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The role of fieldwork in rock decay research: Case studies from the fringe

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ABSTRACT

Researchers exploring rock decay hail from chemistry, engineering, geography, geology, paleoclimatology, soil science, and other disciplines and use laboratory, microscopic, theoretical, and field-based strategies. We illustrate here how the tradition of fieldwork forms the core knowledge of rock decay and continues to build on the classic research of Blackwelder, Bryan, Gilbert, Jutson, King, Linton, Twidale, and von Humboldt. While development of nonfield-based investigation has contributed substantially to our understanding of processes, the wide range of environments, stone types, and climatic variability encountered raises issues of temporal and spatial scales too complex to fit into attempts at universal modeling. Although nonfield methods are immensely useful for understanding overarching processes, they can miss subtle differences in factors that ultimately shape rock surfaces. We, therefore, illustrate here how the tradition of fieldwork continues today alongside laboratory and computer-based investigations and contributes to our understanding of rock decay processes. This includes the contribution of fieldwork to the learning process of undergraduates, the calculation of activation energies of plagioclase and olivine dissolution, the high Arctic, the discovery of a new global carbon sink, the influence of plant roots, an analysis of the need for protocols, tafoni development, stone monuments, and rock coatings. These compiled vignettes argue that, despite revolutionary advances in instrumentation, rock decay research must remain firmly footed in the field.

1. Introduction

Scientists publishing papers on the decay of rocks hail from archeology, architecture, astrobiology, botany, chemistry, civil engineering, geochemistry, geography, geology, hydrology, microbiology, microscopy, pedagogy, soil science, stone conservation, and zoology. Methods employed include a host of strategies including bench geochemistry, computer modeling, culturing microorganisms, DNA analysis, geographic information science, light and electron microscopy, modeling through physical experiments, numerical modeling, various theoretical approaches, and different field methods.

The authors of this paper, like many other researchers, have training in multiple disciplines and often use different methodological strategies—following the warning of Yatsu (1988, p. 150) “that many geomorphologists ensconse themselves comfortably in authoritative positions, merely on the basis of their field observations without any vigilant attention to knowledge in other sciences.” While we use different research approaches, we all advocate the position in this paper that fieldwork offers unique and vital insight into theory building in rock decay research. We do not contend that every field-derived concept has maintained its value over the years. For example, in his influential textbook, Merrill (1906: 293) writes about a *Personal Memoranda* with Israel C. Russell:

> Professor I.C. Russell, who has devoted much attention to the subject of rock-weathering in both high and low latitudes, is of the opinion that rock *decay* [italics in the original] is a direct result of existing climatic conditions. He states that decay goes on most rapidly in warm regions where there is an abundant rainfall, and it is scarcely at all manifest in arid and frigid regions. Professor

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Russell's observations are of more than ordinary value, since he has discriminated between decay and disintegration, which most writers have failed to do (Merrill, 1906).

We are of the opinion that this oft-repeated perspective is wrong (Dixon et al., 1984; Thorn et al., 1989; Pope et al., 1995; Dixon and Thorn, 2005) and has slowed our understanding of rock decay in warm deserts, alpine, and Arctic/Antarctic settings. In general, however, fieldwork by pioneers in geomorphology has provided much of the core knowledge we pass on to the next generation. Simply evaluate a basic course in geomorphology. Many of the basic concepts and terms presented in Table 1 derive from fieldwork.

The purpose of this paper is to highlight the continued importance of fieldwork in the study of rock decay. We accomplish this through presenting a series of vignettes, each emphasizing that fieldwork remains indispensible.

2. Case studies

A vital and vibrant field of academic research must contain a number of elements. The case studies presented below exemplify why field research in rock decay rests in no danger of becoming the academic equivalent of ice stagnation topography. Top undergraduate students must find research in the field relevant and exciting (Section 2.1). Basic research must not adher to untenable paradigms, even as this research includes iconic locations such as Kärkevagge (2.2), Petra (2.3), or Yosemite Valley (2.4). Basic research must connect with the interests of the general public that supports research (2.5 and 2.3) and yet must continue to invigorate core concepts taught in introductory courses (2.8). The research must connect with the bigger issues of science, such as global climate change in the early 21st century (2.6 and 2.7). Research must also be able to identify forks in the roadways of investigation, when ongoing efforts require a new vision (2.9).

In each case study, we have avoided the term weathering. We advocate the conclusion of Hall et al. (2012, p. 9): "given the inadequacies entrenched within the term and the current explosion in techniques and data availability, we need a term that reflects the reality of what is happening more accurately. Our choice would be 'rock decay' evaluated with the notion of energy transfer as the basis for considering process." More than a century ago, Merrill's (1906) treatise distinguished between decay and disintegration. While we understand the reasons for this differentiation, we agree that rock decay connotes the broad intent of weathering researchers as well as the subject that we all study.

2.1. Building a Rock Decay Nerd, by Casey D. Allen, Kaelin M. Groom, Tyler J. Thompson, Niccole Cerveny

Yatsu's (1988: 505) seminal work on *The Nature of Weathering* concludes: "YOUNG STUDENTS FULL OF **ENTHUSIASM** AND ENERGY WILL PLAY THE MOST ACTIVE PART IN THIS FIELD (capitalization and bold in the original)." Thus, we start with a vignette that illustrates fieldwork's importance in educating the general population about our field and recruiting future geomorphologists with interests in rock decay. University-level introductory texts, while providing minimal treatment of rock decay, usually accompany explanations with especially beautiful yet very static and flat imagery. This portrayal does not sit well with today's students raised on three-dimensional IMAX movies, interactive motion-sensing video games, or visual displays on their smartphones. In fact, when it comes to geomorphology in general and rock decay specifically, without fieldwork, the learning landscape can be uninspiring and two-dimensional, plain, and boring. Fieldwork helps create interest in subject matter, principles, content, and concepts, while at the same time creating a rich landscape of possibilities and endless tracks of interest that drive the budding rock decay nerd[1] (RDN). Indeed, *seeing* that same textbook rock decay form *in situ* enhances the understanding of process(es) that helped create it. Take case hardening as an example, notoriously difficult-to-explain. Imagery and textual explanation, no matter how illustrative and spectacular (Dorn et al., 2012), cannot express the feel a budding RDN gets when they tap on a case-hardened rock and hear its hollowness, or actually see the rock being eaten (decayed) from the inside-out. With undergraduate fieldwork, the important rock decay forms and processes are suddenly and intimately realized.

Those who have experienced it know: students learn concepts better by *doing* fieldwork rather than sitting in the classroom—and research certainly backs up this claim (Kent et al., 1997; Warburton and Higgitt, 1997; Hudak, 2003; Ellis and Rindfleisch, 2006; Fuller et al., 2006). Recent studies demonstrate the power of combining fieldwork with rock decay specifically, to deepen understanding of its complex forms and processes (Allen, 2008, 2011; Allen and Lukinbeal, 2011; Allen et al., 2011); these studies also note gender, ethnicity, content interest level, and learning style as nonfactors when engaging students in fieldwork using rock decay as an interface.

In the classroom, however, unless the instructor is an RDN themselves, the importance of this most foundational (yet highly complex) concept is lost on students, as many relate it specifically to atmospheric phenomena ("weather"/"weathering") and sometimes confuse it with erosion (Dove, 1997). Even if the instructor *is* an RDN, incorporating field time into the (perhaps required) pedagogy is often tedious at best. Following this logic then, it seems that many potential RDNs might not be recognized or, perhaps worse, never be inspired because they never get to experience fieldwork. Instead, students are left to peer/parental pressures, job market demands, and career counseling sessions to help them find their passion, which very likely will *not* include geomorphology. A potential solution to this stagnation rests in exposing undergraduates to rock decay with hands-on applications and research via fieldwork.

One way to accomplish this lies in using the local landscape as an introductory study site. As rock decay is ubiquitous, using campus buildings, sidewalks, and even building interiors provides the promising RDN access to understanding the connections between forms and processes (Fig. 1). Whether as part of an introductory class or a more in-depth independent research project, these experiences serve as a primer to "hook" students on rock decay concepts and principles. Then, given more time—and maybe for an advanced course or as part of the instructor's research agenda—students extend their rock decay prowess to nonlocal and more specialized settings.

Building upon these premises in the past few years, up-and-coming undergraduate RDNs at University of Colorado Denver have studied rock decay locally, but also regionally and internationally in such locations as the Painted Desert, Grand Tetons, the Wasatch Front, London, Paris, and the Caribbean—making grander connections (Allen, 2011; Allen and Lukinbeal, 2011). If you are fortunate to have rock art, old buildings or even old cemeteries near your campus, visit this instructor's guide on how to teach about rock decay in introductory courses: http://alliance.la.asu.edu/rockart/NSF/RASI_InstructorsGuide.html. Certainly, catching the RDN early in their undergraduate career remains key, but infusing rock decay fieldwork into our pedagogy, and by extension their studies, will help solidify the nascent RDN mold and, eventually, allow the undergraduate to emerge as a full-grown, experienced, rock decay nerd, ready—and excited!—to work at the forefront of cutting-edge rock decay science that integrates fieldwork.

As each new generation of students come to our classrooms with increasingly high expectations for stimulating (not boring) educational experiences, fieldwork offers a unique venue to connect faculty

[1] According to the *Urban Dictionary*, the term *nerd* is actually an acronym for Never Ending Radical Dude. We ascribe to this definition and see being called a rock decay nerd as having earned our varves (stripes, as it were) in the discipline.