

NOMENCLATURE OF THE LATE MISSISSIPPIAN WHITE PINE SHALE AND ASSOCIATED ROCKS IN NEVADA

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Late Mississippian detrital rocks in eastern and southern Nevada and adjacent California have been assigned to at least nine different formations and there is no consensus regarding their classification. Although our current investigations are incomplete (Langenheim, 1956a, 1956b, 1960) my own prior use of the classification proposed in this paper (Langenheim and Tischler, 1960; Langenheim *et al.*, 1960), imminent use by fellow workers and needs arising from preparation of a correlation chart for the Great Basin by a committee of the Eastern Nevada Geological Society require preliminary publication of nomenclatorial problems regarding these rocks.

The Late Mississippian detrital rocks of the central Great Basin consist of a basal calcareous siltstone unit, a black fissile shale unit, a sandy shale unit and an upper sandstone and conglomerate unit (Figs. 1, 2). The sequence as a whole generally thickens toward the west and the upper, coarser members increase in relative importance. The basal, calcareous siltstone unit, however, thickens eastward and at least one interbedded limestone unit occurs within the black fissile shale unit in eastern Nevada. The entire detrital sequence rests disconformably on Early Mississippian or older rocks and appears gradational with

overlying later Paleozoic carbonate rocks. A disconformity may be present either at the base of the sandy shale unit or within the conglomerate and sandstone unit, but this has not been fully demonstrated.

HISTORY OF THE NOMENCLATURE

The first significant account of the late Mississippian rocks in the Great Basin is that of the King Survey (Hague, 1870; Hague and Emmons, 1877; King, 1876), in which Hague (1870) mapped and described the White Pine Mining District. Here he recognized, in ascending order, a calcareous shale, a siliceous limestone, an argillaceous shale divided into a lower "bituminous" portion and an upper sandy portion, a "reddish yellow" sandstone and Carboniferous limestone. Hague's map and descriptions (1870: 409-421, Atlas Sheet 14) permit ready identification of his units on the ground and correlation with Humphrey's (1960) recent description and map. Furthermore, Hague appears consistent in his own terminology and apparently always refers to these units as "calcareous shale", "siliceous limestone", etc. in later publications and in conjunction with formally proposed stratigraphic names. Thus the "White Pine Shale" of Hague is

always described as composed of argillaceous and sandy shale in the White Pine District.

Hague (1882) first used the name "White Pine Shales" in a brief administrative report in which he refers to "black argillaceous and arenaceous shales which overlie the limestone" to the "White Pine Shales." He also states that these rocks are named "White Pine shales from the locality where they were first recognized in Eberhardt Cañon, and underlying the town of Hamilton" (Hague, 1882: 28). In later work Hague refers to sections in Applegarth Canyon which is a strike valley in the White Pine Shale trending south from Hamilton. Applegarth Canyon is shown as the upper part of Cathedral Canyon in the Treasure Hill (edition 1950) and Illipah (edition 1951) 15 minute series topographic maps of the U. S. Geological Survey. One year later, Hague (1883), in an "Abstract" of his forthcoming monograph on the geology of the Eureka District, described the White Pine Shale as a "heavy body of black shale . . . having been first recognized as a distinct horizon in the White Pine Mining District." This latter reference is cited in Wilmarth (1938) as the first reference to the White Pine Shale. Although these two citations and the 1870 description of the White Pine District clearly identify the rocks upon which Hague's concept of the White Pine Shale rests, some confusion has arisen because the 1882 and 1883 papers were chiefly concerned with the geology of the Eureka District. This has led some to accept exposures in the southern Diamond

Range as the type locality or the most important reference locality for the White Pine Shale concept.

In 1883 Hague first applied the name, "Diamond Peak Quartzite", to the sandstone and conglomerate resting on the White Pine Shale at Eureka and in the White Pine District. Previously these rocks had been referred to as "reddish yellow Sandstone" (Hague, 1870), "Ogden quartzite" (Hague in King, 1880: 27) and "Weber quartzite" (Hague, 1882).

In 1892 Hague fully described the Eureka District, redescribed the rocks of the White Pine District and discussed correlation between these two areas and other localities. The section at Sugar Loaf in Packer Basin near Eureka, important in nomenclatorial problems, is described on page 81 as paraphrased below:

Top

1. Shaly sandstone with interbedded shale and conglomerate. . . 1,000 feet.
2. Black argillaceous shale with gradational upper contact. . . 400 feet.
3. Gray crinoidal, sandy limestone with *Chonetes* 50 feet.
4. Yellow-weathering, black, argillaceous and calcareous fossiliferous shale 300 feet.
5. Blue, fossiliferous limestone. 250 feet.
6. Siliceous limestone. 150 feet.

Bottom

Hague (1892: 80-81) somewhat ambiguously remarks that the "beds directly underlying the shale are of course the uppermost members of the Nevada limestone." From this and from his correlation of the Packer Basin section with the section in Applegarth Canyon in the White Pine District, it is apparent that units 1-4 are considered part of

the White Pine Shale and 5-6 are part of the Nevada limestone.

Thus, in regard to the Applegarth Canyon Section in the White Pine District, Hague (1892: 193) states, "A more characteristic White Pine fauna is preserved in the black shale than has yet been obtained in the corresponding beds at Eureka, and a belt of intercalated limestone in the shale similar to that found east of Sugar Loaf at Eureka bears equal evidence of its Devonian age. Here the limestone appears as a lenticular body in the shale, with beds identical in composition both above and below." These statements taken alone are also somewhat ambiguous and it is impossible, out of context, to be absolutely certain whether the "lenticular body" of limestone is in Applegarth Canyon, if so it is certainly a body of limestone wholly within the "argillaceous shale" and, therefore, part of the White Pine Shale as typified by Hague in the White Pine District. If, however, one assumes that the "lens" is in Packer Basin and that the limestone in Applegarth Canyon is a continuous bed, then it may be argued that Hague had modified his conception of the White Pine Shale in Applegarth Canyon and elsewhere in the White Pine District to include the "calcareous shale" and "siliceous limestone". This conclusion may be justified by rigorous analysis of Hague's grammatical construction on page 193, but it is rejected for the following reasons: (1) If Hague included the "siliceous limestone" and "calcareous shale" in Applegarth Canyon within the White Pine Shale as suggested by his phraseology on

page 193 of Monograph 20, this is the only place wherein such a correlation is suggested in his writings. Otherwise he is consistent in his use of lithologic terminology and restricts the White Pine Shale of the White Pine District to rocks described as either "argillaceous," "arenaceous," or "bituminous" shale. (2) On page 193 Hague states that the shale above and below the "lenticular body" is of the same composition, but on page 81 the shale layers above and below the limestone with *Chonetes* in Packer Basin are described differently. Thus the "lenticular body" must be the limestone in Applegarth Canyon.

This means that Hague, in 1892, correlated units one through four of his Packer Basin Section in the Eureka District with the White Pine Shale of the type area in the White Pine Mining District. Inasmuch as Nolan *et al.* (1956) have identified the limestone with *Chonetes* in Packer Basin as the Joana Limestone and unit 4 as the Pilot shale, this means that Hague's 1892 correlation is incorrect, according to our present knowledge of these rocks, because he equates the upper Mississippian shale of the White Pine District with the uppermost Devonian shale, lower Mississippian limestone and upper Mississippian shale of the Eureka District. Furthermore, this miscorrelation has been the source of much confusion regarding the limits of the White Pine Shale, the upper Mississippian shale unit in question.

Lawson (1906) followed Hague's correlations in describing the White Pine Shale in the Robinson (Ely)

District. Lawson (1906: 296) states, "This shale formation, with its included limestone bed agrees well with the descriptions that have been given by Hague for the White Pine shale of the neighboring White Pine and Diamond Ranges . . . Even the thick bed of limestone in the midst of the shale has its analogue in the White Pine shale of the Eureka and White Pine sections." Lawson refers to Hague's 1892 discussion on pages 192-193, thus making it plain that he is referring to the lens of limestone in Applegarth Canyon and the limestone with *Chonetes* at Packer Basin. Spencer (1917: 25-26) accepted Lawson and Hague's correlations and assigned formal stratigraphic names to the three units described by Lawson. The lower shale, equivalent to Hague's "calcareous shale" of the White Pine District, was named, "Pilot Shale." The middle limestone, equivalent to Hague's "siliceous limestone", was named, "Joana Limestone," and the upper shale, equivalent to Hague's "argillaceous shale", was named, "Chainman Shale." Thus Lawson (1906) and Spencer (1917) correctly correlate rock units in the Ely District with those of Hague's Packer Basin section near Eureka, but are incorrect in company with Hague, in comparing these sections with the type White Pine Shale in the White Pine Mining District.

The Chainman Shale in the Robinson Mining District consists almost entirely of black, fissile shale (Fig. 2). Thus the poorly exposed, thin calcareous siltstone unit is not mentioned by Lawson (1906) or by Spencer (1917). In addition, the relatively thin sandy shale unit is

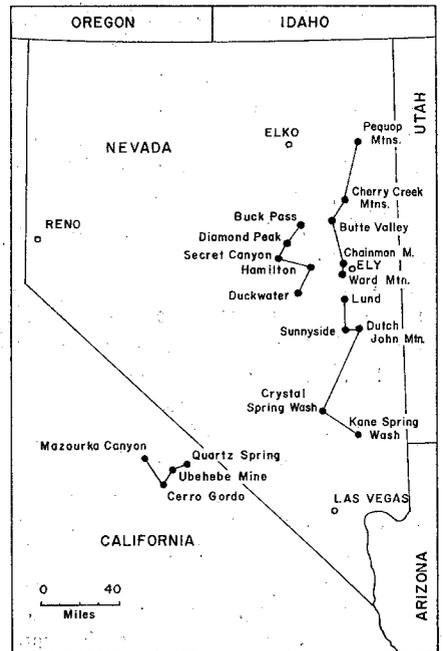


FIG. 1.—Location Map.

only briefly discussed by Spencer (1917) who also points out the absence of the Diamond Peak Quartzite in the mining district.

In 1932 Westgate (Westgate and Knopf, 1932: 19-21) described the sequence at Silverhorn in the Pioche District and at Dutch John Mountain about 40 miles north of Pioche. Here Westgate assigned the detrital rocks between the Lower Mississippian Bristol Pass (Joana or "siliceous") Limestone and the Late Mississippian or Early Pennsylvanian Bailey Spring Limestone to the newly-described Peers Spring Formation and Scotty Wash Quartzite. Although the Scotty Wash Quartzite is analagous to the Diamond Peak Formation, it is of slightly differing composition, is presumably

derived from a different source area, and probably is geographically separated from the Diamond Peak Quartzite (James, 1954). The Peers Spring Formation, however, occupies the same stratigraphic position, includes rocks of the same sort and is presumably geographically continuous with the Chainman Shale as defined by Spencer (1917) and the White Pine Shale in the White Pine Mining District as defined by Hague (1882, 1883, 1892) (Langenheim and Peck, 1960).

Westgate describes the Peers Spring Formation as follows: "The most noticeable type (of rock) is a black, dense, fine-grained limestone, much of it gray-white on the weathered surface, very thin bedded, locally almost shale-like in its lamination. Probably a more common facies, though not so often seen in actual outcrop because it is a softer rock, is a brown calcareous shale that effervesces slightly in warm hydrochloric acid. The formation as a whole weathers easily, so that outcrops are scarce, the surface being covered with fine gray, lavender, or rusty debris. Interbedded in the shale and thin limestones of the lower part of the formation are blue-black limestones, some layers of which are 4 feet thick. These seem to form a transition by intercalation to the underlying Bristol Pass limestone." (Westgate and Knopf, 1932: 20). Re-examination of the type and reference areas (Langenheim and Peck, 1960) has shown that accidents of exposure make outcrops of the calcareous siltstone unit (Fig. 2) most extensive in the Peers Spring area and, as suggested by Westgate (Westgate and

Knopf, 1932: 20), give an erroneous impression regarding the formation. Thus, although Westgate's description pertains almost entirely to the calcareous siltstone unit, all three units—calcareous siltstone, black fissile shale, and sandy shale—are present. These relationships are difficult to detect at Peers Spring but are well displayed at Dutch John Mountain (Langenheim and Peck, 1960).

Problems of exposure also led Westgate (Westgate and Knopf, 1932) to misinterpret the basal contact of the Peers Spring Formation at Peers Spring and the Peers Spring-Scotty Wash contact at Dutch John Mountain (Langenheim and Peck, 1960). Lower Mississippian fossils reported from lenses in the basal Peers Spring Formation at Peers Spring are actually from unfaulted blocks of Bristol Pass Limestone and the great thickness of Scotty Wash Quartzite reported at Dutch John Mountain appears largely to result from inclusion of talus-covered shale slopes within the quartzite formation (Langenheim and Peck, 1960).

In 1953 the stratigraphic correlation committee of the Eastern Nevada Geological Association (Easton *et al.*, 1953) accepted Hague's (1883) designation of the White Pine Mining District as the type area for the White Pine Shale. The Pilot Shale, Joana Limestone and Chainman Shale, however, were included as members within the White Pine Formation at Ely and Eureka (Easton *et al.*, 1953, fig. 2) and, by implication, within the White Pine Mining District as well. In their column for the Pioche District

(Easton *et al.*, 1953, fig. 2) the Pilot Shale and Joana Limestone (Bristol Pass Limestone) are shown as members of the White Pine Formation, but the Peers Spring Formation is treated separately because, "It is probable that the Peers Spring formation includes the Chainman shale and part of the Diamond Peak formation." (Easton *et al.*, 1953: 149). Thus, Hague's (1892), Lawson's (1906) and Spencer's (1917) mis-correlation of the Eureka and Ely sections with the White Pine Shale of the White Pine District was reinforced. Also, by implication, the type section in the White Pine District was revised to include the "siliceous limestone" and "calcareous shale" previously assigned to the Nevada Formation by Hague (1870, 1892) and King (1878).

McAllister (1952: 22-26) created local formations in dealing with Late Mississippian detrital rocks in the Quartz Spring Area, northern Panamint Range, California. Calcareous siltstone and shale with interbedded limestone is included in the upper part of the Perdido Formation. Black argillaceous shale resting on a *Cravenoceras* biostrome at the top of the Perdido Formation is assigned to the Rest Spring Shale. The upper part of the Rest Spring Shale is silty, includes minor interbeds of quartzite and is succeeded by the Pennsylvanian Tihvipah Limestone. Langenheim and Tischler (1960: 110, fig. 5) have redescribed the Perdido Formation in greater detail and correlated the Upper Perdido Formation with the regional calcareous siltstone. The Rest Spring Shale is correlated with a Chainman Shale concept restricted

to the "argillaceous and arenaceous shale" of the White Pine District.

Nolan *et al.* (1956) review the nomenclature of the White Pine Shale in a restudy of the Paleozoic section in the Eureka District. Nolan *et al.* (1956: 54) cite the White Pine Mining district as the type locality of the White Pine Shale. They appear, however, indecisive regarding Hague's conception of the White Pine Shale in the Eureka District. On one hand they state, in reference to the Joana Limestone in the Eureka District, that "although the unit was clearly recognized in a section measured in Packer Basin, southeast of Eureka (Hague, 1892: 81). It is not clear from this reference, however, if Hague intended to include the Joana with the underlying Devonian sedimentary rocks, or with his White Pine Shale." (Nolan, *et al.*, 1956: 54). Elsewhere, they state in regard to the Pilot Shale, "The lowest beds of the White Pine Shale, as defined by Hague (1892: 68-69), differ in lithologic character from the rest of the beds that were assigned to that unit and appear to be equivalent in stratigraphic position and relationships to the Pilot shale of the Ely district (Spencer, 1917: 26)." (Nolan *et al.*, 1956: 52): Although Hague's (1892: 81) discussion of the Packer Basin section regarding assignment of the limestone with *Chonetes* (Joana Limestone), appears ambiguous out of context, his correlation of this section with the Applegarth Canyon section (Hague, 1892: 193) clearly indicates that he placed the limestone with *Chonetes*, and the shale below in the White Pine Shale, as

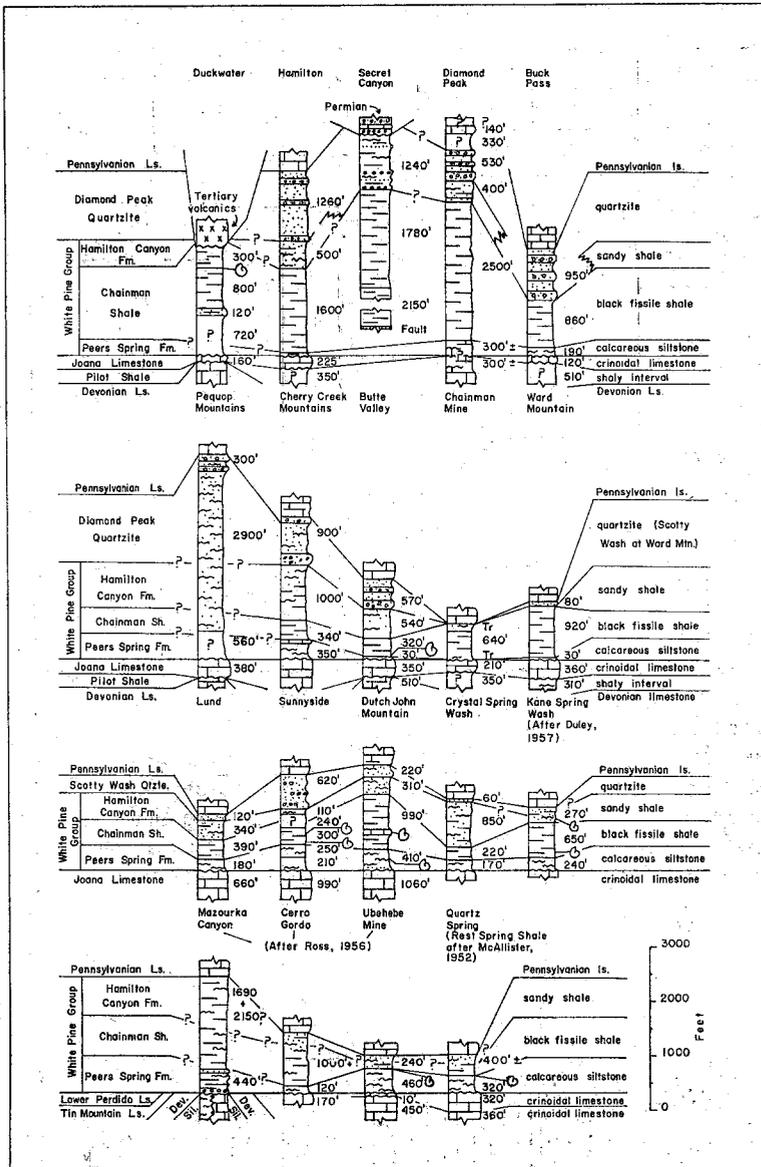


FIG. 2.—Columnar sections of Late Mississippian detrital rocks in the central Great Basin.

he conceived it in the Eureka District.

Nolan *et al.* (1956) further point out that most workers were confused regarding the nature of the White Pine Shale and that many used the name, "White Pine" incorrectly. Therefore, they proposed rejection of the White Pine Shale concept and adopted the Chainman Shale concept for use in the Eureka District, because:

1) Hague's White Pine Shale and Diamond Peak Quartzite were not satisfactory mapping units for their work in the Eureka District. These units show extreme differences in thickness and lithologic character both between and within individual thrust plates.

2) The White Pine Shale has been applied to black shale sequences of excessively wide range as, for example, in the Eureka District where it became necessary to remove the Pilot Shale and Joana Limestone from the unit mapped as White Pine Shale by Hague.

3) Inclusion of the Pilot Shale, Joana Limestone and Chainman Shale as members within the White Pine Formation, as employed by the stratigraphic committee of the Eastern Nevada Geological Association (Easton *et al.*, 1953) "has the advantage of retaining the name, "White Pine" for the dominant black shale sequence, (*but*) does not provide for satisfactory treatment of the thick gradational zone between the black shales and the coarser clastics characteristic of Hague's Diamond Peak." (Nolan, *et al.*, 1956: 57). Nolan *et al.* (1956) solve this problem by separately recognizing the Chainman Shale and

Diamond Peak Formation where they can be satisfactorily distinguished and elsewhere referring to the undivided sequence as "Chainman and Diamond Peak Formations undifferentiated."

Johnson and Hibbard (1957: 356-360) introduce another set of local formations in mapping the A. E. C. Proving Grounds. The Narrow Canyon Limestone consists of platy, buff-weathering silty limestone which appears similar to the Lower Pilot Shale of Langenheim (1961) and is tentatively correlated with the Pilot Shale by Johnson and Hibbard (1957: 356). The Camp Mercury Limestone is described as a probable correlative of the Joana and Tin Mountain Limestones, but the Eleana Formation is less readily compared with rocks of other areas. Although the Eleana Formation was not observed in stratigraphic contact with the Camp Mercury Limestone, Johnson and Hibbard (1957) assume it to be stratigraphically above the limestone. The lower part of the Eleana Formation consists of black shale and is compared with the Chainman Shale of the Eureka District as recognized by Nolan *et al.* (1956) (Johnson and Hibbard, 1957). The middle quartzitic portion of the Eleana Formation is tentatively correlated with the Diamond Peak Formation of Nolan *et al.* (1956), but no attempt was made to compare the upper, shaly portion of the Eleana Formation to rocks elsewhere (Johnson and Hibbard, 1957). Poole *et al.* (1961) have revised this treatment of the Eleana Formation after discovery of a locality in which the Eleana Formation rests disconformably on Devon-

ian limestone. Thus they correlate the basal Eleana Formation with the Narrow Canyon and Camp Mercury Limestone and approximately equate the remainder of the Eleana Formation with the Chainman Shale, Diamond Peak Formation and, possibly, basal Ely Limestone of the Eureka District (Poole *et al.*, 1961, table 328.2).

SUGGESTED REGIONAL TERMINOLOGY
FOR THE LATE MISSISSIPPIAN ROCKS
OF THE CENTRAL GREAT BASIN

Part of the confusion regarding Late Mississippian stratigraphic nomenclature in the central Great Basin arises from conflicting needs of geologic mapping and those of basin-wide stratigraphic synthesis. Local formational concepts are needed in many localities for efficient mapping within a mountain range or mining district. These local concepts, however, may not coincide with formational units of greatest regional significance. In some instances, growth of knowledge may "overtake" such local concepts and it may be useful either to abandon or revise them to bring them into conformity with regional units having the same local value. The terminology of Johnson and Hibbard (1957) and Poole *et al.* (1961) refers to a set of such presently useful local formational concepts. Spencer's (1917) units at Ely and Westgate's (Westgate and Knopf, 1932) units at Pioche are other examples in which the advance of stratigraphic knowledge has made the need for a local terminology more or less obsolete.

Units for regional synthesis should reflect the distribution of major rock types within the basin because only

units such as these are of environmental and paleogeographic significance. In the central Great Basin, the Late Mississippian detrital sequence includes five major rock units of this sort. They are the basal calcareous siltstone unit, the black fissile shale unit, the sandy shale unit and the two geographically distinct quartzitic and conglomeratic units mentioned in the introduction to this paper. Three of these units were recognized by Hague in 1870 as the bituminous and sandy members of the black argillaceous shale and the reddish yellow sandstone. The basal calcareous siltstone unit is thickest in the Pioche District and is the dominant lithologic type described by Westgate (Westgate and Knopf, 1932) in his discussion of the Peers Spring Formation. The black fissile shale unit is widespread throughout the area and constitutes almost all of the Chainman Shale as described by Spencer in the type area. The sandy shale sequence is thickest in the western part of the area but has not been as yet the basis of a separate formational concept. The uppermost quartzitic and conglomeratic sequence includes the Diamond Peak Quartzite. This formation is thickest in the Eureka District and is separated by an area in which quartzite is absent from exposures of the Scotty Wash Quartzite. Distribution of the Scotty Wash Quartzite centers on the Pioche District.

A rational classification for regional synthesis should include all of these units and should also follow priority in definition and naming of stratigraphic concepts. Thus the White Pine Shale, raised to

Group status, is retained for the entire fine-grained detrital sequence and the Scotty Wash Quartzite and Diamond Peak Quartzite concepts are applied to the appropriate, separate coarse-grained rock bodies.

Retention of the White Pine Shale as a Group is justified for the following reasons:

1) Hague's original statements in 1882 and 1883 clearly designate the argillaceous shale of the White Pine Mining District as the basis for this formation concept. His map of 1870 and the more extensive discussions of 1892 establish the type section of the White Pine Shale as including the entire body of fine-grained detrital rock stratigraphically above the "siliceous limestone" and below the Diamond Peak Quartzite.

2) The recommendation of the Eastern Nevada Geological Association Stratigraphic Committee (Easton *et al.*, 1953) that the White Pine Shale be treated as comprising the Pilot Shale, Joana Limestone and Chainman Shale is rejected as based on miscorrelations by Hague (1892), Lawson (1906) and Spencer (1917) of rocks at Eureka and Ely with the type section of the White Pine Shale in the White Pine District.

3) The recommendation of Nolan *et al.* (1956) that the name "White Pine" be suppressed and the name, "Chainman" be applied to the upper shale is rejected because the Chainman Shale of Spencer (1917) is a junior synonym of the White Pine Shale of Hague (1882, 1883, 1892) in the type area. The arguments of Nolan *et al.* (1956) to the effect that Hague's formational concept does not satisfactorily serve the

needs of geologic mapping in the Eureka District and elsewhere are considered in large part equally applicable to use of the same formational concept under a junior name. These arguments are valid in respect to the needs of local mapping and, it may be pointed out, have been met by Nolan *et al.* (1956) through recognition of a local, undifferentiated Chainman and Diamond Peak unit.

4) Finally, it has been widely argued that the Chainman Shale concept is untainted by past confusion regarding its application and that current usage favors use of the Chainman concept and name. This argument is rejected because it is felt that the White Pine concept of Hague is in fact clearly recognizable and that differences of opinion regarding its application are capable of resolution by comparison of the rocks in question with those of the type locality. In fact, the White Pine Mining District section, selected as a reference section by Humphrey (1960), is superior to the Chainman type section in that it is better exposed, less metamorphosed and deformed, and has a better representation of the three recognized lithologic subunits within the sequence. The appeal to general usage is rejected as not being capable of objective resolution.

The three lithologic units within the White Pine Group now require definition and designation of type or reference sections. It is suggested that the Peers Spring Formation concept be restricted to the basal calcareous siltstone unit with units 2-5 in the section south of Dutch John Mountain (Langenheim and Peck, 1960: 541, fig. 3) designated

as a reference or type section for the restricted formation concept. This seems appropriate inasmuch as the calcareous siltstone is best developed in this area and Westgate's (Westgate and Knopf, 1932) original description is actually almost entirely a description of the calcareous siltstone assemblage. Further, it is recommended that the Chainman Shale concept be restricted to the black fissile shale unit with section V. (Langenheim *et al.*, 1960: 149, 151, fig. 1) on the west side of Ward Mountain south of Ely designated as a reference section for the restricted formational concept. This seems appropriate inasmuch as Spencer's concept enjoys priority and the section in the Ely area consists almost entirely of the black fissile shale unit.

Inasmuch as the uppermost sandy shale unit is not presently recognized as a formal stratigraphic unit it is proposed that the unit be referred to as the Hamilton Canyon Formation. The type section is designated as the appropriate portion of the White Pine Shale section shown for the White Pine District in Figure 2. This section was measured along a traverse starting at the White Pine-Joana contact on the north side of the water gap through the Joana Limestone in the NE $\frac{1}{4}$, sec. 31, T. 17 N., R. 58 E., Illipah Quadrangle, White Pine County, Nevada. The traverse proceeds eastward through cover to the end of a spur in the Chainman Shale Formation and thence continues roughly along the crest of the spur to the base of the Ely Limestone near the Hamilton-Illipah Road. The base of the Hamilton Canyon Formation is well-marked

by a soil and vegetation change at the top of the black, fissile shale to open grassland with scattered outcrops of silty shale and fine-grained sandstone. The upper contact is taken at the base of the lowest significant sandstone layer. The thickness and general character of the Hamilton Canyon Formation in its type locality and elsewhere in eastern Nevada are shown on Figure 2.

The Diamond Peak Quartzite and Scotty Wash Quartzite concepts are retained for the dominantly quartzitic and conglomeratic units spreading eastward from the Diamond Range and centering on the Pioche District respectively.

ACKNOWLEDGMENTS

Special thanks are due Philip Playford for his energetic defense of the Eastern Nevada Geological Association classification in a prolonged running debate on the questions discussed herein. J. H. Langenheim and L. J. Stensaas served as field assistants and the Department of Paleontology and the Faculty Research Fund of the University of California at Berkeley supplied field expenses for the field studies upon which this work ultimately rests. H. R. Wanless kindly read and criticized the manuscript. Finally the author begs forgiveness for any excessive zeal in pressing his argument and invites reply in the same spirit.

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