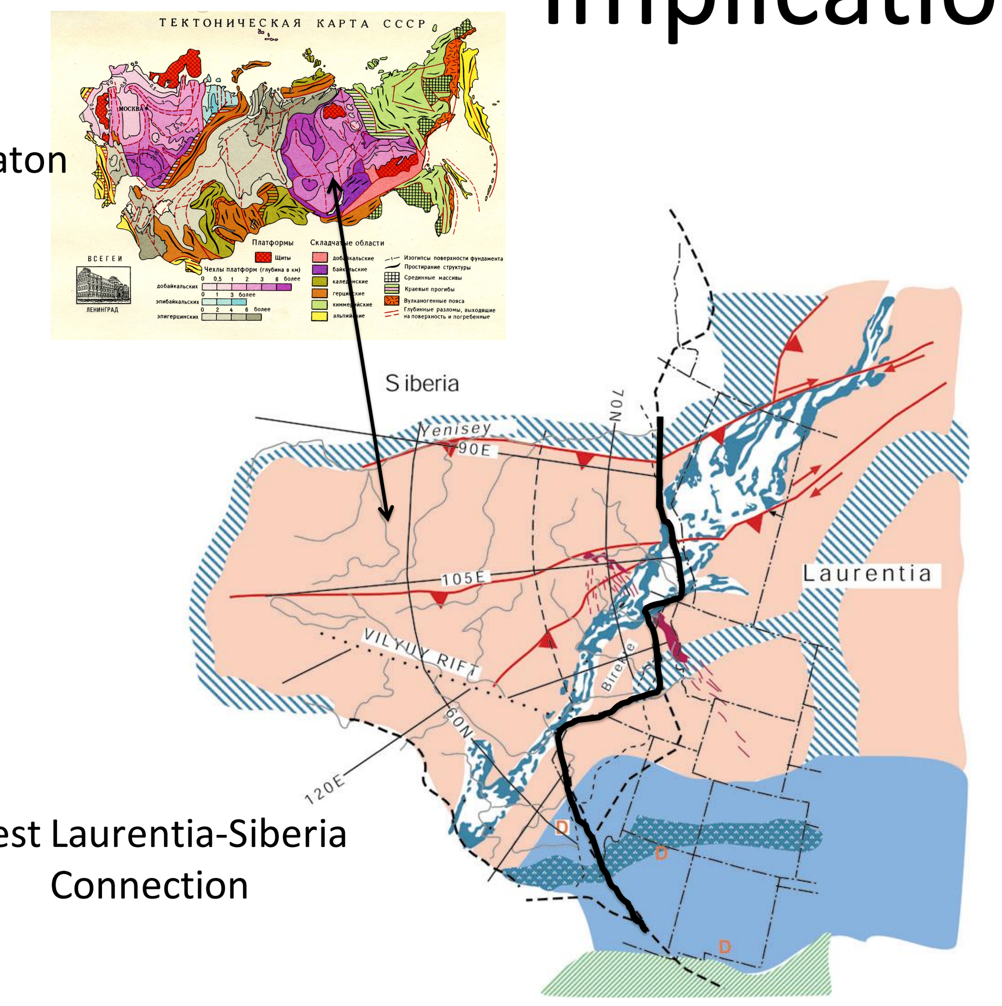
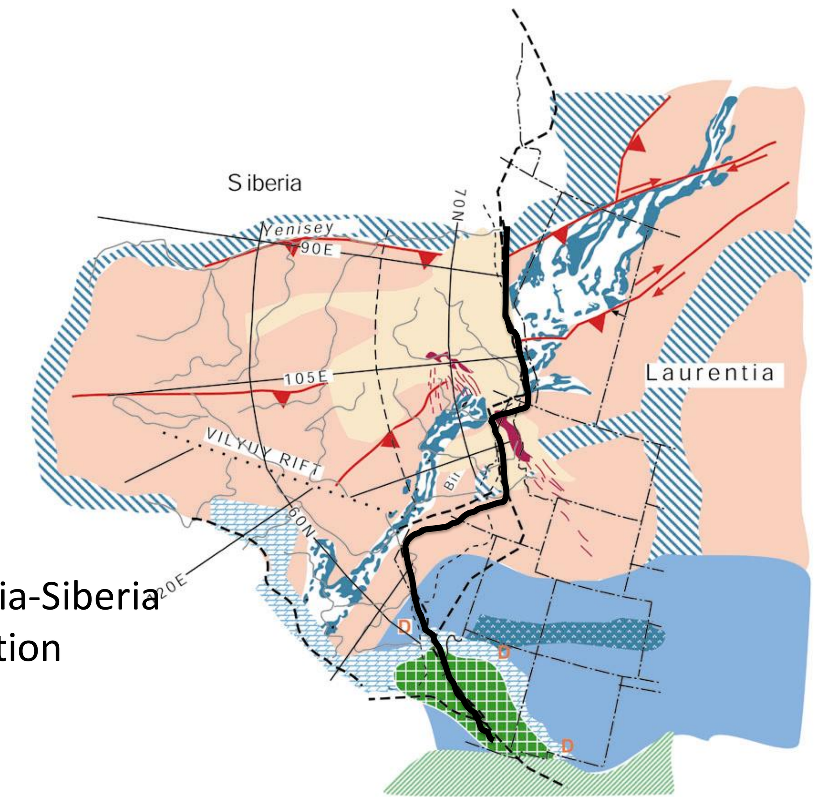
Significant Quadrupole Moment for Precambrian Geodynamo? Implications from West Laurentia-Siberia Continental Reconstruction and Neptunian Homologue

James W. Sears, University of Montana, 2018



Archean and Proterozoic basement correlations
(Sears and Price, 2003)

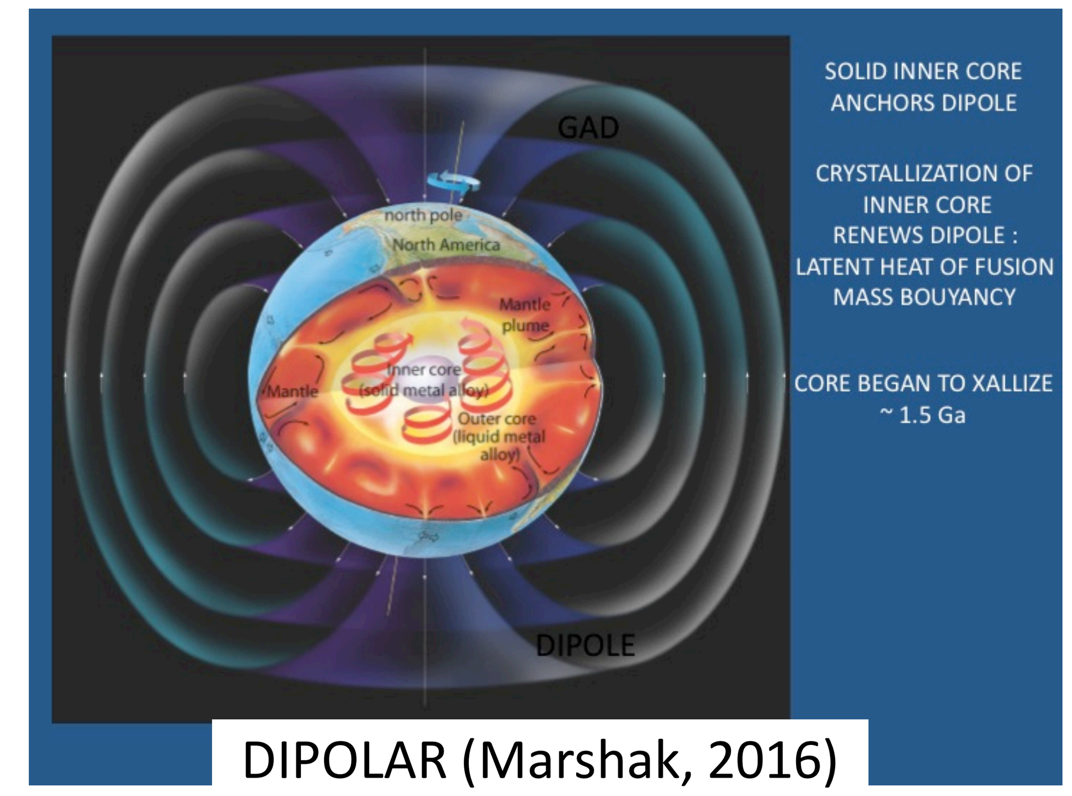


Mesoproterozoic cratonic basins and continental shelves
(Sears and Price, 2003)

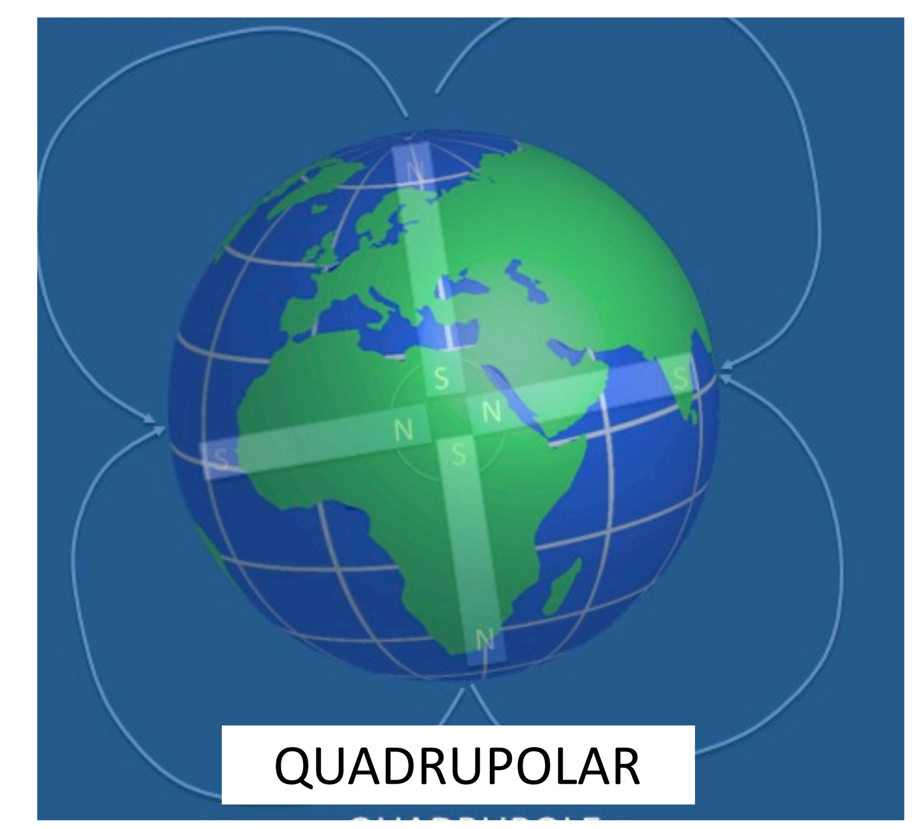
A Precambrian continental reconstruction that places the rifted eastern margin of the Siberian craton against the rifted western margin of the Laurentian craton (Sears and Price, 1978, 2003) yields precise geologic matches between >20 crustal features. These range in age from 1.72 Ga to 550 Ma. The reconstruction model also provides a geologically viable rift/drift scenario for displacement of the Siberian craton from a Precambrian position adjacent to western Laurentia to its Paleozoic position adjacent to Europe.

Although the reconstruction is geologically permissible, it is not permitted by a geocentric axial dipole geodynamo for Precambrian time. However, it may be permitted by a Precambrian geodynamo with a significant quadrupolar moment. The magnetic field of modern-day Neptune exhibits strong quadrupolar magnetic intensities (Connerney et al., 1991), and may provide a homologue for Precambrian Earth.

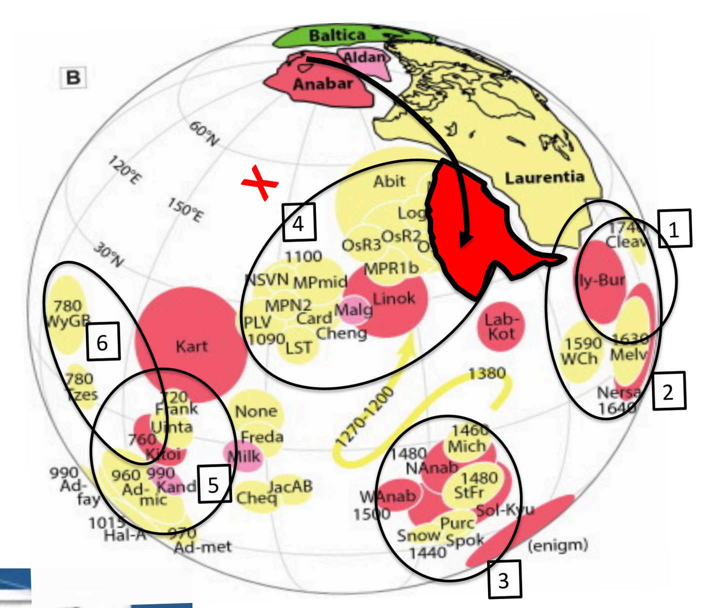
Hubbert et al. (1995), Stanley and Bloxham (2004, 2006), and Tian and Stanley (2013) propose that Neptune's magnetic field derives from the planet's fluid core and results from convection within a thin outer shell above a stably-stratified interior. Those conditions may also describe Precambrian Earth, before growth of the solid inner core stabilized the axisymmetric dipolar field. The solid state and conductivity of Earth's inner core and the geometry of its tangent cylinder evidently anchor and stabilize the dipolar geodynamo (Hollerbach and Jones, 1993). Earth's solid inner core may not have begun to crystallize until after 1.5 Ga ago, and a dominantly dipolar field may not have been achieved until Early Paleozoic time. Episodes of rapid true polar wander in Ediacaran and Cambrian time could record the transition to a dominantly dipolar field.



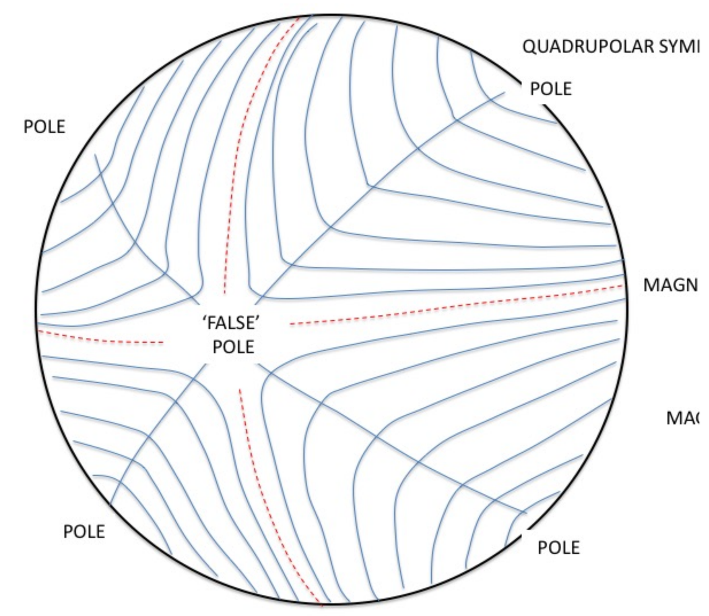
DIPOLAR (Marshak, 2016)



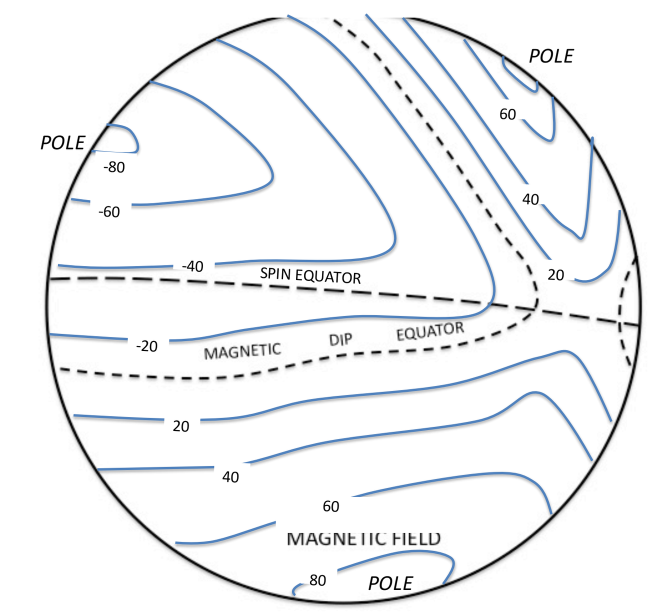
QUADRUPOLAR



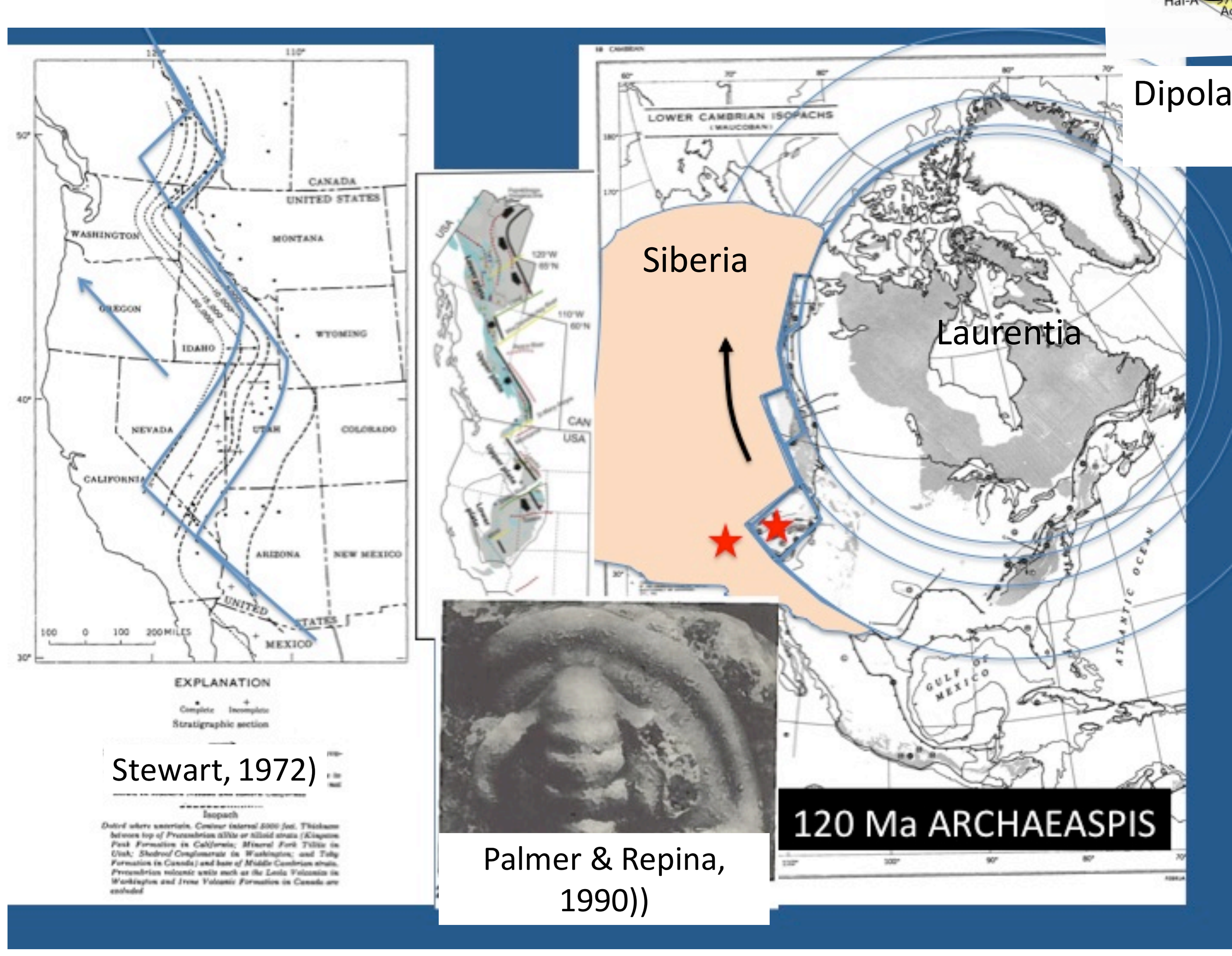
Dipolar Paleomagnetic Solution
(Evans et al., 2016)



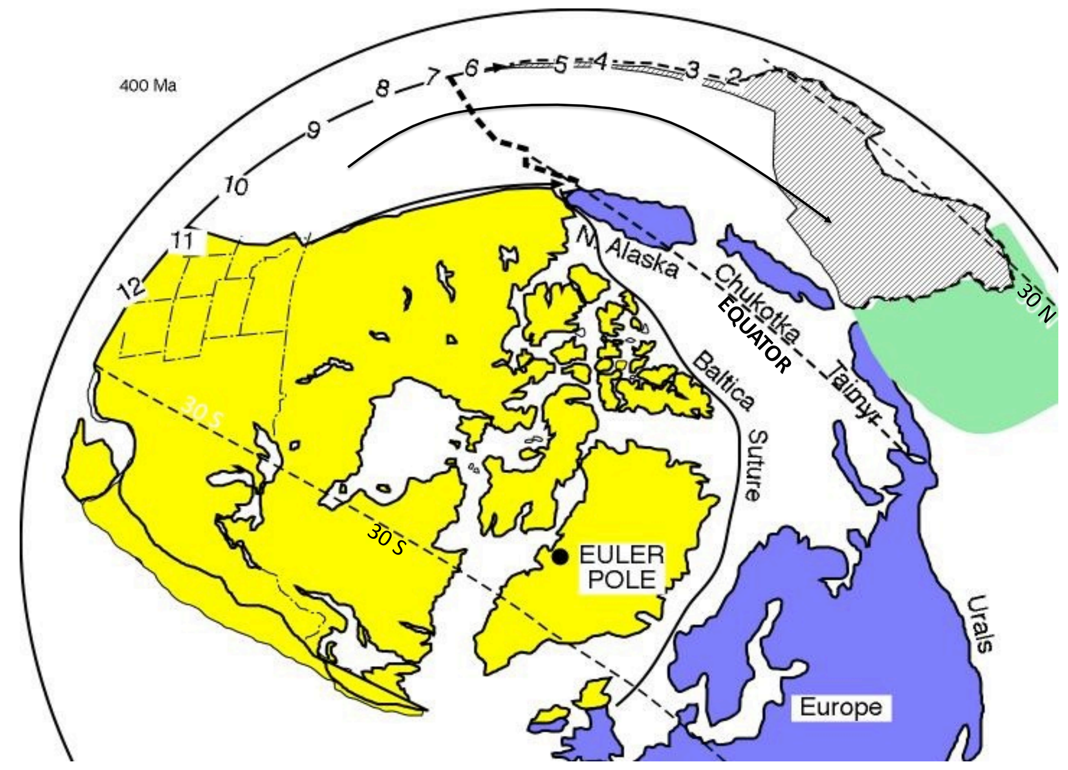
Ideal Quadrupolar Qeodynamo
(Adapted from Knapp, 1980)



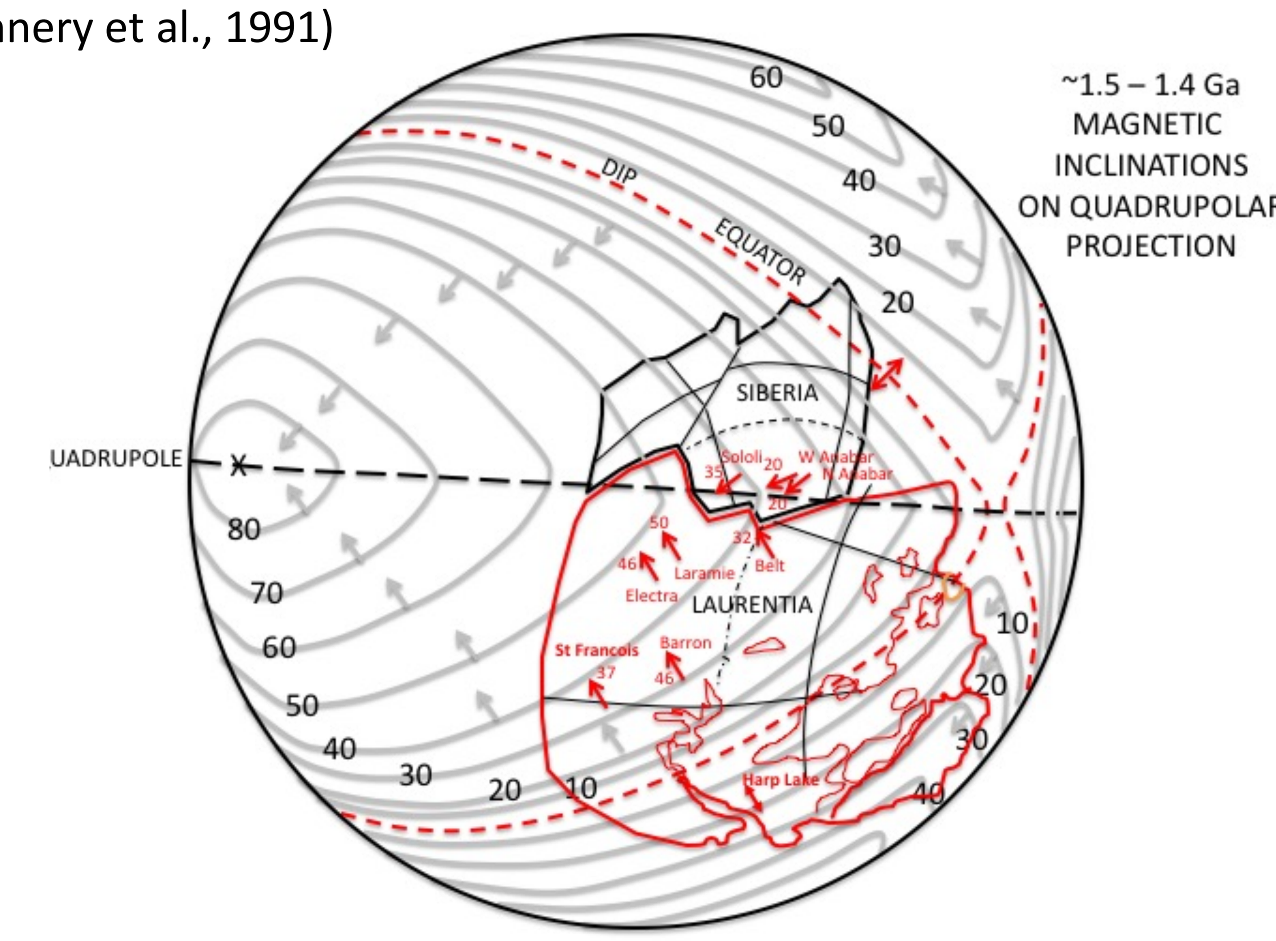
Neptune Magnetic Isoclines
(Adapted from Connery et al., 1991)



Concentric fault zones represent transforms.
Pull-apart basins have common early Cambrian dz, trilobite genera



Transform path consistent with paleomagnetic data
and geologic evidence (Sears, 2013)



~1.5-1.4 Ga Paleomagnetic vectors
Plotted on Quadrupolar Isoclines.
Data transposed from Group 3 of Dipolar Solution