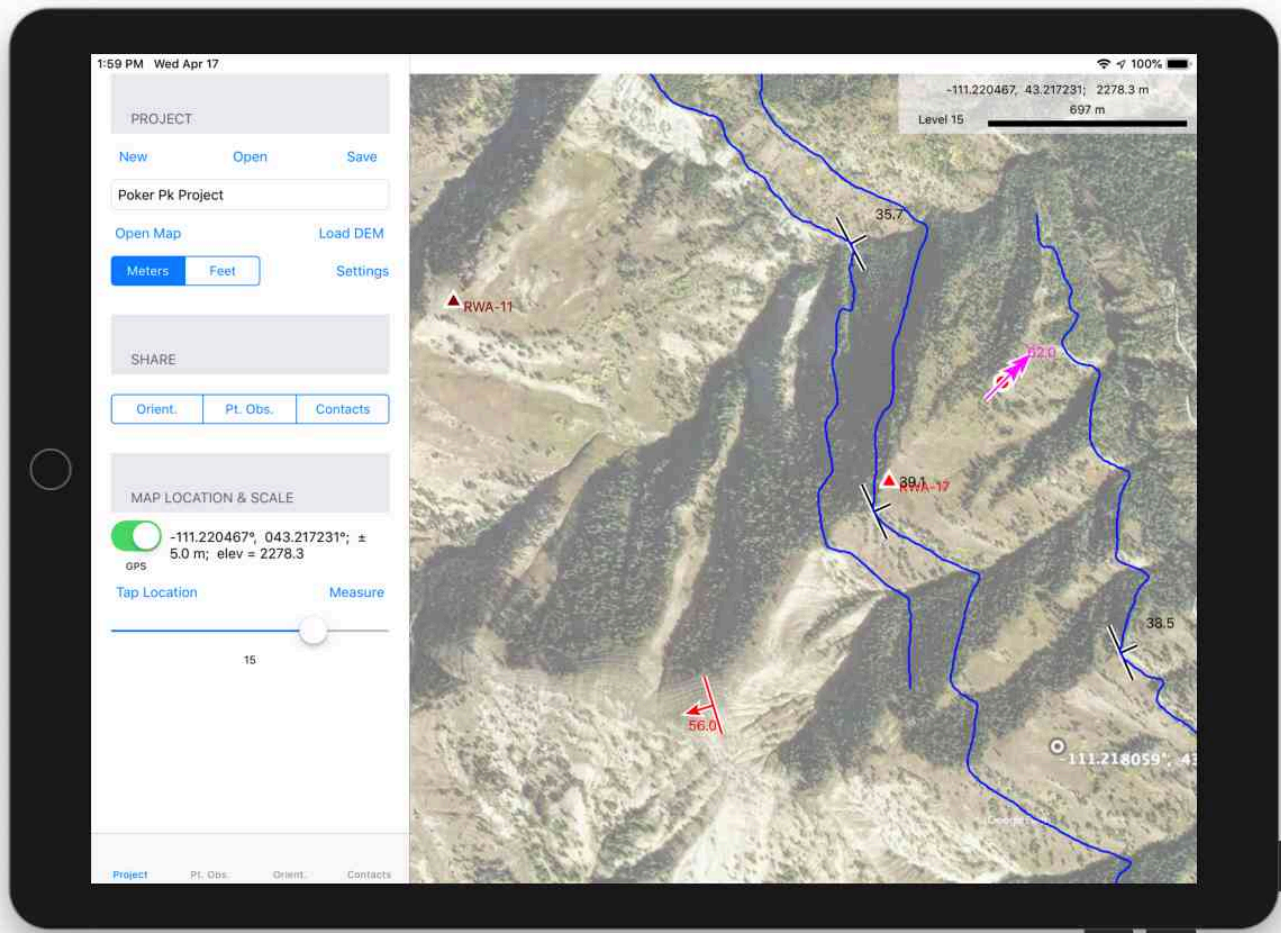# *GMDE Mobile for iOS, v. 1.1*

by Richard W. Allmendinger © 2019

(ALL CONTACTS ON THIS IMAGE WERE PROJECTED FROM 3-POINT ORIENTATIONS WITH JUST 9 TAPS)

(DOWNLOAD THIS MANUAL AND KEEP IT ON YOUR IPAD FOR REFERENCE)

CONTENTS

DISCLAIMER

GMDE Mobile is provided "as is" without any warranty, explicit or implicit. The author will not be liable for direct, indirect, incidental, or consequential damages resulting from any defect in this software or this user's manual, even if he has been previously been made aware of the defect. Furthermore, I make no systematic effort to inform all users of either bug fixes or upgrades. Recall that your iOS device is very sensitive to magnetic fields and the compass bearings can easily be off by 10-20°! Use this app at your own risk. This program should not be used as a sole source of navigation data. This program may not be sold or offered as an inducement to buy any other product.

INTRODUCTION

Most mobile device field mapping software is excellent for locating the geologist horizontally (in X and Y, longitude and latitude, etc.) but does not bring the third dimension, elevation (i.e., Z), into the picture. However, to do significant calculations that can aid the geologist while in the field, you need X, Y, **and** Z.

GMDE Mobile is one of the first mapping programs to allow the user to load a digital elevation model (DEM) for off-line use in the field. This allows the geologist to do realtime calculations in the field where the predictions can be tested, including:

- Project a planar contact across topography, giving the mapper an immediate hypothesis to test in the field as well as improving mapping overall by plotting planar contacts exactly as they should cross topography.

- Calculate orientations from three-point problems, yielding strike and dips that reflect much more accurately the orientation at the map scale rather than the outcrop scale (of course, you can also enter outcrop scale orientations measured with a compass or with the iPad itself).

- Calculate a planar orientation by best-fitting a plane to the vertices of a contact drawn on the map.

- Determine map thickness of stratigraphic units just by tapping a point on the base and a point on the top of the unit.

- Measure slope angle as well as distance.

To perform this magic, the user of GMDE Mobile will need to know or have access to the following skills (use links to go to detailed instructions):

- Download GridFloat DEMs of the area in which they are interested. See <u>additional notes later in this manual</u>.

- Produce base mapping materials (satellite images, topo maps, etc.) in <u>mbtiles format as described later in this manual</u>.

- Upload these large digital files to the iPad that will be used in the field by connecting the iPad to a computer with iTunes software installed on it. Once connected, the user will <u>use iTunes File Sharing to transfer the digital files</u> to GMDE Mobile's document folder.

QUICK START

App Prep

1. **Prepare your map(s) and digital elevation model (DEM)** — Maps are entered as <u>MBtiles</u> and the <u>DEM should be in GridFloat format</u>. You will want to trim your DEM to the size of the maps so that you do not consume excess space on your iPad. I use the MapTiler program from Klokan Technologies to prepare mbtiles but Global Mapper, Move, <u>GDAL</u> and a variety of other programs can also produce mbtiles.

2. **Install the beta of GMDE on your iPad** — You will have to install the Test Flight app from Apple in order to participate in the beta test.

3. <u>**Use iTunes File Sharing to install your map and DEM in the GMDE documents folder**</u> — I know this is clunky but at present that is the only way: hook up your iPad via Lightening cable to your computer, start iTunes, find the iPad icon in the upper left and click on it, then select "File Sharing" from near the bottom of the list. Make sure that your DEM has three files: the .flt binary file that has the DEM but also the .hdr and .prj files. I recommend that you put all of the files into a single folder with the name of your project on the desktop and then drag the folder into the iTunes file sharing window.

4. **Launch GMDE on the iPad and open the map and load the DEM** — Use the **Map** button to open the map mbtiles file and the **DEM** button to open the DEM. The Open, Save, and Clear buttons at the top of the Project Tab pane are to manipulate the project files once you have saved them.

5. **Save the Project File** — the project file saves all of your data as well as the location of your map and DEM files. At present, it is a simple text file that is saved in the same directory as your map mbtiles file. You must tap the **Save** button periodically

to save your results. You can use the **Open** button to switch between different projects.

6. **The Recovery File has your back** — Behind the scenes, every time you press a **Save…** button, GMDE saves your results to a file called "Recovery.txt" and when you first launch the program it will look for and read this file into memory so that, even after a crash, you can get back to work without significant data loss. Although you don't see the file in the program, you can also copy this program out to your computer from iTunes File Sharing.

7. **If GMDE crashes immediately on startup, it is likely that the Recovery file has been corrupted** — If that happens, connect your iPad to your computer and delete the Recovery file using iTunes file sharing. The final version of the program will try to trap this case.

8. **Determine your pointing device** — GMDE is optimized for the Apple Pencil, however, you can use your finger or any other pointing device. If not using the Apple Pencil, you will probably want to change the Tap point offset in the Settings View. Tap the **Settings** button in the Project tab and the settings screen will slide in, covering the map. The screen coordinate system is positive to the right and positive down. For right-handed people using their finger, I suggest setting $\Delta X = -40$ and $\Delta Y = -40$. Taps are recorded when you lift the pointing device, not where you first tap.

9. **You are now ready to enter data!**

Auto-project a Contact

1. **Set the map scale with the slider on the Project Tab or by using a pinch gesture** — Zooming the map works only on integer values of the map level. Thus, you have to move the slide or your fingers a finite distance before the map will jump to a new scale.

2. **Perform a 3 point calculation of bedding orientation** — Adjust the map view so that all three points that you will use are visible. Tap the "Orient" tab, tap the **3-Points** button at top left, then tap on the three points. Note that GMDE records the orientation when you lift the pointer, not when you first tap. GMDE will show you the pending orientation, both on the map and in the text boxes at the top of the screen. If you are satisfied with the result, tap the large **Save Orientation** button at the bottom of the New Orientation section. The orientation will show up in the data table.

3. **Select the new orientation** — You can select it either by tapping on it in the table (the map will zoom to the orientation) or by tapping on it in the map view.

4. **In the Contact Tab, tap the Project from S&D Button in the new contact section** — GMDE will calculate the contact and project it across the topography for about 500 m beyond the two most distant points taped for the orientation. It shows up as a pending contact; if you like the result you can save it.

5. **Contacts, once saved, can be edited** — if the projected contact fits partly but the ends deviate from the actual contact, select the contact, tap the Lasso button, then drag the pointer on the screen to select the vertices that you want to delete. When they are selected, tap the Delete button.

6. **Any selected orientation can be used to project a contact** — This example uses an orientation from a three point problem, but any saved orientation (typed in manually, using the iPad orientation, etc.) can be used to project a contact.

7. **You can also enter a contact simply by drawing on the screen**.

THE APP ORGANIZATION

GMDE is organized around tasks that geologists typically need to do in the field and that organizations is reflected in the tabs at the bottom of the left hand panel (from left to right): (1) manage projects, (2) make point observations, (3) measure orientations, and (4) plot contacts.

In general, the narrow panel on the left is the "control panel" for the app whereas the larger area on the right shows the map and the data plotted on the map. Various commands such as choosing a file, changing program wide settings or looking at the details of a measurement or observation are carried out in panels that slide in from the right, temporarily covering the map. You can always return to the map by tapping the return arrow in the upper left corner of the slide in panel, or by tapping again the same button that produced the-slide in panel in the first place.

In general any entered datum is considered "pending" until you tap the large Save… Button on the appropriate tab. While data are pending, the Save… is displayed in red text; if it is blue, there is nothing to save. Pressing the delete button in each tab will erase data that are pending without saving them; if no data are pending and a datum is selected in the scrolling list, then the entered datum will be deleted along with any associated data (e.g., photos). ***Deleted data cannot be recovered!***

The Project Tab

The project tab is where you manage your data, base maps, and DEM. Note that badges on each tab show the number of observations of that type.

Opens a project that you have already saved. Both New and Open will erase any existing unsaved data

Save a Project. You must give the project a name in the text box

Use to start a New project after working on an existing project. The existing project is automatically saved

Toggle between meters and feet. Data are always recorded in meters

Change project-wide settings

1. Allows you to display any map that you have entered. Your first stop in starting a new project

2. Allows you to read in a DEM. Your 2nd stop in starting a new project

Read a kml file that has been uploaded to the GMDE-M Documents Folder

Toggle on or off the GPS receiver in your device. Certain operations require the GPS receiver to be on. When it is on, you will see your current lat-long displayed in the upper right corner of the map view. Leaving the GPS receiver on too long can seriously drain your battery

Opens the system Sharing panel so that you can transfer the data type as a text file to your computer using Air Drop or another app on your device. The StraboSpot button (only visible when StraboSpot is enabled in Settings) allows you to upload your data to the StraboSpot database

You can get the location and elevation of any point on your map by selecting this button and then tapping the pointer anywhere on the map

use this button and then tap and drag on the map screen to measure distance, azimuth, and slope angle

Use the slider to change the map zoom. At present only integer values of zoom are supported so the zoom will change in jumps

use the tabs at the bottom of the panel to change to a different task. Badges show the number of observations of each data type

---

The Orient Tab

The Orient Tab is where you enter orientation data. If you wish to enter rake data manually, select the rake segment, type in the strike and dip, then tap Save Orientation. The Dip text box will be replaced by a Rake text box. Enter the rake and tap Save… again.

manually type in your orientation if you are doing your measuring with a different device. Right-hand rule is assumed for planes

If GPS is on, this button will read current location and tapping it will place the measurement at the GPS location. If off, then you will tap on the map to place a manually entered location.

To use the iPad orientation, tap the From iPad button. The strike and dip given by the iPad will be displayed in the text boxes along with the error. When you are satisfied, record the measurement with Save Orientation. This option turns on the device GPS!

To enter the orientation of a plane using a 3-point problem tap this button and then tap 3 places on the contact displayed on the map

Use this control to determine whether a line or a plane is being entered

Import data on clipboard from Stereonet Mobile

Set the plane or line type with this scrolling picker control

Save the measurement with this button. If the button is red, then there is a pending measurement that has not yet been saved

This is a scrolling list of all measured orientations. Tap on one to select it. You need to select an orientation before you can project a contact base on it or delete it

This button will delete the selected orientation or, if a measurement is pending, it will delete the pending orientation. A message box is appear asking if you are sure

The More Info button will display all of the entered information about the selected orientation in a panel that slides over the map view. You can edit anything about the orientation in the details view

Show the stereonet view of all or a subset of the data

8:29 AM   Tue May 14

NEW ORIENTATION

Strike: [   ]   Dip: [   ]

3-Points   Tap to Place   iPad

Import from Stereonet Mobile

| Plane | Line | Rake |

bedding

Save Orientation

17. 133.6; 33.6 (S & D)
   -111.12278; 43.18547

18. 134.0; 38.2 (S & D)
   -111.12945; 43.19212

19. 120.9; 27.2 (S & D)
   -111.12025; 43.18500

20. 126.4; 20.7 (S & D)
   -111.15231; 43.21342

21. 328.8; 31.2 (S & D)
   -111.22979; 43.22310

22. 156.0; 22.0 (S & D)
   -111.20193; 43.19990

23. 331.4; 42.9 (S & D)
   -111.20792; 43.19847

Delete   Stereonet   More Info

Project   Pt. Obs.   Orient.   Contacts

The Contacts Tab

Enter a new contact by drawing or projecting it based on the selected orientation.

The name for the new contact (you can enter contacts without names or add them later in the More Info panel)

To define the contact by drawing on the map, tap this button. It turns red when GMDE is waiting for you to tap and drag in the map view to draw the contact. If a contact is already selected, you will be asked if you want to add the new contact to the one already selected

This is the scrolling list of contacts that have already been entered. As you can see, projected contacts have a lot of vertices. You can reduce the number of vertices in the More Info panel for the contact to preserve memory

You can calculate the map thickness between two contacts with this button. After selecting it, you first tap on an orientation that was collected right on the first contact, then make a 2nd tap anywhere on the 2nd contact and the thickness will be displayed in a message box

If vertices have been selected with the Lasso, Delete will erase those vertices, otherwise it will erase the pending contact or the selected contact.

To project a contact based on the orientation selected in the Orient Tab tap this button. A new pending orientation will be created

Select the contact type from this scrolling picker control

Record the pending contact by tapping Save Contact. If the button is red, there is a pending contact that has not yet been saved.

Calculate an orientation by selecting vertices along a selected contact and then tapping this button. A best fit plane will be calculated and the resulting orientation will be entered as a pending orientation. To record the orientation, you will have to go to the Orient tab and tap Save Orientation.

The More Info button will display all of the entered information about the selected contact in a panel that slides over the map view. You can edit anything about the contact, including reducing the number of vertices

Join two segments of a contact. Select the first segment, tap Join, the select or tap the second segment

You select individual vertices on the selected contact with the Lasso command

Screenshot content:

1:10 PM Sat May 11

NEW CONTACT

enter the name of the contact here

Draw   Project from S&D

Anthropogenic

Save Contact

ENTERED CONTACTS

1. Jp top; Bedding
   204 vertices

2. Ke top; Bedding
   164 vertices

3. Ke top; Bedding
   163 vertices

4. Ke top; Bedding
   204 vertices

5. **Fault; Structure**
   85 vertices

6. Ke top; Bedding
   188 vertices

7. Kb top; Bedding
   73 vertices

Thickness   Join   Verts->S&D

Delete   Lasso   More Info

Project   Pt. Obs.   Orient.   Contacts

The Settings View

Select the data class that you want to edit

Select the data type within the class that you want to edit

Change the colors with the RGB sliders. Alpha controls the transparency

This rectangle shows the color you've set

For contacts, controls will appear allowing you to set solid or dashed lines and line weight

set color and alpha using sliders and then tap this button to change the map highlight color

Tap to apply your modifications to an existing data type

Type in the name for a new data type

save settings as default

Settings

‹ Map

⎗ VPN 71% 🔋

Assign Colors & Styles

| Planes | Lines | Contacts | Obs |

name   symbol

bar-tick
bar-triangle
bar-box

bedding
contact

Red

Green

Blue

Alpha

Set Highlight Color

Modify

Highlight Selected

Add New   Delete   Defaults   Save Settings

Import Settings

enter name for new type

add a new data type

delete a data type

return to program defaults

About GMDE Mobile v. 0.9.14

by Richard W. Allmendinger © 2019

GMDE Mobile is a geologic mapping solution to accompany the desktop version of GMDE. It incorporates special functions like the ability to load DEMs and project the trace of planar contacts across the topography.

GMDE Mobile is provided "as is" without any warranty, explicit or implicit. The author will not be liable for direct, indirect, incidental, or consequential damages resulting from any defect in this software or this user's

INFO

Documentation

Privacy Policy

OFFSET TAP POINT

ΔX = 0   ΔY = 0

Show tap target

MAP TRANSPARENCY

Opaque   Transp

USER

Name:

This text area scrolls! Tap and drag to see all of the contents

This table also scrolls! Tap and drag to see all of the contents

If you are using anything other than an Apple Pencil, you will probably want to set the offset from the tap point. For right handers, I suggest -40, -40 but you will need to experiment

Show a symbol at the point on the map that GMDE will record the tap

Change the map transparency which may help you to see your symbols better on a dark background.

User name and email can be useful to automate StraboSpot uploads.

The Stereonet View

Select data class to plot

Select plane type to plot

Select line type to plot

tap on 2 points in the stereonet to calculate the angle between them

If stereonet view is showing while using the iPad orientation to measure a plane or line, the current pending line or plane will be plotted interactively on the net as in Stereonet Mobile

Cylindrical best fit showing the three eigenvectors

Selected orientation highlighted with yellow halo

Point Observation Details View

There is a "Details" view for each of the three basic types of data and all are accessed from the **More Info** button in the lower right corner of the corresponding tab at the left. The Point Observations Details is shown here because of the photos functionality.

close the details view and return to the map view

This panel only shows if the obs. has a photo.

Tap to import a photo from your Photos Library

use the sharing panel to upload to Photos Library

Thumbnail of a photo taken with the iPad camera and annotated within GMDE. Tap to see the photo full screen and edit

The Photo Annotation View

The Photos Annotation View is accessed by tapping the photo thumbnail in the Point Observations details view. To draw on the photo, toggle on the Annotate switch. While you are drawing, all annotations are vectors and can be undone (newest first) by tapping the **Undo** button. However, once you tap Save, the annotations become a permanent part of the photo. To make sure you have a pristine copy of the photo, you can either (a) Take the photo with the camera app on the iPad and then import it into your observation (the pristine photo remains in your Photos Library with its EXIF data intact), or (b) take the photo with GMDE Mobile and then share it with your Photos Library before annotating it (the shared photo will not have location info in its EXIF data but the Observation will have both location and azimuth of the photo).
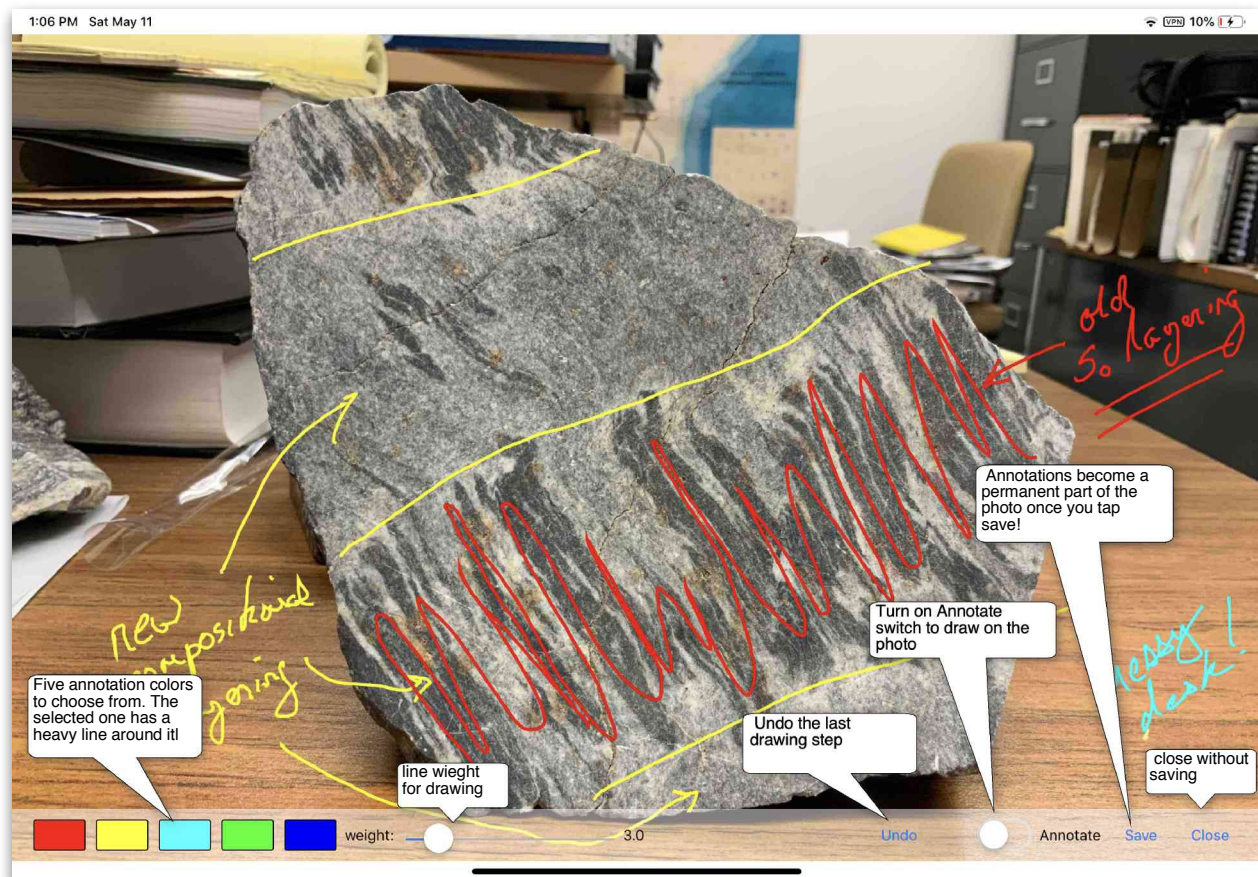
TASK-ORIENTED INSTRUCTIONS

Manage a Project

Start a New Project

Typically, your first step will be to upload a folder containing both your map(s) as <u>mbtiles</u> and your <u>GridFloat DEM</u> to the <u>GMDE Mobile documents folder in iTunes File Sharing</u>. Then, launch GMDE Mobile on your iPad. In the Project Tab, Import section, do the following in this order: (1) tap the **Map** button and, in the view that slides in from the right, navigate to your mbtiles file and tap on it to open it. (2) Next, tap the **DEM** button in the Projects tab, find your DEM file with the .flt suffix and tap on it. (3) Finally, enter a name for your new project and tap Save in the Project section of the Project Tab.

Following this sequence of events will identify the folder with your mbtiles and DEM files as the project folder. The project file, which contains all of your measurements, the photos database, and specialized settings for the project, will all be saved inside this folder automatically.

Switch Base Maps

You can switch base maps for a project at any time. Just tap the **Map** button in the project sections and choose a new mbtiles file. For one of my projects, I have three different maps that I uploaded in my project folder: a topo map, the previous geologic map of the area, and a satellite image. I use the satellite image most frequently, for three-point problems and to verify that the projection of a planar contact matches the geology shown on the satellite image.

Import Data Digitized Elsewhere

You can also upload in your project folder one or more .kml files. This file can contain point or path objects that you have digitized ahead of time in Google Earth. Many GIS programs can also output .kml files.

To load the .kml file into your project, tap the **KML** button in the Import section of the Project Tab. Navigate to your .kml file and tap on it to open it into your project. While the labels in the .kml file will be translated to object names in GMDE Mobile, you will have to apply data types manually, one object at a time, after import.

Transfer Data from One GMDE User to Another

Field work is commonly done in teams and there are times when you will want to transfer data from one team member to another. This can be done offline in the field as long as the two devices can establish a Bluetooth connection between them. Here's how:

From the Project tab of the sender's device, in the Sharing section, tap the button for the data type that you want to transfer. The Sharing Panel will appear; wait until the receiver's iPad shows up in the AirDrop section. Tap the circle for the receiver's iPad.

On the receiver's iPad, a menu will appear showing you the apps that can receive data via AirDrop (GMDE Mobile will not be listed). Select one that will allow you to edit text files; either Notes or the Files app are good choices and have the advantage that they are backed up to iCloud. The app you selected should open automatically, showing your data. Select ALL of the data, including the header lines, and choose copy from the pop-up menu.

Go to GMDE Mobile and open the project tab if it is not already open. Tap the button **GMDE via Clipboard**. The app will parse the data into the appropriate data type. If your data types for the data one the Clipboard do not match those already in GMDE Mobile, new data types matching the sender's data types will be created.

Note that Bluetooth connections are not terribly fast and contacts with a lot of vertices can take time to transfer.

Filter the Data you see on the Map

You can view subsets of your data one the Map by tapping the **Filter** button on the Projects Tab. The Filter & Find view will appear (see figure, next page) on the right hand side, allowing you to specify exactly what data appear on the map. To toggle on or off an entire class of data, use the switch. For example, to turn off all lines, toggle off the switch next tot the "Show Lines" label. You can also plot just one data type within a data class. As shown in the figure below, only the "Photograph" point observation, the "Bedding" contact type, and "Fold axial surface" and "Fold hinge" orientation types will be show. For the switches and spinner controls, the search happens as soon as you change the type or toggle the button.

You can also search by text in the Title/Name field, the Notes field, or any field. Type the text you want to search for in the text box and then tap the Find or Find Opposite button. Text searches do not happen until you tap one of those two buttons. In the figure, we are searching for all occurrences of "Ke" in any field.
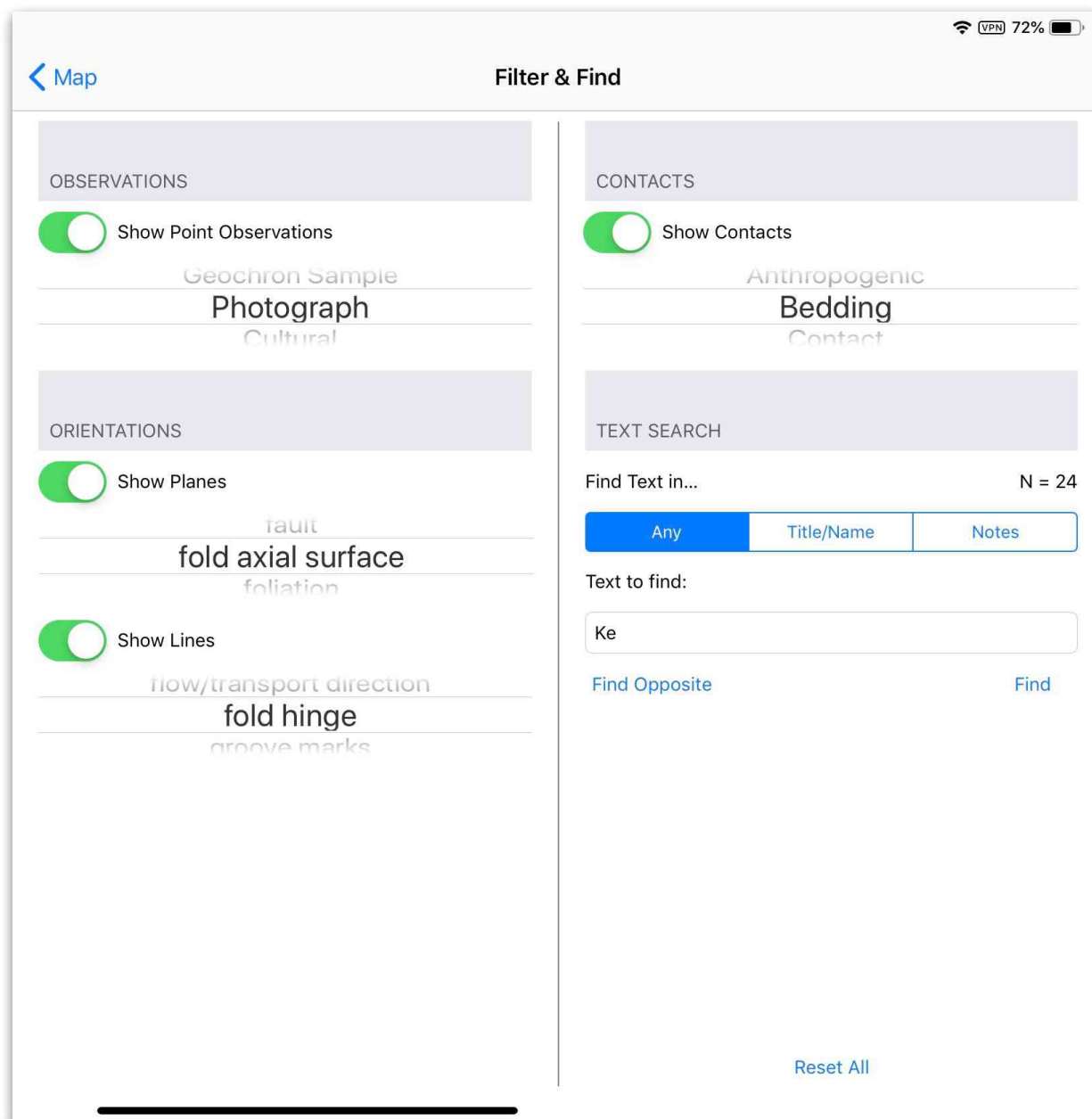
Modify and Save Settings for the Project

You do not have to use the GMDE Mobile default settings for data types, colors, etc. All of these can be modified completely as you like. For example, in areas of sparse exposure, you might want to have a point observation type for each different map unit rather than, or in addition to, the built in types. Note that, if you have StraboSpot integration turned on, you cannot change those data types.

Tap the **Settings** button in the Project section of the Project tab. The Settings View will slide in from the right, covering the map. The right hand part of that view is where you change the names and appearances of data types, as well as adding new data types.

To modify an existing data type, select the data class in the segmented button, then adjust all of the characteristics that you want: color, line weight and appearance (for contacts), symbol, etc. You can even change the name of an existing data type. When you have everything set as you like, tap the **Modify** button. To add a new data type, type a name in the text box, set the appearance as you like, and tap the **Add New** button.

The above procedure modifies the data types for your current session but does not save them permanently. To do so, once you have made all of the modifications or additions, Tap the **Save Settings** button. This will save a default settings file for the project and the next time that the Project is opened, those settings will be used.

Measure/Enter an Orientation

There are multiple ways to capture and record orientation data. GMDE Mobile records the method as part of the the metadata for a measurement.

From a 3-Point Problem

When you know XY and Z, and have a good satellite image, it is faster and more accurate to measure bedding orientations using a three point problem. Tap the Orient Tab, then tap the **3-Points** button in the new orientation section. The button text will change to **Tap 1st Pt.** Tap the pointer on the map where the contact is well exposed/determined. ***The point is recorded when you lift the pointer off the screen***. Tap two additional points along the contact (the button text will change each time to remind you which point remains to be tapped) and, when you are done, the orientation will be displayed in the text boxes and on the map as a "pending" orientation. If you are satisfied with the result, tap the **Save Orientation** button.

Note that the calculation assumes that the three points are non-collinear. Thus the greater the difference of elevation of one of the three points with respect to the other two, the more accurate the calculation.

Typing in the Orientations

You may wish to use a separate device, either analog or digital, to capture orientations. If that is the case, simply select the data class with the segmented control and then type (or dictate) manually the values for strike and dip or trend and plunge into the appropriate text box at the top of the tab. If you have GPS turned on (Project Tab) and are located inside the map, the middle button will read **Current Loc**; tap it to place the observation at your current location. Otherwise, the button will read **Tap to locate**. Tap that but-

ton and then tap the map at the location of your measurement. Finally, tap the **Save Orientation** button to record the measurement.

Entering a plane and rake of line is a little different: Select "Rake" on the segmented control and then enter the plane and locate it as described in the previous paragraph. Tap the **Save Orientation** button; a dialog box will appear telling you to enter the Rake in the text box at the top of the Project Tab (the Dip label will have changed to "Rake" and the Strike text box will have disappeared). Type in the rake and then tap **Save Orientation** again. A new plane and new line will both appear in the scrolling list below the save orientation button.

Using the iPad Orientation

A cellular iPad has the same array of sensors that an iPhone has. Thus, another way to measure an orientation in GMDE Mobile is to tap the **iPad** Button. The iPad will then immediately start measuring its orientation and location. If you happen to have the Stereonet View open, the strike and dip of the iPad will be displayed as a heavy magenta great circle that changes orientation as you change the position of the iPad.

To freeze the iPad measurement, tap the **iPad** button again. If the Stereonet View is open, tapping anywhere inside of the Stereonet will also freeze the measurement. To record the measurement, touch the **Save Orientation** button. An orientation measured this way will always be located at the current position of the iPad.

Best fit Orientation to Contact Vertices

GMDE Mobile can also determine a strike and dip by calculating the least squares best fit to selected vertices along a contact. Tap the Contact Tab and then select the contact you want to use. This will display small squares at each vertex.The the contact selected, tap the **Lasso** button and then draw a loop surrounding the vertices that you want to use for the orientation calculation; the selected ones will turn red. Touch the **Verts->S&D** button. The best fit orientation will be calculated and displayed as a pending orientation and the Orient tab brought to the front for your approval.

To accept the measurement, go to the Orient Tab and tap Save Orientation. The notes field of the measurement will record the contact and number of vertices used as well as information about the goodness of fit.

Import from Stereonet Mobile

Because iPads can consume a lot of power in the field, you may wish to use a more energy efficient device like an iPhone to measure strikes and dips. If you use Stereonet

Mobile to measure your orientations, here is how to import them en masse to GMDE Mobile:

1. Both devices must be on and there must be a Bluetooth connection between the two (a wireless or cellular connection is not necessary).

2. In Stereonet Mobile on the iPhone, select the Sharing Panel in the tool-bar at the bottom of the screen (see image).

3. Find your iPad in the AirDrop portion of the Sharing Panel and tap on it.

4. The iPad will popup a message box with a list of programs that can open the Stereonet Mobile text file. At present, GMDE Mobile will not be listed. Select a simple text editor like the Notes application.

5. A new page will be created in Notes on the iPad with your Stereonet Mobile data. Select and then copy all of the text on that page.

6. In the Orient Tab of GMDE Mobile, tap the **Import from Stereonet Mobile** button. If all goes well, your Stereonet Mobile orientation data will be added to the rest of your orientation data in GMDE Mobile
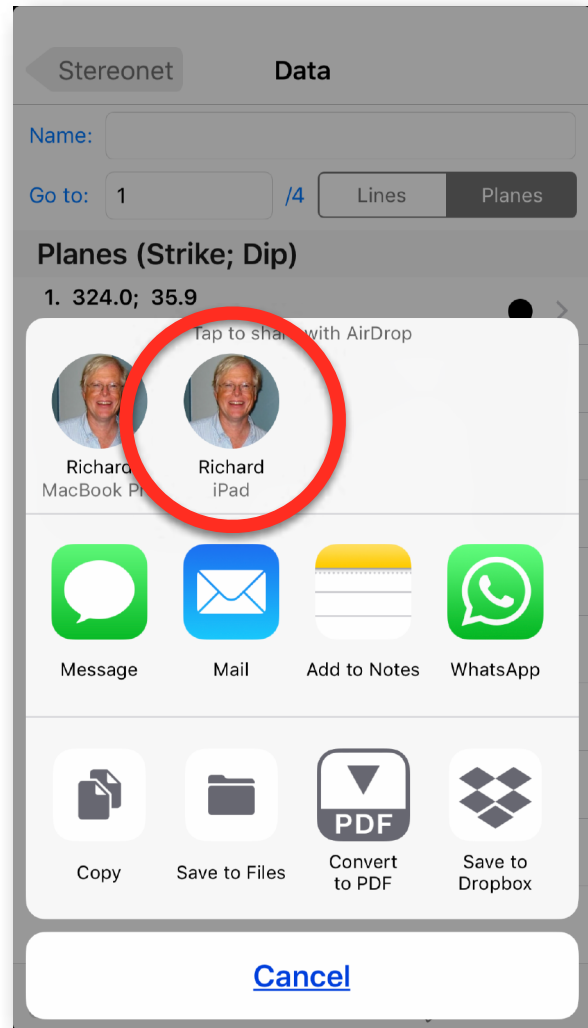
THE SHARING PANEL IN STEREONET MOBILE

Locate a Rogue Point on the Stereonet

If one of your orientations looks particularly unusual on the stereonet, you can easily locate that datum on the ground for further investigation. In the Stereonet View, tap the pole to the plane or the line that you want to locate. When you lift the pointer from the Stereonet, the tapped orientation will be selected in the list view in the Orient tab. If you close the Stereonet View, you will see that the map has been zoomed in and centered on the selected rogue measurement.

Map a Contact

Projecting the Contact from a Strike and Dip

If a contact is truly planar, it can be mapped much more accurately by having the iPad project the contact across the topography (as represented by the DEM) than by drawing it by hand. Additionally, a projected contact gives the mapper an immediate hypothesis to test while still in the field.

To start, select a strike and dip on the Orient Tab (or tap the strike and dip on the map view); if you have highlight selection turned on in Settings (the default value), the selected orientation has a translucent yellow circle plotted behind it. Then, go to Contacts Tab and touch the **Project from S&D** button. You can also tap the **Project from S&D** button without a selected strike and dip. In that case, a message box will instruct you to tap the orientation on the map that you want to project and, once you do that, the projected contact will appear without any further action on your part. GMDE Mobile will calculate the trace of the contact across topography and display it as a pending orientation.

If the selected strike and dip was calculated with a three point problem, the pending contact will be drawn about 500 m beyond the two farthest points used in the three point problem. If the contact was entered as a single measurement, then GMDE Mobile will calculate two additional points on the plane, either up or down dip from the selected point by about 500 m, and then project the contact 500 m beyond those two points.

After you save the pending contact, you can <u>edit the vertices, deleting those on either end which do not match the geology as described below</u>.

Drawing the Contact by Hand

Open the Contacts Tab, tap on the **Draw** button near the top of the screen, and start drawing your contact. It is that simple! To finish the contact, just lift the pointer off of the screen. Drawing begins the moment the pointer touches the screen. If you are using an accurate pointing device like the Apple Pencil, this shouldn't be a problem but if you are using a finger and have set the pointer offset in settings to something other than zero, the first part of your contact may not be accurately located. In this case, just save the contact and then delete the rogue vertices at the beginning of the contact.

Import from Google Earth (or other GIS program)

Point and path/polygon objects digitized in Google Earth can be imported into the GMDE Mobile by saving those features as a .kml file and then transferring the .kml file to the GMDE Mobile documents folder using iTunes File Sharing. In GMDE Mobile, go

to the Projects Tab and then tap the **KML** button in the import section. Navigate to the .kml file and tap it in order to import its contents.

Continue or Join Two Contacts

Two separate contacts can be merged into a single contact easily in GMDE Mobile. Select the first contact by selecting it in the table list view in the contacts tab or by tapping on it on the map. Next, Tap the **Join** button near the bottom of the Contacts Tab. A message box will appear with instructions. Click Okay and then select or tap on the second contact that you want to join with the first. The two contacts will be joined into a single contact.

If you are drawing contacts, you can save a segment and then continue it. Here's how: select the first contact and then tap the **Draw** button. GMDE Mobile will ask you if you want to continue the selected contact or draw a new contact. Select continue and then just start drawing near either end of the old segment. When your are finished, GMDE Mobile will make a new pending contact which includes both the old segment and the newly drawn part. If you save the pending contact, the old segment will be replaced by the newly extended contact. If you delete the pending contact (rather than save it), the old contact will remain untouched.

Delete Part of a Contact

To delete part of a contact, select it and then tap the **Lasso** button on the Contacts tab. draw a loop around the vertices of the contact that you want to delete. They will become selected and the selection squares turn red. Tap the **Delete** button to actually delete them. You will be asked to confirm the deletion.

What are Point Observations?

Point observations are just that: any observation that you make at a particular point on the ground. They can be sample locations, photographs, lithology or formation descriptions, etc. You can define as many different types as you wish and have you can have several observations at a single point. Two types of point observations deserve special mention: the "Lith/Fm" type and the Photograph Type.

Tag an Observation with a Lithology or Formation Name

"Lith/Fm" is short for "Lithology or Formation". Commonly, especially in regions of poor exposure, mapping is accomplished by noting the rock type (i.e., lithology) or the formation name at sparse outcrops. you can define whatever lithology or formation name scheme you want in Settings: Tap the "**Lith/Fm**" part of the segmented control on the

right. Then, enter a new name, set the color and symbol type, and tap the **Add New** button. Repeat as often as you like. When you are finished, be sure to tap Save Settings button; otherwise if GMDE Mobile gets purged from memory you can lose your custom data scheme. You can delete or rename the placeholder lithologies that come with GMDE Mobile.

Once your classification scheme is set up, when you go to add a "Lith/Fm" type observation, a new spinner control will appear next to the observation type, listing your custom scheme. Select the rock type (or formation) from the right hand spinner, place your observation on the map using either the Tap to Locate or Current Location button and press save. You do not need to enter a title or notes for the "Lith/Fm" type; in the data table, if there is no title, then the name of the rock type will be used. The symbol type and color are those that apply to the lithology types and not the observation types.

Note that you can attach a photo to any point observation, including the "Lith/Fm" type. Which brings us to…

Take a New Photo from within GMDE Mobile

Photos can be taken within GMDE Mobile by tapping the **Photo** button at the bottom of the Pt. Obs. Tab. If no point observation is selected then activating the **Photo** button will automatically create a new point observation labeling it as a photo-type observation. However, if an existing observation is selected, then tapping the **Photo** button will add the photo to that observation. *You can only have one photo per observation*. If you need more than one, create a new observation instead. The only way to delete a photo is to delete the observation it is associated with.

The **Photo** button brings up the standard iOS camera interface. Once you tap the button you get to decide whether you want to keep or retake the photo. When you keep the photo, it becomes part of the new point observation. GMDE Mobile captures not only the location that the photo was taken but also the azimuth and plunge of the camera look direction. By default, GMDE Mobile automatically saves a copy of the photo in your Photos Library on your iPad; this behavior can be toggled on or off in the Settings View. Note, however, that location info is not written to the photo EXIF data or transferred to Photos Library, but is recorded as part of the observation.

In the Point Observations Details view, you will see a thumbnail of the entire photo. The thumbnail is, itself, a button: when you tap it, you will be taken to the photo annotation view.

Import a Photo from the Photos App Library

Alternatively, you can take a picture using the traditional iPad camera app and interface. These photos are automatically stored in the Photos Library and have full EXIF metadata attached to them. From the Point Observations details view, you can <u>tap on the Import from Photos button</u>; a standard picture picker interface will appear allowing you to select a photo from the Photos Library. If you select a photo, a duplicate of it will be incorporated into the photos database for your project. The original photo in the Library remains untouched.

Annotate a Photo

Once a photo has been incorporated into your project, either by taking it from within the app or by importing it from the Photos Library, you can tap on the thumbnail to bring up the <u>Photos annotation interface</u> where the photo covers the entire screen. Here, you toggle on the Annotate switch so that you can sketch on top of the photo, using five different line colors and multiple line widths. While in editing mode in this view, your annotations are vector objects; you delete them in the reverse order that they were drawn by tapping the **Undo** button. *Once you tap the **Save** button, the annotations become a permanent, raster part of the photo; you can no longer delete them or change them in any way*. If you want to exit the photo annotation view without making any changes, tap the **Close** button.

DATA INPUT AND OUTPUT

To use GMDE Mobile, the user must enter both base maps and, unique to GMDE, also digital elevation models. It is the later than enables GMDE Mobile to perform its magic: projecting contacts, calculating orientations from three points, determining map thickness, etc. At the present time, data can be retrieved as text files and photos can be shared with the device photo album.

Preparing Base Maps

Base maps are entered in GMDE Mobile as mbtiles, a format that enables devices with limited RAM memory to display a large amount of data quickly. As the name implies mbtiles are a way of dividing up the base map into manageable tiles of different sizes and resolutions to serve them quickly. The set of mbtiles for the area is actually a SQLite database which enables rapid retrieval and display. An mbtiles set can be made

from any georeferenced map or satellite image and you can load several different images into a single project in GMDE.

For users in the United States, the entire country is covered by images from the National Aerial Imagery Program (NAIP) which have resolutions of 0.6 to 1 m. They can be downloaded using the USGS Earth Explorer (https://earthexplorer.usgs.gov/). Detailed instructions are given, below, courtesy of Nathan Niemi, to convert these images to mbtiles for use in GMDE Mobile.

Commercial Programs

Several software packages facilitate the production of mbtiles from original base materials (satellite images, topographic or geologic maps, etc.). Perhaps the easiest to use is the program MapTiler from Klokan Technologies (https://www.maptiler.com), which is available for Windows and Mac operating systems. The free and low-cost "Starter" versions have an image size limit of 10,000 by 10,000 pixels which is sufficient for many projects. For bigger or higher resolution projects, you can use a commercial GIS system such as Global Mapper or ArcGIS. These packages can be expensive and usually only work on Windows computers.

GDAL: An Open Source Alternative

The open source Geospatial Data Abstraction Library, GDAL, can produce mbtiles that work very well in GMDE and have no restrictions on size. Here, are instructions graciously provided by Nathan Niemi (University of Michigan) to download and process NAIP images and to use GDAL on a Macintosh to produce mbtiles. Note that the steps in the terminal can be carried out by the applet (Macs only) referenced below.

1. Find the NAIP image tiles that you need using USGS Earth Explorer (https://earthexplorer.usgs.gov/)

    1.1. Set your search area

    1.2. Select NAIP under Aerial Imagery in Datasets

    1.3. Confine search to last 3 years to get most recent images under Additional Criteria (NAIP flies each state every ~3 years)

    1.4. Bulk download the imagery as GeoTIFF images (you will need a free account with the USGS), also a fair amount of disk space. Imagery ranges from 0.6 m to 1 m resolution, depending on state and time of acquisition

1.5. Each GeoTIFF images arrives in a zip archive that unpacks to include a .tif image and a .txt metadata file, inside a folder for each quarter quad

1.6. Move the .tif and .txt files for each quarter-quad that you want to mosaic and tile in to a single FOLDER. (You will have a folder full of .tif and .txt files)

2. Download and install the complete package for GDAL for your version of MacOS - http://www.kyngchaos.com/software/frameworks/

2.1. Run the installer to install GDAL

3. Open the Terminal.app on your Mac (or use the applet described below)

3.1. Using the command line, navigate to FOLDER

3.2. Issue the following gdal commands

3.3. `>gdalbuildvrt -b 1 -b 2 -b 3 tempraster.vrt *.tif`

3.3.1. This creates a virtual raster from bands 1, 2, and 3 of all of the NAIP GeoTIFF quarter quads in FOLDER. NAIP images have 4 bands (4 is NIR), and the mosaic product fails if the 4th band is not explicitly excluded from the mosaic (this is what the -b 1 -b 2 -b 3 commands do, include only bands 1, 2, and 3). This command should not harm the process for any other 3 band (RGB) image, but could crash the process on a single band image (e.g. black and white air photo).

3.4. `>gdal_translate tempraster.vrt outputfile.mbtiles -of mbtiles`

3.4.1. This command "translates" the virtual raster file, composed of the FOLDER of GeoTiff images, in to mbtile format in a file called outputfile.mbtiles

3.5. `>gdaladdo -r average outputfile.mbtiles 2 4 8 16 32 64 128 256`

3.5.1. This command adds zoom levels to the mbtiles output file at 2x downsampling, 4x downsampling, etc. The -r flag defines resampling method.

The steps in the terminal (3.x, above) can be carried out using a small Mac OS X Automator applet, mbtiles using GDAL, which can be downloaded from my web page at:

http://www.geo.cornell.edu/geology/faculty/RWA/programs/mbtiles-using-gdalapp.zip

Just launch the applet and select the folder you made in step 1.6 above. The only notification that the script is running is a small revolving gear icon in the menubar (which you can use to kill the process if you need to). It is likely that it will take several minutes to complete, at which point as notification will appear and the gear icon will disappear.

Preparing Digital Elevation Models (DEMs)

The thing that makes GMDE unique is the ability to read high resolution DEMs that are stored on the device and thus accessible for offline use. When you have X, Y, **and** Z, there are all sorts of calculations you can perform while still in the field where the results can guide your field efforts.

DEMs come in a bewildering array of formats and there are even variations amongst standard formats. GMDE Mobile accepts only a single, but widely popular format: Grid-Float. This type of DEM is one of those offered by the U.S. Geological Survey and other government agencies for direct download, and can be written by most popular GIS programs such as ArcGIS and Global Mapper. The GridFloat DEM consists of three files:

1. A small header file with the suffix ".hdr" which has information about the number of rows and columns in the DEM, the grid spacing, etc.

2. A second small file with the suffix ".prj" that has information about the datum and projection of the DEM

3. A large file with the suffix ".flt" that is a binary file containing the actual elevation file.

All three files should be uploaded to your iPad and must have the exact same root name or GMDE Mobile will not be able to find them!

The GridFloat DEM comes in two basic flavors:

1. A grid spacing and bottom left corner specified in **decimal degrees**. The USGS releases its ⅓ arc second DEMs as 1° × 1° tiles. GMDE has no problem or restrictions with this format. The 1° × 1° tiles do tend to be much larger (~ 0.5 Gb) than necessary for any particular project and, if you are pressed for space, you can read these larger DEMs into the desktop version of GMDE and then use that program to save a new GridFloat DEM trimmed to your map area. Note that GMDE Mobile does not read the DEM into RAM memory but instead does a direct read from the binary file when it needs an elevation.

2. A grid spacing and bottom left corner specified in **meters**. GMDE Mobile can read these DEMs *as long as the central meridian of the DEM is a standard UTM central meridian*. Although this is usually the case, some GIS programs output DEMs with non-standard central meridians. You can determine whether or not this is the case by opening the ".prj" file in a text editor program and finding the central meridian. Add 3 to that number and then divide the result by 6. If

there is no remainder (i.e., nothing to the right of the decimal point), then it is a standard UTM central meridian.

Finally, DEMs can be produced using a variety of map datums. GMDE Mobile can recognize several different types of map datums and account for the difference with WGS84 which is the datum that mbtiles use. For example, older USGS DEMs used an NAD27 datum which can have an offset from NAD83/WGS84 of as much as 65 m, compromising the utility of the DEM considerably. GMDE Mobile does recognize NAD27 and corrects for the offset meaning that you can use those DEMs in the app. If the app does not recognize the datum specified in the ".prj" file, it will default to WGS84 which might not be correct.

Bottom line: if you have control over the format of your GridFloat DEM, specify a format in decimal degrees and a datum of WGS84. That is the best way to ensure correct readability of the DEM.

In the United States, you will probably want to download your DEM from the U. S. Geological Survey's the National Map website: https://viewer.nationalmap.gov/basic/. Be sure to select GridFloat for the DEM Format.

The USGS site allows you to download the ⅓ arc second DEMs as 1°× 1° tiles which are large, ~480 MB. GMDE Mobile has no problem with DEMs that size but that could fill up the storage space on your device quickly. The GMDE Desktop program (v. 6) can read the large DEM and can save just that part of the DEM in the area of your map. The Desktop program can be downloaded from: http://www.geo.cornell.edu/geology/faculty/RWA/programs/strikedipthickness.html.
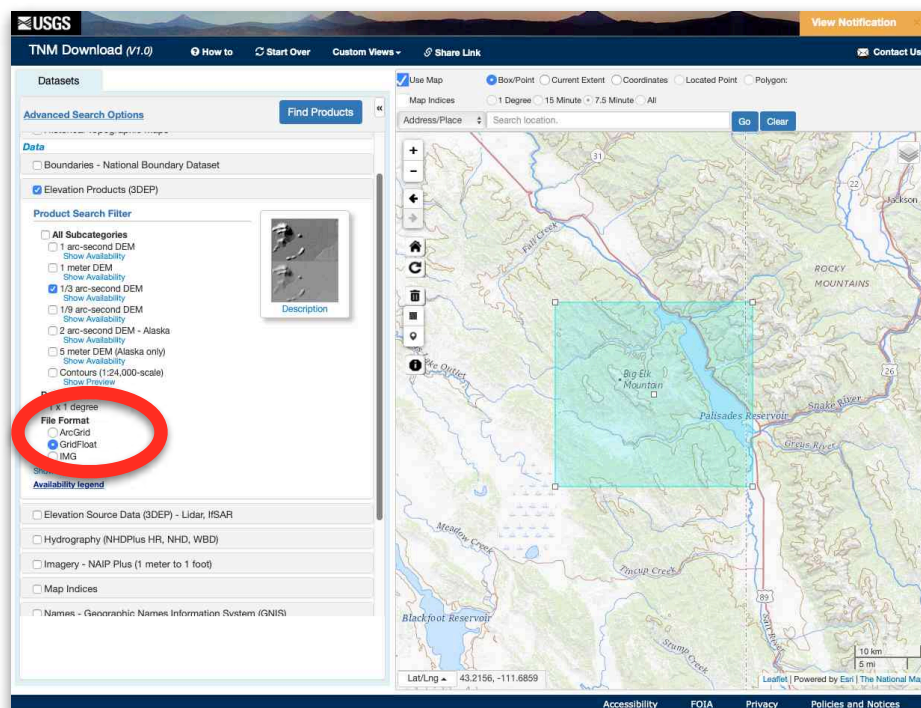
Use iTunes File Sharing to Upload Maps and DEM

In version 1 of GMDE Mobile, you must use iTunes File Sharing to transfer your maps and DEM to your iPad. Proceed as follows:

1. Plug your iPad into your computer with your Lightening or USB-C cable.

2. Launch the iTunes app on your computer.

3. Find the icon of your iPad in the upper right corner of the iTunes Window and click on it (see image, below).
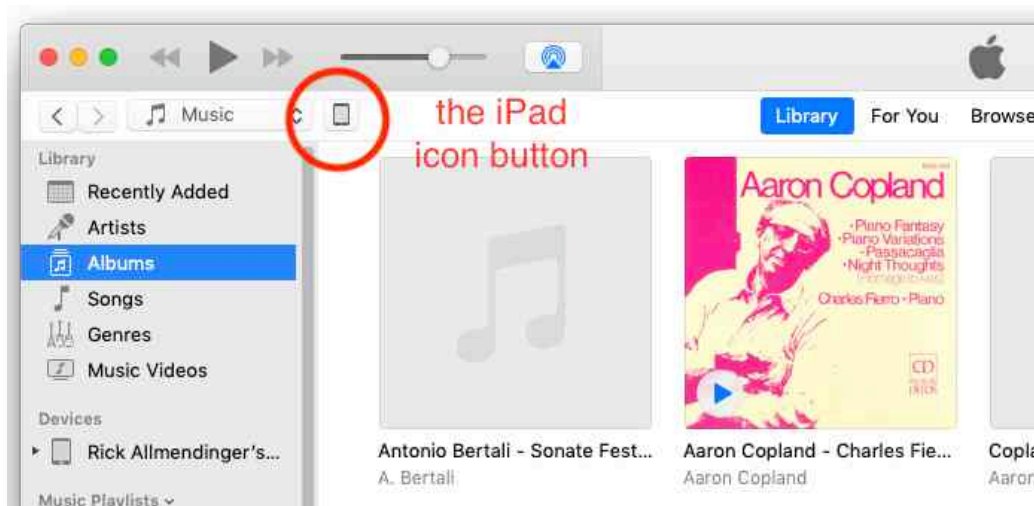
4. You will go to the iPad Summary screen. Find and click on the File Sharing option in the sidebar menu (image, below).
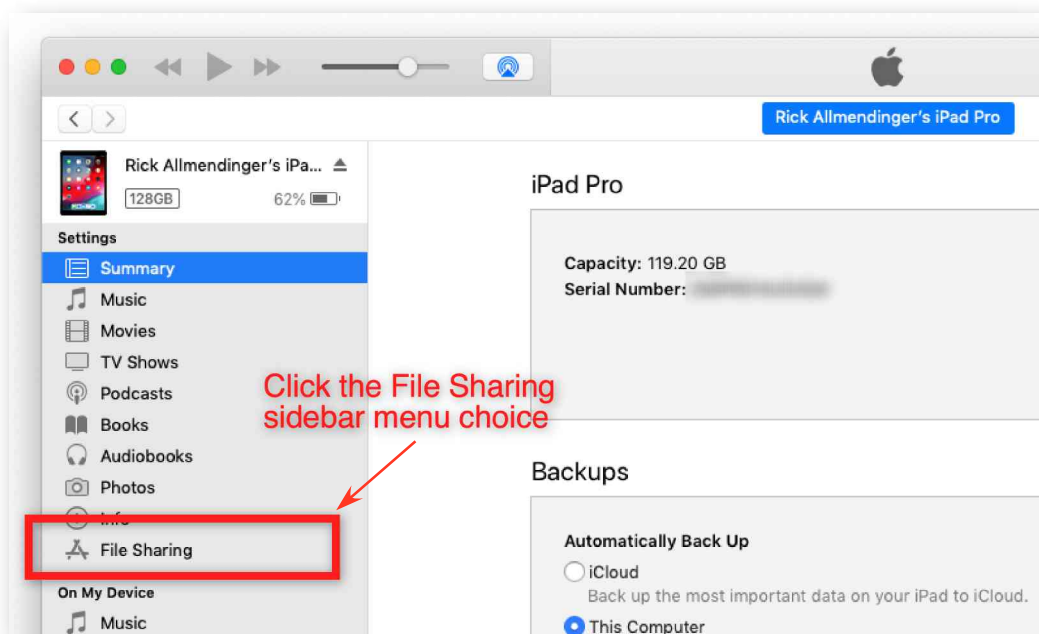
5. the File Sharing option will bring up a list of all apps on the iPad and give you access to their documents folders. Find GMDE Mobile in the list and click on it to see its documents folder.
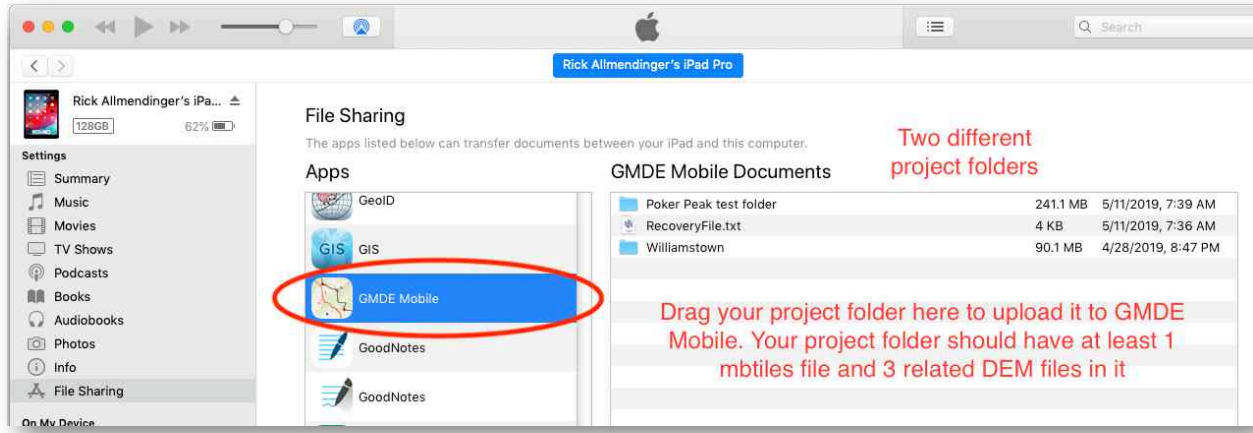
6. Drag the folder for your project onto the documents pane to upload it to GMDE. Your folder should contain: one or more mbtiles files and three related DEM files all with the same root name and suffixes ".hdr", ".prj", and ".flt". Note that the iTunes interface does not allow you to put new items into existing folders. Thus if you decide later that you want to add another mbtiles map file to your project, you will have to upload the entire folder again with the new file inside it.

7. One way to recover your data and photos files is to follow the above process, but then drag the project folder out of the iTunes window and onto your desktop. This will make a copy rather than moving the data.

8. You can also delete files that are no longer necessary. If GMDE Mobile crashes on start-up, the RecoveryFile.txt is probably corrupted. You can delete the recovery file by selecting it in the above window and pressing the delete key. If you delete the folder of the most recent project

Output of Data

Most data from GMDE Mobile is by a simple text file for maximum compatibility and longevity. This may, however, result in some additional processing of the data by you after it has been transferred from the iPad.

Use Sharing Panel to Transfer Data

You can transfer text files of your orientations, contacts, and point observations using the segmented control button in the Projects Tab, Sharing Section. Tap the type of data that you want to transfer; the standard iOS sharing panel will appear, allowing you to

transfer the data type to another device (via AirDrop), to iCloud (use "Files"), or to another program on your iPad. Just tap the destination that you want and a text file with that data type (orientations, contacts, or point observations) will be transferred. Once these text files have been transferred to your computer, they can be opened in GMDE Desktop. GMDE Desktop can save those the data as .kml files, including with three dimensional symbols.

You can also use the sharing panel to output a text file formatted as .kml. In order to use this file in another program, you will have to change the suffix from ".txt" to ".kml".

Any photos that you have taken with the iPad can be uploaded to your Photos Library using the Sharing Panel that is available from the Point Observations details view for the observation that has the photo. When the iPad is connected to iTunes File Sharing, the entire SQLite database that contains the photos can be transferred to your desktop machine and the photos extracted from the database.

StraboSpot Database Upload

GMDE Mobile can also upload your data to your account at the StraboSpot database (https://strabospot.org). You must have StraboSpot Integration enabled in the Settings View to do this and it is recommended that you assign the formal StraboSpot vocabulary to your data types before uploading. When StraboSpot integration has been turned on in Settings, you will see a 4th segment, called "StraboSpot", in the segmented control in the Sharing Section of the Project Tab. Tapping this segment will bring up the StraboSpot Upload View, shown below.

Enter your StraboSpot username and password and click the **Login** button. If you have entered your email in Settings, it will use that by default as your username unless you enter a different user name. Once you do that, the scrolling table list will appear below with one of your projects on each row of the table. If you want to start a new project, enter the name of the project in the text box and then tap the **New Project** button. The table will refresh (eventually, depending on the speed of your connection) with the new project listed.

The data set to upload is, by default, given the name of your project followed by an underscore and the data type in the Data set name text box but you can rename the dataset whatever you want.

Use the segmented control button to specify what type of data you want to upload to StraboSpot. If you are using your project name as data set name, it will be changed by appending an underscore and data type.

To upload your data, simply tap the row of the table which lists your project. It may take some time especially if you have a lot of contacts entered because contacts tend to have a lot of vertices. GMDE Mobile will not upload any data the have been turned off with the switch in one of the details view. A message box will eventually appear telling you whether your upload was successful or not.

Uploading to StraboSpot is a good way to back up your data but be aware that this is a one way street. At the present time, there is no way to download data from StraboSpot to GMDE Mobile.

PRIVACY STATEMENT

Asking Permission

GMDE Mobile always asks your permission to access sensitive data on, or from, your device. This includes:

- Location Data — The app needs your location data to carry out its core functionality as a mapping program. The first time you turn on GPS, you will be asked for permission to access location data while using the app; no background data are ever collected. If you deny access to location information, you will not be able to use the device GPS to locate yourself, use the iPad orientation to measure geological orientations, or have the Photo provide azimuth information. Otherwise, the app will function normally. Location data for individual observations is stored in plain text in the GMDE Mobile document folder which, thanks to sandboxing, is not accessible to any other program except iTunes File Sharing when you connect your iPad to your computer. If you choose to Share data, you will of course also be sharing the location data for each observation with whatever app or device you select.

- Access to the Camera — GMDE will ask for access to your camera the first time you tap the **Photo** button on the Pt. Obs. Tab panel. If you deny access, you will not be able to take photos from within the app. Photos taken within GMDE Mobile are stored in an unencrypted SQLite database in the documents folder of the app, which is not accessible to any other program except iTunes File Sharing when you connect your iPad to your computer.

- Access to the iPad Photos Library — The first time you tap **Import from Photos** or **Share Photo** in the Point Observations Details View, you will be asked permission to access your Photos Library. If you deny access you will not be able to import or share photos. Imported Photos are stored in an unencrypted SQLite database in the documents folder of GMDE Mobile, which is not accessible by any other program except iTunes File Sharing when you connect your iPad to your computer.

If you deny access and then decide later that you want to enable the above features, you can do so by enabling GMDE Mobile in the device Settings app under Privacy.

Internet Access

GMDE Mobile can access the internet in the following way:

- Uploading data to the StraboSpot online database for structural geology data, a database whose development has been supported by the U.S. National Science Foundation. This upload does not happen automatically but must always be initiated by the user, and the user must have a StraboSpot account and must log in with their account password. GMDE Mobile uses the https:// protocol to negotiate this data transfer and never saves the user StraboSpot name or password to disk but does keep your password in memory during your current session so that you do not have to log in again during the session.

Data Access

All of the data you collect using GMDE Mobile is stored unencrypted in the app document folder and is accessible only from within GMDE Mobile or by attaching your iPad to your computer and using iTunes File Sharing. At present, the data are stored as simple text files that are readable by any Text Editor or, in the case of photos, a simple SQLite database. No proprietary binary files are currently used. In the future, all of the data may be stored in a SQLite database or a binary file if it becomes apparent that full mapping use of the app is taxing the memory on the device too much.

Programmer Access

GMDE Mobile **never** sends ANY information to me, the programmer of the software. It has no ability to send me crash reports, copies of your data, location information, or anything else that you enter in the program or have on you computer. GMDE Mobile does not use cookies or any other persistent tokens other than the files you save to the app documents folder.

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> Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the ""Software""), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, subli-

The original Python code can be found at: https://www.maptiler.com/google-maps-coordinates-tile-bounds-projection/.

Steve Oriel, Gene Boudette, and Max Crittenden -- all great USGS field geologists now deceased -- taught me a great deal about geologic mapping many years ago and they have my deep gratitude. I hope they would have approved of this use of technology to make mapping better.