Virtual Field Experience and Digital Geologic Methods in the Apennines, Italy

George Mason University
GEOL 404 (6 credit hours)
May 19 – July 1, 2021

Faculty and Staff

Dr. Alan Pitts, George Mason University / University of Camerino. Specializing in clastic sedimentology/stratigraphy, basin analysis, geologic field mapping

Dr. Paul Betka, George Mason University. Specializing in structural geology and tectonics, geologic field mapping

Dr. Geoff Gilleaudeau, George Mason University. Specializing in sedimentology/stratigraphy and geochemistry

Visiting University of Camerino Lecturers

Dr. Emanuele Tondi, University of Camerino. Specializing in seismic hazards, active tectonics, and structural geology.

Dr. Claudio Di Celma, University of Camerino. Specializing in deep water and shallow marine sedimentology and stratigraphy.

Dr. Marco Materazzi, University of Camerino. Specializing in geomorphology, hydrogeology, and landslide hazards.

Dr. Stefano Mazzoli, University of Camerino. Specializing in structural geology, geophysics, geodynamic evolution of the Apennine Chain

Instructor contact info

Dr. Alan Pitts – apitts1@gmu.edu
Dr. Paul Betka- pbetka@gmu.edu
Dr Geoff Gilleaudeau - ggilleau@gmu.edu

Course Description and Objectives

This is a capstone course intended to provide an alternative to summer geology field camp. Virtual field sites in the spectacular geologic setting of the Apennine mountains in central Italy will be visited using Google Earth enhanced with GigaPan images, Drone-based 3D digital outcrop models, and digital elevation models with geologic map overlays. In addition to providing meaningful virtual field experiences in this course students will build skills using new software packages used to extract quantitative outcrop data using virtual outcrop analysis software such as LIME and. This online course will occur over six weeks consisting of three weekly virtual class meetings to conduct introductory lectures, present course materials, and assign projects to be completed outside of class meetings. Instructors will hold virtual office hours in order to check on students' progress and answer questions.

This course will focus on developing computer based geologic skills that will prepare students for a job as a geologist in the private or public sector or for research at the graduate level. The learning goals of this course will be:

- Implement fundamental practices of digital geologic mapping to extract quantitative data. Use digital data to create geologic maps (both on paper and digital).
- Measure and construct stratigraphic columns, correlation panels, and geologic cross sections
- Write a geologic report, producing professional figures of geologic outcrop interpretations

Prerequisites

Successfully completing the following seven courses or their equivalents are required before attending the Geology Field Camp in Italy: 1) Physical geology, 2) historical geology, 3) mineralogy, 4) stratigraphy/sedimentology, 5) igneous and metamorphic petrology, 6) geomorphology, and 7) structural geology.

Structure of the virtual course

This course will break into 4 learning modules followed by one final project to produce a digital map and geologic report. Each teaching module will involve virtual lectures, which will be reinforced by "faculty-led" and "self-guided" Google Earth-based Virtual Field Trip Experiences (VFE), which will integrate: 1) 3D outcrop models and hand samples, 2) Gigapixel imagery, 3) drone-based imagery, 4) georeferenced field photos, and 5) digital elevation models with geologic map overlays. Each learning module will begin with an introductory lecture, followed by VFEs to provide a background of the topic. Faculty led VFEs will be conducted as a group with students following from their own computers and expected to maintain detailed notes, engage in-group conversations, and simultaneously interact with embedded digital content. "Self-guided" VFEs will be completed outside of class time and students will maintain field notes of observations, hypotheses, and produce outcrop interpretations in the form of annotated "field photos". Each module will conclude with a final project completed using data extracted and analyzed from digital geologic content including: 3D Structure from Motion (SfM) and Photogrammetry-generated Virtual Outcrop Models (VOM).

PROJECT DESCRIPTIONS (detailed project descriptions and instructions for the assignments will be delivered at the start of each project

Project 1: Intro to Apennine Geology:
This project will provide an introduction to the regional geologic and tectonic history of the Apennines
Objectives & Learning Goals:

- Introduction to Apennine regional geology
- Make field observations, maintain a field book, creating professional annotated field photos
- Introduce fundamental aspects of the Meso-Cenozoic Umbria Marche Stratigraphic Sequence

Student Project/Deliverable:

- Umbria-Marche Stratigraphic Sequence photo atlas
- Brief geologic report with annotated outcrop photos

Project 2: Clastic sedimentary systems:
This project will be focused on the syntectonic clastic basins of the central Apennines and introduce students to clastic facies analysis and digital stratigraphic field methods.

Objectives & Learning Goals:

- Describe sedimentological characteristics such as grain size, sedimentary structures, bed thickness, stratigraphic contacts of clastic sedimentary systems.
- Construct detailed stratigraphic columns and correlations panels from digital geologic content.
- Use field data to interpret depositional processes and sedimentary environments.

Student Project/Deliverable:

- Several detailed measured stratigraphic sections from different digital outcrops
- Stratigraphic correlational panel
- Describe facies distributions and interpretation of depositional processes and environment.

Project 3: Intro to fundamentals of Geologic mapping:

This project will provide an introduction to the basics of map reading, cartography, and geologic map construction.
Objectives & Learning Goals:

- Introduction to reading topographic maps
- Understanding the relationship between flat and inclined strata and topography
- Introduction fundamental elements of making a geologic map

Student Project/Deliverable:

- Geologic map from the University of Leeds 'Virtual Landscapes' mapping assignment.
- Geologic cross-section derived from data points.

Project 4: Virtual Geologic Mapping at Monte Lago:
This project will provide an introduction to the regional geologic and tectonic history of the Apennines
Objectives & Learning Goals:

- Make field observations, maintain a field book, creating professional annotated field photos
- Reinforce fundamental elements of making a geologic map

Student Project/Deliverable:

- Hybrid traditional geologic map with data extracted from digital geologic content
- Geologic cross-section derived from gigapans, 3D outcrops models and topographic map
- Brief geologic report with annotated outcrop photos

Project 5: Active fault mapping and seismic hazards
This project will focus on the analysis of surface rupture mapping and structural analysis of fault zone architecture or the epicenter area of the 2016 Mw 6.5 Central Italy earthquake
Objectives/Learning goals:

- Introduce the Central Apennine Fault System
- Understand capable/active faults and seismogenic potential
- Learn to map co-seismic ruptures in aerial imagery
- Identify and measure fault zone architecture in 3D digital geologic models

Student Project/Deliverable:

- Surface rupture map of the Monte Vettore Fault system
- Annotate photos of fault zone architecture
- Construct geologic cross section of seismogenic basin incorporating surface rupture and geologic map data

Project 6: Landslide & mass wasting hazards mapping

This project will focus on mapping and assessing the hazards relating to active landslides and other mass wasting phenomenon using Google Earth, UAV-based Structure from motion-derived DEMs.
Objectives/Learning goals:

- Recognize different landslide and slope deformations in aerial imagery and topographic maps
- Map slope deformations in Google Earth and extract measurements.
- Use the Italian landslide hazards scheme to assess the landslide hazard of given slides.

<u>Grading:</u>

Each project will be graded based on: 1) Mapping assignment and associated materials, graded according to a rubric distributed before starting each project. 2) Exercises related to self-guided VFE assignments. 3) Participation points are gained by being an active participant in all group aspects of the course, punctuality, and maintaining a positive attitude.

Final Project Grade	Field map and associated materials	75%
	Self-guided activities	15%
	Individual participation	10%

The grade percentage for each project will be as follows below.

Project 1:	Intro to Apennine Geology	10%
Project 2:	Clastic Sedimentary Systems	15%
Project 3:	Intro to Geologic Mapping	15%
Project 4:	Active fault mapping and seismic hazards	15%
Project 5:	Virtual geologic mapping at Monte Lago	15%
Project 6:	Landslide and mass wasting hazards mapping	15%

***Field camp is a fast-paced course in which we will move from one project to the next each week. Due to the nature of the course, no late work will be accepted. Incomplete assignments will be graded based on their level of completeness according to the rubric given for that assignment.

<u>Recommended textbooks</u>

Compton (2017): “Geology in the Field”. Earthspun books ISBN: 9781520617718
Freeman (2010) “Geology Field Methods”

http://faculty.missouri.edu/freemant/Geology_Field_Methods.html

Readings from selected texts and journal articles will be available in the course manual.

Academic and Personal Conduct

All students registered in GEOL 404 are subject to the GMU Honor Code and other GMU codes of conduct. We are required to report cases of suspected academic misconduct to the GMU Dean's office. Penalties for the violations of the GMU Honor Code may include immediate suspension or expulsion from the course.

**Specific to this course: You should share data only when instructed to do so in collaborative exercises. Otherwise never read another student's written work nor copy their measurements, maps, or field notes. Do not alter or embellish your own field data.*

Computer requirements:

This course will make use of different digital geologic content that will be referenced using the Google Earth web-based platform. Most of the content used for our group-based VFE activities are freely available through web-based utilities.

Projects will make use of additional software for geologic data extraction. The software descriptions and hardware requirements are shown below.

**For students without sufficient or otherwise incompatible computer workstations, we will provide a GMU-based computer workstation which can be accessed remotely, students may request a 'loaner' laptop from GMU, if needed.

Recommended computer configuration:

- Dedicated GPU for running the 3D graphics (NVIDIA recommended, e.g. Quadro series >2GB).
- >4GB RAM (recommended 16GB or more) is needed to load larger 3D model data
- A multi-core processor is beneficial for multi-threaded data loading
- High-speed hard drives for faster out of core data loading for level of detail (LOD) datasets
- Plenty of hard drive space for those large 3D datasets, and/or:
- *A good Internet connection if using cloud 3D data connections (e.g. to V3Geo)*

LIME (Windows) http://virtualoutcrop.com/lime is the software we will use for extracting structural and stratigraphic measurements from digital outcrop models as data for completing mapping assignments.

From LIME software developers:

> *LIME is a high performance 3D viewer for working with models acquired using laser scanning, photogrammetry and related spatial measurement techniques. The software focuses on novel and advanced visualization of surface meshes and photorealistic textured models, and allows additional data types (photos,*

georeferenced image files, hyperspectral images, panels, annotations) to be placed and overlaid in the 3D environment. LIME includes interpretation tools to allow digitization and measurement of features. The combination of large data handling, ability to load multiple object types, and novel rendering makes LIME a unique tool for preparing high quality graphical products for presentation and collaboration.

LIME will run on most laptops and workstations running the 64bit Windows operating system. However, the following hardware recommendation will help you increase performance, especially with larger datasets.

The recommended GPU and RAM specifications are most important to use LIME as it was intended. Alternatively, LIME can be accessed remotely on a GMU workstation.

Inkscape Mac/Windows - https://inkscape.org/ is a free and open source vector graphic design software. We will use this program to create annotated field photos to illustrate key geologic features of the virtual outcrops visited. If you have an existing license to **Adobe Illustrator**, you may use that instead of Inkscape.

What is a *virtual* field geology course??

Modern field geologists combine both 'traditional' methods of field geology with 'digital' geologic mapping techniques to produce maps and cross sections, analyze data, and interpret the geologic history of a study site. Ideally, we would do this too, however, during a global pandemic we can still spend valuable time learning digital mapping techniques that will be useful to you in geoscience industry or graduate school. The **table on the next page** compares "traditional" field camp exercises with the planned "digital" exercises to give you a sense of how these methods overlap and complement one another. We hope this helps you understand how the learning objectives and exercises in a virtual field class will be both similar to and different than those of a traditional field camp.

Field camp exercise	Traditional methods	Digital methods
Describing and measuring stratigraphic sections; stratigraphic correlation	Use jacob’s staff, Brunton compass, and notebook to log inch-by-inch stratigraphic measurements. Correlate between measured sections using outcrop photographs and/or seismic data. Advantages: unlimited data resolution (can collect and analyze samples in lab for details). Disadvantages: Limited by physical access to outcrops.	Use scaled, high-resolution outcrop Gigapan imagery to measure stratigraphic sections and correlate between sections. Advantages: unlimited access (e.g. can measure otherwise inaccessible cliffs). Can be readily combined with other datasets (e.g. seismic). Disadvantages: detail limited by photo resolution.
Geologic mapping	Physically walk field site to make observations and measurements, create a geologic map on paper, piece-by-piece. Advantages: access to outcrops for detailed rock identification and measurement, geologist creates map “in real time” as they make discoveries. Disadvantages: limited by physical access to outcrops, limited observational perspective on large-scale features. Map accuracy limited by location accuracy.	Use various types of satellite imagery, digital elevation models, aerial photographs and drone imagery to interpret a geologic map. Can combine with existing geologic information such as located outcrop measurements. Advantages: unlimited access to scale and perspective on geological features (e.g. can pan/zoom on imagery to see landscape). Location accuracy is not an issue. Disadvantages: ability to interpret rock types and structures is limited by quality of imagery and existing data.
Detailed outcrop visits for targeted learning and analysis	Visit interesting field site, receive lecture and take notes. Make observations and measurement, sketches, take photographs. Advantages: can experience outcrop on-site and in detail. Disadvantages: limited by outcrop access (e.g., the interesting thrust might be just out of reach…).	Examine scaled, high-resolution, 3D outcrop models of interesting field sites (created from photogrammetry or LiDAR data). Receive lecture and take notes. Interact with and take measurements on virtual outcrop. Advantages: can zoom/pan & experience in 3D, unlimited by access. Disadvantages, detail limited by resolution of 3D model.
Data synthesis and report writing	Assemble field notes, maps, observations, photos etc. Plot stereograms and construct cross sections on paper. Convert data/observation to digital format and generate report on a computer. Advantages, limited computer skills not a problem. Disadvantages, time consuming data-transcription step to convert notes to digital products.	Assemble digital data and use computer software to plot stereograms and construct cross sections. Advantages: data is already collected/generated in digital format eliminating transcription step. Disadvantages: additional computer skills required.