Geospatial Science Using an iPad Off the Grid: a Brief Technical Overview

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This brief technical overview is meant to introduce the concept of using mobile computing to support field work in remote locations. I have included some of the basic concepts of Geographic Information Systems and requirements for outdoor mobile data analysis. My background is in exploration geology and geophysics and I focus almost exclusively on gold exploration. I primarily work with satellite and airborne images for the purpose of mapping alteration mineralogies associate with gold bearing systems.

The rapid growth in mobile devices with built in GPS capability has expanded the average user's appreciation of the importance of geo-location. Early users of Apple's iPhone found that the device could be used for road navigation, eliminating the need for dedicated navigation devices. As the app database has grown an average user now takes it for granted that location services are part of modern life. Forsquare, Color, and Yelp have begun to make our social networks tightly coupled to our location. Advanced location dependent Augmented Reality features such as Yelp's Monocle provide a computer enhanced real time perception of the world near a person's location.

While all of these location dependent features are accelerating us into a world that would seem like science fiction only a few years ago, they share a basic limitation: they only work when a mobile device is connected to the communication grid. People who travel outside the US with an iPhone or iPad are aware of this but can still get data services if they are willing to pay for it or find a WiFi hotspot. But, many natural scientists and engineers that work in remote regions face a more difficult dilemma – a complete lack of connectivity.

Scientists that work in the field often depend on geospatial databases to conduct their work. A geologist exploring for gold may be trying to find a point on the earth that corresponds to an anomalous area extracted from a satellite or airborne image. A forester may need to do a similar exercise looking for anomalies associated with insect infestation. Of course, we can use old technologies and navigate to a location identified in the office using a handheld GPS or simple orienteering with a compass. However, many natural phenomena are better understood within their spatial context. Thus interactive navigation to a remote location using a display device loaded with multiple layers of image other data (typically attributed points, lines, and areas) is highly desirable. Devices to do this have been around for many years. The tool of choice for many has been the HP iPaq handheld PC. The downside to handheld PC's has been a small screen (or acceptable size screen and high weight and cost), screens that are difficult to see outdoors (or ones that were good outdoors and very expensive), lack of built in GPS, short battery life, and relatively high price. The introduction of the Apple iPad was, therefore, greeted with excitement by the field orientated geospatial community.

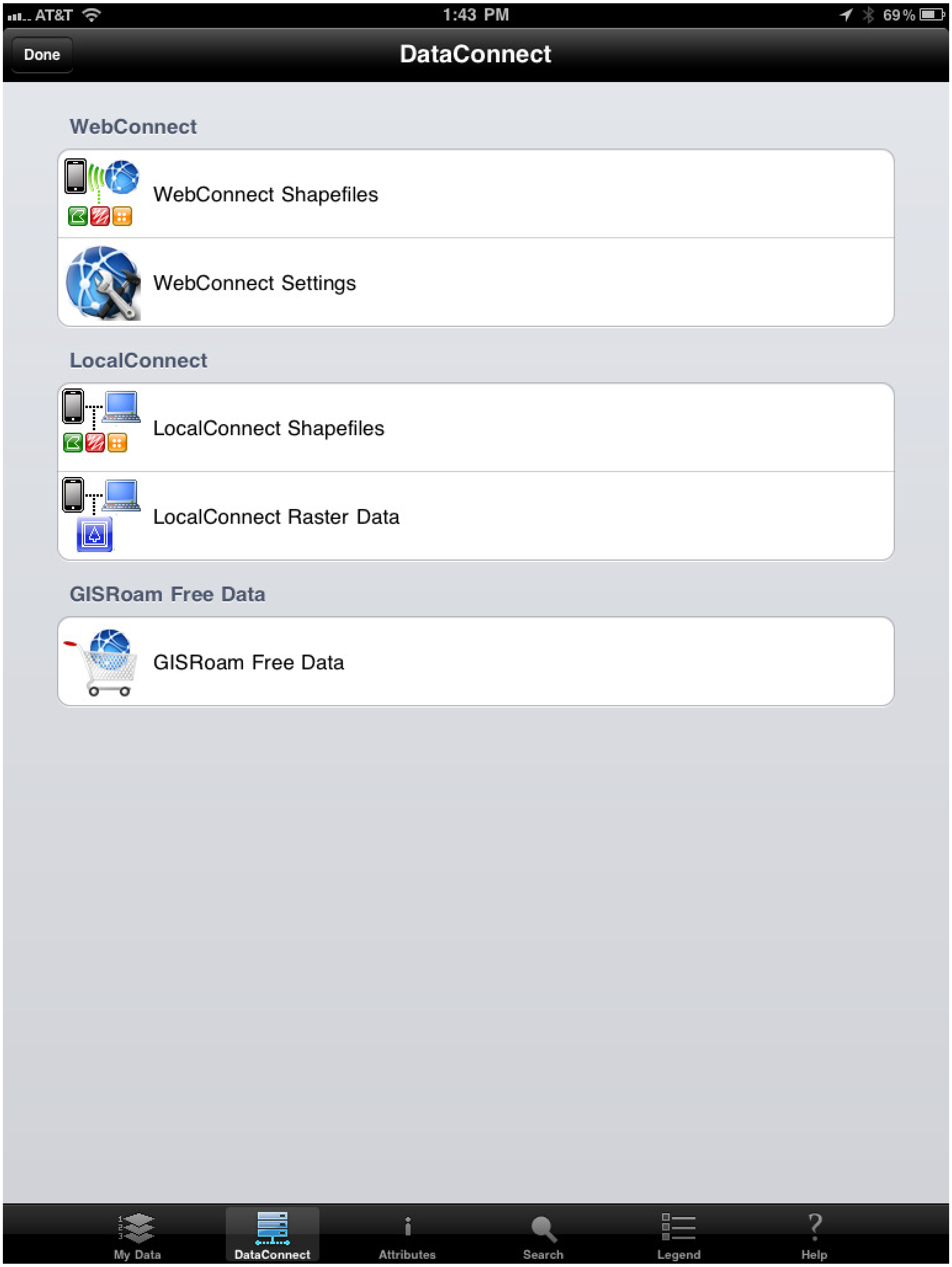
The initial excitement turn to initial despair as we found that the WiFi version lacked a GPS and Apple was not forthright on the 3GS version's GPS capabilities. Bloggers reported that Apple Store "Geniuses" initially claimed the device's GPS was unusable without 3G or WiFi connectivity. Fortunately users and developers quickly discovered this was not true. I was able to verify that the GPS accurately positioned me without 3GS or WiFi connectivity to around 10 to 20 feet. Others were reporting similar results (https://www.stanford.edu/group/ats/cgi-bin/hivetalkin/?p=609). On other fronts the iPad's performance in the field was also spectacular. The screen is readable in all but direct sunlight conditions (this is probably the most important attribute for a field device), the battery life allows one to work all day without recharging, the screen is large, and the device is relatively light weight (certainly compared to the 4 pound tablet I had been using in the field!).

Armed with a device that met all of the technical hardware specifications the only thing that was needed was an App capable of supporting the demands of fieldwork.

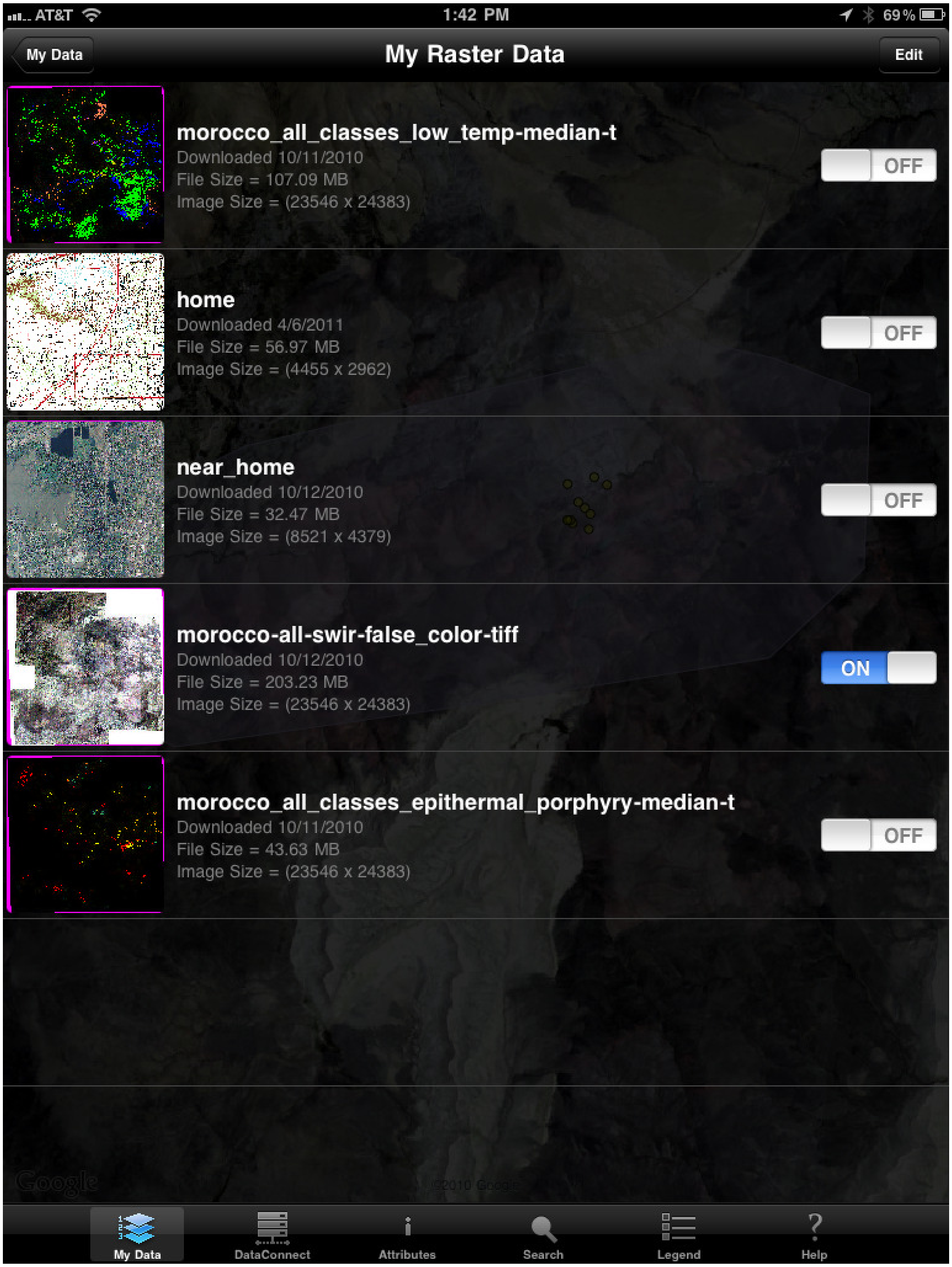
Applications that manage geospatial data are called Geographic Information Systems (GIS). These allow the display, manipulation, and analysis of data that have location information attached to them. The base unit of a GIS database is a point – a location on the Earth's surface that has information attached to it. An example of this for exploration is a geochemical sample site. The site is located on the Earth and has various element concentration attributes attached to it from laboratory analyses. Other GIS units are lines (a road is a good example), and areas (e.g., fields with different crops). Images are also commonly used in GIS's. Images are handled different because the location information is inherent in the image raster itself. Therefore the pixels need not be individually located with coordinates; instead we only need to know the coordinates of a corner and the spatial size of the pixels to know the location of every pixel in an image. In field applications we need an App that allows us to stack layers of GIS entities, turn them on and off, and display and potentially edit the attributes (and potentially even modify the location if it is found to be incorrectly located in the field).

The leading supplier of GIS software is ESRI (www.esri.com). They develop the Arc series of GIS packages for a wide variety of platforms. ESRI rapidly came out with an App for iPhones and iPads (ArcGIS for iOS). Unfortunately the App utilizes shared and/or proprietary data only from central live database servers so you must be connected to display and use data (and have previously uploaded proprietary data). The need for offline data access was an obvious one and a second GIS App quickly appeared that addressed this. The app is called GISRoam and is developed by Cogent3D (http://www.gisroam.com). GISRoam loads GIS data onto the iPad so that remote field work can be conducted without connectivity. Data can be sourced either on a local machine and loaded to the iPad through iTunes (Localconnect) or a REST / JSON enabled server and loaded via 3G or WiFi (WEBConnect). Data updates made in the field are automatically updated to the server if the data are write enabled. The GISRoam App is free, Localconnect is priced at $29.99, and RESTConnect is an annual subscription. Image data can currently only be loaded from a local PC.

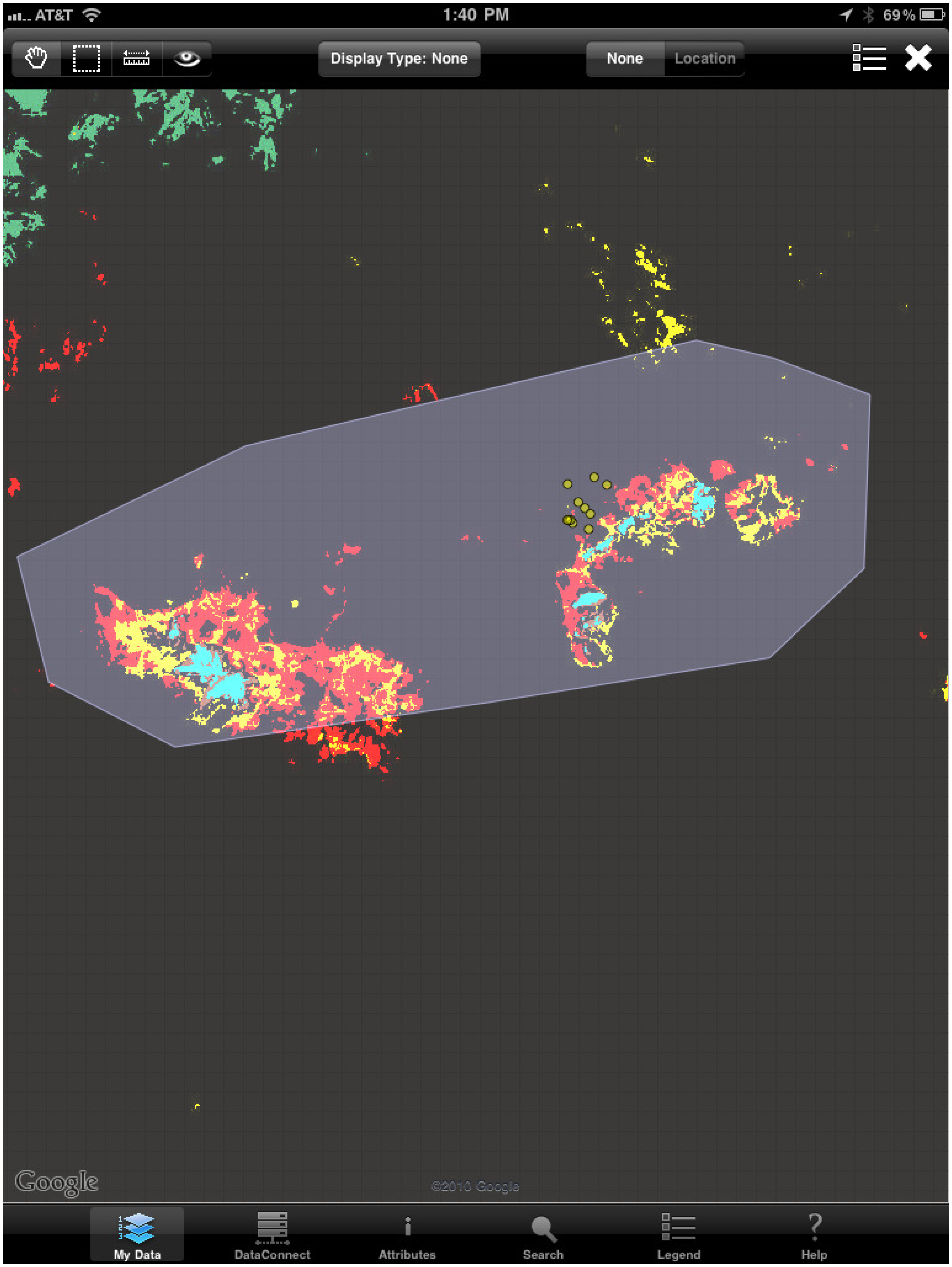
In summary, lightweight mobile devices are becoming the tool of choice for field investigations involving image and GIS data. The iPad 1 provides a good tool for working in the field because of its bright and large screen, long battery life, accurate GPS, and light weight.



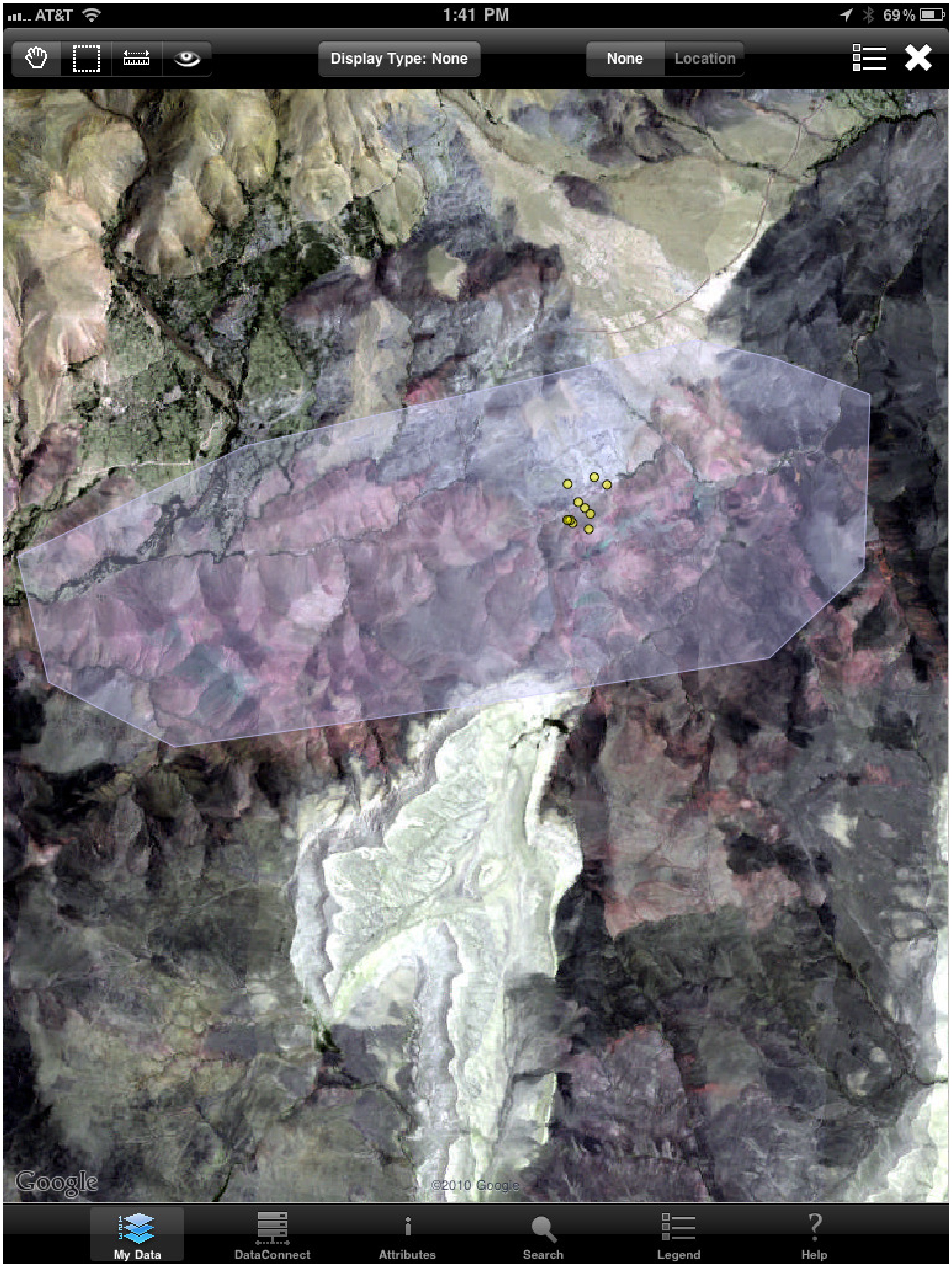
GISRoam data transfer interface. This allows GIS files to be transferred from a central server or a local machine. Image (raster) files are currently only supported through a local connection.



Raster data layer selection interface.



Geospatial layers of an exploration area in Morocco. The various colored zones represent alteration minerals potentially associated with a gold deposit. The dots are point locations of samples collected in the field, and the polygon defines a target area defined for field followup.



Shortwave Infrared (SWIR) False color imagery of an area in Morocco collected from a high spatial and spectral resolution airborne survey using the ProspecTIR instrument (www.spectir.com). Pixels are 5 meters in size and contain 357 spectral bands per pixel.