Navajo Pedagogy and Earth Systems

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ABSTRACT

The Navajo interpretation of nature attributes geological change and equilibrium, and the sustainability of life in the surface environment, to dynamic processes of renewal driven by interactions between Nohosdzáán (Earth environment) and Yádilhil (Sky environment). An introductory physical-geology course for Navajo students at Navajo Community College incorporates this Navajo model within an Earth systems curriculum, wherein geological materials, landforms, processes of change, and Earth history are interpreted as the result of interacting endogenic (tectonic, magmatic) and exogenic (atmospheric, hydrospheric) processes. Second-order parallels between Navajo and "Western" (Euro-American) models of dynamic equilibrium can be employed to teach rock-cycle processes and other geochemical cycles. Use of Navajo and Euro-American sets of geologic concepts in concert is intended to enhance Navajo students' abilities to do science, to reinforce their understanding of their culture, and to foster appreciation and stewardship of their lands.

Keywords: Education – geoscience; education – special clientele; education – undergraduate; geology – teaching and curriculum; geology – women and minorities; philosophy of science; science.

The Navajo Model of Natural Systems

Traditional Diné (Navajo) knowledge teaches that there are two great systems that are responsible for all processes and existence on Earth. First, there is a system in all darkness above: the Sky, termed Yádilhil. (See the Appendix for a guide to pronunciation of Navajo terms.) The Sky system is symbolized by a male form with his feet to the east and head to the west, in the direction of the rising and setting Sun. The second system is Nohosdzáán, ground or Earth, symbolized by a female form oriented from west to east, directly opposed to Yádilhil. Landforms, flora, and fauna occupy the space between the Earth and Sky systems.

According to the Diné, processes of atmospheric, geologic, and biologic change result from dynamic interaction between male-like and female-like principles. Male-like principles such as light from the Sun and heat within the earth are driving forces for change. Female-like principles are those that re-establish harmony and balance in the system. A frequently cited example of the difference between these qualities is the contrast between powerful late-summer thunderstorms ("male rain") and gentler showers ("female rain") in the spring and fall, both attributes of climate on the deserts and steppes of the Colorado Plateau. Male rain, accompanied by strong winds and intense lightning, erodes soil, rapidly saturates small catchments, and causes flash floods. Female rain moistens parched soil and nurtures plant growth, which protects against soil erosion and provides a source of food.

Interaction between male-like and female-like principles causes the movements, changes, and cyclical activity operating within the Earth and Sky systems (Figure 1). Each cyclical process is said to occur by means of four sequential steps (see Table 1).

Four Sequential Steps	Approximate English Translations
nitsáhákees	consciousness or thought
nahat'á	planning or action
iiná	purpose, life, or existence
siihasin	stability, durability, or balance

Table 1. Four sequential steps of cyclical processes and their approximate English translations. (Navajo Community College, 1992).

The Diné paradigm for cyclical processes is empirical and is analogous to Le Châtelier's principle in Euro-American physical chemistry, which states that a system in equilibrium, if disturbed, responds so as to counteract the disturbance. Nitsáhákees is the perturbation of a natural system; nahat'á is change or feedback in the system, in response; iiná is a new equilibrium state, and siihasin is the continued stability of the new equilibrium under the altered conditions.

Continuous interaction among dynamic processes in the Nohosdzáán and Yádilhil systems maintain hózhó, a state of balance and harmony, in the near-surface environment, rendering it hospitable to life. The Diné model recognizes the contribution of both constructive and destructive processes, such as soil formation and mass wasting, to hózhó. However, events that cause excessive damage and destruction are attributed to imperfections in the natural order.

Application to the Introductory-Geology Curriculum

The organizational concept of Earth and Sky, including the dynamic cycles of change operating within each realm and their interactions, is common to many Native American worldviews (Williamson and Farrer, 1992). The concept parallels what may be termed a bilateral Earth-systems framework for the introductory-geology curriculum, wherein geological materials, landforms, changes, and Earth history

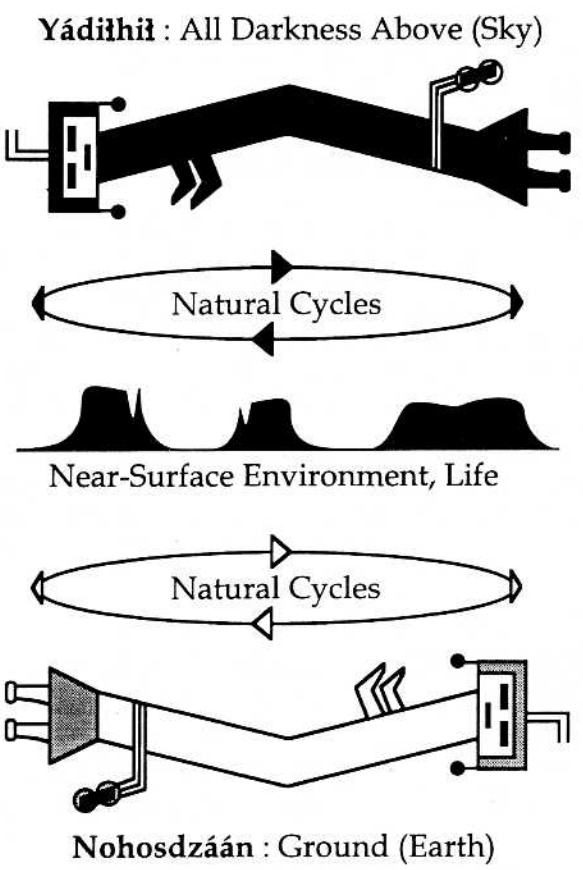

Figure 1. Diné model of natural systems.

are interpreted as the result of interacting endogenic (plate-tectonic, magmatic) processes in the solid Earth and exogenic (atmospheric, hydrospheric) processes in the fluid Earth. Endogenic and exogenic processes of change are equally visible in the surface environment, which is the major frame of reference for beginning students.

This bilateral, system-oriented view is central to at least one popular physical-geology textbook (Hamblin and Christiansen, 1995) and is given significant treatment in some others (for example, see Judson and Richardson, 1995). Earth systems as driving forces for geologic change are discussed more unilaterally in many other texts (for example, see Press and Siever, 1994). In these, plate tectonics is usually emphasized, particularly in the introductory sections.

Our institution, Navajo Community College (NCC), is an accredited two-year college operated by the Navajo Nation to serve a student body that is nearly one hundred percent Native American. As a cultural resource and academic bridge chartered by the Navajo people themselves, NCC has a mission to enhance its students' knowledge and appreciation of their culture, their language, their history, and their homelands, while preparing them for technical or business careers or transfer to university baccalaureate programs.

Specifically referring to the teaching of science at NCC and other principally Navajo institutions, a bicultural group of research biologists and educators (Garrison and others, 1995) argues that encouraging Navajo science students to draw on both Native and mainstream worldviews improves their abilities to formulate and work with multiple hypotheses. Many NCC faculty share this opinion and are actively developing ways to use Navajo knowledge and pedagogical methods (collectively referred to as Diné educational philosophy or DEP) in concert with their "Western" (or, as we prefer, Euro-American) equivalents.

Geological aspects dominate the environment and the cultural history of the Diné, and the introductory physical-geology course at NCC in Shiprock has been identified as a pilot for integration of DEP material into a classically Euro-American college science course. Geology 101 currently serves a handful of Earth and environmental-science majors and a much larger group of non-majors. Bilingual Diné elementary-school teachers are in great demand across the Navajo Nation, and an increasing number of NCC students are pursuing such careers. Education majors are drawn to the physical-geology course because of their enthusiasm for learning more about the rocks and landforms they literally grew up on, and an understanding that they must someday address the same enthusiasm for geology in their own young students. They are also particularly responsive to the use of DEP concepts and Navajo language in the geology class.

Integration of DEP into Geology 101 has only begun. We offer below an outline of this work in progress, and examples of student activities that reinforce the Navajo cultural content of the course. Parallel to this effort, we and others are investigating specific aspects of Navajo ethnogeology in order to obtain new curriculum materials. These include traditional Diné terms for lithology, landforms, and geography; the influence of landscape and surficial processes on Diné lifeways; and more recent concerns about the environmental impact of extractive industries on Navajo Nation land (Semken, 1994; Semken and others, 1996). We have found the culturally integrative geoscience curricula developed by Savoy (1995) and by Tewksbury (1995) to be very useful models.

The Earth Systems Framework

The bilateral Earth systems model of interacting endogenic and exogenic processes is concordant with the Diné model of Nohosdzáán and Yádilhil, and we use it as an organizational theme for the physical-geology syllabus. This framework allows us to supplement lectures and student activities with appropriate Diné ethnogeologic content wherever it is available. Another advantage of this approach is that it provides a consistent set of "driving forces," relating processes such as magmatism, orogeny, metamorphism, weathering, and sedimentation that might otherwise be seen by first-time geology students as disparate and unrelated.

We begin by identifying the two primary Earth systems and the major cyclical or quasi-cyclical processes, which we term Earth-forming cycles, that operate within each realm:

Nohosdzáán (solid-Earth) system:

Plate tectonics, mantle plumes, Wilson cycles;

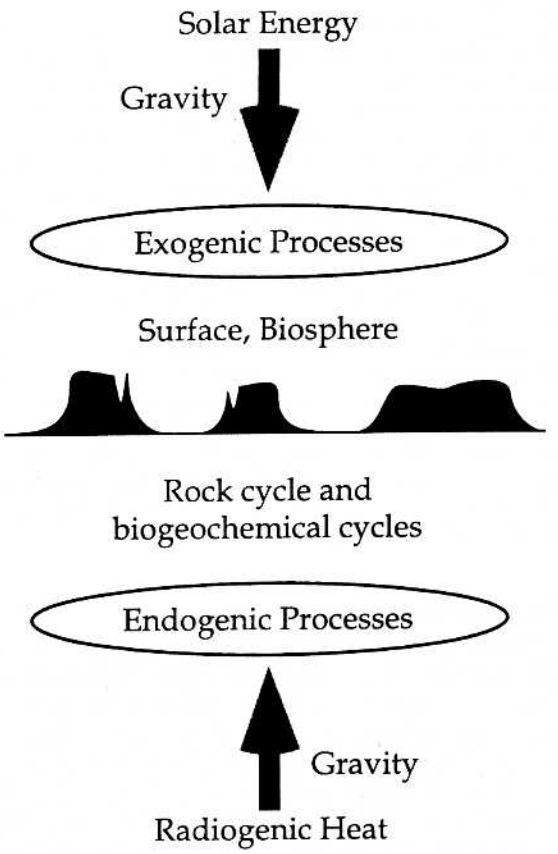

Figure 2. Bilateral Earth systems model.

Yádilhil (fluid-Earth) system:
Water cycle, atmospheric circulation, climate.

Figure 2 is a simple diagram of the bilateral Earth-systems model, arranged to illustrate similarities with the Diné model shown in Figure 1. In the curriculum, each Earth-forming cycle is characterized in some detail by its sources of energy (for example, radiogenic heat, solar energy, gravity), its major mechanisms (for example, plate interactions; evaporation and precipitation), and its geological effects (for example, mountain-building, volcanism, erosion, landscape formation). By means of quantitative exercises in which they utilize simplified formulae and data to calculate rates of plate motion, isostatic rebound, crustal uplift and downcutting, deposition in sedimentary basins and so forth, the students derive a working understanding of actualism, geologic time, and the characteristic time scales of fluid-Earth and solid-Earth change.

Dynamic Equilibrium in the Earth and "Diné Systems Analysis"

Introduction and classification of the Nohosdzáán and Yádilhil systems is first-order Diné geologic pedagogy. Second-order Diné geologic pedagogy is treatment of Earth materials, processes, and history as manifestations of the interaction of these two great systems.

We discuss and compare some of the major constructive and destructive aspects of the Earth-forming cycles, and ask students to consider what the consequences might be if some of them were to cease functioning. They quickly recognize that the dynamic interaction between Nohosdzáán and Yádilhil, even where it is terrifying and destructive, is necessary to keep Earth hospitable to life. This concept is important both to Diné and Euro-American science but is generally not explored in detail in contemporary physical-geology textbooks.

The rock cycle, which is essentially a manifestation of dynamic equilibrium in Earth materials between endogenic and exogenic processes, is amenable to modeling according to the Diné paradigm of nitsáhákees, nahat'á, iiná, and siihasin. As a class exercise, we select an arc or chord of the familiar cyclical model, with two different geological materials at its endpoints, and ask students to relate the processes involved to the stages of the Diné paradigm.

A local example we have used is the weathering and erosion of Proterozoic granite, exposed in the Pennsylvanian Ancestral Rocky Mountains, to form Permian clastics. These were buried, lithified, and then exposed by Neogene uplift and erosion as the spectacular red sandstone buttes of Monument Valley along the northern border of the Navajo Nation (Baars, 1979). A relatively simple "Diné systems analysis" (Semken, 1994) of the rock-cycle processes involved here might read as follows:

Nitsáhákees: a system in equilibrium is disturbed
Deep-seated crystalline rock (Nohosdzáán system) is exposed to Yádilhil processes and conditions in the surface environment;

Nahat'á: the system responds to the disturbance
The rock weathers, physically and chemically. Quartz is progressively reduced to fine clasts, feldspar to fine clasts and clay. Ferromagnesian minerals react with weathering agents to form metal oxides and clay;

Iiná: a new equilibrium state results
The resulting sediments are more stable with respect to the surface environment than was the granite;

Siihasin: there is continued stability
Clastic rocks formed from these sediments are comparatively resistant to weathering and erosion at the surface today and form cliffs and monoliths.

Such an analysis can be as quantitative or detailed as we wish the students to make it; for example, we could also ask for chemical equations for the weathering reactions. The result can be presented as a brief text (as shown above), orally, or graphically as a concept map or matrix (Smith, 1992).

A "Diné systems analysis" enhances student understanding of dynamic natural processes because it compels them to clearly identify and characterize each stage in a selected process or a whole system and consider exactly how it relates to all the other stages. We are now working to adapt this method to more complex systems such as the "tectonic rock

cycles" described by Fichter (1996) and biogeochemical cycles such as the carbon cycle.

These exercises are particularly effective during a field trip to Monument Valley or another classic exposure of Navajo Nation geology, Shiprock. Out of doors, anywhere within the four sacred mountains that define the homeland of the Navajo (Arthur and others, 1982) is the most appropriate place to do Diné science.

Summary

The parallel use of Diné and Euro-American scientific concepts in the introductory physical-geology course at NCC is intended to reinforce student understanding of, and to stimulate thinking and discussion of, ethnogeological concepts that have long been known to Diné people. We believe, as others have proposed (Garrison and others, 1995), that the capacity to draw on two systems of scientific knowledge will better enable our students to hypothesize and think critically. However, our most important goal is to foster the appreciation and stewardship of their homelands by all Navajo students.

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APPENDIX

Guide to pronunciation of Navajo terms used in this paper

Ter m	Pronunciation*	English translation
Din é	Din-NEH	the people, Navajo
hóz hó	ho-ZHO	balance, harmony
iin á	ee-NAH	life
nah at'á	nah-hot-AH	planning
nit sáhákees	int-SAH-hah-kess	thinking
Noh osdzáán	No-host-ZAHN	ground, Earth
sii hasin	see-hass-SEEN	stability or security
Yádilhil	YAAH-dilth-hilth	all darkness above, Sky

* Phonetic pronunciations and English translations given here are only approximate. For a more thorough treatment of the Diné language refer to the unabridged dictionary by Young and Morgan (1987).