The Greenbrier Karst

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Abstract

The segment of the Appalachian karst known as the Greenbrier karst is located in the lower valley of the Greenbrier River in southeastern West Virginia. The karst is developed in the Mississippian Greenbrier Limestone which thickens from 100 to 365 m northeast to southwest. The region can be subdivided into drainage basins which drain by subterranean routes to big springs. The Greenbrier karst contains more than 2000 caves of which 24 have surveyed lengths exceeding 5 km. The accumulated length of those 24 caves is 503.7 km.

1.1 Introduction

The Greenbrier Valley in southeastern West Virginia contains some of the longest caves in the USA. The Greenbrier karst is part of the extensive Appalachian karst and is located in Pocahontas, Greenbrier, and Monroe Counties, West Virginia (Fig. 1.1). For an overview showing the relationship of this karst area to other karst regions in the Appalachians and in the USA overall, see Palmer and Palmer (2009). A state-wide description of the karst of West Virginia is given by Dasher (2012). Details of the topography are provided by the US Geological Survey 7.5 min (1:24,000) for which an index is provided in Fig. 1.2.

1.2 Regional Setting

The Appalachian Mountains are usually divided into the Valley and Ridge Province with strongly folded and faulted strata and the Appalachian Plateaus Province where the strata are only slightly deformed. The two provinces are separated by a steep escarpment, called the Allegheny Escarpment (or Allegheny Front) in the north and the Cumberland Escarpment in the south. In eastern West Virginia, there is substantial deformation in the rocks on the eastern margin of the plateau so that the topographic front and the structural front do not coincide. East of the main plateau and west of the mountains that form the topographic front, the Greenbrier Valley has developed in the intermediate geological setting.

The Greenbrier River has its headwaters in the Allegheny Mountains near Spruce Knob, West Virginia, and flows south and southwest following the regional strike for 278 km to its confluence with the New River. The total basin area is 4290 km^2. For much of its length, the Greenbrier Valley is underlain by the Greenbrier Limestone which forms a karstic zone between the Allegheny Mountains to the east and the main Appalachian high plateau to the west (Fig. 1.3). The controlling structural features include the Browns Mountain Anticline and other folds which are formed west of the Allegheny Escarpment. To the west, the limestone dips beneath the younger rocks of the plateau. What is here described as the Greenbrier karst occupies the middle section of the Greenbrier River Valley. Omitted is the headwaters region where the limestone is thinner, and although it contains significant caves, the karst is less well developed. Also omitted is the downstream section where the river is flowing on clastic rocks.

In the northern part of the Greenbrier karst, the river flows along the eastern margin of the valley where it has incised a secondary valley into the clastic rocks that underlie the limestone. Because of the westerly dip, these clastics form a groundwater dam that prevents direct discharge from the karst into the river. Thus, tributary streams entering the river from the east flow entirely on clastic rocks, whereas the

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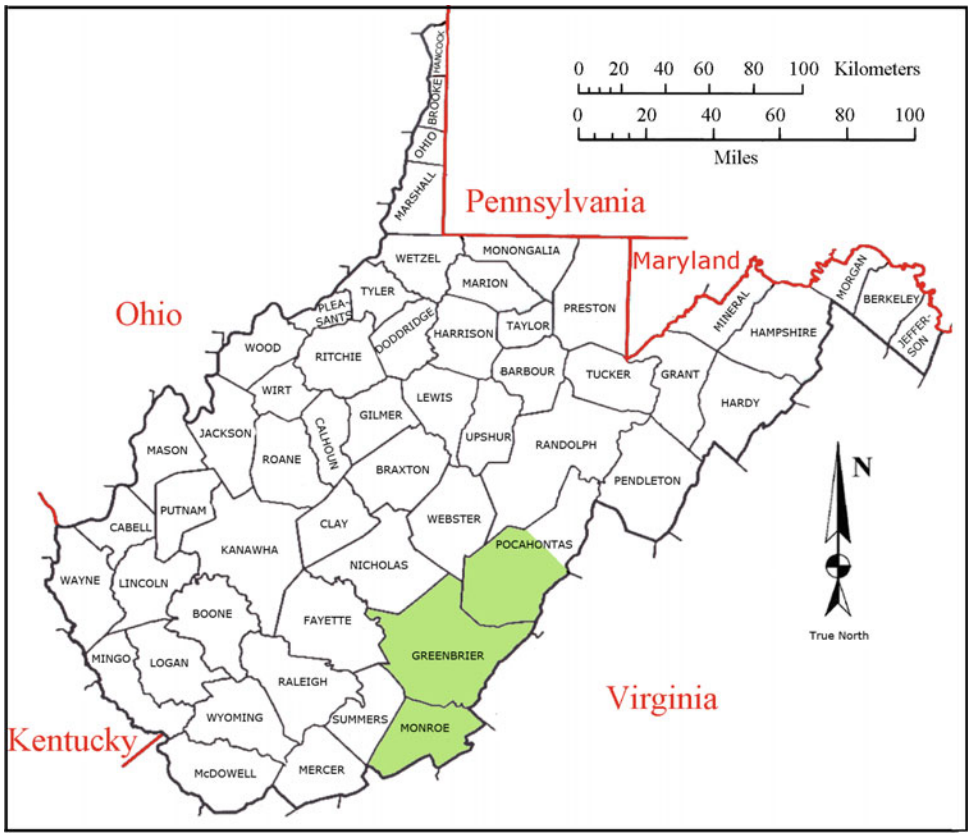

Fig. 1.1 Location map for the Greenbrier karst. Outline map from the US Department of Commerce, 1990

tributaries entering from the west have a pronounced fluviokarstic component.

The limestone thickness varies from about 100 m in the headwaters of the Greenbrier River to 365 m at the southern limit in Monroe County (McCue et al. 1939). The narrow band of Greenbrier Limestone widens to the southwest, and the topography changes from high-gradient fluviokarst basins such as the Swago Creek Valley in central Pocahontas County to the sinkhole plain called the Little Levels in southern Pocahontas County to wide sinkhole plains north and south of the Greenbrier River in Greenbrier and Monroe Counties (Fig. 1.4).

The interbedded shales within the Greenbrier Limestone are important controls on cave development. Near the top of the section, the Greenville Shale is rarely penetrated so that caves in the overlying Alderson Limestone tend to be perched on the shale. The Taggard Formation, a limey shale, is sometimes breached underground and sometimes not. Perched underground drainage is common.

1.3 Karst and Karst Hydrogeology

The Greenbrier karst can be subdivided into a sequence of small drainage basins nearly all of which ultimately drain through springs to creeks tributary to the Greenbrier River. The character of the individual basins changes north to south. The Swago Creek basin, the northernmost basin, is predominantly fluviokarst with primary recharge from mountain streams sinking at the limestone contact. The basins are of more mixed character in the intermediate region of southern Pocahontas and northern Greenbrier Counties. The Locust Spring basin receives surface stream recharge from Millstone Creek and from Hills and Bruffey Creeks and also an extensive recharge from the doline karst of the Little Levels. The Friars Hole System, separated from the Little Levels by Droop Mountain, is recharged primarily by mountain runoff with drainage to the south into Spring Creek. The Culverson Creek basin has a large surface catchment feeding into a very large cave system.

The thickening of the limestone beds and the development of additional anticlinal structures cause the karst region to widen in Greenbrier and Monroe Counties (Fig. 1.4). The result is a broad region of doline karst with mainly internal drainage and most recharge through closed depressions. The close depressions form on a range of size scales and appear to be guided by fractures and faults (Lessing 1979). The southern section of the karst is split into two segments by the Greenbrier River which east of Lewisburg changes from its generally southern course to a generally westward course. The northern segment was subdivided into smaller drainage basins by a series of tracing experiments with fluorescent

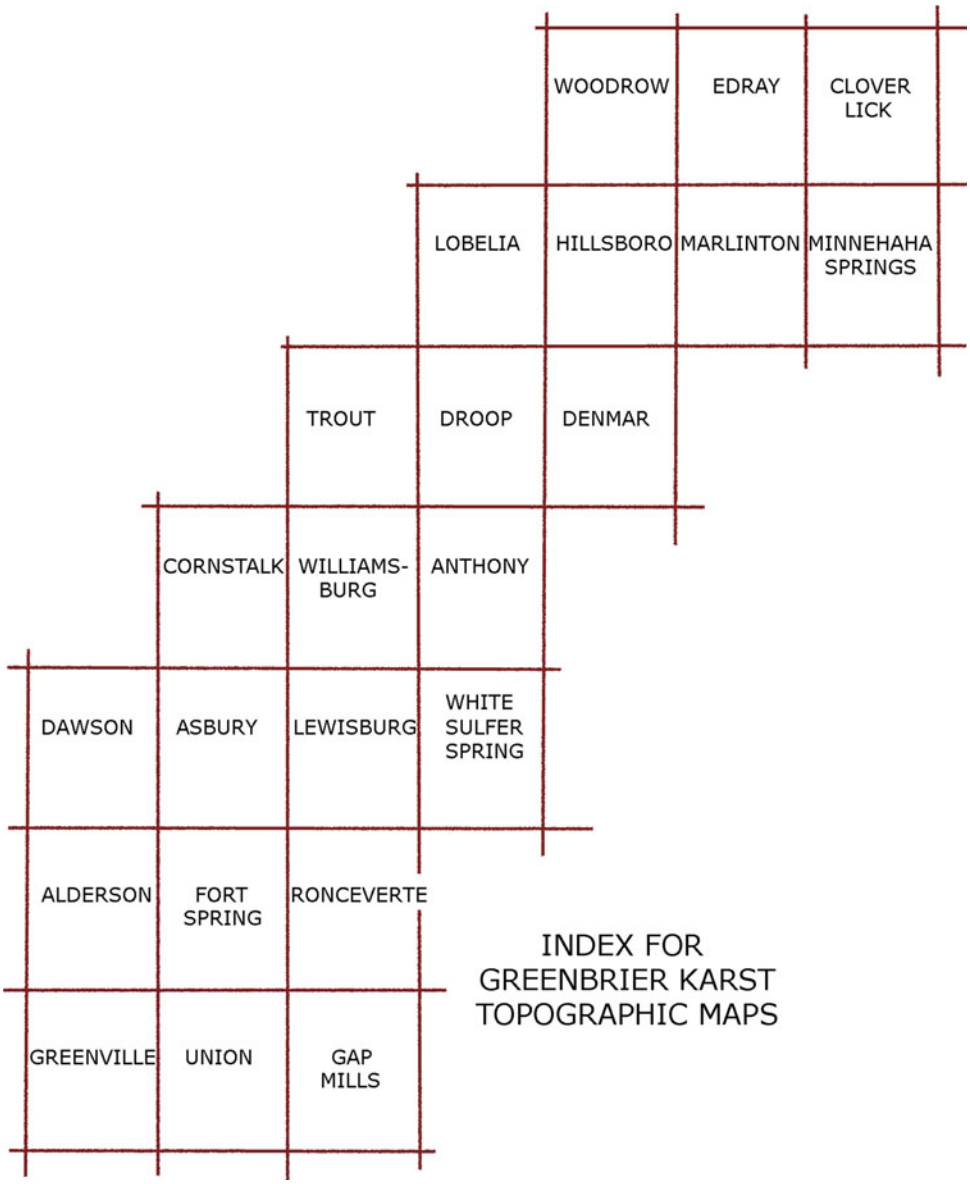

Fig. 1.2 Index map for US Geological Survey 7.5 min quadrangle maps spanning the Greenbrier karst

dyes (Jones 1973). These subbasins have associated large cave systems. The southern segment is also subdivided into distinct groundwater basins (Jones 1997). Further detail is provided by two PhD theses written on the hydrogeology of Greenbrier County (Heller 1980) and Monroe County (Ogden 1976).

1.4 Caves

Many exceptionally large caves occur in the thick and gently dipping limestone in the southern reaches of the Greenbrier Valley along with hundreds of smaller caves. Early cave descriptions for West Virginia were compiled by Davies (1949, 1958). Later, many cave explorers and their organizations contributed to the exploration and mapping of West Virginia caves. The two most prominent organizations were the West Virginia Association for Cave Studies (WVACS) and the West Virginia Speleological Survey (WVASS). The Bulletins of the West Virginia Speleological Survey are the primary documentation for West Virginia caves. The history of exploration in the Greenbrier karst is given in some detail in Chap. 5.

The three counties of the Greenbrier Valley karst are the most cavernous in the State. Dasher (2012) lists the number of caves in each county:

Pocahontas County	621 caves
Greenbrier County	1375 caves
Monroe County	435 caves

Fig. 1.3 Relief map of Pocahontas, Greenbrier, and Monroe Counties, West Virginia. Extracted from US Geological Survey 1:500,000 shaded relief man of West Virginia, 1968

The total is 2431 caves although some of the Pocahontas County caves are north of the area considered in this volume.

Table 1.1 lists the caves with surveyed lengths exceeding 5 km. The rank on the US long cave list is given for those with lengths greater than 20 km and the world rank for those with lengths greater than 30 km. Adding up the lengths produces a total of 503.7 km (312.9 miles) of mapped cave passage, making the Greenbrier Valley one of the most cavernous regions on the planet. A complete tally would require adding in the accumulated length of more than 2000 smaller caves, many of which are of substantial length. Most, but not all of the listed caves appear somewhere in the description chapters.

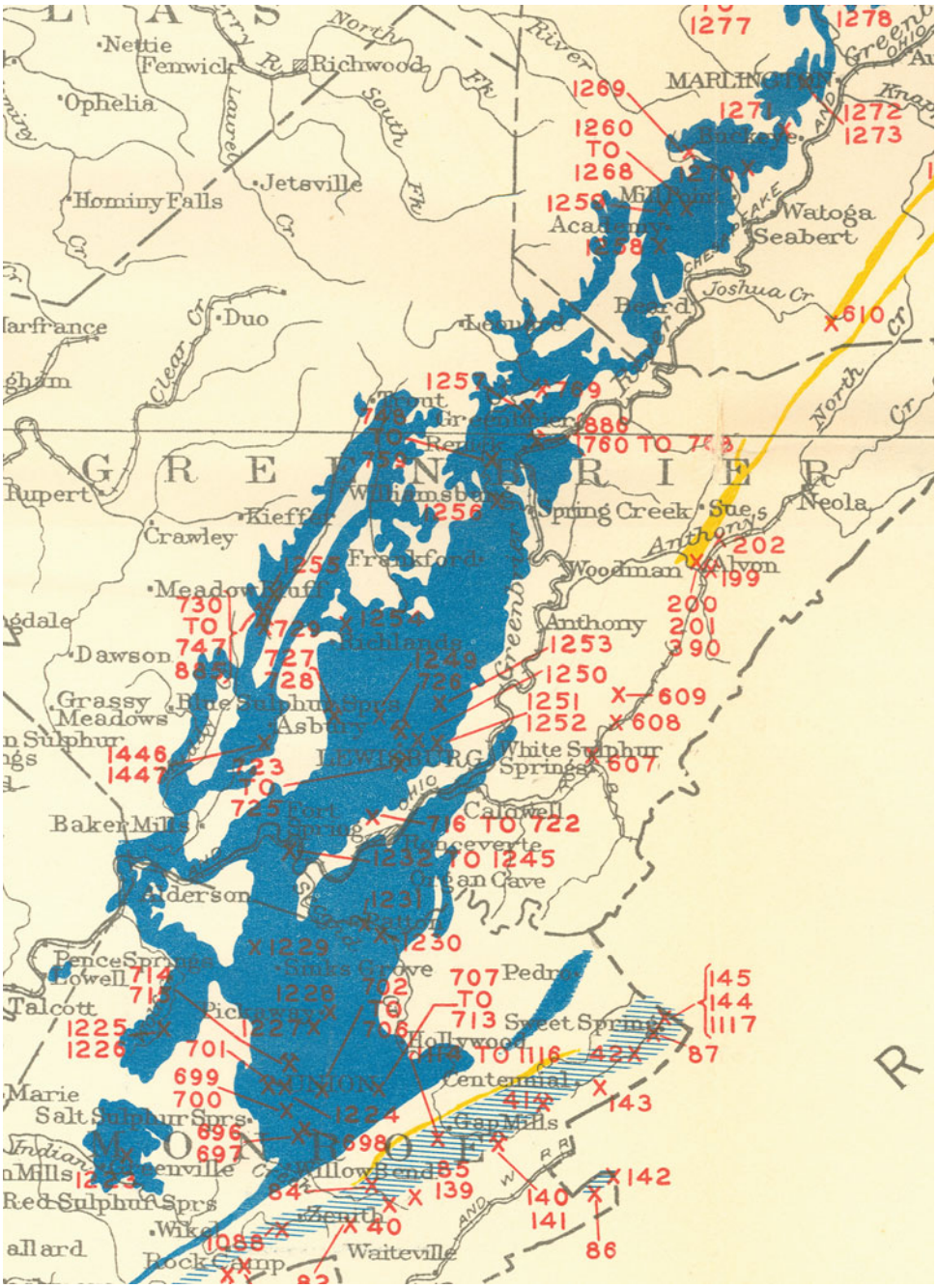

Fig. 1.4 Outcrop area of Greenbrier Limestone in Pocahontas, Greenbrier, and Monroe Counties, West Virginia. *Red numbers* refer to limestone quarries. Extracted from the limestone map of McCue et al. (1939)

1.5 Presentation of the Greenbrier Karst

For purposes of description, the Greenbrier karst was subdivided partly by drainage basins and the large cave systems. These subdivisions become the individual descriptive chapters.

The northernmost basin, Swago Creek (Chap. 6) is an isolated basin connected directly with the Greenbrier River and separated by Rogers Mountain from the next basin to the south. The Little Levels (Chap. 7) is a limestone upland with caves along the perimeter but which does not function as an integrated drainage basin. Separated from the Little Levels by Droop Mountain, but hydrologically interconnected, are the valleys of Hills and Bruffey Creeks. To the south extends the abandoned karst valley of Friars Hole beneath which is the longest cave in West Virginia (Chap. 8).

Moving south into the Big Levels, the wide doline karst on the Greenbrier Limestone, dye-tracing studies have defined drainage basins and their associated cave systems. Some basin boundaries are created by geologic barriers and other by the west-trending Greenbrier River which bisects

Table 1.1 Long caves of the Greenbrier Valley

Cave	Length (km)	US rank	World rank
Friars Hole System	73.4	6	31
Organ Cave	61.9	10	42
Scott Hollow Cave	47.5	17	68
The Hole	37.0	24	104
Culverson Creek System	33.7	30	134
McClung Cave System	29.1	36	
Windy Mouth Cave	29.0	37	
Benedict's Cave	23.9	52	
Bone-Norman System	22.7	55	
Maxwelton Sink Cave	18.8	64	
Portal-Boar Hole System	16.8	71	
Ludington's Cave	14.7	81	
Acme Quarry Cave System	13.6	87	
Overholt Blowing Cave	12.6	98	
Dry Cave	9.2		
Destitute Cave	8.0		
Union Cave	7.4		
Buckeye Creek Cave	7.2		
Carpenter's—Swago System	7.0		
Greenville Saltpetre Cave	6.7		
Wades Cave	6.4		
Laurel Creek Cave System	5.8		
Zicafoose Blowhole	5.8		
Plastic Bag Cave	5.5		

the region. The area is large and complex, and the subdivision into chapters is to some extent arbitrary.

North of the River, there is a major divide between caves that drain eastward to Spring Creek and those that drain southwest to Davis Spring. The Buckeye Creek-Rapps Cave System (Chap. 9) and the Culverson Creek System (Chap. 10) drain to Spring Creek and have large surface catchments making these caves very dynamic during flood flow conditions. Along the eastern edge of the area, the limit of the limestone is formed when the contact with the underlying clastics reaches the land surface. Along this extensive contact zone are formed a sequence of very large caves, the contact caves (Chap. 11). These collect drainage from the clastic terrain between the contact and the Greenbrier River and collectively drain to Davis Spring. To the west, the linear karst valley of Sinking Creek forms an independent basin (Chap. 12).

South of the Greenbrier River, the Organ Cave area (Chap. 13) is an isolated plateau bounded on the north by the river, on the east by the limestone contact, and in the south by the incised valley of Second Creek. Dickson Spring (Chap. 14) is one of the largest karst springs in the area. Its basin contains significant caves but not the exceptionally long ones. Scott Hollow Cave and associated Windy Mouth Cave are in a north-flowing drainage basin that drains directly into the Greenbrier River (Chaps. 15 and 16). Finally, at the extreme southern edge of the Greenbrier karst is an isolated island of limestone surrounded by clastic rock, the Laurel Creek system (Chap. 17). Laurel Creek is a south-flowing tributary of Indian Creek which flows westward into the New River below its confluence with the Greenbrier River and so is part of the Greenbrier Limestone karst but not a tributary of the Greenbrier River.

Not every detail of every cave is described in these chapters, but in broad brush terms, at least, there is a reasonable picture of the type of cave systems and associated karst drainage patterns that developed in this particular geologic and geomorphic setting.

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