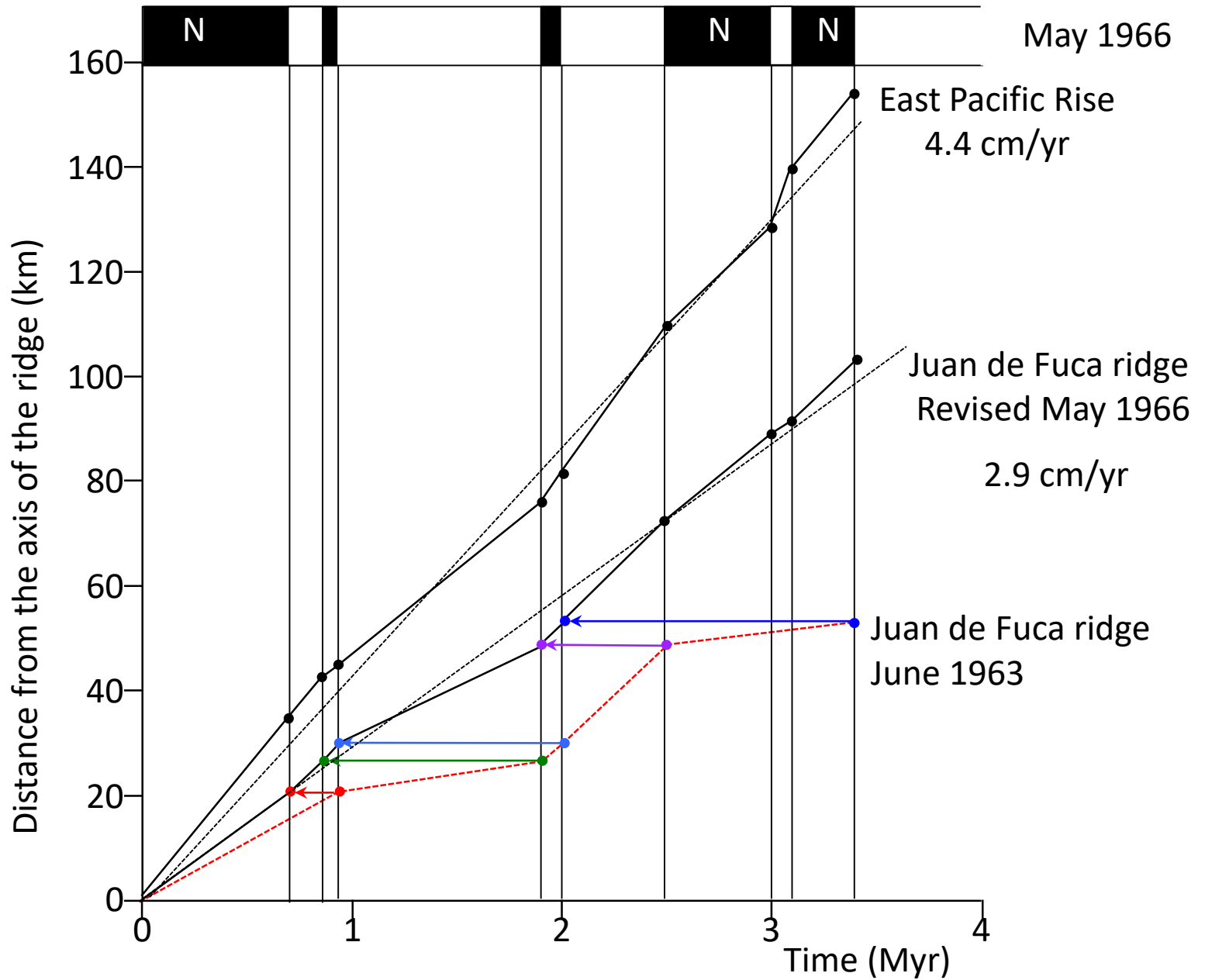
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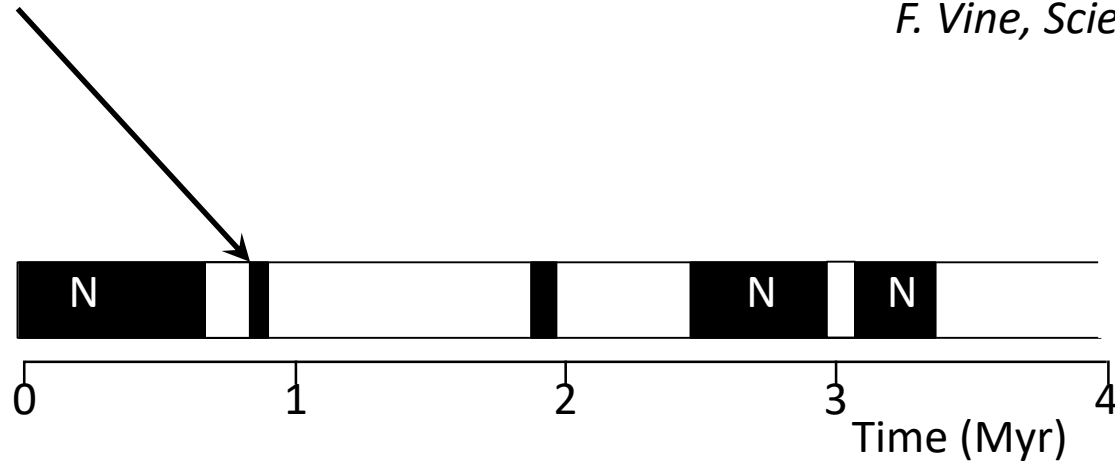
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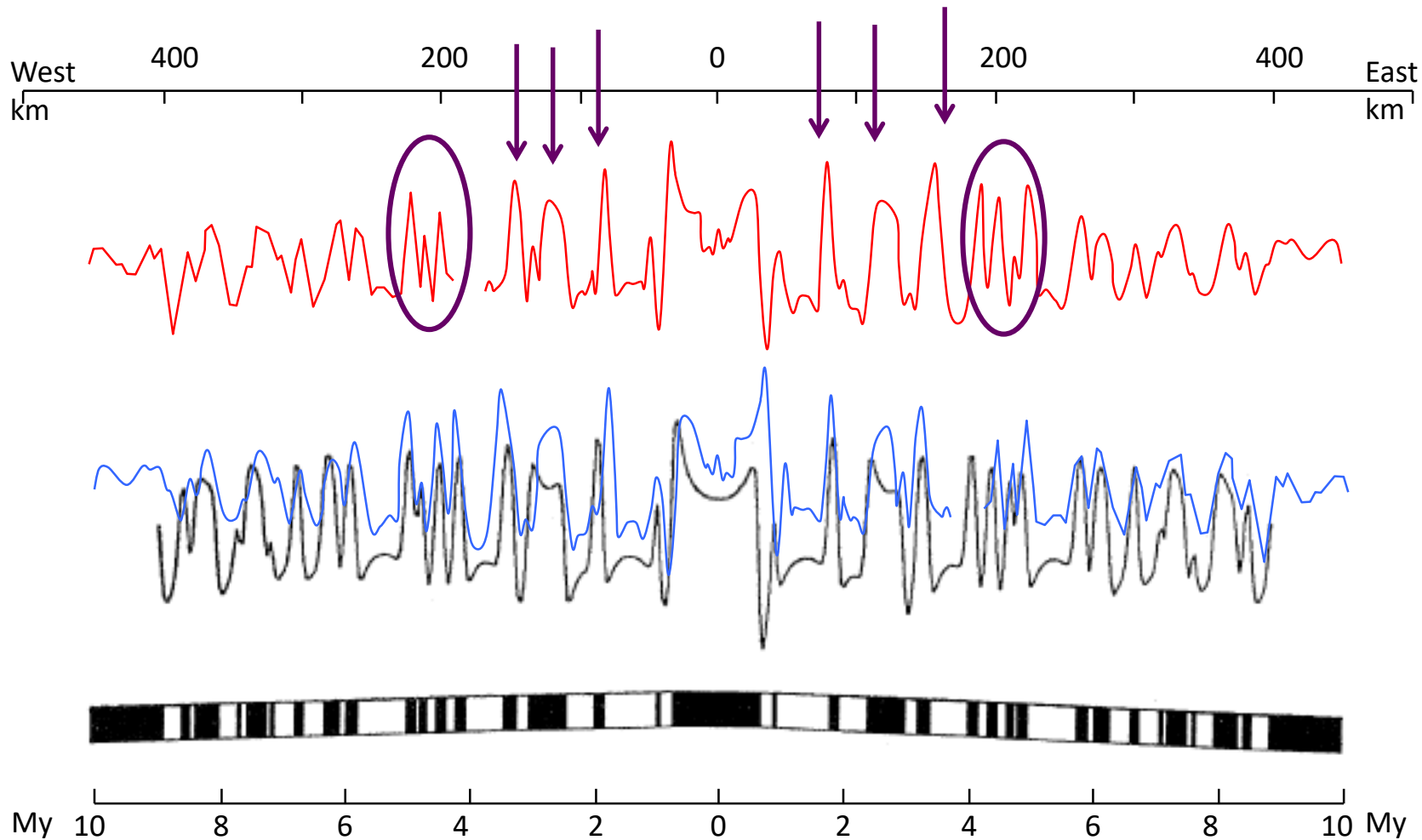




It will be seen that, had the authors had more faith in the idea and the probability of a more constant rate of spreading, for inertial reasons, they could have predicted the Jaramillo event.

F. Vine, Science, 1966





Eltanin 19 profile, Pitman and Heirtzler, 1966

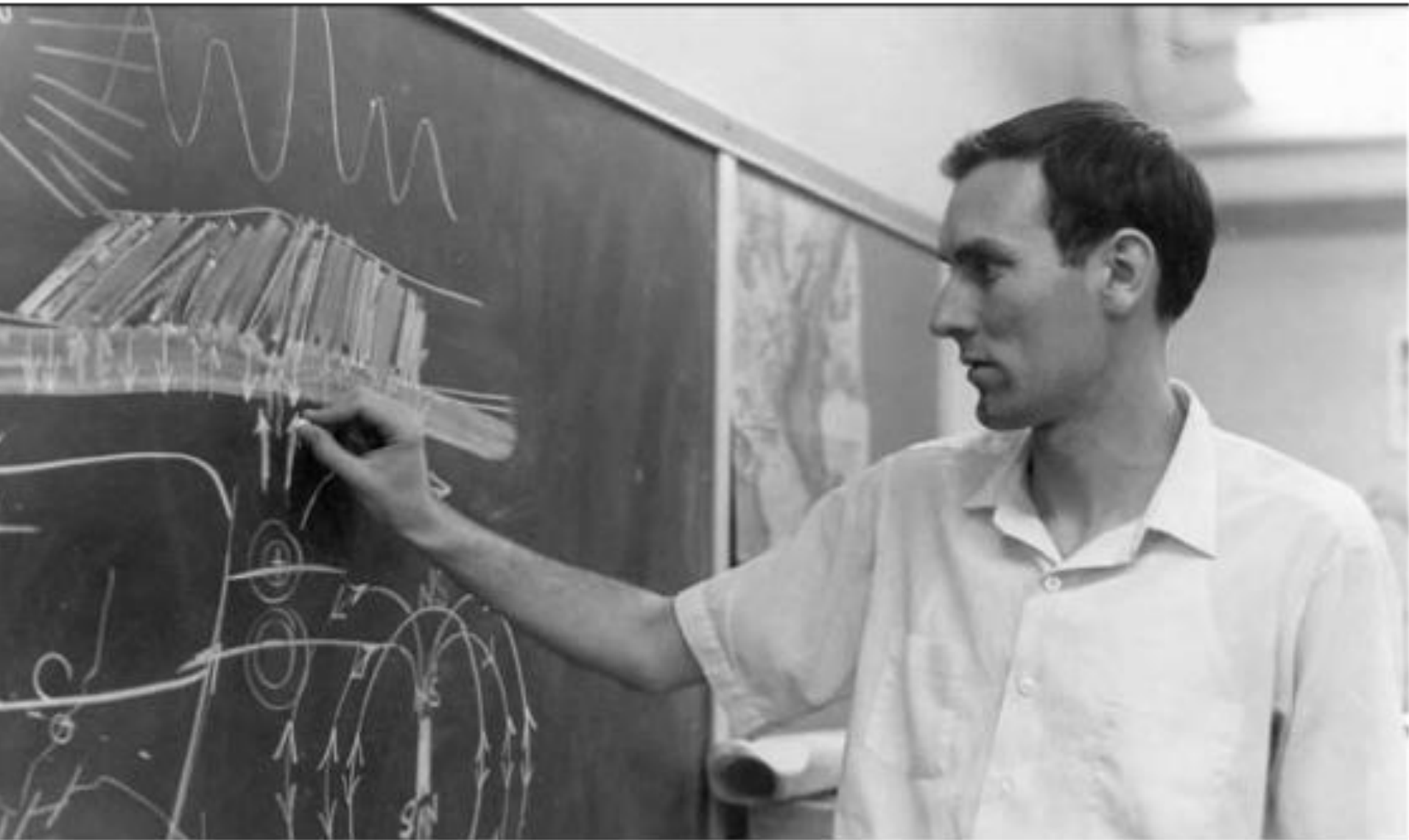


My one regret, as a geologist, was that this detailed record, written within the 60 percent of the earth's surface covered by oceanic crust, is only available for 5 percent of geologic time. Earlier phases of continental drift would have to be deduced from the more complex and fragmentary geological record within the 40 percent of the earth's surface covered by continental crust.

Teddy Bullard had worked on the origin and nature of the earth's magnetic field. Bullard and Maurice Hill were working in marine geology and geophysics, and Drum Matthews was one of very few people who had measured the magnetic properties of basaltic rocks dredged from the ocean floor. I also had the advantage of having heard talks by Patrick Blackett and Harry Hess on continental drift and sea floor spreading.

Basically, there was very little left for me to do.

Frederick Vine, Reversals of fortune, 2003



Courtesy Fred and Sue Vine

WILLIAM GLEN

The Road to Jaramillo

Critical Years of the Revolution
in Earth Science



STANFORD UNIVERSITY PRESS, STANFORD, CALIFORNIA

1982

