A New Geologic Map of Germany Valley, Pendleton County, West Virginia with Cross Sections and Revised Structural and Stratigraphic Interpretations

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Abstract

A new geologic map of Germany Valley, a deeply eroded anticlinal valley developed along a culmination of the northeast-trending Wills Mountain Anticlinorium, is presented. The valley is underlain by a sequence of speleologically significant Ordovician carbonate rocks in which several major caves are present including Hellhole, the 7thlongest cave in the U.S. with > 40 miles (64 km) of known passage. The Wills Mountain Anticlinorium is the westernmost fold of the Valley and Ridge province in this area, and it can be traced for nearly 200 miles (320 km), from western Virginia northward into Pennsylvania. Prior maps (the most recent being by William J. Perry in 1971) showed Germany Valley as an asymmetrical, northeast plunging anticline, with a moderately dipping southeast limb, a nearly vertical to overturned northwest limb, with faulting restricted to siliciclastics (Juniata and Tuscarora Formations) along the northwest limb. Our mapping has revealed that the structure of this valley is more complex than was shown on any prior maps, and the older Ordovician carbonates are also faulted. Deformation at all observable scales in these carbonates including fault gouge strain indicators and outcrop-scale folding of bedding collectively suggests east over west, brittle zone deformation. A flexural slip faulting model synchronous with formation of the Wills Mountain Anticlinorium is suggested for numerous bedding parallel faults. A map scale fault inferred by juxtaposed stratigraphic units is hypothesized to be the result of a local buttressing fault block or fault horse at depth that likely occurred prior to the bedding parallel faulting.

Structure

Ordovician carbonates and overlying clastic sedimentary rocks of Germany Valley were folded under brittle conditions across the northwest verging, overturned Wills Mountain Anticline. Aside from the Wills Mountain Anticline, the carbonates suffered only minor additional flexing. Tighter folds are locally recognized in units above the carbonates especially in the shale of the Reedsville Formation. Faults recognized by slickenlines and coarse, pressure solution calcite, are observed locally in the carbonates and are usually bed parallel. This suggests that most faulting is a result of flexural slip synchronous with development of the Wills Mountain Anticline. Apparent stratigraphic juxtaposition is the basis for recognition of a fault hypothesized to be a high angle reverse fault dipping steeply to the southwest. Its regional extent however, is thought to be very limited. This apparent fault is thought to be later than the Wills Mountain Anticline and its related flexural slip faulting. Faulting in the overlying clastics has not yet been recognized. The fissile nature of the shale in the Reedsville Formation along with locally observed tight folds suggests significant shearing across its entire thickness. Thus, it is probable that the Reedsville absorbed the majority of the regional deformation and may even have acted as a decollement between the underlying carbonates and the overlying sandstones. Further field work is needed on each these specific areas.

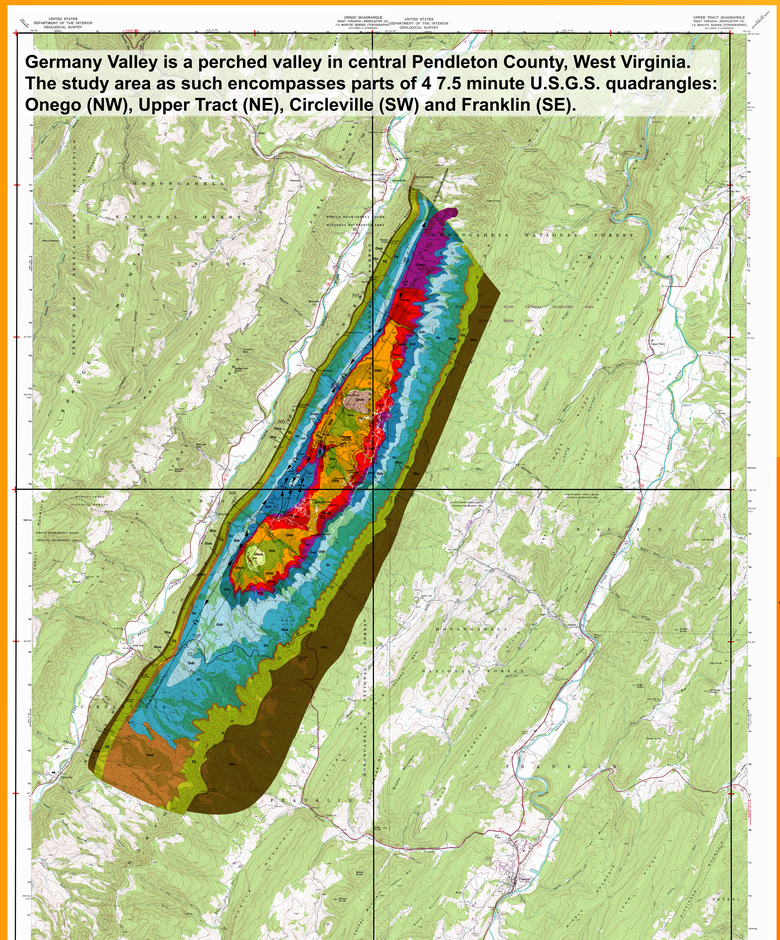
Stratigraphy

Stratigraphically, a dark gray limestone underlying the New Market Limestone in some stream valleys and which was not recognized on any prior maps is tentatively identified as the upper Row Park Limestone, pending additional study, as it could be Beekmantown. Above the New Market the Big Valley Formation includes the Lincolnshire, Ward Cove, Peery, and Benbolt Limestones of prior workers, but we have determined that in this area the Big Valley is best used only for the lower three units undivided, as the Benbolt can be recognized and mapped separately in many areas. Carbonate units above the Benbolt are the McGlone, McGraw, and Nealmont Limestones, and the Dolly Ridge and Reedsville Formations.

We continue to work in the field and the laboratory to refine and improve our understanding of the stratigraphic succession of the Ordovician carbonate sequence above the New Market and beneath the Dolly Ridge, in anticipation of a field trip to this area in the spring of 2015 that will accompany the 12th International Symposium on the Ordovician System that will be held on the campus of James Madison University in Harrisonburg.

Our ongoing field work in Germany Valley includes efforts to acquire stratigraphic data from subterranean exposures in the passages of the Hellhole-Shoveleater and Memorial Day systems, continued scrutiny of the many exposures in Germany Valley that occur in pastures, stream beds and ravines, and quarries such as the old Riverton quarry in Arc Hollow, as well as a study we are undertaking in collaboration with geologists from Chevron and Weatherford to use a hand-held x-ray fluorometer in the exposures along the length of Arc Hollow. The petrographic work in the laboratory continues to focus on detailed and methodical thin section analyses, as well as some preliminary conodont analyses from selected samples of several of the Ordovician carbonate units.

Germany Valley is a perched valley in central Pendleton County, West Virginia. The study area as such encompasses parts of 4 7.5 minute U.S.G.S. quadrangles: Onego (NW), Upper Tract (NE), Circleville (SW) and Franklin (SE).





Key to Symbols

- Outcrop location with station number
- Trace of bedding contact, dashed where inferred
- Horizontal bedding
- Strike & dip of bedding
- Strike & dip of overturned bedding
- Strike & dip of overturned bedding, ball indicates topping direction observed in outcrop
- Strike & dip of 1st generation cleavage (N1) or fault surface if slickenlines are present
- Strike & dip of 2nd generation cleavage (N2)
- Trend & plunge of N1 lineation
- Trend & plunge of slickenlines
- Sense of rotation
- Trace of anticline fold axial surface
- Trace of syncline fold axial surface
- Trace of overturned anticline fold axial surface
- Trace of N1 fault, dashed where inferred
- Strike and dip of fracture set
- Cave survey line plot, presented in white

Stratigraphic Units

YOUNGEST

Stu	Tuscarora Fm.
Oj	Juniata Fm.
Oos	Oswego Fm.
Or	Reedsville Fm.
Odr	Dolly Ridge Fm.
Onl	Nealmont Fm.
Omgr	McGraw Fm.
Omgl	McGlone Fm.
Obb	Benbolt Fm.
Owc	Ward Cove Fm. (not recognized in this study area)
Oln	Lincolnshire Fm.
Onm	New Market Fm.
Orp	Row Park? (sub-New Market Fm.) litholgy

OLDEST

Pockets of an adjacent lithic type observed in the dominant outcrop lithic type

Chert

a "reefy" fossil assemblage

Cross section A-A' throught the Wills Mountain Anticline in Germany Valley, Pendleton County, West Virginia



Cross section B-B' throught the Wills Mountain Anticline in Germany Valley, Pendleton County, West Virginia



Cross section C-C' throught the Wills Mountain Anticline in Germany Valley, Pendleton County, West Virginia





Structure in the Dolly Ridge Fm.
This degree of folding is observed only locally at the outcrop scale.

Cross section X-X' throught the Wills Mountain Anticline in Germany Valley, Pendleton County, West Virginia

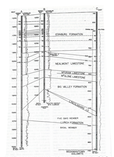




Geologic interpretations and map from Perry (1964,1971 & 1972)









References

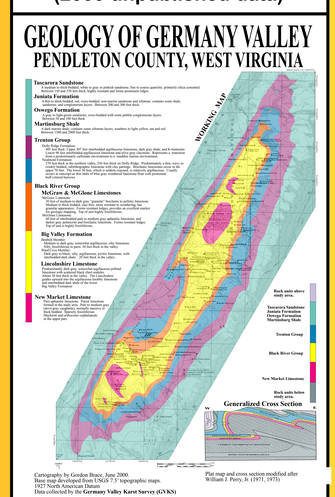
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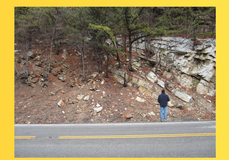
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Geologic map of Brace (2000 unpublished data)





Contact between the Tuscarora (right) and the Juniata (left) Formations.



The Juniata Formation



The Oswego Formation



The Reedsville Formation



Transitionon between the Reedsville and the Dolly Ridge Formations.



The Dolly Ridge Formation



The Nealmont Formation



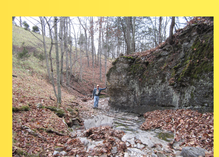
The Nealmont (left), McGraw (left-center) and McGlone (right) Formations.



The McGraw (left), McGlone (center) and Benbolt (right) Formations.



Top of the Benbolt Formation.



The Benbolt Formation in ARC Hollow.



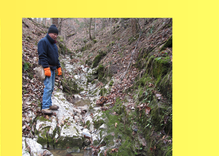
Chert in the Benbolt Formation.



Undivided Big Valley Group in ARC Hollow.



Stromatolites in the basal Lincolnshire Formation



Contact between the Lincolnshire (moss covered) and the New Market Formations.