k33 Evidence of protocontinents < Proterozoic miogeoclines >

Science is the art of not deceiving oneself. —Richard Feynman.[1]

A defining feature of a continent is that it has one or more cratons. Traditionally, *cratons* are areas of continental granitic crust that have not been involved in fold-mountain building during the Phanerozoic. Prolonged erosion gives cratons a broadly convex-upward surface for which the descriptive term *shield* is used. This surface, close to sealevel, is from time to time flooded by epeiric seas (due to sealevel eustatic rise or craton epeirogenic down-flexing, or both). At such times the craton accumulates sediments. The reverse exposes these sediments to erosion. On the craton, these sediments are called *platform sediments*. A characteristic of platform sediments is that, although they are often broadly arched, basined, and variously faulted, they are not folded. Cratons where free of (not covered by) platform sediments, are called *shields*.

Shields expose over vast areas Precambrian crystalline rocks (basement complex). These ancient rocks were long interpreted as being a record of primordial continental crustal formation involving granite emplacement and metamophism. The features of the basement complex mostly confounded uniformitarian explanations, and still do, though less so now in the light of plate tectonics.

Phanerozoic miogeoclines are still forming at the passive margin of continents. Orogenic belts are where Cenozoic and Mesozoic geosynclines are being currently deformed. Paleozoic mobile belts (where orogenesis has long since ceased) have folded geosynclinal sediments into which batholiths of granite are revealed to have been intruded where erosion exposes the roots of former mountains.

A revolution in geological thinking came about when Proterozoic miogeoclines were identified within shields. The first to be documented was the Penokean-Huronian mobile belt of the Southern (structural) province that received sediments from the Superior province. Other Aphebian platforms and belts, identified in what was called the *Churchill* province of the Canadian shield, are the provinces: Trans-Hudsonian, Hearn, Snowbird, Thelon, Rae, Dorset, and Torngat (***Figure k33.1***). The northern boundary of the Trans-Hudsonian province is analyzable as a continental magmatic arc that formed 1.8-2.0 Ga. The oldest once miogeocline found in present North America is the Wopmay province. It formed 2.1-2.3 Ga (***Figure k33.2***).[2]

Information as the foregoing led, by the early 1960s, to the idea of "continental growth" whereby continents get larger in time by the annular accretion of orogens that later stabilize. This model for the growth of individual structural provinces has application but as originally conceived, as a generalization (pre-plate tectonics) of the Grenville-Southern-Superior provinces sequence, it is false. Between joinings of structural provinces, continental breakup commonly intervenes to make a continental margin of the deep interior a former shield. A example of this is the Davis Strait between Labrador and Greenland that opened in the interval 40-75 Ma. Such margins can remain passive and accumulate sediments, as the eastern Appalachian margin of North America has for 180 My. But, sooner or later, plate tectonics turns margins into orogenic belts. The northern boundary of the Central province cuts across the trends of the more ancient structural provinces to its north.

The first Proterozoic arc accreted to Wyoming's southern margin 1.78-1.75 Ga. A north-south transect across this (Cheyenne) suture has been described in 2001 by Ken Dueker, Huaiyu Yuan, & Brian Zurek: On its northern side, from the base of an imbricated Moho, is a north-dipping slab that is seismically imageable in the mantle to a depth of 200 km. On the southern side, is a like south-dipping slab. Evidently the subduction polarity flipped from south- to north-directed after or during accretion of the Proterozoic arc. Such a "subduction flip" is a common feature of sutured Proterozoic arcs.

In North America, in the mantle beneath the Great Plains physiographic province and near its western margin, is a major geophysical boundary. To the east, the lithosphere is thick, both chemically and thermally as characterizes a craton. In the Rocky Mountain region to the west, due to thermal lithosphere thinning, the former extension of this craton is evidenced by the yet chemically thick Proterozoic lithosphere. As described by Ken Dueker: "The high- [seismic] velocity mantle on the easternmost side (beneath the western Great Plains) is the western edge of the lithospheric root of the North American plate, which extends to depths of 200-250 km:"

> This chemical lithosphere is thought to be high velocity because a buoyant, chemically differentiated root stabilizes the mantle root against convective disruption. This allows a cold cratonic geotherm to be developed to 200-250 km depth, hence the thick chemical lithosphere coincides with thick thermal lithosphere. On the westernmost side ... very low velocities are found beneath the western United States plate margin and Basin and Range province (notable exceptions being the high-velocity subducting Juan de Fuca plate and the high-velocity body beneath the Sierra Nevada batholith). In this region, the thermal lithosphere is thin. In between these two velocity provinces lies a domain of average velocities beneath the Rocky Mountains and High Plains physiographic provinces. — van der Lee and Nolet, 1997.[3]

Now uniformitarian thinking is that folded, and granite intruded, geosynclinal sediments of Proterozoic age are an unsurprising part of the continuing formation of cratons. No great surprise now for the "Iditarod rocks" (3.96 Gy Acasta gneiss). ❑

Figure k33.1

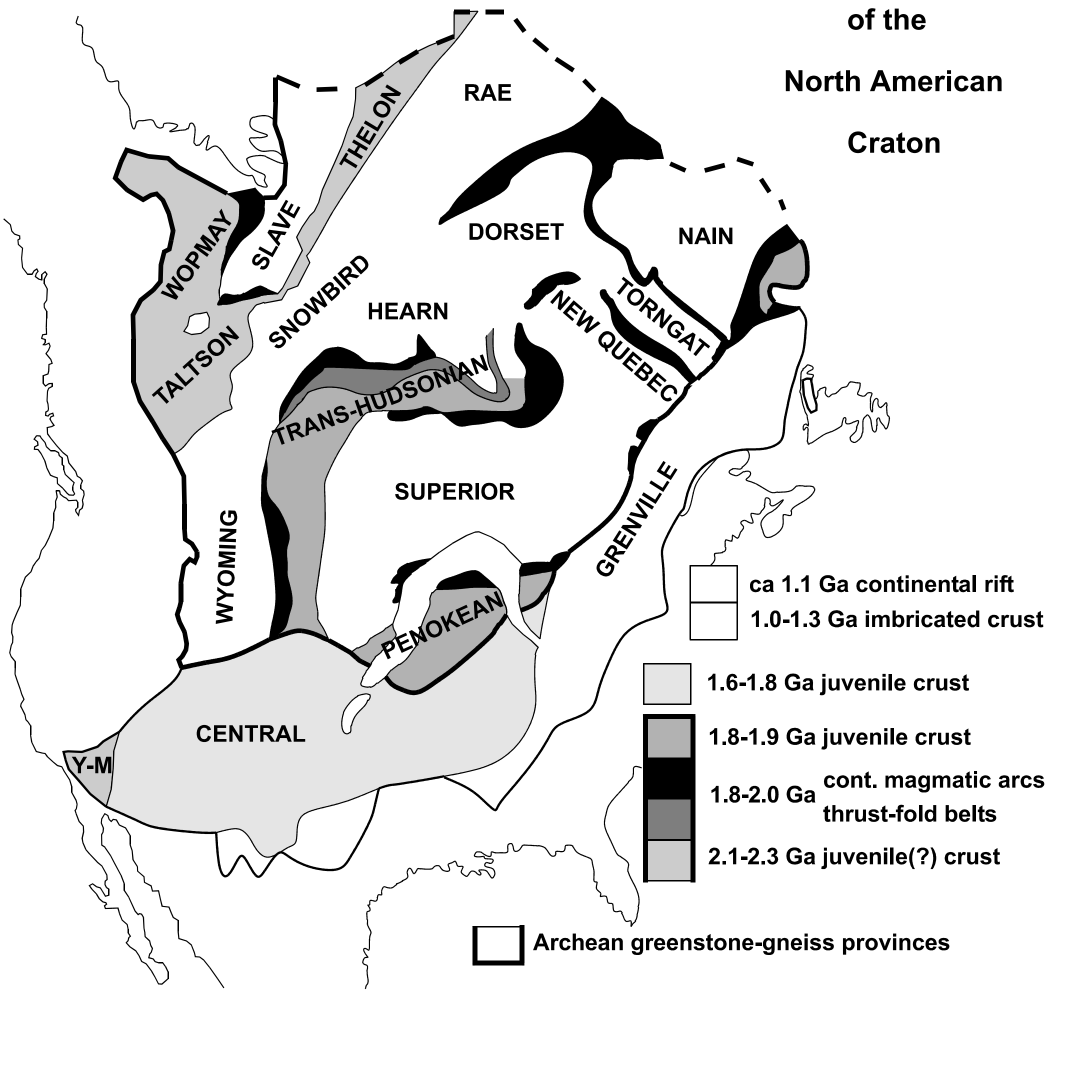
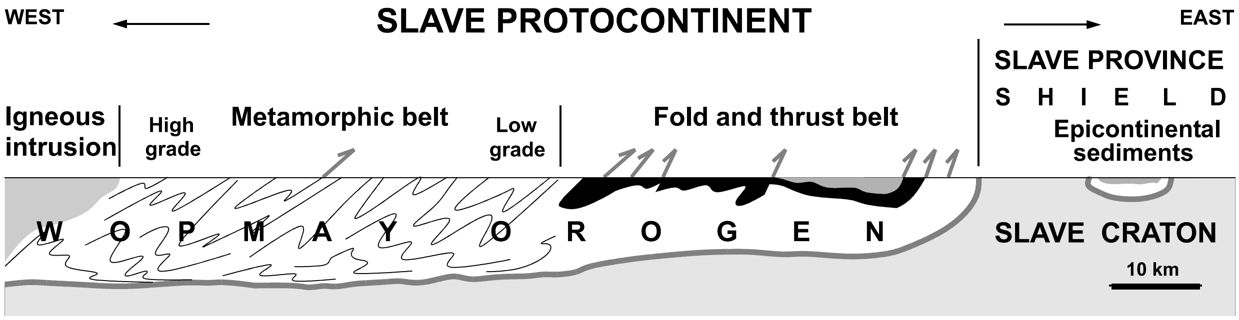


Figure k33.2 [4] **Cross section of the Wopmay orogen**



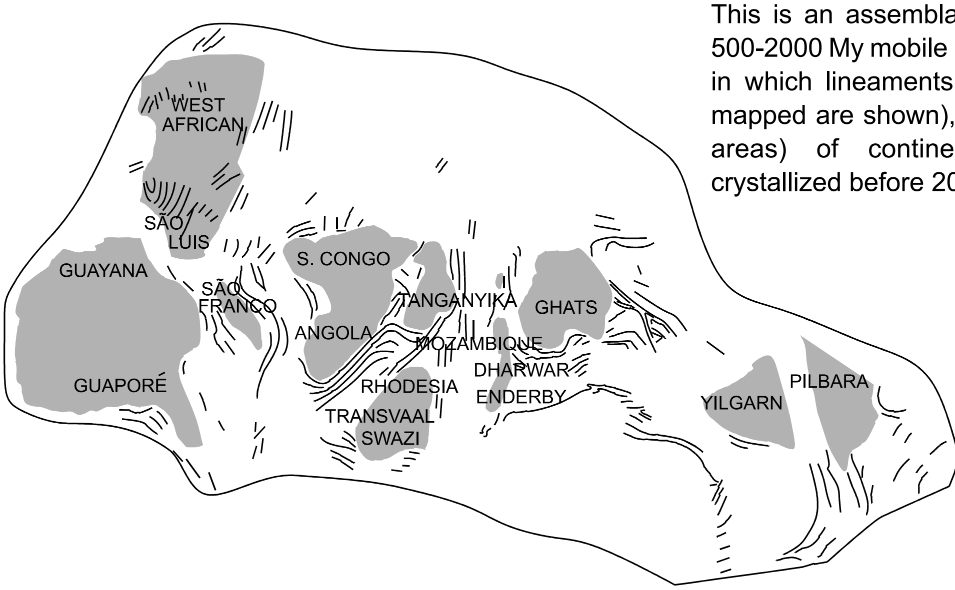
The folds and thrusts, and synorogenic granitic igneous intrusions, record the local culmination 1.6 Ga of the Hudsonian orogeny.

The Hudsonian orogeny had begun by 1.8 Ga with deep foundering of the Slave protocontinent margin as outward directed subduction carried it into a trench. Flysch (graywacke turbidites) derived from a then offshore volcanic island arc accumulated on the founded margin. Continentward of these, deepwater laminated and concretionary shale accumulated.

Before the onset of Hudsonian orogeny, the Slave province had a passive margin for a great length of time. The evidence for this is shelf and flanking miogeoclinal thicknesses of stromatolitic (shallow water) shaley and cherty dolomite.[5] The basal unit to these, a thick quartz sandstone, records that the Slave province was then a shield. On this cratonic part of the Slave continent, platform (epicontinental) sediments also accumulated.

The Slave protocontinent is evidently a fragment of a prior protocontinent. The separation of Slave protocontinent, by grabening associated with the seafloor spreading, is evidenced by rudites (granite-pebblestones and arkoses) and basaltic pillow lavas. These Early Proterozoic sediments and volcanics bury a profound nonconformity across a basement complex. These basement rocks, by their stratigraphic position, are Archean in age. Within the Slave province their last crystallization is found to have been 2.6 Ga and before.

Figure k34.2 [1] **Shield area of Gondwana**



This is an assemblage, recorded by 500-2000 My mobile belts (white area, in which lineaments that have been mapped are shown), of cratons (gray areas) of continental rock that crystallized before 2000 Ma.