

Chapter 1

Introduction to *Geology and Geomorphology of Eastern Santa Cruz Island, California*

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Abstract

The Northern Channel Islands of California are part of the western Transverse Ranges. The islands are the surface expression of an extensive anticline produced by north-south shortening and east-west extension associated with the Big Bend of the San Andreas Fault. The geology and geomorphology of Santa Cruz Island, the largest of the Northern Channel Islands, records the complex history of the Transverse Ranges. This volume is a collection of papers developed during a Fall 2010 graduate seminar in Geology at the University of California, Davis. The class conducted a reconnaissance of the eastern end of Santa Cruz Island, contained within Channel Islands National Park. The volume contains papers on the tectonic history of the Transverse Ranges and the neotectonics of the Northern Channel Islands. In addition, papers explore the geology, marine terraces, stream profile development and hillslope processes of the eastern portion of the island. Finally, two papers examine the overall wave regime of the island and associated shoreline geomorphology.

Introduction

As part of a Fall 2010 graduate seminar in the Department of Geology at the University of California, Davis, we (eight students and me, the professor) chose to study the Channel Islands of California. This work centered on the largest of the islands: Santa Cruz Island. We conducted a five-day field reconnaissance of the eastern end of the island, all within the Channel Islands National Park. Fieldwork was conducted by hiking and sea kayaking, which afforded a unique look at the numerous and complex landforms and geologic units of the island. After this reconnaissance, the students of the class chose a suite of topics to explore about the geologic history and geomorphology of the island. This volume assembles these papers with the intention of making them available use by future classes. In addition to these papers, the

Geology and Geomorphology of Eastern Santa Cruz Island

students prepared FLOGs (Field Logs) that describe places or processes of interest that can be found on eastern Santa Cruz Island¹.

This paper provides a brief introduction to the Northern Channel Islands and describes the papers included in this volume. Most of the material covered here is examined in more detail in the following papers.

Background

The Continental Borderland of Southern California stretches from the coastline to the Patton Escarpment (Figure 1.1). In Southern California, the Borderland reaches its maximum width of more than 160 km. This geographic region—known as the Southern California Bight—consists of a complex array of northwest-trending basins, ridges and banks. One of the most distinctive aspects of the Bight—at least to most Californians—is the occurrence of the Channel Islands. These eight major islands, scattered across the Bight, are all a product of the development and evolution of the San Andreas Fault system since the early Miocene. They are, in effect, the tops of mountains being constructed by regional dextral shear that is rotating, deforming or translating numerous discrete tectonic blocks (Atwater, 1998).

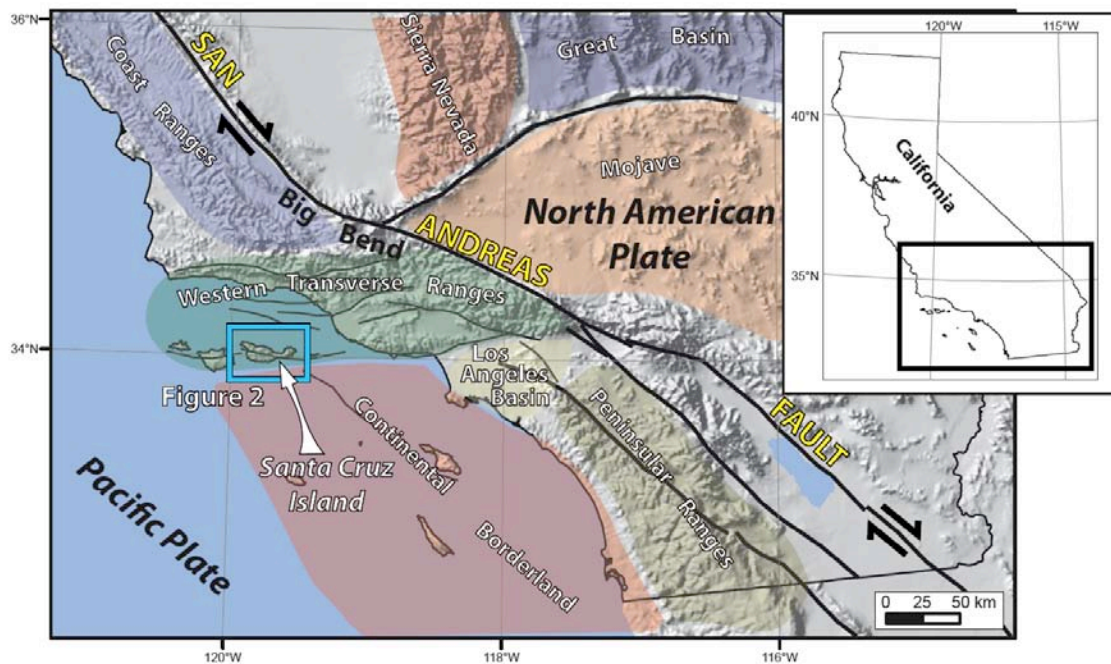


Figure 1.1. Southern California Continental Borderland and Northern Channel Islands.

¹ The FLOGs can be found at: <https://www.geology.ucdavis.edu/~shlemonc/> For those interested in running geology field trips on the island, the FLOG by Mount and Margid describes some of the logistics.

Geology and Geomorphology of Eastern Santa Cruz Island

At the same time that tectonic activity has been creating the mountain-islands of the Bight the processes of erosion have been removing them. These include wave action that erodes their shorelines, shrinking island footprints, and the lowering of island elevations through weathering, mass wasting, and erosion from runoff and wind. These processes of island destruction have varied in intensity and location through time, as both climate and sea level have changed during the Quaternary. Thus, the geomorphology of the Channel Islands today is a work in progress. The islands' rocks, shorelines, hillslopes and streams are a product of a continuum of historical events being modified by current conditions.

At more than 250 km², Santa Cruz Island is the largest of the northern Channel Islands archipelago. The island is elongate, stretching more than 35 km along an east-west axis, and narrowing to five km in width along a distinctive "neck" on its eastern end (Figure 1.2). The island's topography reflects its current high rates of tectonic deformation and uplift (Pinter, 2003). It is rugged, with multiple peaks above 600 m, numerous deeply incised canyons, and vertical sea cliffs along most of its shoreline. The island margins display at least three prominent marine terraces, recording late Quaternary island uplift. In addition, the island has numerous large active and stabilized landslides.

The island is bisected by the Santa Cruz Island Fault (Figure 1.2). This left lateral strike slip fault bounds a prominent strike valley in the central and eastern portions of the island and shows abundant evidence for late Quaternary slip (Pinter, 1998). Geologic units exposed south of the fault consist of pre-Jurassic metamorphic rocks and Tertiary volcanoclastic rocks. The geology north of the fault is dominated by two Miocene formations: the Santa Cruz Island Volcanics and the Monterey Formation (Weaver, 1969). The Monterey Formation is an important petroleum source and reservoir in the nearby Santa Barbara Channel.

The northern Channel Islands form the southern margin of the western Transverse Ranges. This mountain range is an expression of transpressional conditions and clockwise block rotations along the "Big Bend" of the San Andreas Fault (Atwater, 1998). The islands are part of an extensive regional anticline that stretches to the Santa Monica Mountains on the mainland.

The field reconnaissance conducted for this class focused on the eastern end of Santa Cruz Island within the portions of the island managed by Channel Islands National Park. This portion of the island lies north of the Santa Cruz Island Fault. The bedrock is made up entirely of blocks of Santa Cruz Island Volcanics and Monterey Formation that are extensively faulted. The contrasting erosional resistance and internal cohesion of the two geologic units exerts a major control on the geomorphology of the island. These contrasts influence the formation and orientation of stream networks, the location, mechanics and magnitude of hillslope erosion, and the nature of sea cliff retreat. The field area also has well-preserved remnants of the late Quaternary marine terraces. The most prominent terrace—dated at approximately 400 ka (Pinter et al., 2003)—forms the top of the larger sea cliffs of the coast.

Geology and Geomorphology of Eastern Santa Cruz Island

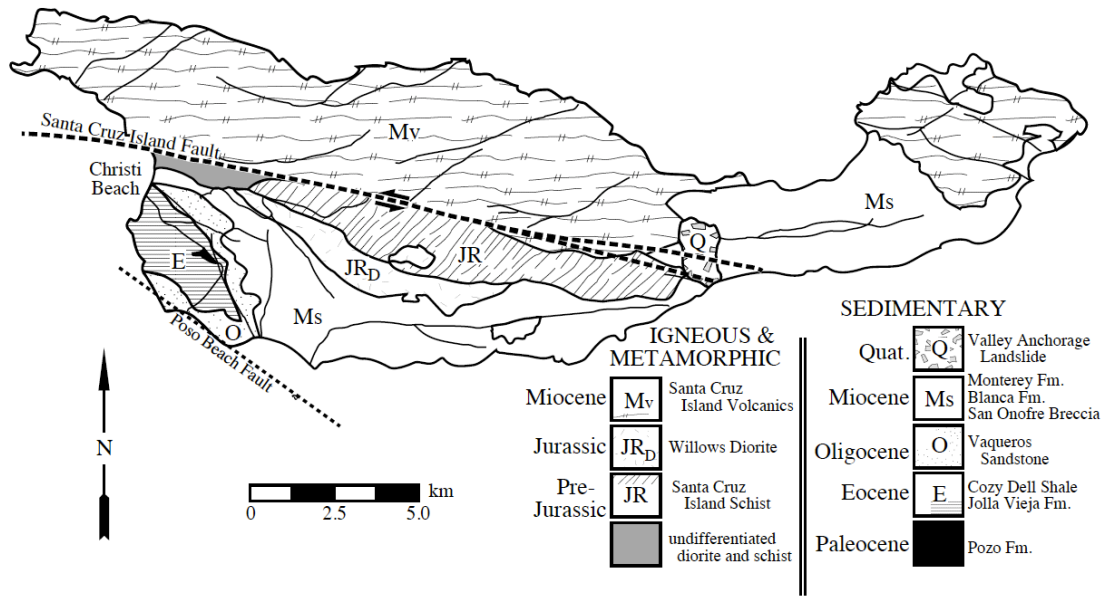


Figure 1.2. Generalized geologic map of Santa Cruz Island. Focus of fieldwork for this volume was on eastern third of the island. Two Miocene units studied include the Santa Cruz Island Volcanics and the Monterey Formation, including terrace deposits not shown here. See Chapters 2-4 in this volume for more description. Map modified from Pinter et al, 1998.

This Volume

Outside of this introduction, there are eight papers that make up this collection. The first in the series is by Bartolomeo and Longinotti and describes the assembly of the Channel Islands and the Transverse Ranges (Chapter 2). This paper highlights the complex tectonic processes that were associated with southern California’s transition from a convergent margin to a transform margin in the Cenozoic. This paper is followed by Longinotti and Bartolomeo’s description of the main geologic units found on eastern Santa Cruz Island (Chapter 3). This paper summarizes the mid-Miocene history of the western Transverse Ranges, including widespread volcanism followed by rapid subsidence and the formation of deep, anoxic ocean basins.

The third paper in this series is by Selander and Clark and analyzes the complex neotectonic history of Santa Cruz Island (Chapter 4). The paper details the Quaternary deformation of the island associated with north-south shortening and east-west extension (“extrusion”) of the Transverse Ranges. This paper is paired with one by Clark and Selander that examines the uplifted and deformed marine terraces of the island (Chapter 5). Precise age-dating of these terraces by other researchers allows for estimates of rates of uplift of the island and assessment of the processes of terrace erosion.

The fifth paper in this volume is by King and Tracy (Chapter 6). This paper uses a GIS-based analysis of longitudinal stream profiles to evaluate the interaction between rates of island uplift and differential erosional resistance of the two main geologic units in controlling stream incision. This paper is followed by Tracy and King’s assessment of the key hillslope processes of

the island (Chapter 7). This paper describes the taxonomy of soils on the island and the many forms of erosion or mass wasting.

The final papers of this volume focus on the processes controlling shoreline erosion and sea cliff morphology. The paper by Burley and Suddeth offers a detailed description of the wave regime of the island (Chapter 8). High variability in orientation, type and intensity of waves create the complex coastline and wave cut platform of the island. The final paper, by Suddeth and Burley, provides an empirical analysis of the morphology of sea cliffs on the island and relative rates of sea cliff retreat (Chapter 9). The island shorelines, whether sandy beach backed by gentle slopes, or rocky shoreline backed by cliffs, are an expression of the wave regime, the erosional resistance of the bedrock, and rates of uplift.

Conclusion

The Channel Islands of the Southern California Bight are well known for their unique island biogeography, including more than 1000 endemic plants and animals, and abundant marine life. These islands are less well known for their unique geology and geomorphology. Eastern Santa Cruz Island provides an outstanding natural laboratory for studying the continuum of tectonic and geologic processes that shaped the western Transverse Ranges and the Northern Channel Islands. The papers presented in this volume describe many of the aspects of this continuum, including the tectonic development of Santa Cruz Island, the history encapsulated in its geologic units, and the processes that are shaping it today. It is the consensus of the authors of the papers in this volume (Figure 1.3) that this field site provides an exceptional opportunity for learning geology, both by hiking and, of course, kayaking.



Figure 1.3. From left to right: Eleanor Bartolomeo, Jacob Selander, Alicia Clark, Robyn Suddeth, Jeff Mount, Nate Burley, Nicole Longinotti. Inset left: Bridget Tracy. Inset right: Aaron King.

Acknowledgements

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<https://www.geology.ucdavis.edu/~shlemonc/>

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