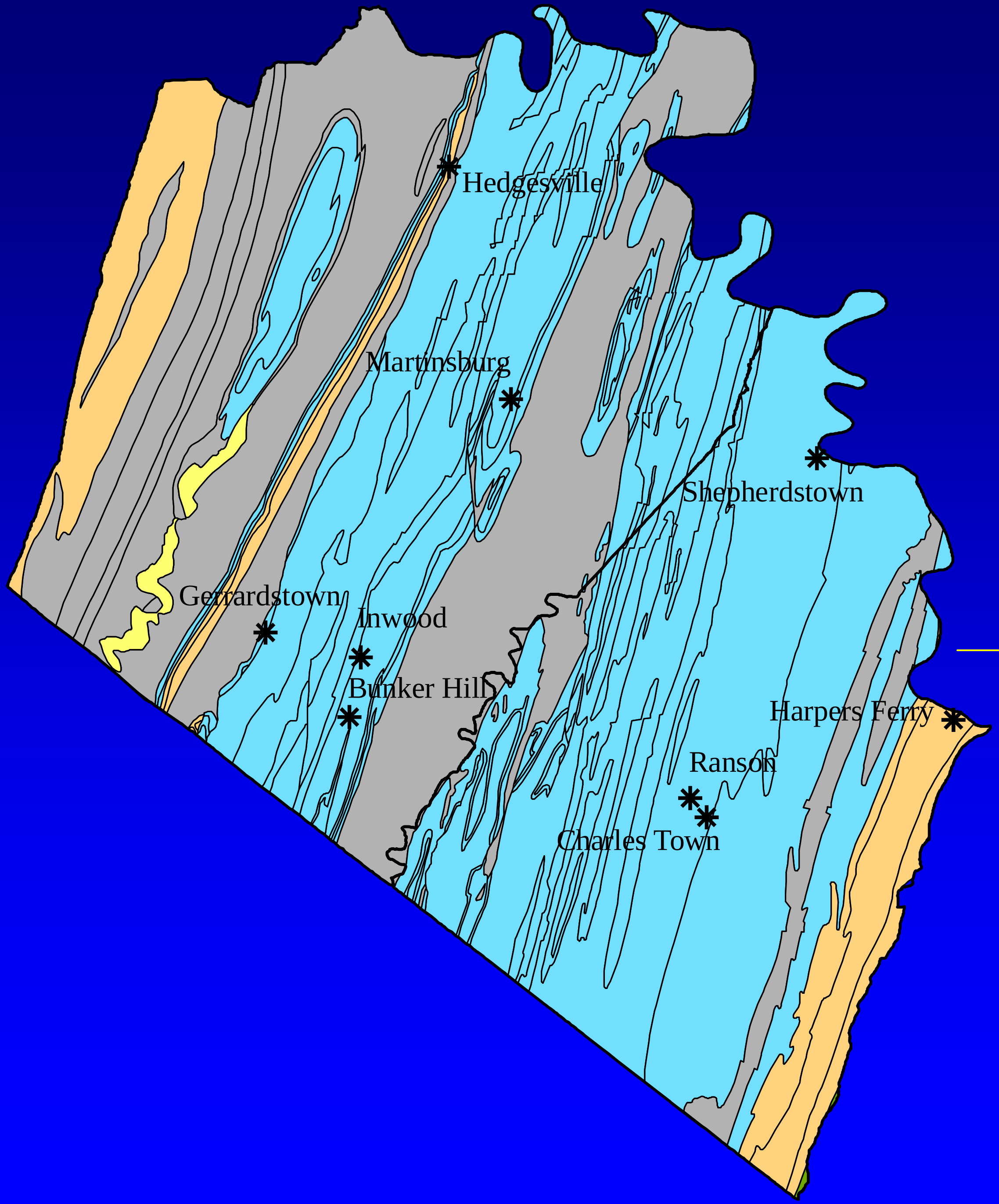

Use of sinkhole and specific capacity distributions to assess flow directionality in the Great Valley

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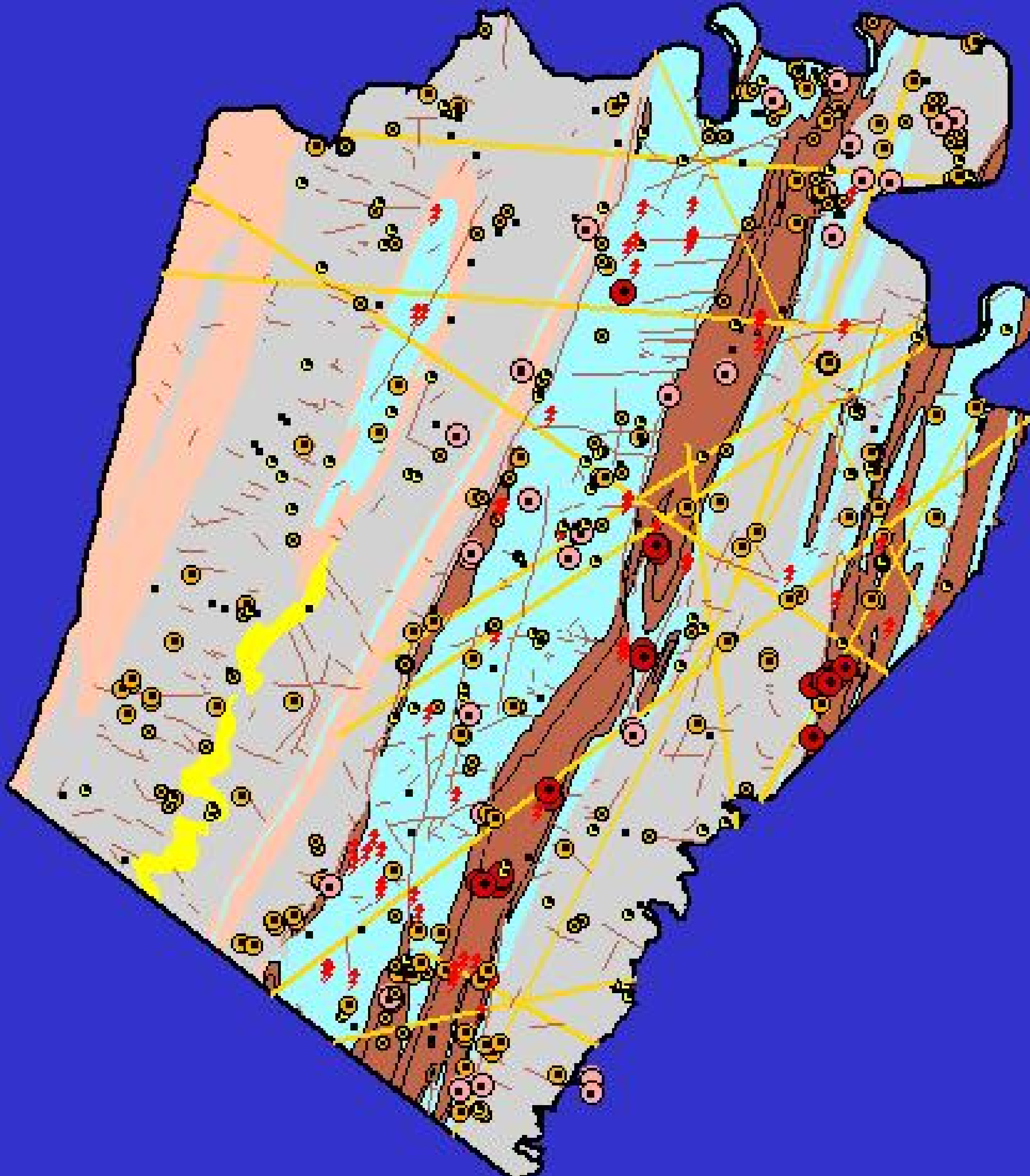
Kurt J. McCoy

USGS-WRD
WVWSC
Charleston WV



Berkeley County Geohydrology

Well Yield (gpm)

- 0-5
- 5-10
- 10-20
- 20-50
- 50-100
- 100-2000

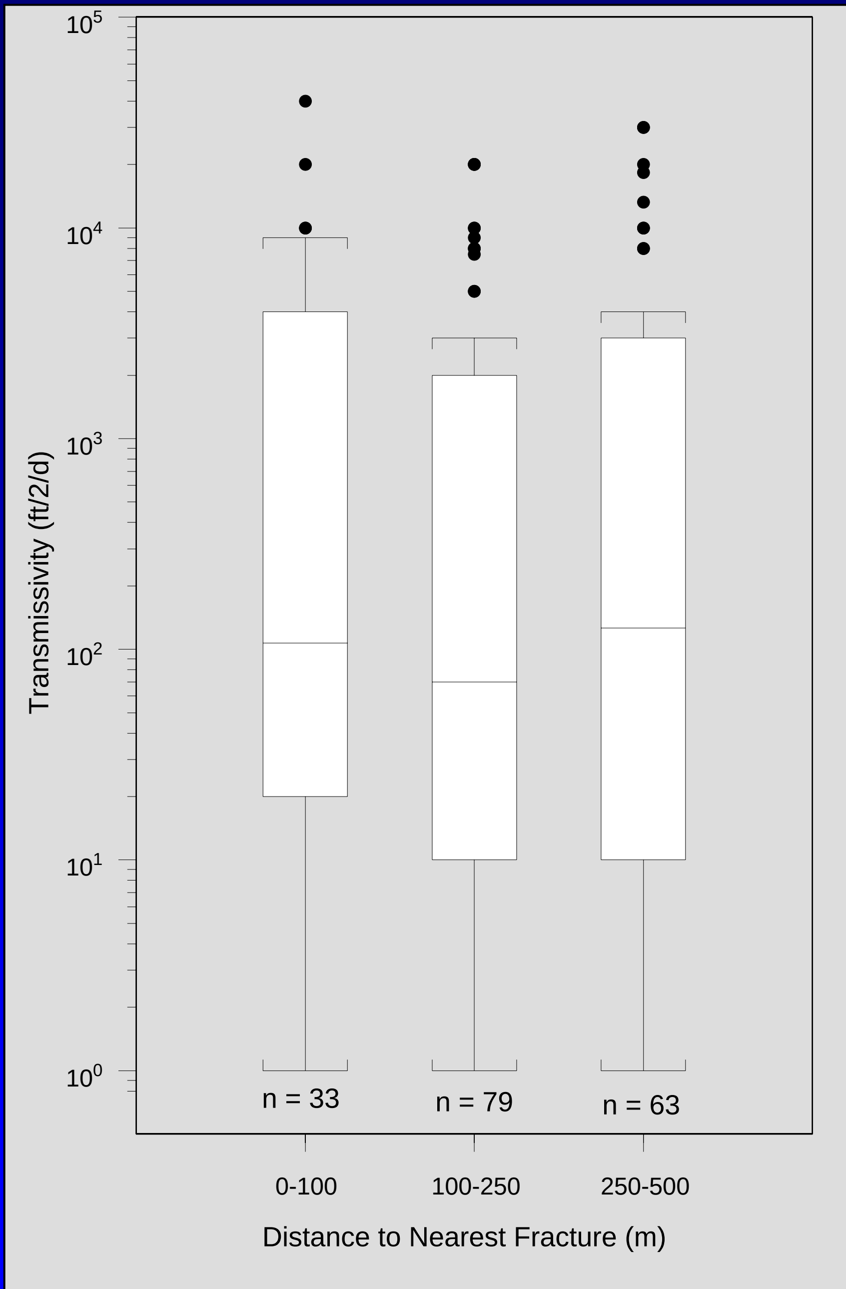
- alluvium
- dolostone
- limestone
- sandstone
- shale
- ss/ls

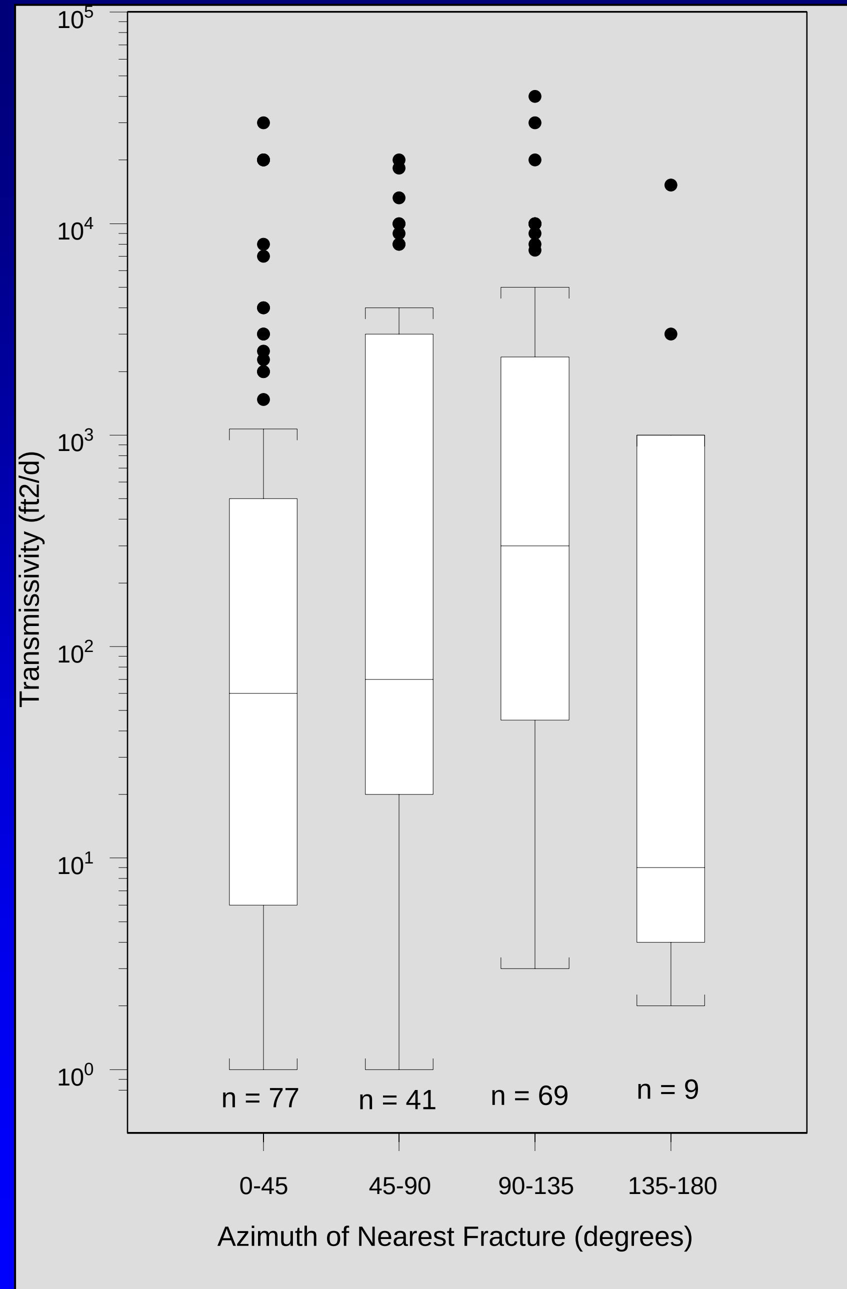
Lineament

Fracture/Fault

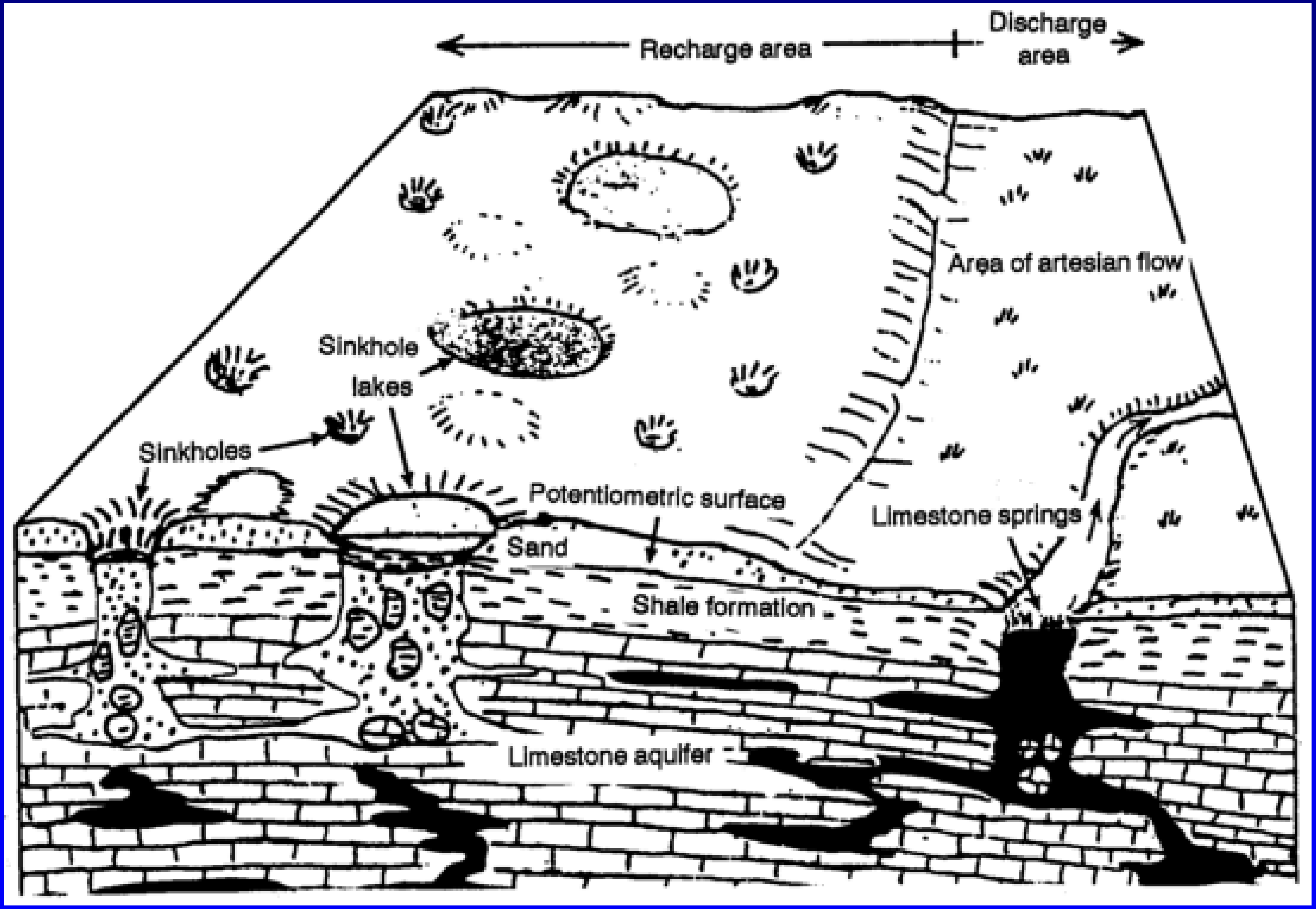
Beekmantown Group

Preliminary Data


Transmissivity (ft/2/d)
10^5
10^4
10^3
10^2
10^1
10^0
n = 33
n = 79
n = 63
0-100
100-250
250-500
Distance to Nearest Fracture (m)

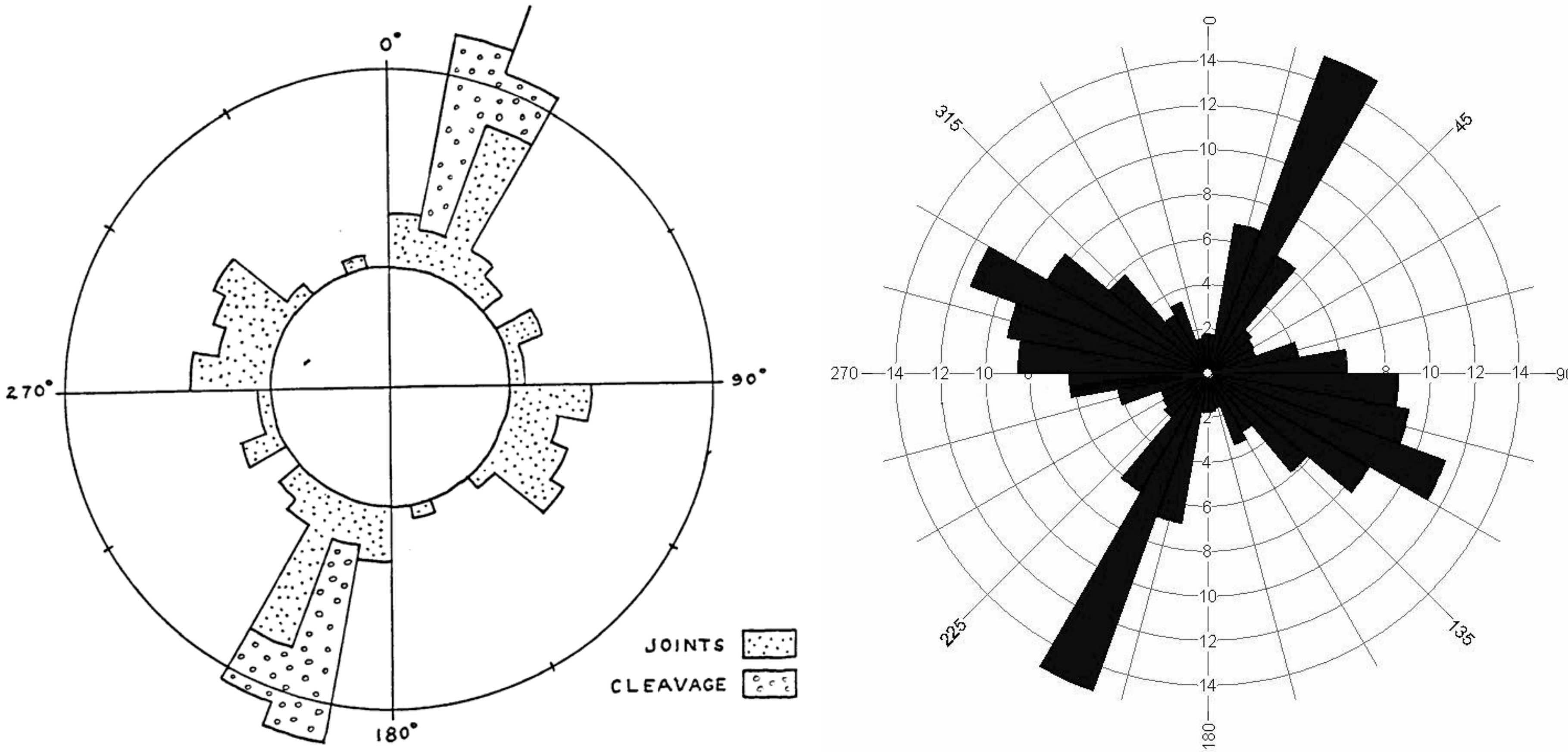

Transmissivity (ft2/d)
10^5
10^4
10^3
10^2
10^1
10^0
n = 77
n = 41
n = 69
n = 9
0-45
45-90
90-135
135-180
Azimuth of Nearest Fracture (degrees)

Objective



Source: www.globalsecurity.com

Hypothesis: Starting place



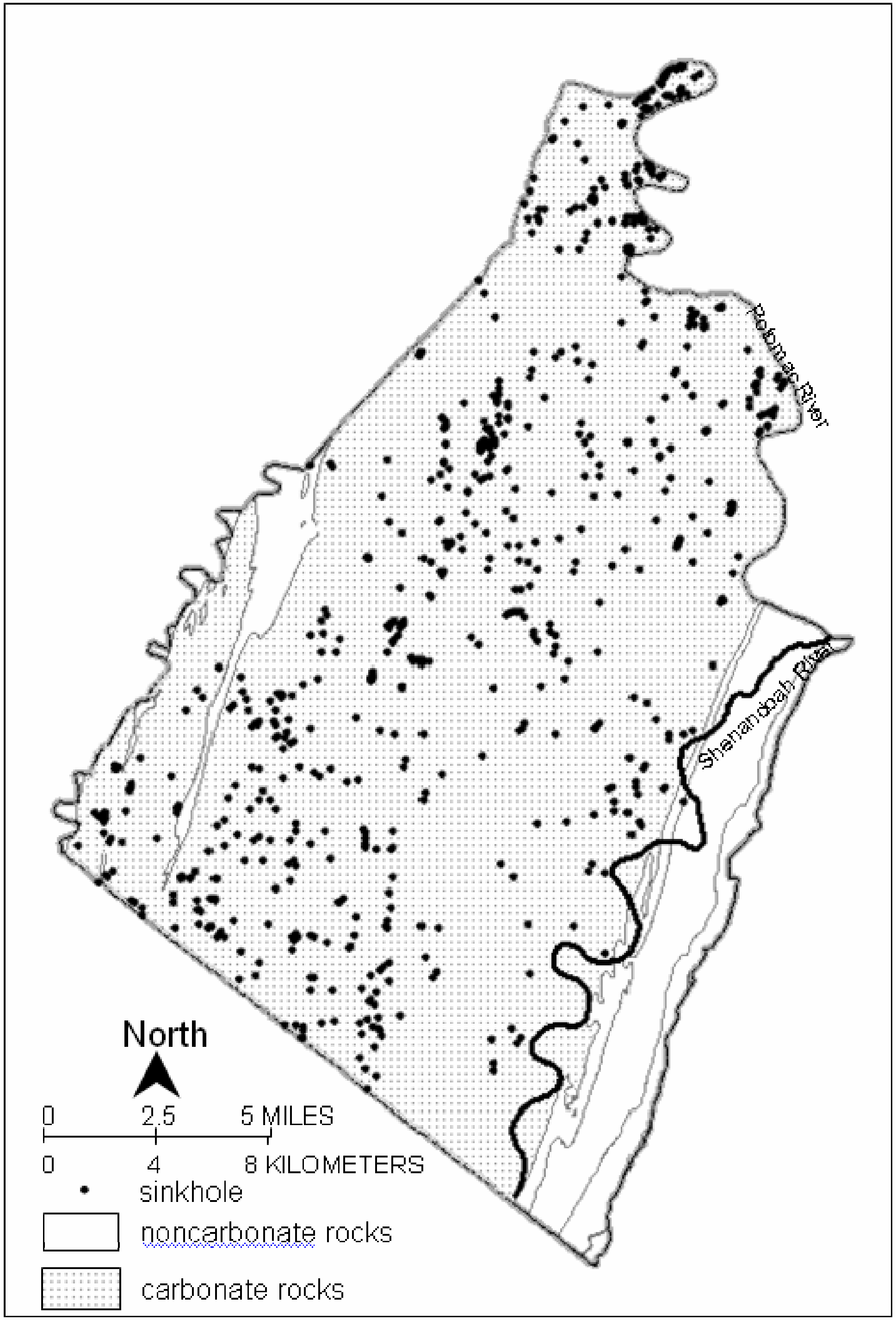
Rose diagrams of a) cleavage and joints (Jones and Deike, 1981) and b) fracture traces (McCoy and others, 2005a; 2005b). Attention is called to the multi-peaked distribution of all the fracture data.

Orientation of Fractures

	Direction	Dip
Cleavage	**10-25°**	**70-85°E**
Joints	**5-20°**	**60°E**
Joints	25-35°	45-50°W
Joints (rare)	70°	80°N
Joints	**90-110°**	**90°**
Joints	**120-130°**	**60-70°S**

Dominant cleavage and joint orientation trends in the Great Valley, WV (Jones and Deike, 1981).


Direction of bedding



Sinkhole mapping (Kozar and others, 1991)

Role of Structure

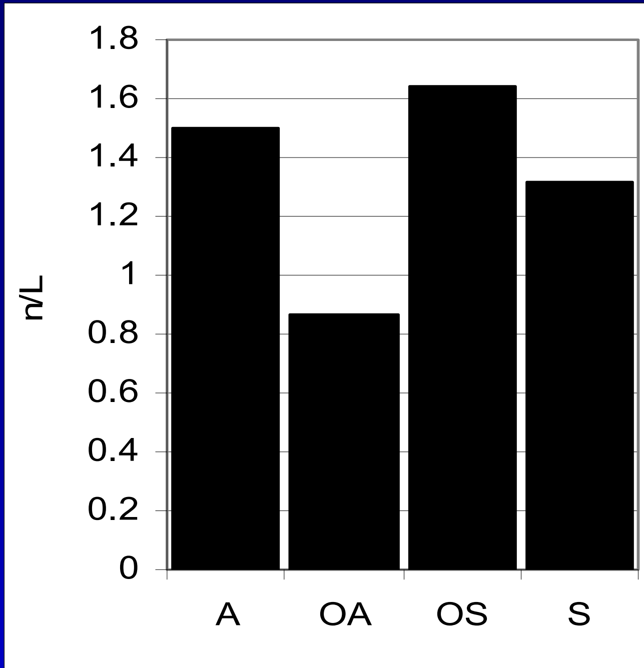
Sinkhole distribution vs. High specific capacity wells

Downward movement of water is implied by the vertical direction of development for most sinkholes in the area (Jones, 1973)

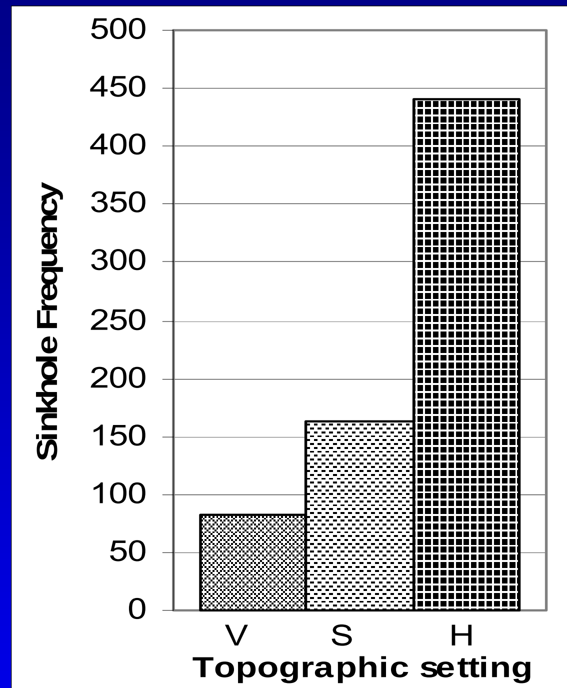
Folding?
Faulting?
Topography?

USGS

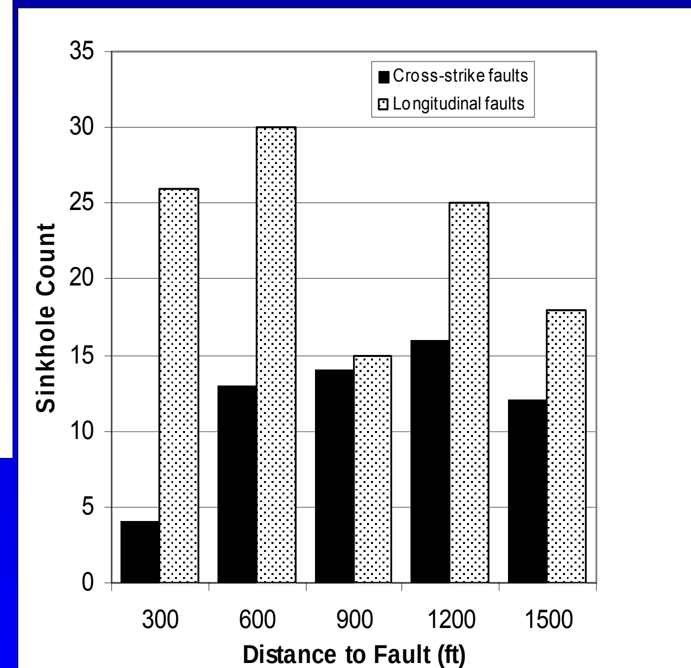
Sinkholes



Folding

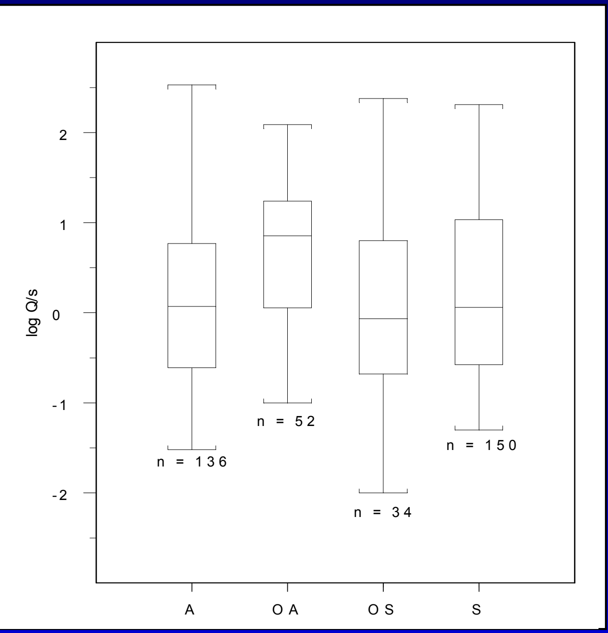


Topography

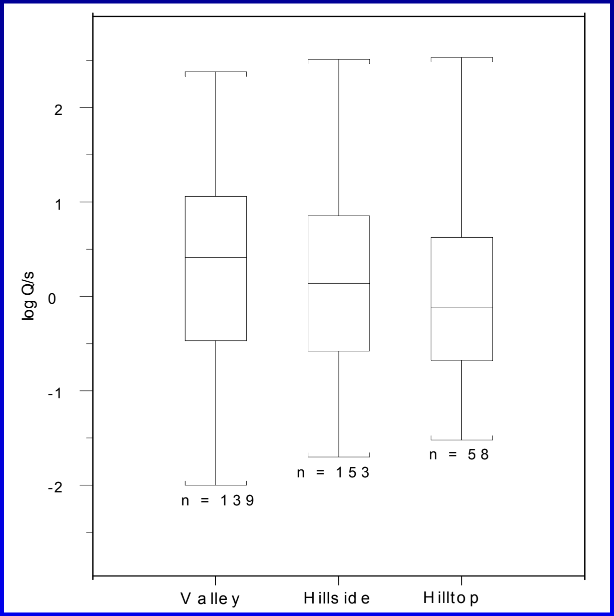


Faults

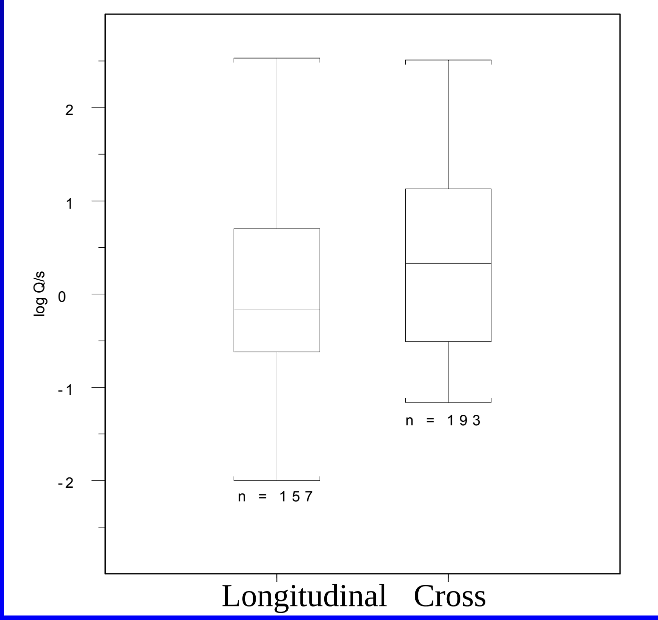
Folding



Topography

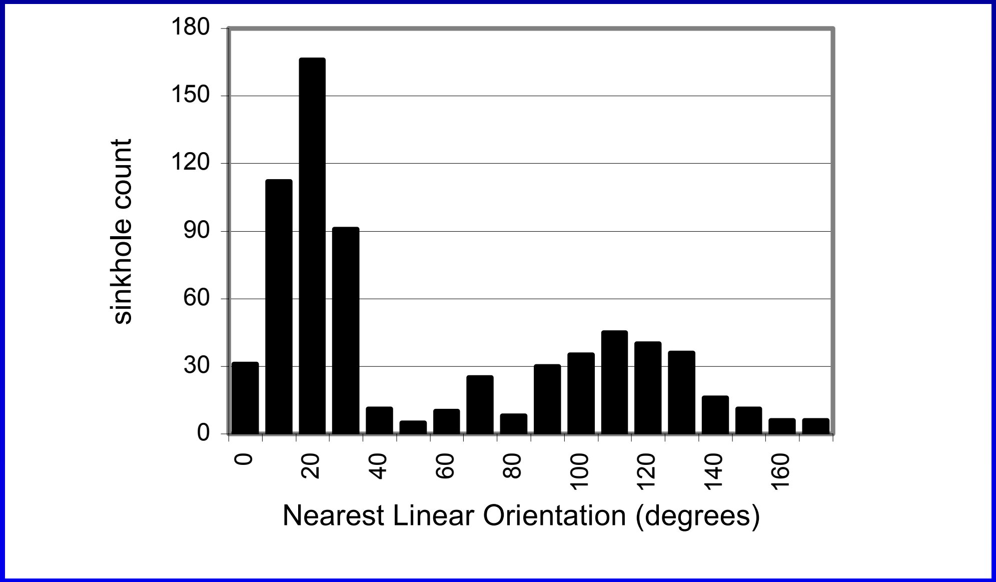


Faults

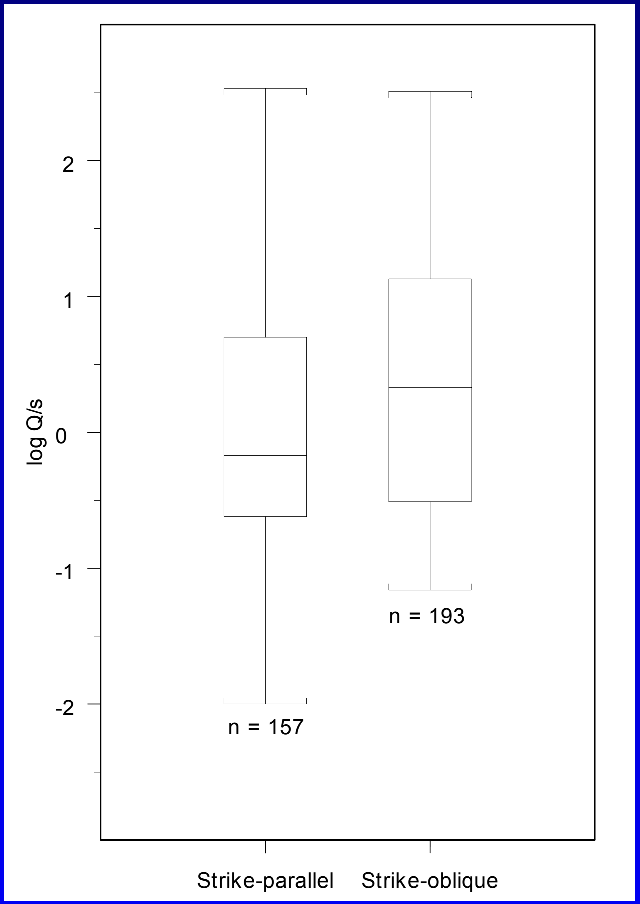


Specific Capacity

Linear orientation

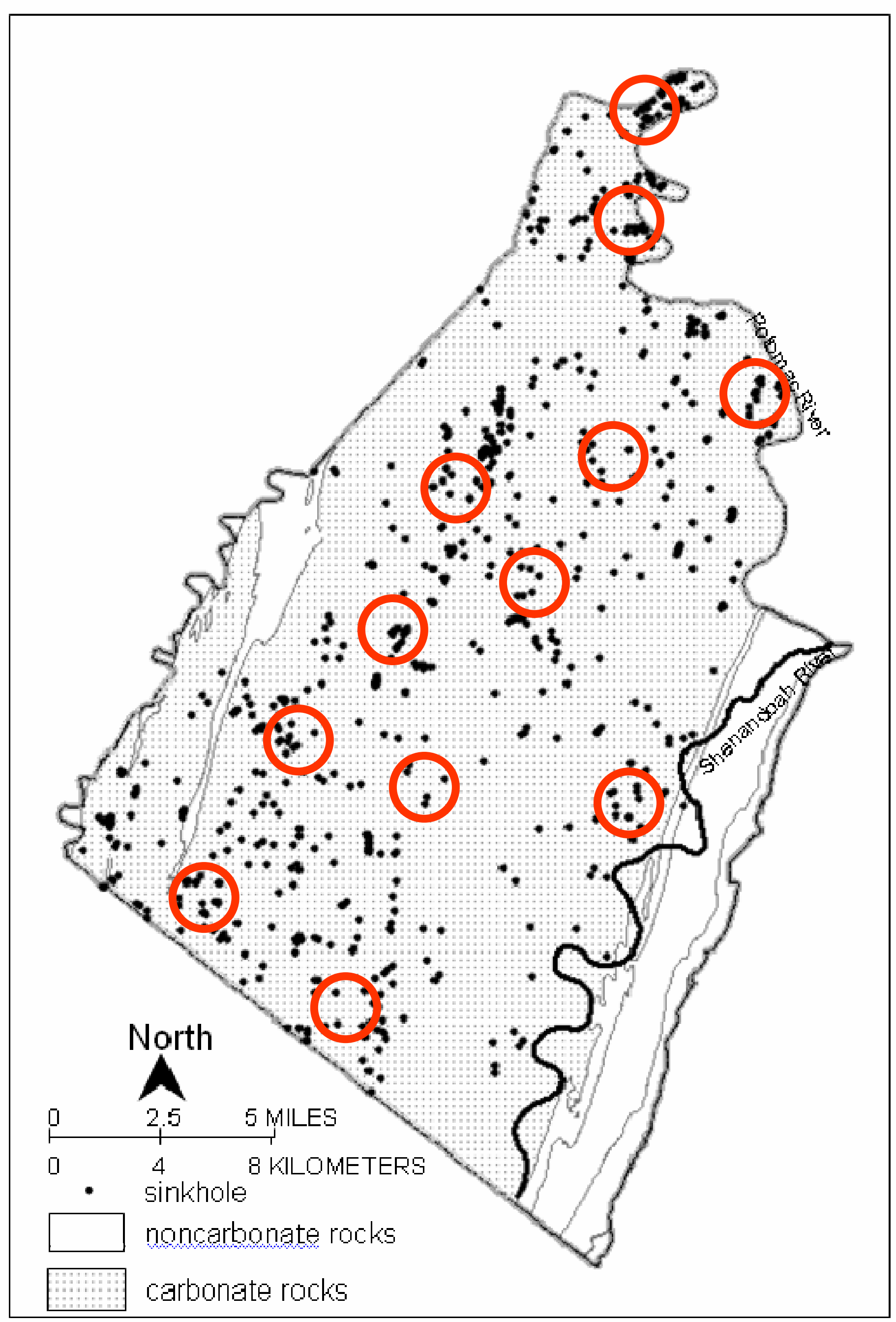


Sinkhole

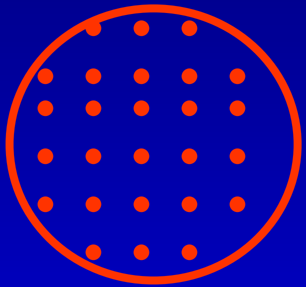


Specific capacity

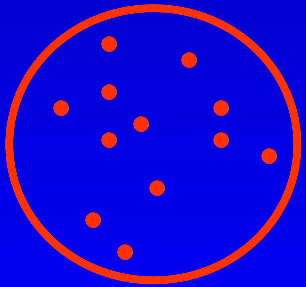
A more rigorous approach



Grid-aligned



Random



Sinkhole mapping (Kozar and others, 1991)

USGS

A more rigorous approach

Orientation, in degrees	Observed frequency, in percent														
			Potomac River Drainage				Opequon Creek Drainage				Shenandoah River Drainage				
	Random sinkholes	Grid-aligned sinkholes	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Theoretical distribution
0-180	12	25	18	18	6	13	9	20	16	9	33	33	60	16	16.7
30-210	20	12	21	5	13	13	9	27	16	27	33	33	0	16	16.7
60-240	10	12	21	18	44	21	30	13	21	9	0	17	0	21	16.7
90-270	22	25	18	23	31	29	30	13	21	9	0	8	0	16	16.7
120-300	19	12	12	14	6	13	9	7	11	27	0	0	10	21	16.7
150-330	17	12	12	23	0	13	13	20	16	18	33	8	30	11	16.7
χ^2	6.67	13.5	5	14	88	13	33	15	4	24	98	58	176	4	----------
Interpretation	----------	----------	random	both	oblique	oblique	oblique	parallel	random	parallel	parallel	parallel	parallel	random	----------

Implications

1) Since the area is dominated by aerial recharge, sinkholes are not considered areas of focused recharge.

2) Rather their distribution may allude to tendencies of the fracture network to permit lateral or downward vertical flow.

3) High sinkholes occurrence along hilltops, longitudinal faults, strike parallel linears.

4) Strike oriented fractures (namely bedding and cleavage planes, longitudinal faults, and bedding oriented joints) are suggested to be vertical pathways of downward flow, although the primary source of recharge to the aquifer is widely accepted as more uniform diffuse-type flow.

USGS

Implications cont'd

1. High Q/s values are found in valleys, near cross-strike linears, cross-strike faults, and overturned anticlines

2. Frequent spring occurrence along cross-strike faults may force water upward to surficial discharge zones

3. Similarities between spring occurrences and high Q/s distributions suggest that vertical pathways of upward flow along cross-strike features

USGS

A comparison of data

Location	WL	Logs	GIS
Hilltop	Down	Both	Down
Hillside	Down	Up	
Valley	Down	Up	Up
Longitudinal fault	Down	Up	Down
Cross-strike fault			Up
Anticline	Down	Down	Down
Syncline	Up		Down
Overturned anticline			Up
Overturned syncline			Down

Is it a question of scale?

USGS

Conclusions

1. Reconsider conceptual model of aquifer, not dealing with textbook hydrogeology

2. Fracture trace analysis, while effective, is not enough to fully characterize controls on flow.

3. Vertical and lateral groundwater flow gradients are suggested as the primary factor controlling sinkhole and well productivity distribution in the Great Valley, West Virginia.

4. Enhanced permeability pathways underlying both distributions are described by structural features differing prominently only on orientation with regards to strike.

Bottom Line

Vertical flow gradients

Structural orientation

Fracture Trace Map and Single-Well Aquifer Test Results in a Carbonate Aquifer in Berkeley County, West Virginia

http://pubs.usgs.gov/of/2005/1040/

Fracture Trace Map and Single-Well Aquifer Test Results in a Carbonate Aquifer in Jefferson County, West Virginia

http://pubs.usgs.gov/of/2005/1407/