GEOL 465 Maymester field course:

The Geological History of Southern Spain

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Introduction

Field-based observation is an essential part of the Earth Sciences, and forms the basis for much continuing geological research. This field-based Maymester course on the Geological History of Southern Spain will provide undergraduates with an integrative geological field experience that will allow them to apply their knowledge to a research problem involving most aspects of the Earth Sciences. As such it will help them place the various courses they have taken in context with each other, and to think in an interdisciplinary and creative fashion. The field experience in southern Spain will also allow students to experience some aspects of the culture, architecture, and language of a European country shaped by contrasting civilizations over three millennia.

Course outline

The course will consist of three parts.

Part A will comprise a set of 8-10 preparatory seminars at USC centered around the geological problems posed by the mountain chains and basins that form the southern part of Spain and adjacent areas of Morocco and the western Mediterranean Sea. These will take place during the Spring semester, 2018, after Spring Break.

Part B consists of a 10-day field trip in Andalucía, southern Spain, during which the students will investigate a set of inter-related research questions. This will be held during the second half of May.

Part C consists of the preparation of a term paper about an aspect of the research carried out in the field. This phase will be supported by a set of discussion sessions held during the field course, and must be completed by June 30, 2018.

All instruction will be carried out by Professor John Platt, of the Department of Earth Sciences at USC, and by graduate Teaching Assistants from the department.

Course details

Part A

Seminar sessions will be held during the Spring Semester preceding the field course. Participation in the seminars will include verbal presentations and the submission of written summaries: assessment will be provided in time for the following seminar. The seminars will be based on published literature relating to the topics listed below. Reading lists will be provided in advance of each seminar.

- Plate tectonics, retreating subduction zones and back-arc basins
- Regional geology of Betic-Rif arc
- External Betic-Rif thrust belt.
- History of subduction in the Betic Cordillera

- Back-arc extension in the Alboran Domain
- Mantle rocks in the Alboran Domain
- Neogene basins, magmatism, and strike-slip faults

Part B. The field program. This consists of 10 field days, plus two days travel time to the location in southern Spain, and one day travel time on the return. A series of field exercises will be carried out during the course; these will be completed during the evening of each day, and assessed while the course is in progress.

Day 1. Introduction. Active tectonics of the Carboneras strike-slip fault zone. Neogene calc-alkaline magmatism. Messinian reef complexes fringing a late Miocene volcano.

Day 2. Clastic sedimentation and structure in the Late Miocene Sorbas-Tabernas extensional basin. Early extensional growth faulting; deep marine channels on a submarine fan; giant submarine slide structures; folding and reverse faulting during basin inversion; unconformable Messinian evaporites.
Assessed exercise: structural mapping of an intrabasinal structure using sedimentological younging criteria.

Day 3. Structure of recumbent fold-thrust complex in the Sierra Alhamilla. Use of fold-cleavage relations, polyphase folding and multiple foliations, and porphyroblast-matrix relations to analyse a low- to medium-grade metamorphic sequence involved in folding and thrusting on a range of scales.
Assessed exercise: structural analysis of a recumbent fold-thrust structure.

Day 4. High-pressure metamorphic rocks associated with early Miocene subduction of the Iberian margin. Eclogite, amphibolite, high-pressure pelitic schist, and Paleozoic granite involved in subduction and exhumation.

Day 5. The structural and sedimentological evolution of the Late Miocene Huercal-Overa basin. Low-angle syn-sedimentary normal faults in syn-rift and post-rift sedimentary sequences; normal faulting in the underlying crystalline basement.
Assessed exercise: reconstruction of a rollover structure above a low-angle normal fault.

Day 6. Stratigraphic evolution of the Mesozoic rifted margin of Iberia, and the structure of the Miocene thin-skinned fold-and-thrust belt. Triassic continental evaporites; platform and basinal facies Mesozoic carbonate sequences, debris flows and slump folds developed in an active marine rift, the Cenomanian-Turonian anoxic event, use of stratigraphic contrasts to identify major thrust structures.
Assessed exercise: internal structure of a thin-skinned thrust belt.

Day 7. Stratigraphic and geomorphic evolution of a continental collision zone. The Sierra Nevada, the Guadix and Granada basins, the Subbetic and Prebetic thrust belts, transfer faults, unconformity of late Miocene basinal sequences above folded and thrusted Mesozoic sediments.

Day 8. A journey through the continental crust to the sub-orogenic Moho and the mantle. Zoned metamorphic sequence through exhumed rocks with an early subduction-related high-pressure/low temperature metamorphism, overprinted by progressively lower pressure and higher temperature metamorphism during exhumation.
Assessed exercise: construction of a PT path for exhumed lower crustal rocks.

Day 9. Thermal and structural evolution of the Ronda peridotite massif. Mylonitized garnet peridotite, spinel peridotite with tectonite fabric, spinel peridotite with melt percolation features, plagioclase peridotite with late shear zones, and the upper and lower contacts of a peridotite sheet emplaced into continental crust.

Day 10. Thrust belt, olistostrome, or accretionary wedge? A section through the Mesozoic and Tertiary sediments of the Gibraltar area, variously interpreted as being formed by sedimentary or tectonic processes at the front of an advancing thrust belt.

Part C. Discussion sessions will take place during the evening of each field day, and a final discussion and debriefing will be held on the afternoon of the last field day. These discussions will be designed to assist the students in the preparation of a term paper researching some aspect of the geological evolution of the area. The students will have a choice of topics, and will submit the term paper electronically by the official end date of the program.

Grading Structure

5 graded seminar presentations prior to the field trip, 8% each	40%
5 graded exercises during the field trip, 8% each	40%
term paper	20%

Recommended Preparation:
Introductory Earth Science course (e.g., GEOL105)
GEOL 315L Minerals and Earth Systems.
One or more of GEOL 316L Petrologic Systems; GEOL 320L Surficial Processes and Stratigraphic Systems; GEOL 321L Structural Geology and Tectonics.

Teaching/study load
Contact hours for this course consist of 10 2-hour seminars at USC, and approximately 70 hours of contact time in the field, including evening sessions for discussion and working up assessed exercises. The total commitment of 90 contact hours is equivalent to a 4-unit semester course with 6 contact hours per week.

Logistics
Students and faculty will stay in hotels in a number of different towns in southern Spain, and travel in rental vehicles to field locations. To ensure safety in the field, students will always work in a group together with the instructor, and there will always be more than one vehicle available for transportation. There are excellent publically funded clinics in each of the towns where we will stay (Carboneras, Velez Rubio, Loja, and Ronda), which can provide medical services as needed. Students will need to be in good health,

physically fit, and able to walk in the field for distances up to several miles. We will be in contact with several long-standing research colleagues of Professor Platt at the University of Granada, and subject to their time and availability, we will meet them in the field or at the university for discussions.

Student matters

The course will need a minimum of 7 and a maximum of 20 students to be viable. It will be of benefit to both junior and senior undergraduates who have taken some essential courses in the Earth Sciences, as well as graduate students. Participants will be selected by the Undergraduate Advisor in consultation with the instructor.