GEOLOGY OF THE EAST-CENTRAL PART OF THE SPRING MOUNTAIN RANGE, NEVADA.

WALDO S. GLOCK.

INTRODUCTION.

The Spring Mountain Range lies in Clark County in the southern tip of Nevada (Fig. 1). In general, the area belongs to the "arid Southwest"; structurally, it forms part of the Basin Range System, lying in the narrow portion of this province between the Sierra Nevada Mountains on the west

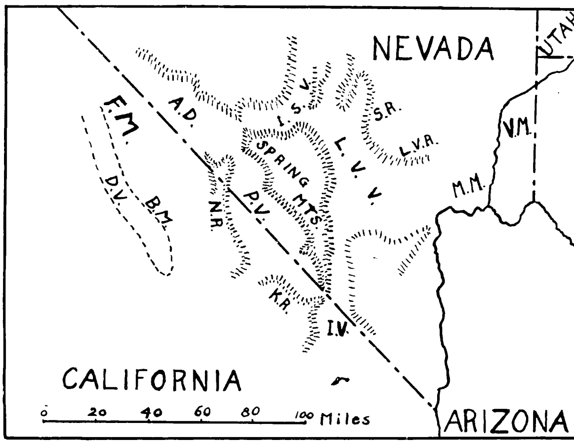

Fig. 1. Index Map. S.R. = Sheep Range. L.V.R. = Las Vegas Range. N.R. = Nopah Range. K.R. = Kingston Range. F.M. = Funeral Mountains. B.M. = Black Mountains. M.M. = Muddy Mountains. V.M. = Virgin Mountains. L.V.V. = Las Vegas Valley. I.V. = Ivanpah Valley. P.V. = Pahrump Valley. D.V. = Death Valley. A.D. = Amargosa Desert. I.S.V. = Indian Springs Valley.

and the Colorado Plateau on the east. That part of the range with which this paper is concerned lies directly west of Las Vegas and the great bend of Colorado River, and is shown on the Las Vegas topographic sheet of the United States Geological Survey.

The general features of geology, topography, and climate, and their diverse problems make this area one of peculiar interest. It is hoped that the data here presented will bear on the problems of a regional nature.

Previous Work.—Little has been written on the particular area here considered. Apparently the first geologist to visit the Spring Mountain Range was Gilbert who crossed the range at Mountain Springs and stopped at Cottonwood Spring to measure a section. On the basis of the work done by R. B. Rowe in 1901, J. E. Spurr included the area on his map of Southern Nevada, published in 1903. In 1922, D. F. Hewett, of the U. S. Geological Survey, mapped the south end of the range shown on the Goodsprings topographic sheet, but his report has not yet been published. Works touching on contiguous areas have been listed in the appended bibliography.

Nature of this paper.—The field work upon which this report is based was done during the summer of 1923, and the present paper gives in abstract form the essential results of that survey.

Acknowledgments.—The writer is deeply indebted, and expresses his sincere thanks, to Doctor C. R. Longwell for assistance in field work and constant advice and encouragement during the survey and the preparation of the report; to the Faculty of the Geology Department of Yale University for a grant from research funds which made possible the prosecution of the field work; and to Doctor C. O. Dunbar for the determination of critical fossils. The writer is also indebted to Professors Schuchert and Gregory for valuable suggestions during the entire course of the investigation. For instruments and field equipment acknowledgment is due the United States Geological Survey. Several difficulties were avoided and much time saved by the assistance of Mr. Sexton and Mr. Hill, both residents within the area.

GEOGRAPHY.

Topography and Drainage.—The Spring Mountain Range is highly irregular in plan and contrasts sharply with the linear ranges immediately to the north across Indian Springs Valley. Beyond Las Vegas Valley rise the Muddy and Virgin Mountains, the easternmost of the Basin Ranges, and still farther east are the Grand Wash Cliffs which rise to the summit of the Colorado Plateau.

The part of the range with which this paper is concerned can be divided into four parts. (1) La Madre Mountain, with its tributary spurs, trending northeastward and (2) Shark Tooth Mountain, running slightly west of north, approach each other in the vicinity of (3) Sexton Ridge, while the nearly right-angled reëntrant thus formed holds (4) the Cottonwood Spring district. All units, save Sexton Ridge, present toward the south or east bold and precipitous fronts.

No permanent streams exist within the area. Except Las Vegas Valley, which drains to Colorado River, all of the drain-

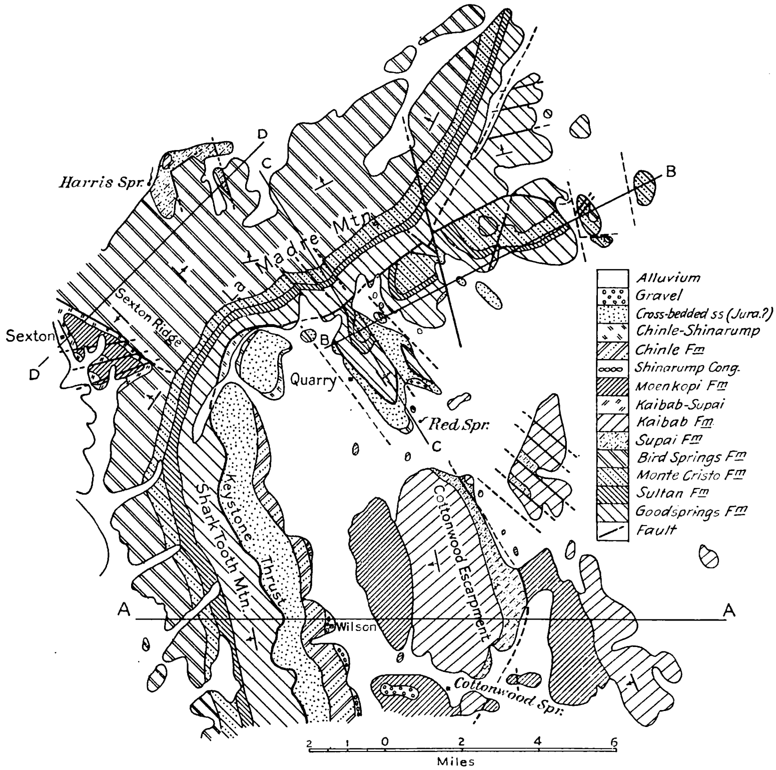

Fig. 2

Fig. 2. Geologic Map.

age in the general area is of the interior type. The line between exterior and interior drainage follows the divide along Shark Tooth Mountain, crosses to Sexton Ridge, runs northwest for a short distance, and turns northeastward to meet the head of Las Vegas Valley—this line along its described course delineating the eastern boundary of the Great Basin in the region.

Climate.—The average annual rainfall of the lowland bordering the Spring Mountain Range approximates five inches and typical desert conditions prevail. Precipitation, however, increases with elevation to such an extent that pine and fir appear above 7,500 feet within the range.

Era	Period	Epoch	Formation	Thickness (feet)
Cenozoic	Quaternary		Alluvial deposits	0–?
			— Unconformity —	
	Tertiary	Late Tertiary ?	Conglomerate	0–110
			— Unconformity —	
Mesozoic	Jurassic (?)		Cross-bedded sandstone	2440–2640
	Triassic	Upper	Chinle formation	650
			Shinarump conglomerate	40–87
			— Disconformity ? —	
		Lower	Moenkopi formation	1786–1836
			— Disconformity —	
Paleozoic	Permian		Kaibab limestone	0–670
	Pennsylvanian ?		Supai formation	1275 +
	Pennsylvanian		Bird Springs formation[1]	3550 ±
	Mississippian		Monte Cristo formation[1]	925 ±
	Devonian		Sultan formation[1]	370 +
	Ordovician-Silurian		Goodsprings formation[1]	1250–1800
	Cambrian	Upper	Overthrust contact	

[1] Formation name given by D. F. Hewett.

STRATIGRAPHY.

The area under consideration contains sedimentary rocks only, embracing formations deposited during the Paleozoic, Mesozoic, and Cenozoic eras. Most of the Paleozoic formations are thicker than in the Muddy Mountains to the eastward, but fall short of the thicknesses of corresponding formations in the Eureka and Manhattan districts to the northward. Late Paleozoic and Mesozoic sections resemble those of the Muddy Mountains, southern Utah, and northern Arizona.

The 12,000-foot section exposed in this area constitutes an almost unbroken succession, from late Cambrian into Jurassic (?), beginning with a thick series of limestones and ending with continental sediments. Conformity indicative of quiet conditions typifies the section, while unconformity seems to be more typical of post-Jurassic time.

Paleozoic Formations.

From the oldest rocks up into those of the Pennsylvanian, rather wide-spread dolomitization has occurred, so that locally fossil remains are mere unidentifiable fragments. Formational boundaries were traced northward from the Goodsprings area mapped by Hewett and his determinations are accepted in this report. The best and most complete exposures of the Paleozoic limestones may be observed in Shark Tooth Mountain and La Madre Mountain with its outlying spurs.

Dark carbonaceous limestones and dolomites constitute the bulk of the Paleozoic rocks, although commonly dolomitization has been accompanied by loss of color. This alteration is especially evident in the Mississippian rocks.

Goodsprings Formation.—The Goodsprings formation, chiefly of upper Cambrian age, but with some Ordovician and Silurian at the top, comprises 2,000 feet, or more, of strata lying immediately above great overthrusts. Because of the relations involved, the given thickness refers only to that part of the Cambrian which overrode the younger rocks. In general, the formation is a thin-bedded, dark-gray, fine-grained dolomite. Two fairly distinct horizons were recognized in the more complete sections; near or at the base some 250 feet of black, fine-grained dolomite with gray spots, like mud spatters, and at the top 200 to 300 feet of yellow sandy beds, containing algal-like forms, interlayered with gray dolomite.

Sultan Formation—Devonian.—Three hundred and seventy feet, or more, of dolomite and limestone directly overlies the Goodsprings formation. This unit, the Sultan formation, is rather uniformly medium-bedded, dense, and commonly dolomitic in the lower portion. Gray color predominates, although yellowish layers appear in the upper parts. In certain localities the formation begins with 70 feet of black coarse-grained dolomite, in beds two to four feet thick. At the top the rocks are succeeded by thin-bedded limestone of Mississippian age with no observed structural break.

Monte Cristo Formation—Mississippian.—The Monte Cristo formation, 925 feet thick, is divided into four members. (a) A basal zone, 200 to 225 feet thick, consists dominately of thin-bedded, dark-gray, rather coarse-grained limestone. The upper 75 feet have been extremely shattered, crushed, and reddened by the shearing of the superjacent member over the one below. In Shark Tooth Mountain a one-foot stratum of limestone conglomerate lies at the top. Member (b) is composed of limestone and dolomite 600 feet thick. The lower two-thirds is medium-bedded, dark-gray, and coarse-grained. The upper third of the member serves as a conspicuous horizon marker for it is composed of heavy-bedded, cream-colored dolomite. Member (c) consists of 10 to 15 feet of thin-bedded, dark-gray, highly fossiliferous, shaly limestone. The formation ends with (d) 100 to 115 feet of gray-black, fossiliferous, rather massive limestone which has been altered to light-colored dolomite in localities of excessive deformation.

Horn corals and species of *Spirifer, Productus, Archimedes,* and *Pentremites*, carried by the formation, are typical of Mississippian time.

Bird Springs Formation—Pennsylvanian.—Although no complete section exists within the immediate area, the thickness of the formation approximates 3,500 feet, as determined in other parts of the range. Two members may be recognized. Member (a) is a striking horizon marker for it contains thin-bedded, brown, quartzitic sandstone, alternating with red and yellow sandstone, and gray, fossiliferous limestone. The thickness averages 100 feet. (b) Gray-black, fossiliferous limestone, rather heavy-bedded and coarse-grained, rests directly upon the sandstone zone. About 600 feet above the base the rocks gradually become thinner bedded, lighter colored, and, as the top is approached, reddish arenaceous layers begin to alternate with the platy limestone. The change progresses until calcareous sandstone with very little limestone merges into the Supai. Pennsylvanian fossils (*Fusulina*, for instance) characterize the main part of the formation.

Supai Formation—Pennsylvanian (?).—The Supai formation, including the transitional beds at the base, has a maximum measured thickness of 1,275 feet. A distant view brings out the striking features of red color, outline of step and incline (alternation of sandstone and shale), and the predominant sloping profile. As a rule the formation is fine-grained and calcareous. Ripple-marks, raindrop impressions, cross-bedding, and truncation with dip and flow are common characteristics. The Supai of the Cottonwood district shows the following succession beginning at the bottom: 150 feet of blue-gray gypsiferous shale containing thin beds of limestone and sandstone; 400 feet of typical "red beds"; 180 feet of heavy-bedded, pink sandstone; and 225 feet of red sandstone with lentils of gypsum from 8 to 40 feet thick.

The formation, including the transitional beds at the base, is placed in the Pennsylvanian (?) to correspond to the main part of the Supai of the Grand Canyon district (Schuchert, 1918; Noble, 1922). All the characteristics of the Supai seem to require a semi-arid climate, shallow shifting waters, and continental conditions in part at least.

Kaibab Limestone—Permian.—The Kaibab attains a thickness of 670 feet, maximum, in the Cottonwood district. Although chiefly a limestone formation the Kaibab includes the following sequence: a lower member of limestone, 190 feet thick; a 32-foot parting of clay and gypsum; an upper limestone member, 375 feet thick; and, at the top, 75 feet of sandstone and shale with some gypsum and thin-bedded limestone. The limestones are gray, dense, and in large part heavy-bedded. Chert bands and nodules exist in such quantities that the formation appears to be thin-bedded. In the Cottonwood escarpment the limestones are separated by 32 feet of red, sandy clay, but in the scarp five miles eastward the parting has increased to 90 feet and contains lenses of gypsum. The topmost member, known to exist only on the dip slope of the Cottonwood escarpment, consists of red or yellow sandstone and shale, with masses of gypsum up to 50 feet thick, and 15 feet of dark-gray, fossiliferous limestone.

The fauna of the Kaibab (species of *Productus* predominate) is Permian in age, as determined by Girty. The *Bellerophon* fauna of the topmost member very probably corresponds to the Harrisburg gypsiferous member in southwestern Utah and northwestern Arizona of Reeside and Bassler (U. S. Geological Survey Professional Paper 129-D, 1921), to the Super-Aubrey beds of Huntington and Goldthwait, and to the Bellerophon limestone of the earlier geologists.

An erosional unconformity separates the Kaibab from the overlying Moenkopi. Pre-Moenkopi erosion varied from small valleys cut 75 feet into the Kaibab to an entire removal of the Kaibab as well as much of the underlying Supai. In the northwestern part of the area the only indications of the Kaibab are conglomerates of limestone and chert fragments—the old land waste of a Kaibab surface recemented to form the basal conglomerate of the Moenkopi. This, then, represents the Paleozoic-Mesozoic interval of erosion, evidence of which has been observed elsewhere by Gregory, Reeside and Bassler, Longwell, and others.

Mesozoic Formations.

Triassic System.—The *Moenkopi formation* has 650 feet of limestone overlain by 1,100 feet of red beds. Alternation of thin-bedded, dense, gray limestone and yellowish sandy shale is responsible for the step-and-incline profile of the lower part of the formation. Red shales and sandstone with several layers of homogeneous buff sandstone constitute the red beds. The formation ends with 40 feet of limestone conglomerate, sandstone, and shale.

The *Shinarump conglomerate* crops out in patches through the alluvium. Measurements of thickness range from 40 feet to more than 80. The conspicuous portion of the formation is a strong conglomeratic phase, 40 feet thick, containing jasper, flint, and quartz pebbles sub-angular in shape and firmly cemented by silica and iron. At the base the pebbles average an inch in diameter but upwards the conglomerate grades into a coarse sandstone which contains an abundance of silicified wood. Prevailing colors range from yellow to greenish-brown. The conglomerate is a maze of dove-tailed and inter-layered lenses of gravel and sand, the latter lined by stringers of gravel. Rapid alternation is highly characteristic. Some ten feet of red and gray shale lie below the conglomerate, while 35 feet of coarse, cross-bedded sandstone, gray to greenish in color, lie at the top. At most localities, however, only the conglomerate protrudes from the cover of alluvial and talus materials.

Because of stratigraphic position and lithologic similarities the formation is correlated with the Shinarump of the Muddy Mountains and the Plateau area.

The *Chinle formation,* 650 feet thick, consists, in general, of thin-bedded shales, sandstones, and sandy shales colored a deep rich crimson. At the base there are indications of gray and greenish beds. A 50-foot ledge of fine-grained, cross-bedded, calcareous sandstone crops out some 80 feet below the top. The upper beds contain fine-grained, ripple-marked sandstone, banded pink and reddish-brown. Compared with other sections to the eastward the Chinle of this area is fairly uniform in texture, color, and composition. No unconformity was noted above the Chinle; it simply gives way to the more massive, cross-bedded, buff Jurassic (?) sandstone. Because of lithologic similarity and analogous stratigraphic position, the formation is correlated with the Chinle of the Muddy Mountains.

Jurassic (?) System.—A great mass of buff sandstone, 2,500 feet thick, rises in bold cliffs west of the Wilson Ranch. The central portion is marked by a red zone which thins to the southward. On the whole, the Jurassic (?) sandstone is fine-grained and massive although block jointing is common at certain places. Cross-bedding exists on a giant scale and in detail.

The formation has been traced across Arizona and southern Utah to the Muddy Mountains, and the sandstone of the Spring Mountain Range is correlated with that of the Muddy Mountains on similarity of stratigraphic position. Since there is no certainty in the area that the formation reaches its complete development, and since the pink zone could in no case be considered as a member, the formation was not subdivided.

Cenozoic Formations.

Late Tertiary (?) Gravels.—Two small patches of conglomerate, 110 feet thick, were observed near Cottonwood Spring. Dense, mainly black limestone fragments are set in a gray limy matrix. At the bottom the pebbles are small and well-rounded; but above the basal portion, they become large and angular. Since the gravels truncate the Moenkopi upon which they rest, they must be younger than the greater part of the erosion on the Moenkopi; and because of their isolated position on the dip slope of the cottonwood escarpment, older than the recent valley cutting.

Quaternary Deposits.—These include detrital materials, which fill valleys and canyons and lap upward on the mountains as alluvial slopes, piedmont alluvial plains, or talus cones. Since no permanent streams are to be found within the area, ordinary river alluvium and flood plain deposits do not occur,—their places are taken by slope gravels and playa silts. Wells near Las Vegas, out in the center of Las Vegas Valley, have penetrated 1,100 feet in the fill without entering bed rock. Thicknesses, however, decrease to zero on the flanks of, or within, the range.

STRUCTURE.[1]

Complicated faulting of several types has affected the area. On the whole, the structure consists of a rather flat thrust, numerous normal faults, a second thrust, relatively unimportant folding some of which may be connected intimately with the second thrust, and a steep reverse fault. At no place were the formations found undisturbed in their original positions.

Red Spring Thrust.[2]—The oldest structural feature of the region—a nearly flat thrust—has been intersected sparingly by the present erosion surface in the hilly region southeast of La Madre Mountain. Upper Cambrian limestone, now highly shattered and deformed, overlies the Jurassic (?) sandstone, the bedding of the limestone paralleling in the main the plane of movement. At one locality, however, the overlying beds bend under and abut against the underlying sandstone, indicative of local back-drag as the trust plate moved forward. Stratigraphic throw approximates 12,000 feet. It appears probable that the thrust plate moved over an erosion surface on the sandstone because deposits of sheared pebbles, derived from the front of the mobile mass, have been found by Longwell[3] in depressions on the sandstone.

Keystone Thrust at the south.—The Jurassic (?) sandstone constitutes the foundation over which the massive thrust-block of Paleozoic limestones moved. As a highly sinuous line above the sandstone cliffs the contact can be traced from the south edge of the area to the north end of Shark Tooth Moun-

[1] Contiguous areas to north and west have been mapped by C. R. Longwell. The section on structure has been modified from a regional standpoint and in detail by oral communication with Doctor Longwell and by his paper in Bull. Geol. Soc. Amer., 37, 551-584, 1926.
[2] Name applied by Longwell, ibid, 565.
[3] Oral communication.

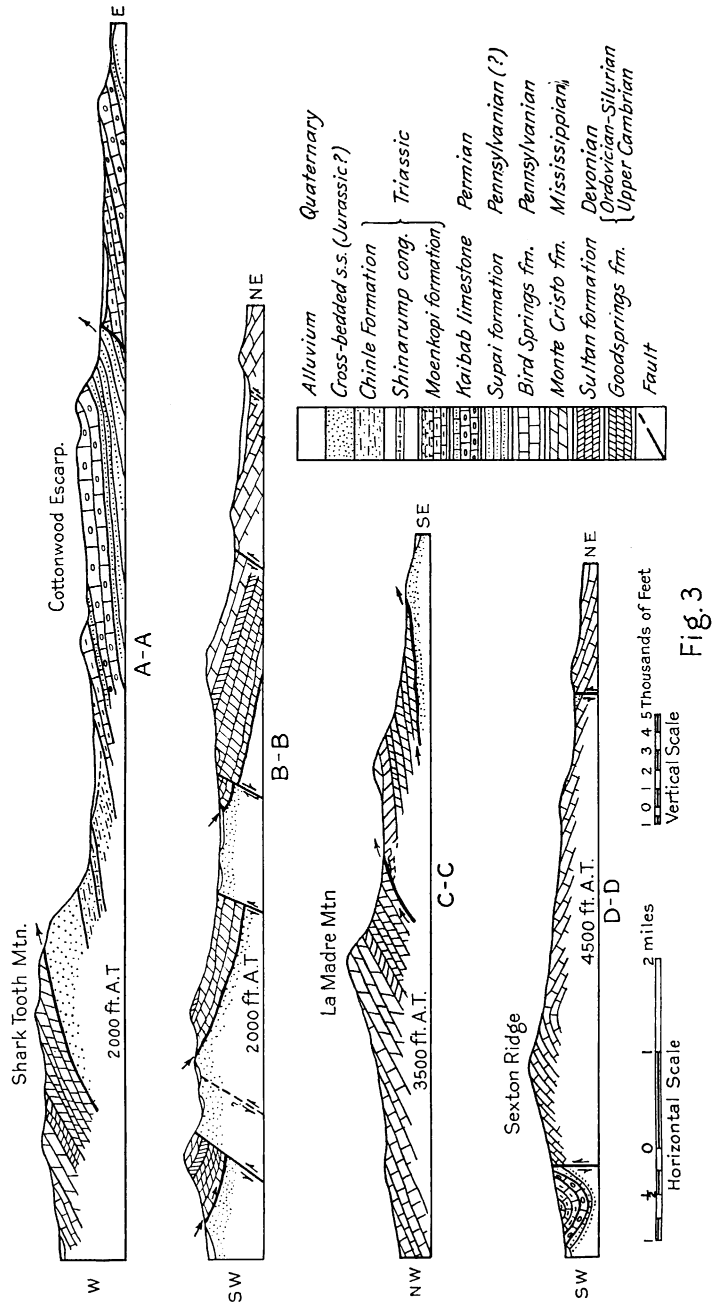

Fig. 3. Structure sections.

tain where the line descends and turns northeastward. The thrust dips eight degrees westward, but in the canyons that cut the front of the sandstone cliffs the dip steepens rapidly until it approaches 30 degrees. The stratigraphic displacement amounts approximately to 12,000 feet while the visible horizontal displacement is slight because of the unified front presented by the sandstone cliffs.

Keystone Thrust and related features at the east.—Here the thrust plate has moved over tilted fault blocks of the Red Spring thrust. The trace of the fault strikes northeastward, and contact observations show that the dip is much steeper than that at the south—as high as 35 degrees.

Evidence of pressure, movement, and overriding is of several kinds. (1) The limestones of La Madre Mountain have been shoved southeastward on top of the Mississippian limestone near the saddles connecting the mountain with the lower ridges. (2) At places the rocks of the ridges abut squarely against those of the mountain. (3) Near the saddles between the ridges and the mountain sharp folds have been developed which pitch steeply to the northeast and are overturned in some cases to the southeast. (4) The rocks show intense crushing, contortion, and mineralization, both above and below the thrust. (5) The ridges indicate the effects of partial rotation by the twists imparted to their southeastern tips, by intense shattering and crumpling at the same places, and by small reverse faults whose planes dip northwestward. (6) In the vicinity of Sexton Spring the Supai, Kaibab, and Moenkopi have been squeezed into a closely compressed synclinal basin cut by reverse faults which strike northeast-southwest and are marked by intense back-drag. The district near Harris Spring duplicates that of Sexton Spring in all essentials. In addition to the above features, the southeast tips of the small ridges, which lie immediately northeast of the Cottonwood escarpment, show steeply plunging, asymmetrical folds (axes trend northeast), and minor thrusts and wrinkles.

Sexton Ridge anticline appears to have been a result of compression during thrusting. Beds dragged back in two directions at the saddle between Sexton Ridge and Shark Tooth Mountain furnish evidence of intense horizontal movement, although the fault could not be traced eastward. That an important structural line passes between the Red Spring-La Madre Mountain districts and the area contiguous to Cottonwood escarpment is evident—a line which lies hidden beneath a thick cover of alluvial materials.

Cottonwood Fault.—The Cottonwood escarpment appears to be outlined at the east by a steep reverse fault,[4] very probably a northward continuation of a similar fault in the Ivanpah quadrangle mapped by Hewett. At the foot of the escarpment the Supai lies in contact with the Moenkopi in such fashion that the true structure can here be seen with difficulty. The trace of the fault is invisible beneath alluvium along most of its course. Vertical displacement reaches at least 2,500 feet.

Normal Faults.—The majority of the normal faults are among the ridges southeast of La Madre Mountain. In fact, the ridges or spurs are delineated by the faults, many of which have valleys developed along their traces. The strike varies from N. 45° W. at the west to east-west at the northeast, with the upthrow sides lying on the east and north. Vertical displacement commonly averages 100 to 200 feet, but in one case it reaches more than 1,000 feet. The normal faults appear to be of two ages: those southeast of La Madre Mountain cutting the older thrust and antedating the Keystone thrust, and those to the east and northeast succeeding this thrust, since it is offset.

SUMMARY OF GEOLOGY HISTORY.[5]

Southern Nevada throughout the greater portion of the Paleozoic lay within the Cordilleran geosyncline, east of the area which received the thickest sediments. The general rock section indicates remarkably uniform conditions, interrupted from time to time by the close approach of the shore line. From evidence on the west side of the range it is probable that the Lower Cambrian sea covered the area although the shore line was not far away—between the Spring Mountain Range and Frenchman Mountain lying 25 miles to the eastward.

Ordovician-Silurian rocks were deposited in a rather shallow sea. In the Grand Canyon district rocks of these systems have not been found while to the west and northwest of the Spring Mountain range they attain thicknesses up to 4,000 and 5,000 feet. The sea gradually deepened during Mississippian time, but retreated to a considerable extent at the end, as is recorded in a zone of quartzitic sandstone. Thick beds of limestone reappear above the sandstone phase, and, as Pennsylvanian

[4] Longwell, C. R., Structural studies in Southern Nevada and Western Arizona: Bull. Geol, Soc. Amer., 37, 566, 1926.

[5] In the preparation of this summary use has been made of the literature of surrounding areas.

time passed, the waters decreased in depth while disturbance and oscillation increased. As the shore line approached, the arenaceous content of the rocks began to dominate over the calcareous until typical Supai replaced the earlier limestone.

Permian and Triassic rocks record aridity of climate and a transitional stage in sedimentation with alternation of marine and continental conditions. At the close of the Permian the area was uplifted and eroded. Following the deposition of the Moenkopi, southern Nevada, as a part of the rising Central Cordilleran axis, received continental deposits from highlands to the south and southeast. Sedimentation practically ceased with the Jurassic, for late Tertiary (?) conglomerate and Quaternary alluvium of the valleys constitute the only sediments of the Cenozoic. Under the present arid climate alluvial slopes are being augmented and valleys filled by detrital materials swept from the adjacent highlands.

Geologic history after the Jurassic is recorded by structural events. However, these cannot be dated accurately since sedimentary time-markers are absent. The sequence of events appears to have been as follows: (1) production of the Red Spring thrust; (2) normal faulting of this thrust block; (3) rather deep erosion; (4) development of the Keystone thrust, and probably the steep reverse fault of the Cottonwood district at the same time; (5) second phase of normal faulting; and (6) later erosion. Subsequent to Jurassic time there were three general periods of orogeny in western United States; namely, post-Jurassic, post-Cretaceous, and later Tertiary. A comparison[6] of the thrusts in the Nevada region with those of Utah, Idaho, and Wyoming suggests a late Cretaceous or early Tertiary date. It might well be that the two thrusts represent two successive pulsations during the same epoch of movement. If such is the case sufficient time must have elapsed between the two phases of thrusting to permit the development of the normal faults cutting the first thrust block and to permit rather deep erosion. The dates of later faulting are unknown since almost no Tertiary deposits exist within the area.

[6] Oral communication with Doctor C. R. Longwell and Doctor E. M. Spieker.

BIBLIOGRAPHY.

Baker, Charles L., Notes on the Later Cenozoic history of the Mohave Desert region in southeastern California: Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, 333-383, 1911.

Ball, S. M., A geologic reconnaissance in southeastern Nevada and eastern California: U. S. Geol. Survey Bull. 308, 1907.

Carpenter, Everett, Ground water in southeastern Nevada: U. S. Geol. Survey Water-supply Paper 365, 1915.

Darton, N. H., A reconnaissance of parts of northwestern New Mexico and northern Arizona: U. S. Geol. Survey Bull. 435, 25-27, 1910.

Dutton, C. E., Report on the geology of the High Plateaus of Utah: U. S. Geog. and Geol, Survey of the Rocky Mtn. Region, 1880.

Ferguson, H. G., Geology and ore deposits of the Manhattan District, Nevada: U. S. Geol. Survey Bull. 723, 1924.

Gilbert, G. K., Report on the geology of the Henry Mtns.: U. S. Geog. and Geol. Survey of the Rocky Mtn. Region, 1880.

Gilbert, G. K., Report upon the geology of portions of Nevada, Utah, California, and Arizona, examined in the years 1871 and 1872: U. S. Geog. and Geol. Expl. and Surveys west of the 100th meridian, vol. 3, 1875.

Gregory, H. E., Geology of the Navajo country: U. S. Geol. Survey Prof. Paper 93, 1917.

Gregory, H. E., The Shinarump conglomerate: this Journal, 35, 424-438, 1913.

Hague, Arnold, Geology of the Eureka district, Nevada: U. S. Geol. Survey Mono. 20, 1892.

Hewett, D. F., Structure of the Spring Mountain Range: Bull. Geol. Soc. Am., 34, 89-90, 1923.

Hill, J. M., The Yellow Pine Mining District, Clark county, Nevada: U. S. Geol. Survey Bull. 540, 223-274, 1914.

Hill, J. M., Notes on some mining districts in eastern Nevada: U. S. Geol. Survey Bull. 648, 1916.

Knopf, Adolph, and Kirk, Edwin, A geologic reconnaissance of the Inyo Range and the eastern slope of the southern Sierra Nevada, California: U. S. Geol. Survey Prof. Paper 110, 22, 40-43, 1918.

Longwell, C. R., Geology of the Muddy Mtns., Nevada, with a section to the Grand Wash Cliffs in western Arizona: this Journal, 50, 39-62, 1921.

Longwell, C. R., The Muddy Mtn. overthrust in southeastern Nevada: Journ. Geol., 30, 63-72, 1922.

Longwell, C. R., Geology of the Muddy Mtns., Nevada: Thesis in Yale University Library, 1920.

Longwell, C. R., The Pre-Triassic unconformity in southern Nevada: this Journal, 10, 93-106, 1925.

Longwell, C. R., Structural Studies in southern Nevada and western Arizona: Bull. Geol. Soc. America, vol. 37, 551-584, 1926.

Longwell, C. R., Miser, H. D., Moore, R. C., Bryan, Kirk, and Paige, Sidney, Rock formations in the Colorado Plateau of southeastern Utah and northern Arizona: U. S. Geol. Survey Prof. Paper 132-A, 1923.

Noble L. F., A section of the Paleozoic formations of the Grand Canyon at the Bass Trail: U. S. Geol. Survey Prof. Paper 131-B, 1922.

Noble, L. F., and Mansfield, G. R., and others, Nitrate deposits in the Amargosa region, southeastern California: U. S. Geol. Survey Bull. 724, 1922.

Powell, J. W., Some remarks on the geologic structure of a district lying north of the Grand Canyon of the Colorado: this Journal, 5, 457-458, 1873.

Powell, J. W., Report on the geology of the eastern portion of the Uinta Mtns. and a region of country adjacent thereto: U. S. Geog. and Geol. Survey of the Terr., 2d div., 54-69, 1876.

Ransome, F. L., Emmons, W. H., and Garrey, G. H., Geology and ore deposits of the Bullfrog district, Nevada: U. S. Geol. Survey Bull. 407, 1910.

Ransome, F. L., Geology and ore deposits of the Goldfield district, Nevada: U. S. Geol. Survey Prof. Paper 66, 1909.

Reeside, John B., Jr., and Bassler, Harvey, Stratigraphic sections in southwestern Utah and northwestern Arizona: U. S. Geol. Survey Prof. Paper 129-D, 1921.

Robinson, H. H., The San Francisco volcanic field: U. S. Geol. Survey Prof. Paper 76, 1913.

Schuchert, Charles, On the Carboniferous of the Grand Canyon of Arizona: this Journal, 45, 347-361, 1918. The Cambrian of the Grand Canyon of Arizona: idem, 362-369.

Schuchert, Charles, Textbook of Geology, Pt. II, 1924.

Spurr, J. E., Origin and Structure of the Basin Ranges: Bull. Geol. Soc. America, vol. 12, 217-266, 1901.

Spurr, J. E., Descriptive geology of Nevada south of the 40th parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, 1903.

Waring, G. A., Ground water in Pahrump, Mesquite, and Ivanpah valleys, Nevada and California: U. S. Geol. Survey Water-supply paper 450, 51-81, 1920.

Ohio State University,
Columbus, Ohio.