# DEPOSITION OF SAUK SEQUENCE ROCKS ON THE UNDERLYING UNCONFORMABLE PROTEROZOIC COMPLEX IN THE OHIO REGION DEMONSTRATES THE EMERGENCE OF A BROAD PLATFORM DURING CAMBRIAN TIME

Charts show: current (Janssens, 1973; Sanford and Arnott, 2010) and revised nomenclature and proposed lithostratigraphic model for the Sauk

LOWER

sequence units in Ohio and the surrounding region. Logging of Ontario deep core verifies the proposed lithostratigraphic model for the Waverly

Arch and emergent platform. Nepean Fm and Covey Hill outcrops in eastern Ontario are lithostratigraphically similar to the Conasauga/Sandusky

and Mt. Simon, respectively. Sanford and Arnott's (2010) Jacobsville and Middle Run should be placed in the Proterozoic.

Rose Run sandstone

**ROME FM** 

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# **ABSTRACT**

deep wells, redefine Sauk sequence rocks in the Ohio region. Stratigraphic adjacent structural and depositional sags (proto-Illinois-Michigan Basin, to Neoproterozoic extension of the Ontario, Canada, Laurentian (Algonquin) Mt. Simon graded laterally with mixed clastic-carbonate Conasauga Group nomenclature and boundaries for the lower part of the Sauk sequence were Chatham Sag, proto-Appalachian Basin, and Rome Trough). Development Arch, which controlled deposition, the stable Ohio Platform developed, refined and updated. Results indicate that following the Grenville Orogeny of the Cincinnati Arch appears to have been unaffected by either the Waverly proto-Illinois-Michigan and Rome Trough. dominated by cyclical, mixed clastic-carbonate sediments of Eau Claire and East Continent rifting, and about a half-billion years of subsequent Arch or Ohio Platform, as neither feature exhibits tectonic coincidence with Thickness and extent of potential Cambrian reservoirs have been redefined Formation and Conasauga Group. The new term Sandusky formation has erosion, a broad platform developed during the Cambrian Period, marking this later-formed feature. This revised framework provides new information on an emergent platform for the Ohio region. The Mt. Simon Sandstone been proposed to clarify confusing nomenclature where the Eau Claire and the start of the Paleozoic Era on Laurentia. Further, essential elements of pertaining to saline reservoir studies for industrial-waste and brine disposal, was deposited in an area limited to western Ohio and the adjacent proto- Conasauga intertongue. The redefined sub-Knox units of the Ohio region basin architecture in the Ohio region appear to be fivefold: (1) the Waverly gas storage, CO<sub>2</sub> sequestration, and hydrocarbon exploration. Arch, redefined as a result of this research; (2) the northwestern Rome Trough Updated maps of the Proterozoic complex (Granite Rhyolite and Grenville astride a broad, reduced Waverly Arch of the exposed Laurentian craton. deposited on a Precambrian peneplain, as traditionally mapped.

high (a new term), a rift shoulder in southern Ohio and adjacent Kentucky Provinces and the East Continent Rift Basin) unconformity surface in the The Mt. Simon subcrops to a feather edge along the reduced Waverly Arch

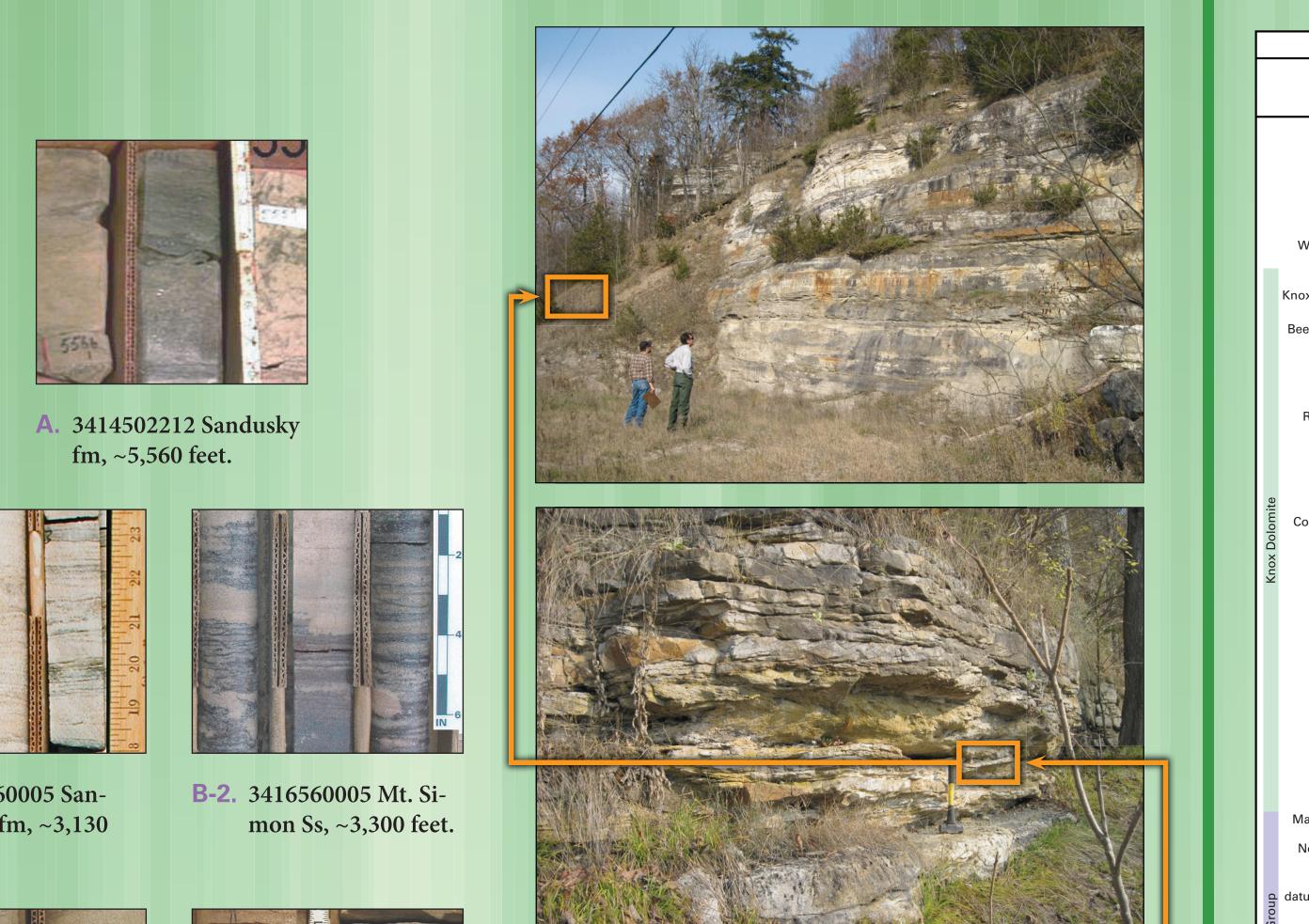
**STOP 2**—Revised sub-Knox nomenclature

Rome sandstone facies

and West Virginia; (3) the north-south trending Grenville front boundary Ohio region are essential when selecting potential sites for injection into saline and along an ENE-trending shoulder of the Rome Trough, which formed Recent subsurface correlations, using wireline and core data from zone of west central Ohio; (4) the stable cratonic Ohio Platform; and (5) Cambrian reservoirs. The Waverly Arch is considered a Late Mesoproterozoic paleotopographic barriers to deposition. Between these positive areas, the Michigan-Illinois basin. The eastern limit of the Mt. Simon is redefined illustrate that the Mt. Simon is not the regional basal "blanket sandstone,"

## **STOP 3**—Revised sub-Knox nomenclature.

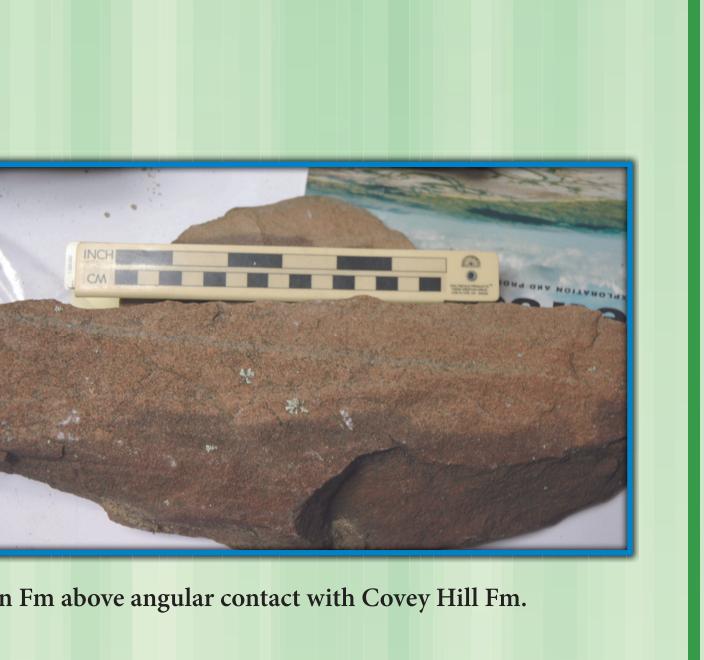
The diamond core recovered from deep wells shown on the cross section at Stop 4 are the foundation for the proposed lithostratigraphic model for the Waverly Arch and emergent platform. The Sandusky is notably bioturbated and heterolithic compared to the underlying Mt. Simon. Nepean Fm and Covey Hill outcrops in eastern Ontario are lithostratigraphically similar to the subsurface Conasauga/Sandusky and Mt. Simon, respectively.







trace to minor carbonate cement. Arrows and boxes point to approximate locations.

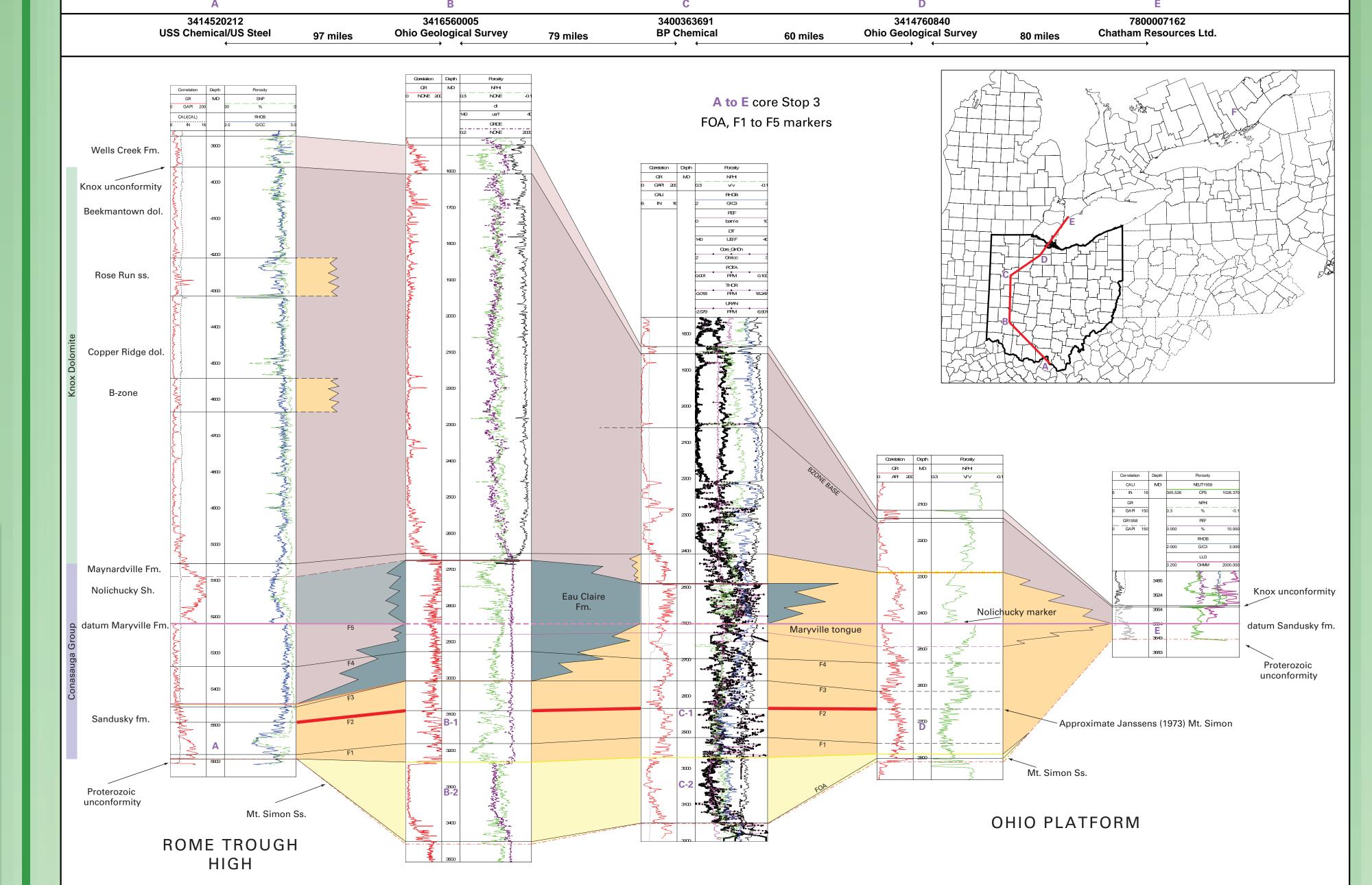






ping, eolian, cross-bedded quartz arenite of Covey Hill Fn

**STOP 4**—Regional cross section showing redefined Mt. Simon thickness decreasing onto the Ohio Platform and Rome Trough high. Consistent thickness of the overlying Cambrian units emphasizes the stability and uniform subsidence of the Ohio Platform and additional saline reservoirs. The F2 marker beds correlate in part with previously defined Mt. Simon. See regional map at Stop 1 for approximate well and outcrop locations. Stop 3 shows representative diamond core examples. Previous Mt. Simon workers (e.g. Janssens, 1973) apparently were caught in the "peneplain trap" for regional correlations. All sandstones deposited on the Precambrian unconformity surface in the Ohio region are NOT categorically mappable as the Mt. Simon.



Unit name	Generalized lithology and bedding	gamma ray units = API relative natural radiation	density units = calculated grams/cc relative to fresh water	photoelectric units = barns
Knox Dolomite	dolostone—light to medium to dark gray; massive to medium bedded; locally, vuggy, glauconitic, arenaceous, shaley, wispy to laminated, nodular, rip up clasts	low	high	medium
Conasauga Group, Maynardville Formation	dolostone and limestone—light to medium gray; thin to medium and wispy bedded; locally, glauconitic, arenaceous, nodular, rip up clasts	low to medium	medium to high	medium
Conasauga Group, Nolichucky Formation	shale and dolostone—medium to dark gray to black; laminated to interbedded, to thin to medium and wispy bedded; locally, fossilferous, glauconitic, arenaceous	high	low medium	low to
Conasauga Group, Maryville Formation	dolostone—light to medium gray; thin to medium to massive bedded; locally, bioturbation, glauconitic, arenaceous, nodular, anhydrite, rip up clasts	low	high	medium
Sandusky formation (proposed new name)	quartz arenite to subarkose to siltstone to dolostone—variable color: light to medium gray to pinkish gray to dark gray to light brown to reddish brown to white; interbedded to thin to medium to massive to wispy to cross bedded; cyclical; bioturbation; feldspathic, arenaceous to dolomitic; locally pelloidal; glauconitic, paleosols, shaley, anhydrite, rip up clasts	medium to high (cyclical response)	low to medium (cyclical response)	medium (cyclical response)
Eau Claire Formation	quartz arenite to subarkose, shale, siltstone, dolostone and limestone—variable color: light to medium gray to pinkish gray to dark gray to light brown to reddish brown to white; interbedded to thin to medium to massive to wispy to cross bedded; cyclical; bioturbation; glauconitic, rip up clasts	medium to high (cyclical response) 40 to 190 API units (mean 140) BP	low to high (cyclical response) 2.25 to 2.75 units (mean 2.55) BP	medium (cyclical) response) 4.0 to 4.9 units (mean 3.5) BP
Mount Simon Sandstone upper	quartz arenite—white to light gray to red to purple; medium to massive to cross bedded; bioturbation, rip up clasts	low to medium 20 to 100 API unit (mean 50) BP	low to medium 2.45 to 2.60 units (mean 2.5) BP	low 1.8 to 2.2 units (mean 2.0) BP
Mount Simon Sandstone lower	quartz arenite to arkose to shale, siltstone— white to light gray to red; interbedded to thin to medium to massive to wispy to cross bedded; locally conglomeratic, cyclical, bioturbation, rip up clasts	medium (cyclical response) 40 to 140 API units (mean 90) BP	low to medium (cyclical response) 2.45 to 2.60 units (mean 2.5) BP	low to medium (cyclical response) 2.0 to 3.0 units (mean 2.5) BP
basal arkose	quartz arenite to arkose to shale, siltstone— white to light gray to red; interbedded to thin to medium to massive to wispy to cross bedded; locally conglomeratic, cyclical, bioturbation, rip up clasts	high	low to high	na
Precambrian	highly variable—quartz, arenite, granite, rhyolite, gabbro, schist, mnarble, diorite, amphibolite, granodorite, anorthosite	variable	variable	variable

complex is assumed to be an "impermeable" sealing interval, the injection Following Mt. Simon deposition, Eau Claire Fm, the upper

potential of the basement complex is poorly understood and requires updating and modernizing of available rock and geophysical data.

**STOP 5**—Chart showing distinguishing character-

istics of the Sauk sequence units in Ohio. Previous workers

(e.g. Janssens, 1973) have inconsistently carried Upper

Mississippi Valley and southern Central Appalachian

Basin surface nomenclature into the Ohio subsurface

using deep test wells. The Sandusky fm is introduced to

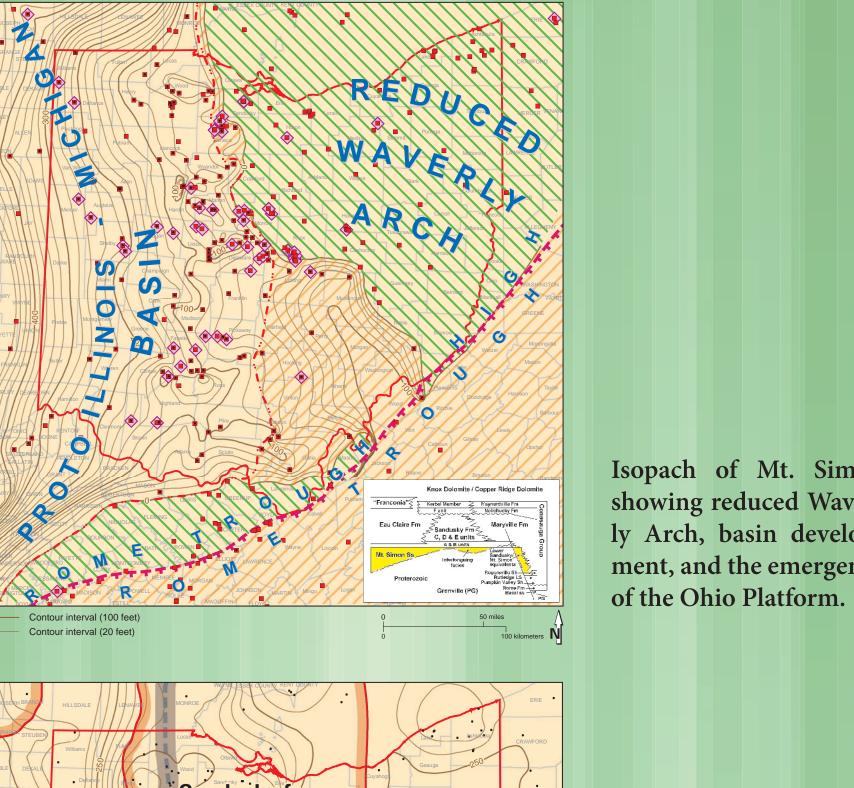
eliminate and clarify correlation problems with the sub-

Knox. Previous Mt. Simon correlations across the Ohio

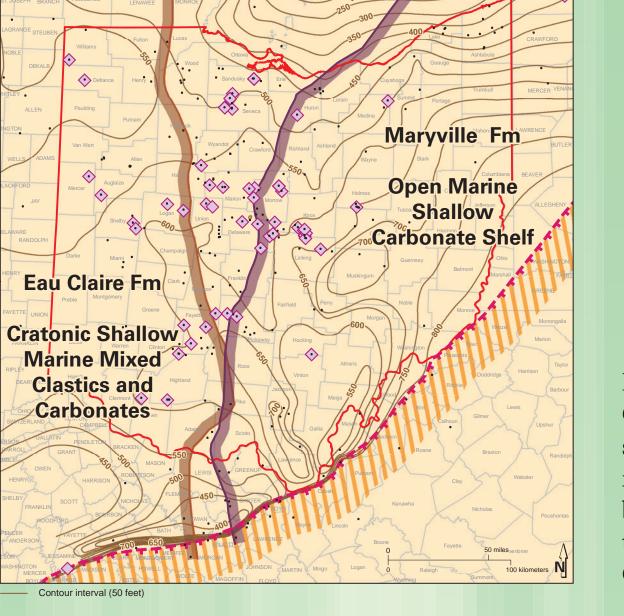
Platform region included the Sandusky F2 (B-unit on

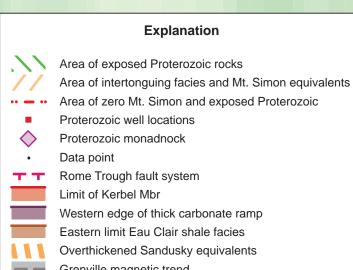
Waverly Arch and development of the emergent Ohio Platform. sub-Knox correlation problems. development of the Waverly Arch, Rome Trough, proto-Illinois/ subsidence and part of Conasauga Gp deposition. The Rome Mt. Simon respectively. Michigan & proto-Appalachian Basin architecture, and deposition of the Trough high and reduced Waverly Arch acted as barriers, • Updated mapping of the extent and quality of Cambrian reservoirs Sauk Sequence in Ohio and surrounding region. Although the basement effectively controlling Mt. Simon and Conasauga deposition.

**STOP 6**—Isopach maps showing complex structural and stratigraphic relationships of the Mt. Simon and overlying Eau Claire, Conasauga, and Sandusky.



area astride the Grenville duced Waverly Arch on the emergent Ohio Plat-





portion of Conasauga Gp, and equivalents formed the stable, very-low relief Ohio Platform, which was dominated by cyclical, mixed clastic-carbonate sediments throughout central Ohio and primarily carbonates eastward.

◆ The Mt. Simon is not a regional "blanket sandstone" extending 
◆ Proterozoic monadnocks are completely buried during Sandusky across Ohio into the Appalachian Basin, as traditionally Eunit deposition, marking a previously unknown regional hiatus. mapped. Updated mapping demonstrates the presence of the 

The Sandusky fm is proposed to eliminate and clarify current

◆ Subsidence of proto-Illinois/Michigan Basin during Mt. Simon → Nepean Fm and Covey Hill outcrops in eastern Ontario are

has implications for hydrocarbon exploration, gas storage, CO<sub>2</sub>



**STOP 1**—Major tectonic elements affecting Cambrian

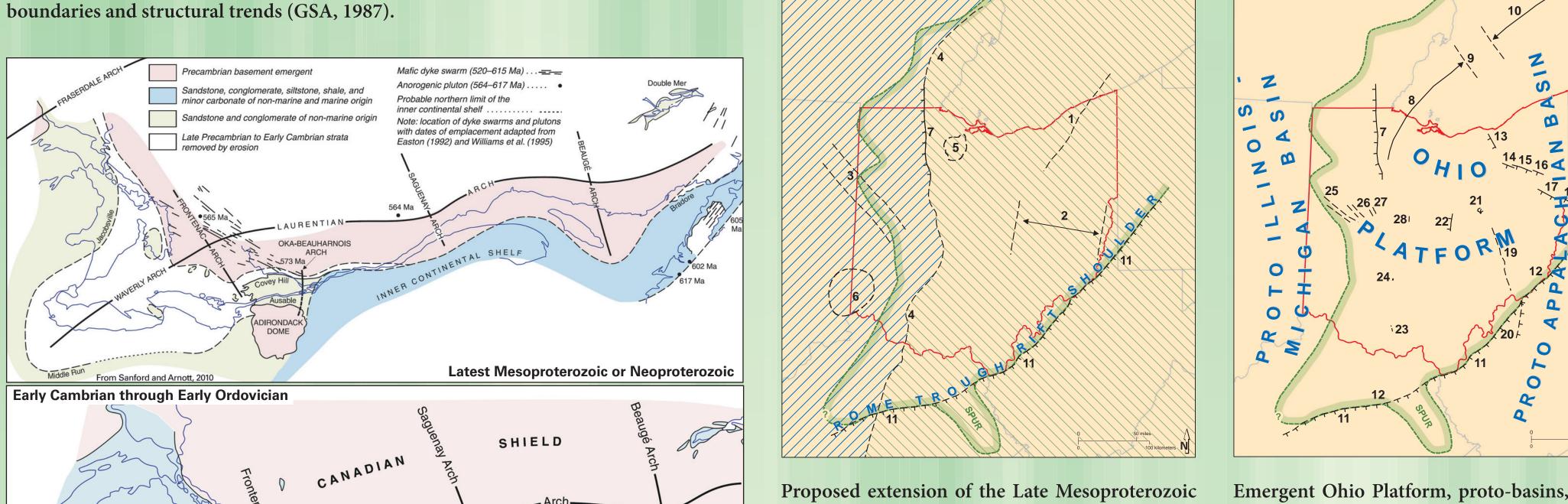
• Precambrian Provinces: Eastern Granite Rhyolite, East

• Waverly Arch, Ohio Platform, and Rome Trough.

Proto-Illinois/Michigan and proto-Appalachian Basins.

Continent Rift Basin, Grenville.

Paleogeography and proposed extension of the Waverly Arch during late Middle Cambrian Rome Trough time. Modified from Blakely, 2006.



Regional maps showing major tectonic features and deep-well and outcrop locations for this poster and generalized paleogeography during Cambrian time and revised Waverly

**ANOMALY MAP** 

Carr and others (2000), Reed (1993), hite and others (2000), Van Schmus (1996)

Precambrian/Paleozoio

Allochthon boundary

Western central meta

boundary thrust zone

Nd pre-1,600 eastern

Grenville domains

-- Extent of Waverly Arc

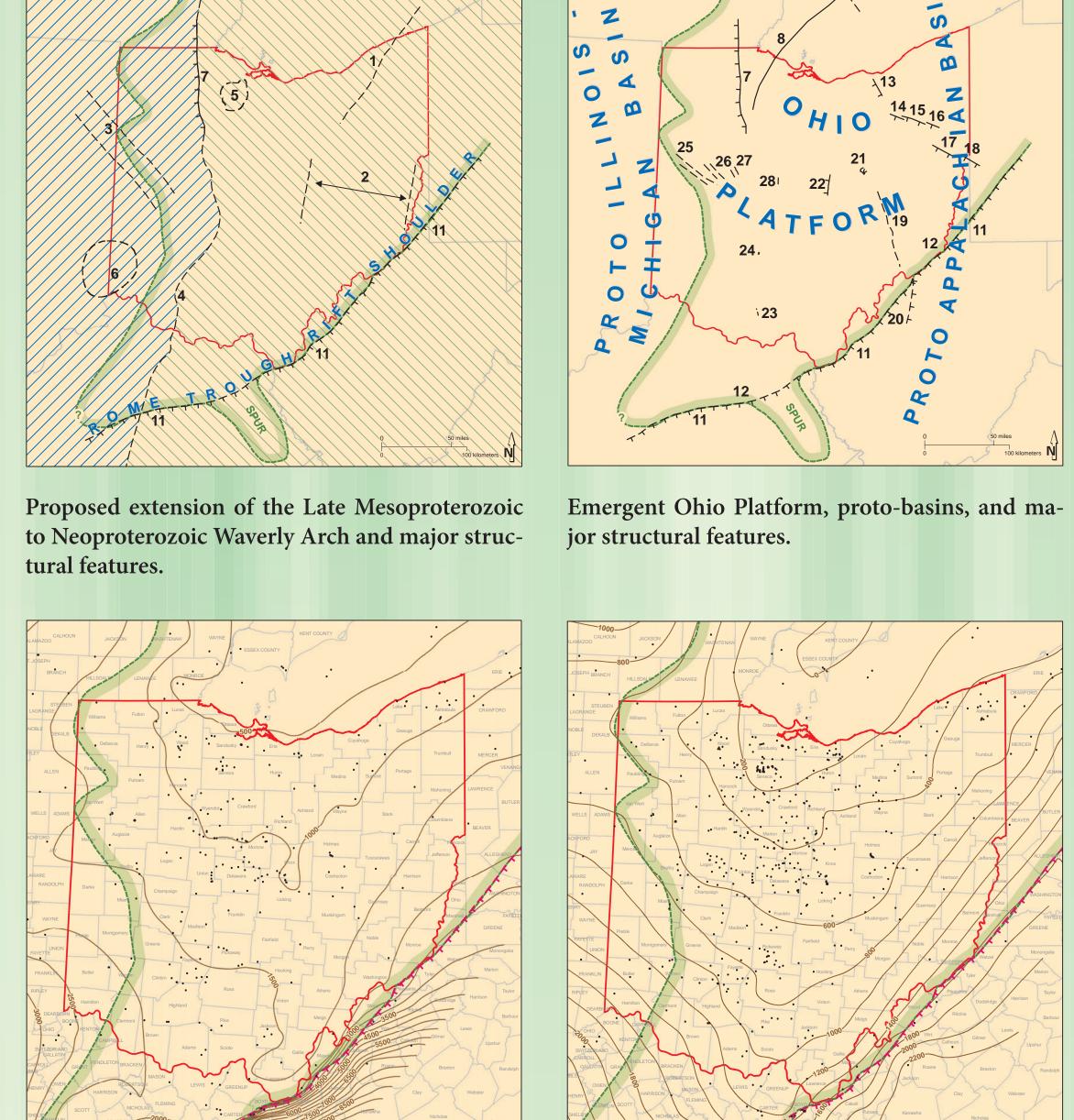
Parry Sound

limit continental crus

— Grenville Front/GFTZ

Anna-Champaign fault system Logan fault systemDelaware structure Interpreted boundary, trend, or fault → T Normal fault —— Small fault 8 Pittsburg-Washington cross-strike structural discontinuity • Data point

9 Cambridge cross-strike structural discontinuity T T Rome Trough fault system 0 Burning Springs fault system



Isopach of upper Sauk sequence shows Cambrian

Meeting, Charleston, W. Va., Sept. 13, 1988 [proceedings]: Appalachian Geological Society (imprint), p. 6–18. ological Society of America Committee for the Magnetic Anomaly Map of North America (GSA), 1987, Magnetic Anomaly Map of North America: Boulder, Colo., Geological America Memoir 39, p. 91–123. Lidiak, E.G., and Hinze, W.J., 1993, Grenville Province in the subsurface of eastern United States, in Reed, J.C., Bickford, M.E., Houston, R.S., Link, P.K., Rankin, D.W., Sims, P.K.,

White, D.J., Forsyth, D.A., Asudeh, I., Carr, S.D., Wu, H., Easton, R.M., and Mereu, R.F., 2000, A seismic-based cross-section of the Grenville orogen in southern Ontario and and Van Schmus, W.R., eds., Precambrian—Conterminous U.S.: Geological Society of America, The Geology of North America, v. C-2, p. 353–365.

eng, S.C., Babcock, L.E., and Cooper, R.A., in press, The Cambrian System, in Gradstein, F.M., Ogg, J.G., and Ogg, G., eds., A geologic time scale 2010: Cambridge University Rankin, D.W., Sims, P.K., and Van Schmus, W.R., eds., Precambrian—Conterminous U.S.: Geological Society of America, The Geology of North America, v. C-2, p Sloss, L.L., Krumbein, W.C., and Dapples, E.C., 1949, Integrated facies analysis, in Longwell, C.R., chairman, Sedimentary facies in geologic history: Geological Society of Van Schmus, W.A., Bickford, M.E., and Turek, A., 1996, Proterozoic geology of the east-central Midcontinent basement, in van der Pluijm, B.A., and Catacosinos, P.A., eds. Basement and basins of eastern North America: Geological Society of America Special Paper 308, p. 7–32.

Shale, siltstone, sandstone, dolomite, and limestone

Eastern Granite Rhyolite

Middle Run Formation arkose

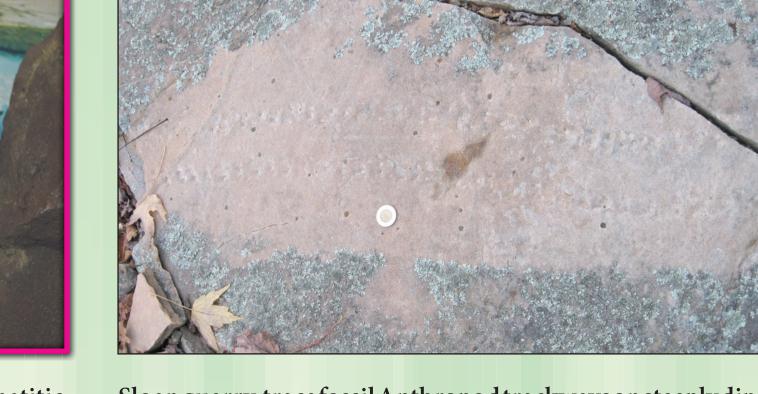
Grenville Province,
igneous and metamorphics

fm), ~3,620 feet.





cross bedded of Covey Hill Fm.



revised nomenclature chart) marker on the cross section in Stop 4. Note the similarity of lithology and geophysical log response of the Sandusky fm and Eau Claire Fm, which contrasts with the underlying Mt. Simon Ss.

## **STOP 7**—Conclusions.

• A deeply eroded, tectonically complex Proterozoic surface controlled deposition was in part contemporaneous with Rome Trough lithostratigraphically similar to the Conasauga/Sandusky and