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Huron River: Precambrian unconformities and alteration at and near Big Eric's Crossing, Michigan

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LOCATION

Big Eric's Crossing (Fig. 1, Site 1) is a county bridge across the Huron River (NW¼NW¼Sec.35,T.52N.,R.30W.), Skanee, Michigan 15-minute Quadrangle, about 12 mi (19 km) northeast of L'Anse, Michigan, along the road that continues north from Main Street. The second locality (Site 2), a small, southeast-facing granite hill, (SE¼SE¼Sec.26) is about 1 mi (1.6 km) northeast of the bridge and lies about 600 ft (200 m) south of the road.

Big Eric's Crossing is a famous fishing spot on the Huron River, and Baraga County maintains a campground at the bridge. The river is high from late September until late May, so the outcrops along the river are best visited during the middle and late summer.

Sites 2 and 3 are on private land. However, so long as visits are brief, and visitors continue to respect the surface and the exposures, property owners in the Upper Peninsula tend not to post their lands.

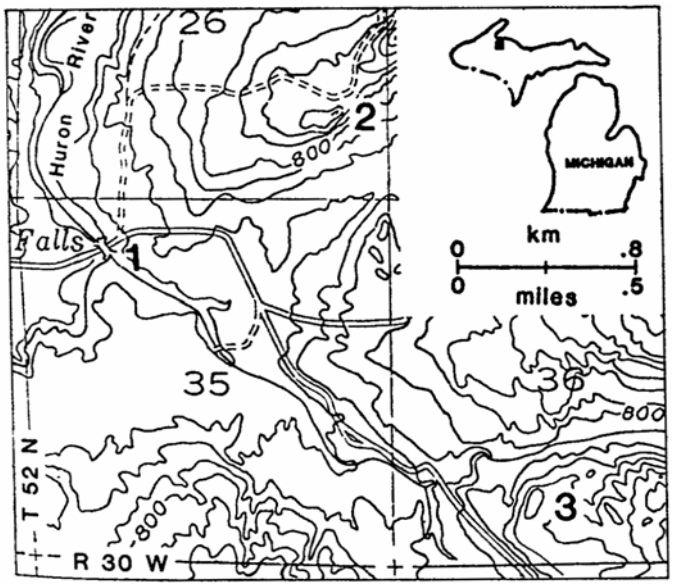

Figure 1. Location map for the Huron River area, Baraga County, Michigan. Site 1, Big Eric's crossing; Site 2, granite bluff.

SIGNIFICANCE

The river outcrop has been known since 1887 for the well-exposed unconformity between the Archean granitic basement and flat-lying Early Proterozoic lean iron-formation, cherts, and calcareous and clastic sedimentary rocks. There is also a patch of Middle Proterozoic red fluvial sandstone. Because of the easy and free access, geology groups have been visiting the unconformity for years, each developing and modifying its observations and interpretations. These notes provide a formal introduction to this area and also add some new ideas regarding the nature of the alteration along the unconformity.

These outcrops show evidence of two contrasting types and ages of alteration (Lynott, in progress). The earlier is restricted to the Archean rocks and is interpreted to be a paleoregolith, a product of subaerial weathering that took place prior to the deposition of the Early Proterozoic sedimentary strata. Subsequent to this deposition, the basement, the paleoregolith, and some of the overlying strata became replaced and cemented extensively by introduced chert and carbonate. This later chert-carbonate alteration is particularly significant because it is identical in mode of occurrence, textures, and structures to that reported from Archean strata below several other Proterozoic iron-formations in North America. We interpret the extensive silicification and carbonatization at the two localities to represent sea-water alteration of those rocks and strata that predate the iron formation, during a marine transgression and subsequent chemical (iron-formation) sedimentation (Lynott, in progress).

ARCHEAN BASEMENT ROCKS AND THEIR WEATHERING

At Site 1, the oldest rocks are a white, coarse-grained, massive granite, cut by one larger and two smaller diabase dikes (Figs. 2 and 3). The dark material can be identified as an intrusive igneous rock by its geometry, a relict chill margin, and relict diabasic texture visible in thin section. Resting on this basement is a 13-16 ft (4-5 m) sequence of Early Proterozoic conglomerate, quartzite, limestone, and lean cherty iron-formation, possibly correlative with the upper part of the Michigamme Formation of the Baraga Group (Cannon and Gair, 1970). These strata are distal from the nearest metamorphic node of James (1955) and consequently show no evidence of Penokean thermal metamorphism. The upper surfaces of some of the Early Proterozoic strata contain joint-controlled depressions, and these are filled by a few centimeters of Middle Proterozoic Jacobsville Sandstone.

At Site 1, in the vicinity of the highest knob in the river bed, the upper surfaces of both the granite and the diabase are altered over a thickness of about 6 ft (2 m) to paleosaprolite in which feldspars are illitized but the granitic and diabasic textures are recognizable,

particularly in thin section. This alteration decreases in intensity downward, and on the surface of the largest body of diabase it is associated with spheroidal weathering structures which demonstrably were replaced later by carbonate. Under the overhang on the west bank, the granitic paleosaprolite is overlain by poorly indurated shale that may be either a paleosol or interstratally altered sediment. On both the granitic and diabasic paleosaprolites are small patches of regolith. On granite this is a light colored arkose with rounded grains of illitized feldspar, quartz, and chert, and on the diabase it is a dark calcareous sandstone.

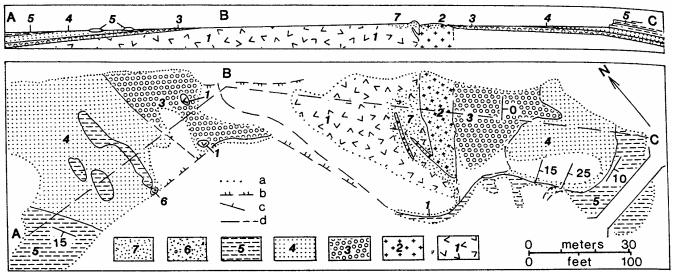

Figure 2. Geology at Site 1, Big Eric's crossing. 1) Archean coarse-grained massive granite; 2) Archean diabase; 3) Lower Proterozoic basal elastics (Fig. 3); 4) laminated chert and clastic material; 5) lean, cherty iron-formation; 6) joint-fillings of Middle Proterozoic Jacobsville Sandstone; 7) area of abundant chert and calcite; (a) limit of outcrop; (b) river bank; (c) inclined bed; (d) contact.

Site 2 (Figs. 1 and 4) is a bluff of garnetiferous, equigranular, gneissic granite with some pegmatitic zones and abundant amphibolite xenoliths. Near the top of the bluff, the feldspars likewise show illite alteration in thin section, and, in places, the illitized gneiss has a faint subhorizontal foliation—almost like a schistosity—interpreted to represent the compaction of weathered granite in early Lower Proterozoic time.

The thickness of the paleosaprolite profiles (up to 3 ft f 1 m] at Site 1 and 20 ft [6 m] at Site 2) suggests a shallow groundwater table. Of the two alterations at both localities, the illite alteration is the older in that it has been overprinted by the younger chert-carbonate veining and impregnation.

LOWER PROTEROZOIC SEDIMENTATION

At Site 1 the paleosaprolite and paleoregolith are overlain by a thin (13-16 ft [4-5 m]), laterally continuous sequence of clastic and chemical strata (Fig. 3). The lowest unit is a fairly mature basal conglomerate with well-rounded clasts of quartz, chert, and granite in a highly silicified matrix, overlain by layers of dolomitic sandstone with lenses of cherty limestone and phosphatic material.

The basal clastic unit is overlain by wavy-bedded, laminated chert with interbeds of clastic material, now consisting of quartz grains and flat, angular chert fragments in a chert matrix. Its original lithology is indeterminate. The uppermost unit at Site 1 is a finely laminated, brownish to reddish chert, in part a lean iron-formation, in beds 4-12 in (10-30 cm) thick. Downstream, the iron-formation is overlain along an irregular, jointed surface, by the Middle Proterozoic Jacobsville Sandstone—a fluvial red bed sequence deposited late in the history of the Midcontinent Rift System.

This succession of Lower Proterozoic strata is interpreted as representing initial prograding deposition along a low, sediment starved, gradually submerging shoreline; a period of chert and carbonate deposition with minor elastics represents more stable and quiet conditions. Finally, the deposition of lean iron-formation represents a further decrease in clastic deposition and some fundamental change in the chemistry of the overlying sea water. This succession is much thinner but suggests a sequence of depositional environments somewhat similar to that described by Ojakangas from the Gogebic and Mesabi ranges where sedimentation culminated in the deposition of major iron-formations (Ojakangas, 1983).

SIUCIFICATION AND CARBONATIZATION

At Sites 1 and 2, introduced chert and carbonate are widespread in the Archean rocks and, at Site 1, also in strata below the lean iron-formation. Chert and carbonate are most conspicuous as joint fillings, and at both Sites 1 and 2 such veins are more abundant in the upper parts of the granite outcrops. On the northwest side of the granite knob at Site 1 there are several sub-horizontal, symmetrically zoned veins in which thinly banded to colloform gray chert alternates with layers of fine-grained calcite. On the northeast corner of the granite outcrop a taller horizontal cavity is filled with 0.4-1.6 in (1-4 cm) beds of limestone with chert laminae. Chert veinlets also occur in the basal calcareous beds and in some of the higher strata. At Site 2 there are both horizontal and vertical chert veins up to 4 in (10 cm) wide that decrease in abundance downhill. The former are structureless, banded, or colloform, whereas the vertical veins are of chert breccia or chert-granite breccia in a chert matrix. The chert in the vertical veins collapsed, perhaps because of a weak clay surface along the walls. All of these filled structures are interpreted to represent low temperature, open-space deposition from the same seawater from which the overlying chert, lean iron-formation, and carbonate beds were precipitated.

At Site 2 the amphibolite xenoliths show a conspicuous vertical gradation of carbonatization: those xenoliths low on the scarp are fresh, whereas those closer to the top contain progressively more carbonate. At the top of the hill there are masses of dark, impure limestone in highly altered granite, as well as impure limestone blocks resting on the surface.

At both Sites 1 and 2, an additional, inconspicuous silica-carbonate alteration event has taken place. At Site 1, on the highest part of the granite knob, the granite is penetrated by a diffuse network of fine-grained chert-carbonate veinlets (Fig. 2, Unit 7). In thin sections of the granite at Sites 1 and 2, and of the diabase, the previously illitized feldspar can be seen to be almost completely replaced by carbonate. At Site 1 the Lower Proterozoic basal conglomerate on the west bank also contains introduced chert in the thoroughly silicified matrix; chert veinlets also occur in the basal calcareous beds and some of the higher strata. Physically, all of this introduced chert is indistinguishable from that in the Archean basement rocks.

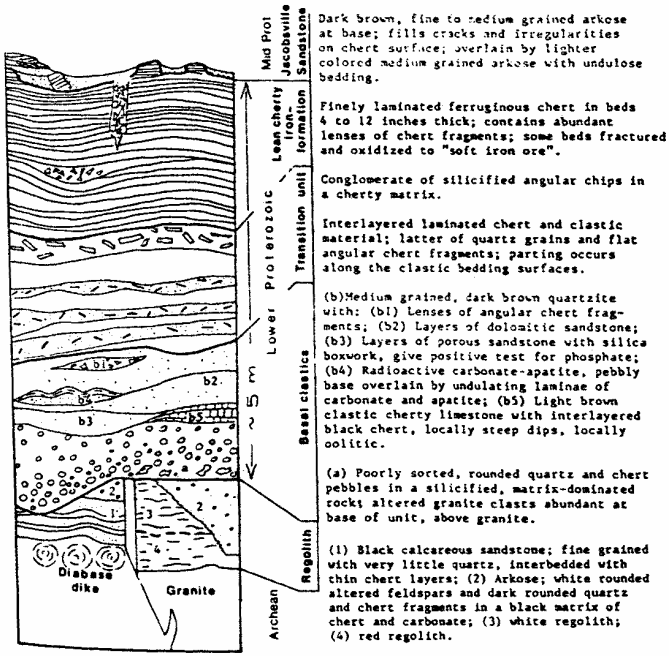

Figure 3. Stratigraphic section at Site 1.

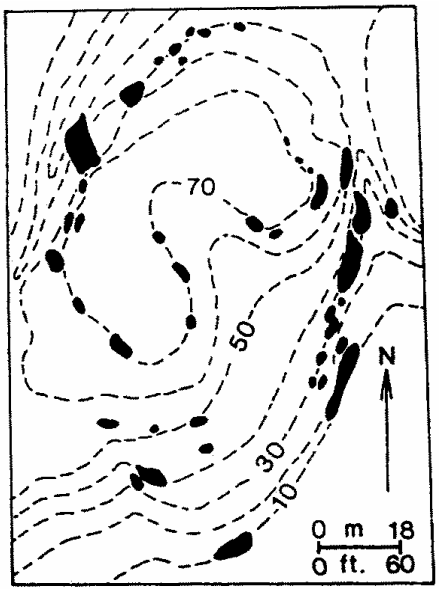

Figure 4. Outcrop map of Site 2; elevations in feet

ORIGIN OF THE CHERT-CARBONATE

The widespread occurrence of introduced chert and carbonate in the rocks above and below the Lower Proterozoic unconformity is apparent from field observations. Clues to the origin of these minerals come principally from a consideration of their broader characteristics: 1) The modes of occurrence of chert and carbonate are unlike any described occurrences of modern pedogenic, subaerial caliches or silcretes. 2) The restriction of the introduced chert to a shallow profile at Site 2 suggests that the chert was not introduced from below. 3) Identical carbonatization and silicification of Archean basement rocks below iron-formations has been described from the south margin of the Marquette trough by Gair and Simmons (1969), and from the Mistassini region of Quebec, Canada by Chown and Caty (1983). Silicification below iron formation was recognized by Leith (1925).

Based on these lines of evidence, we propose that the widespread silicification and carbonatization in these outcrops represents the coeval alteration of the basement rocks and preexisting strata by seawater during the general period of iron-formation deposition.

OTHER INTERESTING FEATURES IN THE VICINITY

Microfossils have been reported from the lean iron-formation (Cloud and Morrison, 1979).

Small phosphatic, hummocky features that may be biohermal occur on the west bank, below the iron-formation, downstream from the granite knob (Mancuso and others, 1975). The phosphatic material is radioactive (215 ppm U).

At Site 1 the chert veinlets are cut by a radioactive fissure with reddened walls. This may represent Beaverlodge-type uranium mineralization near the sub-Jacobsville unconformity (174 ppm U, 15 ppm Th, [Johnson, 1977]; 1340 ppm U, 150 ppm Cu, [D. Frishman, personal communication]).

On the west bank, downstream from the bridge, two inclined sequences of iron-formation are separated by limey strata, the lithologic repetition suggesting the possible existence of a southeast-dipping thrust fault.

Some parts of the iron-formation have been altered to “soft iron ore.” The age of .this weathering is unknown.

At Site 1, about 100 ft (30 m) north of the granite knob, some parallel, coarse-grained quartz veins, with galena, cut the granite.

Half-way to Site 2, on the north side of the road, is a low outcrop of chert with a variety of interesting textures, possibly a silicified sedimentary rock.

About 1.3 mi (2.1 km) southeast of Big Eric's Crossing (SE¼SW¼ sec 36), and 850 ft (260 m) northeast of the gravel road is a small cluster of outcrops on a northwest-facing dope (Fig. 1, Site 3). There is also a shallow prospect shaft. Blocks of carbonatized gneiss and chert are scattered on the surface. In a small pit, a subhorizontal layer of chert rests on granite; some of this chert contains sphalerite. Nearby, pieces of jet-black hydrocarbon can be found

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