Geology of Utah

OSHER 747-001
Dates: Thursdays, 4/02/15-5/07/15
Times: 9:30-11:00AM
Location: Commander's House, Fort Douglas
Instructor: Joseph S. Gates

Course Overview

CLASS 1.—The Beginnings, formation of the Universe, formation of the Solar System and Earth.
Early Days—mostly molten earth, bombarded by meteorites.
Differentiation—separation of light minerals from heavy. Formation of continents begins and continental plates grow by accretion.
Plate tectonics begins, types of plate boundaries, causes of plate movement.

Some basics—igneous, metamorphic, and sedimentary rocks
Geologic time and development of a time scale: tracing rock formations (early 1800's), defining relative age using fossils, radioactive age-dating (early 1900's).

The Pre-Cambrian, now divided into Hadean (4.6-3.8 BY), Archean (3.8-2.5 BY), and Proterozoic 2.5 B-543 MY). Consists of 88% of geologic time. Poorly known but much research being done, especially in the Proterozoic.

Oldest rocks in Utah— basement of metamorphic rocks at a few locations 2.7 BY to about 1.7 BY, late Archean to early Proterozoic. At about 1.7 BY, a small piece of continental crust collided with North America, adding southern Utah and other areas.

Late Proterozoic—slightly to moderately metamorphosed meta-sediments. Lots of interesting things going on. At about 1.1 BY all the continental plates joined into the super-continent of Rodinia, about at the equator. North America was joined by Antarctica and Australia along its west coast. At about 1 BY the Uinta Aulocogen formed, an ENE-WSW trough across Utah with it's axis about at the present-day Cottonwood Canyons. This trough received large amounts of sediment—16,000 ft in Cottonwood Canyons—until about 850 MY.

Worldwide glaciation occurred in at least two cycles about 750-700 and 600-565 M—"Snowball Earth"—we have, in Salt Lake area a distinctive and interesting formation that was deposited during this time—the Mineral Fork Tillite.

CLASS 2. The first half of the Paleozoic, 540-360 MY. After Rodinia split up, Utah was on the west coast of North America (actually Salt Lake City was right on the coast 23 times during this period). A long and quiet (in terms of plate tectonics) period followed with a shallow warm sea to the west in which large amounts of limestone (the major part), sandstone, and shale was deposited, thickening to the west. The evolution of marine life exploded and fossils abound, including Utah's famous trilobite

The second half of the Paleozoic, 360-250 MY—still mostly marine conditions bur things changing somewhat with collision of plates off the southeast coast of North America (Oklahoma and Texas) which produced basins and uplifts all the way into Utah. The Oquirrh Basin of northwest Utah received up to

30,000 of sediments, mostly limestone with some sandstone. The Paradox Basin of southeastern Utah received up to 14,000 ft of sediment, much from the nearby Uncompahgre uplift—mostly sand and silt with some arkose and, at depth, salt and gypsum deposited in low areas that were cut off from the sea and deposits were a result of evaporation.

CLASS 3. Dinosaurs in eastern Utah and deserts and dune deposits in southern Utah. Early part of Mesozoic (250-145 MY). The beginning of big changes in Utah—from the relative calm of marine conditions to geologic upheavals (mountain building etc) that continue to the present day. Formation of another supercontinent (Pangea) started about 300 MY ago—North America attached to Europe, Africa, S. America on its east coast—west coast still open. Formation of Appalachian Mountains. At about 200 MY, Pangea started breaking up and the Atlantic Ocean formed. North America started moving west and northwest and colliding with a Pacific plate, the Farallon plate, which began subducting under North America with mountain building in California area. This may have cut off moisture from the west, resulting in dry desert conditions in Utah, with deposition of up to 2,000 ft of sand—such as Navajo Sandstone of Zion National Park.

To east, inland sea invaded central US, swampy conditions in eastern Utah in which dinosaurs thrived.

Later part of Mesozoic 145-65 MY. Sevier Orogeny as leading edge of Farallon plate reached W. Utah. Substantial mountains rose in W. Utah. Thrust faulting prominent as compressive forces pushed thick slabs of marine deposits (mostly limestone) from west to east up to 20-30 miles or more—this occurred from about 120 MY to 60 MY, peaking about 100 MY. Sediments eroded from western mountains deposited to east—swampy conditions continue with much organic material deposited (origin of E. Utah coal deposits). Dinosaurs continue to thrive with much organic material for food—however by 65 MY they become extinct.

CLASS 4. Early part of the Tertiary 65-34 MY. The Laramide orogeny followed the Sevier orogeny as the leading edge of the Farallon plate moved under E. Utah and Colorado. Structural aspects changed as the subducting plate went from a steep dive to a flatter path and hit harder material (igneous and metamorphic instead of limestone) and thrust faulting was replaced by uplifts of blocks of material with adjacent subsiding basins. Creation of early Rocky Mountains. Creation of Uinta Mountains uplift and adjacent Uinta and Green River basins. Uintas one of the few uplifts oriented east-west, probably related to the much earlier aulocogen at the same location. In the Salt Lake area, the Uinta uplift called the Cottonwood arch—large fold that can be seen in the Wasatch Range. In eastern Utah at about 60 MY, was Lake Flagstaff when colorful rocks at Bryce Canyon were deposited, followed by Lake Green River where oil shale was deposited along with famous fish fossils.

From 55-34 MY much volcanic activity, both extrusive volcanics and intrusions—moved into the more extensive igneous activity of the following period.

CLASS 5. Mid Tertiary, 34-17.5 MY. Intense volcanic activity—extrusive volcanic rocks of southwestern Utah and igneous intrusions in central and northern Utah. The subducting Farallon plate, which had been flat during the Laramide orogeny, resumed its steeper dive, creating space above it, which filled with hot, buoyant mantle material, which was susceptible to rising into the crust. In southwest Utah, two giant calderas, Indian Peak-Caliente and Marysvale. Have large magma chambers followed by eruptions and loss support for chamber roof, then collapse of roof and enormous explosion which scatters ash and debris over a large area, both as hot ash and volcanic debris avalanches. Crater Lake in Oregon a more recent example. Some extrusive volcanics in Salt Lake area on a smaller scale—Traverse Mountain.

In central and northern Utah, igneous intrusions continue to be emplaced from 30-21 MY, including the largest, the Little Cottonwood stock, which was quarried to obtain rock to build the Salt Lake Temple. Many of these intrusions were accompanied by deposition of valuable minerals—silver, lead, and zinc plus the large low-grade copper deposits at Bingham Canyon. The richest deposits, other than at Bingham, were at Park City and Tintic. At Cedar City, intrusions were accompanied by iron deposits. What caused this igneous activity—the North American plate had finished swallowing the Farallon plate, and this led to a reduction in compressive force and perhaps a relaxation which enabled igneous material to rise.

CLASS 6. Later Tertiary through the Pleistocene and Holocene, 17.5 MY to the present. The present-day landscape began to form. Another time of change, as the area between Salt Lake and Reno, instead of being compressed and shortened, began stretching and pulling apart, related to complex plate movements. Subduction along much of the west coast ceased and transform movements took over—with the Pacific plate moving northwest against North America's westward movement—which basically is the San Andreas fault. The distance between Salt Lake and Reno has increased and the Great Basin subsided, forming a basin with no outlet to the ocean. Stretching recently has been about an inch every 10 years—not much, but over one million years, it is 1.6 miles.

The Wasatch fault is the eastern edge of the pulling apart and the Salt Lake Valley has subsided along the fault with the stretching. Average vertical displacement along the fault is about 1-2 mm per year, but the movement is several feet every 1300 years or so.

Other events include glaciation every 100,000 years or so with associated lakes, the most recent of which was Lake Bonneville. Little Cottonwood Canyon was extensively glaciated along with Mt. Timpanogos, the Uinta Mountains, and other areas.