U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

George Washington Carver National Monument

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for George Washington Carver National Monument

gwca_geology.pdf

Version: 2/7/2022

Geologic Resources Inventory Map Document for George Washington Carver National Monument

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Geologic Resources Inventory Map Document

George Washington Carver National Monument, Missouri

Document to Accompany Digital Geologic-GIS Data

gwca_geology.pdf

Version: 2/7/2022

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for George Washington Carver National Monument, Missouri (GWCA).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Map and Source Citation** – The GRI digital geologic-GIS map produced for this project along with the source used in its completion. In addition, a brief explanation of how the source map was used is provided.

3) **Map Unit List** – A listing of all geologic map units present on the map for this project..

4) **Map Unit Descriptions** – Descriptions for all geologic map units.

5) **Geologic Cross Sections** – Geologic cross section graphics with source geologic cross section abbreviations.

6) **Ancillary Source Map Information** – Additional source map information.

7) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

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About the NPS Geologic Resources Inventory Program

Background

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI. The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Many additional partners participate in the GRI process by contributing source maps or reviewing products.

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report. These products are designed and written for nongeoscientists.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: https://www.nps.gov/articles/gri-geodatabase-model.htm

Geologic Reports: GRI reports synthesize discussions from the original scoping meeting, follow up conference call(s), and subsequent research. Chapters of each report discuss the geologic setting of the park, distinctive geologic features and processes within the park, highlight geologic issues facing resource managers, and describe the geologic history leading to the present-day landscape. Each report also includes a poster illustrating these GRI digital geologic-GIS data.

For a complete listing of GRI products visit the GRI publications webpage: https://go.nps.gov/gripubs. GRI digital geologic-GIS data is also available online at the NPS Data Store: https://irma.nps.gov/DataStore/Search/Quick. To find GRI data for a specific park or parks select the appropriate park(s), enter “GRI” as a Search Text term, and then select the Search button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: https://www.nps.gov/subjects/geology/gri.htm. At the bottom of that webpage is a “Contact Us” link if you

need additional information. You may also directly contact the program coordinator:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division. Learn more about I&M and the 12 baseline inventories at the I&M webpage: https://www.nps.gov/im/inventories.htm.

GRI Digital Map and Source Map Citation

The GRI digital geologic-GIS map for George Washington Carver National Monument, Missouri (GWCA):

GRI Digital Geologic Map of George Washington Carver National Monument and Vicinity, Missouri (*GRI MapCode GWCA*)

The GRI map was produced from the following source maps and data,

> Scherlinck, Kyle J. 2015, Geologic Mapping of George Washington Carver National Monument and Surrounding Area, Missouri: Missouri Geological Survey, Open File Report OFM-2015-655-GS, scale 1:24,000. (*GRI Source Map ID 75961*).

Additional information pertaining to each source map is also presented in the GRI Source Map Information (GWCAMAP) table included with the GRI digital geologic-GIS data.

Index Map

The following index map displays the boundary for George Washington Carver National Monument (as of February, 2022) in green. The extent of the GRI digital geologic-GIS data for the park is displayed in black. The 7.5' quadrangles the map is in are also shown.



Index map by Stephanie O'Meara (Colorado State University)

Map Unit List

The bedrock geologic units present in the digital geologic-GIS data produced for George Washington Carver National Monument, Missouri (GWCA) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Mw - Warsaw Formation). Units are listed from youngest to oldest. Information about each geologic unit is also presented in the GRI Geologic Unit Information (GWCAUNIT) table included with the GRI digital geologic-GIS data.

Paleozoic Era

Mississippian Period

Mw - Warsaw Formation
Mbs - Burlington Limestone, Short Creek Oolite member
Mbk - Burlington Limestone and Keokuk Limestone, undifferentiated

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

Mw - Warsaw Formation (Mississippian (Osagean))

The Warsaw in this area is thick-bedded light to dark grey wackestone, weathering to light grey, this formation contains calcite both microcrystalline spar and in rhombohedron crystal form. There were small cubes of weathered pyrite on the samples collected. No pyrite was found in any samples of the Keokuk in the GW Carver project area. These samples are sparsely fossiliferous and contain a very small number crinoids and sparse brachiopods. According to Thompson the Warsaw is described as, “a slightly cherty limestone in which the bryozoan *Archimedes* and the brachiopod *Spirifer pellaensis* are common. In the Tri-State area and in Newton and Jasper counties the formation is over 150 ft thick (Thompson, 1995, p. 83).” Description from source map: (George Washington Carver National Monument and Surrounding Area).

Mbs - Burlington Limestone, Short Creek Oolite member (Mississippian (Meremecian))

The Short Creek Oolite Member of the Keokuk Limestone is the accepted boundary between the Burlington-Keokuk and the Warsaw formation (Thompson, 1995, p. 81). This is the transitional facies between the Osagean stage and the Meremecian stage of the Mississippian age. In the field sample collected the Ooids are about 1 millimeter or less in diameter and they are nucleating around sparry calcite most likely from broken crinoid stems, which is very similar to a confirmed sample of the Short Creek Oolite Member from Springfield, Missouri. After comparing the two samples the only difference is the percentage of ooids in the limestone, the Springfield sample is an Oolitic grainstone with approximately 80% Ooids by volume, and the field sample is an Oolitic packstone with approximately 55% Ooids by volume. The description according to Thompson is, “a thin, persistent bed of Oolitic limestone, 2 to 8 ft thick…the ooliths are usually less than one millimeter in diameter, round in cross section, and often have as a nucleus a doubly terminated quartz crystal (Thompson, 1995, p. 81).” The Short Creek Oolite Member was found at 36°52’37”N, 94°24’25” W, which is located at 950ft in elevation. This establishes a new contact at 950 ft in this area. Description from source map: (George Washington Carver National Monument and Surrounding Area).

Mbk - Burlington Limestone and Keokuk Limestone, undifferentiated (Mississippian (Meremecian))

The Burlington-Keokuk in this area is a thick to thin bedded densely fossiliferous crinoidal packstone, light grey to white in color. It weathers to a dark grey to black exterior, and contains a small amount of chert varying in color from light grey and white to a buff or reddish-brown exterior when weathered. Most of the chert is found as nodules with minor occurrences along bedding planes. According to The Stratigraphic Succession of Missouri, the Burlington Limestone is described as, “a white to gray, medium-to coarsely crystalline, medium-to coarsely crinoidal, medium-to thick-bedded, often cross-stratified, chert-free to sparsely cherty limestone. Chert occurs in zones 1-10 ft thick, separated by chert-free zones 30-50 ft thick (Thompson, 1986, p. 91-92).” Thompson goes on to describe why the Burlington-Keokuk in this area is undifferentiated, when he says, “The contact with the overlying, lithologically similar Keokuk Limestone is transitional and often difficult or impossible to identify (Thompson, 1986, p. 92).” Description from source map: (George Washington Carver National Monument and Surrounding Area).

Ancillary Source Map Information

The following sections present ancillary source map information associated with the source used for this project.

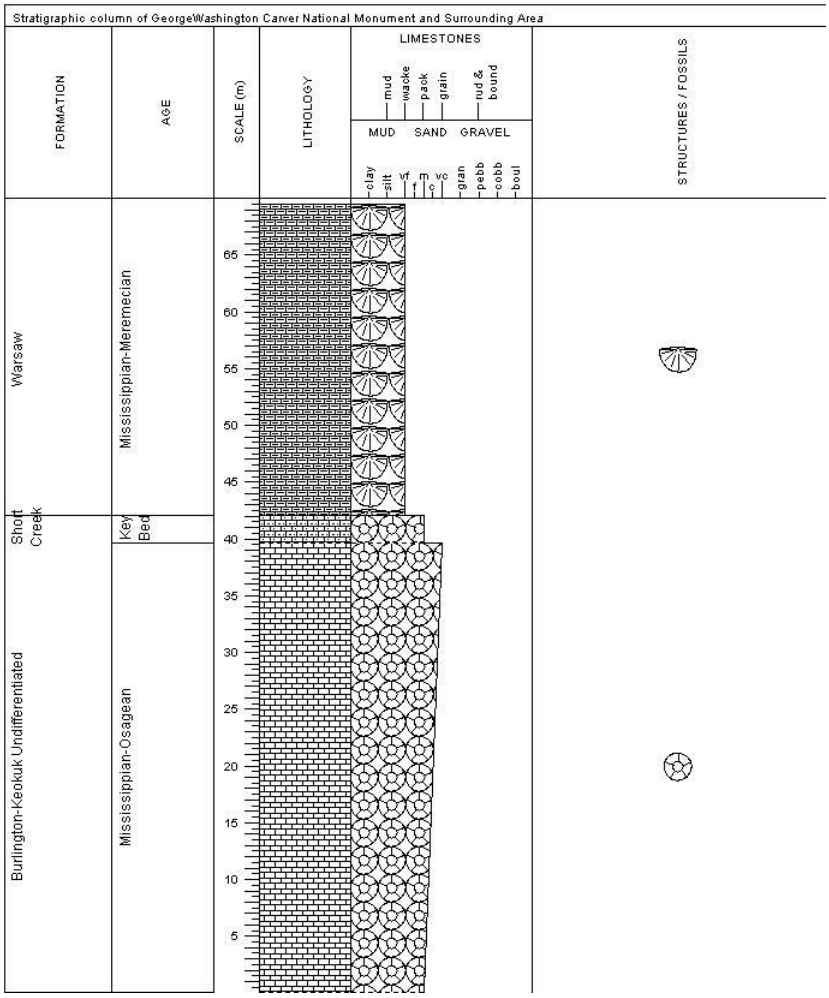
George Washington Carver National Monument and Surrounding Area

The formal citation for this source.

> Scherlinck, Kyle J. 2015, Geologic Mapping of George Washington Carver National Monument and Surrounding Area, Missouri: Missouri Geological Survey, Open File Report OFM-2015-655-GS, scale 1:24,000. (*GRI Source Map ID 75961*).

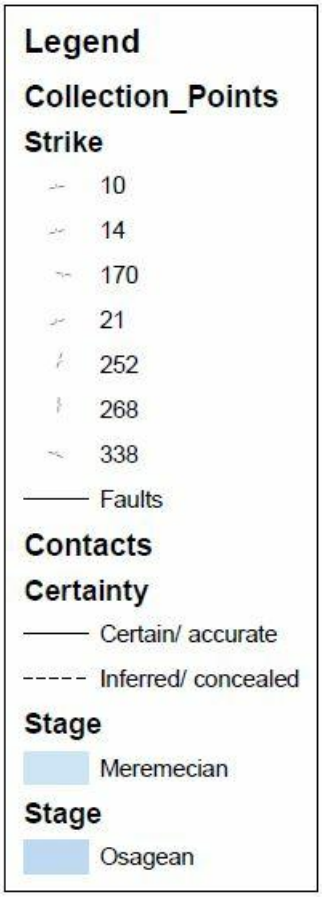
Prominent graphics and text associated with this source.

Startigraphic Column



Graphic from source map: (George Washington Carver National Monument and Surrounding Area).

Legend



Graphic from source map: (George Washington Carver National Monument and Surrounding Area).

Report

Abstract

The purpose of this project was to create 1:24000 geologic maps for the George Washington Carver National Monument and surrounding area. This project was a Geocorps America project working together with the National Park Service. The area mapped consisted of three 2.5 minute quads – one containing GW Carver National Monument and one on each side of the monument (one 2.5 minute quad east and one to the west). The current map of the area is a 1:500,000-scale state geologic map produced by the Missouri Geologic Survey in 2003 (Middendorf M. A., 2003). On this map, the units in this area are Burlington-Keokuk undifferentiated (Osagean stage of the Mississippian), and the Warsaw formation (Meremecian stage of the Mississippian).

For the current mapping effort, samples were taken within and just outside the target area and aerial photographs were also analyzed to identify and locate new outcrops or contacts. Using these methods, this project was able to identify two new data points (compared to Middendorf M. A., 2003) where formation contacts were identified.

At (36°57’37”N, 94°24’16”) the in the southwestern portion of the mapping area, the Short Creek Oolite Member of the Keokuk formation was found and identified. The Short Creek Oolite Member is an

acknowledged marker for the boundary between the Keokuk and the Warsaw Formation (Thompson, 1995, p. 81). This data point puts the Keokuk-Warsaw boundary at 950 ft elevation in the southwestern portion of the map area.

In the northern portion of the mapping area, Middendorf (2003) shows an inferred contact between the Keokuk and Warsaw near Diamond, Missouri; which is a continuation of the inferred contact from the Fidelity Quadrangle to the north. This contact is shown at an elevation of 1120 ft. When examining air-photos of the area from 1960, this contact can be seen crossing a road at (36°58'32"N, 94°19'). This contact is located to the south of the current inferred contact, but it occurs at the same elevation of 1120 ft. The contact becomes overlain by regolith before it meets the inferred contact to the north. Outcrops just outside the mapping area to the south (at: 36°56'17"N, 94°19'0"W) show the Warsaw formation at an elevation of 1160 feet, while other outcrops in the area show the highest outcrop of Keokuk sampled to be at 1050 feet. Therefore, a transition from Keokuk to Warsaw occurs somewhere between 1050 and 1160 feet in this northeastern portion of the map.

Text from source map: (George Washington Carver National Monument and Surrounding Area).

Introduction

This Geocorps project is a basic mapping project where fieldwork as well as data analysis were combined to produce a new geologic map of the area. Prior to this project, no geologic map of the area had been produced at the 1:24000 scale. The National Park Service has been updating their geologic map databases for some of their parks, and that included this project for the George Washington Carver National Monument. In a combined effort between Geocorps America and the National Park Service this project came to be.

The area of interest is composed of three 2.5-minute quadrangle sections. This equals roughly one-third of a 7.5-minute quadrangle. The area covered for this project is from: 36°56'30"N to 37°0'0"N, and 94°17'30"W to, 94°25'W, which includes the town of Diamond, MO, the George Washington Carver National Monument, and the northeastern most 2.5-minute section of the Tipton Ford 7.5-minute quadrangle.

Text from source map: (George Washington Carver National Monument and Surrounding Area).

Fieldwork and Analysis

The first step in the mapping process was to get boots on the ground and find rock outcrops. The fieldwork for this project included locating outcrops and noting their locations via handheld gps, collecting samples at outcrops both within and just outside the mapping area, and measuring the strike and dip of the beds using a Brunton. This area proved to be somewhat difficult due to a layer of regolith covering a majority of the area, which limited the rock exposures. Table-1 below shows the outcrop locations accessed, rock unit identification, and recorded strike and dip of the beds.

Because of the limited number of accessible outcrops, it was necessary to also use aerial photography to help discern the landscape. The air photos used for this project were from 1960 and they were produced at a scale a little larger than 1:24000, the exact scale is not available with these photos. The air photos showed a feature, which was interpreted to be the contact between the Burlington-Keokuk and Warsaw formations. This feature was a visible shelf that can be readily seen at 36°58'32"N, 94°19'W. This contact is also visible using Google Earth, but it shows much more relief in stereoscopic vision. The contact occurs at 1120 ft in elevation, which is the same elevation as the inferred contact from the larger 1:500,000 map of the area (Middendorf M. A., 2003).

The Aerial photographs also confirmed the existence of faults in the area that had been previously mapped by the Missouri Geologic Survey. The relief in the air photos shows that these faults are very low displacement faults. On the ground these faults cannot be seen as they are covered over by regolith.

Text from source map: (George Washington Carver National Monument and Surrounding Area).

Table 1: Field Measurement Observations

Outcrop Location	Rock Unit I.D.	Strike	Dip
36°56’17”N, 94°19’0”W	Warsaw	194°	5°
36°59’47”N, 94° 25’54”W	Burlington-Keokuk	88°	3°
36°59’46”N, 94° 25’58”W	Burlington-Keokuk	190°	1°
36°56’37”N, 94° 24’25”W	Short Creek Oolite Member of Burlington-Keokuk	170°	5°
36°56’24”N, 94°16’0”W	Warsaw	158°	2°
36°58’52”N, 94° 22’08”W	Burlington-Keokuk	201°	3°
36°59’14”N, 94° 21’15”W	Burlington-Keokuk	72°	3°

Because of the limited number of accessible outcrops, it was necessary to also use aerial photography to help discern the landscape. The air photos used for this project were from 1960 and they were produced at a scale a little larger than 1:24000, the ex act scale is not available with these photos. The air photos showed a feature, which was interpreted to be the contact between the Burlington-Keokuk and W arsaw formations. This feature was a visible shelf that can be readily seen at 36°58’32”N, 94° 19’W . This contact is also visible using Google Earth, but it shows much more relief in stereoscopic vision. The contact occurs at 1120 ft in elevation, which is the same elevation as the inferred contact from the larger 1:500,000 map of the area (Middendorf M. A., 2003). The Aerial photographs also confirmed the existence of faults in the area that had been previously mapped by the Missouri Geologic S urvey. The relief in the air photos shows that these faults are very low displacement faults. On the ground these faults cannot be seen as they are covered over by regolith.

Table and text from source map: (George Washington Carver National Monument and Surrounding Area).

Of note, strike and dip values in Table 1 were edited by the GRI to follow the "right-hand rule" where the strike azimuth also denotes the dip direction, and thus the dip value doesn't include the dip direction (e.g., 5 and not 5 NE).

Lithological Analysis

The Burlington-Keokuk in this area is a thick to thin bedded densely fossiliferous crinoidal packstone, light grey to white in color. It weathers to a dark grey to black exterior and contains a small amount of chert varying in color from light grey and white to a buff or reddish brown exterior when weathered. Most of the chert is found as nodules with minor occurrences along bedding planes. According to The Stratigraphic Succession of Missouri, the Burlington Limestone is described as "a white to gray, medium-to coarsely crystalline, medium-to coarsely crinoidal, medium-to thick-bedded, often cross-stratified, chert-free to sparsely cherty limestone Chert occurs in zones 110 ft thick, separated by chert-free zones 30-50 ft thick (Thompson, 1986, p. 91-92)." Thompson goes on to describe why the Burlington-Keokuk in this area is undifferentiated, when he says. "The contact with the overlying, lithologically similar Keokuk Limestone is transitional and often difficult or impossible to identify (Thompson, 1986, p. 92)."

The Warsaw in this area is thick-bedded light to dark grey wackestone, weathering to light grey, this formation contains calcite both microcrystalline spar and in Thombohedron crystal form. There were small cubes of weathered pyrite on the samples collected. No pyrite was found in any samples of the Keokuk in the GW Carver project area. These samples are sparsely fossiliferous and contain a very small number crinoids and sparse brachiopods. According to Thompson the Warsaw is described as, "a slightly cherty limestone in which the bryozoan *Archimedes* and the brachiopod *Spirifer pellaensis* are common. In the Tri-State area and in Newton and Jasper counties the formation is over 150 ft thick (Thompson, 1995, p. 83)."

The Short Creek Oolite member of the Keokuk Limestone is the accepted boundary between the Burlington-Keokuk and the Warsaw formation (Thompson, 1995, p. 81). This is the transitional facies between the Osagean stage and the Meremecian stage of the Mississippian age. In the field sample collected the Ooids are about 1 millimeter or less in diameter and they are nucleating around sparry calcite most likely from broken crinoid stems, which is very similar to a confirmed sample of the Short Creek from Springfield, Missouri. After comparing the two samples the only difference is the percentage of Ooids in the limestone, the Springfield sample is an Oolitic grainstone with approximately 80% Ooids by volume, and the field sample is an Oolitic packstone with approximately 55% Ooids by volume. The description according to Thompson is, "a thin, persistent bed of Oolitic limestone, 2 to 8 ft thick...the ooliths are usually less than one millimeter in diameter, round in cross section and often have as a nucleus a doubly terminated quartz crystal (Thompson, 1995, p. 81)." The Short Creek Oolite was found at 36°52'37'N, 94°24 25 W, which is located at 950ft in elevation. This establishes a new contact at 950 ft in this area.

Text from source map: (George Washington Carver National Monument and Surrounding Area).

Mapping

This area of Southwestern Missouri is known for its basic layer upon layer stacking of beds with almost no dip. The largest dip taken from any outcrop was 5° which makes this area relatively flat. The field map produced of this area was created using the 7.5-minute Quadrangle maps of Granby and Tipton Ford with a transparency overlay on them. The outcrop locations were plotted and, based on the lithologic identification, base contour lines of the different beds were traced with a permanent marker creating the contacts of the beds on the overlay.

The next step in the mapping process was to digitize this information into ArcMap. For this project ArcMap version 10.1 was used. Using ArcCatalog, a new shape file for the contacts was created and plotted on the Esri world topographic map as a background. A field for scientific certainty was added to the attributes table to insure FGDC compliance. The contact lines were drawn in their respective places and symbolized following the FGDC guideline following the scientific certainty of their location (FGDC, 2006).

Next polygon shape features were created for the Burlington-Keokuk and Warsaw units. The fields of Rock unit, Age, and Stage were added to the attributes table for these features. Using the polygon

features the contact lines were traced to place the respective rock unit in their proper places. The Burlington-Keokuk and Warsaw polygon files were colored following the FDGC CYMK color code of 531 and 42A where the k value always equals 0, each number represents a percentage for that color, and the A stands for 8% (FGDC, 2006).

Next a point feature was created to show the locations of sample points. For this feature class, the attributes of Rock ID, strike, and dip were added. The points were then plotted in their location on the map. The sample points are displayed with their lines of strike and general direction of dip, using the FGDC strike and dip symbols (FGDC, 2006). The last thing imported and incorporated into this map was the line shape file of faults in the area that had been generated by the Missouri Geological Survey (Missouri Department of Natural Resources, 2005).

To finalize the map, a geo-database was created for the mapping area. Each of the feature classes created were saved as individual layers and exported into the geo-database. The final Product is the GWCNM Map geo-database. The files it contains are, mo_faults.shp (Missouri Department of Natural Resources, 2005), Contacts.shp, Mbk.shp, Mw.shp, and Collection_points.shp. The coordinate system for all files is WGS 1984 based on the World Topograpgic Basemap from Esri (ESRI, 2014).

Text from source map: (George Washington Carver National Monument and Surrounding Area).

Conclusion

In conclusion, this project has created new 1:24000 scale geologic maps of George Washington Carver National Monument and the surrounding area. The new maps were created using standard mapping techniques with a gps, Brunton, and aerial photography. Then based on the FGDC guidelines the map was digitized using ArcMap 10.1. This is the first attempt in this area to produce a geologic map at this scale. The study area proved to be somewhat difficult due to the fact a heavy layer of regolith and topsoil covers most of it. This project is part of the Geo-corps America internship program through the Geologic Society of America. The map resulting from this project is a good start toward producing full 1:24000 scale geologic maps of the Tipton Ford and Diamond 7.5 minute quadrangles, however there is still work to be done in this area.

Text from source map: (George Washington Carver National Monument and Surrounding Area).

References Cited

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Revised, p. 81-83.

References from source map: (George Washington Carver National Monument and Surrounding Area).

GRI Digital Data Credits

This document was developed and completed by Stephanie O'Meara and Georgia Hybels (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara.

The information in this document was compiled from the GRI source map, and intended to accompany the digital geologic-GIS map and other digital data for George Washington Carver National Monument, Missouri (GWCA) developed by Georgia Hybels and Stephanie O'Meara (see the GRI Digital Map and Source Map Citation section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS map).

GRI finalization by Stephanie O'Meara (Colorado State University).

GRI program coordination and scoping provided by Bruce Heise, Jason Kenworthy and Tim Connors (NPS GRD, Lakewood, Colorado).