Geology

GEOLOGY OF THE BIG CREEK AREA

TOIYABE RANGE

LANDER COUNTY, NEVADA

BY

HARRY JOHN HANSEN, III

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ABSTRACT

The Big Creek group is part of an allochthonous sequence of interbedded cherts and argillites. The thrust plate, except for two localities where the thrust appears, has been normal faulted into juxtaposition with the autochthon.

Complex intraformational structure inhibits a precise measurement of the Big Creek section; however, it is in excess of 5000 feet.

The Big Creek group is differentiated on the basis of color and resistence to erosion (i.e. percentage of argillitic interbeds in the unit) into four formations.

The Big Creek group which apparently lacks volcanics and coarse terrigenous material is inferred to have been deposited in a deeply subsiding, volcanically quiescent environment far from any source lands.

The silica of the Big Creek Group is believed to have been organically concentrated as Radiolarian ooze which epigenetically underwent alteration and redistribution during the compaction and lithification processes to produce chert.

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INTRODUCTION

Location:

The area mapped is in the Toiyabe Range, 14 miles south of Austin, the county seat of Lander County, in central Nevada. It lies between latitudes 39° 20' 50" North and 39° 23' 40" north, and longitudes 117° 11' west and 117° 07' west, a rectangle having an area of about 8.5 square miles. Big Creek is essentially the southern boundary of the area and the Dry Canyon road, the northern, although a small area immediately north of Dry Canyon road, is included. The main crest of the Toiyabe range marks the eastern limit and the west is delimited by pediment deposits contiguous with the Reese River Valley.

The area can be reached by turning left off U. S. route 50, 1.8 miles west of Austin, on to the Big Creek Road, a light-duty, dirt road. At about 7.2 miles on the Big Creek Road is the Dry Canyon road, an unimproved dirt road, that is traversable only with jeep or similar type vehicle. The Dry Canyon road provides access to the norther part of the area mapped. Continuing past the Dry Canyon road on the Big Creek Road for 5.1 miles, one enters the Toiyabe National Forest. The Big Creek road is passable by auto as far as the North Fork Canyon jeep trail which provides access to the southern part of the mapped area. (fig. 1)

Austin (pop. 452) is the center of the old Reese River silver mining district. Today the town merely is a stop-over for highway travelers, and a supply center for ranches and small mines. The nearest large, modern town is Fallon (pop. 3200), 105 miles to the west by U. S. route 50.

Drainage, Topography, Climate and Culture:

Big Creek is one of the two perennial streams in the area. It has its source in springs on the west flank of Toiyabe Peak at an elevation of about 7800 feet. The stream flows north westward into the Reese River Valley, where it is lost. The other perennial stream is Birch Creek heading in the northeast portion of the area mapped; it flows eastward, eventually reaching and drying up in the Smokey Valley.

Each of the gulches which traverse the west slope of the Toiyabe Range in the mapped area bearsan intermittent stream. North of Big Creek these gulches, locally called Canyons, are First, Porter, Tank, and Dry Canyons from south to north. Jeep trails allow vehicle access to the lower reaches of all the gulches except Porter; however, the entire area is accessible by foot.

Toiyabe Peak, the highest summit in the area, rises to an elevation of 10,793 feet. The mouth of Dry Canyon, elevation 6,555 feet, is the lowest point. Hence the maximum relief is more than 4200. The gulches are moderately steep sided; cliffs are lacking except for minor development in several localities. This topography which is underlain by cherts and argillites is in marked contrast to Toiyabe peak which on its west face exhibits precipitous cliffs carved into limestone.

The climate is semiarid with precipitation amounting to 12 to 15 inches annually, most of which is winter snow. The intermittent streams of the area are unable to maintain continuous flow at the surface during the summer. Big Creek is spring feed and is perennial. Summer storms in the Toiyabes are predominantly of the short, local thunder shower type. In midsummer the days are indeed hot; however, except for short periods, the nights are comparatively cool. Frost and snow flurries have been reported as early as September and as late as June; in the fall and winter the wind frequently attains considerable force (Ross, 1953).

The nearest inhabitance, the Kingston Ranger Station, is located seven miles to the south. Many campers and hunters frequent the Big Creek campsite which is maintained by the Forest Service.

Purpose and Scope of Work:

Six weeks were spent in the field in an attempt to differentiate and map a sequence of interbedded cherts and argillites. It was hoped that fossil evidence would facilitate dating; after extensive, but certainly not final investigation, no mega fossils were found. Radiolarians that appear in the cherts, because of their fragmental nature, make dating tenuous at best. It is hoped that the work will serve as a basis for more extensive investigation in the future.

Acknowledgements:

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Previous Work:

Until recently very little geologic work had been done on the sedimentary rocks of the southern Toiyabe Range. The Old Reese River Mining District immediately north of the mapped area is well described. The interested reader is referred to Ross (1953) for a comprehensive bibliography. David MacLachlan is in the process of completing a Ph. D. thesis (Columbia University, 1960) on the structure of the Kingston Canyon area. J. D. Lowell has completed a sketch map of the area between Dry and Indian Canyons.

Regional Aspects:

The mapped area is within the central part of the Basin and Range Provence. Although it is of small dimension it is typical of Nevada geology along the so-called Roberts zone of overthrusting. Most of the Toiyabe Range is included within this zone which has a breath of about 45 miles. There is no doubt that major thrusting has occurred in this zone. The distinction of facies between the over-riding (allochthonous) eugeosynclinal sequence and the overridden (autochthonous) miogeosynclinal section is quite striking. The thrust plate includes the typical lithologies of the eugeosynclinal trough; these are chiefly cherts, argillites, and volcanics. The autochthanous rocks are generally quartzites and limestones. The dating, of the Robert's thrust is uncertain. For example, in the Mount Lewis Nevada quadrangle allochthanous rocks as young as Triassic rest on parts of the thrust plate. However, the question of whether the late Paleozoic and Mesozoic rocks have actually participated in the entire movement of the allochton or have been thrust out on an older fault plate has not yet been resolved (Gilluly, 1954).

Within the mapped area the thrust is exposed in several localities. Elsewhere in the area the thrust sheet has been normal faulted into contact with the autochthon. The normal faulting is probably associated with the regional forces that caused block faulting of Tertiary age throughout the Basin and Range Province. The present form of the Toiyabe Range is chiefly the result of block faulting and tilting to the west; the crest of the range exceeds 10,000 feet and forms a steep scarp facing Smokey Valley which is the eastern boudary of the range.

GEOLOGIC MAP:

The base map upon which the geology of the Big Creek area was plotted is an enlargement, (1" = 1300') of the U.S.G.S. fifteen minute series topographic map of the Austin, Nevada quadrangle. Ross Cann previously set up a triangulation net in the area on the enlarged topographic base map. The author reestablished these stations and plane tabled several of the fault contacts directly on to the base map. Otherwise mapping was done on air photos (20,000:1) and later transferred to the base map; orientation was achieved by Brunton ressection.

No attempt is made to correlate the Allochthonous rocks mapped in the area with named formations; a new group name (Big Creek) is used to denote this sequence. Mention will be made presently, however, of lithic, if not chronologic, similarities to previously described and named chert-argillite sequences. The autochthonous units are correlated with named formations and so bear established names.

Distinguishable units are separated into three divisions, that is groups, formations, and members. In the Allochthon these three terms are used solely to facilitate discussion; they are not to be strictly defined in the conventionally accepted sense and apply only to the immediate area under consideration.

Whereever possible unit boundaries are drawn on the top or bottom of distinctive lithic types which can be traced across the area. In many instances, particularly within the allochthon, this proved impractical because of poor exposure and talus cover. These circumstances coupled with apparent lensing and enigmatic intraformational structure made "walking out" contacts very tenuous. Because of these factors, members, except when clearly distinguishable, have not been mapped. Formational contacts within the allochthon can be followed with more confidence; separation is based primarily on color and resistance to erosion. Since resistence to erosion is directly related to the percentage of argillitic interbeds, this factor, at least qualitatively, has also been employed as criteria for differentiation.

Within the Big Creek allochthon no known unconformities or diastemic intervals have been found; in other words sedimentation was continuous. Hence, the reader should be warned that the formational contacts are gradational; when the upper or lower contact of a member within the zone of gradation could be traced, it was made the formational contact. Since this was not possible in the majority of cases the reader should not be enamored with their exactness. By necessity the formational contacts represent gradations in sedimentations and so, if considered in the realm of stratigraphic orthodoxy, are, to a degree, arbitrary. None the less the contacts are quite definitive if considered in the proper perspective; their sedimentational significance will be discussed subsequently.

STRUCTURE

General:

The structure of the Big Creek area is complicated by the fact that the underlying regional structures, as reflected locally, are not the same in both the autochthon and allochthon. The geologic map indicates clearly the gross structural differences between the two lithically distinct sequences which are in faulted contact. The thrust itself appears in the north central part of the area; a limestone fenster is found approximately 2500 feet southwest of the southern limit of the thrust. In the remaining areas of contact the thrust plate has apparently been normal faulted down into juxtaposition with the autochthon.

Folding in Allochthon:

Although the thrust plate bears a relatively simple regional structure, the intraformational structure is complex; its details have not been mapped. In general the allochthon consists of a homoclinal sequence of cherts and argillites; the tilted formations strike approximately N25°W and dip between 40° and 60° to the southwest.

The cherts being more resistent than the argillites show in several exposures small scale folding. These closed, assymmetrical or isoclinal folds are typically no more than 18 inches from crest to trough. Aside from the expected variance, their fold axes tend to parallel the strike of the formations. There are two localities which best show these folds. One is in formation B of the Big Creek Group about one quarter way up the ridge which separates Tank and Dry Canyons; at this exposure the axial planes vary in attitude from N60°W to N20°W. The plunge of their fold axes is variable.

The second locality worth noting also appears in formation B and is located on the North Fork--First Canyon ridge about 1,500 feet from its summit. At this exposure the weathering of thin (one half inch maximum) argillitic interlaminae has given the folded chert beds relief, accentuating their development. The fold axes trend N30°W, more or less paralleling the regional strike, and appear to have a persistent, southward plunge.

Large scale folding does not occur in the Big Creek Homocline; that is, formations do not repeat. However, folding of an order of magnitude larger than that just described is present. These folds can not be seen in outcrop but are inferred to exist because of reversal of dip; detailed, small scale mapping is necessary to bring out the structural relationships of these intraformational folds.

Within Formation B a prominent, though thin (40 feet), member of interlaminated chert and black shale occurs. The black shale laminae are structurally significant because they bear minute assymmetrical folds. The chert layers (maximum 6 inches) do not show folding of this magnitude. It is apparent that the folds within the black shales are drag folds formed as the competent chert layers slipped past incompetent shaly laminae.

Within the Big Creek Homocline several orders of folding appear, ranging from near microscopic drag folds to folds of intraformational size. These folds are genetically similar and differ only in magnitude. The Big Creek Homocline is apparently the limb of a large fold; the smaller folds of intraformational size reflect relative movement between units within the "homocline". Since it is possibly to recognize the three magnitudes of drag folds described above the term homocline is used in this paper merely to denote to the regionally uniform dip of the Big Creek Group.

Many of the folds and cremulations within the Big Creek group are genetically unrelated to the hierarchical drag effect of folding. Probably the thrust itself has contributed to the formation of many of the folds. Some of the drag features appear to be associated with bedding plane faults of small displacement which are quite numerous. Furthermore, much of the deformation may be penecontemporaneous; however, the parallel attitude of axial planes of many of the folds probably bears greater structural significance. To determine the relative importance of these several possible origins is beyond the scope of this paper.

It should be pointed out that structural interpretation is made tenuous within the Big Creek Group because of the absence of reliable criteria to distinguish tops from bottoms. Stratigraphic evidence of repetition is hindered by the absence of fossils, talus cover, and lithic similarity of the cherts.

Faulting in the Allochthon:

Within the thrust plate, faults are generally recognized by brecciated zones rather than stratigraphic offset. Most of these faults are areally limited and appear to be the result of shearing along bedding planes. However, the majority of local breccias in the Big Creek Group is genetically unrelated to faulting. Many of these breccias are riebungsbreccias (fold breccias) which are "the result of sharp folding of thin-bedded, brittle layers between which are incompetent plastic beds" (Pettijohn, p. 281, 1957). Interbedded cherts and argillites subjected to tight, isoclinal folding are very likely to form a riebungsbreccia. These fold breccias are local and pass into unbroken beds. A third type of cataclastic breccia is also represented in the cherts. Deformation of brittle, closely jointed rocks produces brecciation; in several localities the breccia zones grade into closely jointed, but unbrecciated cherts. The more prominent joints in the area trend between N25°E to N50°W and dip nearly vertically.

Three faults of significant extent within the allochthon have been mapped; two are associated with major boundary faults and will be discussed in the next section. The third fault appears on the divide between Birch Creek and First Canyon. It is inferred to be a rotational normal (i.e. Scissor) fault. Inference is necessary because the actually fault plane is not exposed. The fault is defined by stratigraphic offset of the lithically distinctive argillite member of Formation A. This member is easily mapped because of its consqicuous absence of bedded chert. The fault is not of the simple translation type. This conclusion is based on one undeniable factor. The argillite member is overlain by the typical bedded cherts of Formation A; which bear only shaly stringers and thin shaly laminae. This unit is particularly resistent to erosion and is one of the few that can be traced across the area. It is not offset by the fault, that is, the contact between the argillite member and the chert trends uninterrupted across the area where the fault would be expected to appear. With the evidence at hand rotational movement seems essential; however, the strike slip component may have dominated. The fault can be traced eastward for a short distance into the cherts, chiefly as a zone of brecciation. However, the limit of the fault is unknown and has not been mapped.

Folding in Autochthon:

The author has not treated in any detail the minor structures within the autochthon. Only the folding will be discussed at length. An understanding of general fold trends is critical because it aids in interpreting displacement on the North Fork boundary fault.

The Autochthon in the Big Creek area outcrops in two localities, the Dry Canyon area and the Toiyabe Peak area. In the former the Antelope Valley Limestone (Ordovician) and Masket Shale (Silurian) outcrop; in the latter the Masket and Antelope Valley are exposed as well as the older Toiyabe Peak formation (Ordovician). The Dry Canyon Autochthon is delimited by both thrust and normal faults. The Toiyabe Peak autochthon is bounded by normal faults.

Folding in the autochthon within the Dry Canyon area appears to be enechelon. The folds are not of great extent and seem to overlap to some degree. On the ridge slope southwest of the eastern most loop in the Dry Canyon road a resistent, nonfissile member of the Masket outcrops. Upon weathering it has a characteristic banding of silty and relatively pure carbonate layers; it can be followed with confidence in the field. The map plan of the member is characteristic of a plunging fold; on the Dry Dry Canyon--Birch Creek ridge the fold limb dips approximately 40 to 50 degrees to the northeast. From here to the Dry Canyon road the member appears only as surface debris. However, just east of Dry Canyon road at the base of the slope a northwest strike is recorded; the dip ranges 55° to 60° to the southwest. The southwest limb of the anticline can be traced southward to near the top of the Dry Canyon-Tank Canyon ridge. The northeast limb of this inferred anticlinal structure is bevelled by the thrust; the southwest limb is cut off by a high angle normal fault.

On the northwest side of the Dry Canyon road the Masket Shale and Antelope Valley Limestone outcrop. Their map plan is suggestive of folding; in typical zig-zag pattern, the Masket appears to be synclinally folded into the underlying Antelope Valley. The southwest limb of this structure dips steeply (65° to 85°) to the southwest; it is considered to be overturned by the author. No primary structures were found to substantiate this hpothesis, however, structural continuity necessitates such a postulation. An anticline overturned to the northeast shares the inverted limb. These folds plunge to the southwest; their inferred axis strike about N45°W which is more or less parallel to the anticlinal axis southwest of the Big Creek road. The folding is en echelon with the offset anticlines slightly overlapping as they plunge toward each other. The silty, nonfissile member of the masket which serves as a structural datum for the southeast anticline, is believed to be near the top of the Masket. This stratigraphic position accounts for its being missing northwest of the Dry Canyon road; the Masket exposed here is stratigraphically older.

The structure of the Toiyabe Peak autochthon consists of a large overturned syncline. The Masket Shale is exposed in the core of the syncline, the Antelope Valley Limestone and Toiyabe Peak formation appearing outward from the axis. The south limb of the syncline is steeply (75° to 85°) overturned. The north limb dips moderately (40°) to the south. The inferred fold axis strikes essentially east-west. The syncline is cut off on the west and south by high angle normal faults. To the northeast, outside of the area under discussion, the Birch Creek Granodiorite is in contact with the Toiyabe Peak formation. Within the contact zone the argillaceous Toiyabe Peak has been raised to a micaceous schist.

Assuming one generation of folding, there seems to be a deviation in orientation of fold axes between the Toiyabe Peak and Dry Canyon autochthons. The former trends N45°W, the latter N85°E. If the axes were originally parallel, scissor faulting on one or more of the normal faults which dropped the allochthon into juxtaposition with the autochthon may well be the explanation.

Autochthon - Allochthon Boundary Faults:

Within the Big Creek area the autochthonous and allochthonous sequences are in both thrust and normal fault contact. The thrust appears in two localities. The main exposure is alone the Dry Canyon-

Birch Creek ridge. The thrust trends approximately north-south, following the topographic contours. It has been offset by an inferred strike--slip fault in the vicinity of the antimony mine; displacement is estimated to be 1800 feet. The strike-slip fault extends into the chert-argillites to the east; it can be followed about 2000 feet, chiefly through brecciation. Exposure is poor in the vicinity of the thrust; since it cannot be examined in outcrop, the thrust is necessarily an inferred one. The exposures immediately northwest of the mine bear slickensides. However, the outcrop is highly jointed and since many of the joint blocks have obviously been rotated, the author made no attempt to record detailed attitudes.

About 750 yards east of the inferred thrust a window in the thrust sheet is observed. At this locality the Antelope Valley Limestone is surrounded by chert, although its southern contact is covered by alluvium. There is very little doubt that the fenster is Antelope Valley. Lithologically, the Antelope Valley of Toiyabe Peak and the fenster are similar and both contain a characteristic macluritid gastropod. The occurence of Antelope Valley in the window tends to substantiate the author's interpretation of structure in the Dry Canyon Autochthon. The limy nonfissile member of the Masket used as a structural datum indicates an anticlinal structure southeast of Dry Canyon road. Since the anticline is plunging to the northwest, the underlying Antelope Valley would be expected to appear south eastward. This interpretation is borne out by the fenster.

There appears to be two generations of normal faults. The earlier faults trend approximately N75°W. and are well represented in the area. The Dry Canyon-Tank Canyon ridge fault belongs to this group. It forms the contact between the autochthon and the down dropped thrust plate. On the northern slope of Tank Canyon, as well as on the floor of the canyon cobbles and boulders of brecciated debris are found. Angular particles of both chert and Masket Shale cemented by a limy matrix constitute the breccia. The fault zone can be traced into the chert by means of a series of isolated, brecciated outcrops; approximation of its position has been tenuously mapped.

A second fault of this generation has down dropped the thrust plate into contact with the Toiyabe Peak formation on the southwest flank of Toiyabe Peak. A zone of springs 2500 feet south of this fault marks the location of a minor fault of similar orientation. Breccia zones, and in some places mylonite, enable the fault zone to be mapped. A third inferred fault which trends parallel to Big Creek appears to be genetically related to the faults just described; this conclusion is only based on orientation (i.e., parallelism) and so may not be significant.

The second generation of faults of which the North Fork Canyon fault is the only one major representative parallels the great range boundary fault and is so interpreted to be genetically related. These faults which trend approximately N30°E are considered younger than the other generation of normal faults because they characteristically cut them off.

As explained above, the axis of the Toiyabe Peak syncline trends N85°E while the axes of the en echelon folds of the Dry Canyon Autochthon trend N45°W. If the folds are related their axes should be subparallel in orientation. To account for this discrepancy the author proposes that the North Fork normal fault (or the Dry Canyon-Tank Canyon Ridge normal fault) is a scissor fault. Amount of displacement can not be determined, but the rotational component shifted the east-west trending axes of the hanging wall approximately 55° northward. In light of this the strike readings in the Big Creek Allochthon north of the North Fork fault must be reoriented to determine their prefault attitudes if rotation occurred along that fault. To account for this rotation, displacement along the fault had to increase southward. In support of this hypothesis there is an apparent increase in height of the triangular facets of the North Fork fault scarp in that direction; this is best seen in air photos.

It is interesting to note that if the thrust exposed on Dry Canyon-Birch Creek ridge is rotated 55 degrees to the west it is subparallel to the fault that throws the thrust plate into juxtaposition with the autochthon on the southwest slope of Toiyabe Peak. This at least hints that the "thrust" in actuality is a normal fault; this is just conjecture, but a rotational fault as just described would result in a flattening of the fault plane. The ramifications of this problem are complex: If the North Fork fault is rotational then the Dry Canyon-Tank Canyon ridge fault and the Big Creek fault must be rotated 55° to the west assuming these faults pre-North Fork faulting. If this is true then no clear parallelism exists among the "first generation" faults. To resolve this problem the rotation may have taken place on the Dry Canyon-Tank Canyon ridge fault. This would explain the orientation of fold axes without disrupting the suspected fault pattern.

The structure of the Big Creek area is at best conjectural without exacting structural analysis. The author offers the above discussion to illustrate the structural complexity of the area. The conclusions that have been reached are open to debate.

STRATIGRAPHY

AUTOCHTHON

The stratigraphy of the autochthonous sequence was not studied extensively; only a brief statement of the general section will be presented. The autochthon outcrops in two localities within the Big Creek area (i.e. Dry Canyon, Toiyabe Peak).

Toiyabe Peak Formation (Ordovician):

The Toiyabe Peak Formation of the Big Creek area is correlated with the Stoneberger Formation of the Toquima Range (Kay, oral communication). It is a formation composed dominantly of fine grained clastic sedimentary rocks. These rocks are essentially interbedded medium gray, argillaceous calcisiltites and gray, thin bedded argillites. The argillites predominate; they have been metamorphosed slightly to a slaty appearance and in places, chlorite-bearing phyllites appear. Within the slaty and phyllitic layers limonite pseudomorphs of pyrite are commonly found.

The Toiyabe Peak Formation appears on the flanks of an overturned synclinal structure on the northeast and southwest slopes of Toiyabe Peak. The formation is relatively nonresistent and is poorly exposed; it is generally confined to surface float and scattered outcrops of more resistent beds.

The total thickness of the Toiyabe Peak Formation can not be given because a complete section is not available in the Big Creek area. On the southwest flank of Toiyabe Peak, the Toiyabe Peak formation has been thrown into contact with allochthonous chert by an inferred high angle normal fault. The thickness measured from this fault, to the contact with the overlying Antelope Valley Limestone is about 2410 feet;

the total thickness of the Toiyabe Peak formation is indeterminately greater than this. Northeast of the Big Creek area the Toiyabe Peak formation is intruded by the Birch Creek granodiorite. The contact is clearly intrusive because the Toiyabe Peak has been raised to a micaceous schist in the area of the contact zone. In the immediate vicinity of the contact the Birch Creek granodiorite is fine grained, probably indicative of a relatively thin chill zone.

In the Indian Canyon area 2.5 miles north of Dry Canyon a thick section of slates and phyllites outcrops. Lowell (unpublished sketch map) makes no attempt to correlate them stratigraphically. The author believes these lithically similar rocks are stratigraphically equivalent to the Toiyabe Peak formation (i.e., Stoneberger).

Antelope Valley Limestone (Ordovician):

The Limestone overlying the Toiyabe Peak Formation in the Big Creek area is correlated with the stratigraphically and lithically similar Antelope Valley Limestone of the Toquima Range (Kay, oral communication). It has a maximum thickness, as indicated on the south slope of Toiyabe Peak of about 1690 feet.

The Antelope Valley is an impure, dark gray limestone that appears light gray on the weathered surface. It is medium to massively bedded. Some shales and argillaceous limestones are interbedded particularly in the lower part of the section. Dolomitic pods and lenses occur throughout it while calcite veining is ubiquitous.

Insoluble residues were taken from several specimens of the Antelope Valley. From 15 to 20% by weight constitutes the insoluble fraction of the rock. The residue consists chiefly of detrital quartz grains of silt size, quartz euhedra, and unidentified lutaceous material. The detrital quartz totals about 75% of the residue; these grains are well sorted and have a roundness of 0.8 on Krumbein's visual chart for estimating roundness. Even though well rounded the surfaces of these grains show definite pitting or frosting which probably resulted from intrastratal solution. The carbonate matrix appears to have etched or corroded the embedded quartz grains. The silica thus put into solution was not completely leached away. Rare quartz euhedra of near perfect crystal form which are clearly of authigenic origin seem to bear this out. In hand specimen the Antelope Valley Limestone has a characteristic "sandy touch" on the weathered surface.

The Antelope Valley has been moderately metamorphosed as has the underlying Toiyabe Peak Formation. Because of this its fauna is all but obliterated. Suspected brachiopod remains consisting of fragments and faint calcitic outlines are widespread, but unidentifiable. A thick shelled Macluritid gastropod (Maclurites sp. or Palliseria sp.) preserved as a coiled calcitic trace can be identified to super-family with some confidence.

The Antelope Valley Limestone outcrops in three vicinities within the Big Creek area. It outcrops near the core of the Toiyabe Peak syncline and in the folded structure of the Dry Canyon area; its third exposure is near the head of Birch Creek Canyon where the thrust sheet has been breached and the Antelope Valley Limestone appears as a fenster.

The Antelope Valley Limestone is very resistent to weathering in the semiarid climate of the region and is therefore the chief cliff former in the Big Creek area. The summit of Toiyabe Peak is supported by the Antelope Valley; its north western face, near the summit, consists of several small (maximum 60 feet), but precipitous cliffs. Cliffs supported by Antelope Valley also appear in the gulches north of Dry Canyon.

Masket Shale (Silurian):

The platy, silty limestones overlying the Antelope Valley Limestone in the Big Creek area are correlated with the stratigraphically and lithically similar Masket Shale of the Toquima Range (Kay, oral communication).

The typical Masket is dark gray on the fresh surface; it weathers a light grayish to reddish brown. It is thinly bedded and fissile. Interbedded with these silty limestones are more massively bedded (6" to 1') crystalline limestones which are relatively nonsilty and have a maximum thickness of 12 feet; they constitute less than 30% of the lower part of the section.

The Masket outcropping in the core of the Toiyabe Peak syncline represents the basal part of the section; it is composed chiefly of fissile, brown-weathering silty limestones. However, several beds (2 to 3 feet) of quartzose sandstone occur; an iron oxide cement gives them a brownish red color. These beds are not found on the north ridge of Dry Canyon; the author, believing that on the basis of structural considerations this location is also representative of the basal Masket, concludes that the red arenaceous beds are not areally important.

The Masket on Toiyabe Peak like the underlying Antelope Valley contains several prominant quartz veins that are as much as 15 feet thick. The emplacement of these veins is structurally controlled, paralleling the bedding cleavage in most instances. The source for this silica invasion is probably the Birch Creek Granodiorite which outcrops less than 3/4 of a mile to the northeast.

The upper part of the Masket is represented by the rocks at the head of Dry Canyon. They are typically fissile, brown-weathering silty-limestones. However, a lithically distinct member, which has been mapped for structural clarification, is present; it is not fissile although consisting of thinly interbedded, layers of lutaceous and non-lutaceous limestone. This banding is very evident on the weathered surface where medium dark gray limestone is interbedded with yellowish-brown clay which occurs as a raised "crust". In thin section the lutaceous material because of its fine grain and disseminated state is not conspicuous. This member is relatively resistent and outcrops in several localities, a notably on the Birch Creek Canyon-Dry Canyon Ridge and on the southeast slope of Dry Canyon near its head. Its thickness varies from 500 to 650 feet. The Masket as a whole is not resistant and usually occurs as talus debris.

Since the area lacks a complete, continuous section of the Masket, no estimation of full thickness is possible. It exceeds 1800 feet, however.

Alluvium (Quaternary):

The Big Creek area is borded on the west by dissected pediment deposits; bed rock begins to be visible at about the 6600 foot contour. Alluvium is found covering the floors of all the larger gulches. Most of it is talus debris which has crept down from the adjacent, moderately steep slopes. Flash flooding during short torrential rains has also added to the alluvial cover on the canyon floors.

Allochthon (Big Creek Group)

The interbedded cherts and argillites of the allochthon could not be dated by the author. In the cherts fragmental radiolarians can be near the top of Formation A. The argillisiltite is a medium-gray, brownish-gray weathering, thinly-bedded rock; chert veinlets are common. Near the top of this member interbeds of dark blue chert appear. The argillisiltite has a maximum thickness of 520 feet. It is easily weathered and does not outcrop except as platy protrusions no more than 8 inches above the ground surface. These exposures appear on the divide between Birch and First Canyons and on the north slope of Tank Canyon near its head. Except for these two localities the contacts were mapped on the basis of float. The argillisiltite is superficially similar to the Masket Shale in color and fissility; however, at their faulted contact near the crest of the Dry Canyon-Tank Canyon ridge they are easily differentiated because of the limy composition of the Masket. The argillisiltite has been offset by an east-west striking inferred, scissor fault on the Birch Canyon-First Canyon divide.

Above and below the argillisiltite member the typical dark blue chert of Formation A which contains only thin interbeds of greenish gray argillite appears. Formation A is, aside from the argillisiltite member, the most resistent formation of the Big Creek group. It can be followed with confidence across the area, both in the field and on air photos. It is a persistent cliff-former.

The Upper contact of Formation A is placed at the top of a resistent dark blue chert member. Higher in the sequence the percentage of argillites increases appreciably. These rocks have been grouped together as Formation B. The lower contact of Formation A grades into undifferentiated cherts and argillites. Formation A is the oldest formation in the author's Big Creek group; however, it is not the oldest rocks in the allochthon. A section of undifferentiated cherts and seen in thin section and on the surface of polished sections etched in hydrofluoric acid. Identification of these fragments is inhibited by their poor state of preservation. The argillites in the sequence are barren; their highly contorted nature suggests that anything once preserved was subsequently obliterated. Several thin beds of dense, siliceous limestone appearing in Formation C also proved unfossiliferous.

Without faunal evidence no attempt is made to correlate the allochthonous sequence with any of the described rocks of the western assemblage. Roberts describes the upper part of the Valmy Formation of Middle Ordovician age as "consisting of principally dark thin-bedded chert interbedded with dark shales and a little greenstones" (Roberts 1958, p. 2832). He is able to date the Valmy in the Battle Mountain section by means of graptolites. Fagan in the North Fork area of the Northern Independence Range describes rocks that are lithically quite similar (Fagan, unpublished Ph.D. thesis). However, on the strength of a meager productid-spiriferid brachiopod fauna he dates these rocks as carboniferous.

The absence of a graptolite fauna in the allochthonous sequence, which the author refers to as Big Creek Group for convenience, lends credence to a later Paleozoic age (i.e., post-Devonian); however, without any positive evidence at hand, no age assignment is made.

FORMATION A

Formation A is dark blue, medium-bedded, subvitreous chert, with thin interbeds of greenish-gray argillite. These thin argillites are subordinate, accounting for less than 15% of the section; however, a thick, slightly siliceous argillisiltite, mapped as a member, appears argillites lies between Formation A and the thrust plane.

The maximum apparent thickness of Formation A is on breadth of outcrop and average dip 2730 feet; however, because of intraformational folding and faulting it may be considerably less.

FORMATION B:

Formation B is composed of varied lithic types, light blue to black, medium-bedded subvitreous cherts; interbedded dark blue cherts and thin black shales; and graded siltites of subgraywacke composition.

The basal beds of Formation B are interbedded light blue to black cherts and medium-gray argillites which are less resistent than the overlying massive cherts of Formation A so the contact can be traced with some confidence. Overlying the basal beds is a member composed of siltites of subgraywacke composition. It outcrops 1300 yards northeast of the Big Creek - North Fork Road intersection near the base of the ridge and can be traced to within 40 yards of the top of the ridge. A lithically identical laminated subgraywacke outcrops on the north slope of Tank Canyon at about the same stratigraphic level. These two units are tentatively correlated. The former is 40 feet thick, the latter approximately 90 feet; both are nonresistent and appear as talus. To explain the absence of the graded subgraywacke across the area, it is suspected that the unit thins to an insignificant thickness and is obscured by minor structural complexities. For this reason it has not been mapped.

The banding of the subgraywacke is readily seen in hand specimen. The laminae are about .5 millimeters thick. In thin section it is observed that the silt sized quartz particles are found in both the light and dark laminae being more abundant in the former. The lutaceous material is, on the other hand, much more abundant in the dark layers, imparting to them its color. This rhythmic interlamination is the result of rapid pulsational sedimention that was probably initiated by a series of minor turbidity flows.

A thin (40 feet) member of interbedded dark blue chert and black organic shale outcrops 390 yards east of the 8470 foot nob on the north slope of First Canyon. It can be traced 1200 yards southward in outcrop and surface float on to the south slope of First Canyon. This lens-like member can be mapped over this interval with confidence because the thinly-bedded black shales enable it to be differentiated from the surrounding cherts. Laterally, these shales grade into the usual interbedded medium gray argillites. The light to dark blue chert within the member can not be distinguished from the cherts within the rest of the formation. In the member the fissile black shale never exceeds 3 inches in thickness, the more massively interbedded chert has a maximum thickness of 8 inches. The member is stratigraphically located approximately 400 feet from the top of Formation B. It is intensely contorted; presumably, organic remains once recognizable within the black shales have been obliterated.

Formation B has a maximum thickness of 2015 feet. However, as is true for the entire Big Creek Group, intraformational repetition due to small scale folding is suggested, so that actual thickness of Formation B probably is somewhat less.

FORMATION C:

Formation C consists of interbedded dark blue, to black chert and dark gray argillites; the argillaceous interbeds are thin and compose less than 30% of the section. The contact between Formation C and the underlying Formation B is drawn at the base of a resistent chert unit which outcrops on the north slope of Big Creek Canyon about 1520 yards east of the Forest Service Campsite. It can be traced with some discontinuities across the area.

Formation C, unlike Formation B in which argillites are abundant, is a resistent unit which forms ledges and small cliffs. There is a sharp topographic break between Formation C and the overlying Formation D which, like Formation B, is less resistent because of an abundance of argillitic interbeds. This contrast is particularly noticeable on the Big Creek - First Canyon ridge.

The cherts of Formation C and Formation D are superficially similar; they both weather to a reddish-brown. In thin section both cherts contain disseminated limonite specks. However, on the fresh surface the cherts of Formation C are drak blue to black while those of Formation D are greenish-gray. The formational contact has been mapped on this basis as well as by topographic discontinuity.

Formation C contains the only carbonate rocks found in the Big Creek group, dense, grayish siliceous limestones outcropping 910 yards northwest of the Big Creek - North Fork road intersection in a steep gully about 30 yards up the north slope of Big Creek Canyon. These limestones are medium bedded and contain stringers of siliceous shale. Two limestone beds (2 to 3 feet thick), separated by four feet of cherts and thin argillites, were traced half way up the ridge, until lost beneath talus cover. The only other occurrence of carbonates in the allochthon is a six foot bed of dark gray siliceous limestone found near the head of Birch Creek in a section of undifferentiated cherts and argillites; it could be traced only a short distance.

The thickness of Formation C is a maximum of 1250 feet.

FORMATION D:

Formation D is a succession of interbedded argillites and cherts. The argillites are thinly-bedded, rarely exceeding 4 inches. The cherts are more massively bedded but rarely exceed 3 feet. The cherts can be recognized from the underlying cherts of the section on the basis of color, a light greenish-gray which weathers to a reddish-brown. As indicated in thin section the color of the weathered surface is due to desseminated iron oxide. The interbedded argillite is typically medium-gray on the fresh surface. The formation is highly brecciated; the breccia is characteristically cemented with limonite.

Formation D is relatively nonresistent and is not well represented in exposure; it has been mapped mainly by surface float. However, on the northern side of Big Creek road at the entrance to the canyon the formation appears as a series of prominent outcrops; the rocks in this vicinity are more resistent than those exposed to the north because they are part of a well-cemented (ferruginous) breccia zone which traces the trend of an inferred high angle normal fault along the floor of Big Creek Canyon.

The total thickness of Formation D can not be accurately determined because the upper contact is concealed by the bordering pediment deposits. The lower contact is traceable, although no one member can be followed across the area. In the Big Creek area there is an apparent maximum of 4000 feet of Formation D; the true thickness is probably considerably less than this. As the Big Creek Homocline has a regional strike of N20°W, the lower contact of Formation D intersects the Pediment deposits of the northeast trending range front near the mouth of Porter Canyon. It is not found north of Porter Canyon where Formation D appears on the south ridge near its mouth almost exclusively as surface debris; there are exposures on both the north and south ridges of First Canyon.

Formation D appears at the top of the Big Creek Homocline; it is assumed to be the youngest formation of the Big Creek group.

UNDIFFERENTIATED CHERT AND ARGILLITES:

The Big Creek Group is in a block which is surrounded by inferred high angle normal faults. Allochthonous cherts and argillites not appearing within this fault block have been mapped as undifferentiated interbedded cherts and argillites; no attempt is made to correlate these rocks with units in the Big Creek Group. The allochthonous rocks outcropping in the northeast part of the area directly overlie the inferred thrust and are probably older than Formation A of the Big Creek Group.

DEPOSITIONAL SUMMARY OF THE BIG CREEK GROUP:

The interbedded cherts and argillites of the Big Creek Group were deposited in a deep, subsiding trough. These rocks of the western assemblage differ from the typical engeosynclinal assemblage in two important aspects. First, the Big Creek Group seem not to contain volcanic rocks. Second, the absence of coarse terrigeneous material suggests that the depositional environment was distant from tectonic welts or volcanic island source lands.

Big Creek sedimentation began with the deposition of Formation A. During most of this time the area of deposition was uneffected by near-by source lands. The formation is predominantly chert with quantitatively unimportant argillitic interlaminations. The water was free of coarse terrigenous materials and sedimentation progressed through the slow accumulation of silica; discussion of the origin of the silica will be presented subsequently.

About three quarters way through Formation A a major influx of coarser terrigenous materials occurred; silty argillaceous material amounting to 520 feet was deposited relatively rapidly in the area. After this episode the waters cleared and for the rest of Formation A silica accumulated with only minor shaly partings indicative of terrigenous sedimentation. An abundance of radiolarian tests too recystalized and in most cases fragmental for identification are found in the cherts of Formation A; one siliceous sponge spicule was noted in thin section.

Near the top of Formation A the abundance and thickness of the interbedded argillites increase as Formation A grades upward into Formation B. Formation B contains rhythmically interbedded cherts and and argillites indicative of pulsational invasions of fine terrigenous material probably from a distant source. Within Formation B a thin (40 feet maximum) subgraywacke member shows graded bedding; this occurrence is the only indication of very rapid turbidity flow deposition in the Big Creek Group. Thin sections of the cherts of Formation B reveal very fine bands of lutaceous material which were not observed in thin sections taken from the cherts of Formation A or Formation C. Quartz silt grains are abundant in the cherts of Formation B; radiolarians are not abundant, but fragments are present.

Formation B grades upward into Formation C; the water cleared of terrigenous material and as at the beginning of Big Creek sedimentation the argillitic interbeds become subordinant. In thin section radiolarians are abundant; their opaline tests, however, have recrystallized to chalcedonic quartz and, as usual, identification is impossible. Limonite specks and a few quartz silt grains appear; there is a marked absence of lutaceous banding in these cherts.

Near the top of Formation C the beginning of another terrigenous influx is evident as the percentage of argillitic interbeds increases. Formation C grades upward into Formation D which has an abundance of argillaceous material. The chert of this formation is impure containing quartz silt grains and lutaceous material; only a few suspected radiolarian fragments appear.

Assuming that structure does not complicate the section, the Big Creek Group is approximately 9500 feet thick. Without paleontological documentation it is impossible to determine the rate of sedimentation. However, the infrequency of coarse terrigenous material and the abundance of siliceous and argillaceous material suggest that a duration of at least a geologic period was needed to account for such a great thickness.

ORIGIN OF THE CHERTS OF THE BIG CREEK GROUP:

It is not the purpose of the author to innumerate in detail the merits of each of the many origins of chert that have been proposed. The interested reader is referred to Davis (1918), Bramlette (1946), and Pettijohn (1957), for such a discussion.

The author believes that the cherts of the Big Creek group originated as a result of diagenetic alteration of a radiolarian ooze. The concentration of silica in normal sea water (4 parts per million) is substantially less than that needed to flocculate it as an inorganic gel. Volcanism is generally appealed to to supply the silica which is needed to build up the concentration of this material to the point where inorganic precipitation is possible. Within the Big Creek Group there is an apparent absence of submarine flows and tuffs.

Although sea water normally contains only four parts per million of silica, radiolarians are able to extract it as part of their life processes to form opaline tests. Upon death these minute shells "rain" to the bottom and under ideal conditions may accumulate as a siliceous ooze. According to Pettijohn "such deposits today are restricted to areas receiving little terrigenous material and to waters too acid (too deep) for the deposition of calcareous sediment" (Pettijohn, p. 442, 1957). The depositional environment of the Big Creek Chert approximates this setting; the fine terrigenous material that did reach the basin resulted in the interbedding that characterizes some of the cherts as the slow sedimentation of fine detritus was superimposed on to the very slow accumulation of radiolarian tests. The radiolarian ooze was composed chiefly of attrital fragments; few complete tests appear.

After deposition the opaline, radiolarian tests underwent diagenetic alteration during compaction and lithification. In thin section several of the cherts show minute stylolitic structures, indicating intrastratal solution due to pressure. The subsequently precipitated microscrystalline quartz resulted in the redistribution and alteration of the organically derived opaline tests. The stylolite columns are capped with limonite, an ubiquitous impurity within the cherts.

In conclusion the origin of the Big Creek chert may be summarized by stating that: (1) The silica which now constitutes the cherts was originally extracted from sea water during the metabolic processes of Radiolarians and concentrated in their tests; (2) The siliceous ooze formed upon death of these organisms underwent alteration and redistribution; and (3) The alteration and redistribution was epigenetic, occuring during compaction and lithification.

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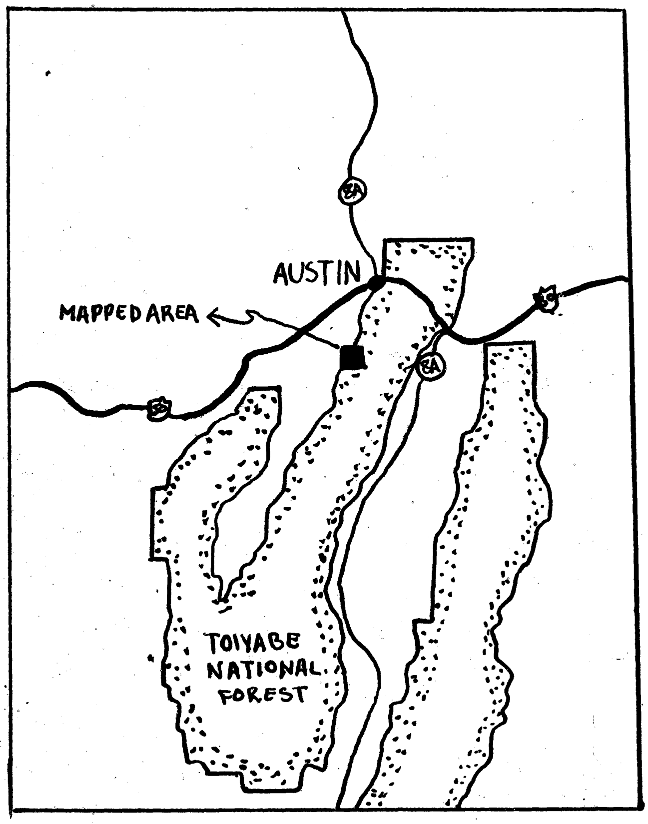
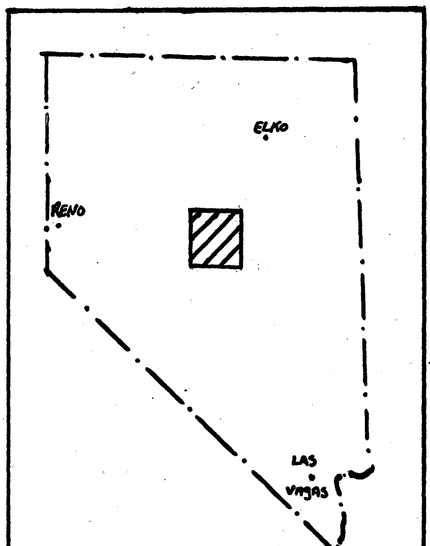
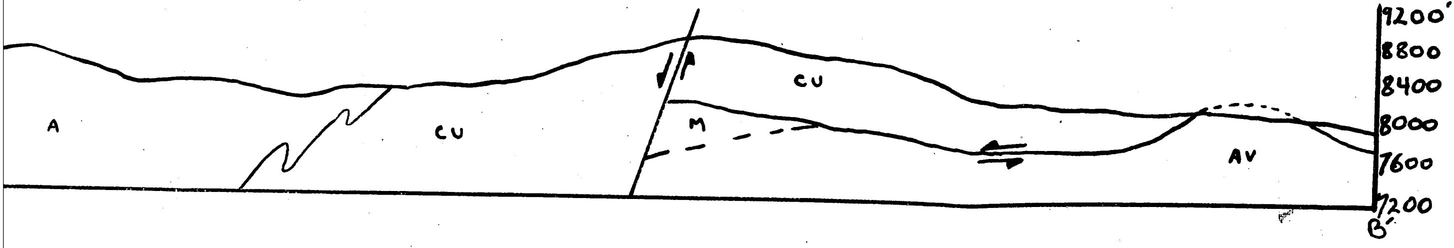


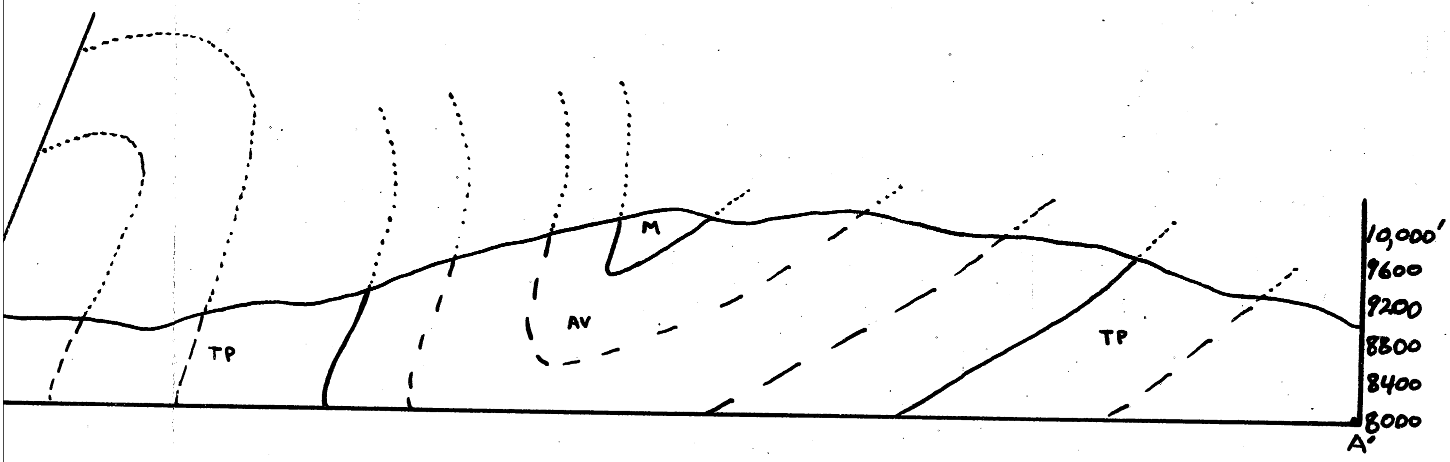
SCALE 1" = 25 miles

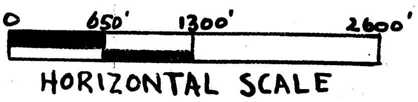


LOCALITY MAP FOR THE BIG CREEK AREA

PLATE II

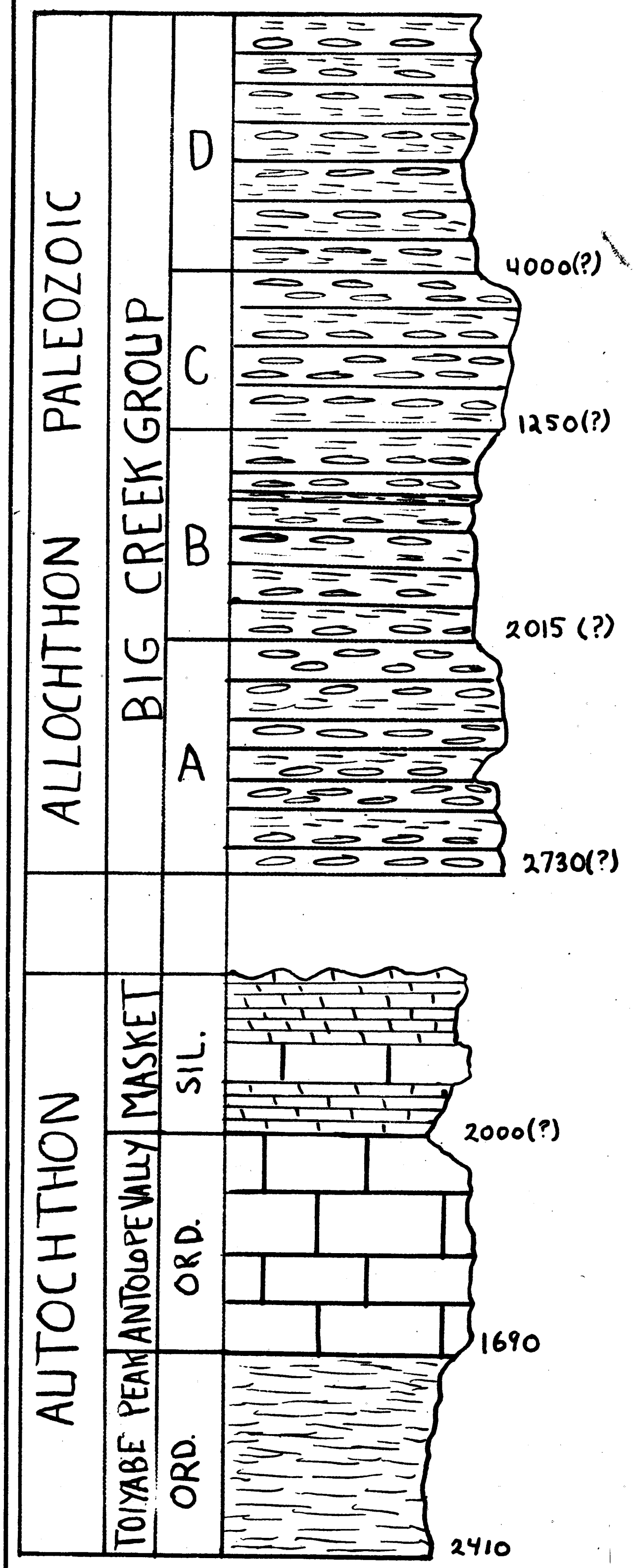






EOLOGIC CROSS SECTIONS

PLATE III

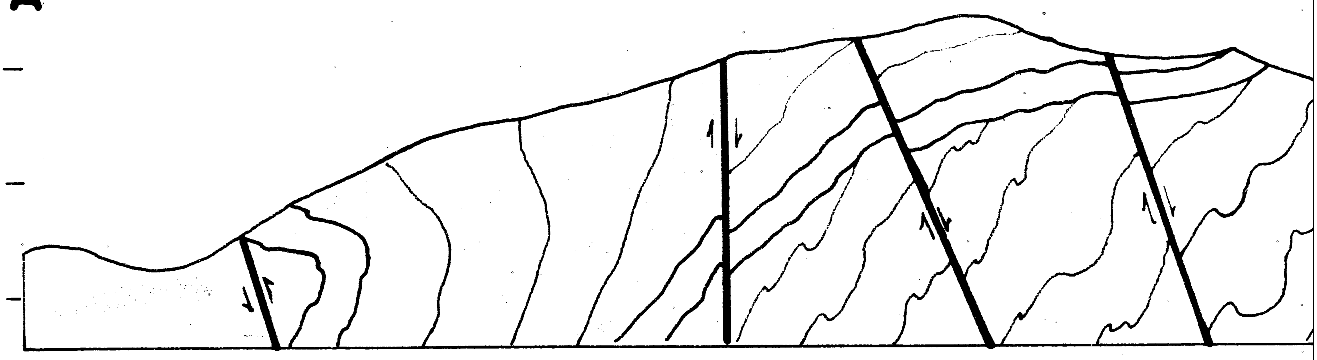


GENERALIZED STRATIGRAPHIC COLUMN

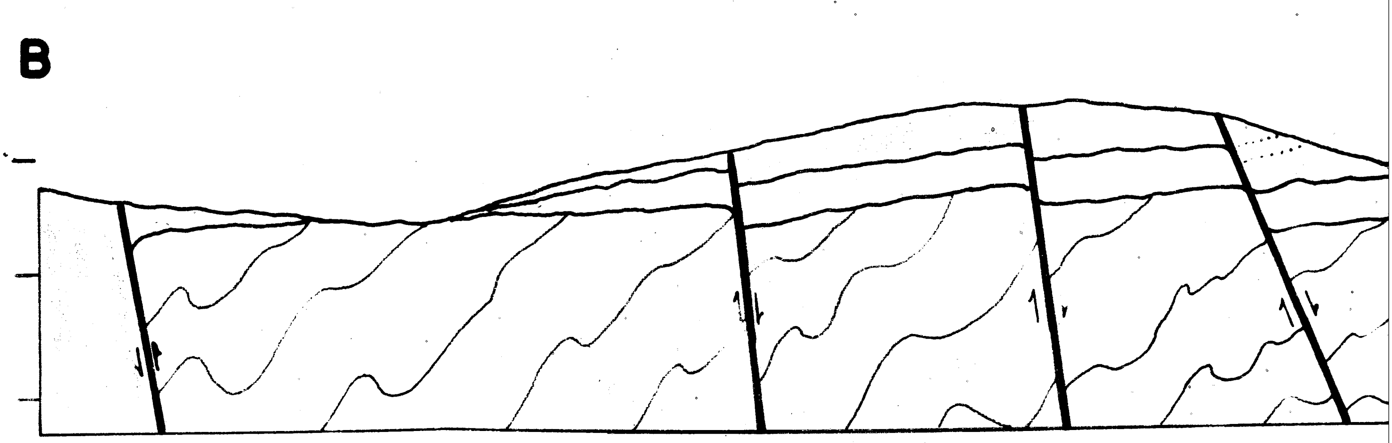
BIG CREEK AREA

STR

A



B



STRUCTURE SECTIONS

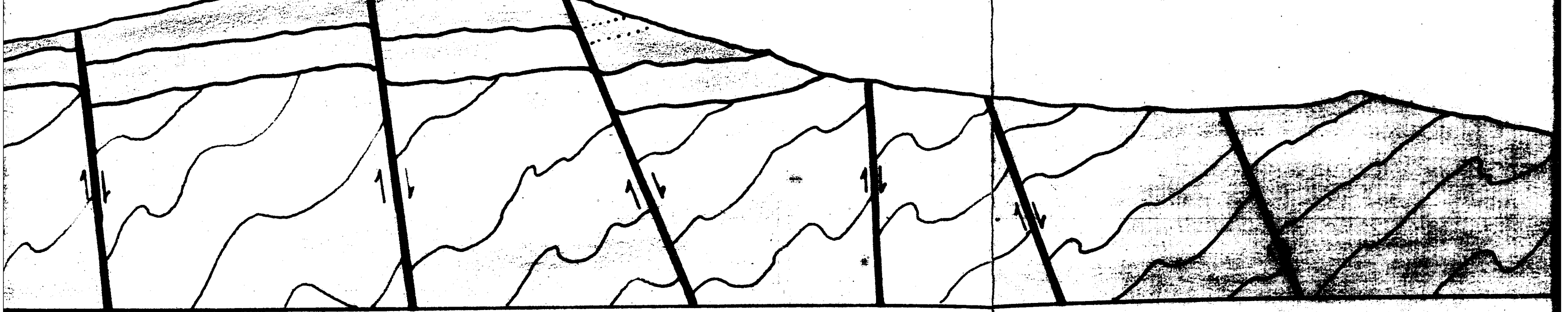


PLATE 2