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THE BARROWS OF BIG SIOUX

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“Wall Drug: Only Five Hundred Miles,” says the most famous yet cultish of all billboards. However, the uninitiated traveler on Interstate 90 likely sees no more than a perplexing, humorous postage-stamp of a sign, its faded graphics marooned on the open prairie since the 40s, left to the elements’ brutal assaults. But when this, the first of a hundred or more variations on the theme awaiting those 500 miles, is spotted by a geologist — undoubtedly heading westward with pensive students anxious to postpone their destiny with summer field school — there awakens a familiar comfort from its peculiar geologic symbolism.

Once traveled, the monotonous interminable hours traversing flat, marsh-dotted glacial soils of the southern Minnesota plains are incomparable to the geologic passage awaiting another call to resurrection lying ahead. So with appropriate practiced derision I explain to my bemused students that Wall Drug is the world’s most famous and largest tourist dragnet knick-knack shop ever conceived. A multimillion dollar “drugstore,” the Wall Drug shop began with the kindly depression era billboard offer of free icewater for travelers approaching the towering entrance to *mako sica*, the “lands bad” to the Lakota: the Big Badlands of South Dakota.

Spotting this sign is noteworthy to time-travelers, but for the others there remains 150 miles before the terrain’s hold on boredom would be loosed and their first geological lesson begun. There, abrupt and startled itself, an altered land stands starkly black and naked awaiting our bridge over the great Missouri River. Here is a geologic crossroads to all. Here the eastern terrain’s heavy mantle of glacial soil abruptly ends with an almost intentional force of contrast: a face-off between the west’s barren black bluffs — which never knew the Pleistocene’s Great Ice — against the now almost inviting and softened slopes of brown prairie grass. So precipitous is this headlong leap across 80 million years from Pleistocene Epoch to Cretaceous Period that one would swear the crossing to be a transcendence of Alice’s otherly Looking Glass where, in the words of Grace Slick, time’s “logic and proportion have fallen sloppy dead” — portal to the western Great Plains and passage to time’s reflexive motive.

Here the Missouri’s west bank affords a preview of the Big Badlands ahead, and here there lie entombed in the soft, black bluffs of the Pierre Shale such skeletal treasures as swimming monosaurs and molluscan relatives of the chambered Nautilus — gems still plated in mother-of-pearl, brilliant as abalone shell. Once most prolific, these extinct reptilian predators and their swarming schools of pearly octopoid prey were smothered lifeless in the putrid muds of the shallow Cretaceous Interior Seaway where they lay protected from decay for 80 million

years.

But on to more important lessons from the land. Increasingly frequent sightings of the Wall Drug billboards and talk of crossing the wide Missouri signal well in advance our approach to a more subtle, circumscribed region where humble rock exposures penetrate nearly half of Earth's rocky lifespan and betray revelation of its immense history — these are the low hills of Sioux Quartzite straddling the Minnesota/South Dakota border.

This ocean of brown grass will soon offer fleeting sights of mixed grass prairie island atolls. Gently rising above waves of tall grass, these low mounds now pierce its juvenile tranquil surface, belying a geologic masonry brace so formidable in structure as to have once formed the continent's keystone in the nearly boundless depths of time. Invisible to the most alert of my young geologists, most of whom are by now passing time by calling out the latest variation on Wall Drug's adventures in advertising, my mind moves from extremes of billion-year-old volcanism to rocky barrow mounds, ochre face paint, and sage smoke plumes rising from a red stone pipe with the morning fog.

These rocky windows allow a view beneath the glacial drift to reveal the somata of a vertebral column of stone: literally the continent's "fossil" spine. Known as the Sioux Uplift, here are some of the few exposures geologically related to the Transcontinental Arch, an ancient geologic structure "supporting" the continent as if draped across the continent's cervical spine in an bold strike southwest across Minnesota, its lumbar sections ending in the furthest corner of Utah. Our encounter with this first lesson in a continental anatomy's volcanic spina bifida will begin here in the prairie's midst among the scattered encrypting mounds rising barely more than 10 feet to interrupt a boundless horizon. The marsh and prairie roll by unnoticed for me now, my attention consumed by visions of the continental primordial buttress shrouded in swirling winds of sage smoke.

Surfacing none too soon, these unassuming, mounds rise as low and rough desolate scrap-heaps of pink, blood-red and purple rock. They might well be seen as scabs to the plains farmer, while assuredly they are a geologist's garden oases and perhaps the most universally sacred site in all of the Great Plains to its Native American Nations. To the student, they tell a vague incomplete story of ancient continental movements, to the geologist a critical chapter in Earth's history, and to its native peoples a bloodline enduring as the rock, yet fluid as encircling spirals of sage smoke rising from their shadowed source, and endless as the passage of sixteen billion seasons.

Sioux Quartzite Barrows

Patchy features, defining a region roughly circumscribed by Mitchell, South Dakota in the west to Big Sioux Falls in the northeast and eastward to Pipestone, Minnesota, these mounds of quartzite belie no such historical potential as the fossil bounty of the Pierre Shale, but only lie recondite upon the rocks which gave them birth, capping the strata which fill a structure penetrating to astounding depths. Silence now only permeates these layers of time; “layers” so thick, that had Alice, that reluctant young pathfinder in dimensions of space and time, been drawn into this geological wonderland she’d have had plunged hopelessly down White Rabbit’s hole in time and rock to its bizarre basement nearly half of Earth’s age.

Along a ceaseless horizon the distant scattered risings recall unkempt versions of genteel well-tended grassy slopes of English barrow mounds entombing magical, but sinister Celtic spirits. These scattered scraps of ruddy rock monuments, ragged and encircled by long-grass prairie, encroaching as if upon the untended headstones of forgotten pioneer graves, harbor their own “barrow spirits.”

Where cut by the small, placid Big Sioux River, these sharp cliffs form palisades of subtle magnificence; in places the walls have split-away, isolating towers and spires of eternal countenance. Radiant pink at dawn they compel closer inspection and a meditative walk on the “beach.” It is in such hours when the ancient visage of Earth is renewed by discovery of hardened ripple marks on slabs of quartzite still seeming somehow soft, warm-textured and quick as if just exposed by the receding swash of waves on a lakeshore. And polygonal plates looking brittle as if they had dried in the heat of yesterday’s noon Sun, shrunken and curled at their edges forming mudcracks where a lake or ephemeral river of ancient ages had evaporated under a more powerful, prehistoric heat.

But after four billion summers the light of dawn now only brings to life and light that soft sand and stiff mud long firmed by compaction to sandstone and shale in the primal region of our nature. Unimaginable magnitudes of tectonic compression have recrystallized the sandstone to a frosted quartzite, among the most durable, enduring of rocks. Scattered about the high plains above the Big Sioux River are low mounds of most resistant quartzite not planed flat and smooth by the glaciers that recently abandoned the region for their northernmost refuges.

The farming communities which grew amid the plains needed stable structures that would survive long after the sod, hay-bale, and plank houses had crumbled. The Sioux Quartzite of that continental spine exposed in these mounds was a rare commodity on the plains, making a too-tough, yet workable building stone — and here too as in the sod-covered stone mounds of Celtic barrows, for monuments to the dead as well. But it is not the spirits of plains pioneers that dwell within the mounds of Big Sioux Falls and Pipestone, nor malevolent

wrights such as those of Celtic barrows. The spirits here were, and are, known to some people, but are not of them. The presence here is something beyond such dark apparitions as fearful imaginations might create, feeling threatened by an enveloping wilderness with which one has lost intuitive bond. It is something else. Something deeper. Enduring as the rock from which it emanates yet wispy as the smoke on which it rises, is the persona of all origins encompassing all past, present and future — something of Earth's body, its corporeal soul and once tangible, though now often elusive spirit.

Sandwiched between the massive, steel-hard pink, red and purple layers of quartzite, and within towering columns of royal purple of bedded quartzite, are thin layers of hematitic silica-rich blood-red shales. These hues of red are the stains of North America's lifeblood shed some 1.1 billion years ago, and deposited by rivers and lakes in a 15,000 mile-long, 50,000 foot-deep grave for ancient mountains once as lofty as the Himalayas to the present north. It is these layers of rock which the Plains Native Nations found to be a link to that soul and spirit of Earth.

The Great Recycler

The roots of prairie grass reach deep. They grip tight the black soils beneath which lies a thick layer of leached and decomposing material drawn from both above and below. Beneath a thick layer of glacial gravels, sand, and clay is disintegrating bedrock. Soils in glaciated regions are typically tens of feet thick, their origins reaching back from as few as 10,000 to more than 2 million years. But the weathering rock beneath is far more ancient. It is, of course, the metamorphic Sioux Quartzite deposited as sand during the Late Proterozoic Eon, ranging in age from a "mere" 800 million years to as much as 1.6 billion years.

Earth's outermost layer consists of a 60 to 150 mile-thick rigid shell of relatively light rock fractured into a mosaic pattern of large and small crustal plates. These plates ride on, or are moved about by internal motions of, material in a much thicker internal layer — the asthenosphere, a layer extending to a depth of 450 miles. This thicker layer is more dense, but due to its greater temperature, is buoyant and plastically flowing under stress of fluids moving due to the influences of the temperature differences within. It floats the crust just as the Great Turtle of the Chippewa supports all of Earth on its back.

On a cyclic, 500 million year schedule, supercontinents assemble only to split asunder again. When assembled, the thick, old and cold continental crust insulates the underlying hot asthenosphere, causing rock heated by Earth's core to rise, accumulating in masses beneath the continent's crystalline belly. In instances a continent may move over a fixed spot in the asthenosphere from

within which mushroom-shaped masses of hot rock, several tens of millions of cubic km in volume, rise to the surface periodically over a span of about 100 million years to dome, blister, and burst the crust initiating a rift radiating from a hotspot volcano. The rifting may begin with a swarm of fissures from which pour layer-upon-layer of basaltic lava.

Over a span of 800 million years, powerful tectonic forces were generated by the movements and interactions of a mosaic of thick crustal plates. First plates' motions nearly excised one-quarter of the existing North American continent along a zone in which a single plate began to split into two, the crust on each side of which diverging from central zone of volcanically generated rifting. The region circumscribed by this tectonic rent encompassed an area bounded by a line extending from southwestern Kansas northeastward to south-central Ontario, through Lake Superior's axis, then southward bisecting lower Michigan, and finally terminating in southern Ohio. Adding to this overturned and angled "J"-shape was another branch reaching westward through central South Dakota and forming a more complex twisted "Y"-shape lain on its side. Had the rifting proceeded the entire interior of this region, and that of Oklahoma and Texas in the west and east through central Tennessee to the Gulf Coast, would have been sliced away to form a separate continent. And Illinois would have occupied the approximate center of this small continent.

Building Big Sioux Barrows

Some 1.1 billion years ago during early Keweenawan time the core of what would become North America had just entered its adolescence, and along with the cores of all the others sutured in a single supercontinent prefiguring Pangaea some 800 million years hence, gathered in the southern hemisphere. There a great ridge of crustal abrasions and blisters arose in the North American mid-continent. These disturbances, emerging as fissures and/or crustal doming from rising magma plumes created tensional stresses pulling the crust apart. Though isolated far from active plate boundaries, the North American continent's crust stretched, growing steadily thinner as its temperature increased, until the volcanic wound beneath bowed and breached its surface. From a swarm of fissures or perhaps a chain of hot spot volcanoes — remnant evidence for at least one hotspot forms the highest peaks of the once lofty Porcupine Mountains of Michigan's upper peninsula — the Earth bled. Its iron-rich, 1200(C basaltic lava plasma repeatedly swelled, surged, and solidified as a bandage only to open and bleed again on an unparalleled scale.

Great rivers, glowing red, yellow, and black rose, spilling forth from rents in the crust, coursed down volcanic slopes and spewed from fissures to reach confluence in stinking sulfurous pools of searing fire; roiling roles of hematitic internal fluid forming small surface seas with shores seared black, each in their turn freezing

over as hardened, ragged black basalt scabs. The gash opened and annealed some 400 times; each time lavas surging forth slowly and stiffly, piling to heights of 100 feet or more before ponding and cooling. This great succession of basalt flows, after more than 100 million years began to fill, building upward and spreading to fill the widening rift's central depression, a bundle of rock layers known as the Portage Lake Lava Series in northern Michigan.

The great rift bleeding streams of basalt extended into the subsurface to the very base of the continental crust more than 50,000 feet below. Its margins faulted, the rift's central zone dropped lower still as each flow resurfaced the basin's floor. As each of the flows slowly cooled, contracted and subsided, growing more dense and forcing the underlying crust downward, their increasing weight reactivated earthquake faults which originally bounded the valley when first formed. And so began the genesis of a branching linear depression which probably originated in, and became most prominent as, the ellipsoidal basin of down-warped strata known as the Lake Superior Syncline.

But tectonism continued tearing and forcing the crust apart, just as quickly filling the growing rift with successive waves of lava, and propagating simultaneously southwestward and southeastward as swarms of fissures spread from its locus as several hotspot volcanoes pierced the crust, or as the continent passed over a singular, astoundingly prolific hotspot puncturing the cold crystalline crust every million years or so. So one or more great volcanoes may have been formed above the surrounding plain of the rift valley growing to equal the height of the Island of Hawaii — a volcanic mountain having total relief greater than that of Mount Everest, over 14 miles from sea floor to crater peak.

For more than 1,500 miles to west-central Kansas and southward across the lower peninsula region to southern Ohio stretched this tectonic slash, the "Y"-shape branching precisely where the Big Sioux Quartzite breaches the glacial soils astride the Minnesota-South Dakota border. Its narrowing from Lake Superior toward Kansas suggests that either the source of crustal tension steadily abated or the hotspot volcanism slowly waned until the plumes' source had spent its heat, and finally cooling to extinction, the rifting ceased.

Over more than 100 million years 400 episodic flows interleaved with conglomerates to amass a series of strata averaging 45,000 feet thick. Being more dense than the crust it parted, and its density increasing as the volcanic stockpile cooled, the great mass sagged and settled within the granitic rocks flanking the rift. The volume of volcanic flows had been so great that were they spread one-foot-thick, the layer would cover all of Earth! But this incredible extrusion of asthenosphere was merely what reached the surface. The rift zone's central region was underplated by another 50,000 feet of magma cooled at great depth to form a coarsely crystalline rock known as the Duluth Gabbro. In the Big Sioux region rifting was shallow and little volcanic rock was extruded to floor the valley, its deeper westward and southwestward arms nonetheless immersed in basalt.

To complete the series of events coming to form the Big Sioux Quartzite there lay ahead another two hundred million years of more familiar geologic processes. All rocks and other Earth materials — sediments, magma, soils, even water and atmospheric gases, and thus, life as well — participate in a perpetual transformation following simple sets of fundamental processes commuting all from one form or state to another. Now that we understand that these becomings — metamorphism, weathering and erosion through lithification, and melting through volcanism — result from the movement and interactions among tectonic plates, this circuitous cyclic process of permutation reaching from Earth's core to the outermost atmosphere may be more aptly understood as the “Rock Recycle.” This recycling is the product of a larger dynamic hoop, the Great Recycler driven by the heat which keeps Earth alive.

Hundreds of cycles passed with millions of years, purifying originally coarse and angular sands in mixtures of silt and mud to the winnowed tiny spherical grains of quartz sand. Endlessly recycling every component of the crust, spreading of the rift and volcanism ceased and the slightly acidic rain fell on its uplifted rift margins, coursed in a regional convergence merging as lakes on the floor of this continent's still formidably deep tectonic incision; rift walls spilled, and crumbled sliding and flowing downward forming great cones of sediment cover; rivers gave-up billions of tons of sediment settling interfingered with these layer fanning outward from the valley walls; lakes filled and became land again; and algal crusts bound the grains in soils. The recycling funneled gravel, sand and mud into the midcontinent valley for 200 million years, where now we perceive the forms of conglomerates, and ripple-marked, mud-cracked sandstones and shales. Later continental collisions compressed these, recrystallizing each grain in a metamorphosis of sandstones to give them a sugar-glazed sheen of rock candy, impervious, impenetrable, and so steeled as to break with a knife edge.

These pure quartzites parted by thin layers of still-‘soft’ shale, cap the Minnesota-Dakota rift segment. The plentiful iron of volcanic rocks recycled with the rains beneath, enveloped each grain and coated the sands, staining the Sioux Quartzite pink to purple, and entering the crystal clay lattice of a unique quartz-rich and soft shale found only in the Big Sioux country.

Blood of the Land, Sage Smoke of Spirits

It was sixteen billion seasons past: Earth embodied the Sacred Hoop in its ceaseless becoming, its motions Snake Dancing ‘round in endless life cycles at once dying and emerging from death; a sun dance of seasons where the most centered and sacred drum lay at Earth's core, its timeless pulse coursing with magmatic warmth offering iron blood to mantle the surface, to quicken life and leave only its red remnants marking its passage.

For a millennium or more Native American nations throughout the western Great Lakes to the southern Great Plains — the ever-warring Pawnee, far-ranging Canadian Blackfoot, northern plains Crow, agrarian Mandan of the Missouri River, the unassuming, trenchant Lake Superior Chippewa, and the resolute Northern Cheyenne, brother to the proud Lakota of the Yellowstone and White River basins — had traveled by foot to quarry, collect and trade the select rock of these, the burial mounds of Earth's spirit — the scattered exposures of Sioux Quartzite capping the Great Midcontinent Rift a billion years their elder. They came for rarest of rock within Sioux Quartzite — what mineralogists know as catlinite after the famous ethnographic painter of plains nations, George Catlin — the treasured bloodstone of Mother Earth, the most sacred Pipestone.

A few miles east of Big Sioux Falls in Palisades State Park, Minnesota is Pipestone National Monument. Here within an acre or two are abandoned quarries within the quartzite, where many plains nations labored in peace removing tons of rock harder than steel in a search for the few thin layers of rock chosen for creating the bowls of sacred pipes. Now only the Santee "Sioux" work the new quarries and craft pipes from catlinite.

Scientifically, the red hues of Sioux Quartzite and catlinite are merely the result of oxidation. But reddened iron is much more than rust. Iron is the heaviest common elements forming in star death and solar system rebirth, the cores of the rocky planets; and on Earth, the metabolite of both chemosynthetic bacteria which helped form the Earth's most widespread and voluminous deposits of iron by releasing oxygen to formed deposits of rusted iron. It is that element which captures that poison of life that burns our prey and fires our internal hearths; and, among one species which perceives its existence as much in symbolism as physical variables, it is the symbol of life's continuity by individual exchanges of spirit. Within Earth's core, with its rising and descending spirals of molten iron spinning around a solid iron ball, is generated the magnetic field. And reaching from the ultimate depths of our origins to the scurrying forms of the surface, this field gives us a sense of place, direction and centeredness by direct linkage with the tiny iron oxide crystal compasses lodged within our brains and the magnetic fields generated within the spinning core.

Earth's iron blood-spirit nearly did escape, but with the rifting's failure its life-imparting fluid was retained. Almost infinitely later, in peril of ebbing away after a nation whose creed was manifest destiny, it nearly split again the Heartland nations who protected this spirit. Ever in search of symbols personifying a mythos so primal it is synonymous with our species' origin, the smoke or breath of Earth rises from a bowl fashioned of its blood. The message therein is metabolized, delivered from life's source to its protector. We the archetypal dwellers of the spirit world whose minds recognize hard-wired genetic forms, find animated analogies moving among us, remain safely rooted as surely as the deep-searching tendrils of the cottonwood tree grasp the rock below in

the lifeblood of home. The smoke of carbon stardust now fired within iron and silica pipestone bowls, both forged in the same supernova starburst and passed to Earth's surface through the Great Recycler, mingles with human blood and breath and rises to Grandfather Sky. All are returned home again, from Earth life to Earth-blood, and further, to its Spirit.

On our class stop at the visitor center I happened to overhear a tourist who was observing the displays of sacred pipes. "Where'd they get tobacco anyway, and why are they still making these pipes? There's no reason for smoking a peace pipe anymore. And don't they know smoking causes cancer?" The answers are 16 billion years ancient.

We left for *Paha Sapha*: the Black Hills, sacred land of the Lakota and Cheyenne. The Lakota have said that Paha Sapha has the shape of the heart for it is the heart of this land. The Lakota heart. The heart of Earth. Five hundred years before Landsat satellites sent back their first images from space, Lakota knowledge of the land had told them what the satellites now image: Paha Sapha is shaped as a heart, and so embodied Earth's spirit. A spirit with which each morning a prayer of affirmation is made; "*Mi takuyae Oyasin*," or "We are all related" — not only all Lakota, all humans, nor even all life alone, but all things of the Great Mystery.

Perhaps this knowledge had somehow come from Earth's life-blood, the iron-thick magma, now within the pipestone bowls crafted for it. Knowledge from Spirit, and of Spirit; transferred, transformed, evolved and interchanged from Grandmother Earth — drawn deep as life's breath into 'the two leggeds' spirit for and of themselves that is seen most clearly in their cousins' embodiments — the otherness and sameness of all life; on to Grandfather Sky who, grasping their spirit swirlings cast all as clouds; drawing them down as shadows again thrown over the barrow; all relations enfolded home again as ever — within Grandmother, the ever-unfolding source.

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