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STRUCTURAL TRANSECT ACROSS THE CENTRAL CARLIN TREND, EUREKA COUNTY, NEVADA

by

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Abstract

Gold deposits in the Carlin trend, northern Nevada, are closely associated with tectonic windows through the Roberts Mountains allochthon. Geometric relations of folds between upper and lower plate rocks facilitate interpretation of how the windows formed and may advance the understanding of how the gold deposits are related to deformation styles in and near the windows. Folds and faults from the Roberts Mountains allochthon, and in the para-autochthonous miogeoclinal assemblage in the north part of the Lynn-Carlin window, central Carlin trend, are evidence of events that took place during the tectonic evolution of the region. A generalized three-phase (D_1 – D_3) sequence of tectonic events for the Carlin trend area, between the Paleozoic to late Mesozoic, involves: (1) Antler–Humboldt deformation (D_1, F_1 folds) between late Devonian to late Pennsylvanian in age, roughly synchronous with the emplacement of the Roberts Mountains allochthon; (2) Sonoma–Elko deformation (D_2, F_2 folds) between late Permian and late Jurassic in age, noted for abundant and penetrative NE- and SW-trending, shallow-plunging folds, local intrusives, and NW-trending faults; and (3) Sevier deformation (D_3, F_3 folds) between late Jurassic and early Eocene in age, which rotated or refolded many F_2 folds to N- and NW-trends and produced local WNW-trending F_3 shear folds.

The largest window through the Roberts Mountains allochthon in the Carlin trend area is the Lynn-Carlin window. The northwest part of this window is the West Richmond area and the northern side is the Castle Reef fault area. In the West Richmond area the east-dipping West Lynn thrust truncates the west-dipping Roberts Mountains thrust, and is interpreted to dip at a shallow angle under the Lynn-Carlin window, and may repeat the ore-bearing Popovich limestone and Roberts Mountains Formation at depth. Rocks of the Popovich limestone, west of the West Lynn thrust, lie below the Roberts Mountains Formation, which are in turn over thrust by the Hanson Creek Formation east of the thrust. Bedding attitudes in upper plate rocks have a general, NW strike and a moderate to steep NE dip with NE-plunging fold axes. Lower plate rocks have more northerly-plunging fold axes. Thrusts in the West Richmond area are silicified, which suggests that fluid flow and deformation may be related. An interpretation of the West Richmond area is a sequence of east-dipping, low-angle faults that have thrust older rocks on top of younger rocks—from the east to the west—at angles less than 60°, and would have a sectional form like a recumbent flower structure.

The Castle Reef fault area was divided into three sub-areas of study: (1) Castle Reef fault zone, (2) Carlin Mine area, and (3) Spur area. The Castle Reef fault has a WNW strike, similar to post-Jurassic (D_3) shear zones and folds in the Dillon deformation zone that host the Betze orebody to the north in the Goldstrike Mine. These shear zones

and folds are also postulated to be responsible for rotation of regional F_2 folds into NW-trending fold orientations along much of the Carlin trend The fault zone contains folds that have shallow-plunging fold axes parallel to the strike of the fault zone. Fold axial planes in the footwall of the Castle Reef fault zone are N-trending and change to NE-trending as they approach the Castle Reef fault zone. On the hangingwall side of the Castle Reef fault zone, fold axial planes are oriented NW, suggesting that the Castle Reef fault zone is a D_3, jasperoid-filled, shear fold. High- and low-angle faults are common in both the Castle Reef and West Richmond areas. These faults are sometimes related to the folding; for instance, the faults may lie parallel to the axial planes or along limbs of folds, and therefore many of the faults complement rather than disrupt the fold geometries.

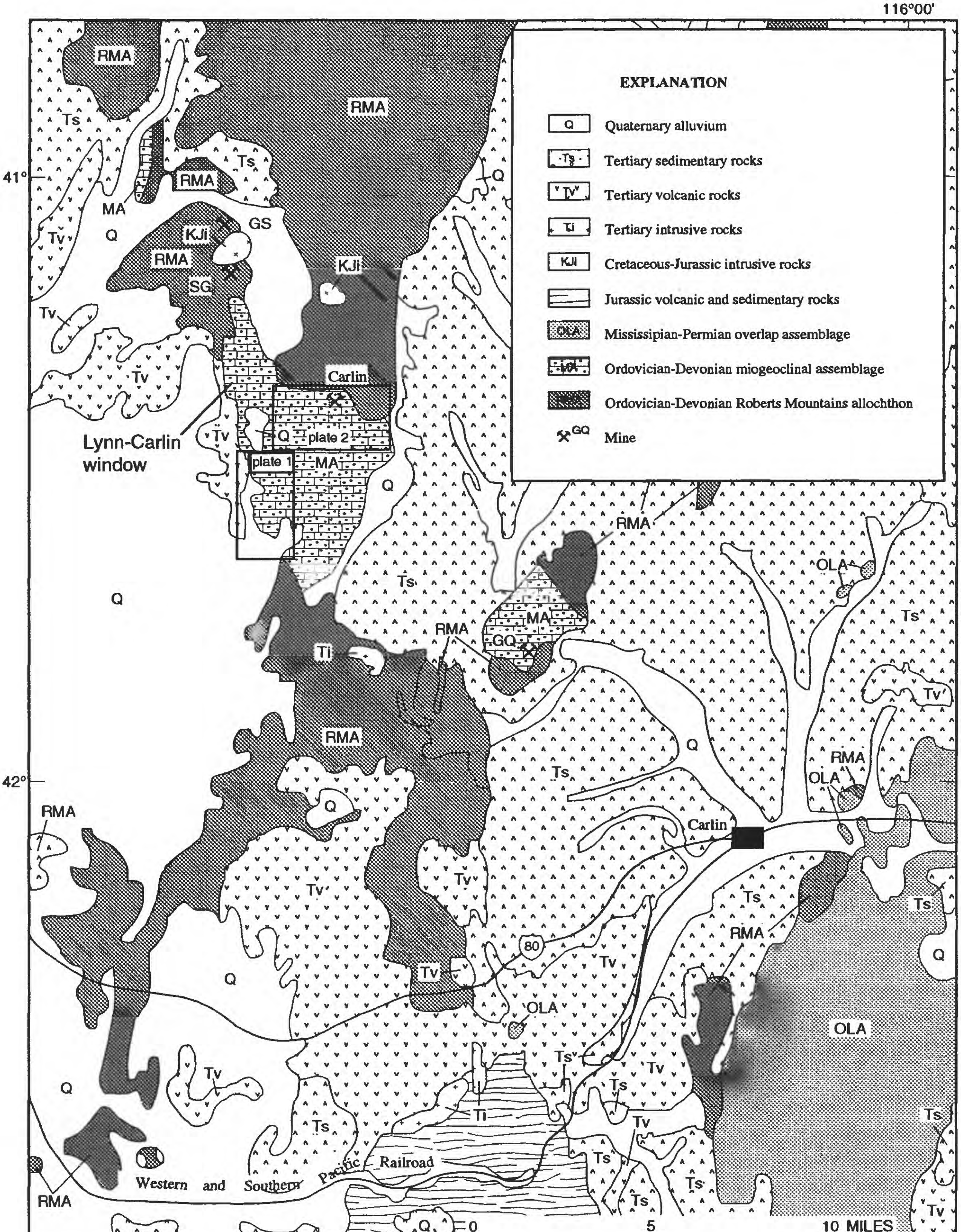
Introduction

This paper describes both outcrop- and district-scale folds, and their structural and geometric relations in the northern part of the Lynn-Carlin window (fig. 1) in the central Carlin trend. Gold deposits are aligned along the Carlin trend in northern Nevada, a northwest-trending belt (Roberts, 1960, 1966; Madrid and Bagby, 1986; Madrid and Roberts, 1990; Thorman and Christensen, 1991), and are associated with Ordovician-Devonian miogeoclinal assemblage rocks in tectonic windows through Ordovician to Devonian rocks in the upper plate of the Roberts Mountains allochthon (fig. 1). Geometric relations of folds between upper and lower plate rocks facilitate interpretation of how the windows formed and may advance the understanding of how the gold deposits are related to deformation styles in and near the windows.

Examples of folds and faults from the Roberts Mountains allochthon, and in the para-autochthonous miogeoclinal assemblage in the West Richmond and Castle Reef fault areas in the Lynn-Carlin window are presented. Premises of the tectonic evolution of the Carlin trend area used in this study to interpret the geometric relations between the structures and are summarized below. Structural data not plotted on plates 1 and 2 and collected for this study are tabulated in Appendix I (West Richmond area) and Appendix II (Castle Reef fault area). Field work was conducted using 1"= 500' outcrop maps, provided by Newmont Exploration Ltd. The maps and illustrations presented are not intended to be definitive representations of the complex geology, but are designed to emphasize and document gross fold geometry in northern parts of the Lynn-Carlin window. The emphasis of the study is on folding and its possible connection to low-angle faults. Numerous high-angle faults are also present in the study area and these geologic features, although important, are assumed to have only local effect on the geometry of the folds.

Structural geologic setting

A number of deformations have affected the rocks in the area of the Carlin trend between Paleozoic to Tertiary time. Each event is reflected in the rocks as fabrics and structures that are products of regional strain. Events in the late Paleozoic are also reflected by stratigraphic unconformities. Fold axes, fold axial planes, shear zones, and tectonized zones produced in each event have unique orientations and styles, although direct correlation between structural styles and age is not always possible (see Thorman and Lund, 1991). A tentative sequence of events is presented below and is based on generally accepted reconstructions of the tectonic history of the region around Carlin. Nev.



fiig. 1. Generalized geology of the Carlin trend, Geology modified from Stewart and Carlson (1976). Rectangles show location of study areas in the northern Lynn-Carlin window described in this report: plate 1 = West Richmond area, plate 2 = Castle Reef fault area. Most mines are located along a NW-trending zone in tectonic windows of lower plate Devonian–Ordovician miosynclinal assemblage rocks (MA), which under lie the Devonian–Ordovician Roberts Mountains allochthon (RMA). The major upper plate unit exposed in the Carlin trend area in the RMA is the Ordovician Vinini Formation. Mississippian–Permian overlap assemblage rocks (OLA) are present in the SE part of the map area. Major mines are noted as follows: GQ = Gold Quarry, SG = Genesis–Blue Star, GS (Goldstrike)

Early and middle Paleozoic, deep-water sedimentary and associated igneous rocks of the Roberts Mountains allochthon were thrust eastward between 75 and 200 km during the late Devonian to early Mississippian Antler orogeny upon coeval, moderate- to shallow-water rocks of the continental platform (fig. 1). These two packages of rocks, the upper and lower plates, are separated by the Roberts Mountains thrust (Roberts and others, 1958). Uplift of parts of the allochthon resulted in the shedding of sediments, that constitute the Mississippian to Permian overlap assemblage, to the east and west (Roberts, 1960; Madrid and others, 1992).

Other reconstructions of the tectonic history suggest early Triassic emplacement of the Roberts Mountains allochthon (Ketner and Smith, 1982; Ketner, 1987; Ketner and Alpha, 1992), and significant tectonism in the region during the late Jurassic Elko orogeny and the Cretaceous to Early Tertiary Sevier orogeny, followed by large-scale extensional detachment faulting in the late Eocene to early Oligocene (Thorman and others, 1991a, b). The following three-phase (D_1 to D_3) generalized sequence of tectonic events for the Carlin trend area has been devised to interpret observations obtained during the current study between the late Paleozoic and late Mesozoic. Multiple orogenies have been combined into these three general deformation events that represent common regional responses to strain. More detailed and less generalized sequences of tectonic events are necessary to interpret the over all complex geology of the region.

Antler-Humboldt deformation (D_1, F_1 folds) is late Devonian to early Pennsylvanian in age (Thorman and others, 1991a) and is responsible for the emplacement of the Roberts Mountains allochthon (Oldow, 1984). The rocks in the allochthon are characteristically isoclinally folded, locally dismembered, transposed, and contain clast-in-matrix rock, mélange fabrics, and shear zones. The Roberts Mountains thrust, which underlies the Roberts Mountains allochthon, is roughly defined by a west-dipping plane with a northwest strike. This deformation style is present predominantly in the upper plate rocks, and is not well-documented in lower plate rocks. Fold axial trends are NW–SE-oriented and mimic F_3, late Mesozoic, window-forming deformation orientation (see below). This D_1 deformation culminated in the Late Pennsylvanian Humboldt orogeny (Ketner, 1977) that formed a north-trending highland producing the overlap assemblage rocks which were shed off it.

Sonoma-Elko deformation (D_2, F_2 folds) represents several orogenies, including the Late Permian to Early Triassic Sonoma orogeny (Silberling and Roberts, 1962) and Late Jurassic Elko orogeny (Thorman and others, 1990). The important characterization of this deformation event—for the discussion of the sequence of tectonic events in the Carlin trend area—is abundant and penetrative NE- and SW-trending, shallow-plunging folds, and NW-trending faults. It is likely that this deformation has affected both the upper and lower plates and overlap assemblage rocks. Rocks in the crystalline basement are not exposed in the region around the Carlin trend, but late Paleozoic to early Mesozoic tectonism of crystalline basement rocks in the Ruby Mountains is likely, according to Snoke (1980) and Lush and others (1988). Many of the folds are broad, cuspate folds with frequencies of between 0.5 and 20 km; however, local, meter-scale bending of F_1 folds is also present. The best example of this style of folding is the NE–SW-trending fold axes in the upper plate rocks to the NE and SW of the Carlin trend, documented by Evans and Theodore (1978) and Evans (1980).

Sevier deformation (D_3, F_3 folds) represents major metamorphic and tectonic events in northeastern Nevada between the late Jurassic and early Eocene (Allmendinger and others, 1984; Ketner, 1984; Snoke and Miller, 1988). In the Carlin trend area D_3 deformation post-dates F_2 NE–SW-trending folds and rotated or refolded many of them to N- and NW-trends, and also produced local development of F_3 shear folds, which are oriented WNW, and plunge at shallow angles to the NE. The relation between F_2 and F_3 folds is demonstrated in figure 2. Shear folding, associated with D_3 deformation, rotated NE-trending F_2 folds to N or NW-trends along a shear zone corridor (see Volk and Lauha, 1993). Discrete D_3 folds are formed locally in the zones of shear. In the Carlin-trend area, these D_3 folds are WNW-trending and dip to the NE between 20° and 40°. This deformation may be partitioned along the length of the Carlin trend, approximately every 3 to 10 km in NW-trending, NE-dipping zones with both right and left lateral shear sense. Examples are the Dillon deformation zone (Peters, 1996) that hosts the Betze orebody in the Goldstrike Mine, and the Castle Reef fault zone (described in this report), south of the Carlin Mine. Internally, the deformation zones contain highly heterogeneous, intense deformation. These WNW-striking shear zones coincide with zones of decalcification, silicification, argillization, dilation, and local mineralization.

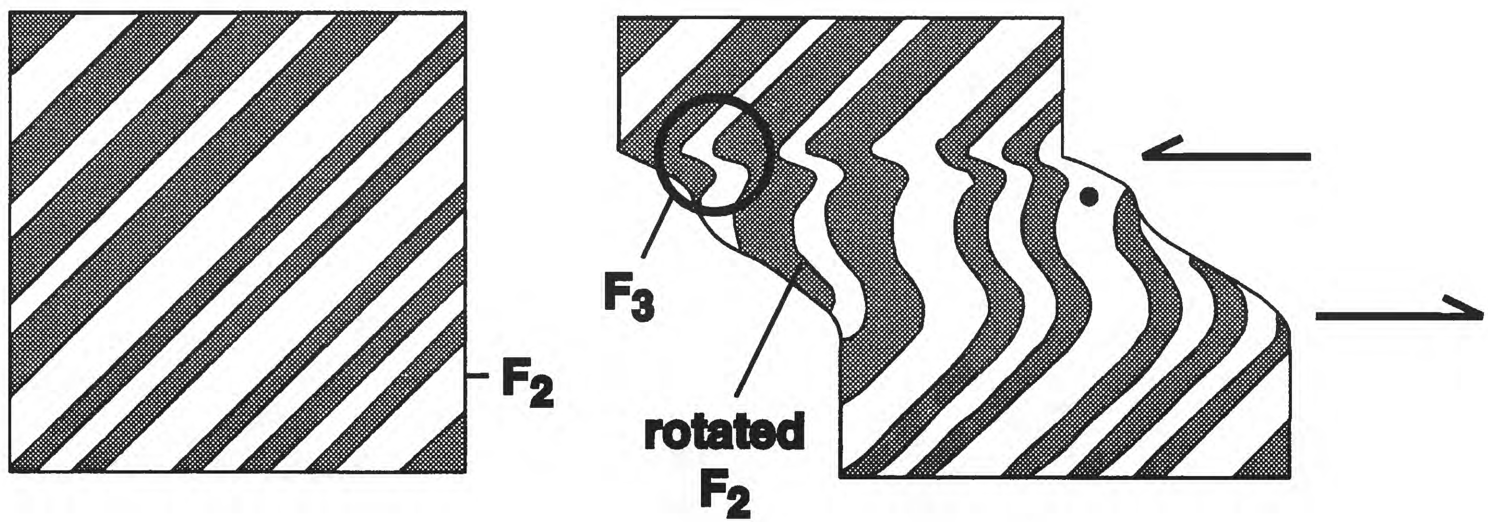


fig. 2. Examples of shear zones forming folds. This shear fold model illustrates the deformation style that may have been present in the Carlin trend area, where the WNW-striking shear zones form a shear fold forming F3 folds and refolding original F2 folds from NE-SW to NW orientations (adapted from Ramsey, 1980).

Summary of Lynn-Carlin window geology

The largest window through the Roberts Mountains allochthon in the Carlin trend area is the Lynn-Carlin window (fig. 1). Lower plate rocks exposed in the Lynn-Carlin window (see Evans 1974a, b, 1980) consist of rocks of the lower most Ordovician Pogonip Group, and possibly Cambrian Hamburg Dolomite, composed of thick-bedded dolomite and thin-bedded limestone, which are overlain by the Ordovician Eureka Formation, a massive, thick-bedded quartzite and sandy dolomite. These rock types are present in the southeastern parts of the window. In the northern part of the Lynn-Carlin window, in the West Richmond and Castle Reef fault areas (pls. 1 and 2), these rocks are overlain by the Ordovician and Silurian Hanson Creek Formation, an approximately 1,000–ft-thick, black to dark gray, fine-grained, thick-bedded to massive dolomite with bioclastic debris and chert. The Hanson Creek Formation is overlain by approximately 1,500 ft of Silurian and Devonian Roberts Mountains Formation, a silty laminated dolomitic limestone that weathers into thin plates, and is generally poorly exposed. The Devonian *unnamed limestone Dl* of Evans (1980), refereed to as the Popovich limestone, overlies the Roberts Mountains Formation, and is composed of an approximately 1,400–ft-thick, platy, laminated, silty dolomitic limestone that is interbedded with thick-bedded, micritic limestone.

The overlying, approximately 400–ft-thick, Devonian Rodeo Creek unit (see Christensen, 1993) is locally in conformable contact with the approximately 350–ft-thick Popovich limestone, and consists of laminated mudstone, siltstone, siliciclastic and cherty rocks, with local limestone. This unit is similar to many of the rocks in the upper plate, and is mapped and described structurally as part of the upper Popovich limestone in this report.

Upper plate rocks are part of the siliceous (western) assemblage of Evans (1980), and are generally assigned to the Ordovician Vinini Formation in the area of the Carlin trend (Madrid, 1987; Madrid and others, 1992). Other western assemblage rocks are also Silurian in age (Evans, 1980). There are two distinct units recognized in the area: (1) an upper unit dominated by cherty mudstone, siliceous mudstone, with lesser sandstone, basalt flows with well-developed pillows near base, and (2) a lower sequence composed of calcareous mudstone, micritic limestone and shale. These rocks are usually more tightly folded or tectonized than lower plate rocks, and in the area of plates 1 and 2 consist of light gray cherty limestone with sand and grit-sized chert clasts and gray to white to black, thin-bedded to massive chert. Some rocks mapped as Ordovician Vinini Formation may also include tectonically imbricated siliceous Devonian and Silurian rocks.

Mesozoic to Tertiary(?) dikes intrude along the zone of the Roberts Mountains thrust in high-angle faults in the West Richmond area, and transect the Carlin Mine area, but are not shown on plates 1 and 2.

High- and low-angle faults are common in both the West Richmond and Castle Reef areas. These faults are sometimes related to the folding; for instance, the faults may lie parallel to axial planes or fold axes, and therefore many of the faults complement rather than disrupt the fold geometries. In some cases, faults may have been reactivated by younger movement. It is not clear whether some of the fold forms portrayed on plates 1 and 2 are valid representations of folds, or whether changes in bedding attitude are the result of local fault rotation. The position of the Roberts Mountains thrust is not agreed upon by all workers in the district, primarily because of the difficulty in distinguishing between rocks of the Rodeo Creek unit in the lower plate and the rocks of the Vinini Formation in the upper plate. The precise location of the Roberts Mountains thrust on plates 1 and 2, is therefore open to question.

West Richmond area (pl. 1)

The West Richmond area, on the western part of the northern Lynn-Carlin window, consists of low rolling hills in the west parts that are underlain by Tertiary quartz latite (pl. 1). Valleys in these western foothills of the Richmond Hills are filled with Quaternary gravels that over lie the quartz latite (see Evans, 1980). Upper plate rocks of the Vinini Formation are exposed east of the Tertiary quartz latite and give way to lower plate rocks of the Popovich limestone and Roberts Mountains Formation beneath the north-striking, west-dipping Roberts Mountains thrust.

The Lynn-Carlin window is partially bordered on the west by the east-dipping West Lynn thrust and the Sheep Creek Canyon fault (Evans, 1974a). The West Lynn thrust truncates the west-dipping Roberts Mountains thrust and is interpreted to dip at a shallow angle under the Lynn-Carlin window by Evans (1974a, 1980) and Peters and Evans (1995), and to repeat the Popovich limestone and Roberts Mountains Formation at depth. An alternate interpretation is that the West Lynn thrust is steep-dipping and therefore does not underlie the Lynn-Carlin window or repeat the upper parts of the lower plate stratigraphy. East of the West Lynn thrust, topography steepens markedly and the stratigraphic sequence is reversed by thrust faulting. Rocks of the Popovich limestone west of the West Lynn thrust lie below the Roberts Mountains Formation, which are in turn over thrust by the Hanson Creek Formation (pl. 1).

The West Richmond area was divided into seven structural domains for this study, based on lithologic or structural boundaries (Areas 1 to 7 on pl. 1; see also Appendix I). Bedding attitudes within each structural domain were compiled and plotted on stereographic nets. Fold axial planes were estimated from map or outcrop patterns, and fold axes for individual folds, and for bedding attitudes within each structural domain, were calculated from stereographic nets. Peters (1996) postulated that fold axes in the upper plate rocks should plunge NE and SW along the western part of the West Richmond area, and should plunge NW in the upper plate rocks in the eastern part of the West Richmond area. Folds in the area were compiled and mapped structurally to test this hypothesis.

AREA 1 (West Richmond area, pl. 1)

Area 1 in the central parts of south Sec. 21 and Sec. 28, T. 35 N., R. 51 E. lies on a NW-trending hill (pl. 1). The eastern part of the hill is composed of Popovich limestone, the central part is capped by laminated, folded chert that is either Rodeo Creek unit, or Vinini Formation. The western flank is composed of silty, locally cherty limestone, and further to the west, cherty limestone.

Field work and data collection in Area 1 consisted of acquisition of strikes and dips on surface outcrops, in three trenches on the northern flank of the hill, and from detailed sketches and analysis of chert outcrops on the northern tip of the hill (pl. 1; fig. 3; Appendix I). The area was subdivided into three subdomains: (1) Popovich limestone; (2) central, laminated chert; and, (3) footwall silty and cherty limestone. Detailed sketching and analysis was conducted on chert outcrops on the hill in Area 1 to determine the nature of the folding (fig. 4; pl. 1), and to determine if the results were similar to analysis of random strike and dips in Area 1.

Bedding attitudes west of the Roberts Mountains thrust have a general, NW strike and a moderate to steep NE dip with a resultant fold axis, based on these readings, trending NW with shallow plunges (fig. 3; Appendix I). Rocks of the Popovich limestone have attitudes that strike NNW with moderate dips to the west, and a fold axis that plunges shallowly to the NW (fig. 3; Appendix I). The resultant fold axes from the Popovich limestone and the allochthonous and para-allochthonous rocks to the west are similar, even though the bedding attitudes are different on either side of the Roberts Mountains thrust.

Two main types of folding are present in the laminated chert outcrop (fig. 4): (1) tight, repetitive, isoclinal folds with NW orientations (F_1?), and (2) broad, cylindrical folds, which refold the isoclinal folds about NE-trending axial planes (F_2). Some of the isoclinal folds have axial planes that have been rotated from steep angles to very shallow angles, and may represent a third type of folding, although this is probably attributable to F_1 folding.

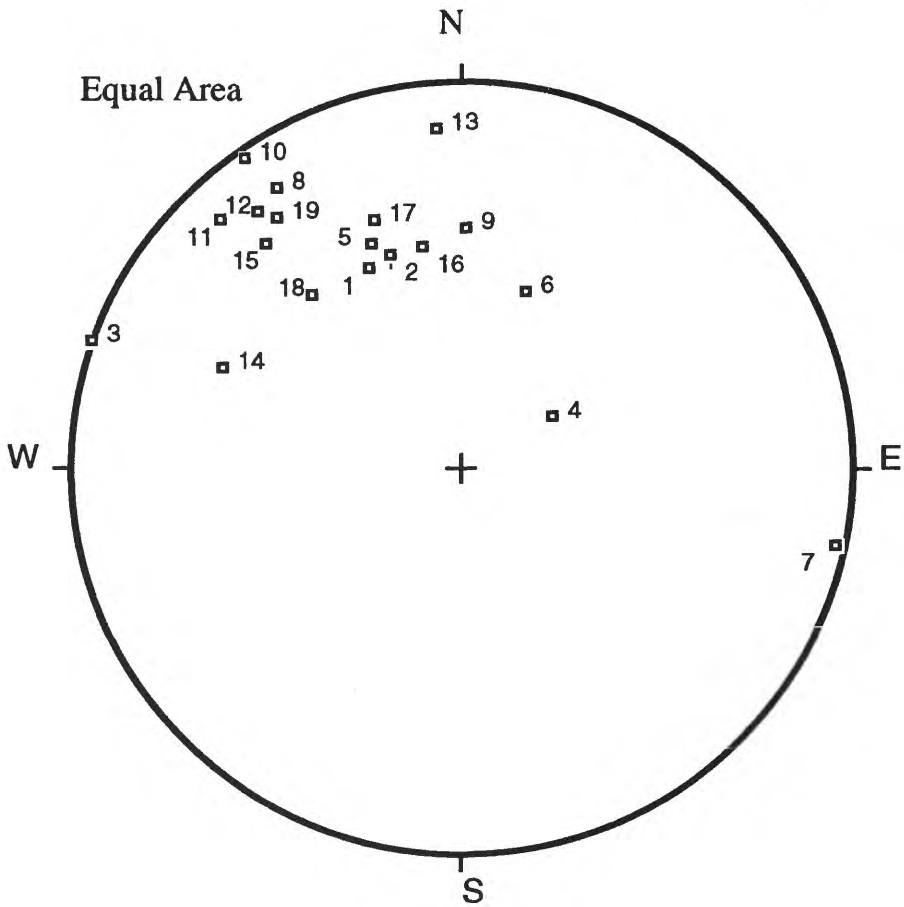


figure 3. Stereographic net of structural linear elements in the West Richmond area. Areas are coded to boxes:

box no	strike	plunge	description
1.	335 °	43°	total outcrop study area (chert)
2.	342°	42°	outcrop study area, part *a*
3.	289°	00°	outcrop study area, part *b*
4.	60°	68°	outcrop study area, part *c*
5.	338°	38°	outcrop study area, part *d*
6.	20°	50°	outcrop study area, fold in part *b*
7.	102°	02°	outcrop study area, fold in part *b*
8.	327°	15°	total trenches
9.	01°	38°	trench 1, all units
10.	325°	03°	trench 2, all units
11.	316°	12°	folds in chert, trench 2
12.	322°	17°	folds in chert, trench 2
13.	356°	13°	folds in chert, trench 2
14.	293°	34°	trench 3, all units
15.	319°	25°	surface mapping data (Newmont)
16.	350°	42°	outcrop study area, F_1 fold axes, pt *c*
17.	341°	33°	cherty limestone unit
18.	319°	41°	Popovich limestone
19.	324°	21°	chert unit

Statistical average of a fold axis for all the bedding attitudes in the outcrop (fig. 4) is 335°/43° NW. The outcrop was divided into four separate areas, *a*, *b*, *c*, and *d*, and the individual fold axes calculated in these areas is *a* = 342°/42° NW, *b* = 289°/0°, *c* = 60°/68° NE and *d* = 338°/38° NW (figs. 3 and 4; Appendix I). The interpretation of these data is that the early, NW-trending, isoclinal folds are related to a D_1 pre- or syn-Roberts Mountains thrust emplacement. This attitude is parallel to and coincidentally mimics the rotated NW-trending F_2 folds of the D_3 event, in the windows. The isoclinal character of the west-trending folds, however, is typical of upper plate rocks, and these F_1 folds are locally refolded by NE-trending, broader F_2 folds. The NW-trending isoclinal folds contain numerous bedding planes—due to the laminated nature of the chert, and repetition caused by the isocline—and therefore give the outcrop statistical NW-trending fold axis direction.

Bedding attitudes in three trenches north of the folded chert outcrop (pl. 1) were taken at about 1 m intervals. When a highly folded area was encountered in the trenches, or where individual folds were evident, bedding attitudes were collected around the fold. These individual folds were analyzed separately. The combined fold axis for all three trenches, resolved on stereographic net, is 327°/15° NW (fig. 2; Appendix I).

The three trenches had slightly differing fold axis resolutions: *Trench 1* = 1°/38° N; *Trench 2* = 325°/3° NW; *Trench 3* = 293°/34° NW. The more northerly strike of the calculated fold axis from all bedding attitudes in upper plate rocks in Trench 1 is interpreted to reflect a higher statistical number of F_2 (NE-trending) refolding in the sample population. This orientation is representative of F_2 folding and is theoretically where all the fold axes should lie, if the sample populations were not biased by the numerous laminated and isoclinal surfaces. Although ambiguous, because of this bias, chert and rocks to the west are interpreted as part of the structural upper plate. Similar fold axes in data randomly acquired in trenches, and in folds in detailed outcrops, where geometry is better understood, suggest that statistically large numbers of bedding attitudes in some upper plate rocks can be taken at random and may be indicative of the general grain of the rock mass (see Peters, 1997).

The chert unit at the top of the hill is mapped as fault-bounded by Evans (1974b) and is correlated with the Rodeo Creek unit by local workers (Steve Moore, oral communication, 1995). The silty limestone is correlated with Roberts Mountains Formation by Evans (1974b, 1980). The cherty limestone in the far west is correlated by Evans (1980) as calcareous members of the upper plate Vinini Formation (pl. 1).

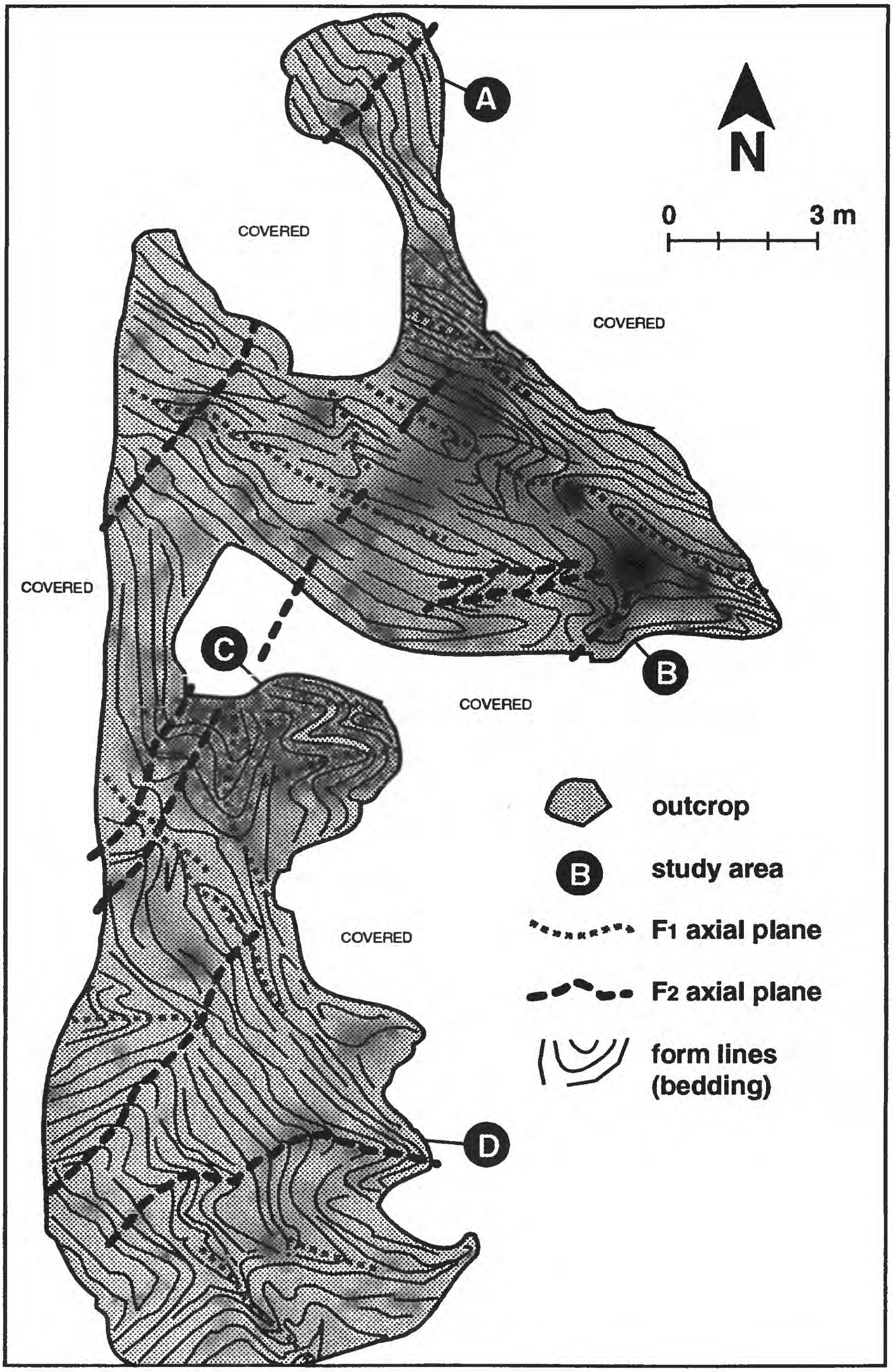


fig. 4. Sketch of outcrop of folded chert, West Richmond area, Area 1 (pl. 1).

The results of this study suggest an alternative assignment of lithology to that previously assigned. Based on similarities of rock types with rocks on the west side of the Roberts Mountains thrust (pl. 1), and those in the Vinini Formation at Beowawe turnoff (Peters, 1996, 1997), all rocks west of the chert–Popovich limestone contact may belong to the upper plate because: (1) deformation is intense in these rocks, particularly the silty limestone and chert, showing tight isoclinal folds, and bedding transposition, and is similar in orientation and style to upper plate rocks; and (2) lithology is also similar to Vinini Formation rocks, particularly black, massive chert in the cherty limestone, as well as laminated chert.

AREA 2 (West Richmond area, pl. 1)

Area 2 lies between the West Lynn thrust and Roberts Mountains thrust, and consists of lower plate Popovich limestone conformably overlying Roberts Mountains Formation (pl. 1). Rocks of the Popovich limestone are markedly folded and contain unusual fold axis orientation resolved from stereographic net (fig. 5) with steep plunges to the south (189°/53° S). Rocks of the Roberts Mountains Formation contain bedding attitudes with a NW-plunging fold axis of 314°/23° NW, with more normal, shallow plunges (fig. 5; Appendix I).

Area 2 is the only domain in the West Richmond area (pl. 1) where Popovich limestone rocks may comformably overlie the Roberts Mountains Formation. The dissimilarity of fold orientations in these two lower plate units suggests that they could represent two tectonic packages, rather than a stratigraphic succession in this area. Elsewhere, the sequence is reversed tectonically, with older rocks over younger rocks.

In the south part of the West Richmond area, rocks of the Popovich limestone and Roberts Mountains Formation may pinch out tectonically between the Roberts Mountains and West Lynn thrust faults to the south (pl. 1). In the north part of Area 2, rocks of the Popovich limestone lie on the hill flanks on the east and on the west of the Quaternary basin, where a broad, (south-plunging?) synform is suggested by form lines on the east and west of the basin.

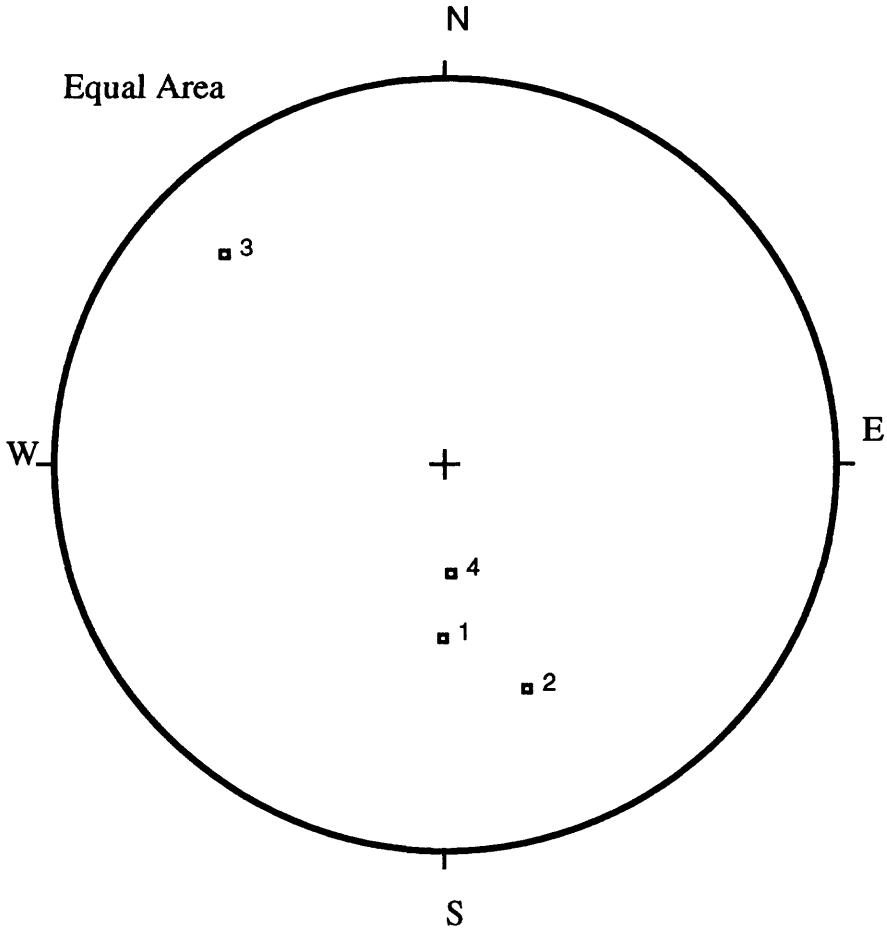


fig. 5. West Richmond area, Area 2 (pl. 1). Stereographic net summary structural linear elements. Number keyed to boxes.

no.	strike	plunge	description
1.	180.0°	53.0°	Popovich limestone
2.	160.0°	38.0°	folded area SE part Popovich ls
3.	314.0°	23.0°	Roberts Mountains Formation
4.	176.0°	67.0°	Total Area 2

AREA 3 (West Richmond area, pl. 1)

Area 3 is located in a 2–mile-long, 1/2–mile-wide, NW-striking fault slice of rocks of the Roberts Mountains Formation, bounded on the west by the West Lynn thrust, and on the east by another thrust fault that has emplaced the rocks of the Hanson Creek Formation above the Roberts Mountains Formation (pl. 1). The rocks in Area 3 are deformed into open, gentle, multiple folds with fold center frequencies of several hundred feet. The northern tip of this structural domain is a complexly folded nose of a north-plunging anticline. Jasperoid is prominent on the west margin of Area 3, that parallels the West Lynn thrust, as well as in the northwestern fold nose, and along the east-bounding thrust (pl. 1). There is a tendency for the fold axes of more intensely deformed, and more jasperoidal rocks to trend to the NW, rather than to the N.

Area 3 was subdivided into three subdomains (*a*, *b* and *c*), and fold axis-resolutions were determined for each domain (fig. 6; Appendix I). Two best-fit planes were constructed to fit all of the fold axes in Area 3 (323°/47° E) and to fit the composite fold axis that lies in the saddle of the girdle from Kamb contours of bedding poles (232°/34° E). These hypothetical planes have similar strikes to the West Lynn thrust, and suggest that if the thrust fault were coincident with the linear grain of the folding, it would dip between 34° and 47° E. This interpretation is compatible with that originally proposed by Evans (1974b, 1980) and suggested by Peters and Evans (1995). Exposures of vertical faulting are present, however, along parts of the trace of the West Lynn thrust (Newmont Exploration Ltd., oral communication, 1995), which suggests that part of the West Lynn thrust may be vertical or that subsequent, steep-angle faults have been superposed on an earlier, shallow, east-dipping fault.

AREA 4 (West Richmond area, pl. 1)

Area 4 lies in the southwest part of the West Richmond area, west of the Roberts Mountains thrust, and contains upper plate rocks of the Vinini Formation (pl. 1). The area is the same as *Area 4* in Evans and Theodore (1978). Bedding attitudes yield a NNW-striking fold axis that plunges 29° to 349°. Two possible interpretations are: (1) that this fold axis is rotated from the NE as it approaches D_3 deformation in the window, and is rotated along the margin of the window, or (2) it is a hybrid of an original F_1 fold in the allochthon that has been rotated to the northeast, but statistically the tight isoclinal folds with in it produce a NNW orientation when combined with the F_2 folds, similar to Area 1.

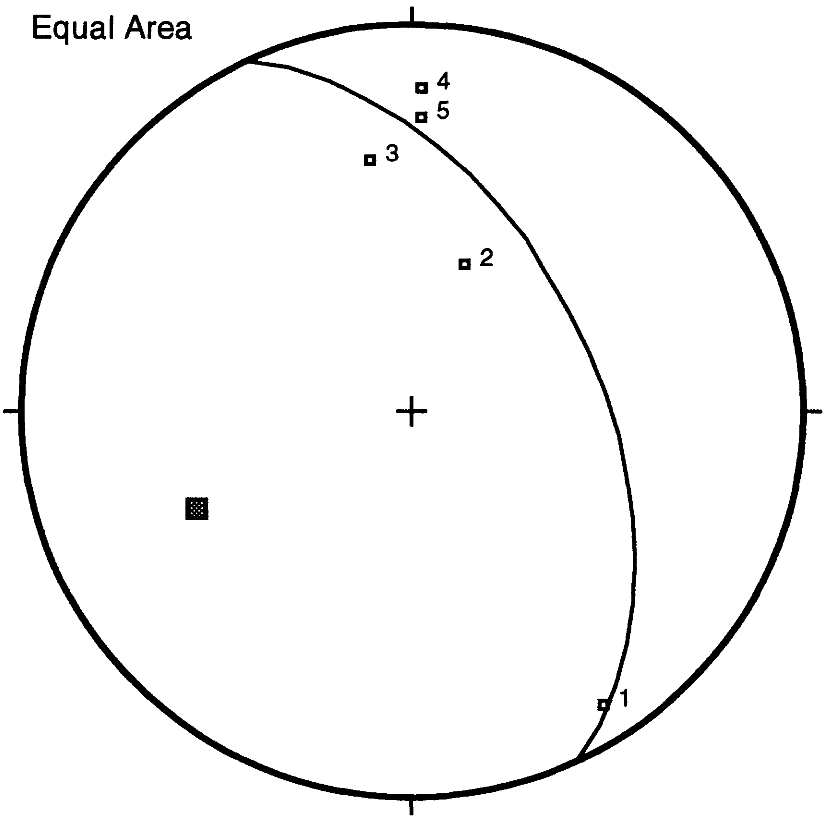


fig. 6. West Richmond area, Area 3 (pl. 1). Stereographic net summary of structural linear elements. Area 3*a* represents the jasperoidal, fold nose in the northern part of Area 3, and contains a fold axis that trends NW–SE. Area 3*b* lies on the northwest jasperoidal margin of Area 3, and was separated to determine if folding has focused the thrust faulting that lies to the immediate northeast (pl. 1). Area 3*c* contains bedding attitudes that lie in the rest of Area 3 to the south. The best fit plane approximates the attitudes of the bounding thrusts. Numbers keyed to boxes.

no.	**strike**	**plunge**	**description**
1.	147.0°	10.0°	N part of part *3a*
2.	20.0°	57.0°	part *3b*, E
3.	351.0°	35.0°	part *3b*, W
4.	2.0°	18.0°	part *3c*
5.	2.0°	25.0°	total Area 3

AREA 5 (West Richmond area, pl. 1)

Area 5 is restricted to rocks of the Hanson Creek Formation on the east part of the West Richmond area, with the exception of a narrow zone in the west parts of the unit adjacent to the West Lynn thrust (pl. 1). Area 5 is bounded on the west by thrust faults that separate rocks of the Hanson Creek Formation from the Roberts Mountains Formation and the Popovich limestone. Form lines in Area 5 define several 0.5–mile-wide, broad pairs of anticlines and synclines with NW-striking fold axial planes (pl. 1). Bedding attitudes were combined in each of Secs. 22, 27 and 34, T. 35 N., R. 51 E., and resolved by stereographic net separately to produce shallow-plunging, north-striking fold axes that lie within the axial planes of the broad folds (Appendix I). Bedding attitudes in all of Area 5 yield a fold axis that trends to the north (356°/28° N).

The N-trending orientation of folds in Area 5 is similar to those in Area 3. An interpretation of their orientation is that they are F_2 folds that have been partially, but not completely rotated to the NW. The folds in Area 5 are of similar size and amplitude to the (F_2?) Post and Tuscarora anticlines to the north (Volk and others, 1996; Schutz and Williams, 1996). The reason that they are only partially rotated may be because they are on the western side of the window, where deformation was not as intense, or that they are exposed in more competent stratigraphic units that are less conducive to deformation.

AREA 6 (West Richmond area, pl. 1)

Area 6 is composed of the Roberts Mountains Formation and is a smaller version of Area 3, bounded on the west by the West Lynn thrust, and bounded on both the north and south by NW–trending, NE–dipping thrust faults (pl. 1). Most outcrops near the thrust faults are jasperoid. Bedding attitudes in Area 6 resolve on stereographic nets to a fold axis of 315°/25° NW, which approximates the fold trends in the Tuscarora Spur, where the Lynn-Carlin window plunges to the north (Peters, 1996).

The NW orientation of the resolved fold axis in Area 6 may be an artifact of a small population of bedding attitudes, or may be due to more intense deformation and rotation along the NW- and WNW-striking thrust faults that bound it on the north and south (pl. 1). The jasperoidal nature of the outcrops, coincident with the more NW orientation of folding, suggests that fluid flow and deformation may be related.

A composite of fold axes derived from subdomains and individual folds from Areas 3 and 6 was fitted to a best fit WNW-striking plane (data from Appendix I). The planar surface that contains these fold axes is similar to the interpreted attitude of the thrust faults, which indicates that the thrust faults could be coplanar with the fold axes in these two areas. The fit is good, and infers that the WNW-striking thrust faults may have 30°- 40° NE dips, and either moved during formation of the folds or broke along weaknesses in the fabric of the folds.

AREA 7 (West Richmond area, pl. 1)

Area 7 lies within and on the margin of Area 5, and represents local deformation of the Hanson Creek Formation against the West Lynn thrust. Bedding attitudes change abruptly from E-W-striking to N-striking and steepen next to the thrust, which suggests more intense deformation near the thrust. A fold axis stereographic net resolution of data in Area 7 contains a fold axis with an orientation of 14°/22° N. This fold axis is coplanar with an hypothetical shallow-dipping orientation of the West Lynn thrust.

Castle Reef fault area (pl. 2)

The Castle Reef fault area lies in the northern part of the Lynn-Carlin window and was divided into three areas of study: (1) Castle Reef fault zone, (2) Carlin Mine area, and (3) Spur area (pl. 2). The Castle Reef fault area contains upper plate Vinini Formation in the north and in the east part of the area, where these rocks are down-thrown on the NW-striking Leeville fault zone (pl. 2). These rocks are separated from the lower plate Popovich limestone and Rodeo Creek unit by the Roberts Mountains thrust (pl. 2), and, in turn, are overlain by the Roberts Mountains Formation, Hanson Creek Formation, and locally by the Eureka Formation in the south part of the area (pl. 2). The Popovich limestone and Rodeo Creek unit also lie in folds in the Spur area and at the Carlin Mine. These rocks may also be present in another folded area in the triangle-shaped zone between the Castle Reef and Leeville faults near the Pete deposit (pl. 2). The Castle Reef fault zone cuts the Roberts Mountains Formation near the bottom parts of the unit.

The Castle Reef fault area was selected for study because it is adjacent to the West Richmond area and represents the eastern part of the northern Lynn-Carlin window (fig. 1). The Castle Reef Fault zone has a WNW strike, similar to post-Jurassic (D_3) shear zones and folds in the Dillon deformation zone that host the Betze orebody to the north in the Goldstrike Mine (Peters, 1996). These shear zones and folds were also postulated to be partially or wholly responsible for rotation of regional folds into the fold orientations observed along the Carlin trend. Study along the Castle Reef fault zone was designed to determine if it had similar features to shear zones and associated folds in the Goldstrike Mine. Field work was conducted in the Castle Reef Fault zone area, and the other two areas on plate 2 were compiled from data supplied by Newmont Exploration Ltd., from Radtke (1973, 1980), and Evans (1974a), with some field checking.

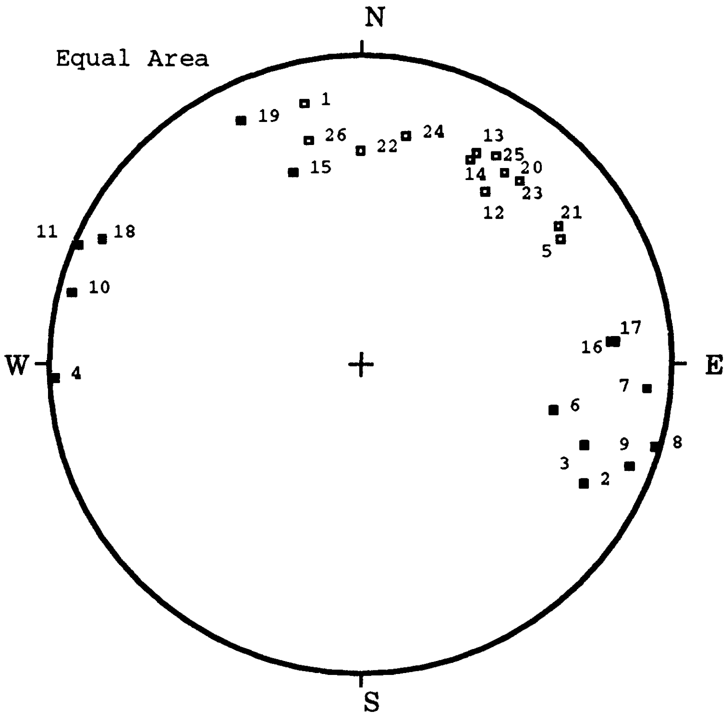


fig. 7. Stereographic net summary of structural linear elements in the lower plate rocks Castle Reef fault area. Dark squares represent fold axes that lie within the Castle Reef Fault zone. The scatter cloud of fold axes is interpreted to approximate the surface of the Castle Reef fault zone, and indicates a shallow-dipping shear fold, dipping to the NE, rather than a steep-dipping fault. Numbers keyed to boxes.

no.	**strike**	**plunge**	**description**
1.	348.0	15.0	Area 1, hanging wall to Leeville fault
2.	118.0	19.0	Area 2 w/o small folds
3.	110.0	24.0	Area 2 w/ small folds
4.	267.0	2.0	small fold A
5.	58.0	25.0	best fit great circle to fold A
6.	104.0	36.0	small fold B
7.	95.0	8.0	Area 3 w/o folds
8.	106.0	1.0	Area 3 w/ folds
9.	111.0	8.0	small fold C
10.	284.0	5.0	small fold D
11.	293.0	2.0	small fold E
12.	36.0	32.0	Areas 3 & 4, lobe of Popovich ls
13.	29.0	23.0	lobe plus rest of Popovich ls
14.	28.0	26.0	above plus Area 5
15.	341.0	35.0	small fold G
16.	85.0	20.0	Area 5 (partial)
17.	85.0	19.0	Area 6
18.	296.0	9.0	Area 7 (partial)
19.	334.0	14.0	Area 7 - total
20.	37.0	24.0	Area 8 - Hanson Creek Formation
21.	55.0	23.0	Area 9 "
22.	0	32.0	Area 10
23.	41.0	23.0	Areas 8 and 9 (total Hanson Creek Fm)
24.	11.0	26.0	Area 11 Roberts Mountains Formation
25.	33.0	21.0	Area 12 Popovich ls within Leeville fault
26.	347.0	27.0	Area 13 Rodeo Creek unit E of Leeville fault

The area within and around the Castle Reef fault zone was subdivided into 13 structural domains, based on lithologic and structural boundaries. The zones are indicated on plate 2 as circles. In each of the structural domains (Areas), bedding attitudes were tabulated and plotted on stereographic nets and fold axes were calculated (Appendix II). The main fold axes for each of the structural domains are plotted on plate 2. Fold axes, resolved by stereographic net for mixtures of bedding attitudes from several areas, as well as tabulation of all the structural elements in each Area, are contained in Appendix II and plotted on figure 7.

Area 1 (Castle Reef fault zone, pl. 2)

Area 1 lies in the hanging wall of the Castle Reef fault zone, where it is joined by the NW-striking Leeville fault zone (pl. 2). Bedding strikes N and dips both to the E and to the W, but also locally strikes more E-W with N dips. The resolved fold axis by stereographic net has a northerly strike and a shallow plunge (fig. 7, Appendix II), which is consistent with folding suggested by the bedding attitudes and form lines (pl. 2). The fold axes within this zone would be roughly coplanar with both the Leeville Fault and the Castle Reef fault zones, if the Castle Reef fault zone had a shallow dip to the NE.

Areas 2, 3, 4, 5, 6, and 7 (Castle Reef fault zone, pl. 2)

Areas 2 through 7 lie within the WNW-striking Castle Reef fault zone. The zone contains numerous hard, brown jasperoidal outcrops in Secs. 2 and 30, T. 35 N., R. 51 E. (pl. 2). The jasperoidal outcrops are present throughout the NW-trending zone, but are most prominent at the margins, and define hangingwall and footwall boundaries to the Castle Reef fault zone. The jasperoids are tightly folded and contain both dense, silicified breccia and open-space brecciation. Local white, milky, dense quartz veins and zones of stibnite- and barite-bearing breccia are contained in some jasperoid outcrops. In the center of the Castle Reef fault zone, many of the folds have similar fold axis orientations to the rest of the zone, but are unsilicified.

Individual, outcrop-scale folds within these areas were also measured and are labeled **A** through **G** in squares, and fold axes are plotted with smaller arrows (pl. 2; fig. 7; Appendix II). Coincidentally, the entire array of fold axes shown on figure 7, roughly define a the plane of the Castle Reef fault zone. This indicates that the Castle Reef fault zone is genetically and spatially related to folding in the northern Lynn-Carlin window.

The fold axes calculated and measured within the Castle Reef fault zone have relatively consistent WNW or ESE trends and shallow plunges (fig. 7; pl. 2). The strike of the fold axes defines the strike of the Castle Reef fault zone, are coplanar with it, and are oriented roughly perpendicular to fold axes that strike to the NE in the hangingwall, and those that strike to the SW in the footwall of the fault zone (pl. 2). The coincidental occurrence of both jasperoidal and altered rocks and WNW-tending fold axis orientations within the Castle Reef fault zone, indicates that fluid flow either accompanied deformation in the zone, or preferentially penetrated the zone after deformation.

The consistent WNW–ESE orientation of folds in the Castle Reef fault zone differs from fold orientations to the north and to the south. This suggests that the Castle Reef fault zone may be a shear fold, because the WNW–ESE-trending folds are contained entirely in the fault zone. The folds contained within the zone would be analogous to F_3 folds shown on figure 2. The ductile style of the folds within the Castle Reef fault zone is not compatible with brittle, gouge-filled, steep-dipping faults present in northwestern parts of the Castle Reef fault zone. This brittle faulting may be superimposed on the shear folds.

Areas 8 and 9 (Castle Reef fault area, pl. 2)

Areas 8 and 9 are in the footwall of the Castle Reef fault zone near the contact between the Hanson Creek Formation and Roberts Mountains Formation. Broad folds, similar to those in the Hanson Creek Formation in the West Richmond area (pl. 1), are present in these two areas, and have shallow-plunging fold axes and axial planes that strike to the NE (pl. 2; fig. 7; Appendix II). The NE-trending axial planes are truncated by the Castle Reef fault zone that has tighter folds, which trend roughly perpendicular to those in Areas 8 and 9 (pl. 2).

Area 10 (Castle Reef fault area, pl. 2)

Area 10 lies to the SW of the Castle Reef fault zone along strike of the fault, but slightly in the footwall. The trace of the Castle Reef fault to the NW, north of Area 10, is obscured by dumps from the Carlin Mine (pl. 2) and may be offset by NE-striking faults. The fold axes calculated from bedding attitudes in this area are N-trending (pl. 2; fig. 7). The most northwesterly fold axis in the Castle Reef fault on plate 2 (Area 7, and fold G) also has a more northerly trend than the other parts of the fault zone (fig. 7; Appendix II). Jasperoid in Area 10 may also represent deformation and fluid flow near the contact between the Roberts Mountains Formation and the Hanson Creek Formation, rather than an extension of the Castle Reef fault zone.

Areas 11, 12, and 13 (Castle Reef fault area, pl. 2)

Areas 11, 12, and 13 lie in and adjacent to the Leeville fault zone at the Pete deposit (pl. 2). Fold axes resolved on stereo net from bedding attitudes in each of these areas have shallow NNE and NE plunges. In addition WNW-plunging folds are present (Newmont Exploration Ltd., written communication, 1996). These shallow-plunging folds are probably not coplanar with the Leeville fault, unless the Leeville fault has a shallower dip as it joins the Castle Reef fault zone to the southeast (pl. 2). The fold axes, however, would be coplanar with a shallow-dipping Castle Reef fault zone (fig. 7; pl. 2).

Carlin Mine area (pl. 2)

In the Carlin mine area (fig. 1), the Roberts Mountains Formation and the Popovich limestone contain fold axes that characteristically plunge at low angles to the NW (Peters and Evans, 1995; Peters, 1996). The Vinini Formation in the allochthon, however, contains fold axes that plunge at low angles to the NE (Appendix II). The Carlin Mine area was analyzed, using data from Radtke (1973), and additional data was taken from an outcrop on the east side of the mine called the mélange zone (fig. 8; pl. 2).

Dips of bedding in the upper and lower plate rocks were contoured in the mine area. Contour intervals define lower plate monoclines, to the W and E of the mine, that are separated by a zone in the center of the mine area in which the dip angles of bedding are very low. This geometry is interpreted as NW-trending folds, the axial planes of which are intruded by NW-striking dikes (not shown on plate 2; see Radtke, 1973). The orebodies are near the contact between the Roberts Mountains Formation and Popovich limestone at the crest of the monocline where the dips flatten along the 45° dip-contour, and in the NW-trending trough in the center of the monocline, between the two monoclinal limbs.

Many deformed rocks, particularly in the upper plate rocks of the Roberts Mountains allochthon near the Carlin trend, have characteristics that are similar to mélange (Peters, 1996, 1997). Mélange is a general term describing a mappable body of fragmented and mixed blocks, typically contained within a scaly, shaley matrix, commonly called *clast-in-matrix rock* or *brokenite*. Obscure stratigraphic relationships and bedding chaos are developed to such an extent that the laws of lateral continuity and superposition are not generally applicable (Hsu, 1968), although outcrops usually retain symmetrical fabrics.

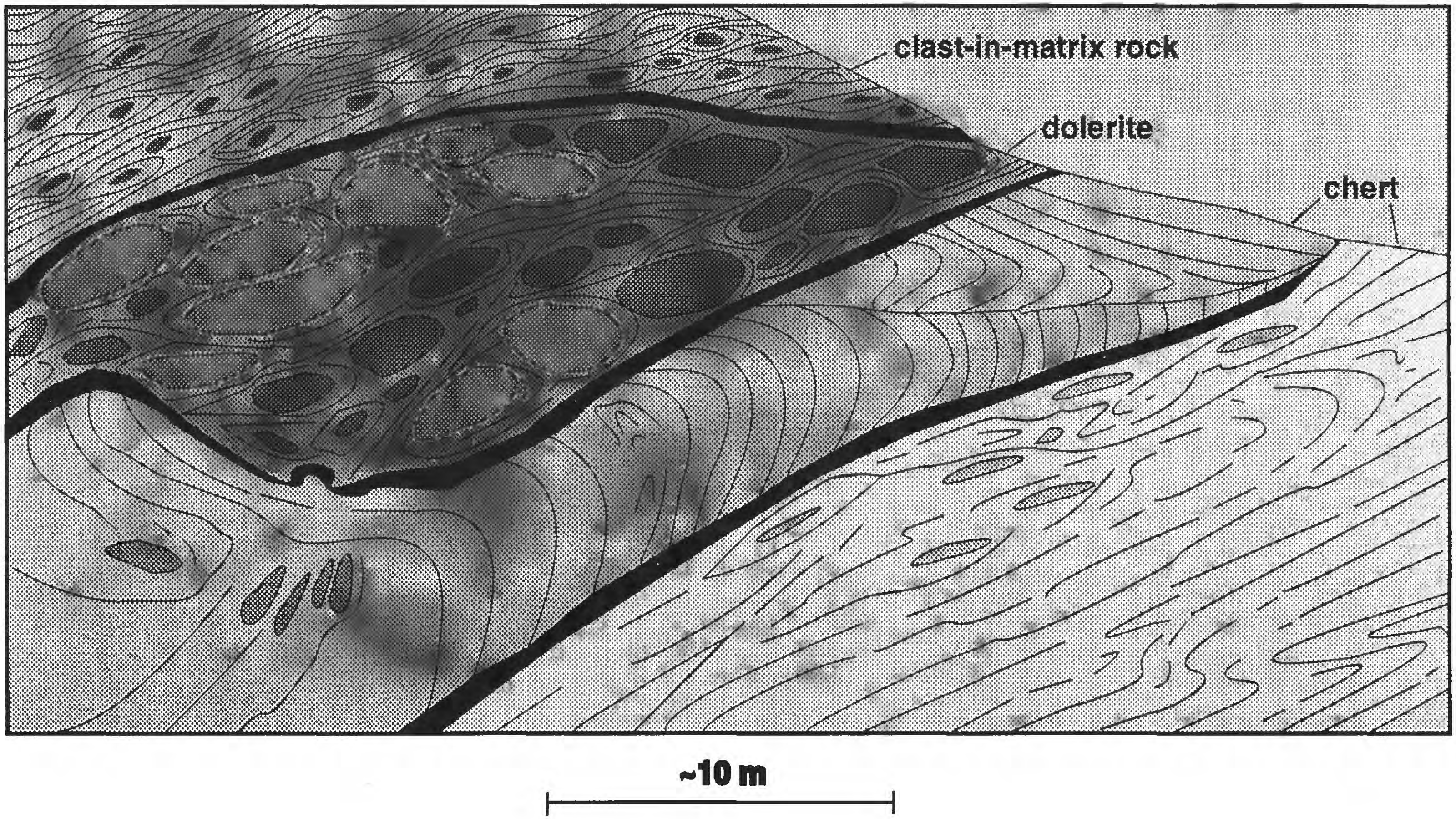


fig. 8. Sketch of Carlin Mine mélange, Carlin Mine area. Four rock packages are: (a) lower laminated isoclinally folded siliciclastic (chert); (b) cylindrically folded siliciclastic (chert); (c) latitic dacite (dolerite) deformed into phacoids; and, (d) black carbonaceous clast-in-matrix rock, containing <20% white, siliceous, 10 cm-scale phacoids in a planar phyllonitic matrix. Each package is separated by a shallow-dipping shear zone (dark heavy lines). Fold orientations in each package are NE–SW, shallow plunging (see text). Adapted from Peters (1996).

An outcrop of Vinini Formation on the east side of the Leeville fault zone in the Carlin Mine contains low-angle shear zones, which separate several 4- to 20-m-thick slabs of deformed rocks (fig. 8). The juxtaposition of distinctly different deformation styles and rock types on either side of the shear zones suggests that significant transport is likely to have taken place in the rock mass. Axes of folds in all the rocks in the outcrop, regardless of slab, plunge at low angles to the SW and are parallel to fold axes in deformed rocks of the Vinini Formation north of the Carlin Mine (Appendix II).

Spur area (Castle Reef fault area, pl. 2)

The Spur area lies to the south of the join between the Sheep Creek Canyon fault and the NW-projection of the Castle Reef fault zone (pl. 2), where Evans (1974a) indicated NE-striking beds of Popovich limestone with a thrust inclusion of Roberts Mountains Formation. Bedding attitudes and information from Newmont Exploration Ltd. indicate NE-trending beds of Popovich limestone, including the Rodeo Creek unit folded with NE-trending axial planes (fig. 9; Appendix II). The folding in this area is similar to that in the rocks of the Hanson Creek Formation in Areas 8 and 9 (pl. 2).

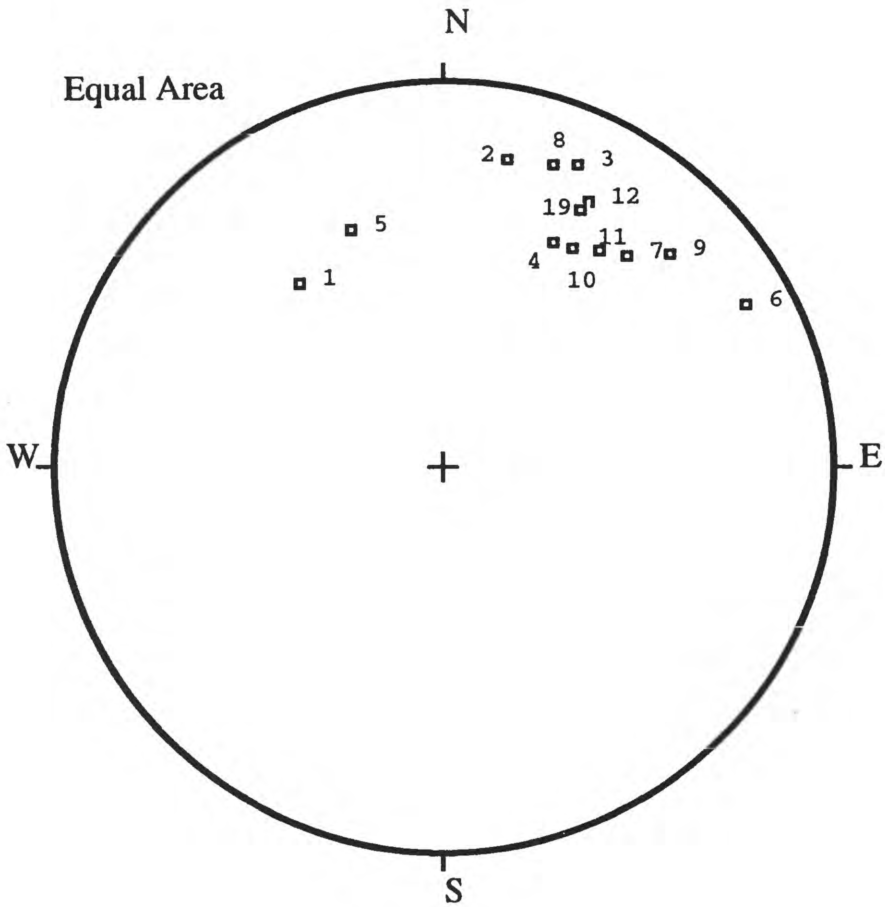


fig. 9. Spur area, Castle Reef fault area (pl. 2). Stereographic net of structural linear elements. Bedding attitudes (Appendix II) were obtained from Newmont Exploration Ltd.

no.	**description**	**strike**	**plunge**
1.	Spur Rodeo Creek area 1	322.0	40.0
2.	Spur Popovich main area	12.0	20.0
3.	Spur Popovich of fault	24.0	16.0
4.	3A + 3B Lobe Popovich	26.0	36.0
5.	4A first st-sl lobe	339.0	35.0
6.	4B spur add Popovich 2	62.0	13.0
7.	4C spur stls	41.0	29.0
8.	Area 2 and 3	20.0	18.0
9.	3A + 3B lobe Popovich	47.0	21.0
10.	4A + 4C lobe stsl	31.0	35.0
11.	Total lobe 3A, 4B, 4A & 4C	36.0	32.0
12.	Total Spur area (partial)	29.0	23.0
13.	Total Spur area	28.0	26.0

Summary and conclusions

The West Richmond area has been divided into seven structural-lithostratigraphic domains. Each domain has a different fold pattern, but there is little variation in the overall fold orientations. Rocks in the west part of the West Richmond area may all belong to the upper plate of the Roberts Mountains allochthon, based on structural interpretation and lithologic similarities to other upper plate rocks. Fold orientations in these upper plate rocks are complex and typified by tight isoclinal folding and bedding transposition. The orientations may mimic, but are interpreted as distinct from those in the lower plate rocks in the tectonic windows.

The West Lynn thrust truncates the Roberts Mountains thrust. The preferred dip of the West Lynn thrust, from the results of this study, is shallow (20° to 45°) E, but more steeper dips are also possible. A block of ground sandwiched between the West Lynn thrust and Roberts Mountains thrust has orientations of folds which are anomalous for the region. The West Lynn thrust is most likely the southern continuation of the Sheep Creek Canyon fault (pl. 1). NW- and WNW-striking thrust faults on the east side of the West Lynn thrust may have dips as shallow as 30° to 45° E, and may be coupled with the West Lynn thrust, because all these faults have similarities to the fold geometries. These thrusts and the West Lynn thrust also contain abundant jasperoid, suggesting abundant fluid flow during or after deformation. An interpretation of the West Richmond area is a sequence of east-dipping low-angle faults that have thrust older rocks on top of younger rocks from the east to the west at angles less than 60°. This structure would have a sectional form like a recumbent flower structure, similar to those described by Harding and Lowell, 1979; Park, 1980, and Prihar and others, 1996).

The Castle Reef fault zone has a similar attitude to the Dillon deformation zone, which hosts the Betze orebody in the Goldstrike Mine (Peters, 1996). The fault zone contains folds that have shallow-plunging fold axes parallel to the strike of the fault zone. Fold axial planes in the footwall, W of the Castle Reef fault zone, appear to be refolded from N-striking to NE-striking as they approach the Castle Reef fault zone. On the hangingwall side of the Castle Reef fault zone, to the north, fold axial planes in the Roberts Mountains Formation are oriented NW, in the Carlin Mine area (fig. 10). The Castle Reef fault zone is likely an F_3 shear fold (fig. 2) that may have folded F_2 folds in a right lateral sense (fig. 10). These observations are consistent with those by Peters (1996) in the Betze orebody in the Goldstrike Mine to the north, where WNW-striking, shallow, NE-dipping F_3 shear folds have rotated or refolded NE regional F_2 folds within the Carlin trend to a NW orientation in a left lateral sense.

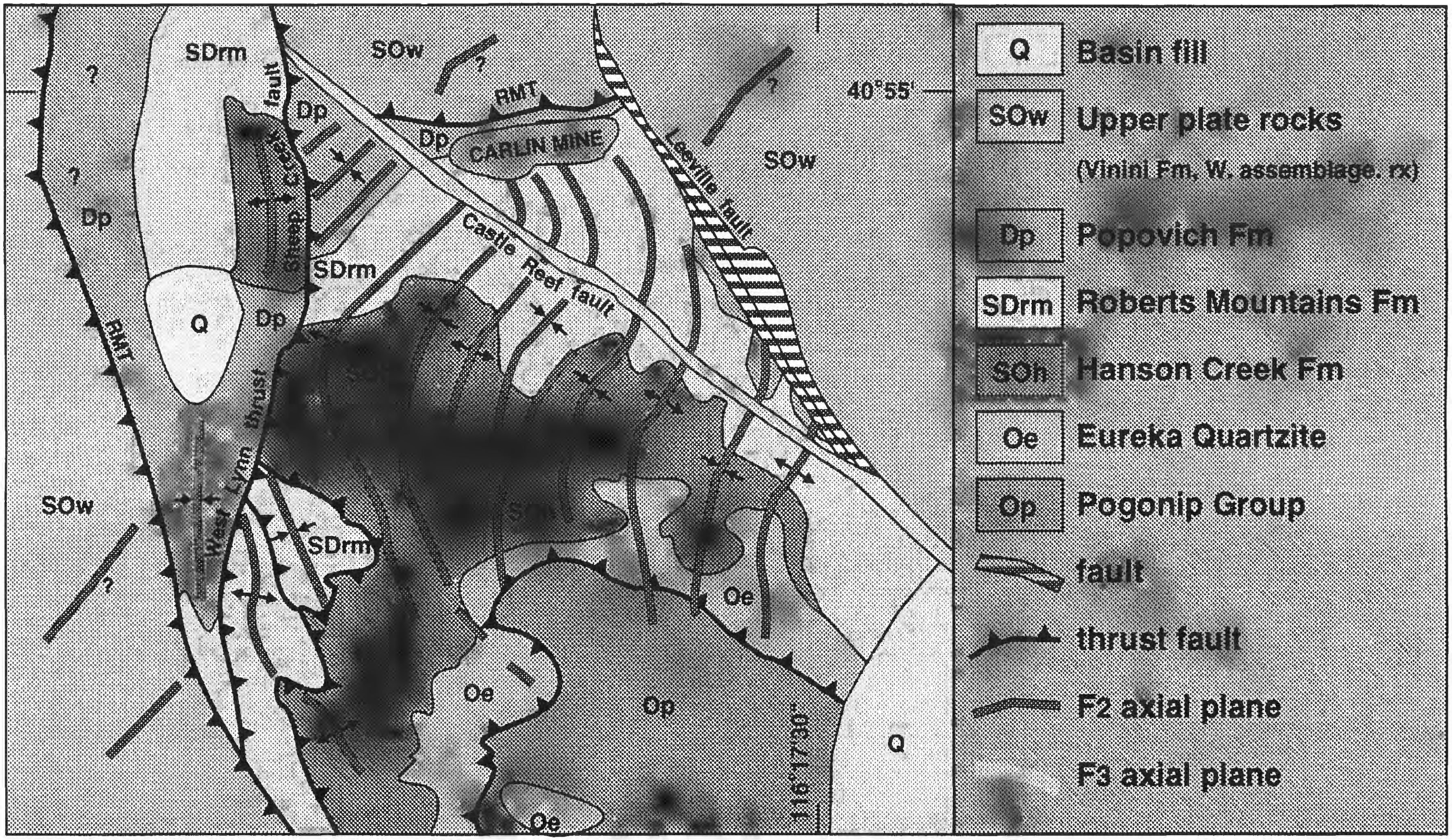


fig. 10. Idealized summary structural geology of the north Lynn window, Carlin trend. Fold axial planes (F2) on the south side of the Castle Reef Fault zone (F3) shear fold appear to be folded from N-striking to NE-striking, and on the north side of the Castle Reef fault are refolded (?) to the NW.

Jasperoid formation in the Castle Reef fault zone and in the most deformed, that is the most NW-oriented, parts of the folds in the West Richmond area indicate that the most intensely deformed zones were the focus for fluid flow and silicification during the late Mesozoic or early Tertiary.

Acknowledgments

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Appendix I - **West Richmond area Bedding attitudes and fold axes on plate 1.**

Area 1 -chert units (west of Roberts Mountains thrust)
total bedding attitudes

128.0	72.0	W
163.0	62.0	W
209.0	49.0	W
180.0	29.0	W
147.0	23.0	W
217.0	46.0	W
142.0	75.0	W
147.0	34.0	W
170.0	55.0	W
46.0	35.0	S
208.0	39.0	W
260.0	90.0	W
188.0	10.0	W
180.0	45.0	W
152.0	68.0	W
154.0	53.0	W
170.0	3.0	W
163.0	26.0	W
142.0	50.0	W
132.0	78.0	W
190.0	68.0	W
145.0	48.0	W
10.0	20.0	E
280.0	15.0	N
170.0	45.0	W
242.0	76.0	N
222.0	74.0	N
163.0	31.0	W
163.0	31.0	W
229.0	42.0	W
205.0	70.0	W
200.0	3.0	W
20.0	20.0	E
3.0	62.0	E
265.0	46.0	N
140.0	72.0	W
125.0	15.0	S
290.0	44.0	N
322.0	90.0	N
350.0	60.0	E
222.0	20.0	N
. 0	60.0	E
47.0	25.0	S
209.0	50.0	N
280.0	12.0	N
145.0	40.0	W
150.0	24.0	W
126.0	50.0	W
122.0	70.0	S
140.0	75.0	S
73.0	50.0	S
230.0	90.0	1
120.0	68.0	S
85.0	50.0	S
128.0	90.0	S
2.0	70.0	E
93.0	48.0	S
125.0	90.0	S
100.0	44.0	S
135.0	86.0	W
110.0	52.0	S
115.0	42.0	S
37.0	20.0	S
352.0	35.0	E
280.0	62.0	N
123.0	62.0	S
134.0	12.0	W
15.0	25.0	E
. 0	.0	E
15.0	35.0	E
10.0	36.0	E
89.0	20.0	S
245.0	36.0	N
246.0	25.0	N
155.0	75.0	W
76.0	25.0	S
12.0	56.0	E
338.0	90.0	E
15.0	37.0	E
205.0	27.0	W
152.0	90.0	W
165.0	40.0	W
334.0	58.0	E
162.0	12.0	W
152.0	90.0	W
103.0	36.0	S
165.0	21.0	W
312.0	86.0	E
158.0	27.0	W
112.0	68.0	S
124.0	90.0	S
304.0	77.0	E
338.0	90.0	E
338.0	42.0	E
170.0	37.0	W
218.0	55.0	W
348.0	80.0	E
302.0	27.0	E
335.0	48.0	E
321.0	55.0	E
348.0	21.0	E
92.0	35.0	S
37.0	20.0	E
278.0	32.0	N
225.0	36.0	W
338.0	59.0	E
290.0	74.0	N
315.0	80.0	E
140.0	42.0	W
240.0	27.0	N
215.0	25.0	N
300.0	44.0	N
275.0	34.0	N
207.0	51.0	W
271.0	28.0	N
176.0	40.0	W
273.0	56.0	N
184.0	50.0	W
185.0	56.0	W
120.0	90.0	W
168.0	90.0	W
144.0	50.0	W
165.0	90.0	W
175.0	54.0	W
209.0	62.0	W
207.0	62.0	W
214.0	55.0	W
195.0	60.0	W
182.0	73.0	W
96.0	90.0	W
184.0	90.0	W
260.0	54.0	N
237.0	20.0	N
208.0	35.0	W
298.0	40.0	N
220.0	55.0	W
268.0	45.0	N
247.0	55.0	N
230.0	62.0	W
155.0	90.0	W
240.0	31.0	W
258.0	46.0	W
350.0	55.0	E
358.0	46.0	E
236.0	52.0	W
261.0	36.0	W
276.0	50.0	N
324.0	60.0	M
325.0	43.0	N
245.0	48.0	N
.0	44.0	E
345.0	74.0	E
340.0	50.0	E
301.0	51.0	E
312.0	58.0	E
132.0	60.0	W
270.0	55.0	W
227.0	44.0	N
40.0	36.0	S
300.0	90.0	E
303.0	70.0	N
318.0	70.0	N
305.0	68.0	N
265.0	78.0	N
285.0	80.0	N
295.0	74.0	N
265.0	77.0	N
310.0	90.0	E
305.0	42.0	N
255.0	46.0	N
310.0	60.0	N
30.0	90.0	E
115.0	90.0	1
260.0	58.0	N
288.0	24.0	N
300.0	32.0	E
280.0	58.0	E
300.0	63.0	E
315.0	9.0	N
265.0	65.0	N
270.0	45.0	N
325.0	55.0	E
298.0	55.0	N
275.0	30.0	N
220.0	54.0	N
275.0	45.0	N
300.0	76.0	E
285.0	50.0	N
315.0	75.0	N
250.0	80.0	N
200.0	65.0	N
335.0	40.0	E
105.0	55.0	W
40.0	25.0	E
340.0	68.0	E
330.0	90.0	E
328.0	70.0	E
355.0	80.0	E
320.0	71.0	E
145.0	80.0	W
2.0	65.0	E
80.0	90.0	E
280.0	48.0	N
192.0	61.0	W
140.0	55.0	W
310.0	62.0	E
330.0	52.0	E

312.0	41.0	E
.0	60.0	E
292.0	46.0	E
315.0	90.0	E
344.0	90.0	E
273.0	65.0	N
235.0	40.0	W
185.0	55.0	W
240.0	25.0	W
250.0	31.0	N
325.0	50.0	E
303.0	80.0	E
290.0	34.0	N
328.0	23.0	E
30.0	55.0	E
28.0	60.0	E

Area 1- Cherty limestones (west of Roberts Mountains thrust)
bedding attitude
(plotted on plate 1)

138.0	58.0	W
320.0	70.0	E
178.0	85.0	W
150.0	3.0	W
107.0	60.0	W
180.0	45.0	W
205.0	35.0	W
190.0	70.0	W
135.0	25.0	W
320.0	75.0	E
265.0	60.0	W
245.0	50.0	N
245.0	76.0	N
242.0	40.0	N
190.0	26.0	W
148.0	90.0	W
162.0	55.0	W
210.0	40.0	W
206.0	32.0	W
205.0	55.0	W
229.0	36.0	N
225.0	48.0	W
115.0	20.0	W
210.0	12.0	N
242.0	42.0	N
215.0	60.0	N
212.0	42.0	N
180.0	45.0	N
230.0	38.0	N
68.0	46.0	S
15.0	35.0	S
10.0	90.0	S
328.0	54.0	E
210.0	70.0	N
10.0	45.0	E
192.0	83.0	W
298.0	75.0	N
190.0	62.0	W
198.0	42.0	W
207.0	45.0	W
195.0	80.0	W
245.0	53.0	W
284.0	47.0	N
226.0	40.0	W
210.0	41.0	W
223.0	38.0	W
230.0	45.0	W
220.0	30.0	W
193.0	52.0	W
194.0	48.0	W
190.0	32.0	W
237.0	46.0	W

Area 1 - Popovich Limestone (east of Roberts Mountains thrust)
bedding attitudes

203.0	55.0	N
30.0	55.0	E
28.0	60.0	E
192.0	28.0	W
280.0	35.0	N
132.0	55.0	S
255.0	76.0	W
168.0	40.0	W
160.0	68.0	W
140.0	90.0	W
172.0	60.0	W
126.0	75.0	S
190.0	26.0	W
178.0	19.0	W
230.0	22.0	W
170.0	90.0	W
244.0	87.0	W
168.0	65.0	W
200.0	65.0	W
184.0	75.0	W

Area 1 Outcrop study area (chert west of Roberts Mountains thrust)
bedding attitudes, part *a* (fig. 4)

325.0	55.0	E
298.0	55.0	N
275.0	30.0	N
220.0	54.0	N
275.0	45.0	N
300.0	76.0	E

Area 1 -Outcrop study area
bedding attitudes, part *b* (fig. 4)

300.0	90.0	E
303.0	70.0	N
318.0	70.0	N
305.0	68.0	N
265.0	78.0	N
285.0	80.0	N
295.0	74.0	N
265.0	77.0	N
310.0	90.0	E
305.0	42.0	N
255.0	46.0	N
310.0	60.0	N
30.0	90.0	E
115.0	90.0	X
260.0	58.0	N
288.0	24.0	N
300.0	32.0	E
280.0	58.0	E
300.0	63.0	E
315.0	9.0	N
265.0	65.0	N
270.0	45.0	N

Area 1 Outcrop study area
bedding attitudes, part *c* (fig. 4)

285.0	50.0	N
315.0	75.0	N
250.0	80.0	N
200.0	65.0	N
335.0	40.0	E
105.0	55.0	W
40.0	25.0	E
340.0	68.0	E
330.0	90.0	E
328.0	70.0	E
355.0	80.0	E

Area 1 - Outcrop study area
bedding attitudes, part *d* (fig. 4)

320.0	71.0	E
145.0	80.0	W
2.0	65.0	E
80.0	90.0	E
280.0	48.0	N
192.0	61.0	W
140.0	55.0	W
310.0	62.0	E
330.0	52.0	E
312.0	41.0	E
. 0	60.0	E
292.0	46.0	E
315.0	90.0	E
344.0	90.0	E
273.0	65.0	N
235.0	40.0	W
185.0	55.0	W
240.0	25.0	W
250.0	31.0	N

Area 1 - Outcrop study area
axial planes, F_1 folds (fig. 4)

230.0	70.0	N
255.0	70.0	N
315.0	26.0	N
20.0	60.0	N
255.0	80.0	N
350.0	65.0	E
280.0	90.0	E
80.0	90.0	E
332.0	60.0	N
315.0	80.0	E
310.0	70.0	E
292.0	75.0	E

Area 1 -Outcrop study area
axial planes, F_2 folds (fig. 4)

30.0	80.0	E
30.0	70.0	E
10.0	30.0	E

Area 2 - Popovich limestone
bedding attitudes
(see plate 1)

Area 2 - Roberts Mountains Formation
bedding attitudes
(see plate 1)

Area 2 - Total bedding attitudes

333.0	80.0	E
125.0	85.0	W
145.0	90.0	W
265.0	20.0	N
238.0	64.0	N
350.0	90.0	N
150.0	19.0	W
110.0	90.0	W
138.0	45.0	W
95.0	90.0	W
150.0	35.0	W
0	65.0	E
5.0	90.0	X
188.0	80.0	W
235.0	73.0	N
185.0	90.0	N
340.0	90.0	N
355.0	30.0	E
82.0	75.0	S
335.0	65.0	E
30.0	55.0	E
132.0	45.0	W
182.0	70.0	W

Area 3 Total bedding attitudes
(see plate 1)

Area 4 bedding attitudes
(see plate 1)

Area 4 fold axis = 349°/29°

Area 5 - Section 22
bedding attitudes
(see plate 1)

Area 5 - Section 27
bedding attitudes
(see plate 1)

Area 5 - Section 34
bedding attitudes
(see plate 1)

Area 5 - Fold axes

11.0	20.0	Section 22
7.0	22.0	Section 27
353.0	17.0	Section 34
356.0	28.0	Total Area (secs. 22, 27 & 34)

Area 6 Bedding attitudes
(see plate 1)

Area 6 Fold axis = 315° / 25°

Area 7 Bedding attitudes
(see plate 1)

Area 7 fold axis = 14° / 22°

Area 1 - calculated fold axes (fig. 3)

1. 335	43	total outcrop study area (chert)
2. 342	42	outcrop study area, part a
3. 289	0	outcrop study area, part b
4. 60	68	outcrop study area, part c
5. 338	38	outcrop study area, part d
6. 20	50	outcrop study area, fold in part b
7. 102	2	outcrop study area, fold in part b
8. 327	15	total trenches
9. 01	38	trench 1, all units
10. 325	3	trench 2, all units
11. 316	12	folds in chert, trench 2
12. 322	17	folds in chert, trench 2
13. 356	13	folds in chert, trench 2
14. 293	34	trench 3, all units
15. 319	25	surface mapping data (Newmont)
16. 350	42	outcrop study area, F_1 fold axes, part c
17. 341	33	cherty limestone unit
18. 319	41	Popovich limestone
19. 324	21	chert unit

Area 2 Structural linear elements
Fold Axes

1. 180.0	53.0	Popovich limestone
2. 160.0	38.0	Folded area southeast part, Pop. ls
3. 314.0	23.0	Roberts Mountains Formation
4. 176.0	67.0	Total Area 2

Area 3 - Linear Structural elements
Fold axes

1. 147.0	10.0	North part of part a
2. 20.0	57.0	part b, east
3. 351.0	35.0	part b, west
4. 2.0	18.0	part c
5. 2.0	25.0	total area 3

Appendix II - **Castle Reef fault area, including Carlin Mine Area, bedding attitudes and fold axes on plate 2.**

Castle Reef Area 1
bedding attitudes
(see plate 2)

Castle Reef Area 2 (with outcrop fold data)
bedding attitudes
(see plate 2)

Castle Reef Area 3 (with outcrop fold data)
bedding attitudes
(see plate 2)

Castle Reef Area 4 (with outcrop fold data)
bedding attitudes
(see plate 2)

Castle Reef Area 5
bedding attitudes
(see plate 2)

239.0	15.0	N
315.0	25.0	N
315.0	29.0	N
.0	38.0	E
2.0	50.0	E
295.0	62.0	N
295.0	51.0	N
95.0	38.0	S
50.0	70.0	E

Castle Reef Area 6
bedding attitudes
(see plate 2)

Castle Reef Area 7
bedding attitudes
(see plate 2)

Castle Reef Area 8
bedding attitudes
(see plate 2)

Castle Reef Area 9
bedding attitudes
(see plate 2)

Castle Reef area 10
bedding attitudes
(see plate 2)

Castle Reef Area 11
bedding attitudes
(see plate 2)

Castle Reef Area 12
bedding attitudes
(see plate 2)

Castle Reef Area 13
bedding attitudes
(see plate 2)

Castle Reef fault zone
fold A, bedding attitudes

235.0	25.0	N
260.0	20.0	N
265.0	65.0	N
230.0	50.0	N
290.0	90.0	N
45.0	60.0	E
300.0	65.0	E

Castle Reef fault zone
fold B, bedding attitudes

310.0	74.0	E
319.0	54.0	E
312.0	37.0	E
325.0	42.0	E
20.0	43.0	E
37.0	45.0	E
350.0	32.0	E
328.0	43.0	E
320.0	49.0	E
330.0	59.0	E

Castle Reef fault zone
fold C, bedding attitudes

295.0	48.0	E
0	.0	E
330.0	22.0	E
300.0	38.0	E
305.0	50.0	E
85.0	30.0	S
298.0	20.0	E

Castle Reef fault zone
fold D, bedding attitudes

288.0	70.0	N
105.0	68.0	S
98.0	75.0	S
300.0	38.0	N
278.0	35.0	N
108.0	38.0	S
95.0	90.0	S
115.0	48.0	S
170.0	20.0	W

Castle Reef fault zone
fold E, bedding attitudes

98.0	42.0	S
105.0	90.0	S
58.0	21.0	S
92.0	30.0	S
35.0	20.0	S
180.0	20.0	W
128.0	70.0	W
120.0	50.0	W
145.0	56.0	W
172.0	23.0	W
190.0	23.0	W
65.0	43.0	S
164.0	13.0	W

Castle Reef fault zone
fold F, bedding attitudes

220.0	35.0	N
230.0	70.0	N
210.0	55.0	N
250.0	59.0	N
215.0	40.0	N
350.0	90.0	N
242.0	50.0	N

Castle Reef fault zone
fold G, bedding attitudes

350.0	80.0	E
323.0	60.0	E
335.0	50.0	E
320.0	60.0	N
.0	73.0	E
305.0	65.0	N
310.0	90.0	N
298.0	64.0	N
210.0	45.0	W
190.0	60.0	W
170.0	68.0	W
335.0	50.0	E
318.0	82.0	E
190.0	70.0	W
330	50.0	W

Carlin Mine - Lower plate rocks
bedding attitudes
(Radtke, 1973)

225.0	35.0	N
250.0	26.0	N
220.0	33.0	N
183.0	40.0	W
204.0	20.0	W
260.0	50.0	N
180.0	70.0	W
191.0	80.0	W
188.0	50.0	W
239.0	30.0	N
293.0	63.0	N
260.0	35.0	N
184.0	40.0	W
184.0	40.0	W
239.0	36.0	N
264.0	38.0	N
271.0	53.0	N
237.0	.0	N
237.0	37.0	N
185.0	40.0	W
243.0	28.0	N
272.0	34.0	N
258.0	52.0	N

262.0	40.0	N
250.0	47.0	N
270.0	52.0	N
249.0	55.0	N
239.0	48.0	N
260.0	35.0	N
227.0	50.0	N
242.0	30.0	N
170.0	65.0	W
242.0	25.0	N
250.0	30.0	N
248.0	42.0	N
300.0	40.0	N
290.0	50.0	N
247.0	30.0	N
290.0	50.0	N
264.0	40.0	N
262.0	28.0	N
260.0	32.0	N
260.0	66.0	N
236.0	52.0	N
255.0	62.0	N
270.0	32.0	N
262.0	40.0	N
266.0	42.0	N
302.0	36.0	N
291.0	50.0	N
283.0	45.0	N
253.0	52.0	N
283.0	52.0	N
286.0	53.0	N
271.0	45.0	N
277.0	58.0	N
245.0	35.0	N
233.0	47.0	N
207.0	38.0	N
203.0	40.0	N
237.0	30.0	N
237.0	30.0	N
227.0	45.0	N
226.0	28.0	N
263.0	40.0	N
247.0	55.0	N
262.0	33.0	N
232.0	52.0	N
240.0	42.0	N
233.0	55.0	N
226.0	60.0	N
231.0	60.0	N
231.0	54.0	N
189.0	65.0	W
193.0	60.0	W
233.0	62.0	N
232.0	45.0	N
287.0	15.0	N
230.0	30.0	N
284.0	35.0	N
276.0	32.0	N
256.0	43.0	N
258.0	55.0	N
270.0	40.0	N
283.0	26.0	N
192.0	52.0	N
238.0	32.0	N
242.0	28.0	N
259.0	27.0	N
238.0	30.0	N
214.0	37.0	N
270.0	40.0	N
242.0	38.0	N
202.0	28.0	N
235.0	35.0	N
250.0	26.0	N
232.0	35.0	N
229.0	30.0	N
255.0	23.0	N
230.0	37.0	N
225.0	26.0	N
234.0	30.0	N
215.0	55.0	N
350.0	42.0	N
18.0	36.0	S
210.0	25.0	W
210.0	25.0	W
249.0	20.0	W
249.0	20.0	W
172.0	18.0	W
255.0	35.0	W
282.0	10.0	E
200.0	26.0	N
252.0	35.0	W
102.0	10.0	W
200.0	26.0	N
252.0	42.0	W
254.0	37.0	W
262.0	25.0	N
240.0	35.0	N
252.0	20.0	N
250.0	40.0	N
228.0	55.0	N
270.0	40.0	N
220.0	40.0	N
306.0	34.0	N
325.0	40.0	N
275.0	30.0	N
273.0	30.0	N
262.0	36.0	N
212.0	42.0	N
265.0	30.0	N
275.0	28.0	N
277.0	23.0	N
277.0	25.0	N
214.0	48.0	N
218.0	22.0	N
209.0	35.0	N
285.0	48.0	N
274.0	37.0	N
203.0	27.0	N
192.0	24.0	N
200.0	23.0	N
271.0	15.0	N
227.0	20.0	N
273.0	70.0	N
252.0	28.0	N
250.0	32.0	N
261.0	25.0	N
267.0	25.0	N
283.0	22.0	N
182.0	40.0	N
256.0	26.0	N
270.0	20.0	W
295.0	25.0	N
280.0	30.0	N
281.0	25.0	N
240.0	25.0	N
241.0	30.0	N
350.0	30.0	N
267.0	22.0	N
239.0	28.0	N
205.0	28.0	N
205.0	27.0	N
250.0	35.0	N
270.0	42.0	N
212.0	38.0	N
188.0	32.0	N
218.0	25.0	N
250.0	20.0	W
235.0	42.0	W
230.0	35.0	W
260.0	40.0	N
240.0	37.0	N
225.0	30.0	N
225.0	30.0	N
215.0	20.0	N
240.0	73.0	N
197.0	55.0	N
245.0	42.0	N
210.0	40.0	N
225.0	43.0	W
252.0	42.0	N
218.0	38.0	N
225.0	35.0	N
220.0	28.0	N
239.0	35.0	N
220.0	32.0	N
243.0	42.0	N
208.0	33.0	N
277.0	37.0	N
251.0	35.0	N
255.0	43.0	N
218.0	52.0	N
267.0	36.0	N
222.0	30.0	N
270.0	22.0	N
282.0	36.0	N
275.0	65.0	N
275.0	52.0	N
276.0	60.0	N
287.0	55.0	N
287.0	55.0	N
292.0	50.0	N
310.0	48.0	N
247.0	55.0	N
274.0	50.0	N
272.0	63.0	N
287.0	60.0	N
292.0	47.0	N
272.0	52.0	N
263.0	47.0	N
202.0	70.0	N
268.0	60.0	N
267.0	50.0	N
249.0	58.0	N
315.0	40.0	N

Carlin Mine - Upper plate rocks bedding attitudes (Radtke, 1973)

270.0	80.0	E
272.0	70.0	E
285.0	60.0	E
251.0	23.0	N
290.0	43.0	N
270.0	45.0	N
270.0	48.0	N
270.0	46.0	N
273.0	48.0	N
251.0	62.0	N
269.0	55.0	N
273.0	50.0	N
261.0	32.0	N
267.0	43.0	N
285.0	30.0	N
254.0	27.0	N
205.0	25.0	N
264.0	38.0	N
270.0	45.0	N
230.0	50.0	N
298.0	27.0	N
260.0	38.0	W
250.0	37.0	N
288.0	40.0	N
255.0	34.0	N
292.0	43.0	N
323.0	47.0	N
55.0	47.0	N
308.0	40.0	E
235.0	47.0	E
242.0	37.0	N
244.0	50.0	N
210.0	45.0	N
283.0	48.0	N
247.0	53.0	N
242.0	53.0	N
245.0	48.0	N
228.0	28.0	N
263.0	35.0	N
266.0	42.0	N
237.0	50.0	N
256.0	60.0	N
266.0	35.0	N

225.0 50.0 N

Carlin Mine - Faults attitudes (Radtke, 1973)

245.0 55.0 N
340.0 65.0 N
335.0 75.0 E
350.0 55.0 E
330.0 55.0 E
290.0 70.0 E
320.0 70.0 E
325.0 60.0 E
358.0 75.0 E
35.0 60.0 E
10.0 70.0 E
10.0 75.0 E

Carlin Mine mélange area fold 1 (fig. 8).

200.0 58.0 N
190.0 15.0 N
225.0 28.0 N
209.0 36.0 N
280.0 38.0 N
210.0 72.0 N

Carlin Mine mélange area fold 2 (fig. 8).

220.0 50.0 N
260.0 15.0 N
210.0 85.0 N
220.0 10.0 N

Carlin Mine mélange area fold 3 (fig. 8).

150.0 18.0 W
100.0 40.0 S
110.0 70.0 S
40.0 65.0 E

Carlin Mine mélange area misc. bedding attitudes (fig. 8).

330.0 15.0 N
235.0 40.0 N
235.0 25.0 N
215.0 70.0 N
200.0 62.0 N

Spur Area bedding attitudes (Newmont data)

196.0 32.0 N
154.0 24.0 W
254.0 31.0 N
312.0 18.0 E
358.0 45.0 E
280.0 18.0 E
321.0 64.0 E
329.0 61.0 E
169.0 70.0 W
262.0 70.0 N
290.0 54.0 N
145.0 82.0 S
292.0 88.0 N
314.0 44.0 N
302.0 82.0 N
198.0 90.0 N
298.0 49.0 N
218.0 52.0 N
225.0 80.0 W
219.0 28.0 N
234.0 20.0 N
.0 44.0 E
.0 20.0 E
315.0 24.0 N
25.0 70.0 E
340.0 50.0 E
42.0 47.0 E
220.0 16.0 N
210.0 30.0 N
248.0 29.0 N
310.0 28.0 E
240.0 48.0 N
240.0 79.0 N
260.0 90.0 N
260.0 64.0 N
265.0 54.0 N
254.0 85.0 N
288.0 85.0 N
275.0 52.0 N
282.0 44.0 N
300.0 40.0 N
255.0 24.0 N
235.0 90.0 N
227.0 90.0 N
264.0 56.0 N
302.0 80.0 E
47.0 42.0 E
220.0 60.0 W
345.0 74.0 E
345.0 40.0 E
237.0 72.0 N
237.0 72.0 N
210.0 90.0 N
80.0 70.0 S
296.0 38.0 N
245.0 60.0 N
215.0 80.0 N
268.0 42.0 N
50.0 46.0 S
61.0 90.0 S
210.0 30.0 N
230.0 55.0 N
238.0 24.0 N
205.0 74.0 W
207.0 54.0 W
220.0 55.0 W
195.0 90.0 W
185.0 90.0 W
15.0 55.0 E
320.0 45.0 E
280.0 30.0 N
330.0 43.0 N
220.0 75.0 W
227.0 57.0 W
243.0 65.0 W
231.0 52.0 W
225.0 58.0 W
230.0 57.0 W
262.0 70.0 N
20.0 59.0 E
280.0 36.0 N
240.0 70.0 N
228.0 20.0 N
200.0 78.0 W
208.0 37.0 W
235.0 49.0 W
220.0 78.0 W
40.0 77.0 S
140.0 90.0 S
215.0 55.0 N
240.0 43.0 N
265.0 61.0 N
272.0 45.0 N
270.0 49.0 N
244.0 44.0 N
230.0 54.0 N
246.0 76.0 N
236.0 47.0 N
250.0 23.0 N
260.0 62.0 N
76.0 82.0 S
59.0 90.0 S
80.0 60.0 S
245.0 63.0 N
245.0 40.0 N
250.0 80.0 N
265.0 38.0 N
164.0 20.0 W
250.0 34.0 N
238.0 20.0 N
334.0 42.0 E
188.0 58.0 W
348.0 43.0 E
316.0 23.0 E
325.0 34.0 E
260.0 50.0 N
250.0 60.0 N
242.0 55.0 N
262.0 76.0 N
237.0 45.0 N
240.0 90.0 N
250.0 80.0 N
242.0 69.0 N
180.0 14.0 W
232.0 15.0 W
227.0 40.0 W
242.0 16.0 W
245.0 32.0 N
255.0 25.0 N
278.0 23.0 N
325.0 25.0 E
222.0 73.0 W
209.0 31.0 W
120.0 25.0 W
294.0 9.0 N
190.0 30.0 W
255.0 49.0 N
240.0 52.0 W
220.0 50.0 W
192.0 58.0 W
230.0 50.0 W
164.0 50.0 W
253.0 40.0 N
232.0 51.0 W
192.0 59.0 W
215.0 55.0 W
220.0 31.0 N
215.0 59.0 W
202.0 62.0 N
212.0 71.0 W
228.0 52.0 W
232.0 51.0 W
253.0 40.0 N
42.0 31.0 S
215.0 55.0 N
192.0 59.0 W
90.0 18.0 W
220.0 31.0 W
140.0 90.0 W
225.0 30.0 W
215.0 59.0 W
252.0 31.0 N
5.0 21.0 E
22.0 62.0 S
229.0 70.0 W
229.0 52.0 W
220.0 81.0 W
255.0 44.0 W
235.0 68.0 N
252.0 31.0 N
325.0 20.0 E
270.0 26.0 N
226.0 23.0 N
246.0 28.0 N
236.0 23.0 N
349.0 15.0 E
302.0 32.0 E
220.0 24.0 W
270.0 33.0 N
255.0 29.0 N

270.0	28.0	N
15.0	40.0	E
358.0	33.0	E
184.0	58.0	W
146.0	85.0	W
221.0	69.0	N
214.0	20.0	N
220.0	32.0	N
212.0	24.0	N
210.0	24.0	W
15.0	20.0	E
20.0	20.0	E
220.0	22.0	W
250.0	36.0	N
282.0	40.0	N
250.0	43.0	N
210.0	49.0	W
215.0	49.0	W
208.0	46.0	W
230.0	20.0	W
188.0	52.0	W
206.0	42.0	W
204.0	34.0	W
228.0	48.0	W
215.0	55.0	W
222.0	50.0	W
231.0	49.0	W
215.0	45.0	W
212.0	39.0	W
300.0	50.0	N
210.0	46.0	W
32.0	40.0	S
205.0	55.0	W
294.0	13.0	N
310.0	59.0	N
312.0	40.0	N
265.0	21.0	N
265.0	22.0	N
348.0	32.0	E
236.0	30.0	N
10.0	9.0	E
335.0	26.0	E
245.0	46.0	N
165.0	60.0	W
198.0	65.0	W
257.0	18.0	W
30.0	72.0	E
115.0	74.0	S
270.0	58.0	N
285.0	44.0	N
290.0	32.0	N
296.0	80.0	N
288.0	44.0	N
292.0	48.0	N
285.0	63.0	N
290.0	68.0	N
314.0	62.0	E
39.0	79.0	E
270.0	66.0	N
260.0	42.0	N
262.0	50.0	N
246.0	20.0	N

Castle Reef fault area, structural linear data,
fold axes

1.	348.0	15.0	Area 1, hanging wall to Leeville fault
2.	118.0	19.0	Area 2 w/o small folds
3.	110.0	24.0	Area 2 w/ small folds
4.	267.0	2.0	small fold A
5.	58.0	25.0	best fit great circle to fold A
6.	104.0	36.0	small fold B
7.	95.0	8.0	Area 3 w/o folds
8.	106.0	1.0	Area 3 w/ folds
9.	111.0	8.0	small fold C
10.	284.0	5.0	small fold D
11.	293.0	2.0	small fold E
12.	36.0	32.0	Areas 3 & 4, lobe of Popovich ls
13.	29.0	23.0	lobe plus rest of Popovich ls
14.	28.0	26.0	above plus Area 5
15.	341.0	35.0	small fold G
16.	85.0	20.0	Area 5 (partial)
17.	85.0	19.0	Area 6
18.	296.0	9.0	Area 7 (partial)
19.	334.0	14.0	Area 7 - total
20.	37.0	24.0	Area 8 - Hanson Creek Formation
21.	55.0	23.0	Area 9 "
22.	0	32.0	Area 10
23.	41.0	23.0	Areas 8 and 9 (Total Hanson Creek Fm)
24.	11.0	26.0	Area 11 Roberts Mountains Formation
25.	33.0	21.0	Area 12 Popovich ls within Leeville fault
26.	347.0	27.0	Area 13 Rodeo Creek unit hangingwall Leeville fault

Carlin Mine area
Total fold axes
Spur area

1. Spur Rodeo Creek area 1	322.0	40.0
2. Spur Popovich main area	12.0	20.0
3. Spur Popovich of fault	24.0	16.0
4. 3A + 3B Lobe Popovich	26.0	36.0
5. 4A first stsl lobe	339.0	35.0
6. 4B spur add Popovich 2	62.0	13.0
7. 4C spur stls	41.0	29.0
8. Area 2 and 3	20.0	18.0
9. 3A + 3B lobe Popovich	47.0	21.0
10. 4A + 4C lobe stsl	31.0	35.0
11. Total lobe 3A, 4B, 4A & 4C	36.0	32.0
12. Total Spur area (partial)	29.0	23.0
13. Total Spur area	28.0	26.0

Carlin Mines area
structural linear elements
fold axes

1.	333.0	34.0	total lower plate rocks
2.	327.0	37.0	Popovich ls
3.	343.0	32.0	Roberts Mountains Formation
4.	37.0	32.0	total upper plate rocks (except mélange)

5	12.0	18.0	mélange fold 1
6.	31.0	7.0	mélange fold 2
7	213.0	38.0	mélange fold 3
8	24.0	15.0	mélange misc. attitudes
9	221.0	4.0	total mélange