Place-based teaching for Earth-system science literacy, sustainability, and sense of place in Arizona and the Southwest

Steven Semken

happy to acknowledge NSF support: GEO1034926, GEO1108044, EAR1101100

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ASU Julie Ann Wrigley Global Institute of Sustainability
Arizona State University

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Earth Science in Arizona and the Southwest (ESAS) is an upper-division place-based Earth-system science course offered to increasingly large and diverse groups of majors and non-majors.

The Geology 301 course is cross-listed in the ASU School of Sustainability as Sustainability 372 to appeal to sustainability science and policy majors for whom an in-depth knowledge of the Southwest is relevant and useful.

ESAS is also a core requirement for pre-service Earth-science education majors, helping all ASU teacher graduates become familiar with the local.

The sole science prerequisite is one college-level geology or physical geography course, opening ESAS to a diverse range of majors.

Piestewa Peak and Phoenix, Arizona

ESAS is authentically place-based—its design, implementation, and assessment are informed by sense of place.

Sense of place encompasses the meanings we make in places and the attachments to places we hold (e.g., Brandenburg & Carroll, 1995).

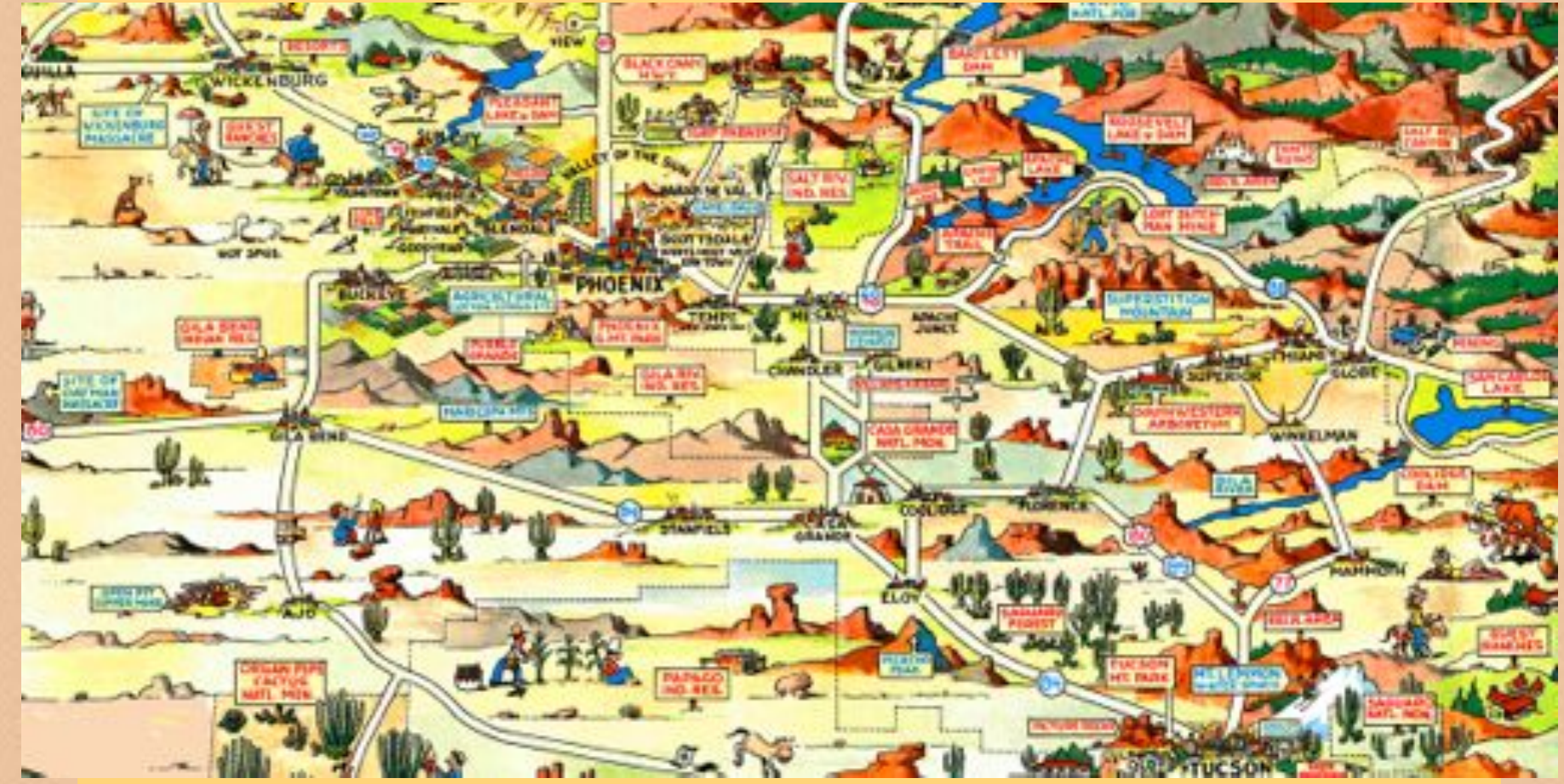
Sense of place is a valid learning outcome and assessment measure for place-based teaching (Semken & Butler Freeman, 2008).

Sabino Canyon, Arizona

ESAS is authentically place-based—its design, implementation, and assessment are informed by sense of place.

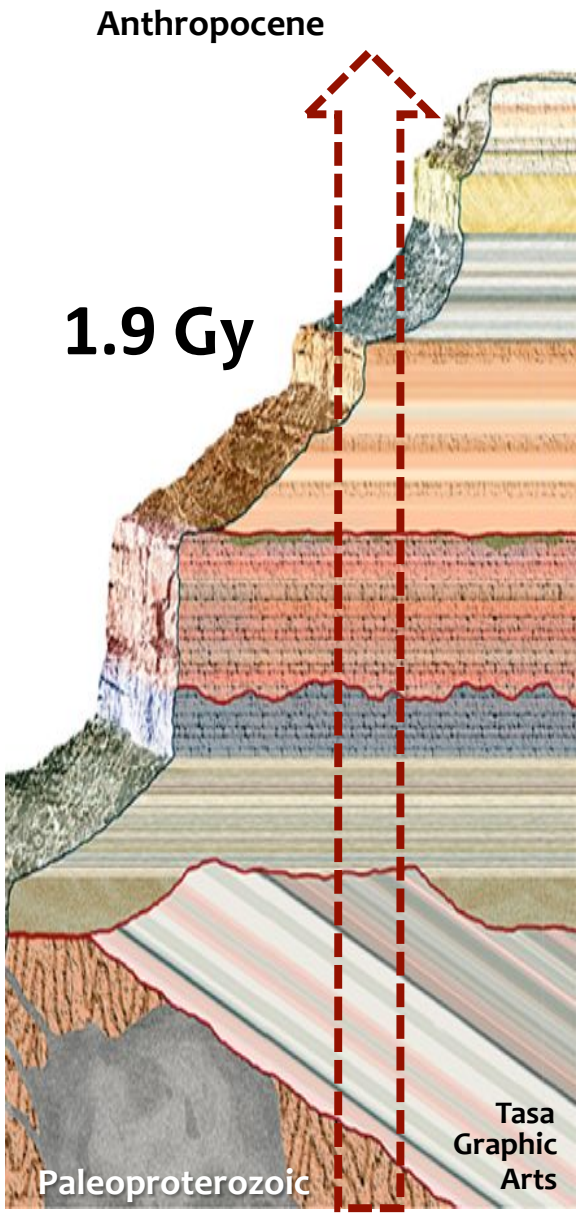
A place is any locality given meaning by human experience (Tuan, 1977).

Places populate the cultural landscape just as landforms, water, and biota comprise the physical landscape (Sauer, 1925).

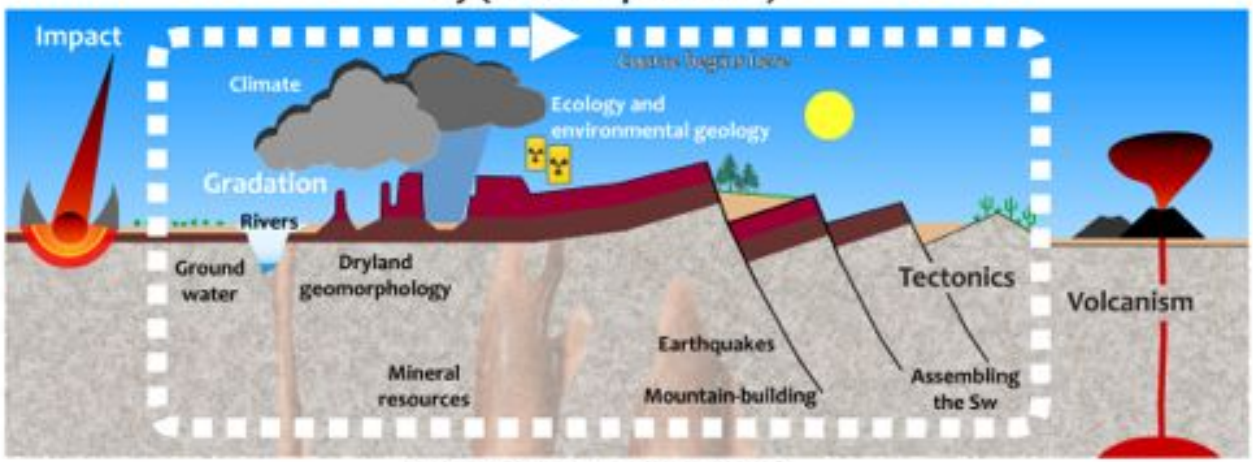


Cartoon tourist map of central Arizona (Bloodgood, 1950)

ESAS is a narrative connecting the geologic record to the Earth-system processes that formed it, in the Southwestern places where we study it.



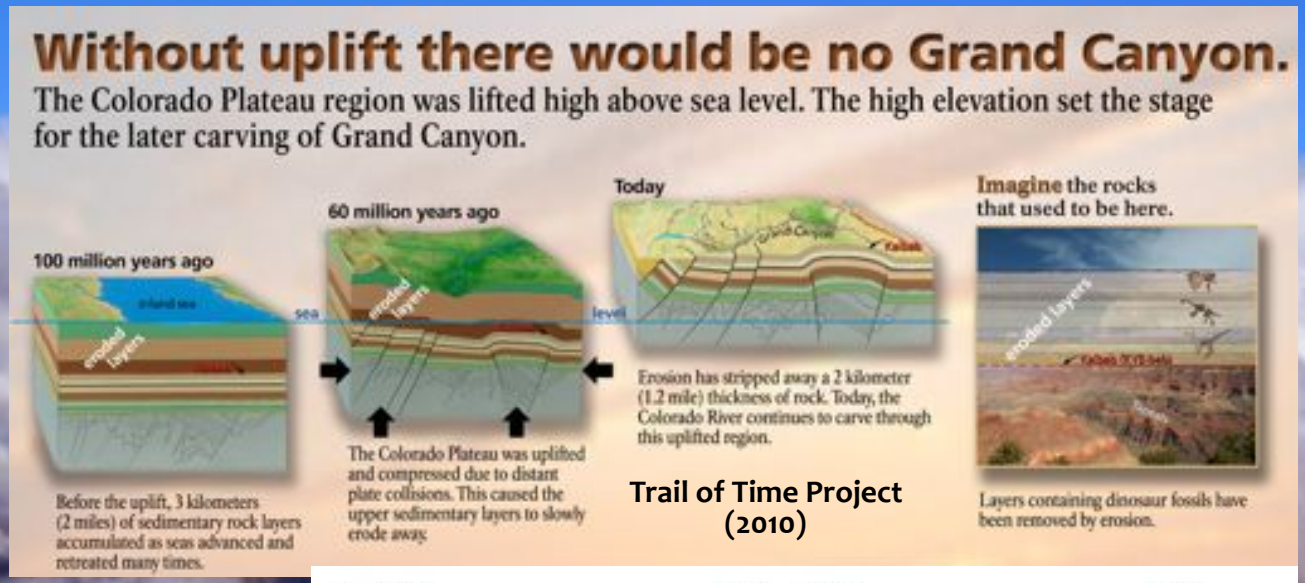
Sky (External processes)



Semken (2011)

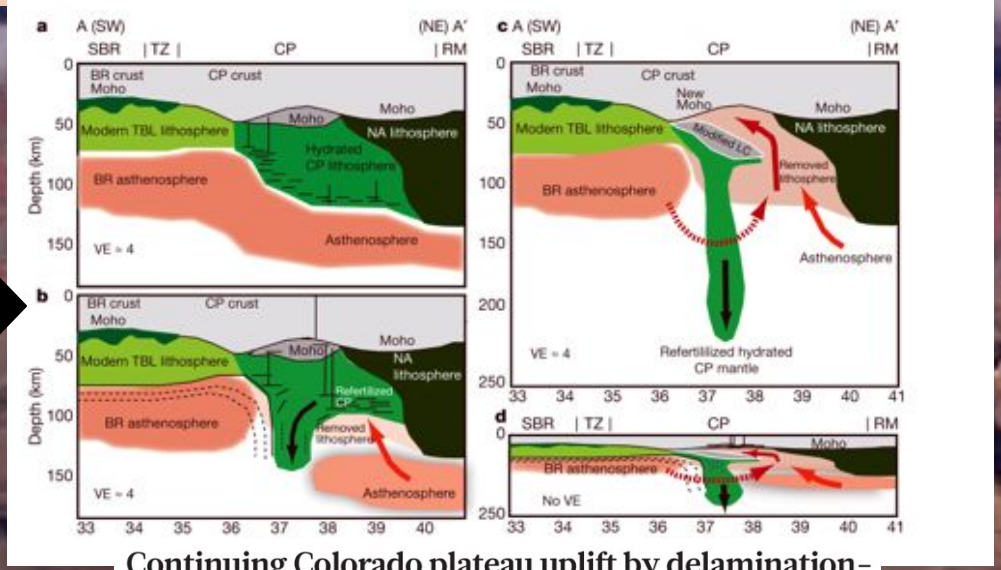
Earth (Internal processes)

ESAS connects the geological evolution of the Southwest to the nature of its spectacular scenery.



Trail of Time Project (2010)

earth scope

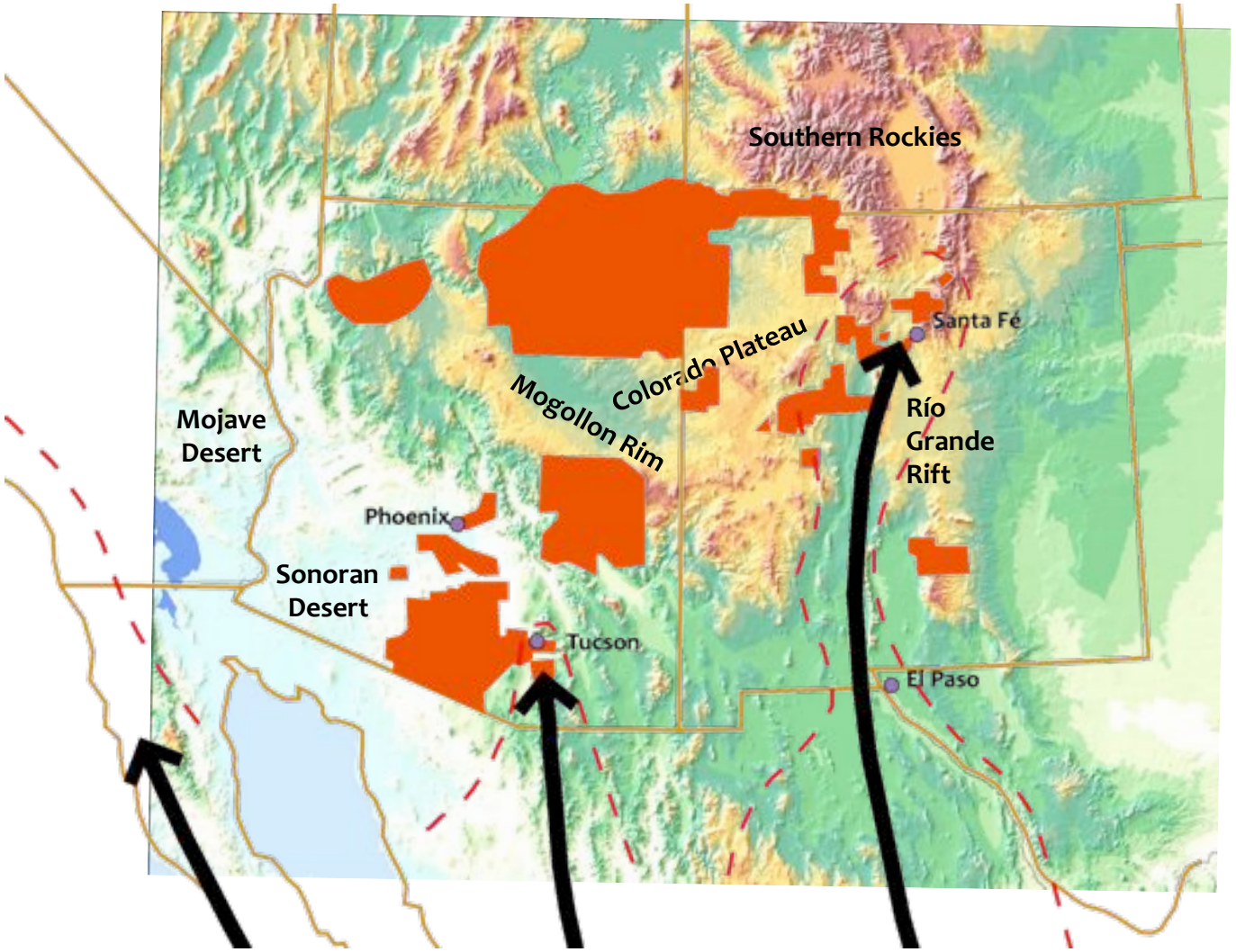


Continuing Colorado plateau uplift by delamination-style convective lithospheric downwelling (2011)

A. Levander[1], B. Schmandt[2], M. S. Miller[3], K. Liu[1], K. E. Karlstrom[4], R. S. Crow[4], C.-T. A. Lee[1] & E. D. Humphreys[2]

Grand Canyon, Arizona

ESAS connects the geological evolution of the Southwest to its human history, writ large and small.



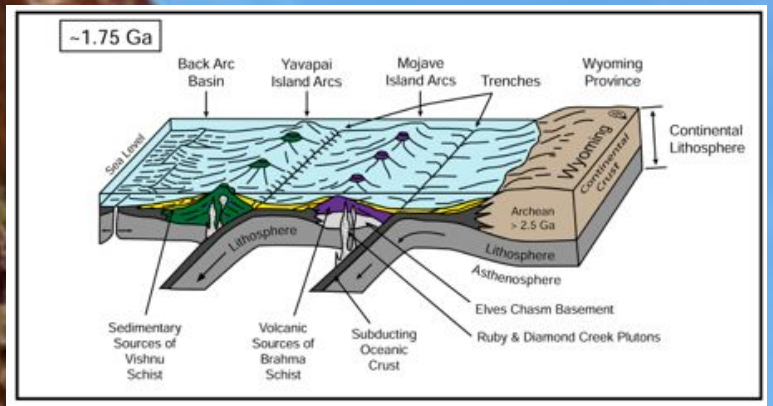
Spanish advances (17th Century CE)

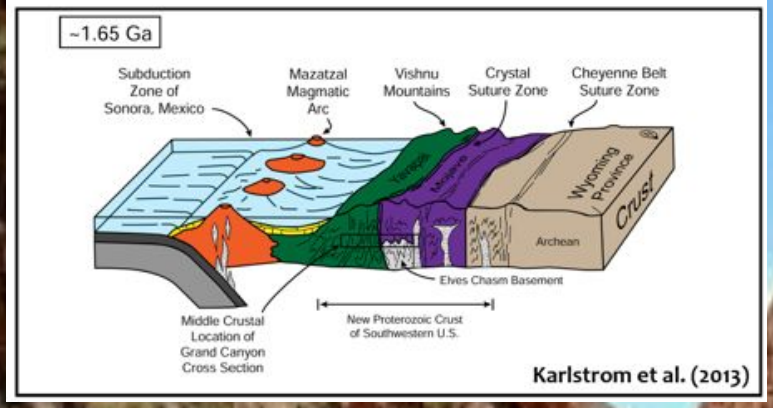
General limits of effective Spanish and Mexican control

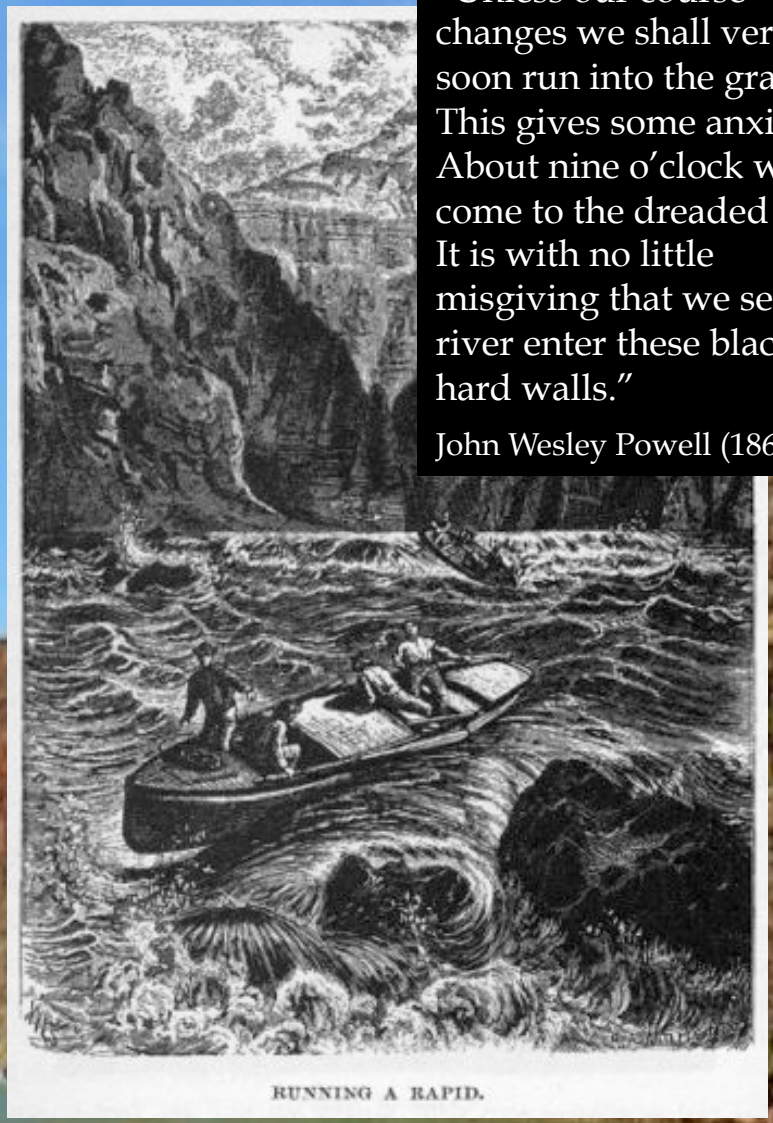
Present-day remnants of Native American lands

Historical map after Meinig (1971); relief map courtesy of R. Arrowsmith, ASU SESE

ESAS connects the geological evolution of the Southwest to its human history, writ large and small.





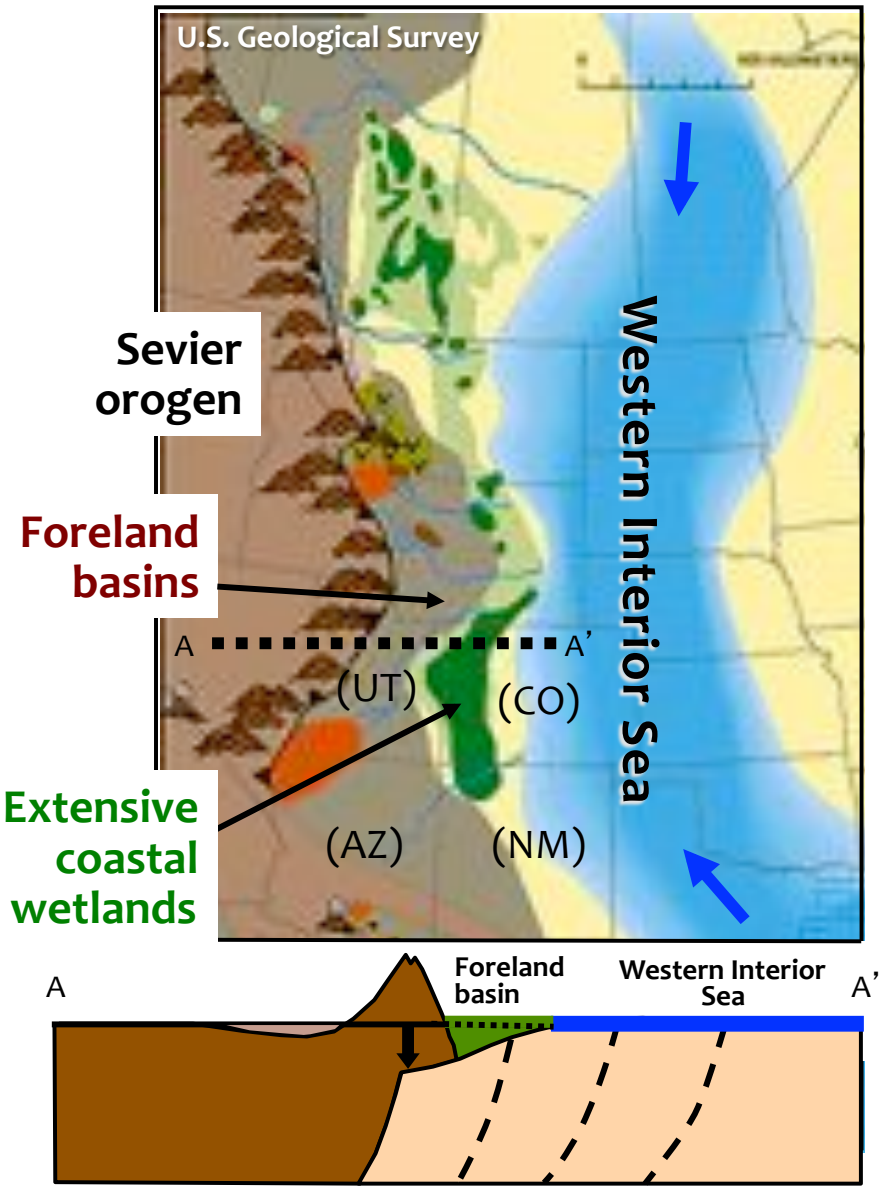

RUNNING A RAPID.

"Unless our course changes we shall very soon run into the granite. This gives some anxiety. About nine o'clock we come to the dreaded rock. It is with no little misgiving that we see the river enter these black, hard walls."

John Wesley Powell (1869)

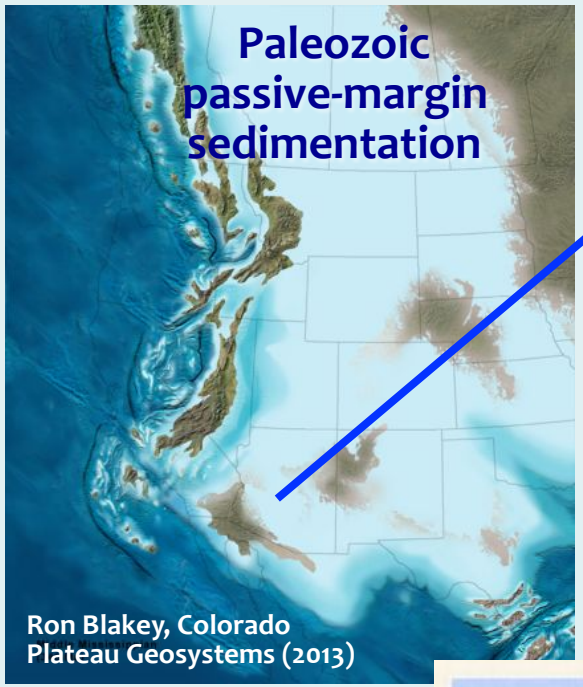
Paleoproterozoic basement,
Upper Granite Gorge, Grand Canyon, Arizona

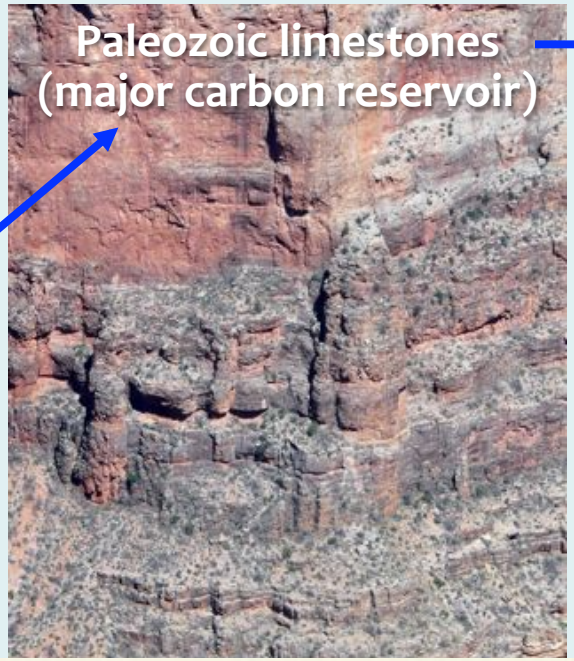
ESAS connects the geological evolution of the Southwest to the origin and distribution of its natural resources.



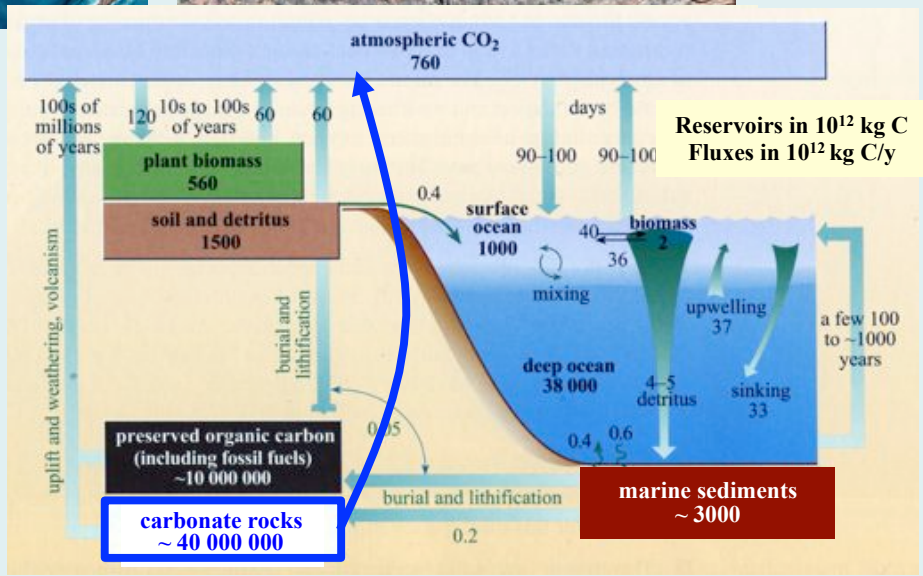
Navajo Coal Mine, northwest NM … recently purchased by Navajo Nation

ESAS connects the geological evolution of the Southwest to sustainable and unsustainable resource use.



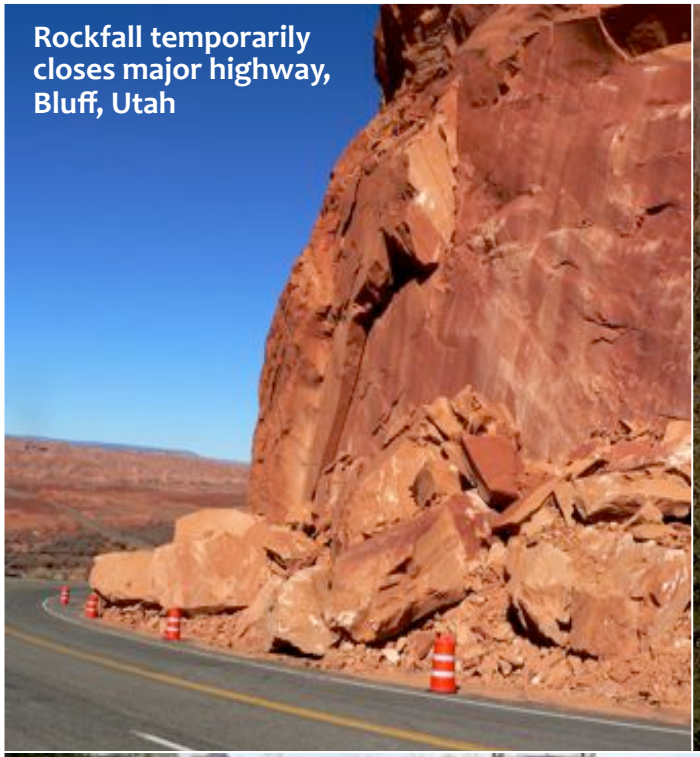


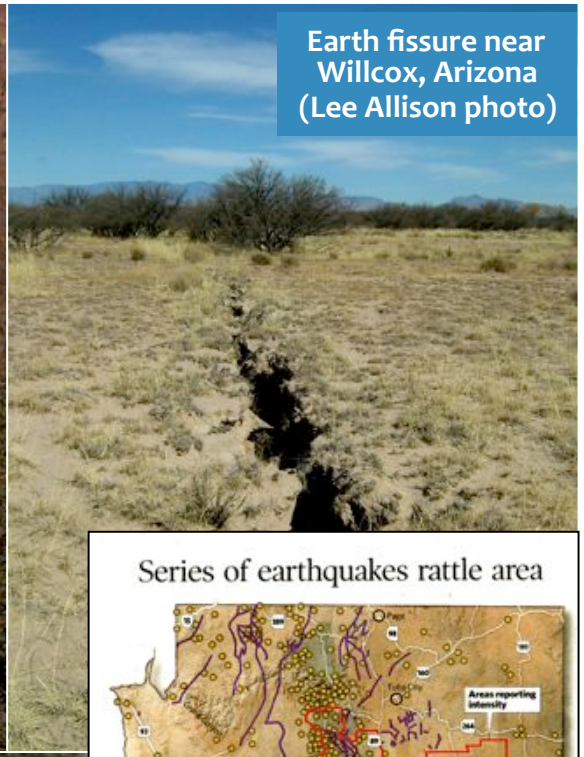
Built the modern Southwest, but also a major source of anthropogenic CO_2.

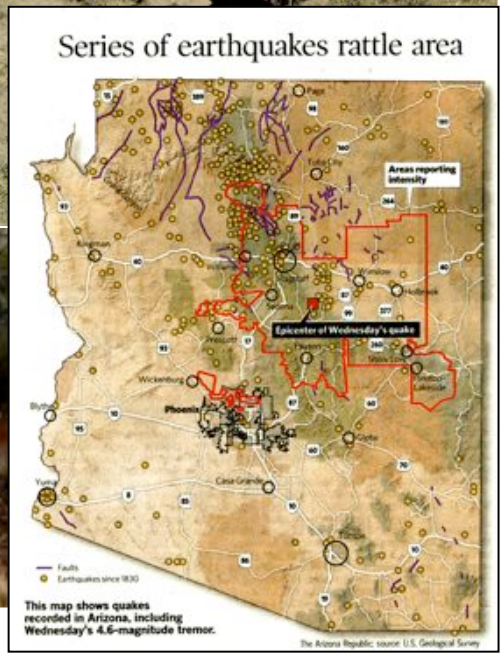


Cockell (2007)

ESAS connects the geological evolution of the Southwest to its natural hazards.


Rockfall temporarily closes major highway, Bluff, Utah


Earth fissure near Willcox, Arizona (Lee Allison photo)



Queen Creek, Superior, Arizona

ESAS connects the geological evolution of the Southwest to the public health of Southwesterners.

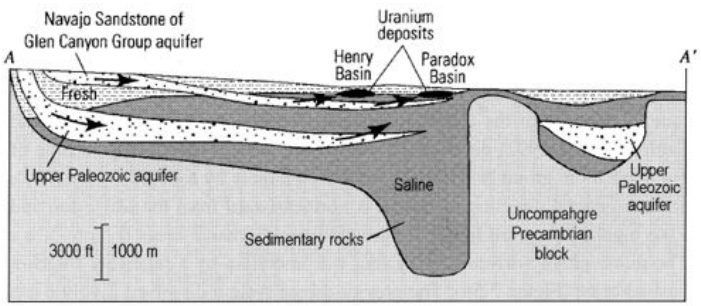
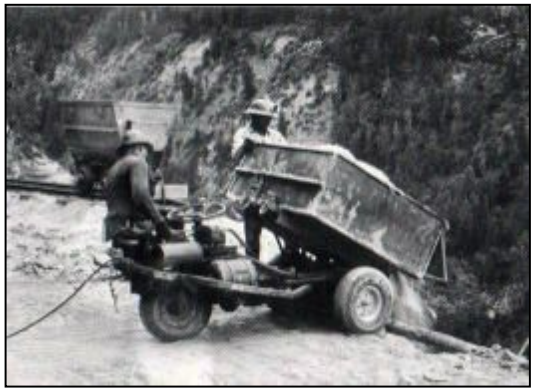
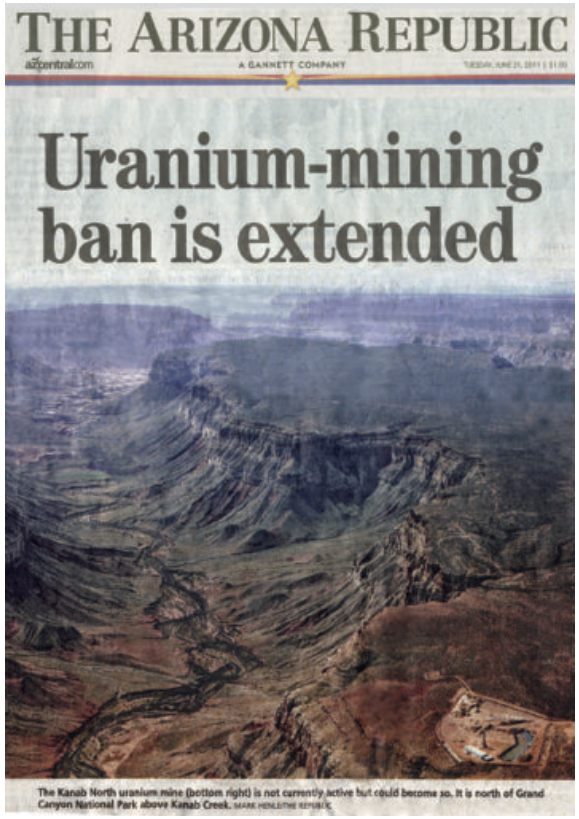


Figure 5.5 (a) Map of the Colorado Plateau area showing inferred groundwater recharge areas, general direction of groundwater flow (arrows), and location of uranium deposits. (b) Southwest–northeast cross section across the Colorado Plateau showing general direction of groundwater flow and location of uranium deposits relative to inferred position of the freshwater–brine interface. In (b) the Morrison Formation overlies the Navajo Sandstone. Hydrogeologic conditions are reconstructed for Late Jurassic (163–144 Ma) time. After Sanford (1992). **Ingebritsen & Sanford (1998)**



Navajo uranium miners near Cove, Arizona, 1960 (D. Brugge)

Bilingual English-Navajo sign near abandoned Shiprock, NM U-mill site

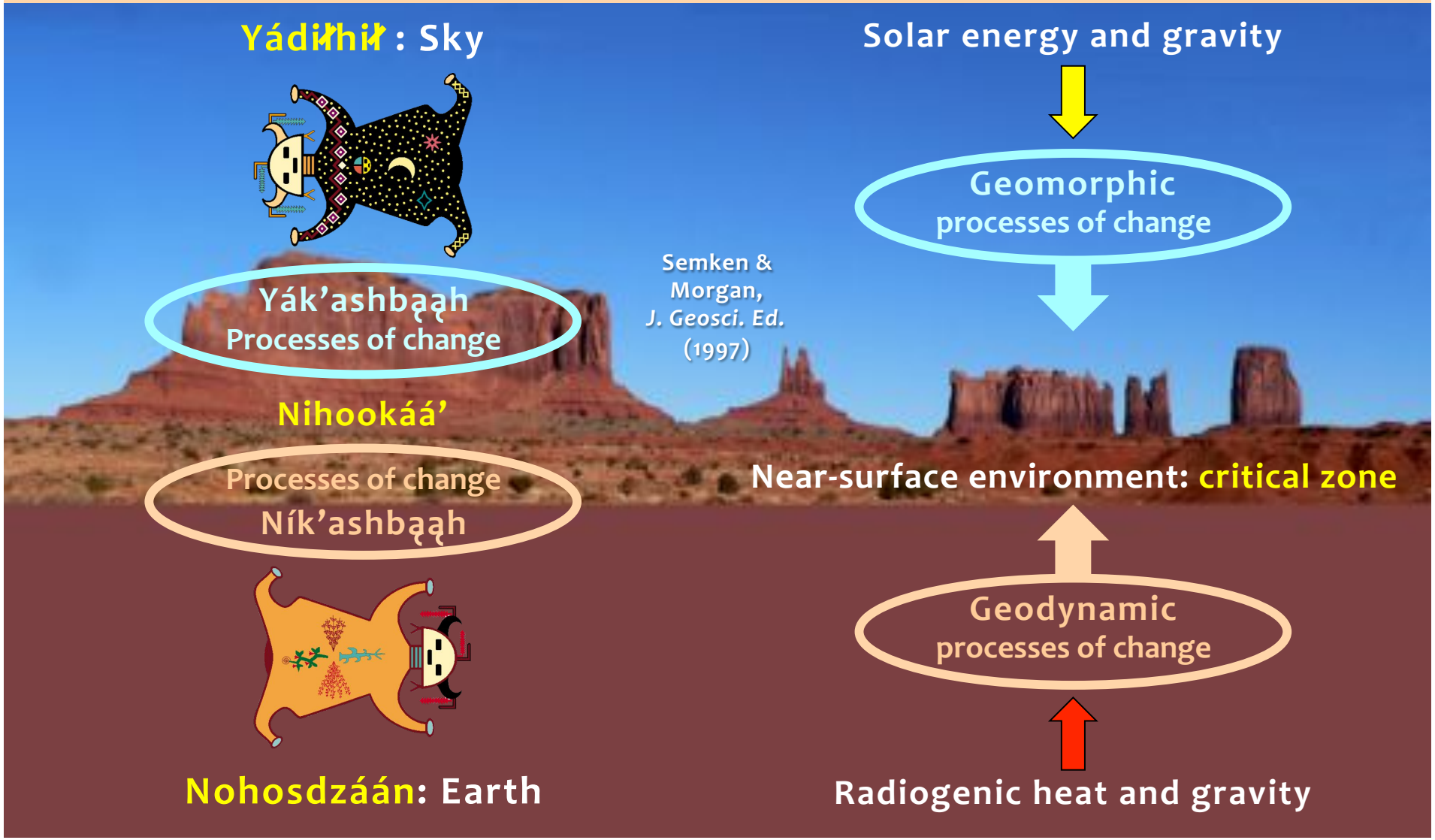


ESAS connects the geological evolution of the Southwest to challenges to its economic and environmental sustainability.


Mile-high haboob engulfs Tempe, Arizona

ESAS integrates indigenous, local, and global knowledge.

For example: a comparison of traditional **Diné** (**Navajo**) ideas of **Earth as a system** with the **global Earth system science model** reveals many similarities.

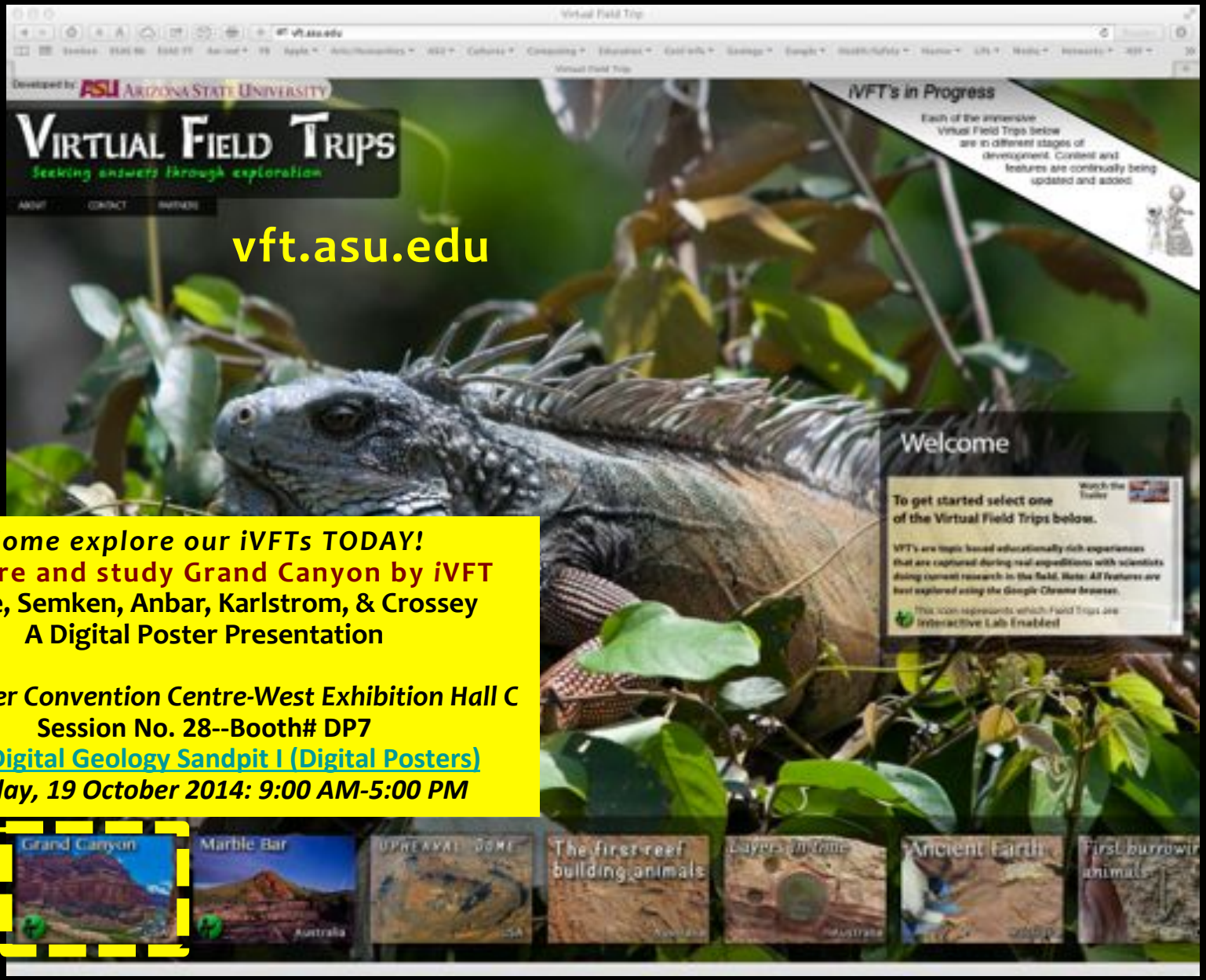


ESAS integrates humanistic ideas and works on nature and culture in the Southwest to foster sense of place and contextualize the science.

ESAS field trips bolster lessons with experiential learning in local natural and built environments, and a regional traverse to Grand Canyon and back.

ESAS students on the Trail of Time, Grand Canyon National Park, Arizona

ESAS will also make increasing use of Immersive Virtual Field Trips.



Come explore our iVFTs TODAY!
Explore and study Grand Canyon by *i*VFT
Bruce, Semken, Anbar, Karlstrom, & Crossey
A Digital Poster Presentation

Vancouver Convention Centre-West Exhibition Hall C
Session No. 28--Booth# DP7
T57. Digital Geology Sandpit I (Digital Posters)
Sunday, 19 October 2014: 9:00 AM-5:00 PM

ESAS students complete a place-based final project in lieu of a final exam.

This enables students to express their senses of place creatively—or to share their knowledge with the local community through service learning.

S. Hobeheidar

W. Akers

Black Mountain Carefree and Cave Creek Arizona

From Wikipedia, the free encyclopedia

Geology and Geography

Black Mountain is located in north-central Maricopa County, AZ. between the towns of Carefree and Cave Creek, AZ., 33.82N, -111.917W.

The mountain is composed of two main rock types that are roughly divided between western and eastern halves of the mountain. The west side of the mountain is primarily composed of a ~250 m. bed of black meta-sedimentary rocks[1] which are distinguishable as phyllite and argillite. Viewed from a distance the meta-sedimentary rock is often mistaken for basalt, which is common in the area, however basalt is not found on Black Mountain. The phyllite has a slaty cleavage and is foliated in all directions, the result of shortening due to pressure-solution volume-diffusion of as much as 50%. As a result of shortening, streambeds of nearby washes are filled with black alluvium.

The western face meta-sedimentary beds strike ~120, 45 and, when fully illuminated by the afternoon sun, resemble overlapping flatirons. The meta-sedimentary beds rise 830 feet above the local topography, with an actual elevation of 3398 feet above sea level. The eastern side of the mountain is composed of a granitic intrusion into the meta-sedimentary rock. The granite is part of the granite formation that extends southward from Black Mountain and is expressed in outcrops in the McDowell Mountains, the Union Hills and Camelback Mountain. Texturally, the granite varies from a large crystal with phenocrysts of up to 2.5 cm., to a finer grained crystal texture devoid of phenocrysts. The granite containing larger crystals has formed large joints as well, fractured both vertically and horizontally, and is weathered into spheroidal boulder columns and balanced rock formations. Jointing in the finer grained granite is smaller and proportional to grain size. The granitic half of Black Mountain tapers to a flat-topped peak that rises to a height just below that of the pointed, black phyllite peak of the western side. The two units meet as a saddle between the twin peaks of meta-argillite/phyllite and granite.

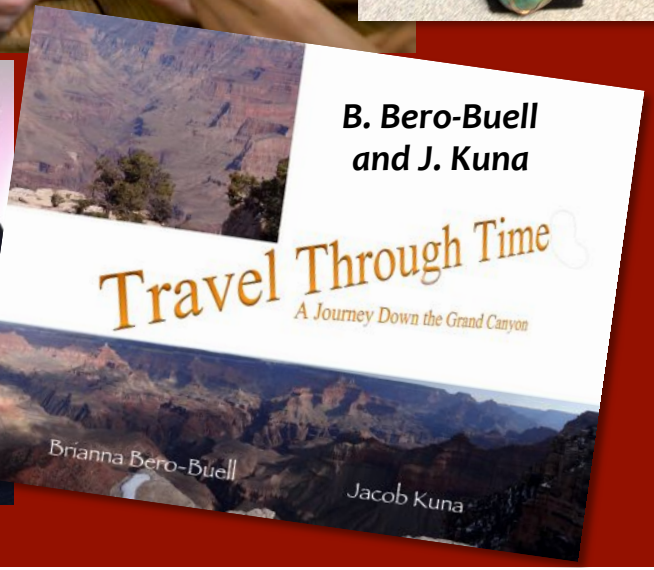
Along the contact on the eastern side of the mountain, clasts of pelitic schist can be found embayed in the large-grained granite.

The granite at the contact is gray in color, having been discolored by the sedimentary rock during emplacement. Clasts of smaller grained granite are also found in the large-grained granite.

The meta-sedimentary rock along with the granite batholith that form Black Mountain are remnants of what lay hidden beneath a sea and underground that are now exposed by headward erosion that continues northward today into Arizona's Transition Zone. The highly shortened and foliated phyllite began as a mudstone which was metamorphosed to shale. The shale was then subjected to pressure-solution volume-diffusion; the rock was metamorphosed while deeply buried then subjected to heating during the emplacement of the batholith. The phyllite at the granite contact formed a weak horizon, which assisted the decollement process after the batholith was emplaced. These chloritic rocks acted as a lubricated sheet, effectively sliding off the batholith and tilting to the northwest during the Tertiary extension event. To the south, grabens formed by normal faulting during crustal extension are filled the alluvium from the subsequent erosion.

People and Culture of the Black Mountain/Desert Foothills Area [edit]

While Carefree and Cave Creek are today a home for upper-income retirees and an enclave for artists and entrepreneurs, the first inhabitants of the area surrounding Black Mountain were Native Americans known as the the Hohokam, who appear at about 750 A.D. They were an agrarian society of hunters and gatherers who also used irrigation to maintain crops. Their "waffle



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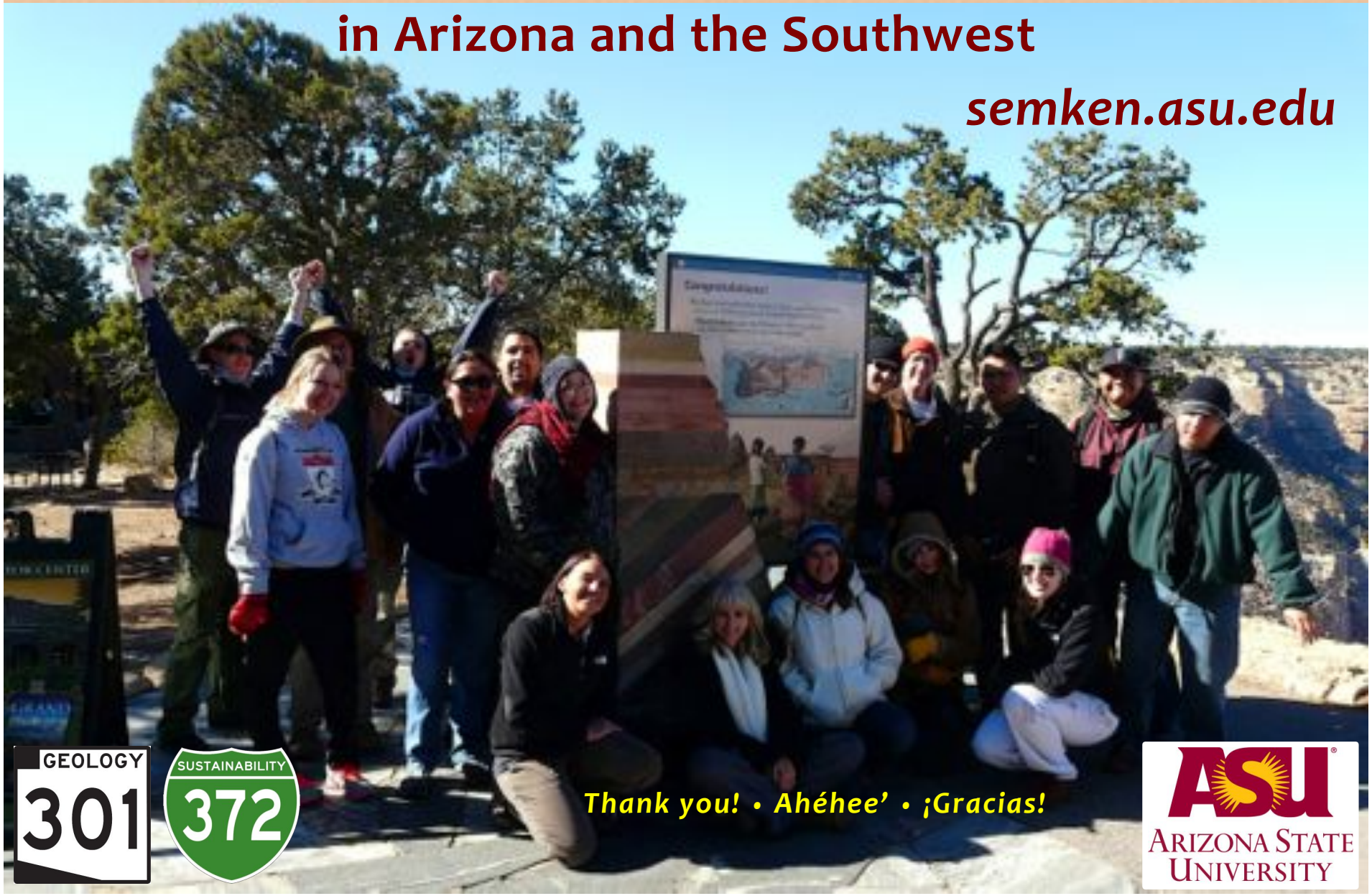

Much has now been published on creating, teaching, and assessing place-based geoscience curricula for different places and groups.

http://nagt.org/nagt/publications/index.html

Journal of Geoscience Education

February 2014 and May 2014 issues

(Volume 62, numbers 1 and 2)

Theme Issue on Teaching Geoscience in the Context of Culture and Place

July 2011 issue (Volume 1, number 3)

Theme Issue on Places of Educational Interest

October 2014 issue (Volume 4, number 4)

Lead article on Restoring a Lost Sense of Place

earth scope

supports place-based education in the United States with transcontinental resources!

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