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DESCRIPTION, STRATIGRAPHIC SECTIONS, AND MAPS OF MIDDLE AND UPPER MIOCENE ESMERALDA FORMATION IN ALUM, BLANCO MINE, AND COALDALE AREAS, ESMERALDA COUNTY, NEVADA

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INTRODUCTION

This report presents information on the stratigraphy of the Esmeralda Formation in the Alum, Blanco Mine, and Coaldale areas in Esmerald County, Nevada. The report supplements the general description and tectonic interpretation of the formation given by Stewart and Diamond (1989).

The Esmeralda Formation was named by Turner (Turner, 1900a,b) for outcrops in the Coaldale and Alum areas (pl. 1 and fig. 1), and the formation has subsequently been studied in greater detail by Moiola (1969), Robinson (1964), Suthard (1966), Robinson and others (1968), Davis (1981), Moore (1981), and Stewart and Diamond (1988). Information on the general geology of the region is included in a study of Esmeralda County by Albers and Stewart (1972). Much of the region has been mapped at scales of 1:62,500 or 1:24,000 (Robinson and Crowder, 1973; Robinson and others, 1976; Crowder and others, 1972; Stewart and others, 1974; Stewart, 1979).

ALUM AREA

The Esmeralda Formation is extensively exposed in the Alum area (pl. 1). Moiola (1969; also *in* Robinson and others, 1968) divided the formation in the Alum area into 7 units, units A to F and the Weepah unit (also called unit G), and his nomenclature is used here except that the Weepah unit is excluded from the Esmeralda Formation. In addition, a tuff unit (tuff unit of Big Smoky Valley) is recognized in the formation between units C and D. Two other units, the Alum and Twin Peaks units, are also recognized in the Alum area but cannot be correlated with other units in the formation.

The stratigraphic and structural relations presented here differ in two major respects from those described by Moiola (1969). First, most of the gravel deposits that Moiola (1969) considered to be older alluvial deposits of Quaternary age are here included in the Miocene Esmeralda Formation. These gravel deposits clearly interfinger with the finer grained, generally tuffaceous, sedimentary rocks of the Esmeralda. Second, Moiola (1969) mapped these gravels as lying depositionally on pre-Tertiary rocks, whereas the mapping presented here (pl. 1) shows these gravels (Esmeralda Formation) to be separated from pre-Tertiary rocks by a major low-angle normal fault (Weepah detachment fault).

Unit A

Unit A occurs only in a small outcrop in the western part of the Alum area (pl. 1). It consists of grayish-orange and dark-yellowish-brown siltstone, sandstone, and conglomerate. Conglomerate may be the dominant lithology although exposures are poor and estimates of relative amounts of rock types are difficult to make. The conglomerate consists of angular to subangular clasts of yellow-gray phyllitic siltstone, medium- to yellow-brown limestone, and black chert. Clasts are generally from l to 5 cm in size, although blocks as large as l m occur locally. The clasts are set in a silt and sand matrix; both clast-supported and matrix-supported conglomerate are present. The clasts are composed of rocks similar to those in Late Proterozoic, Cambrian, and Ordovician stratigraphic sections exposed nearby.

The conglomerate occurs in thin to thick beds interstratified with siltstone and sandstone. The sandstone (Robinson and others, 1968) is fine- to medium-grained and composed of feldspar, quartz, and rock fragments (quartzite, chert, shale, and limestone).

Megabreccia (br, on pl. 1) composed of angular fragments of limestone occurs in masses as much as 500 m long and 50 m thick near the top of unit A. The fragments are mostly of the Lower Cambrian Poleta Formation and Mule Springs Limestone.

The estimated thickness of unit A is about 160 m (Moiola, 1969). The base is not exposed.

Unit B

Unit B is exposed in an outcrop band about 3.5 km long in the western part of the Alum area (pl. 1). The unit forms a fairly conspicuous light-colored ridge composed of sandstone and minor amounts of siltstone, sandy claystone, and clayey sandstone (Alum section A). The sandstone is medium- to coarse-grained, locally contains scattered very coarse grains and granules, and is irregularly thin bedded and locally cross-stratified. The sandstone is composed of rock fragments, feldspar, and quartz in a matrix of zeolitized vitric or argillaceous material (Robinson and others, 1968; Moiola, 1969). Unit B is 73 m thick in a nearly complete section (Alum section A).

Unit C

Unit C is exposed in the western part of the Alum area and is composed of very-pale-orange, yellow-gray, and grayish-orange shale, siltstone, and sparse sandstone. The shale and siltstone are platy splitting and occur in very thin to thin beds. The sandstone is medium to very coarse grained, very thin to thin bedded, and locally cross-stratified. The unit contains abundant epiclasitc volcanic detritus (Robinson and others, 1968; Moiola, 1969). Unit C is about 390 m thick (Alum section A).

Tuff unit of Big Smoky Valley

The tuff unit of Big Smoky Valley forms a narrow 5.5-km-long outcrop band in the western part of the Alum area. The tuff is yellow gray, crystal poor (feldspar, quartz, and a trace of biotite and hornblende), contains 10 percent reddish-purple flow-banded rhyolite clasts and 10 percent or more rounded pumice. This tuff is lithologically similar to, and is correlated with, a tuff mapped as unit Tst by Robinson and others (1976) in the central part of Big Smokey Valley. The tuff is structureless except for local very thin bedded layers. The tuff unit is 15 to about 60 m thick (Alum sections A and B).

Unit D

Unit D is exposed in the western part of the Alum area. The unit is composed of ledges of sandstone and conglomerate that constitute about 25 percent of the unit and of rarely exposed clayey sandstone. The sandstone and conglomerate is very pale orange and grayish orange and composed of intergradational rocks types ranging from coarse to very coarse-grained sandstone to granule and pebble conglomerate. The sand fraction is composed of angular to subrounded quartz, feldspar, and aphanitic volcanic rock fragments; the granules to pebbles are subrounded and composed of grayish-red rhyolitic welded tuff and flow-banded rhyolite, sparse vesicular basalt, and sparse chert. The maximum pebble size is 6 cm. The sandstone and conglomerate occur in 0.2- to 4-m thick layers composed of very thin to thin beds and trough cross-strata. The clayey sandstone is interstratified with the sandstone and conglomerate and is composed of a mixture of clay and very fine to fine sand. Tuff and tuffaceous siltstone occurs locally in unit D. The sandstone and conglomerate layers in unit D, as first noted by Robinson and others (1968) and Moiola (1969), grade out to the northeast along the outcrop so that in the northern part of the the Alum area units D and the lower part of unit E are indistinguishable. To the north beyond the limit of the tuff unit, units C, D, and the lower part of unit E cannot be distinguished from one another and are mapped as one unit (ce on pl. 1). Unit D is about 370 m thick (Alum section B)

Unit E

Unit E is widely exposed in the central part of the Alum area. The unit is composed of two intertonguing rock types, fine-textured tuffaceous rocks (e on pl. 1) and coarse pebble to boulder conglomerate (ec on pl. 1). The fine-textured rocks are generally poorly exposed. They consist of light-greenish-gray to yellow-gray laminated to very thin bedded tuffaceous siltstone, clayey sandstone, and, rarely, tuff. These rocks weather with a "frothy" or "popcorn" surface due to a high content of swelling clays. The coarse pebble to boulder conglomerate is light gray, greenish gray and, rarely, grayish red. It contains clasts of medium-gray and yellow-gray limestone, greenish-gray phyllitic siltstone, yellow-brown very fine to fine grained quartzite, and sparse chert, quartz, and greenish-gray porphyritic mafic igneous rocks. Rarely limestone clasts contains algal oncoliths (so-called *Girvanella*), and very rarely they contain archeocyathids. Oncoliths like those in the clasts are widespread in the Lower Cambrian Mule Spring Limestone exposed near the Alum area. Archeocyathids are common in the Lower Cambrian Poleta Formation and lower part of the Harkless Formation. Phyllitic siltstone like that in the clasts constitute most of the Harkless Formation and the upper part of the Campito Formation. Porphyritic mafic igneous rocks that occur as clasts lithologically resemble igneous dikes that cut the pre-Tertiary rocks near the Alum area. No granitic or volcanic clasts are present in the boulder to cobble conglomerate. The clasts generally are angular to subangular and of pebble to cobble size, although clasts as large as 2 m are locally present. Both clast-supported and matrix-supported conglomerate occurs.

The fine-textured rocks and the pebble and cobble conglomerate interfinger in a complex manner and the two rock types are difficult to map separately. The map (pl. 1) shows the general distribution of the two rock types, but some fine-textured rock and tuff occurs in the conglomerate, and, as mapped, considerable amounts of conglomerate are interstratified with the fine-textured rocks. Fine- to coarse-grained sandstone is common in areas where the fine-textured rocks and the conglomerate intertongue. The sandstone is considered to represent a distal facies of the conglomerate, because of the abundance of grains of phyllitic siltstone in the sandstone that can be considered to represent fine material formed by the breaking up of the coarse clasts of the conglomerate.

Large masses of limestone megabreccia (br on pl. 1) similar to those in unit A, are locally present in unit E.

The thickness of unit E is difficult to determine because of poor exposure, complex intertonguing of units, lack of internal marker units, and structure that includes mapped, as well as possibly concealed, folds and faults. A thickness of about 670 m was indicated by Robinson and others (1968) and Moiola (1969). Estimates made from the map (pl. 1) suggest that unit E may be considerably thicker, possibly 1900 m. This estimate seems reasonable because unit E occurs between well defined marker units or horizons below (unit B, the tuff unit, and the contact of units D and E) and above (the zone of thinolitic tufa at the base of unit F). The consistency of the map pattern suggests that unit E does not contain any major concealed structures.

Unit F

Unit F crops out extensively in the eastern part of the Alum area, and is similar to unit E in that it consists of fine-textured rock (f on pl. 1) complexly intertonguing with coarse conglomerate (fc on pl. 1).

The lower 80 to 250 m of unit F contains 0.5 to 2 m thick lenses of thinolitic tufa that can be traced for 5.5 km along the outcrop (pl. 1). The thinolitic tufa is interstratified with yellow-gray very thin bedded to laminated tuffaceous siltstone and locally with a few conglomerate layers composed of clasts of Proterozoic and lower Paleozoic rocks. The basal tufa-bearing part of unit F is distinctive in the Alum area, because it is the only part of the Esmeralda that contains thinolitic tufa and because the light colored tuffaceous siltstone contrasts strongly with the dark-colored conglomerate of the underlying part of unit E.

The fine-textured rocks of unit F consist, in the lower part of the unit, of distinctive yellow-gray and very-pale-orange evenly laminated to very thin bedded tuffaceous siltstone, shale, and tuff. These rocks locally contain carbonaceous material and, as mentioned above, also contain thinolitic tufa and conglomerate. Higher in unit F, thin to thick layers of yellow-gray to yellow-brown, fine- to coarse-grained tuffaceous sandstone occurs interstratified with the tuffaceous siltstone and increases in abundance upward. The sandstone is very thin bedded or composed of thin trough sets. Tuff and reworked tuff is locally abundant in unit F, particularly in an area about 5 to 6 km southeast of Alum. The tuff is yellow gray, generally evenly very thin bedded or laminated and composed of ash locally containing pumice. The stratigraphic position of the tuff within unit F is difficult to determine, but is most likely high in the unit.

Conglomerate is the most abundant rock type mapped in unit F. The conglomerate consists of angular to subangular, and locally subrounded, clasts of greenish-gray phyllitic siltstone, dark-gray and yellow-brown limestone, lesser amounts of yellow-brown very fine grained quartzite, black chert, very-pale-orange limy dolomite. and dark-greenish-gray porphyritic mafic igneous rocks similar in lithology to, and presumably derived from, dikes that cut pre-Tertiary rocks. The limestone clasts locally contain oncoliths (so-called *Girvanella*) that indicate that the clasts were derived from the Lower Cambrian Mule Spring Limestone, the only formation that contains these oncoliths in the region near Alum. Probable archeocyathids occur in some of the limestone clasts. These fossils occur only in the Lower Cambrian Poleta Formation and the lower part of the Harkless Formation. Clasts of welded tuff were noted at two localities, and clasts of serpentinite were noted in several exposures of conglomerate 2.5 km south southwest of Weepah. No granitic clasts occur in unit F. Clasts are mostly 1 to 10 cm in diameter, although they are as large as 2 m. Both matrix- and clast-supported conglomerate occur. The matrix is composed of silt and very fine to very coarse sand.

Thin to thick layers of sandstone, siltstone, and tuff occur interstratified with the conglomerate. The sandstone commonly contains abundant grains of phyllitic siltstone derived from Late Proterozoic or Lower Cambrian rocks.

Large masses of megabreccia (br on pl. 1) are common in unit F. These masses are as much as 1.5 km long and 100 to 200 m thick. The megabreccia is composed mostly of limestone clasts from a few centimeters to a meter across, but locally intact blocks as large as 10 m of limestone, phyllite, and quartzite are present. All the debris in these megabreccias are derived from Late Proterozoic and Lower Cambrian rocks exposed in the region near Alum. No granitic or volcanic fragments occur in the megabreccias.

The thickness of unit F is difficult to estimate. No marker beds occur within the unit to help decipher structural relations, and high- or low-angle faults could be concealed in the outcrop area. The unit appears to lie depositionally above Tertiary welded tuff in the southeastern and eastern part of its area of deposition. If so, units A to E are missing due to nondeposition or to erosion prior to deposition of unit F. Based on the width of the outcrop and on the dip of the rocks, unit F may be as thick as 1500 m thick, and it could be as much as 2500 m thick.

Twin Peaks unit

Moiola (1969) applied the name "Twin Peak sequence" to a succession of sandstone, conglomerate, siltstone, shale, and tuff that crop out in a relatively small area 4.5 to 7 km south of Weepah. This sequence, here called the "Twin Peaks unit", consists of yellow brown, very thin bedded and cross-stratified, fine- to coarse-grained, locally conglomeratic, sandstone and yellow-gray and yellow-brown very thin bedded siltstone. The conglomeratic sandstone contains granules and pebbles of rhyolitic tuff, and occurs primarily in the basal part of the unit, apparently in unconformable contact with underlying Tertiary welded tuff. The sandstone and siltstone in the Twin Peak unit occur in sequences as thick as 100 to 200 m. The Twin Peaks unit also contains thick sequences of coarse, matrix-supported conglomerate composed of angular to subangular clasts as large as 0.5 m of greenish-gray phyllitic siltstone, medium-gray limestone, and sparse chert and rhyolitic welded tuff in a silt matrix. The coarse conglomerate locally occurs interstratified with yellow-brown siltstone and limy siltstone.

The thickness of the Twin Peaks units is uncertain. It contains intact sequences as thick as 200 m, and may be twice that thick.

Correlation of the Twin Peak unit with other units in the Alum area is uncertain. The unit lies at the base of the Esmeralda Formation and depositionally on ash-flow tuff of probable early Miocene or late Oligocene age in the Twin Peaks area and may be overlain by unit F, although this latter relation is difficult to evaluate because exposures of the contact are poor. Conceivably the Twin Peaks units is a relatively thin equivalent of much of units A to E to the west in the Alum area.

Alum unit

A sequence of coarse conglomerate, conglomeratic sandstone, sandstone, and siltstone in the westernmost part of the Alum area is referred to here as the Alum unit. The unit is in a separate allochthonous block separated from the remainder of the Esmeralda Formation by a low-angle normal fault. Coarse conglomerate, which may constitute about half of the unit, consists of clasts as large as 15 cm of chert, phyllitic siltstone, limestone (some with oncoliths, the so-called *Girvanella*), and welded tuff. No granitic clasts were noted. Interstratified rocks consist of pale-olive and yellow-gray, fine- to coarse-grained sandstone and conglomeratic sandstone containing clasts of chert, phyllitic siltstone, and volcanic rocks. Siltstone also occurs, and much of the siltstone and sandstone is rich in clay and weathers to a frothy surface. The thickness of the Alum unit is unknown, but is probably several hundred meters. Due to the fault contact of the Alum unit with the remainder of the Esmeralda Formation, correlation of the Alum unit with other units in the Esmeralda Formation is uncertain. It coarse lithology suggests a very tentative correlation with the equally coarse units E and F.

Total thickness of Esmeralda Formation

Estimates of the total thickness of the Esmeralda Formation in the Alum area have varied greatly. Turner (1900b) originally indicated that the total thickness of the Esmeralda in the Alum area, excluding what is here called the Weepah unit, is 4084 m. Moiola (1969) indicated 2612 m for the same stratigraphic succession, and Davis (1981) 2075 m. I here suggest the thickness may be 4454 or even 5454 m. The variations in estimates of thickness are the result mainly of different interpretations of structural relations in an area of poor outcrop. The estimate presented here is based on field mapping that suggests a continuity of units across the exposure area. Marker units such as unit B, the tuff unit, unit D, and the thinolitic tufa zone at the base of unit F apparently are not repeated by faults, except for the tuff unit in the western part of the area. A much thinner succession is possible if the sequences is duplicated by faults, but continuity of the units in the area suggests that such faulting is unlikely. Considerable differences in the estimates of the thickness of units E and F are possible, because of poor outcrops that could conceal faults, but the mapped distribution of these units suggest that each unit is 1 to 2 km thick, and these thicknesses combined with fairly certain thicknesses of units A-D indicates that the Esmeralda must be many kilometers thick, certainly in the range of 3 to 5 km.

Age

Fossils of fresh-water mollusks, ostracods, fish, and plants occur in the Esmeralda Formation in the Alum area (Turner, 1900b; Robinson and others, 1968; Moiola, 1969). Of these, only the mollusks and ostracods indicated a specific age for the formation. James Firby (*in* Robinson and others, 1968; Moiola, 1969) assigned a Barstovian age for mollusks in the lower part of unit E and a Clarendonian age for mollusks in the lower part of unit F. Ostracods identified by Rick Forester (written commun., 1981) in undifferentiated units E-C (sample 782-38J at 37°, 56', 14" N. Lat., 117°, 38', 51" W. Long.) are *Heterocypris* new species, and *Limnocythere* new species. Forester indicates that *Heterocypris* sp. is a long ranging form that may be as old as middle Miocene, and that *Limnocythere* sp. probably is restricted to the upper Miocene.

Weepah unit

The Weepah unit (also called unit G) rests unconformably on the Esmeralda Formation. It was originally included with the Esmeralda Formation by Robinson and others (1968) and Moiola (1969), but is here considered a different unit because of its unconformable relation with the Esmeralda Formation and its younger age (Stewart and Diamond, 1989). The Weepah unit crops out in three parts of the Alum area: one in the north, 5 km west to 7 km northwest of Weepah; one in the east, 3 to 5 km south of Weepah; and one in the south, 3 to 8 km south southeast of Alum. In each of these three parts of the Alum area; rocks of the Weepah unit rest unconformably on the Esmeralda Formation. Whether rocks in these three areas are exactly correlative with one another, however, is uncertain.

In the northern part of the Alum area, the Weepah unit is divided into two parts. The lower part consists of lapilli tuff, tuff, tuffaceous sandstone and minor layers of conglomerate. The upper part consists mostly of conglomerate. Clasts in the conglomerate consist of greenish phyllitic siltstone, dark-gray spotted phyllite containing aggregates of metamorphic minerals, medium-gray limestone, light-brown silty limestone, black chert, quartz, porphyritic mafic igneous rock (presumably originally dike rock), andesite, and granitic rocks. The spotted phyllite is identical to phyllite in the upper Proterozoic Wyman Formation near Weepah. The granitic clasts are sparse to abundant . Clasts of diorite, lithologically identical to diorite mapped by Moiola (1969) 1 km north of Weepah, occur locally in the Weepah unit. The conglomerate is generally coarse, and maximum clast sizes are as large as 1.5 m. The Weepah unit in the northern part of the Alum area is probably 100 to 200 m thick, and occurs, along with the Esmeralda Formation, in an allochthonous block above the Weepah detachment surface.

In the eastern part of the Alum area, the Weepah unit consists of a lower and upper sequence of conglomerate and a middle sequence of tuff and interstratified conglomerate. The conglomerate contains clasts as large as 1 m of phyllitic siltstone, light-gray to yellow-brown limestone, and lesser amounts of quartz, very fine grained quartzite, dolomite, and porphyritic mafic rocks. Serpentine pebbles were noted at one locality. Granitic clasts are rare or absent. The middle part of the Weepah unit consists of yellow-gray to light-brown tuff and lapilli tuff interstratified with minor amounts of conglomerate. The middle part of the Weepah unit is probably about 50 m thick, and the entire Weepah unit about 100 to 200 m. A depositional contact of the Weepah unit with the underlying Late Proterozoic Reed Dolomite can be seen in a small outcrop 2.5 km S 5 W of Weepah. This contact relation of the Weepah unit is in contrast to that in the northern part of the Alum area where the Weepah unit is separated from pre-Tertiary rocks by the Weepah detachment fault.

In the southern part of the Alum area, the Weepah unit is divided into three parts. The lower part consists of white evenly thin-bedded tuff and lapilli tuff and light-gray to yellow-gray, fine- to coarse-grained irregularly laminated to thin-bedded and cross-bedded tuffaceous sandstone. The tuff locally contains clasts of volcanic rocks as large as 8 cm. The tuff has been dated (Robinson and others, 1968) by K-Ar methods as 7.1 Ma (recalculated using new constants, Dalrymple, 1979). The middle part of the Weepah unit is a conspicuous 2- to 10-m thick black olivine basalt. The upper part of the Weepah unit consists of yellow-gray tuff and irregularly bedded coarse-grained sandstone. The thickness of Weepah unit in the southern part of the Alum area is about 150 m (Moiola, 1969). The Weepah unit in the southern part of the Alum area rests unconformably on unit F of the Esmeralda Formation (Moiola, 1969, p. 48 and fig. 13).

BLANCO MINE AREA

About 630 m of the Esmeralda Formation is exposed in the Blanco mine area (fig. 1; Vanderbilt area of Robinson and others, 1968; Moiola, 1969). The formation appears to rest unconformably on upper Oligocene and lower Miocene welded tuff, although the basal part of the formation contains only a few thin granule and pebble layers. The basal contact of the formation may be faulted in places. The formation is divided into five units (see stratigraphic section, Appendix), designated units B1 to B5. Units B1, B3, and B5 consist mostly of dusky-yellow, yellowish-gray, and pale-olive clayey sandstone and siltstone and minor conglomerate (see stratigraphic section). The sandstone is locally cross-stratified. The conglomerate contains clasts with an average size less than 3 cm and a maximum size of about 6 cm. The clasts include chert, siltstone, rhyolite, silicic welded tuff, andesite, and vesicular mafic lava. A 9-m-thick volcanic breccia (unit B2) occurs between 111 to 120 m above the base of the formation. It is grayish red and composed of angular clasts that range in size from less than a centimeter to about 1 m, of hornblende andesite, other intermediate composition volcanic rocks, and sparse silicic welded tuff. These clasts are set in a poorly sorted silt to very coarse grained matrix. The volcanic breccia is probably a volcanic debris flow (lahar). Tuff, tuffaceous sandstone, and interstratified clayey sandstone and conglomeratic sandstone form unit B4 which occurs between 218 to 279 m above the base of the formation. The tuff contains 10 to 15 percent phenocrysts of feldspar, quartz, and biotite, 3 percent clasts of andesitic lava, and 10 percent rounded pumice in an ashy matrix. On the basis of its crystal content and type of lithic clasts, this tuff is considered a distal eastern part of the tuff unit of Jacks Spring that is widespread in areas to the west (Stewart and Diamond, 1989; Stewart, 1981a, b).

Vertebrate fossils in the middle of the Esmeralda Formation in the Blanco mine area are Barstovian or Clarendonian in age (Robinson and others, 1968; Moiola, 1969).

COALDALE AREA

The stratigraphy of the Esmeralda Formation in the Coaldale area (fig. 1) has been described by Turner (1900a, b), Hance (1913), Robinson and other (1968), Moiola (1969), and Moore (1981). I divide the formation, which is about 1327 m thick in an incomplete section (see stratigraphic section, Appendix), into eleven units (units C1 to C11) that can be mapped in the Coaldale area. Three additional units (unit C12 to C14) are recognized in the southern part of the area, but these units cannot be clearly correlated with any of the other eleven units. Robinson and others (1968; 1976) and Moiola (1969) did not subdivide the Esmeralda in the Coaldale area in as much detail as presented here. They considered the Esmeralda to be about 930 m thick in the Coaldale area. Moore (1981) divided the Esmeralda into four members in the Coaldale area and considered the formation to be about 646 m thick. My study in the Coaldale area, based in part on mapping south of that by Moore (1981), indicates that units considered by Moore (1981) to be correlative, are actually separate units. Thus my subdivisions and thickness of the Esmeralda in the Coaldale area are different than those of Moore (1981).

Unit C1

Unit C1 is exposed in the western part of the Coaldale area. It rest unconformably on upper Oligocene and lower Miocene tuffs, one of which is 22.1 Ma, on the basis of a K-Ar date (Robinson and others, 1968, revised using new constants). The basal 42 m of unit C1 consists of a heterogeneous sequence of siltstone, porcelaneous siltstone, carbonaceous siltstone, lignite, waterlain tuff, sandstone,and conglomerate. The basal meter of the unit contains silicified tree logs as large as 2 m in diameter lying parallel to bedding. The top 6.1 m of this lower part of unit C1 contains beds of lignite that have been prospected extensively (Hance, 1913). A tuff, apparently the one that yielded a 13.0 Ma K-Ar date (Evernden and James, 1964, recalculated using new standands) occurs from 42 to 57 m above the base of unit C1, although it is lenticular and locally absent. The tuff contains about 14 percent phenocrysts (plagioclase, sanidine, quartz, and biotite) and sparse flattened pumice in an ashy matrix. Overlying the tuff, unit C1 consists of an upward coarsening sequence of siltstone, sandstone, conglomerate, and limestone about 204 m thick. The limestone forms only a minor part of the unit, but forms conspicuous moderate brown layers containing abundant pelecypods and gastropods. The conglomerate contains clasts of Paleozoic chert and Tertiary silicic tuff. Unit C1 is 262 m thick (see stratigraphic section).

Unit C2 to C4

Units C2 to C4 are composed of volcanic breccia and an intervening unit (unit C3) is a eastward thickening wedge of mostly fine-grained sedimentary rock. The volcanic breccia is composed of angular sand- to boulders-size clasts of aphanitic to porphyritic andesite, pale-red rhyolitic ash-flow tuff, and sparse chert set in a fine sand to mud matrix. Locally blocks of rhyolitic ash flow tuff are as large as 30 m in maximum diameter. The volcanic breccia probably formed as volcanic debris flows (lahars). Unit C3 consists mostly of porcelaneous siltstone and siltstone, and minor amounts of muddy granule conglomerate and silty limestone. Unit C3 pinches out westward between units C2 and C4. Units C2 and C4 have a combined thickness of 131 m (see stratigraphic section) in an area where unit C3 is absent.

Unit C5

Unit C5 consists of very-pale-orange and very-light-gray evenly laminated to very thin bedded siltstone and porcelaneous siltstone, and, in the upper third, about 50 percent dusky-yellow very fine to fine-grained indistinctly bedded to massive sandstone. The unit coarses upward and forms a part of a major coarsening upward sequence that includes unit C6. Unit C5 is 107 m thick in the measured section.

Unit C6

Unit C6 consists of an upward coarsening sequence of siltstone, sandstone, and granule conglomerate, and, from 99 to 105 m above its base, of volcanic breccia. The granule conglomerate occurs only in the top half of the unit. The volcanic breccia consists mostly of 2- to 10-mm clasts of andesite and rhyolitic tuff in an ashy matric. Locally the andesite clasts are as large as 3 m. These large clasts distinguish what is otherwise a rather inconspicous layer of volcanic breccia. Unit C6 is 177 m thick.

Unit C7

Unit C7 is a thin (33 m), but distinctive, ridge forming unit of tuff, carbonaceous shale, sandstone, siltstone, and minor limestone. The basal part of the unit consists of a 0.5-m layer of tuff composed of about 10 percent phenocrysts (plagioclase, sanidine, and quartz) and 15 percent rounded pumice in an ashy matrix. The tuff is overlain by 1.5 m of carbonaceous shale. The middle 21.9 m of the unit is sandstone, siltstone, and minor limestone, and the top 9.1 m is a tuff. This tuff at the top of the unit contains 7 to 22 percent phenocrysts (plagioclase, sanidine, and a trace of biotite and hornblende), very space clasts of black chert and brown andesitic lava, and a variable amount of flattened pumice. This tuff is lithologically similar to, and is tentatively correlated with, the tuff unit of Jack Springs that occurs in the Blanco Mine area and areas to the west of there (Stewart and Diamond, 1989). The sequence of lower and upper tuffs and an intervening layer of carbonaceous shale distinguish unit C7 from other units in the Coaldale area.

Unit C8

Unit C8 is a thick (about 280 m) sequence of siltstone, sandstone, and conglomerate. The conglomerate contains clasts of andesite and rhyolitic tuff as large as about 2 cm in diameter. Unit C7 and the basal 88 m of unit C8 form an upward coarsening sequence. Unit C7 contains only fine-grained sandstone, whereas sandstone in unit C8 is mostly coarse to very coarse grained and grades to conglomerate. The basal part of unit C7 probably contains only 30 to 40 percent sandstone and conglomerate, whereas near the top of the basal 88 m of unit C8, 60 to 70 percent is sandstone and conglomerate. Above 88 m, no consistent patterns of upward coarsening or fining sequences were noted in unit C8.

Unit C9

Unit C9 consists of interstratified siltstone, sandy siltstone, silty sandstone, sandstone, and conglomerate. The conglomerate occurs mostly from 53 to 73 m above the base of the unit and contains granules and pebbles of rhyolitic tuff. Unit C9 is 134 m thick.

Units C10 and C11

Units C10 and C11 are everywhere separated from units C3 to C9 by faults and thus the relation of units C10 and C11 to units C3 to C9 is unknown. Most likely, however, units C10 and C11 overlie unit C9 because the sequence of units and the rock types in units C10 and C11 are different than those in any part of units C1 to C9. The amount of strata missing, if any, between units C9 and C10 is unknown. Unit C10 and C11 form an upward coarsening sequence starting with siltstone in the lower part of unit C10 grading upward to siltstone, sandstone, and conglomerate in the upper part of unit C10 to largely sandstone, conglomerate, and diamictite in unit C11. The diamictite consists of angular to subrounded clasts as large as 1 m of rhyolitic welded tuff and minor chert and argillite set in a silty to very coarse sand matrix. The diamictite occurs in 1 to 1.5 m structureless layers that are interpreted to form by debris flows. Unit C10 is 136 m thick in the measured section, but the base of the unit is a fault. Unit C11 is 65 m thick in the measured section, but the top is not exposed.

Units C12 to C14

Units C12 to C14 are exposed in the southern part of the Coaldale area. They apparently lie conformably below units C5 and C6, and thus may be equivalent to units C1 to C4. The structural and stratigraphic relations in this southern part of the Coaldale area, however, are uncertain. Unit C12 consists mostly of yellow-gray siltstone to very fine grained sandstone, and units C13 and C14 are volcanic breccia units that are either within or interfinger with unit C12. Units C13 and C14 are lithologically similar, and perhaps correlative to, units C2 and C4 respectively. The uncertainties of the stratigraphy of units C12 to C14 and of their relation to units C1 to C4 may be due to rapid facies changes, perhaps due to syndepositional faulting or warping that downdropped the sedimentary sequence in the southern part of the Coaldale area. Such rapid changes in stratigraphy related to syndepositional faulting have been noted in similar Upper Miocene rocks of the Wassuk Group (Gilbert and Reynolds, 1973; Golia and Stewart, 1984) in Mineral County, Nevada, 110 km northwest, as well as in the Esmeralda Formation in the Alum area and in the Silver Peak Range (Stewart and Diamond, 1989).

Age

The Esmeralda Formation in the Coaldale area contains a fairly abundant flora consisting of carbonized plant remains, pollen,and silicified wood (Knowlton, 1900; Axelrod, 1940; J.P. Bradbury *in* Moore, 1981) and fauna of molluscs, ostracods, fish, and vertebrates (Lucas, 1900; Stirton, 1936; J.R. Kirby *in* Robinson and others, 1969; J.R. Kirby, R.M. Forester, G.R. Smith, and C.A. Repenning *in* Moore, 1981). These fossils indicate a late Barstovian (middle Miocene) to Hemphillian (late Miocene) age (Robinson and others,1968; Moore, 1981). A 13.0 Ma K-Ar date (Evernden and James, 1964, recalculated using the new constants) in the lower part of unit C1, perhaps in a tuff unit 42 to 57 m above the base of this unit, confirms a middle Miocene age for the lower part of the sequence.

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APPENDIX: STRATIGRAPHIC SECTIONS

Alum section B, measured about 1.5 km west of Alum, about Lat 37°54' N., Long 117°41' W. Exact location shown on plate 1.

[Measured by J.H. Stewart, June 1981]

Esmeralda Formation (incomplete):

Unit E (unmeasured): Meters

11. Claystone to siltstone, yellow-gray (5Y 7/2) and pale-olive (5Y 6/2), weathering yellow-gray (5Y 7/2); very thin to thin even bedding,weathers to form frothy surfaced slope. Probably mostly montmorillonitic clay based on frothy surface weathering. Sparse platy splitting siltstone .... unmeasured

Unit D (incomplete):

10. Sandstone, very poorly exposed; about 10 percent of unit is outcrop of sandstone; the rest of the unit weathers to a soft fine sand surface suggesting that remainder of unit may be mostly friable fine-grained sandstone. Sandstone that crops out is yellowish gray (5Y 7/2), coarse to very coarse grained, common granules, composed of subangular quartz, feldspar, and volcanic rock; indistinct very thin bedded, possibly some cross strata; occurs in 0.1 to 0.5 m layers. Sparse outcrops of light-gray (N7) very fine to fine-grained tuffaceous sandstone in lower third of unit 27.4
9. Siltstone, probably tuffaceous, yellowish-gray (5Y 7/2), fine to coarse silt, platy splitting, weathers to form conspicuous "white" marker unit .... 3±
8. Sandstone to conglomerate and clayey? sandstone, unit poorly exposed; about 25 percent of unit consists of outcrops of sandstone to conglomerate; the clayey sandstone is exposed rarely; the rest of the unit is covered. Sandstone to conglomerate, very pale orange (10YR 8/2) to grayish-orange (10YR 7/4), coarse- to very coarse grained sandstone to granule and pebble conglomerate; sand fraction composed of subangular to subrounded quartz, feldspar, and aphanitic volcanic rock; granules to pebbles are subrounded and composed of grayish-red rhyolitic welded tuff and flow-banded rhyolite, sparse vesicular basalt, and sparse chert. Maximum pebble size in one layer was 60 cm; in another 50 cm. Sandstone to conglomerate occurs in 0.2- to 4(?)-m thick layers; very thin to thin-bedded; common shallow trough sets of low-angle cross strata. Clayey(?) sandstone, very poorly exposed, very pale orange (10 YR 8/2), very fine to fine-sand, frothy weathering. Sandstone to conglomerate form small ridges Clayey sandstone locally exposed in low areas between the ledges 221
7. Very poorly exposed. Abundant chips at surface and sparse exposures indicate that most of unit is probably yellow-gray (5Y 7/2) ashy tuff and fine-grained siltstone. Tuff contains sparse crystals of quartz and biotite, and volcanic rock fragments. Some chips of opalized tuff. Siltstone apparently most abundant in upper half of unit 33.2
6. Tuff(?), very poorly exposed, main rock appears to be light-greenish-gray (5GY 8/1), moderately crystal rich with quartz, feldspar, and biotite(?) crystals, and volcanic rock fragments in ashy matrix. Outcrop mainly recognizable due to abundant clast ranging in size

from 10 cm to 30 m that lie on the surface. These clasts consist of grayish-red welded tuff and flow-banded rhyolite. One clast of garnet-bearing leucocratic granitic rock and one possible metasedimentary rock noted. Large blocks could have been carried in with the ash, or this unit could possibly be a laharic breccia. The matrix is definitely tuffaceous, however. Unit weathers to form smooth-surfaced low "ridge." The isolated large blocks distinguish this unit from all others 13.7

5. Tuff, yellowish-gray (5Y 7/2), crystal poor, composed of 0.25- to 1-mm quartz, feldspar, and sparse biotite in ashy matrix; no pumice........ 1.5
4. Covered........ 21.3
3. Tuff(?), light-brownish -gray (5YR 6/1) and grayish-orange (10YR 7/4), composed of aphanitic volcanic rock clasts from 1 to 15 mm in size in an ashy(?) matrix; irregular, horizontal white streaks in rocks resemble flattened pumice and mainly on this basis unit is considered a tuff. Alternatively, rock could be sedimentary. Unit weathers to form small ridge........ 6.7
2. Covered except for outcrop of sandstone from 8.8 to 9.5 m above base of unit. Sandstone, pale-yellowish-brown (10YR 6/2) to very pale orange (10YR 8/2), very coarse grains composed of quartz, feldspar, and biotite, with scattered granules, that appear to be volcanic rock; sedimentary structure not determinable. Rock almost has an igneous texture with euhedral biotite, but is probably a sedimentary unit 39.0

Total of Unit D........ 366.8

Tuff unit of Big Smoky Valley:

1. Tuff, yellow-gray (5Y 8/1), weathers same color with a slight green tint; composed of sanidine quartz, biotite, and feldspar crystals and pale-red rhyolite clasts in ashy matrix; common pumice as large as 20 cm; rhyolite clasts are commonly as large as 2 cm; structureless; slightly to moderately indurated; weathers to form light-colored rolling terrain belowpediment level. Top 1 m of unit is opalized and dense. Also in this top 1 m are irregular zones (shape not determinable) of moderate-brown (5YR 4/4) limestone that are as large as 30 cm across at base of unit. Limestone may fill cavities in opalized tuff. Plant stems noted in one of these limy zones; some of these zones could be root structures. Equivalent to unit 8 of Alum section A. Thickness is estimate of incomplete section........ 60+

Total of tuff unit of Big Smoky Valley........ 60+

Total of incomplete Esmeralda Formation........ 426.8

Alum section A, measured about 2.5 km north-northeast of Alum approximately Lat. 37°56', Long. 117°41'.

Exact location shown on plate 1.

[Measured by J.H. Stewart, June 1981]

Top of section; top of good exposures. Meters

Esmeralda Formation (incomplete):

Unit D (incomplete):

10. Siltstone (50 percent) and sandstone to conglomerate (50 percent). Siltstone, yellow-gray (5Y 7/2), fine to coarse silt, some parts are frothy weathering and may be clayey very fine grained sandstone. Sandstone to conglomerate, very pale orange (10YR 8/2), medium- to coarse-grained, some layers are conglomerate with granules and pebbles of volcanic rock (mostly pale-red rhyolite); irregularly thin-bedded, indistinct cross strata. Unit is exposed in gullies below pediment surface; sandstone to conglomerate form ledges. About 30 to 37 m above base of unit is a tuff. Tuff, yellow-gray (5Y\7/l), composed of 5 percent crystals (feldspar, quartz? sparse biotite), 5 percent pale-red rhyolitic clasts (1 to 10 mm), and 10 percent pumice (10 to 20 mm) set in an ashy matrix. Pumice is pale green, probably due to hydrothermal alteration. Thickness us estimate of incomplete section........ 45+

9. Tuff and tuffaceous siltstone to sandstone. Tuff, yellow-gray (5Y 7/2) ash size debris, some 0.5- to 1-mm size quartz crystals and lithic clasts. Tuffaceous siltstone to sandstone, yellow-gray (5Y 7/2), grades from coarse siltstone to fine-grained ashy, sandstone; indistinct very thin beds. Unit exposed in gullies below pediment surface........ 18±

Total of incomplete unit D........ 63±

Tuff unit of Big Smoky Valley:

8. Tuff, yellow-gray (5Y 7/2), composed of 0.5- to 10-mm clasts of pale-red aphanitic rhyolite (10 percent of rock), 0.5- to 2-mm quartz crystals (1 percent of rock) and pumice as large as 20 cm set in fine (ashy?) matrix; no stratification; weathers to form white smooth outcrops........ 15

7. Tuff, yellow-gray (5Y 8/1), composed of 0.5-0 8-mm clasts of aphanitic volcanic? rocks (rhyolite?) set in 1- to 3-mm matrix of pumiceous material and quartz; evenly very thin bedded. Perhaps an air-fall tuff formed before main tuff unit........ 1.2

Total of tuff unit of Big Smoky Valley........ 16.2

Unit C:

6. Siltstone to clayey sandstone (80 percent) and sandstone (20 percent). Siltstone to clayey sandstone, yellow-gray (5Y 7/2) and one 10-ft interval of pale-greenish-yellow (10 Y8/2), fine siltstone to clayey very fine sandstone, evenly laminated platy splitting siltstone in places, most of stratification not determinable. Clayey sandstone forms frothy surfaced outcrops; siltstone in places forms similar outcrops and in other places forms resistant layers. Sandstone, very pale orange (10YR 8/2), coarse-to very coarse grained, some layers contain granules; composed of subrounded grains of quartz, feldspar

and volcanic rock; irregularly thin-bedded; minor amounts of thin trough sets of low-angle cross strata; occurs in 0.3-to 1-m layers interstratified with the siltstone to clayey sandstone. Unit exposed in flat terrain; sandstone forms minor ledges.......... 34.8

5. Shale and siltstone and sparse (<2 percent) sandstone. Shale and siltstone, very pale orange (10YR 8/2), yellowish-gray (5Y 7/2), and very thin bands of grayish-orange (10YR 7/4), fine silt; siltstone occurs in very thin to thin layers that are platy splitting; all of grayish-orange layers are siltstone and are slightly limy. Sandstone, grayish-orange (10YR 7/4), medium-grained occurs in very thin to thin layers interstratified with the shale and siltstone. Sandstone locally contains abundant ostracods with quartz and feldspar grains. Top one-quarter of unit contains minor amounts of clay sandstone to sandy claystone similar to that in unit 4. A white (N9) well indurated ash tuff occurs from 170 to 175 m above base of unit and forms a conspicuous white band on outcrop. Unit as a whole forms low flat area covered mostly by alluvium and pediment gravel. Unit is poorly exposed.......... 264

4. Very poorly exposed. Discontinuous exposures of yellow-gray (5Y 7/8) and very pale orange (10YR 8/2) claystone to clayey very fine to fine-grained sandstone. Unit weathers to form flat area covered by alluvium and pediment gravels. Contact with unit 5 placed at change to shaly strata containing very thin beds of yellow-brown limy siltstone and sandstone. Contact gradational from unit 4 to unit 5 and lithologic contrast between these two units may be slight.......... 93

Total of unit C.......... 391.8

Unit B (incomplete):

3. Sandstone (95 percent) and siltstone (5 percent) Sandstone, very pale orange (10YR 8/2), medium-to coarse-grained, scattered very coarse grains to small granules in coarsest parts; poorly sorted; subangular grains; composed of irregular very thin to thin beds thin shallow trough sets of low- to medium-angle cross strata, and thin tabular planar sets of cross strata; common contorted strata with sharp anticlines and broad synclinal structures 1 m across. Siltstone, very pale orange (10YR 8/2), fine to coarse silt; irregular platy splitting. Siltstone forms perhaps 20 percent of basal 6.4 m of unit and 15 percent of top 10.4 m of unit and occurs only as a few 1- to 3-m-thick units elsewhere in unit. Unit weathers to form ridge; top 10.4 m is dip slope on ridge. Sequence from base of unit 2 to 10.4 m from top of unit 3 is coarsening upward sequence. Top 10.4 m of unit 3 is somewhat finer grained units and contains more siltstone than rest of unit 3 and is thus a fining upward sequence relative to the main part of unit 3.......... 28.7

2. Sandy claystone to clayey sandstone, very pale orange (10 YR 8/2) to yellow-gray (SY 7/2) mixture of very fine to fine sand and clay; weathers to form frothy surfaced slope along and at bottom of ridge formed by units 2 and 3.......... 24.4

1. Siltstone and sandstone, very poorly exposed. Siltstone, yellowish-gray (5Y 7/2), fine to coarse silt, platy splitting. Sandstone, pale-yellowish-brown, medium- to coarse- grained; apparently occurs in very thin beds; unit weathers to form flat area at base of ridge form by units 2 and 3. Largely covered by pediment gravel.......... 19.8

Total of incomplete unit B.......... 72.9

Total of incomplete Esmeralda Formation.......... 543.4

Base of section; base of good exposure.

Blanco mine section (Vanderbilt area of Moiola, Robinson and others, 1968), measured in area near and extending about 1.5 km northeast of the Blanco mine (montmorillonite mine), about 3 km east of Emigrant Pass, on east side of Silver Peak Range. Lat. 37°54.3'N. to 37°56'N., Long. 117°49.8W. to 117°50.6'W. Exact location shown on figure 1.

(Measured by J. H. Stewart, June 1981)

Top of section; top of continuous exposure — Meter

Esmeralda Formation (incomplete):

Unit B5 (incomplete):

14. Clayey sandstone to conglomerate and clay siltstone, very light gray (N 8) to light- greenish-gray (5GY 8/1), minor pale-olive (10 Y 6/2). Unit similar to unit 13 except for lighter color, which may indicate high content of tuffaceous material. Unit exposed on slope between modern wash on northwest and pediment surface on southeast. Thickness is estimate .... 75(?)

Note: A conspicuous high-angle fault separates unit 13 from unit 14. Fault noticeable because of contrast in color between the two units.

13. Clayey sandstone to conglomerate, minor clayey siltstone, intergradational rock types, dusky-yellow (5Y 6/4) to pale-olive (10Y 6/2), minor yellowish-gray (5Y 7/2), very light gray (N 8), and grayish-orange (10YR 7/4), grades from clayey coarse siltstone, (minor rock type), to clayey, very fine to medium- rained sandstone to conglomerate; generally poorly sorted. Conglomerate probably constitutes 15 percent of unit and occurs in 0.2 to 1 m thick layers interstratified with clayey sandstone or siltstone. Maximum pebble size in most layers is 1.5 to 2.5 cm; in some layers maximum pebble size is 6 cm. Coarseness of conglomerate appears to increase upward. Granules and pebbles are subangular to round and composed of chert, siltstone, rhyolitic welded tuff, and minor andesite and vesicular basalt(?). Some layers in lower part of unit contain mostly chert and siltstone clasts, but most layers contain a mixture of clast types. The clayey siltstone and clayey sandstone to conglomerate occur in indistinct, somewhat irregular, thin to thick layers; locally good outcrops of clayey sandstone expose thin trough sets of low- to high-angle cross strata. Unit exposed on slope between modern wash and higher pediment surface. Unit from about 180 to 235 m above base contains about 5 percent very pale orange (104YR 8/2) to grayish-orange (10YR 7/4) fine-grained siltstone. The siltstone is evenly laminated, platy splitting, and occurs in 0.2 to 1 m thick sets interstratified with clayey sandstone. The siltstone forms small ledges. Unit contains a few very thin pale-yellowish-brown (10 YR 6/2) silty limestone beds. Thickness is estimated on map .... <u>300±</u>

Total of incomplete unit B5 .... 375±

Unit B4 (tuff unit of Jacks Spring):

12. Tuffaceous sandstone, yellowish-gray (5Y 8/1) weathering white (N9), fine- to medium-grained, composed of feldspar and biotite in ashy matrix; very thin evenly bedded and common 10- to 150-cm-wide shallow trough sets of low-angle cross strata; weathers to form conspicuous white band on outcrop 1.5

11. Clayey sandstone to conglomeratic sandstone and minor clayey siltstone, intergradational rock ypes, yellowish-gray (5Y 7/2) to pale-

olive (10Y 6/2), mostly very fine to fine-grained sandstone, commonly mixed with minor amounts of medium to coarse sand, and in a few layers with very coarse grains to small pebbles (as large as 2 cm). Granules and pebbles are of subangular chert and siltstone except in one thin layer about 6 m below top of unit which contains rounded granules and small pebbles of tuff similar to that in unit 10. Unit is indistinctly thin to thick bedded. Weathers to form frothy surfaced low hills. One very thin layer of pale- brown (5YR 5/2) weathering limestone occurs about 25 ft below top of unit.......................... 21.4

10. Tuff, yellowish-gray (5Y 8/1) to white (N8) contains 12 to 13 percent crystals (plagioclase, sanidine, and trace amounts of biotite and hornblende), 3 percent clasts of andesitic lava, and 10 percent rounded pumice as large as 10 cm in an ashy matrix. Correlated with tuff of Jack Springs (Stewart and Diamond, 1989). Top 3 m of unit contains cylindrical structures 20 to 100 cm in diameter consisting of indurated outer surface, probably gas escape structures. Unit weathers to form yellow-gray, smooth weathering ridge.. 27.4

9. Covered.. 7.0

8. Tuff, yellowish-gray (5Y 7/2), weathering very light gray (N 8) composed of 0.5 to 2 mm grains of quartz, feldspar and sparse biotite and volcanic(?) rock set in ashy matrix; some pumice lapilli; weathers to form an almost white layer. In outcrops about 300 m to northeast, a unit that probably is the same as this one, occurs of the base of the main tuff unit (unit 10).. 3.7

Total of unit B4... 61.0

Unit B3:

Offset in section so that unit 8 measured starting about 200 m S. 70° E. of site where top of unit 7 measured.

7. Clayey and silty sandstone and minor clayey siltstone, intergradational types, yellowish- gray (5Y 7/2) to pale-olive (5Y 6/2), silty and clayey, very fine to fine-grained, minor medium-grained parts, grades to clayey coarse siltstone, all rocks are poorly sorted many have sparse medium to coarse grains in a fine matrix; from distance, even thick- bedded character of unit can be seen; weathers to form frothy surfaced low hills. On exposures 60 to 100 m northwest unit appears to be only about 60 m thick; unit may thin, or unseen faults may cause differences in apparent thicknesses.. 97.6

Total of unit B3... 97.6

Unit B2:

6. Volcanic breccia, grayish-red (5R 4/2), composed of angular clasts ranging from less than a centimeter to about 1 m in size of hornblende andesite, related rocks of intermediate composition, and sparse rhyolitic welded tuff. Clasts set in poorly sorted silt to very coarse-grained matrix. All gradations in clast size; no basic contrast between matrix and clasts; no stratification noticeable; weathers to form dark ridge. The rhyolitic welded tuff clasts contain abundant flattened pumice and are moderately crystal rich (quartz, feldspar and biotite). In some parts of unit, the surface of the ground consists of loose sandy, material suggesting sandstone underneath. If so, some soft sandstone is interstratified with the volcanic breccia 9.1

Total of unit B2.. 9.1

Unit B1:

5. Claystone to clayey sandstone, and sparse conglomeratic clayey sandstone, siltstone, and carbonaceous shale. Claystone to clayey sandstone, pale-olive (10Y 6/2), yellow-gray (5Y 7/2), grayish-orange (10YR 7/4), weathering yellowish-gray (5Y 7/2) and minor grayish-orange (10YR 7/4) grades from claystone to very fine to fine-grained sandstone; stratification concealed. The clayey sandstone in parts of unit is conglomeratic; it contains granules of volcanic rock. Siltstone, yellow-gray (5Y 7/2), fine to coarse silt; occurs as 0.1 to 0.3 m sets interstratified with the claystone to clayey sandstone; platy splitting. Pale-brown (5YR 5/2) carbonaceous shale occurs in very thin layers in about lower 12 m of unit. Unit weathers to form rolling hills; surface is everywhere frothy indicating the presence of swelling clays 62.5
4. Sandstone to conglomerate (90 percent) and siltstone (10 percent) sandstone to conglomerate, very light gray (N8) mostly medium- to coarse-grained, some parts are very coarse grained and grade to granule to small pebble conglomerate. Sandstone, composed of subangular quartz, feldspar, biotite, and volcanic rock fragments set in ashy(?) matrix. Conglomerate contains subrounded to rounded granules and pebbles as large as about 3 cm composed of rhyolitic welded tuff, rhyolite, and sparse vesicular mafic lava set in sand matrix similar to that of sandstone; indistinct large-scale, very low angle cross strata, and minor trough sets of small-scale cross strata. Conglomerate probably constitutes only 20 percent of unit and occurs primarily in upper part of unit. Siltstone, yellowish-gray (5Y 7/2) to very pale orange (10 YR 8/2), fine to coarse silt, occurs in 0.1 to 0.3 m thick sets interstratified with sandstone to conglomerate; platy splitting. Unit weathers to form steep ledgy slope visible on many outcrops in area. Overall, unit has irregular stratification characterized by the irregular shape of the ledges on the outcrop. Upper and lower contacts are gradational .... 30±

   Offset in section on top at unit 3 so that unit 4 measured starting about 200 m S. 75° E. of where unit 3 measured.
3. Clayey siltstone to clayey sandstone (70 percent) and siltstone (30 percent). Clayey siltstone to clayey sandstone, yellowish-gray (5Y 8/1), grades from clayey siltstone to clayey very fine to fine-grained sandstone, contains swelling clays that weather to frothy surface. Siltstone, yellowish-gray (5Y 8/1) with common grayish-orange (10Y 8/1) iron staining that give a general brown character to the siltstone on the outcrop. Siltstone occurs as 0.1- to 0.6-m thick units interstratified with the clayey siltstone to clayey sandstone. Unit weathers to form slopes with minor ledges or siltstone layers. Unit forms a local "marker unit" recognized by the brown- weathering ledge-forming siltstone........ 5±
2. Claystone to clayey sandstone, pale-olive (5Y 6/2), yellowish-gray (5Y 8/1) and very light gray (N8), basal 2 m is moderate-red (5R 4/6), composed of claystone to clayey, very fine to medium-grained sandstone, all swelling clays that give surface frothy appearance; stratification concealed by downslope movement of surficial material; weathers to form slope with frothy surfaces. Unit contains a few 1- to 2-m-thick layers of moderate yellowish-brown (10YR 5/4) weathering limestone and grayish-orange (10YR 8/2) platy splitting siltstone.

Thickness of unit uncertain due to minor faulting and possible structural contortion near contact with tuff of unit 1. Judging by outcrop 0.8 km northwest, the measured thickness of combined units 1-4 (as high as the volcanic breccia) is probably reasonable. In these outcrops to the northwest, units 1 to 4 are well exposed, although the contact between unit 1 and 2 is obscure. The large possible thickness for the interval of units 1-4 near the mine is probably related to thickening of the section by folding, and perhaps faulting .... 14(?)

Total of unit B1 .... 111.5

Total of incomplete Esmeralda Formation 654.2

Contact of unit 1 and 2 characterized by 2-m zone of moderate-red (5R 4/6) claystone in basal part of unit 2. Although contact may be faulted and is not well exposed, the basal 30 cm or so of unit 2 appears to contain granules and pebbles of the underlying tuff. Some larger weathered blocks of the tuff may be locally present along the contact. The claystone of unit 2 has moved downslope and mixed with tuff debris, so that the exact stratigraphy and rock types are difficult to determine.

1. Welded tuff, pale-red (5R 6/2) and yellowish- ray (5Y 8/1) (the latter color is probably an alteration from originally reddish color), weathers mainly very pale orange (10YR 8/2) with abundant iron staining; crystal rich with quartz, feldspar, and biotite, common flattened pumice; weathers to form cliffs. Unit probably 60 m thick, and is underlain by black vitrophyre, which is the glassy part of this ash-flow tuff unit. Tuff resembles, and probably the same as, the Candelaria Tuff (Speed and Cogbill, 1979) .... unmeasured

Base of section; about 0.8 km N. 45° W. of shed at mine

Coaldale section, measured in various segments
in sections. 14, 15, 25, 26, 27, 28, 33, 34, and 35, T. 2 N., R. 37 E.
Exact location shown on figure 1.

(Measured by J. H. Stewart, June 1981)

Top of section at fault with unit C5 on east.
Esmeralda Formation (incomplete): Meters
Unit C11 (incomplete):
36. Diamictite similar to that in unit 35 except that it appears to contain a larger proportion of chert clasts than does the diamictite in unit 35. Also unit weathers to a browner color than does unit 35. Unit forms a distinct ledge above slope-forming upper 7 m of unit 35. Unit at base of dip slope formed in upper part of unit 35 .... 7.3
35. Sandstone to conglomerate (65 percent) and diamictite (35 percent). Sandstone to conglomerate, yellowish-gray (5Y 7/2). Sandstone is coarse- to very coarse grained composed of angular to subangular quartz, feldspar, and lithic grains. Conglomerate contains granule to cobbles as large as 5 cm in diameter of rhyolitic welded tuff and minor chert and argillite set in coarse to very coarse sand matrix. Sandstone to conglomerate is irregularly thin to thick bedded. Diamictite, yellowish-gray (5Y 7/2) composed of angular to subrounded clasts as large as 1 m of rhyolitic welded tuff and minor chert and argillite set in silty to very coarse sand matrix; occurs in 1- to 1.5 m structureless units interstratified with sandstone to conglomerate. Clasts in diamictite are matrix-supported. Unit as whole weathers to form ridge with dip slope in upper 14 m; minor ledges form on diamictite layers. Sequence of lithologic types in unit is as follows, thickness in meters from base of unit: 0-4.3, sandstone to conglomerate; 4.3-8.5, diamictite; 8.5-13.7, sandstone to conglomerate; 13.7-14.6, diamictite; 14.6-17.1, sandstone to conglomerate, poor outcrops; 17.1-18.9, diamictite; 18.9-25.0, sandstone to conglomerate (60 percent) and diamictite (40 percent); 25.0-26.5, diamictite; 26.5-39.3, sandstone to conglomerate, minor diamictite, poor outcrops, thin moderate brown layer of limestone in middle of this interval locally; 39.3-43.9, diamictite; 43.9-45.4, sandstone(?) not exposed, but forms break in slope; 45.4-46.9, diamictite; 46.9-49.7, grayish-orange silty to clayey very fine sandstone, frothy weathering; 49.7-50.6, diamictite; 50.6-57.9, sandstone to conglomerate, some clayey, very fine grained frothy weathering sandstone in upper half 57.9

Total of unit C11 .... 65.2

Unit C10:
34. Clayey sandstone to siltstone with minor amounts of sandstone, conglomerate (debris flow), and limestone. Clayey sandstone to siltstone, light-olive-gray (5Y 5/2) and pale-greenish-yellow (10Y 8/2), weathering yellow-gray (5Y 7/2), grades from fine sandstone with abundant clay and silt matrix to fine- to coarse-grained siltstone; appears to be mostly structureless, weathers with frothy surface in most areas. The unit is faulted and exact thickness and sequence of lithologic types not determinable in detail. About 200 m southwest of line of section a 1.2 m layer of conglomerate (debris flow) occurs apparently about 8 m above base of unit. This conglomerate contains subrounded clasts of rhyolitic tuff as large as 1 m. Along line of section, the top 10 m of the unit contains 20 percent pale-yellowish-

brown (10YR 6/2) platy splitting limestone, and 20 percent very coarse to coarse-grained sandstone. This limestone and sandstone sequence does not occur to southwest along outcrop where the frothy weathering clayey sandstone to siltstone extends to unit 4. Either the limestone and sandstone grade or pinch out southward, or this part of unit is cut out by faults southward. Unit as whole weathers to form slopes below main cliff-forming unit. Thickness uncertain due to numerous faults.. 44?

Offset in section so that unit 34 measured starting 200±m northeast of where unit 33 measured

33. Siltstone to sandstone (20 percent) and sandstone to conglomerate (80 percent). Siltstone to sandstone, yellowish-gray (5Y 7/2), coarse-grained siltstone to very fine grained silty sandstone; thick bedded. A few very thin layers of very pale orange (10YR 8/2) platy splitting siltstone also occurs in lower three- quarters of unit and constitute about 20 percent of upper one-quarter of unit. Sandstone to conglomerate, very pale orange (10YR 8/2) weathering same color and pale-yellowish-brown (10YR 6/2), consist of thin to thick layers of sandstone, conglomeratic sandstone, or conglomerate interstratified with the siltstone to sandstone. Sandstone layers are fine- to medium-grained and are indistinctly cross stratified, probably shallow trough sets. The conglomerate consists of angular to subangular granules and small pebbles of dark-gray chert and minor light gray rhyolitic tuff(?), set in coarse to very coarse sand matrix. Conglomerate is irregularly and indistinctly thin to thick bedded. Two well-defined coarsening upward sequences occur in unit, from 0-7.9 and 7.9-17.1 m above base of unit. Both start with very pale orange siltstone (the lower one is unit 32 and the upper one is a very thin set); upward in sequence the number and coarseness of the sandstone to conglomerate layers increase at the expense of the very fine grained sandstone and siltstone. The top of sequence is a conglomerate, 1 m thick in the lower sequence, 1.5 m in the upper sequence. Unit as a whole weathers to form an orange-colored gentle slope containing small ledge.. 24.7

Offset in section so that unit 33 measured starting 150 m north-west of where unit 32 measured

32. Siltstone, very pale orange (10YR 8/2) to grayish-orange (10YR7/4), weathering same colors, fine to coarse silt, in some layers contains a small amount of very fine to coarse silt, in some layers contains a small amount of very fine to medium grains, platy splitting indicates evenly laminated stratification. Unit poorly exposed. Weathers to form area of low relief.. 67.1

Total of unit C10.. 135.8

Note: Break in section. Units 32-36 cannot be tied with continuous sequence of units 1 to 31. Units 32 to 36 considered to overlie units 1 to 31 with an unknown amount of section missing between units 31 and 32. Alternately, units 32 to 36 could be a different facies of some part of the sequence of units 1 to 31. This alternative explanation is unlikely due to geographic closeness of the exposure of all the units and the significantly different rocks in units 32 to 36 in comparison with unit 1 to 31.

Note: Unit 29 to 31 measured about 1 km south of highway 95 and 3 km S. 85° W. of Omni station along Silver Peak Road.

Unit C9:

31. Siltstone, similar to unit 27. One very thin layer of pale-yellowish-brown (10YR 6/2) limy medium-grained sandstone in middle of unit .... 3±

30. Covered 12.2

29. Siltstone, light-brownish-gray (5YR 6/1) to very pale orange (10YR 8/2) weathering yellowish-gray (5Y 8/1) to very pale orange (10YR 8/2) fine silt; commonly calcareous; evenly laminated; platy splitting; weathers to form "white" outcrops in very low hills at contact with Quaternary alluvium. Unit contains a few very thin beds of pale-yellowish- brown (10YR 6/2) limestone to limy fine- to medium-grained sandstone composed of quartz, feldspar, and lithic grains 46.3

28. Sandstone to conglomerate, very pale orange (10YR 8/2) to yellowish-gray (5Y 7/2), weathering same colors, grades from coarse to very coarse grained sandstone to granule and small pebble conglomerate, composed of quartz, feldspar, and rhyolitic tuff grains, granules and pebbles are mostly (entirely?) rhyolitic tuff; irregularly thin bedded; a few indistinct trough sets of very low angle cross strata; weathers to a very minor ridge 18.3

27. Siltstone (70 percent) and silty sandstone to sandy siltstone (30 percent). Siltstone, light- brownish-gray (5YR 6/1), weathering yellowish- gray (5Y 8/1), fine silt, platy splitting. Silty sandstone to sandy siltstone, yellowish- gray (5Y 8/1) to light-greenish-gray (5GY 8/1) weathering same colors, grades from siltstone containing common fine to coarse sand grains to fine- to coarse-grained silty sandstone; evenly laminated; occurs as indistinct layers in the siltstone. Possibly some of the sandy layers are tuffs, but if they are tuffs, most look reworked. Unit as whole form small hills in generally flat area 17.7

26. Silty sandstone (70 percent), sandstone (20 percent), and siltstone (10 percent). Silty sandstone, yellowish-gray (5Y 7/2), weathering same color, very fine to fine-grained, stratification difficult to see, probably mostly thick bedded. Sandstone, yellowish- gray (5Y 7/4), weathering same color, coarse- to very coarse grained, minor granules, composed of subangular quartz, feldspar, and abundant volcanic rock; stratification not determinable; occurs in thin to thick layers in top third of unit; could be, in part, tuff or reworked tuff. Siltstone, very pale orange (10 YR 8/2), weathering same color, fine silt; laminated; platy splitting; occurs as 0.1- to 0.3-m-thick sets interstratified with silty sandstone. Unit as whole weathered to form small rolling hills and valleys. Unit characterized by the distinct even bands of very pale orange siltstone 36.6

Total of incomplete unit C9 .... 134.1

Unit C8:

25. Silty sandstone (80 percent) and sandstone to conglomerate (20 percent). Silty sandstone, yellowish-gray (5Y 7/2) to dusky-yellow (5Y 6/4), weathering same colors, very fine to fine grained, silty, in places grades to coarse siltstone; commonly contains medium to coarse grains in finer matrix; stratification difficult to see, probably mostly thick bedded. Sandstone to conglomerate, yellowish- gray (5Y 8/1), weathering same color and pale- yellowish-brown (10YR 6/2), medium- to very coarse grained sandstone to granule to small pebble conglomerate, composed of subangular to subrounded quartz, feldspar, and lithic grains; granules and pebbles (maximum size generally about 2 cm) are subrounded and composed of andesite and

of rhyolitic tuff. Sandstone to conglomerate occurs in 0.2- to 3-m thick units; laminated to thin-bedded, common shallow trough sets of small-scale low-angle cross strata. Unit as whole weathers to form small hills and valleys. The amount of sandstone to conglomerate does not appear to change in abundance from bottom to top of unit. Top 10 m of unit contains abundant greenish- gray (5GY 6/1) siltstone 144.2

24. Siltstone to sandstone (50 percent), sandstone to conglomerate (50 percent). Siltstone to sandstone, yellowish-gray (5Y 7/2), weathering same color, coarse-grained siltstone to silty fine-grained sandstone, common medium to coarse grains scattered in finer grained rock, poorly sorted, unstratified, indistinctly laminated in places. Sandstone to conglomerate, yellow- gray (5Y 7/2) to dusky-yellow (5Y 6/4), weathering same colors and pale-yellowish- brown (10YR 6/2), mostly coarse- to very coarse grained, common medium-grained parts, common conglomerate with granules and small pebble (generally not over 2 cm in maximum diameter); sand grains are mostly subangular and composed of quartz, feldspar, and volcanic rock; granules and pebbles are subrounded and composed of andesitic rock and rhyolitic tuff. Some conglomerate mostly has white clasts of rhyolitic tuff. Sandstone to conglomerate contains irregular thin bedded stratifications and small-scale low-angle trough stratification. Sandstone and conglomerate occurs in 0.1- to 1.5-m- thick units interstratified with the siltstone to sandstone. Unit weathers to generally low topography. Minor ledges form on the sandstone to conglomerate. Unit contains rare iron-stained sandstone structures that are remnants of fossil logs. Very pale orange (10 YR 8/2), irregularly thin-bedded siltstone and coarse sandstone occurs from 88-89 m above base of unit and forms a conspicuous light band on the outcrop. The unit from the base to 88 m above base forms a sequence characterized by thicker units of sandstone and conglomerate upward and a greater amount of sandstone and conglomerate upward. The base of this sequence probably is the carbonaceous shale of unit 21. At the top of this sequence, near 88 m above base of unit 23, sandstone and conglomerate probably form 60 to 70 percent of section whereas near base of unit 23, they only form about 30 to 40 percent. Above 88 m, unit contains less sandstone and conglomerate, probably only 30 to 40 percent. Current direction measurements on cross strata are mostly from about 60 to 88 m above base of unit 24. A few readings were taken elsewhere in unit 138.7

Total of unit C8 .... 282.9

Unit C7:

23. Tuff, grayish-orange (10YR 7/4) weathering same color, moderately crystal rich with quartz, sanidine(?), and plagioclase(?), sparse biotite; sparse lithic fragments; sparse, if any, pumice fragments; well indurated; weathers to form ridge 9.1

22. Sandstone and minor amounts of siltstone and limestone. Sandstone, dusky-yellow (5Y 6/4) weathering grayish-yellow (5Y 8/4), fine grained, somewhat silty; poorly exposed. Siltstone, very pale orange (10YR 8/2), fine silt, platy splitting; occurs in minor amounts in basal 0.6 m and top 8 m of unit. Limestone, light-brownish-gray (5YR 6/1), in places contain medium to coarse angular grains of chert, quartz, and volcanic rock; occurs from 10.1 to 10.2 m above base of

unit. Unit as whole weathers to form slope; sandstone forms loose soft surface material 21.9

21. Carbonaceous shale, brownish-gray (5YR 4/1), weathering grayish-yellow (5Y 8/4), papery splitting. Units 20 and 21 form distinctive white band on outcrop 1.5

20. Tuff, light gray, weathering same color crystal poor with quartz and feldspar, common angular pumice fragments from 1 to 6 mm in maximum diameter. Units 20 and 21 form distinctive white band in outcrop 0.5

Total of Unit C7 .... 33.0

Unit C6:

19. Sandstone (90 percent) and sandstone to conglomerate (10 percent). Sandstone, similar to that in unit 16. Sandstone to conglomerate, yellowish-gray (5Y 7/2) to dusky- yellow (5Y 6/4), weathering same color, coarse-grained sandstone to granule conglomerate, grains and granules of quartz, feldspar, and volcanic rock; occurs in 0.3 to 1 m layers interstratified with fine-grained sandstone; internal stratification not determinable. Unit as whole weathers to form flat area with minor ledges on the sandstone to conglomerate layers. Light-olive-gray (5Y 6/1), moderate- brown (5YR 4/4) weathering, limestone occurs from 47.4 to 47.5 and 63.7 to 63.9 m above base of unit. Parts of unit are poorly exposed. A few iron stained masses that appear to be remains of logs are scattered in unit 71.6

18. Volcanic breccia, yellow-gray (5Y 7/2), weathering same color, most of unit contains 2 to 10 mm clasts of andesite and related rocks of intermediate composition and sparse clasts of rhyolite tuff, locally unit contains 1 to 3 m blocks of andesite; massive; weathers to form slope. Unit is inconspicuous except for presence of the 1 to 3 m blocks which are visible along outcrop .... 6±

17. Sandstone (95 percent) and siltstone (5 percent). Sandstone, yellow-gray (5Y 7/2) to dusky-yellow (5Y 6/4), weathering same colors, mostly fine grained, medium- to coarse-grained in some layers, fair sorted, common silt; mostly massive, locally laminated layers occur and one layer from 80.8 to 82.3 m above base contained some small-scale cross strata; granule conglomerate with clasts of rhyolite tuff occurs from 86.9 to 87.5 m above base of unit. Siltstone, similar to that in unit 16, occurs in 10-cm to 1 m thick layers interstratified with sandstone. Unit as whole weathers to form ridge. Exact thickness of unit uncertain due to numerous small faults. Possible poorly preserved logs in top 15 m of unit. Thickness approximate 99.1

Total of unit C6 .... 176.7

Unit C5:

16. Siltstone and, in top third, sandstone. Siltstone very pale orange (10YR 8/2) and very light gray (N 8), weathering same colors and grayish-orange (10YR 7/4), fine silt, dense porcelaneous rock, evenly laminated to very thin bedded platy to slabby splitting. Sandstone, dusky-yellow (5Y 6/4), weathering same color, very fine to fine-grained, some silt matrix, indistinctly bedded to massive; occurs in top third of unit where it may constitute about 50 percent of strata. Unit as whole weathers to form slope. Thickness approximate due to many small faults and difficulty in measuring strike and dip. Parts of unit are poorly exposed 92±

15. Covered. Based on exposures elsewhere, this unit probably composed of nonresistant platy siltstone similar to that in unit 16.................. 15±

Total of unit C5 ....107±

Offset in section so that unit 15 measured starting 1 km S. 60° E. of where unit 14 measured.

Unit C2 to C4:

14. Volcanic breccia, similar to unit 12. Poorly exposed. Lower three-quarters of unit contains clasts as coarse as those in unit 12. Top one-quarter of unit contains clasts of a maximum size of about 7 cm. Maximum size of clasts decreased upward in top one-quarter of unit to about 1 cm at top of unit. Unit weathers to form irregular ridge.................... 62±

13. Volcanic breccia, similar to unit 12 except clasts are less than 1 cm in size. One 1-m layer in middle of unit contains clasts as large as 5 cm. Unit contains indistinct even layers. One thin set of laminated platy splitting siltstone in middle of unit. Unit weathers to form valley. To east, interval of unit 13 contains a 200±m sequence of very pale orange platy splitting siltstone. Apparently fine volcanic breccia of unit 13 and this siltstone are finer grained phase of deposition between the two coarse volcanic breccias. Base and top of unit appear gradational with adjacent units.. 26±

12. Volcanic breccia, yellow-gray (5Y 7/2) to dusky-yellow (5Y 6/4), weathering same colors, composed of angular grains to boulder size angular clasts of aphanitic to porphyritic andesite and related rocks of intermediate composition, of sparse pale-red rhyolite ash-flow tuff, and of sparse chert set in fine sand to mud matrix; clasts commonly 0.5 to 1 m across (rhyolitic ash flow tuff clast directly east of line of section 11 is about 30 m in maximum diameter); massive, no internal stratification noted, weathers to form ridge. Rhyolitic ash-flow tuff clasts form light color masses within darker color of unit .... 43±

Total of units C2 to C4 ....131±

Note: Offset in section so that unit 12 measured starting 500 ft east of where unit 11 measured.

Unit C1:

11. Siltstone to silty sandstone (90 percent), sandstone to conglomerate (9 percent), limestone to limy siltstone (1 percent). Siltstone to silty sandstone, yellowish- gray (5Y 7/2) to dusky-yellow (5Y 6/4) weathering sand color, includes fine- grained platy siltstone, similar to that in unit 8, to thin- to thick-bedded silty very fine to fine-grained sandstone which in some beds included scattered medium to coarse grains. Sandstone to conglomerate, very pale orange (10YR 8/2), weathering same color, coarse to very coarse sandstone to pebble conglomerate with clasts as large as 12 cm. Sandstone composed of quartz and feldspar with some silt matrix. Conglomerate contains clasts of Paleozoic chert and of Tertiary rhyolite tuff in sand matrix. Granules and pebbles are subrounded. Sandstone to conglomerate occurs in very thin to thick layers interstratified with siltstone to silty sandstone. Sandstone to conglomerate occurs in following positions, in meters above base of unit: 93.0-94.5, 109.4-110.3, 117.3-123.4, 139.0-139.1, and 142.6-145.4. Limestone to limy siltstone, light-olive-gray (5Y 6/1) weathering moderate-brown (5YR 4/4), common fine to very coarse grains of quartz, feldspar, Paleozoic chert, and Tertiary rhyolitic tuff scattered in some layers of the limestone to limy siltstone. Common poorly preserved gastropods and pelecypods in

the limestone to silty limestone. Because of coarse grains in these limy layers, they may be largely calcarenite accumulated under high-energy conditions, although I can't see any limestone clasts. Limestone to limy siltstone occurs in following position in units, in feet above base of unit: 12.5-13.1, 74.4-74.7, 125.6-125.7, 130.8-131.1, and 135.3-135.6. From 53.3-54.3 m above base, unit contains a very fine grained tuff with opaline cement. Unit as whole weathers to form slope with minor resistant layers that are dense siltstone and limy rocks. Line at section probably crosses minor faults and thickness of unit easily could be in error by 15 m; probably thickness given in too thick. The silty sandstone may in part be debris flows .... 154±

10. Siltstone, similar to unit 8. Tuff with quartz phenocrysts and pumice fragments in ash-size matrix occurs from 8.5 to 8.8 m above base of unit. Unit weathers to form slope 18.3

9. Sandstone, yellowish-gray (5Y 8/1), weathering same color, fine to very coarse grained, very coarse grained parts composed of subangular quartz, feldspar, and fine dense uff(?) grains, fine-grained parts contain quartz and biotite and a large amount of white ash(?); evenly very thin to thin bedded in places, finer grained parts appear massive in places; weathers to form minor ridge 15.8

8. Siltstone, very pale orange (10YR 8/2) to grayish-orange (10YR 7/4), weathering some colors, fine silt, dense and porcelaneous in places; shaly to slabby splitting; weathers to form slope 16.2
Note: Offset in section so that overlying unit measured starting about 100 m, S. 35° E. of where unit 7 was measured. Units 5 through 7 measured along minor ridge. Unit 8 measured starting in minor canyon.

7. Tuff, yellow-gray (5Y 8/1), weathering same color and very pale orange (10YR 8/2) moderately crystal rich (plagioclase, sanidine, biotite, quartz), sparse slightly flattened pumice, sparse charcoal pieces; weathers to form rounded ledge 15.2
After transfer (see note above) interval of unit 7 is only 10 m thick and consists of siltstone and tuffaceous sandstone, all very thin bedded to laminated. Apparently tuff pinches out and siltstone and fine-grained tuffaceous sandstone overlap tuff unit. Tuffaceous sandstone contains biotite perhaps reworked from the tuff. The pinchout of the tuff is evident on other outcrops in area.

6. Carbonaceous shale (90 percent), siltstone (5 percent) and lignite (5 percent). Carbonaceous shale, brownish-gray (5YR 4/1), weathering same color and yellowish-gray (5Y 8/1), evenly laminated. Siltstone, very pale orange (10YR 8/2), fine silt, occurs as very thin beds interstratified with carbonaceous shale. Lignite, brownish- gray (5YR 4/1), weathering same color, occurs as laminae to very thin beds interstratified with carbonaceous shale. Unit weathers to form slope. Unit is main prospect for coal deposits with numerous prospect pits along outcrops. Unit locally contains very thin beds of coarse-grained pumice tuff 6.1

5. Porcelaneous siltstone, light-brownish-gray, (5YR 6/1) and very pale orange (10YR 8/2), weathering latter color, fine silt; evenly finely laminated to very thin bedded; shaly to slabby splitting; weathers to form conspicuous light-colored ledge. Unit in places contains

irregular folds (probably soft sediment deformation) with wave lengths of 0.5 to 1 m 2.6

Note: Section offset so that overlying units measured 120 m N. 65° E. of underlying units. Offset at base of lower of two conspicuous light-colored ledges.

Note: Units 1-4 measured in structurally complex area. Sequence appears to be correct, but faults could cut through part of these units. Unit 1 may be continuous with main Oligocene tuff sequence, but alternately could be tuff layer within Esmeralda Formation.

4. Siltstone (60 percent), sandstone and conglomerate (35 percent), and carbonaceous shale (5 percent). Siltstone, very pale orange (10YR 8/2) to yellowish-gray (5Y 8/1) weathering same colors, fine silt, evenly laminated to thin-bedded, platy splitting; sparse plant fragments. Sandstone and conglomerate, same colors as siltstone, coarse to very coarse sandstone to granule and small pebble conglomerate, subangular to subrounded grains, composed of quartz, feldspar, and lithic fragments, granules and pebbles are mostly white rhyolitic tuff similar to unit 1; occurs in 0.5- to 1-m layers interstratified with siltstone. Carbonaceous shale, pale-brown (5YR 5/2) weathering same color, platy splitting, occurs as 1- to 7-cm-thick layers interstratified with siltstone. Unit weathers to form slope. Carbonaceous shale constitutes most of top 1±m of unit. Siltstone is resistant and conspicuous in basal third of unit .... 31±

3. Sedimentary tuff, light-gray (N7), weathering light-brownish-gray (5YR 6/1), coarse to very coarse grained, composed of pumice, quartz, and feldspar. Rock is opalized so that original composition is difficult to see; evenly laminated to very thin bedded; weathers to form minor ledge. Possibly reworked from unit 1 .... 1.5

2. Covered except for large silicified logs. About 150 m to north one log at this stratigraphic position is 2 m across. This unit can be recognized on basis of these logs for 150 to 300 m along outcrop, although section is badly faulted. Logs are pale- yellowish-brown (10 YR 6/2) and annual growth rings are well developed. Logs are lying parallel to bedding 1.2

Total of unit C1 .... 261.9

Total of incomplete Esmeralda Formation 1,327.6

1. Tuff, yellowish-gray (5Y 8/1), weathering same color, 2 percent crystals of quartz and feldspar, common 1-4-mm pumice fragments; common 5-10-mm pieces of iron- stained plant fragments; moderately indurated, locally opalized; weathers to form white bare rock outcrops. Thickness estimated .... 12±

Base of section; base of relatively in-place sequence.

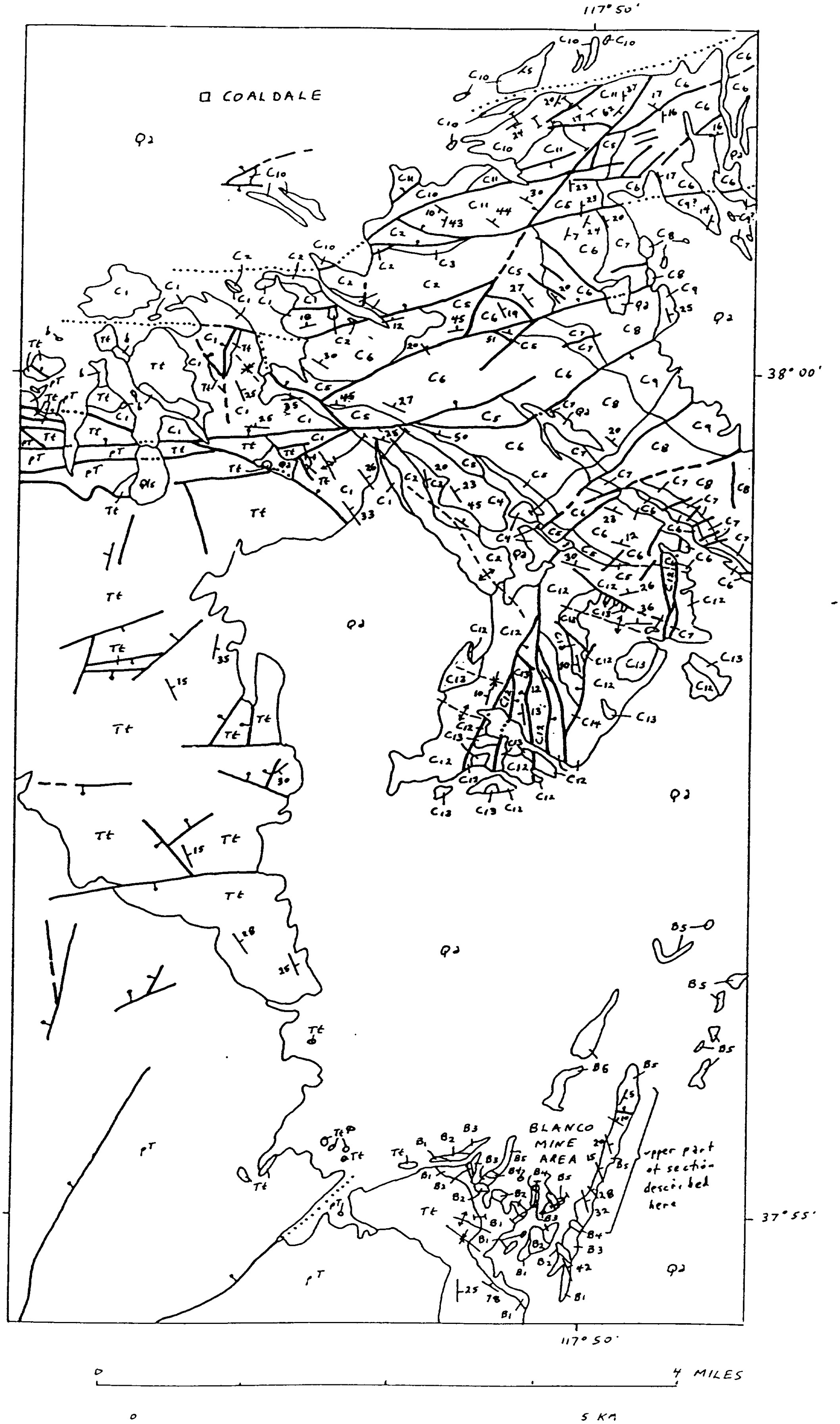

Fig. 1. Geologic map of the Coaldale and Blanco mine areas, Esmeralda County, Nevada

EXPLANATION (Figure 1)

Qa — Alluvial deposits (Quaternary)

Qls — Landslide deposits (Quaternary)

Unconformity

COALDALE AREA

Esmeralda Formation (Middle and Upper Miocene)

C11 — Unit C11

C10 — Unit C10

Fault

C9 — Unit C9

C8 — Unit C8

C7 — Unit C7

C6 — Unit C6

C5 — Unit C5

C4 — Unit C4

C3 — Unit C3

C2 — Unit C2

C1 — Unit C1

b — b, basalt at or near base of Esmeralda Formation

C14 — Unit C14

C13 — Unit C13

C12 — Unit C12

BLANCO MINE AREA

B5 — Unit B5

B4 — Unit B4

B3 — Unit B3

B2 — Unit B2

B1 — Unit B1

Unconformity

Tt — Volcanic rocks (Upper Oligocene and lower Miocene)

Unconformity

pT — Pre-Tertiary sedimentary rocks (Cambrian and Ordovician)

Contact

Fault--Dotted where concealed. Bar and ball on downthrown side

Strike and dip of bedding

Anticline--Dashed where inferred or poorly located

Syncline--Dashed where inferred or poorly located

Line of measured section

EXPLANATION (plate 1)

Qa — Alluvial deposits (Quaternary)

Qls — Landslide deposits (Quaternary

Qp — Pediment gravels (Quaternary)

Qb — Basalt cinder and flows (Quaternary)

wb, w, wc — Weepah unit (upper Miocene)
wb, basalt flow
w, siltstone, sandstone, conglomerate, and tuff
wc, coarse conglomerate

In upper plate of Weepah detachment fault in northern area; post detachment fault in eastern area; and unknown relation to detachment fault in southern area

Upper plate of Weepah detachment fault

Esmeralda Formation (middle and upper Miocene)

f, fc, br — Unit F:
f, siltstone, sandstone, conglomerate and tuff
fc, coarse conglorate
br, megabreccia

e, ec, br — Unit E:
e, siltstone, sandstone, and conglomerate
ec, coarse conglomerate
br, megabreccia

d — Unit D

t — Tuff unit of Big Smoky Valley

c — Unit C

b — Unit B

a, br — Unit A:
a, conglomerate, siltstone, and sandstone
br, megabreccia

ce — Units C to E undivided

al — Alum unit (? – ?)

Twin Peaks unit (? – ?)

Unconformity

Tbi — Basaltic intrusive rocks (lower Miocene)

Tt — Ash-flow tuffs (lower Miocene or upper Oligocene)

Ta — Andesite (lower Miocene or upper Oligoene

Unconformity

pTs — Pre-Tertiary sedimentary rocks (Ordovician and Cambrian)-relatively unmetamorphosed

Lower plate of Weepah detachment fault

pTmg — Pre-Tertiary metamorphic and granitic rocks

EXPLANATION (plate 1)--continued

Contact

Outcrop trend of sedimentary layer

High-angle fault--Dotted where concealed. Bar and ball on downthrown side

Weepah detachment fault (WDF) and structurally higher detachment faults--Dotted where concealed. Boxes on upper plate

25 Strike and dip of beds

53 Strike and dip of overturned beds

Strike and dip of beds--Amount of dip unknown

Horizontal beds

Anticlinal axis--Dashed where inferred or poorly located

Synclinal axis--Dashed where inferred or poorly located

Line of measured section