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# GEOLOGY OF THE SOUTHERN WASATCH MOUNTAINS AND VICINITY, UTAH

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# Geology of the Southern Wasatch Mountains and Vicinity, Utah

*a symposium*

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*Extra copies of map available at $1.00 each.*

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# Geology of the Southern Wasatch Mountains and Vicinity, Utah

## INTRODUCTION

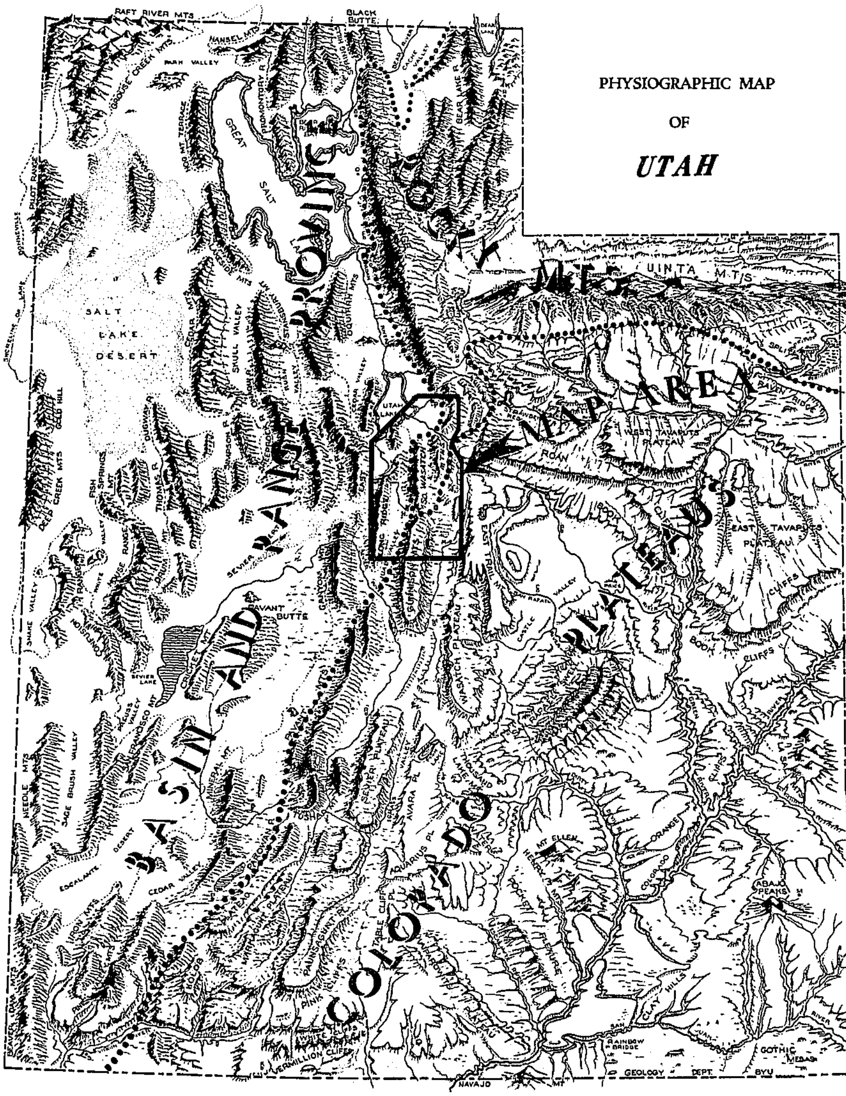
Utah is blessed with geologic features of unusual interest and great variety. The Canyon Lands, the Henry Mountains, the San Rafael Swell, the High Plateaus, the features of Lake Bonneville, the famous mining districts of Tintic, Bingham, and Iron Springs, the magnificent stratigraphic sections exposed in the Book Cliffs and in the Basin Ranges, all have revealed to geologists the tremendous sweep of geologic history and have been made classic through the writings of such pioneer geologists as C. E. Dutton, William M. Davis, C. D. Walcott, and G. K. Gilbert. So complex is Utah's geologic history and so numerous its problems that further detailed work, using improved procedures, continues to increase our understanding of this fascinating area. Each year some aspect is clarified and we wonder why it did not seem more obvious to us before.

In this light we embark on a summary of the current knowledge of the geology of the Southern Wasatch Mountains. The area lies at the junction of three major physiographic divisions: the Middle Rocky Mountains, the Colorado Plateaus, and the Basin and Range Province. It includes sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Quaternary, and representing dominantly marine deposits of the Early Paleozoic Cordilleran miogeosyncline, the later Paleozoic Madison and Oquirrh Basins, the Cretaceous Rocky Mountain exogeosyncline, and Cenozoic deposits in freshwater lakes. The area has been involved in major structural deformation in Precambrian time, in folding and thrusting in Late Cretaceous (Laramide) time, and in block faulting in later Cenozoic time. In all, a greater variety of geologic features can scarcely be found in so limited an area.

The area is part of what is sometimes referred to as the "transition zone" in Utah. The transition involves more than the change from Basin and Range landforms to those of the Plateaus, it also involves older transitions from Cretaceous orogenic elements on the west to depositional sites on the east, from Paleozoic cratonic deposition on the east to geosynclinal behavior on the west. Two previous guidebooks have discussed the transition zone in Utah: to the north the Intermountain Association of Petroleum Geologists 10th Annual Field Conference in 1959 considered the Wasatch-Uinta Mountains transition area; to the south the Utah Geological Society 4th Annual Field Conference in 1949 traversed the transition between the Colorado Plateaus and the Great Basin in central Utah.

## GEOLOGIC MAP

The geologic map accompanying this report was compiled from a great many sources, most of them published and unpublished theses by graduate students of Ohio State University and Brigham Young University (see "Index to sources of data" printed on the map). The original mapping was done on a variety of base maps, some prepared by plane table, some from air photos, and some on U.S.




INDEX MAP.—Shows Southern Wasatch map area in relation to physiographic provinces.

Geological Survey topographic quadrangles. In transferring the mapping from these diverse bases to the common base used innumerable minor adjustments were made in order to fit the original mapping to the new base as well as possible. Air photos aided in making the transfer for it was sometimes necessary to transfer data from the original map to the photos and thence to the final map in case the original map was too distorted to use directly.

In addition, in cases where adjacent mappers disagreed, the compiler has attempted to resolve their differences as best he could in order to eliminate map boundary faults. Many problems, yet to be solved, became apparent during the compilation and it is hoped that the present map may serve as a means of pointing out these problems in their regional setting for the benefit of future students of this complex and interesting area.

## ACKNOWLEDGMENTS

Although many famous pioneer geologists such as William M. Davis and G. K. Gilbert had made reconnaissance observations pertaining to the Southern Wasatch Mountains, the first modern areal mapping in the area was done by Armand J. Eardley in the early 1930's. All later workers are indebted to the perspicacity of his observations.

Impetus for further work in the area came from Professor Edmund M. Spieker who extended his earlier interest in the Mesozoic problems of central Utah by directing Ohio State University graduate students in areas surrounding that of his initial work with the U.S. Geological Survey. Under him, S. L. Schoff's work in the Cedar Hills in 1937 was followed by that of many others of whom the following did work in the area of the present report: Dorothy Taylor, H. D. Zeller, R. E. Hunt, S. J. Muessig, R. E. Metter, A. C. Fograscher, J. E. Cooper, M. A. Khin, R. E. Mase, J. D. Hayes, and G. E. Thomas. Professor George E. Moore, Jr., of Ohio State University acted as graduate thesis advisor for some of these students.

For the past 25 years Professor Harold J. Bissell has been involved in problems relating to Utah Valley and the adjoining ranges. He has inspired a number of students to work in the West Mountain-Long Ridge-Southern Wasatch area and has served as adviser to most of the following Brigham Young University graduate students who have worked in this area: W. O. Abbott, R. S. Brown, R. S. Clark, L. C. Demars, J. H. Elison, D. R. Foutz, P. W. Gaines, R. W. Gates, T. A. Gwynn, H. D. Harris, R. A. Hodgson, K. D. Johnson, J. W. Madsen, D. F. Mecham, C. H. Peacock, H. N. Petersen, D. J. Peterson, D. O. Peterson, R. P. Peterson, J. R. Price, R. R. Rawson, J. A. Rhodes, S. F. Schindler, G. K. Sirrine, C. V. Smith, J. W. Swanson, and B. O. White.

Arthur A. Baker of the U.S. Geological Survey has mapped in the Wasatch Range from Spanish Fork Canyon northward and his work and advice have served as a guide to many of the above listed workers. In addition to the many people whose field work has made the present compilation possible, I wish to acknowledge the efforts of the authors of the papers in the present volume. I also wish to thank Professors Clyde T. Hardy and J. Keith Rigby for help in preparing the road log, and Mr. Colbeth Killip for drafting the geologic map.

*The Editor*

# Precambrian and Lower Paleozoic Rocks of North-Central Utah

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Along the Southern Wasatch Front Precambrian and Lower Paleozoic rocks are exposed in two narrow belts, one just east of Provo, and a longer belt from Santaquin to near Mona. Cambrian rocks also crop out in Payson Canyon and at the south end of West Mountain from the Keigley Quarries northward two miles. Precambrian and Lower Paleozoic rocks are further exposed from the north end of Long Ridge southward 10 miles to Slate Jack Canyon.

## PRECAMBRIAN CRYSTALLINE COMPLEX

The oldest rocks in the map area are similar to basement rocks found elsewhere in the Rocky Mountain region and consist of mica and hornblende foliated rocks intruded by pegmatite dikes and granite. These rocks have been called "Archean" and assigned to the Farmington Canyon Complex by Eardley & Hatch (1940, p. 823). This complex is exposed in the map area only along the lower part of Dry Mountain east of Santaquin. None of the geologists who have mapped the area (Eardley, 1933; Metter, 1955; Demars, 1956) have subdivided the complex on their maps, nor have they described the rocks in much greater detail than as summarized below from their writings.

The foliates include schists and gneisses, the most widespread of which are hornblende-biotite schists containing abundant quartz. Amphibolites and schists composed almost entirely of biotite are present in minor amounts. Gneisses range from porphyritic granite gneisses containing pink feldspar phenocrysts an inch or more in diameter to rocks gradational with schists.

Pegmatites as much as a hundred feet thick intrude the foliates as sills and dikes and comprise about one half of the complex. The pegmatite is coarse-grained and consists chiefly of microcline and quartz, sometimes in graphic intergrowth.

The granite is fine- to medium-grained, in places porphyritic with pink feldspar phenocrysts (albite to oligoclase), quartz, orthoclase, microcline, biotite altered to chlorite, and minor amounts of apatite and magnetite. Some magnetite occurs in small pockets or as small veinlets. The granite is broken by two nearly vertical joint systems.

The unconformity at the top of the Precambrian crystalline complex represents the most intense orogeny to occur in the region. Pre-existing sedimentary rocks were converted into schist and gneiss, intruded by pegmatite dikes and granite, and all were truncated by erosion prior to deposition of the Late Precambrian Big Cottonwood Formation.

## LATE PRECAMBRIAN SEDIMENTARY ROCKS

In the central Wasatch Mountains near Salt Lake City the Late Precambrian rocks have been divided by Crittenden, Sharp & Calkins (1952, pp 3-6) into three formations, in ascending order: the Big Cottonwood Formation, the

Mineral Fork Tillite, and the Mutual Formation. The last named is not present and the Mineral Fork Tillite is found only in the northernmost Precambrian exposures in the area of this report. The Big Cottonwood Formation is displayed in Slate Canyon near Provo, on Dry Mountain and between North and Mendenhall Creeks along the Southern Wasatch Front, and near Slate Jack Canyon on Long Ridge.

### Big Cottonwood Formation

This formation consists of white to maroon quartzite and quartzitic conglomerate, interbedded with green, red, and yellow phyllitic shales. The base of the formation is exposed only on Dry Mountain where Demars (1956, p. 9) and Metter (1955, p. 218) report quartzite and feldspathic sandstone as the basal unit while Eardley & Hatch (1940, p. 823) report a basal quartz conglomerate. Thickness of the complete section exposed on Dry Mountain ranges from 373 feet at the north end (Demars, 1956, p. 9) to 1236 feet at the south end (Metter, 1955, p. 218). The variation in thickness results chiefly from erosion of the upper beds of the Big Cottonwood Formation prior to deposition of the overlying basal Cambrian quartzite which rests upon them with an angular discordance of 15 to 25 degrees (Hintze, 1913, p. 97).

The base of the Big Cottonwood Formation is not exposed elsewhere in the map area but partial thicknesses are reported to be 1088 feet in Slate Canyon east of Provo (Rhodes, 1955, p. 8), and 2265 feet (Price, 1951, p. 15) to 2836 feet (Muessig, 1951) in the Slate Jack Canyon area of Long Ridge. Evidently the formation thickens from Dry Mountain westward to Slate Jack Canyon. Nowhere in the map area do thicknesses approach the 12,000-16,000 feet reported from the type area in the Central Wasatch Range.

### Mineral Fork Tillite

This unique formation has been discussed at some length by Hintze (1913), Blackwelder (1932), Eardley & Hatch (1940) and Cohenour (1959) and it has been described from a number of localities in northern Utah. In the area of this report it occurs only in Rock and Slate canyons east of Provo where it consists of a dark gray phyllitic mudstone containing considerable numbers of subangular to subrounded pebbles, cobbles, and boulders of dolomite, quartzite, and granitoid rocks as much as a foot in diameter. Dolomites are otherwise almost unknown from the Precambrian of Utah and their presence in the tillite is an enigma.

The tillite varies considerably in thickness in northern Utah, the maximum being approximately 3000 feet (Crittenden, Sharp, & Calkins, 1952, p. 4). In Slate Canyon east of Provo where both base and top of the formation are exposed it is 145 feet (Baker, 1947) and it is also at least this thick at the mouth of Provo Rock Canyon (Gaines, 1950) where the base is concealed. Although earlier authors discussed the possibility that the tillite might be Cambrian in age all recent workers have concurred in assigning it to the Late Precambrian on the basis of a regional unconformity at the base of the overlying Tintic Quartzite.

Recently Dott (1961, p. 1302) and Van Houten (1957) have questioned the glacial origin of this and other tillites and have suggested subaqueous mass movement or subaerial mudflow as alternative origins.

## CAMBRIAN

Cambrian terminology used in the Southern Wasatch-Long Ridge area comes from the East Tintic Mountains which lie less than 10 miles west of Long Ridge. The stratigraphy of the East Tintic Mountains has recently been redescribed in detail by Morris & Lovering (1961) and it now appears likely that the Tintic terminology can be employed throughout north-central Utah replacing local terminologies previously used.

The scale of the map accompanying this report is too small to show individual Cambrian limestone formations as mapped by original sources, so in most places they have been lumped. Teutonic to Cole Canyon formations inclusive show as "Middle Cambrian undifferentiated," and Opex and Ajax formations show as "Upper Cambrian undifferentiated."

Post-Cambrian regional warping and erosion developed a pronounced regional Upper Devonian unconformity (Rigby, 1959; Morris & Lovering, 1961) the significance of which has not always been realized in correlations involving pre-unconformity strata in north central Utah. Along the Wasatch Mountains the Devonian rests upon successively older Cambrian beds from Santaquin to Provo. Rocks near Provo which have been shown on previous maps as "Maxfield" or "Lynch" formations are probably better assigned to Teutonic and Dagmar formations. On the present map these are shown as "Middle Cambrian undifferentiated" because of the scale of the map, but the white weathering dolomitic limestone near the top of the Cambrian carbonate succession on Squaw Peak near Provo has the typical Dagmar weathered appearance and is in the proper stratigraphic position to correlate with the type Dagmar Dolomite.

### Tintic Quartzite

This quartzite is easily recognized by the resistant orangish-brown ledges which it forms. It is mostly a white, pink, or light gray, fine to medium-grained quartzite composed of rather clean, subrounded to rounded quartz grains. Some beds contain limonite cement which imparts its brownish color to weathered surfaces. Tintic Quartzite rests with regional angular unconformity on the Precambrian. On Dry Mountain the angular discordance is as much as 25 degrees. In Slate Canyon east of Provo the discordance is slight and the base of the Tintic is recognized by its basal conglomerate bed. Quartz pebble conglomerate beds are common at and near the base of the Tintic Quartzite. Ordinarily the pebbles are an inch or less in diameter, but near the mouth of North Canyon northeast of Mona Eardley (1933) and Phillips (1940) report boulders of gneiss, schist, quartz, and jasper up to 18 inches and more in diameter comprising a basal conglomerate 50 feet thick.

The most unusual unit within the Tintic Quartzite is a sheet of amygdaloidal basalt which has been recognized throughout the Southern Wasatch-Long Ridge-East Tintic area (Abbott, 1951). This ancient flow is now altered to serpentine, kaolinite, sericite, calcite, and iron oxides, but retains its original porphyritic texture. The flow does not anywhere transect bedding; it contains inclusions of quartzite near its base and is channeled at the top. In the Southern Wasatch-Long Ridge-East Tintic area the flow ranges from 0 to 45 feet in thickness. In the Wasatch-Long Ridge areas the flow lies from 90 to 165 feet above the base of the Tintic Quartzite, but in the East Tintic Mountains the flow lies 980 feet above the base of the quartzite. If the flow is used as a time horizon it would indicate that the lowest part of the Tintic Quartzite in the East Tintic Mountains is not represented by any deposition in the Wasatch Mountain area.

Total thickness of the Tintic Quartzite, including the basalt flow, ranges from 3200 feet maximum in the East Tintic district (Morris & Lovering, 1961, p. 13) to 2340 feet in Slate Jack Canyon on Long Ridge (Muessig, 1951) although this latter figure probably includes some fault repetition of beds. Price (1951) reports that he could measure only 1500 feet of beds because of the faulting in the Slate Jack Canyon area. In the Southern Wasatch Mountains the Tintic Quartzite is uniformly reported by all mappers to be 900-1100 feet thick. The contact of the Tintic with the overlying Ophir Formation is gradational and is usually taken where light colors typical of Tintic Quartzite give way to dark browns and greens of the Ophir phyllitic shales and sandstones.

Age of the Tintic Quartzite is uncertain as it has yielded no identifiable fossils. Frequent mention of the Lower Cambrian trilobite *Olenellus* in the literature of north central Utah in connection with this formation is misleading as pointed out by Lochman-Balk (1959, p. 43). Lower Cambrian fossils have not certainly been found any closer to central Utah than the House Range, almost 100 miles away, where uppermost-Lower Cambrian olenellids are known. The oldest fauna in north central Utah is from the Ophir Formation. This fauna belongs to the Middle Cambrian *Glossopleura* zone which is not the lowest Middle Cambrian zone known. Thus the unfossiliferous Tintic Quartzite could be entirely Middle Cambrian in the Wasatch Mountains as suggested by Lochman-Balk (1959, p. 43) although it could possibly include some uppermost Lower Cambrian (Morris & Lovering, 1961, p. 17). Until pre-*Glossopleura* fossils are discovered in north central Utah it seems stratigraphically most logical to regard the entire Tintic Quartzite in the Wasatch Mountains as Middle Cambrian. The thicker sections of the formation in the East Tintic Mountains may be partly Lower Cambrian.

### Ophir Formation

This formation consists principally of olive green phyllitic shale, with interbeds of olive green quartzite common near the base and interbedded limestones common in the middle. The formation thins from 380 feet in the East Tintic Mountains to about 300 feet on Long Ridge and West Mountain, then to about 250 feet in the Southern Wasatch Range as measured at North Canyon near Mona, on Dry Mountain near Santaquin, and in Slate and Little Rock canyons near Provo.

*Glossopleura* zone faunas have been reported from the basal part of the Ophir Formation at many localities (Morris & Lovering, 1960, p. 22; Muessig, 1951, p. 18; Migliaccio, 1958). A younger trilobite assemblage assigned to the *Bathyuriscus-Elrathina* zone has been reported by Muessig (1951, p. 18) from the upper 58 feet of the Ophir Formation in his measured section 10a in Spring Canyon on Long Ridge. A similar fauna was collected by Metter (1955, p. 43) from a limestone bed in the upper part of the Ophir Formation above an abandoned mine near the center of Section 32, T. 9 S., R. 2 E. Thus the Ophir Formation includes two middle-Middle Cambrian faunal zones. There is as yet no record of the three lower-Middle Cambrian faunal zones ever having been found in central Utah.

### Teutonic Limestone

The Teutonic conformably overlies the Ophir Formation and consists of medium to fine-grained bluish-gray limestone, mottled and streaked with brown to yellow weathering mudstone and limy shale. The middle part of the formation contains many oolitic and pisolitic (*Girvanella* ?) beds. Some layers within the formation are dolomitic. The formation is 420 feet thick at its type locality in the East Tintic Mountains,280-340 feet thick as measured on Long Ridge, 360 feet on West Mountain, 350 feet at North Canyon near Mona, 413-476 feet on Dry Mountain, and about 430 feet thick in Rock and Slate canyons near Provo.

Fossils found in the lower 20 feet of the Teutonic at Spring Canyon on Long Ridge (Muessig, 1951, p. 23) were identified by Lochman-Balk as *Bolaspis* and *Glyphaspis*. A. R. Palmer collected *Alokistocare* and *Kootenia* from the lower part of the Teutonic Limestone in the East Tintic Mountains (Morris & Lovering, 1961, p. 27). Similar fossils have been found by the writer and others in the basal Teutonic beds at Rock Canyon near Provo. All belong to the *Bathyuriscus-Elrathina* zone of medial-Medial Cambrian age.

### Dagmar Dolomite

Dagmar Dolomite is a thin but most distinctive marker bed in the Cambrian carbonate succession. It weathers creamy white in contrast to the darker weathering formations above and below. The formation consists of about 80 feet of fine-grained, laminated dolomitic limestone in the East Tintic Mountains. It is reported to range between 30 and 60 feet in thickness by all who have mapped in the Southern Wasatch-Long Ridge-West Mountain area except White (1953) who reports that the Dagmar varies from 40 to 236 feet in thickness in six sections he measured on West Mountain north of the Kiegley Quarries. In the Wasatch Mountains near Provo the light weathering dolomite above the Teutonic (or "Maxfield") Limestone is more than 100 feet thick and comprises the youngest Cambrian beds preserved there beneath the Late Devonian unsonformity.

No fossils have ever been reported from the Dagmar Dolomite.

### Herkimer Limestone

The Herkimer is similar in appearance to the Teutonic from which it is separated by the distinctive Dagmar Dolomite. The Herkimer consists mostly of mottled argillaceous limestone, but in the upper half it contains thin shale beds up to 20 feet thick, some thin flat pebble intraformational conglomerate beds, as well as occasional dark oolitic layers. It is 350-430 feet thick in the East Tintic Mining District, 290-315 feet thick on the Long Ridge, 340 feet thick on West Mountain, 230 feet thick at North Canyon in the Southern Wasatch, 400-440 feet thick on Dry Mountain, and is not completely represented in the Wasatch Range north of Dry Mountain because of pre-Late Devonian erosion.

Few fossils have been reported from Herkimer beds. Muessig (1951, p. 26) reports undiagnostic *Linguella* from Long Ridge. Metter (1955, p. 54) reports abundant unidentified trilobite cranidia from Herkimer float in Santaquin Canyon, and Morris & Lovering (1961, p. 34) report unidentified trilobite fragments from the shale bed in the Herkimer. Despite the paucity of positively identified material from the Herkimer it is surely of Medial Cambrian age as determined by collections from adjacent Cambrian formations.

### Bluebird Dolomite

Bluebird Dolomite is a dark medium-grained dolomite characterized by white "twiggy bodies," short white dolomite rods a centimeter or so long and 1 to 2 mm. in diameter. The rods are straight, curved, or branched and although no organic structures are preserved they seem to be of organic origin. Once seen, the "twiggy bodies" are an easy key to identification of the Bluebird and are abundant in most Bluebird exposures in the East Tintic District and on Long Ridge. In the Southern Wasatch Range "twiggy bodies" are present but less abundant in the dolomite.

The Bluebird is about 200 feet thick in the East Tintic District, 200-300 feet thick on West Mountain, 100-170 feet thick on Long Ridge, 150-190 on Dry Mountain, and 100 feet thick in Payson Canyon. Smith (1956, p. 13) reports only 82 feet from North Canyon near Mona but he also reports an unusually thick section of overlying Cole Canyon Dolomite and it is probable that facies change caused him to select the Bluebird-Cole Canyon boundary lower than other workers.

The only fossils ever reported from the Bluebird Dolomite came from within 10 feet of the top of the formation on Eureka Ridge in the East Tintic District (Morris & Lovering, 1961, p. 38) and were identified by A. R. Palmer as *Brachyaspidon* ? sp. and *"Ehmania"* sp., trilobites of Medial Cambrian age.

### Cole Canyon Dolomite

This formation is characterized by alternating beds of light gray laminated dolomite resembling the Dagmar and massive dusky blue-gray, commonly "twiggy" dolomite resembling the Bluebird. The base of the Cole Canyon is placed at the base of the lowest white laminated dolomite and the top is placed at the base of the thin-bedded limestones and dolomite of the Opex.

Cole Canyon Dolomite is about 850 feet thick in the East Tintic District, 287-487 feet thick as measured on Long Ridge and West Mountain, about 460 feet thick on Dry Mountain, 230 feet thick in Payson Canyon, and 600 feet thick in North Canyon near Mona, although this latter thickness may be excessive because of inclusion of Bluebird equivalents by Smith (1956).

A. R. Palmer collected *Eldoradia* cf. *E. prospectensis* (Walcott) from the upper part of the Cole Canyon Dolomite in the East Tintic District (Morris & Lovering, 1961, p. 43). The same fossil was reported by Lautenschlager (1952, p. 28) from the Cole Canyon beds in the Pavant Range. *Eldoradia* is characteristic of rocks of late-Medial Cambrian age, thus the Middle-Upper Cambrian boundary is probably near the Opex-Cole Canyon contact.

### Opex Formation

Typical Opex in the East Tintic District consists of alternating thin and thick beds of dolomites and shale. Beds called Opex in the Southern Wasatch Mountains differ somewhat from the type area in that they are almost entirely crystalline dolomite, mostly dark bluish-gray, weathering to lighter gray and containing some brownish mottled and streaked beds, some cherty beds and a few oolite beds.

The Opex is 150-250 feet thick in the East Tintic District, and 180 to 300 feet thick on Long Ridge. Elison (1952, p. 33) reports 472 feet on West Mountain, Smith (1956, p. 14) reports 472 feet on West Mountain, Metter (1955, p. 59) says that the Opex ranges from 100 to 330 feet thick on Dry Mountain thinning northward by pre-Late Devonian erosion. Opex is not present in the Wasatch Range north of Payson.

The only fossils yet reported from Opex beds come from the East Tintic area where Morris & Lovering (1961, p. 46) state that a rather extensive trilobite fauna collected by A. R. Palmer from the upper part of the Opex represents the *Elvinia* zone of medial-Late Cambrian age.

### Ajax Dolomite

Three members are recognized in this formation in the East Tintic District: a dark mottled and cherty lower dolomite member 180 feet thick, the massive light colored Emerald Member, about 30 feet thick, and an upper dolomite and limestone member 350-450 feet thick. The same three-fold division is recognized on Long Ridge where the formation is 310-523 feet thick, as reported by H. N. Peterson (1953), Clark (1953), Peacock (1953) and D. O. Peterson (1953). In the easternmost exposures in Long Ridge Madsen (1952) reports only 86 feet of Ajax. The Ajax is absent on West Mountain. Beds 350 feet thick assigned by Smith (1956) to the Ajax in North Canyon of the Southern Wasatch Mountains might be better classed as partly Opex and partly Devonian Victoria formations.

The only fossils reported from the Ajax come from the East Tintic Mountains where Morris and Lovering (1961, p. 50) report *Eoorthis* sp. brachiopods from the lower member of the Ajax and *Eurekia* sp. trilobites from near the top of the upper member. These fossils indicate the Ajax is Late Cambrian.

## ORDOVICIAN

### Opohonga Limestone

The Opohonga is readily distinguished from the Cambrian units by the lack of dolomite. It consists of a series of thin bedded light bluish-gray shaly limestone with abundant intraformational conglomerate and it weathers yellowish or purplish gray. In the East Tintic District it ranges from 300 to 1000 feet in thickness chiefly because of post depositional Mid-Ordovician erosion. (Hintze, 1954, 1959).

Opohonga beds are recognized on Long Ridge only at Current Creek where H. N. Peterson (1953, p. 14) reports 91 feet of Opohonga. North and east from Current Creek the beds are absent probably because of pre-Late Devonian and/or medial-Ordovician erosion.

## SILURIAN

### Bluebell Dolomite

Morris & Lovering (1962, p. 63) have redefined the Bluebell Dolomite and the reader is referred to their discussion for details. The only place in the area of this present paper where Bluebell rocks have been reported is on Long Ridge where Muessig (1951) estimated 1000 feet of Bluebell and where H. N. Petersen (1953, p. 17-18 assigned 234 feet of dolomite to the Bluebell. No fossils have been found in the dolomites assigned to the Bluebell on Long Ridge and the writer thinks that the sandy dolomite beds called "Bluebell" by Peterson and Muessig are better assigned to the Devonian Victoria Formation for paleogeographic reasons. They are so shown on the accompanying map.

## SUMMARY

Cambrian lithologic units of the East Tintic Mountains can be recognized throughout most of the Long Ridge-Southern Wasatch area although the units generally thin eastward by convergence during original deposition. Truncation of upper units by pre-Late Devonian erosion has removed all of the Silurian, Ordovician, and Upper Cambrian from the Wasatch Range near Provo, but part of the Upper Cambrian is preserved further south in the Wasatch Mountains. Strata up to and including part of the Ordovician Opohonga Limestone are preserved beneath the unconformity on Long Ridge and an even more complete section including fossiliferous Silurian and Devonian strata is present beneath the unconformity in the East Tintic Mountains. Devonian Victoria Formation and equivalent sand sometimes included for mapping purposes in the lower part of the Fitchville Formation overlie the older Paleozoic beds with regional unconformity.

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