Wave of the Future Part 2 – Cartography by Computer

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Disclaimer

This article is not really meant to be a step–by–step guide to drafting a cave map on the computer; instead it is intended to be an overview of the basic methods used and a stepping stone for all those cartographers who are either discouraged or searching for a start in the world of digital cartography. Not all steps in the process will be covered by this article; instead a few assumptions need to be addressed. As a cartographer it is assumed that you already use a computer to aid in creating a line plot and to detect errors. For basic purposes it does not really matter which program you use, whether it be *Compass, Walls,* or *Winkarst,* etc. For this article it is also assumed that you have chosen *Adobe Illustrator* as your drawing program. While there are a number of good drawing programs out there, *Illustrator* is one of the most popular and considered by many to be the best program for cave cartography.

It is important to remember that there are multiple versions of *Adobe Illustrator* on both Windows and Mac operating systems. For this tutorial, I will be using *Adobe Illustrator CS 3* for Windows which is the newest version of the program, at least at the time of this writing. There are slight differences among the versions, one of the most important to the cave cartographer, is the ability to import certain file formats. Previous versions would allow the user to import a line plot directly from *Compass*. However, the new versions do not allow this file format; instead the user must take a screen shot of the line plot, import the screen shot into *Illustrator*, then separate and delete everything that is not the physical line plot. This is just one example of the differences between the versions of *Illustrator*; keep this in mind while reading and using the following article.

Introduction

Adobe Illustrator is a vector based drawing program cultivated and marketed by Adobe Systems. It was first developed for the Apple Macintosh and is the companion product of *Adobe Photoshop. Photoshop* is primarily geared toward digital photo manipulation and photorealistic styles of computer illustration, while *Illustrator* provides results in the typesetting and logo graphic areas of design. The program was originally released in the mid 1980's and since then there have been thirteen generations of the product, culminating in the current product, *Adobe Illustrator CS 3. Illustrator* has been adopted by the digital cave cartography community due to its flexibility and customizability. However, *Illustrator* is a very technical program; don't expect to open the program for the first time and draw a perfect cave map – much of the finer details of the program can be learned only through time and practice. Since much of the digital cave cartography community uses *Illustrator* there is no shortage of online support including but not limited to written how-to guides, video tutorials, and freeware in the form of common cartography symbols. See the **Notes** section of this article for a short list of resources.

The Adobe Illustrator CS 3 Workspace

Upon opening *Adobe Illustrator* the user will be confronted with a large drawing canvas and a plethora of both buttons and drop down menus. On a whole this is known as the "workspace" (Figure 1). The workspace is divided into four primary elements: on the top of the screen is the **Menu Bar**, on the left of the screen is the **Tools Palette**, on the right of the screen is the **Individual Palettes**, and the center of the screen is dominated by the **Canvas**.
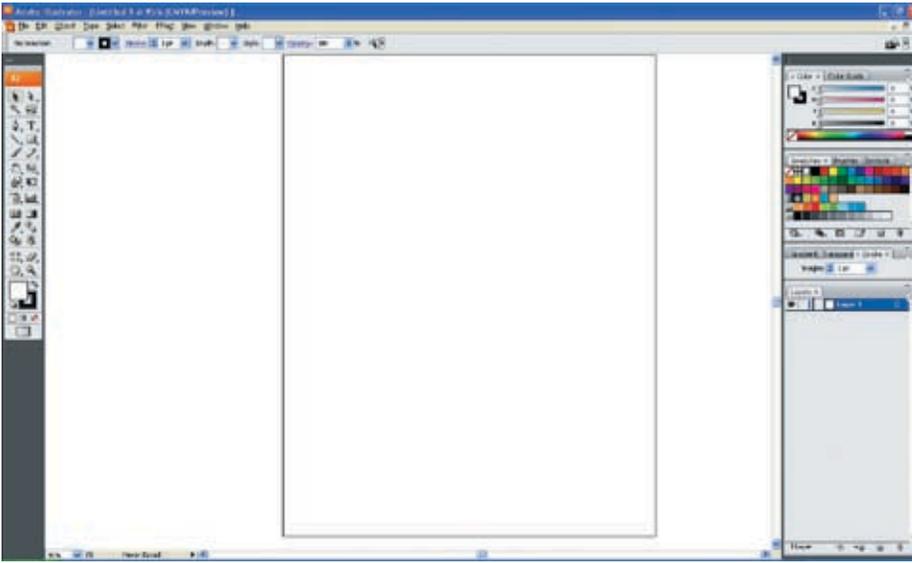
Figure 1: The Adobe Illustrator CS 3 workspace is a well conceived layout; notice the ***Menu Bar*** *at the top, the* ***Tools Palette*** *on the left, the* ***Individualized Palettes*** *on the right, and the* ***Canvas*** *dominating the center of the screen.*

The **Menu Bar** has a number of drop-down menus similar to many Windows based programs; these include **File, Edit, Object, Type, Select, Filter, Effect, View, Window**, and **Help**. The **File** menu has information and commands related to your file (for example, this is where you would go if you wanted to save the file or open a new file). You can use the **Edit** menu to edit your document–options such as copy, paste, and undo are found here. The **Object** menu allows you to edit selectable objects within your document whether they are lines, fills, or shapes. The **Type** menu deals directly with fonts within your document. The **Select** menu provides options for objects that you select in the document. Most of this menu is unusable unless you have an object selected in the **Canvas**. The **Filter** and **Effect** menus apply specific characteristics to drawn or imported objects. These menus are not used very much in cave cartography. The **View** menu has the settings that adjust what you see or how much you see on the **Canvas**. If you wanted to see rulers, gridlines, print preview, or zoom you would change those settings in the **View** menu. The **Window** menu has a listing of all the available palettes and libraries. The palettes,

when selected, will show up in the **Individual Palettes** area of the workspace. They are definable by the user but the common ones for cave cartography include **Color**, **Layers**, **Symbols**, **Stroke**, and **Tools**; these will be discussed later. The libraries allow the user to load, create, and import saved sets of objects like brushes, symbols, and swatches. This is useful because there are already sets of things that other users have created (e.g., cave survey symbols) that you can import from the web. For more information on where to find these symbols please see the Notes section at the end of this article. Finally the **Help** menu allows you to search for ways to fix any problems you may run into while creating your document. Along with the above listed drop down menus, the new versions of *Illustrator* have a set of icons and settings for changing the varying attributes of tools we select. This set of icons and settings is dynamic in that it changes depending on what you may be doing. You also can find these same options by going through the above mentioned drop down menus.

The **Tools Palette** is the second important element in the *Illustrator* workspace. It uses icons to display all the necessary tools that allow you to create shapes, objects, and diagrams. The icons are broken up by use in the **Tools Palette**. The first four tools are grouped together and these are used to select objects on the **Canvas**. The next six icons are employed to create lines, paths, and shapes; the type tool is also found here. The four icons below that deal with modifying an object or path, whether modifications involve rotating, transforming, or skewing. The next two icons are not used during cave cartography since they deal with modifying graphs. However, the six icons after that allow you to fill an object with color or a particular swatch or pattern. The final four icons

allow you to cut, erase, and navigate through the document. Below this final set of icons are two squares, one with a square hole in the middle of it. These define the color of the stroke (the one with the hole in it) and the fill color of a selected object. By double clicking either of these a small box will be opened, known as the 'Fill' color box, where you can adjust the color to anything imaginable. Many of the above mentioned icons actually have multiple options; the ones currently shown are typically the most used. You can change to a different tool by holding down the click on an icon that has a small triangle in the lower right hand corner; if there is no triangle there is only one tool for that icon.

The **Individual Palettes** are located, by default, on the right side of the screen. Since these are user definable you may have to activate a palette by going to the **Menu Bar**, selecting the **Window** menu, and clicking on the desired palette. For the purpose of this article I will briefly go over the palettes that are commonly used for cave cartography. Palettes can be combined or individualized as per the user's desire by clicking on the name of the palette in the top left corner and dragging into another palette or out of an existing palette. Each palette is unique in that it controls a varying aspect on the **Canvas**; since there are so many options only the most popular are shown by default. In order to display all available options for a palette the user must click on the small arrow in the top right corner of the palette. By default the **Stroke** palette is visible and is used to modify the attributes of a selected line or path. The **Layer** palette is extremely useful because it gives an ordered listing of the layers of your document. The importance of layers will be discussed in further detail below. The final palette I find of great importance is the **Symbol** palette. The **Symbol** palette is useful when there is an object that is used repeatedly. In order to add a new symbol to the **Symbol** palette the user must select only the drawn object and drag it over to the **Symbol** palette. This allows for a quick creation of any number of symbols. The symbols then

can be saved for future use or to upload to the internet for communal sharing. To use the newly created symbol or an existing symbol the user simply clicks on the desired symbol and drags it into place. It is important to remember that since the **Individualized Palettes** are user defined they can be adjusted at anytime. If you find yourself using the **Menu Bar** frequently, look at the available palettes for shortcuts.

The last of the four main elements of the *Illustrator* workspace is the **Canvas** which displays a number of facts about your document. At the top is the name, current zoom, and color format of the document. The bottom has a drop down menu for changing the zoom and another drop down for displaying certain characteristics of your document. Finally, at the bottom and on the right are scroll bars that allow you to navigate to a location within your document.

Setting up a Document

To start a new map project, go up to the **Menu Bar**, select the **File** menu, and click on **New**. A small window opens and asks you to name your file and select a few parameters. I typically do not change anything until the map is finished since I can always modify these settings later by going up to **File** and clicking **Document Setup**.

The next basic step in creating a cohesive cave map is creating and setting up varying layers that can handle all of the symbols, shapes, and objects that are required in a cave map. Layering your drawing allows you not only to organize your map but also to create a hierarchy of the symbols, shapes, and objects within the document. New layers can be created by using the **New Layer** button on the **Layers** palette of the **Individualized Palettes** (Figure 2). The layers can be reorganized by simply clicking and dragging them above or below their current position. It is also important to name any new layers in a logical fashion since you will more than likely be turning layers on and off throughout the drawing process. The layer
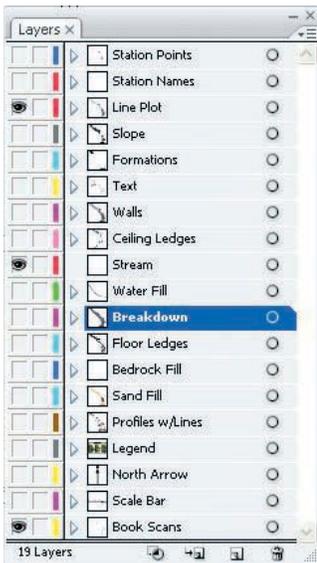
Figure 2: The Layers palette displays all user created layers; remember that layers high on the list will appear on top of those that are lower on the list. Each layer is assigned a color, which can be changed, that allows for easy identification while on the Canvas.

system within *Illustrator* allows the user to decide which pieces of the map should be most prominent and what shapes, symbols, and objects should appear on top of others. What this basically means is that if a symbol is in the top end of the layer order it will appear on top of a shape that is in the lower end of the order. This is useful because in a cave map you will more than likely have symbols and drawings on top of one another. It is important that the user decide for themselves how many layers they want to use and what order the layers should be organized. Keep in mind, the more layers means the more control in your final product. For a typical cave map I use a nineteen layer system (Figure 2). When deciding your layer order it is important to remember what needs to be seen in your cave map. For example, you would not want to place any symbols for slope or formations lower than a fill layer because the fill layer would cover up the symbols. Like much of *Illustrator* these ideas and considerations simply take time to develop.

The Line Plot and Proper Scaling

Importing a line plot from your current cave survey management program will not be discussed due to the variety of techniques available to you. However proper scaling of your line plot and map sketches can prove to be extremely valuable and is therefore worth

mentioning. Once your line plot has been imported into its proper layer, it is time to import your in-cave sketches. It is important to remember that if you do not practice an accurate sketch to scale technique while underground this method will not work for you. Instead of the following method, you will have to print out your line plot at your desired scale and draw the walls around your line plot. You may then scan the line plot with the walls, import and trace them into *Illustrator*, and then fill in the detail of the cave on the computer. However, assuming your sketch to scale technique is highly developed, it is rather easy to transform your hand drawn sketches into a traceable object in *Illustrator*. Simply scan your book pages onto the computer and save them as a .jpeg file. You can import these .jpeg files into *Illustrator* by going to the **Menu Bar** and selecting **Place** from the **File** menu; the images of your book pages will stay the same size as your original ones when you import them. The
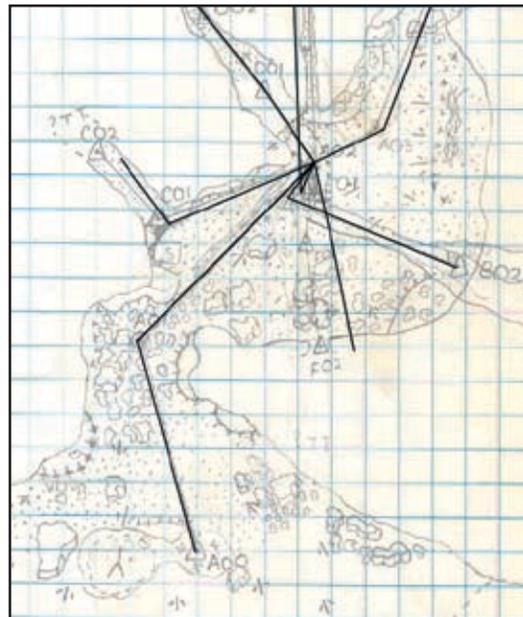

Figure 3: With the layers properly set, it is easy to scale your book sketches to match the line plot. The exactness of the match between the sketches and line plot will vary based on the cartographer's own sketch to scale technique.
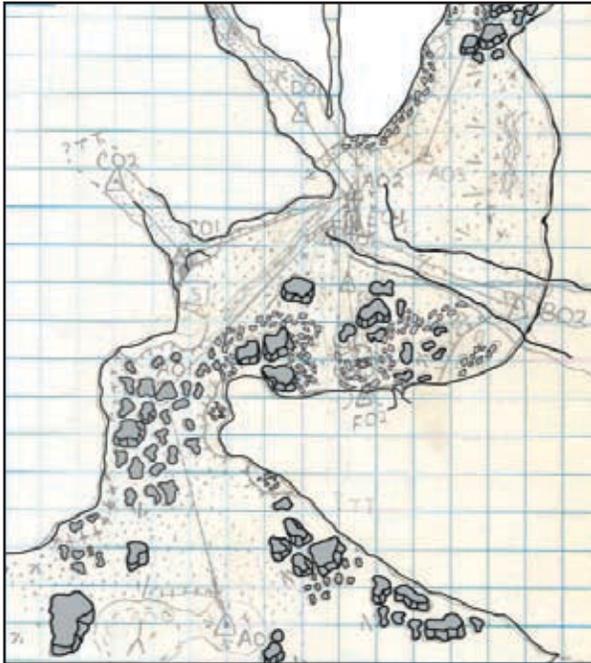
Figure 4 (above): With Illustrator, you can very easily trace your original book sketches to recreate your map. I typically draw the walls first then begin drawing large objects, like the breakdown seen here.

Figure 5 (right): The 'Fill' color box can be found at the bottom of the **Tools Palette**.

breakdown (Figure 4). When tracing the walls of a cave it is important to try to draw one long continuous line, however this can be difficult if your map is large enough to require zooming. To alleviate this, when adding onto an existing line, simply overlap the previous line with the new line; *Illustrator* understands this as continuing an already established line rather than making a new line. The thickness, or weight, of lines can be changed by using the **Brush** palette on the **Individualized Palettes**. Typically the walls of a cave are thicker than any other line on the map; this draws attention to the map and gives the map a nice clean look.

Fills are used when applying color to a drawn shape. In order for the color to be evenly distributed the line that defines the shape must be a solid line. A fill color can be added to any solid shape by merely selecting the shape and double clicking the 'Fill' color box on the **Tools Palette** (Figure 5). When attempting to fill the entire cave with color you can simply copy all of the walls and place them in another layer, labeled appropriately. Join any open ends by either overlapping the lines or using the join command, found on the **Menu Bar,** and then filling the new shape with the desired color. Remember to keep the walls layer above the new fill layer or else you will be unable to see the walls when the fill in turned on.

Creating Symbols and Brushes

Symbols and brushes are extremely useful for representing cave formations and features such as stalactites, stalagmites, slope, ledges, and domes, just to name a few. The initial creation of symbols and brushes can be grueling; however once they are created they can be saved so that each time *Illustrator* is opened they appear.

better your sketch to scale technique the easier it will be to match your drawings to your line plot (Figure 3). However you can stretch the images to match up to the properly scaled line plot if necessary. In order to ensure the vertical and horizontal relationship of your drawing is not tainted during the scaling process, make sure you only stretch the image by clicking in one of the four corners and holding down the **Shift** key as you drag. This method ensures that you do not accidently stretch the image more across the horizontal plane than the vertical plane, or vice versa.

Basic Drawing and Fills

Once the line plot and original sketches are scaled properly, it is time to start the arduous task of using a mouse to redraw your original in-cave sketches. Most of this process can be completed by simply tracing the existing lines and shapes from your in-cave sketches and placing symbols at the appropriate locations. The 'Pencil Tool' or 'Pen Tool' (found on the **Tools Palette**) can be used to trace walls and large pieces of

The first step in creating a symbol is to draw the desired symbol using either the pencil tool, line tool, or some other drawing tool from the **Tools Palette**. When drawing your symbols make sure it is exactly how you want because once the symbol is created it cannot be edited, other than to resize it. Pay particular attention to the stroke weight of the lines, which can be adjusted by using the **Stroke** palette on the **Individualized Palettes**, and make sure they are appropriate for the symbol's size. Once you have created the desired symbol you can simply select all the parts of the symbol together and drag it in the **Symbols** palette on the **Individualized Palettes**. The symbol can be named appropriately by clicking on the 'Symbol Options' button in the **Symbol** palette. With the symbol created, you can now drag the symbol from the **Symbol** palette onto any location on the map.

Brushes are useful for when there is a particular style you want to apply to a line within your map; brushes would be typically used for depicting ledges and domes. Like symbols, brushes can be time consuming to create but very helpful since they are saved and can be used each time *Illustrator* is opened. For instructive purposes and to demonstrate the basic technique what follows is an explanation of how to create a ledge brush. First use your line tool, found on the **Tools Palette**, to draw a short (roughly two centimeters)
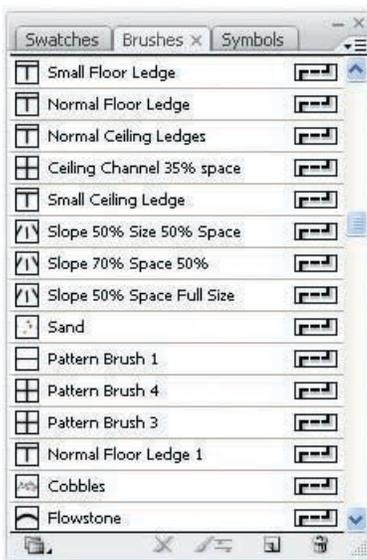

Figure 6: The Brushes layer will display all of the available brushes; remember to name them appropriately. The brushes will be saved so that each time you open Illustrator they will appear.

straight line. Continue with the line tool to draw small vertical lines (hash marks) perpendicular to the previous line. Repeat this as necessary to create a short version of the standard ledge symbol, making sure to space the hash marks evenly. Remember to pay attention to the stroke of the lines; too fat and the hash marks will blend together, too skinny and lines will go unnoticed. Once finished, select all of the newly drawn lines and open the **Brushes** palette on the **Individualized Palettes**. Click the 'New Brush' symbol (Figure 6) on the bottom of the **Brushes** palette; a small window will appear with four options. Select the 'New Pattern Brush' option. Your new brush will now be shown as an option, which can be labeled much like a new symbol. It is important to remember that pattern brushes are directional, meaning that the direction of the hash marks will change based on the direction from which the line is drawn. Try drawing a ledge from left to right; note what direction the hash marks are, then draw the same line from right to left (Figure 7). A brush style can be added to an existing line by selecting the line and clicking on the desired brush in the **Brushes** palette.
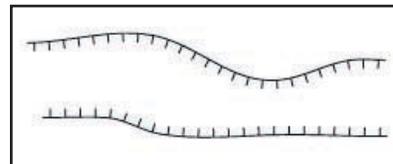

Figure 7: Pattern brushes are directional; these two lines were drawn using the same brush except that they were drawn from different directions. The top line was drawn left to right; the bottom line was drawn right to left.

The Use of Color

Color can play a large role in understanding a cave map, especially for the inexperienced or amateurish onlooker. When deciding on color choices it is important to ask yourself whether adding color to your map will enhance or detract from the overall map. Also if your map is not going to be viewed or printed in color it may be less important to apply a particular color to a particular object; instead you may
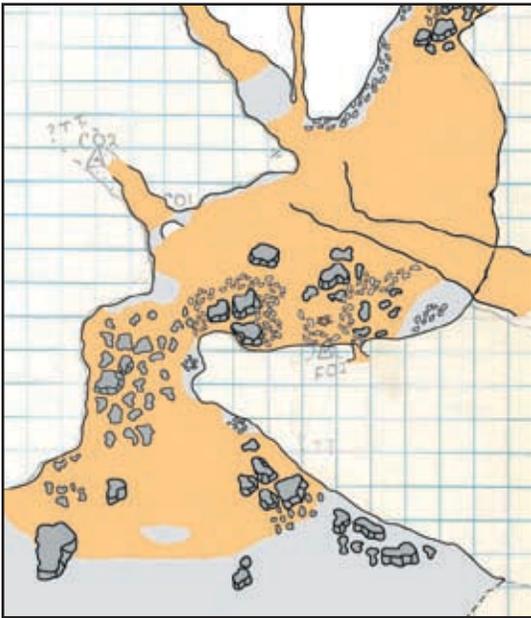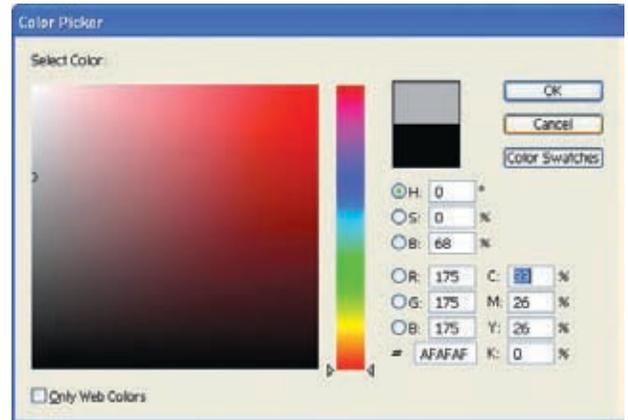
Figure 8: The use of color can help enhance a map's readability if used logically. Here the brown color simulates a sand or dirt floor, the light grey is used for bedrock floors and ledges, and the dark grey can be used for breakdown.

all, it is better to have a black and white map than one that is distractingly colorful.

Adding Text

One of the last bits of information that is typically added to a cave map is textual characters; these can be added by using the type tool found in the **Tools Palette**. The type tool works just like a text box tool in

want to pick colors that contrast sharply rather than blend together. If you are fortunate enough to be able to produce a full color map, choose your colors wisely. The logical use of color will not only enhance the map but also help an onlooker to understand the map better. For example, brown or tan is an excellent choice to show a sand or mud floor and grey is best used for a rock floor or breakdown (Figure 8). Water can easily be recognized by using a blue color. Choosing an easily recognizable color for a shape or fill may be a better choice, especially if you are creating a map without a legend or if the map is going to be viewed by individuals who do not have prior knowledge of standard cave survey symbols. When applying color to multiple similar objects, such as breakdown, it is important to stay uniform throughout. Each color that is created in *Illustrator* is assigned a unique six digit identification that can be used to reproduce the same color continually. It is a good idea, once you find colors that you like, to record the six digit ID for later use (Figure 9). Remember that in some maps adding color can detract from the overall purpose of the map; after

Figure 10 (right):
The information
found in the title
box will vary based
on the individual
cartographer. For
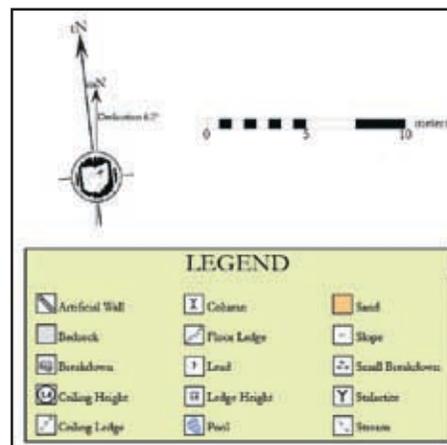*uniformity, remember*
to use the same font
throughout the map.

Figure 11 (left):
Here examples of
a north arrow, scale
bar, and legend are
shown; again these
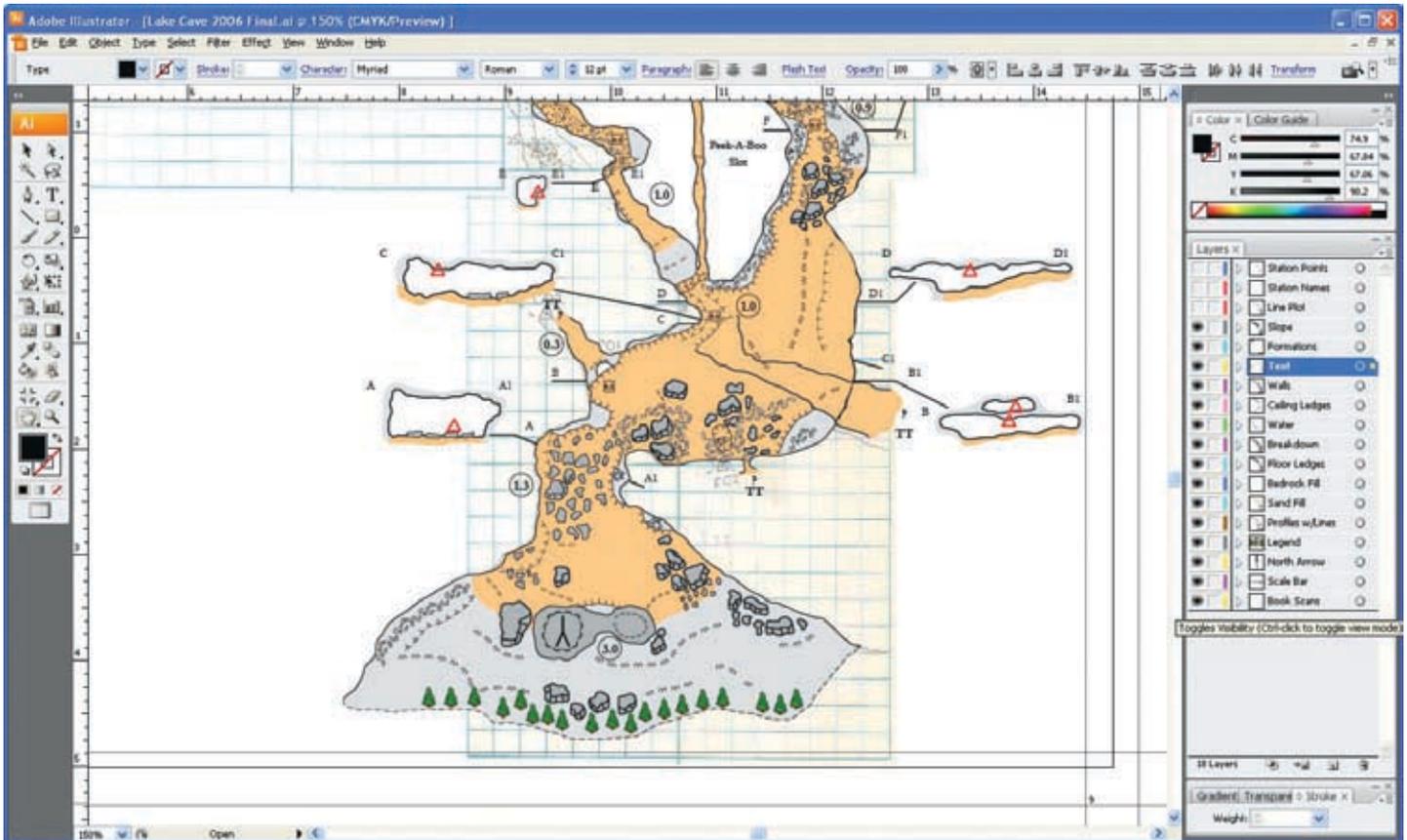*will vary by cartog-*
rapher.

Figure 12: Obviously, each map will be different once completed but it is important to preserve the maps' readability and function.

Microsoft Office in that it allows you to create a box in which you can type. The box can be adjusted for size, outline color, and fill color, as can the text found inside the box. In order to maintain consistency throughout your project make sure all text found on the map is the same font and all similar text objects are the same size. All of these options can be modified in the **Menu Bar** of *Adobe Illustrator CS 3*. The amount of text on a particular map can vary based on the size of the map and cartographer's preference. It is important not to overwhelm an onlooker by having too much text. You also can use text to indicate the location of entrances, unique speleothems, and areas of the cave that are too tight for human travel. Obviously each map will have a title but the amount of information included with the title will vary (Figure 10) based on cartographer and available space.

Final Thoughts and Considerations

The same techniques used in drawing a map can also be used to create other map–related objects, such as legends, north arrows, scale bars, and logos (Figure 11). However, when creating these objects make sure they do not distract from the map itself. The design of these elements and that of the cave is only prohibited by the cartographer's imagination.

You now have a very basic tutorial of how to begin digital cave cartography. Obviously this should only be considered a stepping stone and not a complete how to guide, as it would be close to impossible to write out all the necessary steps to draft a cave map fully. Much of the techniques and shortcuts needed to draft a map efficiently come only with practice and time. The best way to learn these skills, if possible, is by talking to a seasoned digital cave cartographer or at least someone who is familiar with *Adobe Illustrator*. A good substitute however can be found on the internet; for more

information on tutorial videos and guides please see the **Notes** section.

Notes

All screen images used for this article were taken from *Adobe Illustrator CS 3* by the author. The map shown in the images is Lake Cave in Carter County, Kentucky.

For more information on *Adobe Illustrator*, including how to purchase, please visit Adobe's webpage at http://www.adobe.com/.

For up to date information on all aspects of cave survey please visit the survey links page of cavediggers.com at http://www.cavediggers.com/caving.html#Space. The following is a list of useful numbers and topics that correspond to that page:

1. Visit the InCaveDigitalSurvey.com Online Discussion Board

This is a link that will redirect you to a forum of cavers that specialize in all aspects of in cave digital surveying. They can be very useful and informational. In order to ask a question you must be a member, however membership is free.

11. Illustrator Library download (1'-90' Ceiling Heights and Pit Depths .zip file)

This file is a user created set of symbols for ceiling heights and pit depths, the numbers are whole numbers and each is inside either a square or circle as needed. This file is freeware.

43. Adobe Illustrator for Cavers (QuickTime)

This is a link that will redirect you to Brandon Kowallis' website. Here you will find a very good set of tutorial videos that deal specifically with using Adobe Illustrator to draft a cave.

55. Here Be Dragons by Jeff Bartlett (PDF)

This article was written by Jeff Bartlett of Little Rock Grotto; in the article Jeff explains Adobe Illustrator and how he learned to be proficient in its usage.

References

Kissell, Kevin, Polly Bargar, Kate Ferguson, Linda Oxenrider, Aaron Taylor, and Christy Taylor. 2007. Lake Cave, Carter Caves State Resort Park, Kentucky. Pholeos, 25(1): 24-28.