


# Gulf Coast Geology (GCG) Online—Miocene of Southern Louisiana

## Information and Tutorial for DS 90-A, Version 1.0

U.S. DEPARTMENT OF THE INTERIOR
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# About GCG Online

A large percentage of the present and future energy resources of the United States reside in the Gulf of Mexico Basin, one of the major hydrocarbon producing areas of the world. Recent conceptual and technological advances have resulted in significant new finds and opened large areas to new or renewed exploration. The U.S. Geological Survey's Framework Studies and Assessment of the Gulf Coast Project was established in 1999 to provide the geologic, geophysical, and geochemical framework studies that will aid in a reassessment of energy commodities (coal, gas, and oil) in the Gulf Coast Region. The project targets intervals identified during preceding oil, gas, and coal assessments as requiring additional study. It (1) defines the petroleum systems of the region; (2) conducts specific geologic framework studies and petroleum system analyses on selected priority intervals; (3) studies the coal-bearing interval to evaluate coal distribution and quality, coal-bed gas, and source-rock potential; (4) works in cooperation with the National Oil and Gas Assessment (NOGA) Project to conduct a focused assessment of the Gulf Region; and (5) contributes to the next phase of the National Coal Resource Assessment.

Gulf Coast Geology (GCG) Online is a Geographical Information System (GIS) database developed as an ArcMap (ESRI, 2003a) project to be served online utilizing ArcIMS (ESRI, 2003b). It serves three major needs of the project: (1) efficient, centralized data management and visualization; (2) development and sharing of data and interpretations by project personnel; and (3) dissemination of information and products to customers in an easily usable format. Currently, all USGS assessments are petroleum system based and require large amounts of geologic, geophysical, geochemical, and paleontologic data in addition to well and field databases. In mature provinces and especially in large ones such as the Gulf Coast, these data sets can be quite large, so the data management role becomes critical. For example, the Miocene database alone contains nearly 100 layers in addition to the 25 layers of geographic and geologic bases. At the same time, it is necessary for the large number of scientists working under tight deadlines on a wide variety of topics to have ready access to all of these data as well as to each other's most recently developed data and interpretations. An additional requirement is that the output be easily usable by project personnel or customers (management, other scientists, the general public, and others.) who may or may not have any GIS expertise or sophisticated equipment. This is particularly important for government agencies such as the USGS whose primary mission is to provide the best and most current information possible to decision makers and the public.

The USGS will publish DS 90 in a series of releases that will be made available online as they are completed. DS 90-A will pertain to the Miocene only, while DS 90-B, 90-C, etc., will pertain to other parts of the section or other formations. Each release will have a version number so that updates may be tracked and referenced. DS 90-A, version 1.0, for example, deals almost exclusively with the Miocene of southern Louisiana, primarily because of the availability of data. Sources of data spe-




cific to each individual layer within the database are documented in the metadata for that layer. In most cases, the accuracy of data from outside sources is assumed to be sufficient for the purposes of this regional compilation, and the user is cautioned in the use of these data at prospect and smaller scales. All data are in the form of shapefiles and ArcSDE (ESRI, 2003c) layers, which are maintained on the U.S. Geological Survey Central Energy Resources Team server, along with the applications software. An updated version, DS 90-A, version 2.0, perhaps combining data on the Miocene of Texas with the previously published data, will be published at a later date. All versions of all releases will be available through the Central Energy Resources Web site at http://energy.cr.usgs.gov/




# Version 1.0 Introduction

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Version 1.0 of the Miocene deals almost entirely with southern Louisiana primarily because of the availability of data, especially the biostratigraphy. Publicly available data have been used wherever possible; however, in the case of proprietary data, such as the Tenroc Regional Geologic Database, only derivative products are made available so that, for example, the isopach or structure contour maps show the locations of wells in the Louisiana State database used to construct the contours but do not reveal the precise depths of the micropaleontologic identifications. In addition to the data specific to southern Louisiana, a number of regional geologic coverages that will be applicable to all versions are also included for reference.

The Miocene is the most important producing interval in the Gulf of Mexico Basin. Nehring (1991) reported that as of 1987, known recovery from the Miocene was nearly 150 trillion cubic feet (TCF) of natural gas, 19 billion barrels of crude oil, and 6 billion barrels of natural gas liquids (NGL), for a total of nearly 49 billion barrels of oil equivalent (BOE). He also noted that only seven other provinces worldwide contain more petroleum, and none contained more in large (200-500 million BOE) fields. In its 1995 National Assessment of Oil and Gas Resources, the USGS reported the onshore and state waters component of these production totals to be approximately 37.1 TCF of natural gas, 2.5 billion barrels of oil, and 851 million barrels of NGL (Schenk and Viger, 1995). Known recovery from the Miocene in the northern Gulf of Mexico Basin increases upward and eastward from the Lower to the Upper Miocene (Nehring, 1991).

Along the northern Gulf of Mexico Basin, the Miocene comprises a series of thick off-lapping sequences of terrigenous clastics dominated by several long-lived deltaic systems and overlain by transgressive shale tongues. The total updip thickness is approximately 3,900 ft (1,200 m) in onshore Texas and 7,800 ft (2,400 m) in Louisiana (Galloway and others, 1991). It thickens to more than 25,000 ft (7,600 m) in offshore Louisiana (Meyerhoff, 1968). Galloway and others (1991) attributed the tremendous downdip thickening of the Miocene to deposition on and basinward of the underlying unstable Frio Formation and thick salt. The rapid deltaic deposition triggered both growth faulting and movement of salt out of withdrawal basins into nearby diapirs thus providing additional accommodation space and the accumulation of thick, highly expanded sections of sandstone and shale. Eastward thickening is the result of the shift of feeder systems from west to east from early to late Miocene so that the late Miocene deltas occupied the position of the present-day Mississippi Delta (Galloway and others, 1991).

Details of the Cenozoic sediment dispersal axes were documented and correlated with source areas by Galloway and others (2000). They noted that the early Miocene sediment influx exhibited a shift to the central Gulf fluvial axes that dominate




the late Neogene due to a shift of source areas as a result of uplift of the Edwards Plateau and uparching across the western interior of North America at the onset of Basin and Range extension. During the Middle Miocene, unroofing of the Edwards Plateau supplied carbonate-rich sediment directly into the Corsair delta and adjacent northwest Gulf (Morton and others, 1988). The Central and East Mississippi dispersal axes produced a composite delta system that dominated the central Gulf margin (Galloway and others, 2000). Late Miocene rejuvenation of the southern Appalachians, Nashville dome, and continental interior provided sandy sediment to the Central and East Mississippi axes (Boettcher and Milliken, 1994; Galloway and others, 2000) and firmly established the late Neogene depositional pattern.

Recent sequence stratigraphic studies of several offshore Miocene oil and gas fields demonstrate a general correspondence with the global cycles and sequence boundaries of Haq and others (1988) and explain most sequence differences, especially higher frequency cycles, by basin-specific high sediment flux in the vicinity of major sediment dispersal axes (Wagner and others, 1994; Hentz and Zeng, 2003). Wagner and others (1994) used both 2D and 3D seismic data to map sequence boundaries and interpret paleogeography in the vicinity of the Lower Miocene shelf break just offshore from Cameron Parish. Hentz and Zeng (2003) identified the low stand systems tract of some third-order Middle Miocene sequences as being particularly prolific oil and gas producers although the entire section produced hydrocarbons. More specifically, they noted that within the Starfak and Tiger Shoal fields reserves were highly concentrated where the reservoir-scale fourth-order systems tracts stack to form third-order lowstand systems tracts, which compose approximately 30 –50% of the succession. They also noted that although a dominant structural–trapping component is present in the fields, the thick sealing shales of the third-order slope fans and third-order transgressive and highstand systems tracts minimize the risk of cross-fault juxtaposition of lowstand reservoir sandstones against third-order highstand sandstones that can act as points of leakage.




# References

Boettcher, S.S., and Milliken, K.L., 1994, Mesozoic-Cenozoic unroofing of the southern Appalachian basin: apatite fission track evidence from Middle Pennsylvanian sandstones: Journal of Geology, v. 102, p. 655-668.

ESRI (Environmental Systems Research Institute, Inc.), 2003a, arcGIS (arcMAP), v. 8.3: ESRI computer program.

ESRI (Environmental Systems Research Institute, Inc.), 2003b, arcIMS [Internet Map Service], v. 4.01: ESRI computer program.

ESRI (Environmental Systems Research Institute, Inc.), 2003c, arcSDE [Spatial Data Engine], v. 8.3: ESRI computer program.

Galloway, W.E., Bebout, D.J., Fisher, W.L., Cabrera-Castro, R., Lugo-Rivera, J.E., and Scott, T.M., 1991, Cenozoic, *in* Salvador, A., ed., the Geology of North America: the Gulf of Mexico basin: Boulder, Colorado, Geological Society of America, v. J, p. 245-324.

Galloway, W.E., Ganey-Curry, P.E., Li, X., and Buffler, R.T., 2000, Cenozoic depositional history of the Gulf of Mexico basin: American Association of Petroleum Geologists Bulletin, v. 84, p. 1743-1774.

Haq, B.U., Hardenbol, J., and Vail, P.R., 1988, Mesozoic and Cenozoic chronostratigraphy and cycles of sea-level change, *in* Wilgus, C.K., Ross, C.A., Posamentier, H., and St. C. Kendell, C.G., eds., Sea-level changes: an integrated approach: SEPM Special Publication 42, p. 71-108.

Hentz, T.F., and Zeng, H., 2003, High-frequency Miocene sequence stratigraphy, offshore Louisiana: cycle framework and influence on production distribution in a mature shelf province: American Association of Petroleum Geologists Bulletin, v. 87, p. 197-230.

Meyerhoff, A.A., ed., 1968, Geology of natural gas in southern Louisiana, *in* Beebe, B.W., ed., Natural gases of North America: American Association of Petroleum Geologists Memoir 9, v. 1, p. 376-581.

Morton, R.A., Jirik, L.A., and Galloway, W.E., 1988, Middle-Upper Miocene depositional sequences of the Texas coastal plain and continental shelf: geologic framework, sedimentary facies, and hydrocarbon distribution: University of Texas at Austin, Bureau of Economic Geology Report of Investigations 174, 40 p.

Nehring, R., 1991, Oil and gas resources, *in* Salvador, A., ed., The Gulf of Mexico basin: Boulder, Colorado, Geological Society of America, v. J, p. 445-494.




Schenk, C.J., and Viger, R.J., 1995, Western Gulf Province (047), *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., 1995 assessment of United States oil and gas resources – results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS-30, 110 p.

Wagner, J.B., Kofron, B.M., Morin, R.W., Ford, D.W., Mathur, V.R., and Mauro, R.T., 1994, A sequence stratigraphic analysis of the Lower Miocene, West and East Cameron areas, Gulf of Mexico, *in* Weimer, P., Bauma, A.H., and Perkins, B.F., eds., Submarine fans and turbidite systems: sequence stratigraphy, reservoir architecture, and production characteristics, Gulf of Mexico and international: Gulf Coast Section SEPM, 15th Annual Research Conference Proceedings, p. 357-372.

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# Layer Information

## Base Geology:

This group contains a number of general geology layers that constitute an initial basic data set useful in constructing the regional geologic framework. Some, such as the fault and salt diapir layers, are also essential in the evaluation of smaller areas or even individual fields. Much of the data are based on maps and figures contained in The Geology of North America series published by the Geological Society of America and reproduced here with permission of the Society. Multiple data sources were reconciled using whatever information was available. Users are cautioned that most of the map data were digitized from paper prints and therefore are approximately located.

### Seismic Lines:

The lines shown are those used by the USGS in developing the framework geology and models used in assessing the oil and gas resources of the Gulf Coast Region. The data set is comprised of both leased and borrowed company proprietary data.

### Anticlines:

Initially, only major structures such as those shown on Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez), in Volume J, The Geology of North America (1991), have been included, primarily for reference.

### Orogenic Belt:

General location map of the Ouachita and Appalachian structural fronts slightly modified from Plate 4, Natural resources, Gulf of Mexico Basin (compiled by A. Salvador and R. Nehring), in Volume J, The Geology of North America (1991).

### Cretaceous Onlap:

Maximum extent of Cretaceous onlap generalized from Plate 3, Structure at the base and subcrop below Mesozoic marine section, Gulf of Mexico Basin (compiled by A. Salvador) in Volume J, The Geology of North America (1991).

### Fault Zones:

Major fault zones as indicated on Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez) in volume J, The Geology of North America (1991).




## Faults:

Mapped faults modified from Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez) in Volume J, The Geology of North America (1991); Plate 2, Geologic map of the U.S. Appalachians showing the Laurentian margin and the Taconic orogen (compiled by D.R. Rankin, A.A. Drake, and N.M. Ratcliffe) in Volume F-2, The Geology of North America (1989); and Plate 9, Tectonic map of the Ouachita orogen (compiled by W. A. Thomas) in Volume F-2, The Geology of North America (1989).

## Salt Limit:

Approximate limit of Middle Jurassic salt from Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez) in Volume J, the Geology of North America (1991).

## Salt Diapirs:

Locations and shapes modified after J.A. Lopez, 1995, Salt tectonism of the U.S. Gulf Coast basin; Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez) in Volume J, The Geology of North America (1991); and U.S. Geological Survey Miscellaneous Field Studies Map MF-1213, Distribution of salt structures, Gulf of Mexico, by R.G. Martin (1980).

## Volcanic Provinces:

Modified after Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez) in Volume J, The Geology of North America (1991).

## Basins and Uplifts:

Generalized outlines of major basins and uplifts in the Gulf Coast region modified after Plate 2, Principal structural features, Gulf of Mexico Basin (compiled by T.E. Ewing and R.F. Lopez) in Volume J, The Geology of North America (1991).

## Gulf Coast Geology:

The regional geology layer is from Geology of the Conterminous United States at 1:2,500,000 Scale -- A Digital Representation of the 1974 P.B. King and H.M. Beikman Map: USGS Digital Data Series 11 (1994).

## Southern Louisiana Wells and Fields:

This group contains layers showing the location of oil and gas wells, information on each well, the location of all fields in southern Louisiana, and those fields producing from the Upper, Middle, and Lower Miocene. The wells are those contained in the Louisiana Department of Natural Resources Strategic Online Natural Resource Information System (SONRIS) that can be accessed through the “hyperlink” button. Field and producing area polygons have been created to include all those wells satisfying the requisite criteria.




## Southern Louisiana State Wells:

Includes all wells in the southern part of the Louisiana Department of Natural Resources SONRIS database. The online data can be accessed by making this the active layer, clicking on the hyperlink button, and then selecting the well of interest.

## Southern Louisiana Fields:

Field polygons were created by constructing a grid of 0.25 $mi^2$. cells and proximal polygons centered on all wells within the field and then intersecting and combining the polygons. This includes wells that were drilled to any depth within the field.

## Producing Areas:

Producing area polygons were created by constructing a grid of 0.25 $mi^2$. cells and proximal polygons centered on all wells producing from the given interval within the field and then intersecting and combining the polygons. Although the polygons are based on the producing wells only, they may also include some dry holes. The producing interval is determined by comparing the depth of production to the structure contours (see Contouring section).

## Southern Louisiana Drilling History:

The drilling history documents the wells testing a specific interval in 10-year increments from the first reported well to the year 2000. The wells included in each interval are determined by completion date and by comparing the depth of the wells to the structure contours (see Contouring).

## Contouring:

All contoured structure, thickness, and percent sand data are in this group. The structure and thickness contours were created from biostratigraphic data in the Paleo-Data, Inc., Tenroc Regional Geologic Database. Because of their proprietary nature, no actual data can be shown and only those data points contained in the Louisiana State well database are included in the control points layers. Contouring was accomplished in Dynamic Graphics, Inc., EarthVision modeling software (v. 5) using minimum tension gridding. Minimum Tension Gridding algorithms calculate a smooth surface that closely fits the input data values using biharmonic-cubic spline techniques. Three custom programs were used to convert contour lines generated from grids in EarthVision to ArcInfo coverages and then to shapefiles. The sand percent contours were produced by the Louisiana Geological Survey and were digitized from Chapter 11, Cenozoic, in The Gulf of Mexico Basin, Volume J, The Geology of North America (1991).

## Depositional Systems:

The depositional systems represented under this group are presented here with permission of W.E. Galloway and the Jackson School of Geosciences, University of Texas at Austin. For more information and discussion of the various depositional systems, the user is referred to Galloway and others, 2000, Cenozoic depositional history of the Gulf of Mexico basin: American Association of Petroleum Geologists Bulletin,




v. 84, p. 1743-1774. The Lower Miocene is divided into an earlier (Lower Miocene 1) and later (Lower Miocene 2) depositional system separated by a prominent transgressive marine shale tongue containing the *Marginulina* A fauna (Galloway and others, 2000). The Middle Miocene is broken into a lower H system and an overlying I system based on basin center seismic sequences. It should be noted that although differing in detail, the onshore parts of the Lower Miocene depositional systems are very similar as are the onshore parts of the Middle Miocene systems. Each of the depositional system layers also contains the trace of the relict shelf margin break of the underlying system. The trace of the shelf margin break for the subject system is contained in a separate layer, as are the labeling symbols and outlines of the various depositional environments.

## Base:

This group contains the geographic and cultural layers primarily for location purposes. All of the cultural layers were imported from the National Atlas while the hydrologic data come from the USGS Digital Line Graph (DLG) database. The petroleum province outlines for Region 6 are the same as they were for the 1995 National Assessment of Oil and Gas Resources.

## Background options:

The layers under this group comprise the options for a base map on which to overlay the other layers in the database.

### United States:

State outlines and names.

### Mexico States:

The State outlines and names are reproduced here with the permission of ESRI, Inc.

### Shaded Relief:

The shaded relief map is a global digital elevation model (DEM) created by USGS EROS Data Center in Sioux Falls, South Dakota. At larger scales, as when zoomed in to a field or well, the image becomes too grainy or "pixelated" and automatically turns off.

### U. S. Background:

A flat, neutral background for the U.S., particularly useful at large scales or when overlain by certain color combinations.




# Gulf Coast Geology (GCG) Online—Miocene of Southern Louisiana

## Tutorial for DS-90-A, Version 1.0




# General Instructions

This tutorial provides information about the GCG Online interactive maps and describes the components of the maps page (see Screen Overview).

## Tool Descriptions:

Click on (?) to get the description of each GIS tool.

## General Tools:

Tools that perform an action.

### Region Map:

Adds or removes the overview map from the map display area. The overview map displays a miniature image of the Gulf Coast map and highlights the map view area.

### Full Extent:

Zooms to the full extent of the Gulf Coast.

### Set Units:

Sets the measurement units of the scale bar and the measure tool.

### Make Map:

Brings up a window that provides the user with options for saving a custom map to a file that can be subsequently printed. Follow the instructions for saving and printing the map and legend.

### Clear:

Clears measure totals or the selected set of features.

### Measure:

Allows the user to calculate distances on the map. Total and segment boxes will appear at the top of the map view once the user clicks on the measure tool. Click the left mouse button on the map location from which you want to measure. Do not initiate any other functions until the loading sign disappears. Click the left mouse button on another place on the map. A red and white line will appear connecting the points. This may be done several times. The total distance of all segments appears in the total box. The segment box records the distance that the cursor is moved before clicking the mouse button.




### Zoom Back:
Returns to the previous map view.

### Active Tools:
Tools that require an action in the map window.

#### Zoom In:
Zooms to an area of interest that the user clicks on or drags a box around.

#### Zoom Out:
Zooms out from the area of the map that the user clicks on or drags a box around so that the map displays a larger area.

#### Pan:
Moves or slides the map in the direction that the user drags the mouse pointer.

### Layer Specific Tools:
Tools that perform a function on the active layer.

#### Hyperlink:
Presently works only with the Louisiana State Wells theme when it is the active layer. Retrieves well information from the Louisiana State Wells Database.

#### Identify:
Identifies a feature in the active layer by displaying attribute information for that feature.

#### Zoom Active:
Zooms to the full extent of the active layer.

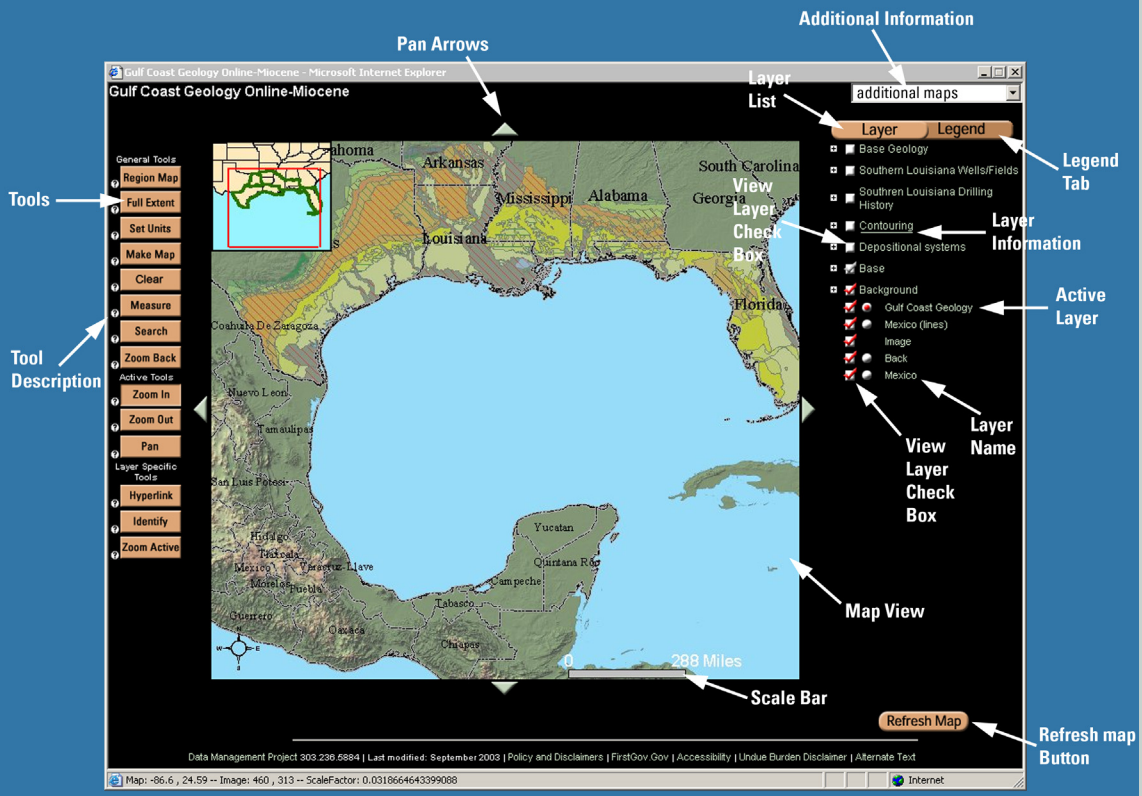

## Screen Overview

### Layer Information:

Click on a layer name to open an information download window where the user can view the metadata and download the shapefile.

### Refresh Map:

To refresh the map, click the redraw map button in the lower right corner of the map viewer.







**Layer Legend tab:** Click the legend tab to display the layer features represented as map symbols. The legend opens in Adobe Acrobat Reader.
Layers are initially displayed in grouped categories (synonymous to folders).

(1) This symbol indicates a closed group of layers. Click on the + to expand the category to show all the layers in the group.

(2) This symbol indicates an open group of layers (synonymous to an open folder). Click to close the list of layers.

(3) This symbol indicates a hidden group/layer. Click on the check box to left of the layer title to view a map layer.

(4) This symbol indicates a visible layer that can be hidden by clicking on the check box to the left of the layer title.

(5) This symbol indicates a visible layer with a scale dependency that is other than the current scale of the map.

(6) This symbol indicates an inactive layer. Click on the (white circle) to make the layer active.

(7) This symbol indicates the active layer. The active layer is the layer against which query, identify, search, select, hyperlinks, and so on, will be performed. Only one layer can be active at any given time.




# System Requirements

## Supported Browsers

· Netscape 4.7 + series and higher

· Netscape 6.1 + series and higher

· Netscape 7.1 + series and higher

· Internet Explorer 5.x series and higher

· Internet Explorer 6.x series and higher

## Supported Platforms

· Windows 98, ME, 2000, and XP

· Macintosh OS X (Using Netscape 7.x or higher)

*Note: Internet Explorer is not supported on any Macintosh Platform. In addition, earlier Macintosh platforms may or may not function appropriately using Netscape 7.x or higher.*

## Bandwidth

The use of 56k standard modem technology is not recommended for use with GCG Online. While the application may function using a 56k modem, performance may be undesirable. The use of a 10mb LAN or higher or highspeed cable or DSL modem is recommended.




## Information For Advanced Users

While the GCG Online application provides a number of useful and sophisticated geoprocessing and cartographic functions related to the geologic framework of the Gulf Coast Region, some users might find the need for more advanced GIS functionality. Some of this functionality may include sophisticated queries, and advanced cartographic functions including labeling and annotation. Given the interoperable nature of the GCG Online product, these data can be used in a variety of applications. The following options are available using the GCG Online map service:

Using ArcGIS Desktop—The services implemented in the GCG Online application and interface can be easily integrated into your existing data in any version of ArcGIS Desktop. Add an internet server using the "Add Internet Server" dialogue in ArcCatalog. The internet host name will be http://certmapper.cr.usgs.gov. Once the internet server has been successfully added, select the map service name, "gulfcoast_miocene1." This service can be used in either ArcCatalog or ArcMap. For more details related to ArcGIS Desktop products, visit the ArcGIS product overview homepage at http://www.esri.com/software/arcgis/

Using ArcExplorer—The GCG Online map service can also be integrated with existing data using a free GIS software viewer called ArcExplorer. For additional information regarding ArcExplorer and to download this free application, visit the ArcExplorer homepage at http://www.esri.com/software/arcexplorer/

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