Virtual Mapping, Three River Hills

Virtual Mapping Exercise, Three River Hills

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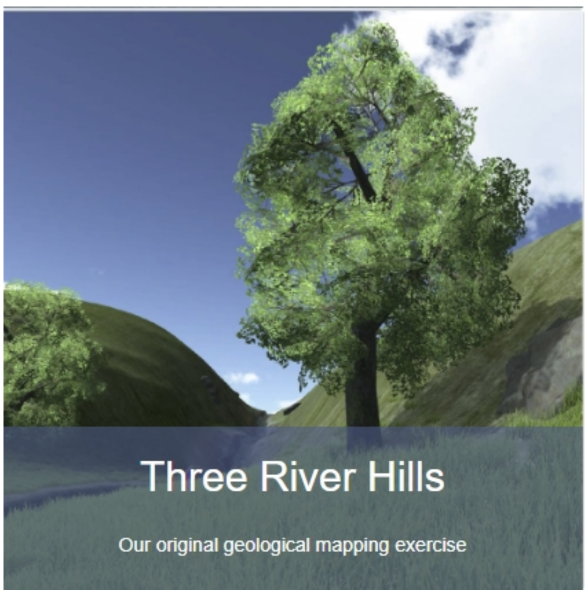


Summary:

Our second virtual mapping exercise builds on the first, but contains a more complicated geological puzzle to solve. The virtual landscape is much larger, with a base map that does not show outcrops. To complete the mapping in the time we have, we will map only a small part of it. The pop-up compass and GPS instrument are still there for navigation, but this time you will plot the outcrops on your base map rather than simply navigating to them. As before, after mapping all of the outcrops and symbolizing the observation from them, you will have what you need to complete a geologic map (either on paper or in PowerPoint) and a stratigraphic column. The additional challenges for this project are a cross section and a brief write-up of the geologic history. The latter is a chronologically ordered, sequential list of events (e.g. deposition, metamorphism, uplift, intrusion, faulting, folding, etc).

I. Instructions

- Please download and unzip the provided zip file (328 Mb; Three River Hills program and its supporting files. Unzips to ~750Mb).
  - ***If your computer is running Microsoft Windows***, run the executable (.exe) file for either the 32- or 64-bit version of *"GeoMapping_PC_xx.exe"* (check your Windows>Setting>About: "System type" to determine if you have a 32-bit or 64-bit computer) and see how it works.
  - ***If your are using an Apple computer with an operating system that is not "Catalina"*** (click the Apple icon at the top of the screen and open "About" to find out), you will instead open the *"GeoMapping_Mac.app"* program. See the instructions for disabling the security settings that might keep it from running. *If your Mac is running Catalina it will not run the program directly from a click on the .app*. The work-around is to install a free, 14-day trial version of CrossOver, a program to run Windows programs on a Mac with the Catalina OS. To do so successfully see the video that walks through the steps.

- ***The program does not run on mobile devices, even within a browser window.***
- Download and read the "Description of Project and Deliverables". Please read this document BEFORE arriving online for virtual trip.
- Print two or more copies of the Three River Hills base map (PDF). You will also want to print a few copies of the cross section template (PDF). Those without printers, or those wishing to map digitally, can instead work with this PowerPoint version of the map and of the cross section. To do so you will need to know how to use the drawing tools, how to rotate objects, copy, paste, etc. in PowerPoint. Most of these functions are demonstrated in a short video.
- Please test the software before the weekend and contact you instructor if you can't get it working.

II. Learning Objectives

- Develop a sense of how geologic outcrop mapping proceeds, from studying base maps to derive a strategy, to executing and modifying strategies as mapping proceeds
- How to record field data with symbols on a map - including faults and folds, rock types, strike & dip of planar fabrics and contacts
- Understanding how to make mapping predictions when building a map from limited field data
- How to develop multiple working hypotheses while mapping
- How to use strike & dip, rule of V's and strike lines to test mapping hypotheses
- How to complete a geologic map from a limited amount of data
- How to use surface data to construct a cross section
- How to use a map and limited field observations to reconstruct a geologic history

III. When

IV. Supporting Materials

- Presentation of Project (PDF)
- Mapping with PowerPoint (MP4, 11 mins)
- Base Map (PDF)
- Base Map in PowerPoint
- Map Symbols
- Cross Section Template
- Cross Section Template in PowerPoint

V. Deliverables - see the handout for details

1. A completed geologic map and map key
2. A stratigraphic column of the rocks units
3. A cross section
4. A geological history, in the form of a chronologically ordered lists of geological events

VIRTUAL TRAINING ENVIRONMENT FOR THE COLLECTION AND RECORDING OF FIELD DATA ON A FIELD SLIP

Explore the landscape. As in real life rivers should be crossed at bridges.

At your disposal is a GPS Handset (G) and Compass (C) to help you navigate.

Click on outcrops to see the field notebook; you need to be close to the outcrop for interaction.

Record the data in pencil onto the field map - you will need to interpret as you go.
Just as in the field, you need to plan your route between outcrops to accurately complete the map

INSTRUCTIONS

Arrow Keys or **WASD** keys - to control movement

Mouse - to control head (where you are looking at)

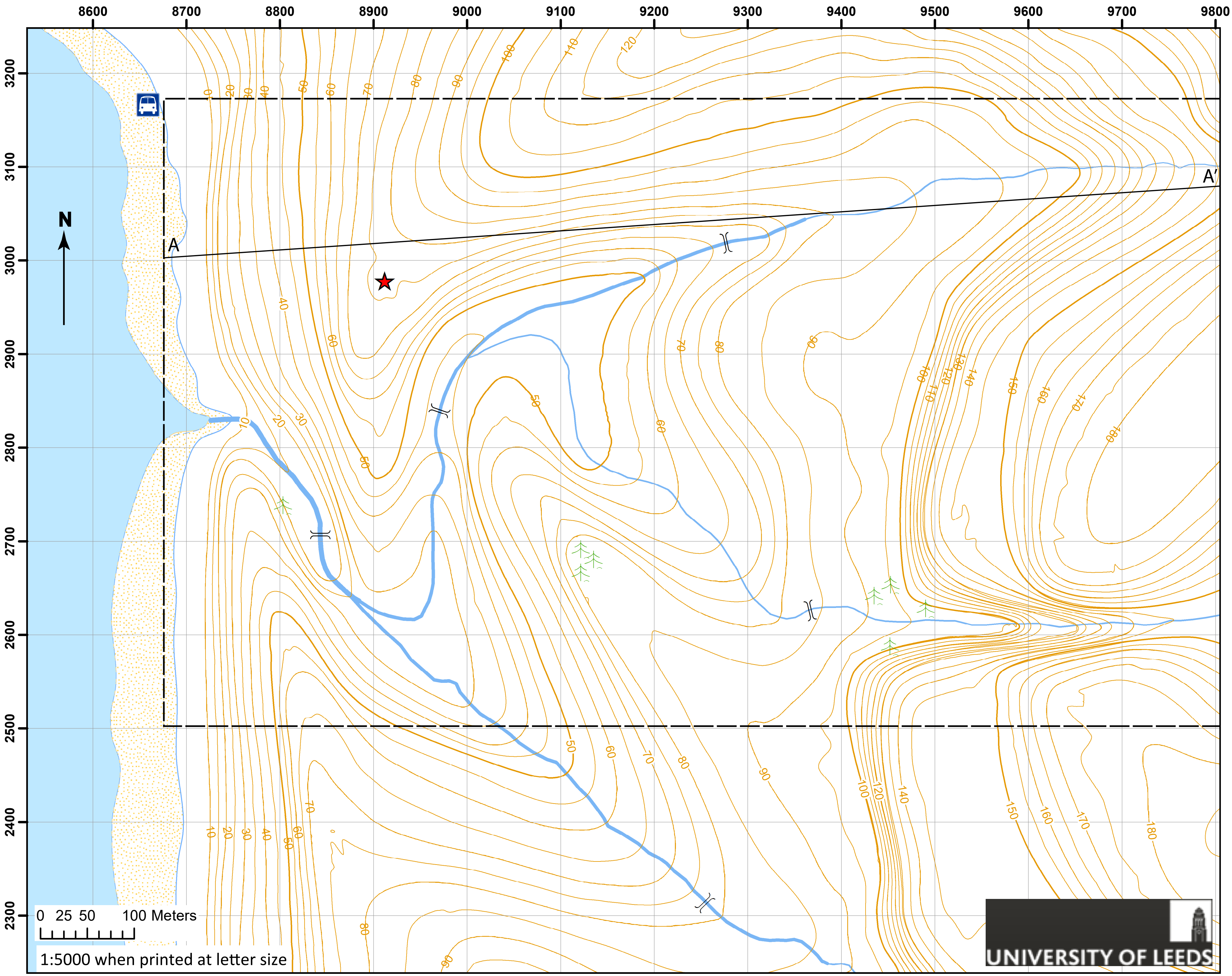
Space Bar - Jump

G - Toggle GPS on / off

C - Toggle Compass on / off

Click on Outcrops when nearby to get field notebook. The notebook can be dragged around the screen

http://www.see.leeds.ac.uk/virtual-landscapes/demo/



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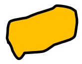
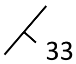
UNIVERSITY OF LEEDS

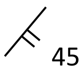
Three River Hills Map Symbols

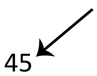
 Rock outcropping

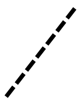
 Strike & dip of bedding

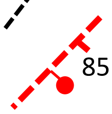
 Strike & dip of overturned bedding

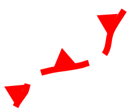
 Horizontal bedding

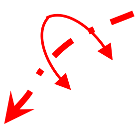
 Strike & dip of foliation; cleavage or schistosity

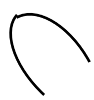
 Plunge & trend of cleavage - bedding intersection lineation

 Contact, dashed where inferred

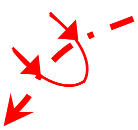
 Normal fault; ball and bar on down side, dashed where inferred, showing dip

 Thrust fault or ductile shear zone; teeth on up-thrown side, dashed where inferred

 Axial trace of plunging overturned anticline, showing vergence and plunge



fold shape in profile

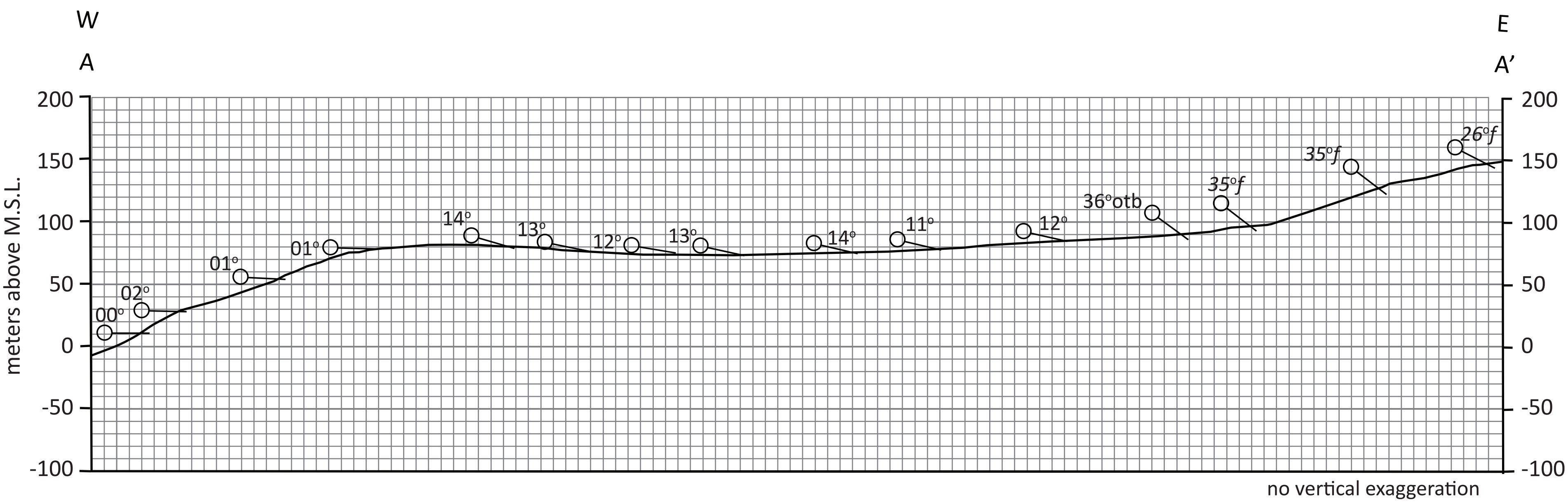
 Axial trace of plunging overturned syncline, showing vergence and plunge

fold shape in profile

Name

Date

Cross Section A-A’, Three River Hills Map Area



12° Dip of bedding

36° otb Dip of overturned bedding (otb)

35° *f* Dip of metamorphic foliation (*f*)

Fault, dashed where inferred, showing slip sense

Depositional contact, dashed where inferred

M. Helper, 4/17/2020

Virtual Mapping Exercise II: Three River Hills

(with special thanks to the Virtual Landscapes team at University of Leeds)

Equipment**:**

- Colored Pencils
- 0.5 mm Pentel pencil and eraser
- Drafting pens (2)
- Field book

- Protractor

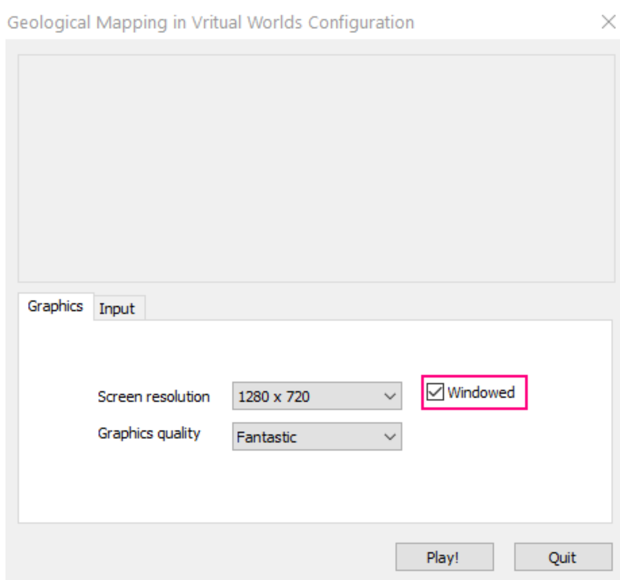
You will also need:

- Metric ruler
- Calculator
- Two or more printed copies of the *Three River Hills* base map AND the cross section template at the front of this document. Print the map in landscape mode and the cross section in landscape mode on standard letter size (8.5x11 in.) paper. Do not "shrink to fit" or use any other printer sizing option. Print it at full size. **Printed version of the base map and cross section are exceptionally useful for this exercise**. If you don't have a printer and have the wherewithal, explore a local printing service (e.g FedEx, UPS, Staples, Office Depot, Walgreens, etc.) before the weekend. Most cities have deemed these essential businesses so they remain open. Most have websites that permit file uploads so that your copies are waiting for you when you arrive.
    - **Important**: Use only the base map provided, which has been resized to print on standard letter size paper. The one that can be downloaded from the Virtual Landscapes web site is for A3 paper (huge; we are mapping just a portion of the entire landscape) and when shrunk to letter size is no longer 1:5,000 scale.
- An alternative to working on paper involves using the PowerPoint versions of these documents. Using them will require that you properly use the drawing ("Insert Shape") options in PowerPoint, including drawing and symbolizing lines and polygons of different sorts. You will also want to be familiar with how to cut, paste, edit and rotate the pre-made symbols (faults, fold axial traces, etc.) that are provided for this project. If you have the option, you might want to try both the paper and digital versions, using paper for your "field" copies and PowerPoint for your final products. A short video of how to use the drafting tools in PowerPoint is available.

Software/Hardware:

- The software for PC and most Macs is provided in a zip folder. Once unzipped, there are executable program files for 32- and 64-bit PCs and Macs ("*GeoMapping_PC32bit.exe*, *GeoMapping_PC64bit.exe* and *GeoMapping_Mac.app*"). The zip file ("standalone version") can also be downloaded from: https://www.see.leeds.ac.uk/virtual-landscapes/demo/index.html. **There is no version that runs on a Mac using the (newer) Catalina operating system, which will not run 32-bit software**. To operate in Catalina, download and install a free 14-day trial version of CrossOver, which lets Catalina OS Macs run the 64 or 3-bit PC version. A short video of how to download and install CrossOver is provided.

- Open the program by a double-clicking on one of the file name listed above. On startup, an initial window allows a choice of how to display the game. The settings below worked well on my computer:



Running it "Windowed" (red box above) will allow you room for a second window to run video conferencing software (e.g. Zoom). If the program runs slowly restart and adjust the Screen resolution/Graphics quality to a lower value. You can also change the navigation keys in the "Input" tab.

- **The program will not operate in a browser on a mobile device (iPad, phone, etc)**.
- A mouse or joy stick is helpful**.** Otherwise, landscape navigation requires use of both your keyboard and touch pad, a slower experience for all but the most dexterous.
- Optional: PowerPoint or other vector graphics software (e.g. Inkscape, Illustrator, AutoCad, etc.) to map with. This exercise is designed to be completed on paper ***– this is not an exercise in learning to use graphics software***. If you don't already have (and

know how to use) graphics software, do this exercise on paper, carefully scan or photograph your results, and submit it as you would a lab exercise.

Deliverables (four components):

1. A completed geologic map that includes:
    a. The trace of all unit contacts, shown with dashed lines where inferred and solid where exposed, in ink. *Unit contacts that are faults require a thicker line weight* than those that are depositional or intrusive. Use your thicker pen for these.
    b. Properly plotted symbols of strikes & dip (see symbol key below) for all outcrops, in ink. This includes separate symbols for bedding and foliation (i.e. cleavage or schistosity).
    c. Axial traces of folds (see symbol key), in ink.
    d. Lightly colored units with inked unit abbreviations. You can create your own abbreviations (e.g. lPz_{Ss1} for lower Paleozoic sandstone 1, J_{lm} for Jurassic limestone, etc.)
    e. An accompanying map key, in ink, that shows:
        i. a labeled & colored box for each unit, *stacked in proper order from oldest at the base to youngest at the top*
        ii. a symbol key, like the one provided below, that strictly shows the symbols that appear on your map.
2. *On a separate piece of paper*, provide a stratigraphic column, like that in your map key (but with larger colored boxes; *see the example below*). To the right of each box include a short, written description of each unit compile from the outcrop field notes and sketches. These should not include strike & dip values. You should compile these in your own field book as you walk the landscape and discover the outcrops.
3. A cross section, A-A', *using the provided template*, with colors that match the map, and with the symbols and dip data that are provided in the template. Rock unit contacts should be continued as dashed line (of appropriate thickness) for a short distance above the topographic profile. Add color to the units below the topographic profile, but not above.
4. A geologic history in the form of a chronologically ordered, numbered list or "sequence" of events recorded by the rocks. **Make your list with the oldest event at the bottom and the youngest at the top.** A purely hypothetical example is:

    4. Erosion to produce the modern landscape
    3. Uplift associated with intrusion of granite
    2. Burial of sediments and accompanying metamorphism to sillimanite grade
    1. Deposition of shale, sandstone and limestone in both marine and nonmarine environments

Neatness and clarity count – you are presenting a professional product

Directions

This is a mapping video game. You navigate a virtual landscape to “collect” outcrops and their field notes, recording your observations and progress on a base map and field book as you go. A pop-up compass and GPS instrument help you navigate, locate, and plot the outcrops and data as they are discovered. A provided key (see below) indicates which symbols to use for different data. Having recorded everything on the base map and compiled the field notes, you have the information you need to complete a geologic map, interpret the map pattern with symbols and complete a stratigraphic column. Making a geometrically sound map from the sparse data requires good reasoning skills and attention to all observations. Rule of V’s concepts and strike lines are also important.

Note that unlike the last exercise, we are mapping only a small portion of the virtual landscape – therefore, like the real world, it is possible to wander off your map and get lost! Too bad reality doesn’t let us reboot and start over… Entering the van parked on the beach will teleport you to second van *off of the base map* in the SE corner of the virtual landscape. Entering that second van will take you back to the beach.

A. Gathering field data

1. Get the software running and become familiar with the navigation keys (see page 3 of this handout). Your point of entry is shown by the red star on the base map. The avatar on the rock in front of you is for scale only; she is not interactive.
2. Study your base map and decide where to go. Rivers must be crossed at bridges (indicated on the map) and there is a coastline and other features to navigate. You need to visit all outcrops but need a strategy to do so. Where are they most concentrated? Is there a predominate dip direction? Your strategy should be enable discovering as much as possible about the geology in the shortest time. Note the cross section line – you will need data along this line before you finish.
3. Open the field book at each outcrop. Most contain a sketch of the outcrop, rock descriptions, and a strike & dip of bedding and/or cleavage or schistosity. While at the outcrop, hop up on the outcrop (space bar), take a GPS reading, and plot the outcrop where it belongs, scaled in size to 1:5000 (1 cm=50m), on your map. We will assume that all outcrops are at least 10m (2mm) in minimum dimension. Some may be considerably larger. Plot the strike & dip on the base map at the outcrop, then choose the appropriate color for that rock unit and shade the outcrop with colored pencil. If an outcrop contains a contact between two units, then use the appropriate colors to shade two halves of the outcrop.
    a. You will find it useful to place the rock units, and notes about them, in a properly ordered (oldest at the bottom, youngest at the top) stratigraphic column ***as you map***. Be systematic in your note taking, recording or screen capturing notes at each outcrop. It is useful to link your notes to an outcrop number, so number the outcrops as you map them.

4. Use the GPS and compass when needed to navigate. **Do not blithely go from outcrop to outcrop collecting data**. After visiting several, try building a mental image of the geometric and stratigraphic relationships as you record new data on the map. **Keeping a working sketch cross section and a developing strat. column in your notes really helps; it will be a necessity for understanding the geology in this project**. This is what accomplished field geologists do.
    a. As you place data on the map ask: What is the stratigraphic sequence so far, from oldest to youngest, based on the notes and dip direction? What do I predict I'll find at the next outcrops to the north, south, east or west?
    b. With some data already plotted, what do the Rule of V's and strike lines predict about what should be found at each outcrop? Draw preliminary contacts and test these predictions by finding outcrops that could be used to test your "educated guess" for the contact location. Repeat this process.
    c. If your predictions aren't confirmed by your new observations (data), you must ask why. Can you discover your error(s) in logic or, if your logic is sound, can you come up with another testable hypothesis that explains the data? The game is far more interesting once it becomes an intellectual exercise of this sort. For many, the joy and pleasure of geologic mapping comes from solving just these sorts of puzzles.

B. Finishing the map

At this point you'll have visited all outcrops, mapped them in color and plotted strikes & dips on the base map. Your next job is to predict where rock unit contacts belong in areas where no rocks are exposed, and to draw them in with dashed lines. Examine the data carefully:

- Where are the oldest rocks? Where are the youngest rocks? Is the stratigraphic sequence repeated, either entirely or partially? If there is repetition, is it accompanied by changes in dip direction? Dip amount? Strike? Do rock unit thicknesses change dramatically?
- What does your working sketch cross section show? What does your working strat. column show? Where are the problematic areas, the stratigraphic breaks on your map, that demand an explanation?
- Are metamorphic rocks present at the top or bottom of the sequence? How might their locations be explained? Metamorphism requires post-depositional burial; metamorphic and igneous rocks are therefore normally **found at the base** of stratigraphic sequences. Contacts with overlying, unmetamorphosed rocks are, in the simplest situations, nonconformities. Is that what happens here?
- Where does the type of metamorphic foliation change (from cleavage to schistosity) and the rocks become garnet-bearing (=higher temperature metamorphism)?
- Can you recognize a pattern to the distribution of rocks types perpendicular to strike? Parallel to strike?

- What does the rule of V's predict?

You will need fine lines and small symbols to capture the details in some parts of the map area. Carefully draw and erase, draw and erase until you get a map pattern that makes sense for the distribution of rocks types, the topography, AND the strike & dip data. This is your first "educated guess". It can then be refined by constructing strike lines on contacts where contacts are exposed. Strike lines can still be used as a guide to help with visualizing rule of V's and providing general constraints, but they will not yield a uniquely accurate solution in this exercise. Thus, when extending contacts away from outcrops use the following rules:

- Rule #1: Contacts must pass through outcrops where they are exposed, even if strike lines predict they should not.
- Rule #2: Contacts must obey the rule of V's for dipping rock units, even if not precisely of the shape your strike lines might indicate
- Rule #3: Make it work using trade-offs between where contacts are known to exist and where strike lines predict they should. We are using dash lines - these are understood to be INFERRED contacts using our very best guesses.

Finally, if you have identified folds from the repetition of units and from strike & dips, they must be interpreted on the map by showing the location of their axial planes with an appropriate axial trace symbol. The axial trace symbol is like a contact – it shows the intersection of a plane (in this case the axial plane) with the ground surface. Like contacts and faults, dipping axial traces must obey the rule of Vs.

Once finished in pencil, go over your lines and symbols with a drafting pen, then lightly erase the pencil underneath. Label the rock units with unit abbreviations (in ink). Shade, very lightly using colored pencils, the rock units to complete the map. Create a rock unit and symbols key.

C. Compiling a stratigraphic column

See the example below; emulate the layout and appearance, but place the written descriptions to the right of the colored boxes. It should be neatly inked and colored, with hand-**printed** or typed text (or, if you're graphic software-proficient, you can finish it that way).

Kdr

Del Rio Clay

Blue-gray to tan gypsiferous, ferruginous, marly shale, 40-60 ft thick (DeCook, 1963); about 45 ft thick in map area. Clays are dominantly illite and kaolinite in unweathered state, but the illite is converted in the weathered zone into plastic montmorillonite. Characterized by gypsum veinlets, pyrite or marcasite, and abundant specimens of <u>*Ilmatogyra arietina*</u>*. Subject to slope failures during construction in the weather zone. Distinguished in the field by predominance of mesquite trees in a clayey soil. Lower and upper contacts readily mappable on air photos. Occurs with Georgetown, Buda and Eagle Ford Formations in a band extending from the northeast to the southwest corner of the map area.*

Kgt

Georgetown Formation

Light-gray and white argillaceous nodular limestone and tan calcareous shale, 25 to 35 feet thick (DeCook, 1956; 1963). Sharp contact with underlying Person Formation is visible on air photos. Supports oak-juniper assemblage. Occurs with Del Rio Clay, Buda, and Eagle Ford Formations in a band extending from the northeast to the southwest corner of the map area.

Ked

Edwards Group, undivided

In Hays County, upper gray dolomitic, siliceous, massive, honeycombed limestone overlies lower light-gray argillaceous, nodular limestone (DeCook, 1963). Thickness is 430-450 ft in the San Marcos area (Rose, 1972). Divided by Rose (1972) into a lower Kainer and an upper Person Formation, separated by the "Regional Dense Member". Comprises the principal aquifer in the map area and throughout central and southwestTexas. Underlies typical hill country landscape, occurring in a broad band in the west and northwest part of the map area. Supports dense growth of oak and juniper. Dolines and karstic solution features are common.

Example Unit Descriptions. Your descriptions *should appear to the right of each color coded rock unit box*. Note the unit abbreviation in the boxes, which have a capital letter for the age (Period) and lower case for the formation name. *Importantly, the boxes are arranged from oldest at the bottom to youngest at the top*, as they would ideally appear in outcrop.