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Examples from the Atlas of Major Applachian Gas Plays

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DISCLAIMER

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CONTRACT INFORMATION

Contract Number	DE-FC21-91MC28176
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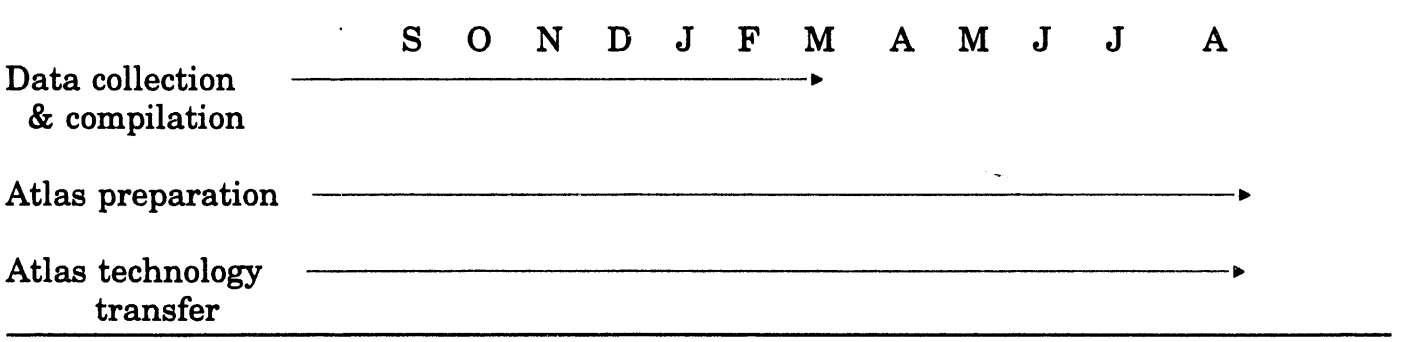
METC Project Manager	Harold D. Shoemaker
Period of Performance	October 1, 1991 to September 30, 1994

Schedule and Milestones

FY94 Program Schedule



OBJECTIVES

The objectives of this contract are to produce a printed atlas of major Appalachian basin gas plays and to compile a machine-readable database of reservoir data.

BACKGROUND INFORMATION

In their "Gas Research Program Implementation Plan" issued in April 1990, the U.S. Department of Energy identified and discussed research activities for natural gas resource assessment and recovery with near-, mid-, and long-term objectives and described how to implement these activities. In the near-term, five research topics were identified, including "Gas Atlases Compilation/Reservoir Classification," and "Database Consolidation and Maintenance." DOE envisioned a close linkage between these two activities with data flowing between both as they were performed concurrently. However, DOE noted that it may be essential to develop an appropriate reservoir classification scheme that divides reservoirs in a region into groups with common geological and engineering characteristics before consolidating databases or producing the gas atlases. They further stated that this combination of activities (classification scheme, database consolidation, gas atlases) "... clearly represents a major effort...", one that will require the assistance of "... universities, industry, and state and federal geological surveys." The report goes on to state that the three activities are " an essential starting point for the entire gas program..." to guide further research and industry development and to expose gaps in data currently available for those pursuits.

The Appalachian Oil and Natural Gas Research Consortium (AONGRC or the Consortium), a partnership of the state geological surveys in Kentucky, Ohio, Pennsylvania, and West Virginia, and the departments of Geology and Petroleum and Natural Gas Engineering at West Virginia University (WVU), agrees with the need to classify gas reservoirs by geologic plays. During meetings with industry representatives, the small independents in the basin emphasized that one of their prime needs was to place each producing reservoir within a stratigraphic framework subdivided by environment of deposition to enable them to develop exploration and development strategies.

The Appalachian basin is a broad geologic province that spans several states. There is no central regulatory authority, similar to the Texas Railroad Commission, acting as a source of detailed reservoir data. The general absence of major oil and gas companies in the exploration and development of the basin has resulted in many small independent operators with limited geologic staffs generating internal reports on prospective areas for drilling; these reports are often not published. Most private vendors of oil and gas well and reservoir information are generally lacking in historical data typical of mature provinces. Finally, significant exploration and development occurred prior to the establishment of statewide regulatory agencies.

PROJECT DESCRIPTION

Six tasks were identified to accomplish the objectives. Task 1, Defining Gas Plays, resulted in the identification of 31 plays. Task 2, Data Collection and Compilation, is on going, as play descriptions are being written, tables and illustrations constructed,

and the atlas database designed. Task 3, Atlas Preparation, is in progress at present. Task 4, Atlas Review, is following Task 3 closely, as an essential part of the play description preparation. Task 5, printing the atlas, will occur during the final months of the contract. Task 6, Technology Transfer, has been on-going throughout the contract, with presentations by project personnel at the 24th Annual Appalachian Petroleum Geology Symposium, the 1993 Eastern Section, American Association of Petroleum Geologists Annual Meeting, METC Contractors Review Meetings, and the Kentucky Oil and Gas Association 1993 Summer Meeting. The 25th Annual Appalachian Petroleum Geology Symposium, to be held in March, 1994 in Morgantown, WV, will be devoted to presentations on all of the Appalachian basin gas plays being included in the Gas Atlas.

RESULTS

The text for eight of the 31 play descriptions has been completed, drafting of illustrations for these plays is underway (or complete for some plays), and the review process is ongoing. The review process has been set up to ensure consistency, accuracy, and completeness for all play descriptions included in the atlas. Following internal reviews by three project members, the text and illustrations are sent to three external reviewers and to the METC project manager. After all external and METC reviewer comments have been examined by the author(s), the text and illustrations are reviewed by the technical editor. Upon approval of the text and illustrations by the technical editor, the production editor then prepares the text and illustrations for publication.

Eleven additional plays are scheduled to be completed by the end of November, 1993. The remaining 12 will be completed in early February, 1994.

Table 1 is the standard outline being used by all authors for the play descriptions. The use of the outline will enable the reader to quickly and easily find the same information for comparison of different plays. Table 2 lists the typical required and optional illustrations for each play. Table 3 is an example of the "Reservoir and Production Data of Major Pools Included in Play XX" table which will be included with each play description. A maximum of 24 fields or pools in each play will be published in the atlas. Data on all the fields and pools included in each play will be contained in the database.

Figure 1 is an example (the Lower Silurian Tuscarora Sandstone Fractured Anticline play) of the map showing the location of the fields and pools included in a play. This figure is designed to show the relative extent of each play within the basin. A correlation chart (Figure 2, for the Cambrian-Ordovician Knox Group unconformity play) serves to locate the play stratigraphically. Correlation charts may show both formal stratigraphic and informal drillers' terms. Isopach (Figure 3) and structural contour (Figure 4) maps of a key field (Oneida Consolidated field, Clay County, Kentucky, Lower Devonian- Upper Silurian unconformity play) are used to illustrate the relationship of structure and thickness to gas production. Type logs for key fields (Figure 5, east central Kentucky, Lower Devonian-Upper Silurian unconformity play) show log characteristics of the reservoir and surrounding units. Stratigraphic cross sections (Figure 6, the Cambrian-Ordovician Knox Group unconformity play) are used to illustrate

regional stratigraphic relationships of the productive zones and overlying and underlying units.

FUTURE WORK

In the remaining year of the contract, all play descriptions and illustrations will be finalized and prepared for printing. The database will be compiled and formatted for delivery.

REFERENCES

Dolly, E.D., and Busch, D.A., 1972, Stratigraphic,structural, and geomorphic factors controlling oil accumulation in Upper Cambrian strata of central Ohio: American Association of Petroleum Geologists Bulletin, v. 56, no. 12, p. 2335-2369.

Janssens, A., 1973, Stratigraphy of the Cambrian and Lower Ordovician rocks in Ohio: Ohio Division of Geological Survey Bulletin 64, 197 p.

Milici, R.C., and de Witt, Wallace, Jr., 1988, The Appalachian Basin, *in* Sloss, L. D., ed., Sedimentary cover--North American Craton:U.S.: Geological Society of America,The Geology of North America, v. D-2, p. 427-469.

Patchen, D.G., Avary, K.L., and Erwin, R.B., 1985, Correlation of Stratigraphic Units of North America (COSUNA) project-Northern Appalachian Region: American Association of Petroleum Geologists, chart, 1 sheet.

Riley, R.A., Baranoski, M.T., Carlton, R.W., Harper,J.A., and Laughrey, C.D., 1993, Measuring and predicting reservoir heterogeneity in complex deposystems: the Late Cambrian Rose Run sandstone of eastern Ohio and western Pennsylvania: Final report, U.S. Department of Energy, contract no. DE-AC22-90BC14657, 220 p.

Table 1. Outline for play description

TITLE (play number, name, and author[s])

Location
Include a brief description of identifying features of the play if appropriate

Production History
Discovery, development, cumulative production

Stratigraphy
Producing formation(s), member(s), sand(s), zone(s), etc.
Age of producing unit(s)
Lateral equivalents of producing unit(s)
Environment(s) of deposition of producing unit(s)

Structure

Reservoir
Type of trap(s)
Source rock (age, lithology, maturity)
Migration of fluids
Depth to pay--range and average
Thickness--range and average
Rock pressure--range and average
Initial open flow--range and average
Final open flow--range and average
Heterogeneity (porosity types, porosity--range and average, permeability--range and average, type of reservoir [single layer, multi-layer], drive mechanism, completion strategies, production [per well--range and average, per acre--range and average], decline curves [typical well(s), typical pool(s)])

Description of Key Fields
(use field name to begin each description)

Resources and Reserves

Future Trends

References Cited

Table 2. List of play illustrations and tables

Illustrations

Typical field illustrations required for each play:

- Isopach or structure map
- Cross section (either structural or stratigraphic)
- Type log
- Pay or porosity map

Other illustrations:

- Pool map on basin base map
- Stratigraphic column (both formal and drillers' terms)
- Correlation chart

Plays defined by depositional systems or environments may include sketches or models of these systems. Other possible illustrations include types of traps, thermal maturity, and decline curve.

Tables

"Reservoir and Production Data of Major Pools Included in Play XX" will be included with each play description. For some plays, other tables may be appropriate.

Other tables which may have to be included:

- One table for one field per play with DOE's 41 data elements
- A table for the bigger plays with field names keyed to numbers on the pool map of the basin

Table 3. Reservoir and production data of major fields and pools in Cambrian-Ordovician Knox unconformity play

	Field/Pool PLAY 31	Lee Chapel Cons.	Burning Springs Cons	Oneida Cons.	Mine Rock	Raccoon Mountain	Tricia Cons.	Buffalo	Wyoming	Lakeshore	Morrow Cons.
BASIC RESERVOIR DATA	POOL NUMBER	1601142368	1600320368	1601461368	1601319368	1601600368	1602002368	310029	310121	310313	3401170974
	DISCOVERED	1975	1984	1985	1984	1955	1983			1949	1959
	DEPTH TO TOP RESERVOIR	1750	3450	3720	4600	3360	3720				3500
	AGE OF RESERVOIR	L.Ord.	L.Ord.	L.Ord.	L.Ord.	L.Ord.	L.Ord.	U.Camb.	U.Camb.	U.Camb.	U.Camb.
	FORMATION	Knox	Knox	Knox	BKMN	Knox	BKMN	THRA	THRA	THRA	Knox
	PRODUCING RESERVOIR	Knox	BKMN	BKMN	BKMN	Knox	BKMN	THRA	THRA	THRA	CPRG
	LITHOLOGY	dol.	dol.	dol.	dol.	dol.	dol.	ss.	ss.	ss.	dol.
	TRAP TYPE	Strat., Struc.	Strat., Struc.	Strat., Struc.	Struc.	Struc.	Struc.				Strat.
	DEPOSITIONAL ENVIRONMENT	Sh.mar.	Sh.mar.	Sh.mar.	Sh.mar.	Sh.mar.	Sh.mar.				Sh.mar.
	DISCOVERY WELL IP (psi)	150	20	700	146	488	90			2200	265
	DRIVE MECHANISM	g.e.	g.e.	g.e.	g.e.	g.e.	g.e.				s.g.,w.
	NO. PRODUCING WELLS	36	24	11	4	10	43	0	6	0	340
	NO. ABANDONED WELLS	5	3	0	0	0	2	2	0	1	241
	AREA (acreage)	3369	1873	725	350	2100	700				9800
	OLDEST FORMATION PENETRATED	Knox	Knox	Knox	Rome	Knox	Knox				MTSN
	EXPECTED HETEROGENEITY DUE TO:	fra.,dia	fra.	fra.	fra.	dia.,fra	fra.,dia				dia.
RESERVOIR PARAMETERS	AVERAGE PAY THICKNESS (ft)	6	33	42	32	17	37				14
	AVERAGE COMPLETION THICKNESS (ft)										18
	AVERAGE POROSITY-LOG (%)	9	8	9	7	9	9				9
	MINIMUM POROSITY-LOG (%)	4	4	4	1	4	4				4
	MAXIMUM POROSITY-LOG (%)	12	16	15	16	15	17				18
	NO. DATA POINTS	4	10	9	4	6	11				30
	AVERAGE POROSITY-CORE (%)					8					8
	MINIMUM POROSITY-CORE (%)					5					3
	MAXIMUM POROSITY-CORE (%)					13					16
	NO. DATA POINTS					2					6
	POROSITY TEST	54	264	378	224	1 53	330				126
	AVERAGE PERMEABILITY (md)					5.8					7
	RELATIVE PERMEABILITY (md/cp)										
	RESERVOIR TEMPERATURE (°F)		85	93	92	83	82				98
	ORIGINAL RESERVOIR PRESSURE (psi)			1100	1450	800					1280
	PRODUCING INTERVAL DEPTHS (ft)	1400–1970	3170–3870	3540–3880	4520–4640	2990–3560	3540–3860				3000–4200
	PRESENT RESERVOIR PRESSURE (psi)/DATE		350/1987		235/1986	245/1991	420/1989				800/1992
FLUID & GAS PROPERTIES	API (gravity)		.06	.06	.06	.06	.06				.04
	GAS GRAVITY (gas)					.698					.62
	GAS SATURATION (%)		59	33	56	74	47				63
	WATER SATURATION (%)		41	67	44	26	53				25
	COMMINGLED										Y
	ASSOCIATED OR NONASSOCIATED	N.	A.	A.	N.	A.	A.				A.
	BUBBLE					1076	1095				1062
VOLUMETRIC DATA	STATUS (producing, abandoned, storage)	P.	P.	P.	P.	P.	P.				P.
	PRODUCTION YEARS										1959–1992
	CUMULATIVE PRODUCTION (gas) *										35,000,000
	ORIGINAL GAS IN PLACE (gas)		12,600,000	4,200,000	2,900,000	10,000,000	4,700,000				52,000,000
	ORIGINAL GAS RESERVES (gas)										42,000,000
	REMAINING GAS IN PLACE (gas/year)										17,000,000
	REMAINING GAS RESERVES (gas/year)										7,000,000
	INITIAL OPEN FLOW (gas)						100			2200	390
	FINAL OPEN FLOW (gas)	131	202	879	346	207	693			80	355
	RECOVERY FACTOR (%)										80

* MAY NOT CORRESPOND TO NUMBER OF WELLS IN BASIC RESERVOIR DATA

AUGUST 25, 1993

ABBREVIATION KEY

U.Camb. - Upper Cambrian
L.Ord. - Lower Ordovician
BKMN - Beekmantown
RSRN - Rose Run
LTFL - Little Falls
THRA - Theresa

GTBG - Gatesburg
UPSY - Upper Sandy
CPRG - Copper Ridge
MTSN - Mount Simon
PC - Precambrian

ls. - limestone
dol. - dolomite
slst. - siltstone
ss. - sandstone
sh.mar - shallow marine
strat. - stratigraphic

struc. - structural
s.g. - solution gas
w. - water
g.e. - gas expansion
fra. - fractures
dia. - diagenesis
depo. - deposition

A. - Associated
N. - Non-Associated
P. - Producing
A. - Abandoned
S. - Storage
E. - Enhanced recovery
Cons. - Consolidated

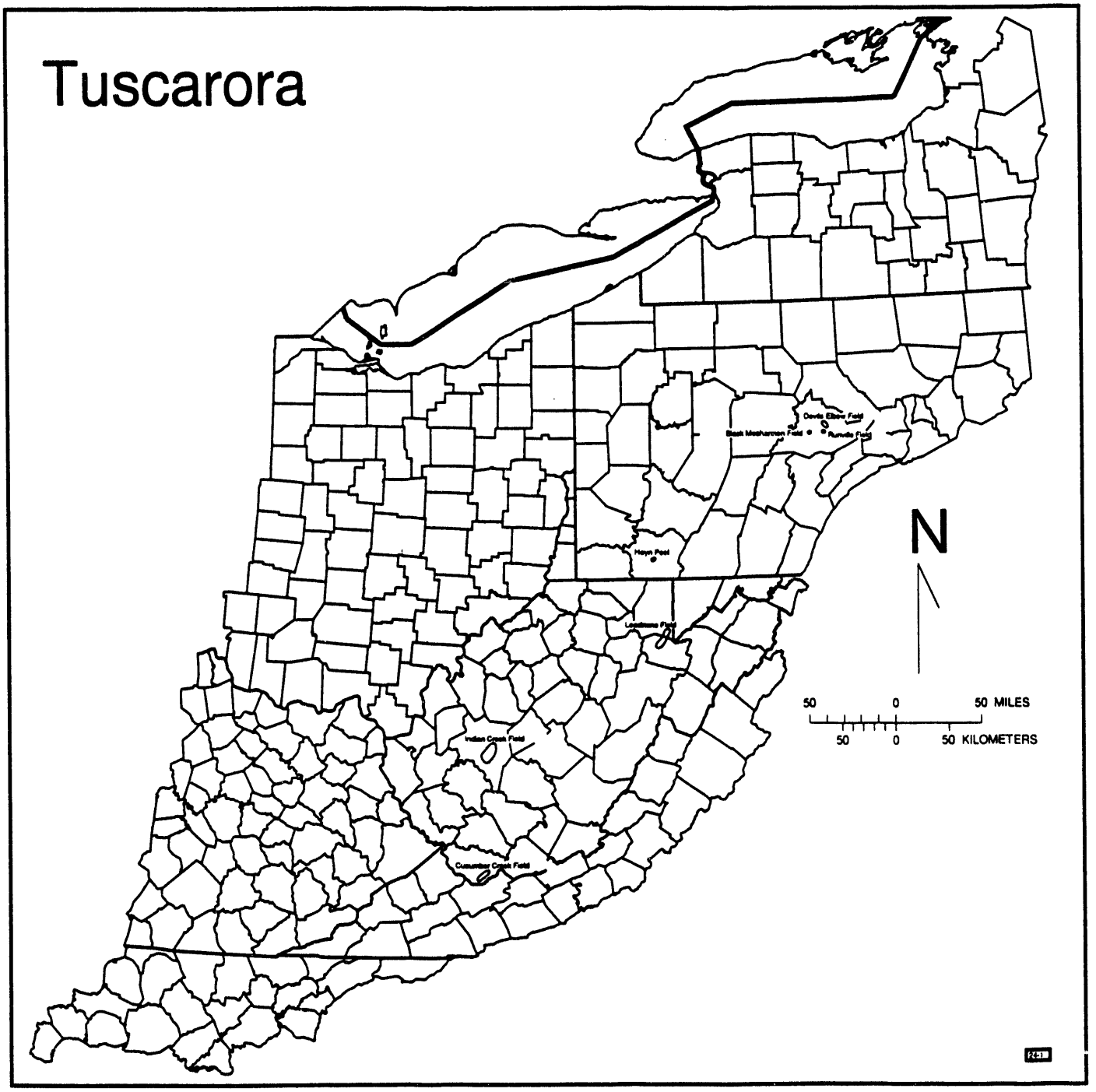


Figure 1. Map of the Appalachian Basin showing the location and extent of the Lower Silurian Tuscarora Sandstone fractured anticline fields and pools.

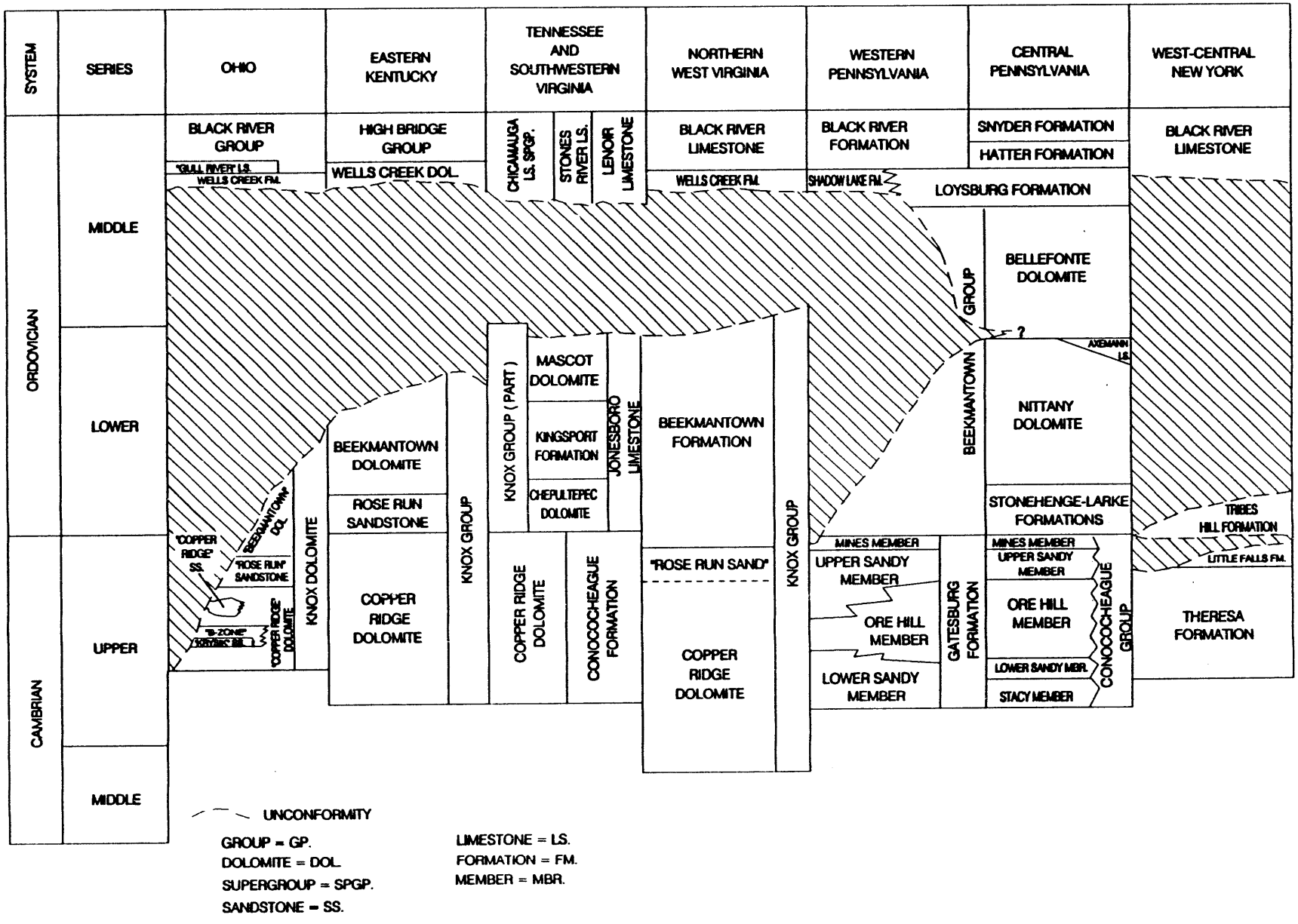


Figure 2. Correlation chart for part of the Ordovician and Cambrian of the Appalachian basin (modified from Janssens, 1973; Patchen and others, 1985; Milici and de Witt, 1988; and Riley and others, 1993), Cambrian-Ordovician Knox Group unconformity play

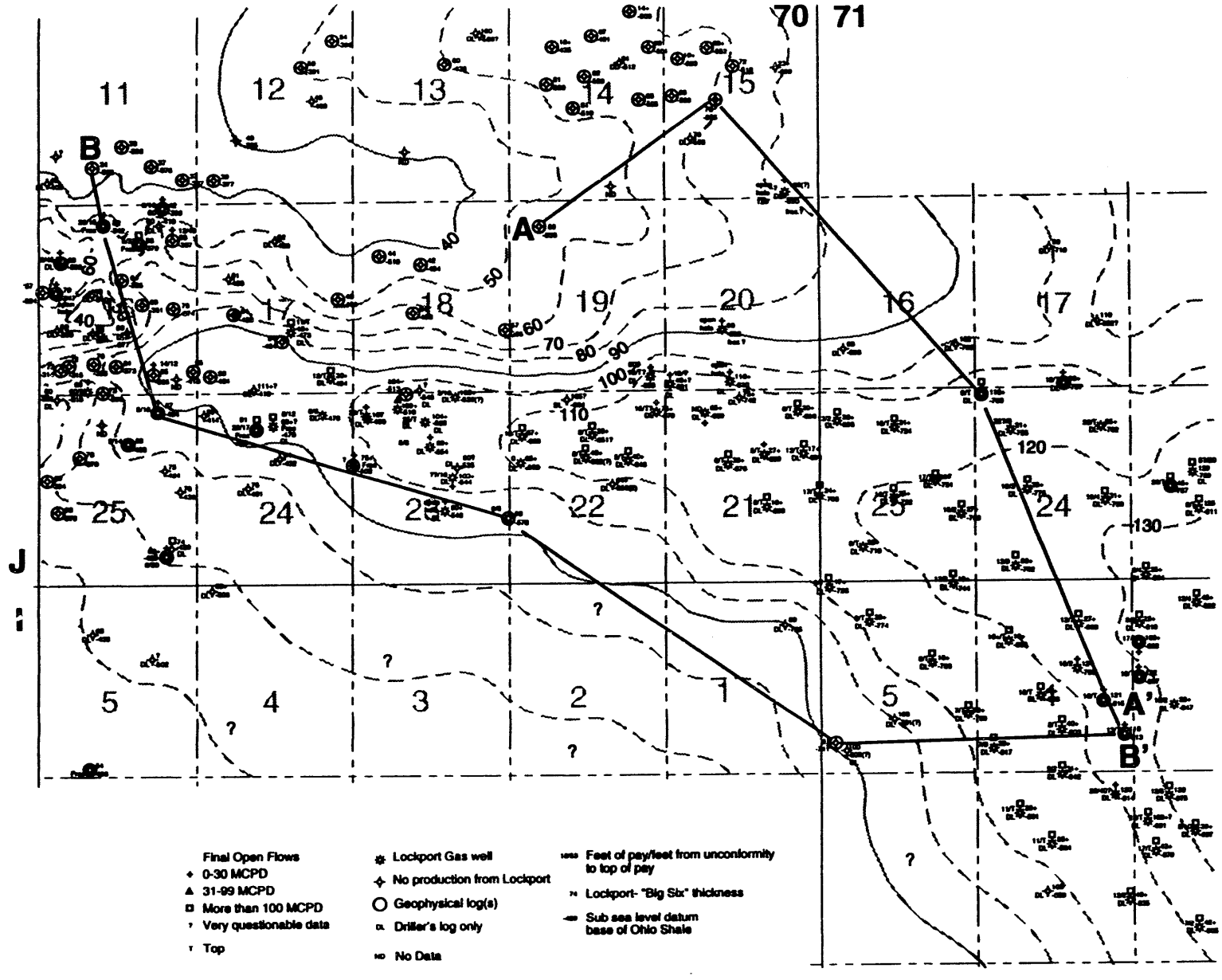


Figure 3. Isopach map of the Lockport Dolomite/"Big Six", Oneida Consolidated field, Clay County, Kentucky, Lower Devonian-Upper Silurian unconformity play

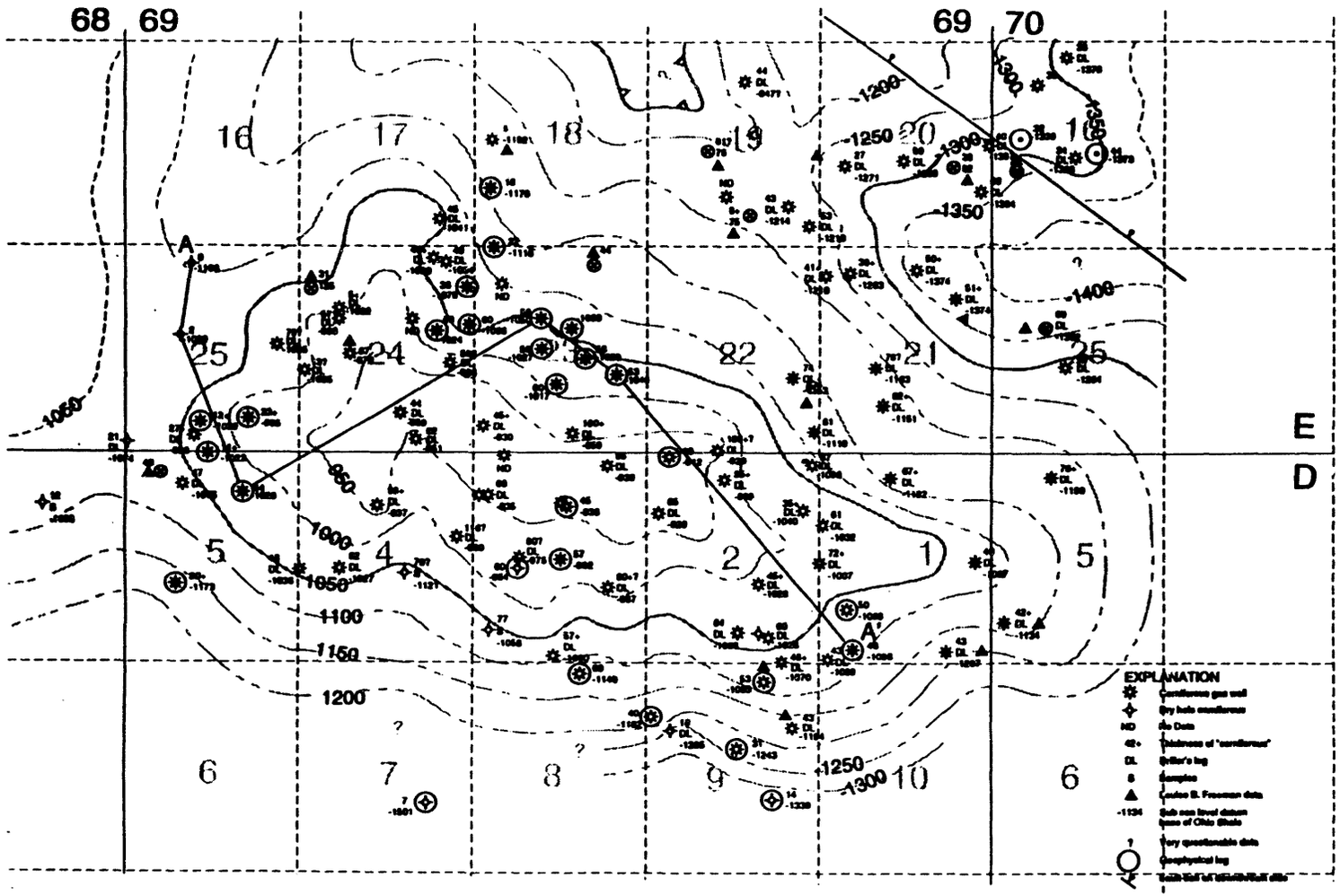


Figure 4. Structure contour map on the base of the Devonian Ohio Shale, Oneida Consolidated field, Clay County, Kentucky, Lower Devonian-Upper Silurian unconformity play

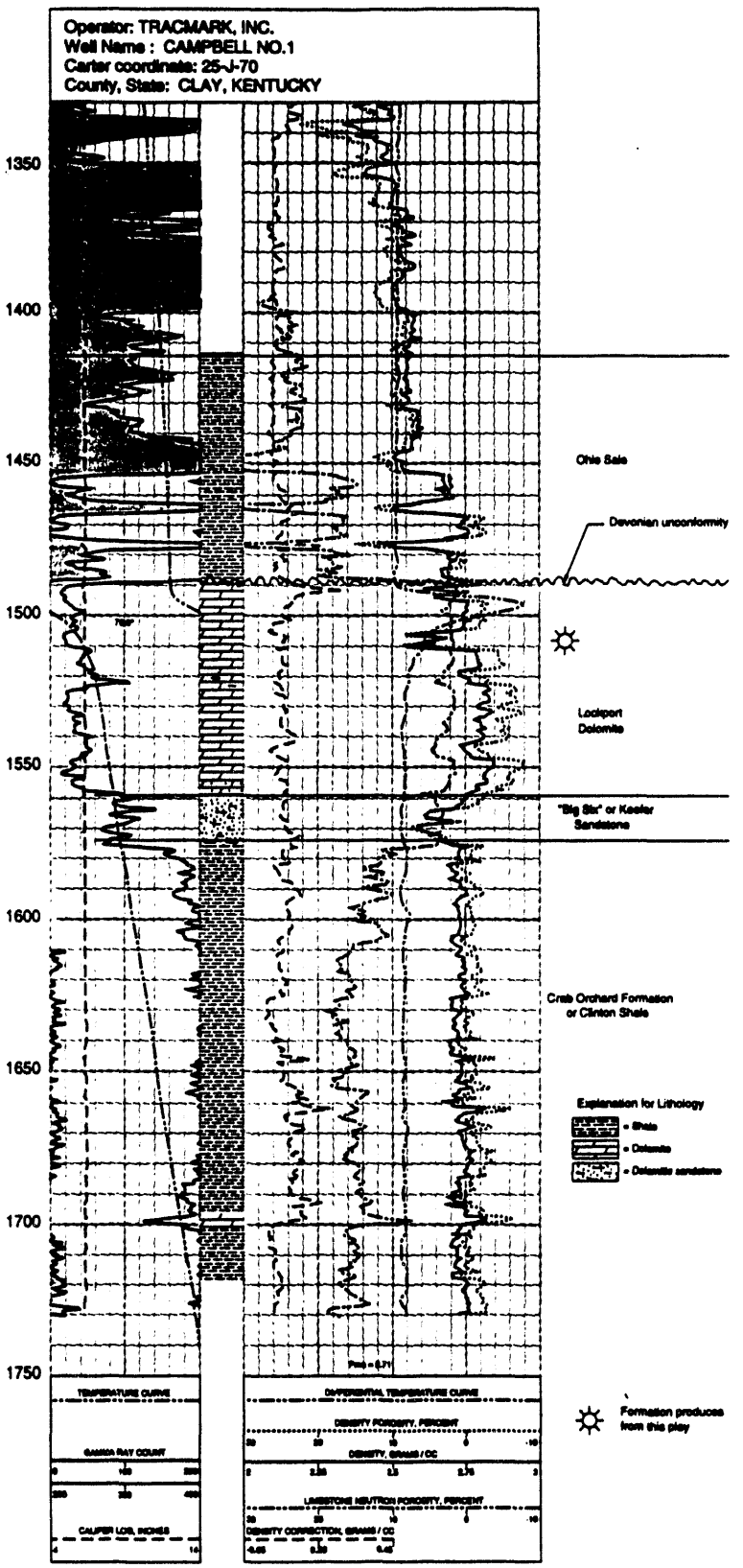


Figure 5. Type log for east central Kentucky (Clay County), Lower Devonian-Upper Silurian unconformity play

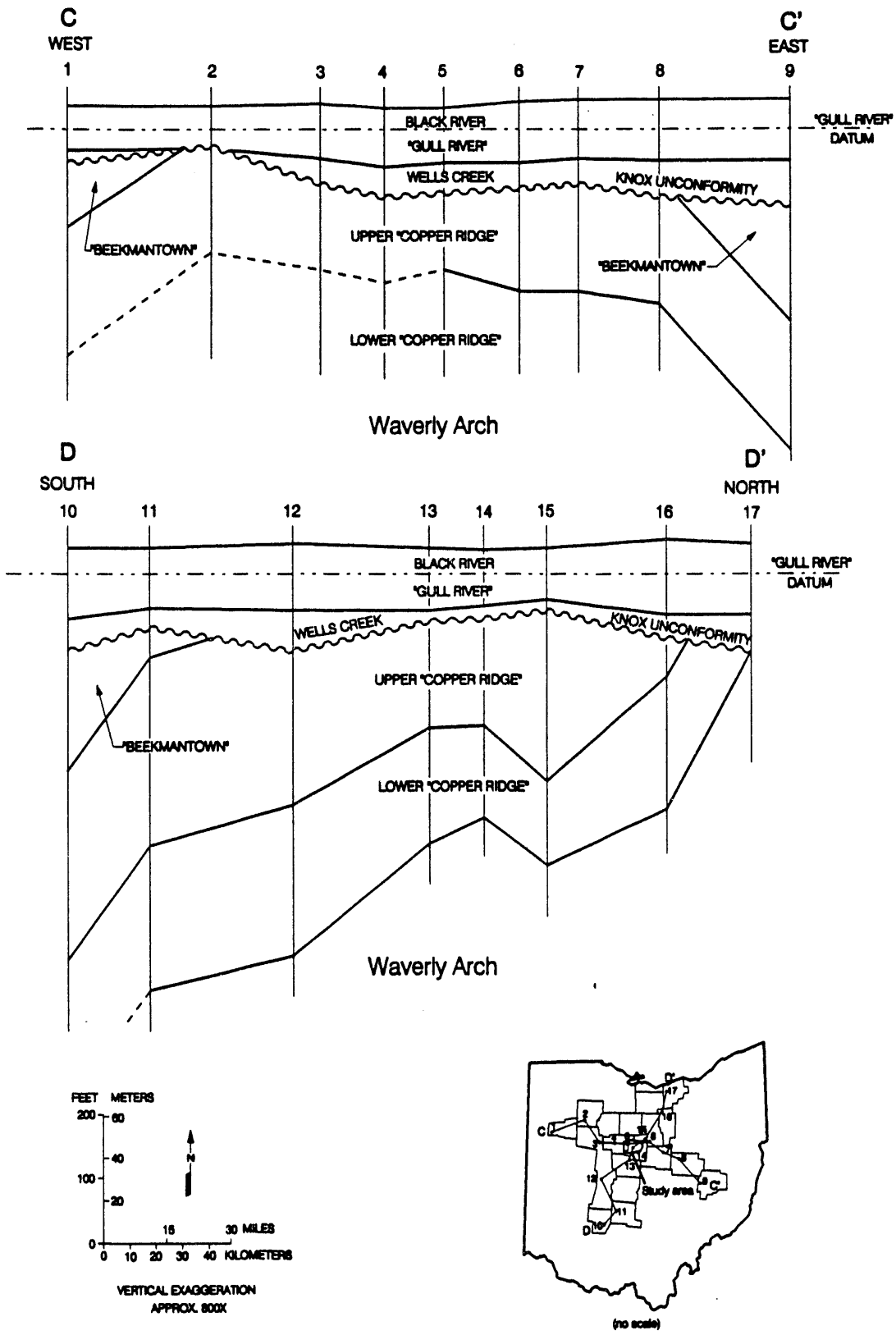


Figure 6. Regional cross sections of the Middle Ordovician and Upper Cambrian in central Ohio demonstrating the Knox unconformity and Waverly Arch (modified from Dolly and Busch, 1972), Cambrian-Ordovician Knox unconformity play

END

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3/14/94