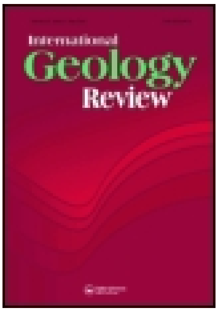

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Kinematics of the Uinta Fault System (Southern Wyoming and Northern Utah) during the Laramide Orogeny

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Kinematics of the Uinta Fault System (Southern Wyoming and Northern Utah) during the Laramide Orogeny[1]

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Abstract

The origin of the Late Cretaceous–Early Tertiary Uinta uplift created during the Laramide orogeny has long been problematic, because the structure is E-trending nearly parallel to the ENE-WSW direction of regional shortening. Early workers have proposed that the Uinta uplift is bounded by a large pop-up thrust system, which suggests that uplift was induced by N-S contraction. The geometric relationship between E-trending Laramide faults that bound the Uinta uplift and nearly N-S–trending folds and thrusts at the eastern end of the uplift implies that the formation of the Uinta uplift could have been related to strike-slip faulting. In order to test whether the Uinta uplift was created by either N-S compression or E-W strike-slip faulting, we performed detailed field mapping, kinematic analysis of fault zones, and construction of detailed cross sections along the E-trending Uinta fault system in the northern Uinta Mountains. The results of our study suggest that the Uinta fault is a reverse left-slip structure that has accommodated ENE-WSW contraction during the Laramide orogeny. Our study also shows that although individual faults in the system have variable kinematics and orientations, their average transport direction is remarkably consistent, either in the ENE or WSW direction. These orientations are consistent with the ENE-WSW direction of regional shortening in the overall Late Cretaceous to Early Tertiary Laramide orogenic belt in the western United States and suggest that the stress field was rather uniform in the central U.S. Rocky Mountains during the Laramide orogeny.

Introduction

THE DEFORMATIONAL EVENT in Late Cretaceous to Early Tertiary time in the western United States is commonly referred to as the Laramide orogeny (e.g., Dickinson and Snyder, 1978; Bird, 1988; Dickinson et al., 1988). Faults formed during this event and involving crystalline basement rocks are referred to as Laramide-style structures (e.g., Erslev, 1993). Deformation of the Laramide orogeny is expressed by a range of orientations and various styles of deformation (Fig. 1). In the southern Canadian Rockies and western Montana, Late Cretaceous and Early Tertiary structures are typically expressed by the development of a thin-skinned fold-thrust belt (e.g., Price, 1981; Dickinson et al., 1988; Yin and Kelty, 1991). In the central and southern U.S. Rocky Mountains, Late Cretaceous to Early Tertiary structures are expressed by structural uplifts that are cored by Precambrian crystalline rocks and flanked by Paleozoic and Mesozoic sedimentary strata. The structures are commonly bounded by both high-angle and low-angle faults (e.g., Erslev, 1993). The Laramide structures in the U.S. Rocky Mountains have three dominant trends: (1) N-S in north-central New Mexico, central and northern Colorado, and southeastern Wyoming; (2) NW-SE in northwestern Colorado, central and northern Wyoming, and southernmost Montana; and (3) E-W throughout northeastern Utah, northwestern Colorado, central Wyoming, and southwestern and central Montana (Fig. 1). The N- and NW-trending structures are commonly linked in map view by E-trending structures, as noted by many workers (e.g., Sales, 1968; Brown, 1988; Hamilton, 1988; Erslev, 1993; Paylor and Yin, 1993).

The dominantly NW- and N-trending Laramide uplifts in the central Rocky Mountains have been related to convergence between the Farallon and North America plates during the Late Cretaceous and early Tertiary (Coney, 1978; Engebretson et al., 1984; Dickinson et al., 1988; cf., Livaccari, 1991; Maxson and Tikoff, 1996). However, the origin of E-trending Laramide structures has long been prob-

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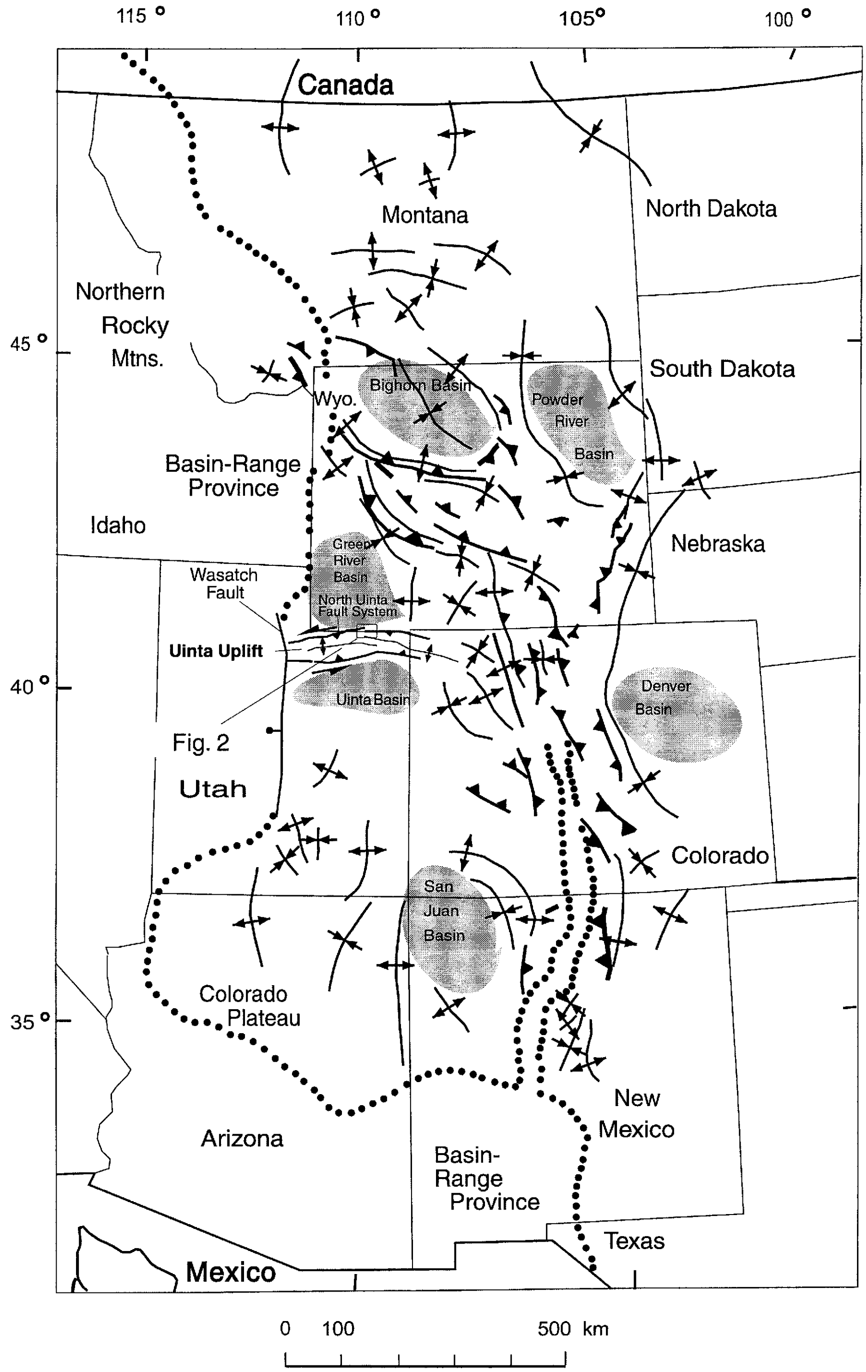


FIG. 1. Tectonic map of major Laramide structures in the western United States, modified from Hamilton (1988) and Dickinson et al. (1988).

lematic and controversial. Most workers viewed E-trending Laramide uplifts as contractional structures expressed by large folds and thrust-bounded tilted blocks (e.g., Gries, 1983a). In principle, the maximum compressive stress should have been aligned in a N-S direction near these structures when they formed. Such a contractional direction is at a high angle (>45°) to the overall ENE-WSW compressional direction in the Laramide orogenic belt, as inferred from plate reconstruction (Coney, 1978; Engebretson et al., 1984), numerical simulation (Bird, 1988), and field observations (Erslev, 1993; Molzer and Erslev, 1995). This local N-S compression implies that the development of the contractional structures within the Laramide orogenic belt in the western United States was produced by a highly inhomogeneous stress field. In contrast to the thrust model for the development of E-trending structural uplifts, Brown (1988) noted that these E-trending structures could be strike-slip transfer zones linking N- and NW-trending contractional structures. This kinematic interpretation means that the orientation of the maximum compressive stress in the western United States during the Laramide orogeny was rather uniform.

The relationship between the rigid body motion of the Colorado Plateau and the formation of E-trending Laramide structures has been emphasized by several workers. Sales (1968) and Hamilton (1988) suggested that E-trending Laramide structures in Wyoming and northern Utah were produced by a modest clockwise rotation of the Colorado Plateau. In contrast, Chapin and Cather (1983) and Cather (1999) have suggested that the Colorado Plateau moved northward with respect to the interior of North America, causing N-S compression and the development of E-trending contractional structures in the Laramide orogenic belt immediately north of the plateau. The need for rotation of the Colorado Plateau during the Laramide orogeny was refuted by a systematic cross-section balancing across the central and southern Rocky Mountains (Yin and Ingersoll, 1997; Ingersoll, 2000). In addition to the debate on the cause of E-trending Laramide structures, some workers have argued that different trends of Laramide structures may have been created by varying stress fields at different stages during the Laramide orogeny (e.g., Long, 1959; Crittenden, 1976; Chapin and Cather, 1983; Gries, 1983a; Erslev, 2001). It should be noted that the Colorado Plateau itself was not a rigid block during the Laramide orogeny. Monoclines were widely developed in the plateau (e.g., Davis, 1978), possibly as a result of reactivation of pre-existing plateau-bounding structures that created a complex stress field over the plateau (Yin, 1994).

A key to testing tectonic models for the formation of E-trending Laramide structures is to establish the history of their detailed structural evolution. Previous kinematic analysis of E-trending Laramide structures focused primarily on those located in central Wyoming (e.g., Western Owl Creek Mountains, Paylor and Yin, 1993; Casper Arch, Molzer and Erslev, 1995). Largely ignored and likely a crucial piece to the puzzle is the Uinta Mountains uplift, the largest and the most prominent E-trending structure in the Laramide orogenic belt (Fig. 1). Gregson and Erslev (1997) presented the first systematic investigation of paleo-stress directions during the development of the Laramide structures in the eastern Uinta Mountains region. In that study, they used the existing geologic maps and correlated their paleo-stress data with fault kinematics. Because the existing geologic maps emphasize fault distribution and regional stratigraphy (e.g., Hansen, 1955, 1965), many unmappable mesoscopic structures were overlooked. However, the mesoscopic-scale structures, when integrated together with detailed field maps, can provide crucial constraints on fault kinematics.

Our work complements the study of Gregson and Erslev (1997). However, the approach we adopted is somewhat different from theirs in that we emphasize integrating detailed mapping and fault kinematic studies. In addition, we use fault slip data only to infer fault kinematics instead of regional stress directions. This approach differs from that of Gregson and Erslev (1997), who assumed a conjugate-fault model in order to interpret fault slip data in the context of the regional stress field. This assumption requires that faults move in a co-axial strain field and that faults with opposite sense of motion moved simultaneously as conjugate sets (e.g., Ratsbacher et al., 1994; also see Twiss and Unruh, 1998 for further discussion on limitations of the method). This is in contrast to the simple shear model, which predicts both a more complex fault pattern (R, R', and P shears) and progressive rotation of principal finite-strain directions (e.g., Naylor et al., 1986; Sylvester, 1988). In this study, we document spatial relationships between variation of fault geometry and corresponding fault kinematics. The principal conclusion is that the E-trending Uinta fault in the northern Uinta Mountains is a left-slip reverse structure developed during the Laramide orogeny.

Structural Geology of the Northern Uinta Mountains

General geologic setting

The Uinta uplift lies along the northern edge of the Colorado Plateau between the synorogenic Green River basin to the north and the Uinta basin to the south (Hansen, 1986; Fig. 1). Structurally, it is bounded by a pop-up structure dipping both to the north and south (Gries, 1983b; Hansen, 1986). To the east, the two Laramide faults bounding the uplift die out into a series of folds and monoclines that trend northwest and north. To the west, the Uinta uplift terminates in the Wasatch Range, at the eastern edge of the Basin and Range province. The overall Uinta structural uplift is expressed by two broad anticlines cored by the Proterozoic Uinta Mountain Group (Fig. 1).

The Uinta Mountains region has undergone several episodes of deformation since the Precambrian (e.g., Marshak and Paulsen, 1996). The thick (>9 km) Proterozoic Uinta Mountain Group was deposited in a rift zone, which was later reactivated during the Laramide orogeny (Hansen, 1965; Stone, 1986). The maximum reverse separation measured by stratigraphic offsets across the S-dipping Laramide Uinta fault is ~10–12 km (Hansen, 1965; Ritzma, 1969; Gries, 1983a; Bruhn et al., 1986). Laramide deformation in the Uinta Mountains region took place between the latest Cretaceous (~75 Ma) and Early Tertiary (~35 Ma) (Hansen, 1986; Cross, 1986; Dickinson et al., 1988).

Our study area is located west of Flaming Gorge at the junction of Utah, Colorado, and Wyoming (Figs. 1 and 2 [Fig. 2 is the foldout map following p. 64]). The Uinta Mountains have been the subject of geologic scrutiny since the earliest territorial surveys of Major John Wesley Powell in 1868. Brief reference will be made here only to the work that concerns the study area directly. Curtis (1950) was among the first to describe and discuss the structure of the north flank of the Uinta Mountains. Anderman (1955) conducted a comprehensive structural and stratigraphic study in the Flaming Gorge area. A significant portion of Anderman's study area overlaps with our current field area (Fig. 2). Several papers describing the general geology of the eastern Uinta Mountains region were published in a field trip guidebook (Lindsay, 1969).

W. R. Hansen has contributed most significantly to the understanding of geology in the eastern Uinta Mountains where the study area is located. His maps of the Flaming Gorge Quadrangle (Hansen, 1955), the Manila Quadrangle (Hansen and Bonilla, 1956), and the work presented in Hansen (1965) overlaps significantly with the eastern portion of our study area. Hansen and Bonilla (1954, 1956) briefly described and mapped the western termination of the Uinta fault in the study area. Most early workers inferred many of the faults (e.g., Uinta fault, South Valley fault, Jassen Butte fault) in the Flaming Gorge area as high-angle reverse faults based on stratigraphic separation (e.g., Hansen, 1965; Schell, 1969). In contrast to this early conclusion, a paleostress study by Gregson and Erslev (1997) showed that the region adjacent to the Uinta fault in the northern Uinta Mountains experienced NE-SW compression during the Laramide orogeny. Their study area overlaps the eastern portion of the current study.

Structural geology

The field area is located at the central segment of the Uinta Fault System (Fig. 1), where the Uinta fault dies out into a tight, N-verging monocline (Fig. 2). Major structures in this area, including the S- to SW-dipping Uinta fault, the SW-dipping Jessen Butte fault, and the left-slip South Valley fault, were mapped by Hansen (1965). However, the detailed geometry of the NE-verging North and South monoclines and several mesoscopic thrusts and folds directly adjacent to the Uinta fault were revealed for the first time by this study. As shown below, the existence of these small-scale structures have direct implications for the kinematics of major faults in the area. For convenience of description, we divide the study area into the western, central, and eastern field areas.

Western area. The dominant structure in the western area is the SW-dipping Uinta fault. In the east, this fault juxtaposes the Uinta Mountain Group in its hanging wall and the Mississippian Humbug Formation in its footwall; to the west, this fault dies out into a monocline (Fig. 2 [following page 64]; also see cross sections AA' and BB' in Fig. 3). The Uinta fault strikes southeast for a distance of ~5.5 km before it becomes E-striking (Fig. 2). Striations that are dominantly dip-slip and other kinematic indicators such as tension gashes, tool marks, and offset beds suggest reverse slip across this segment of the Uinta fault. In contrast, the ~10 km long, E-striking segment of the Uinta fault zone to the west contains minor faults (slip <0.5 m) that commonly have striations indicative of left-reverse slip (Fig. 4). The inferred left-reverse-slip faulting across the

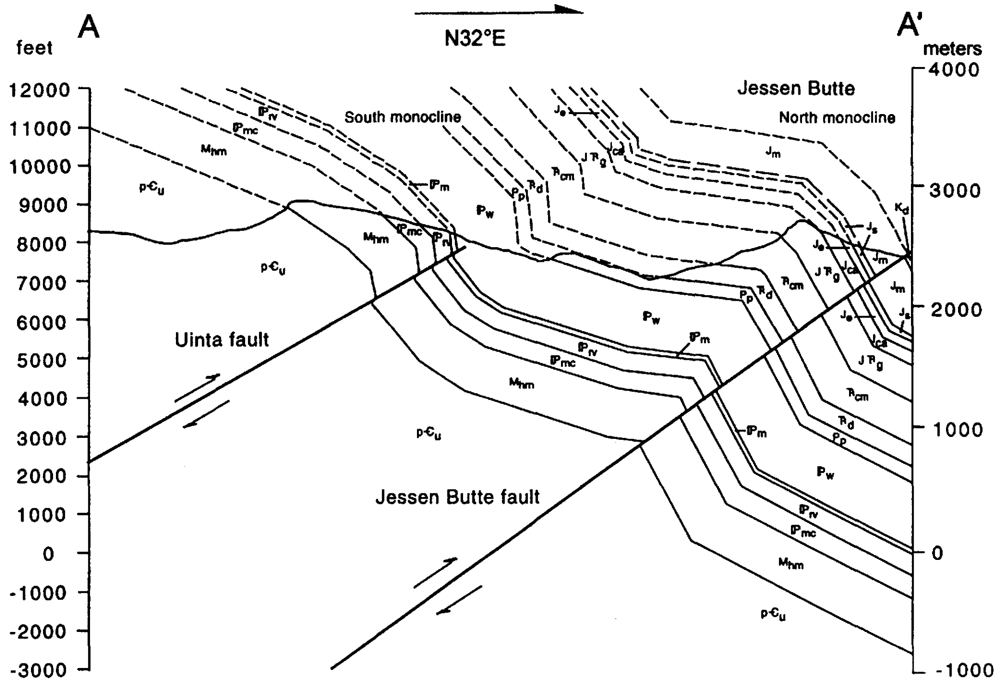


Fig. 3A

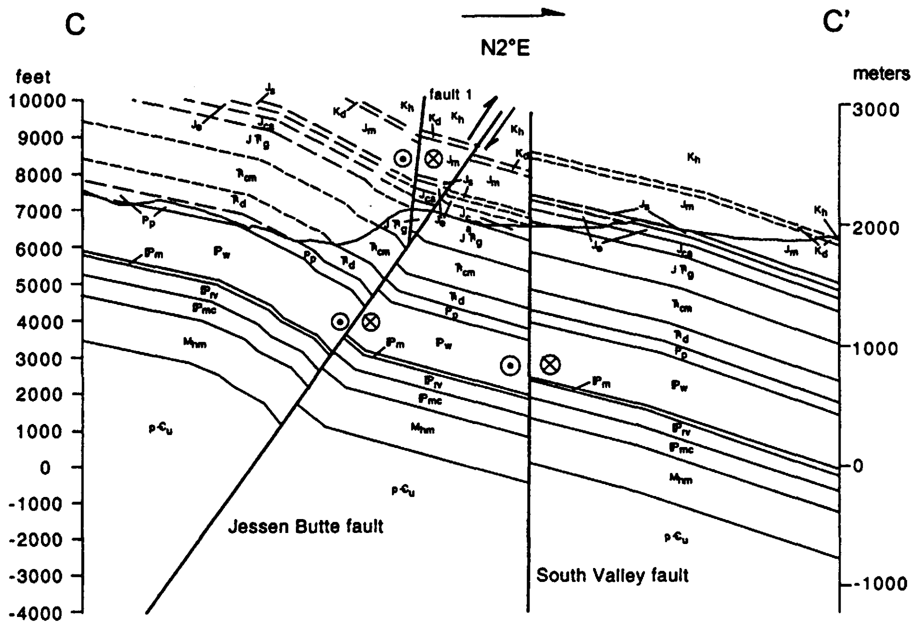
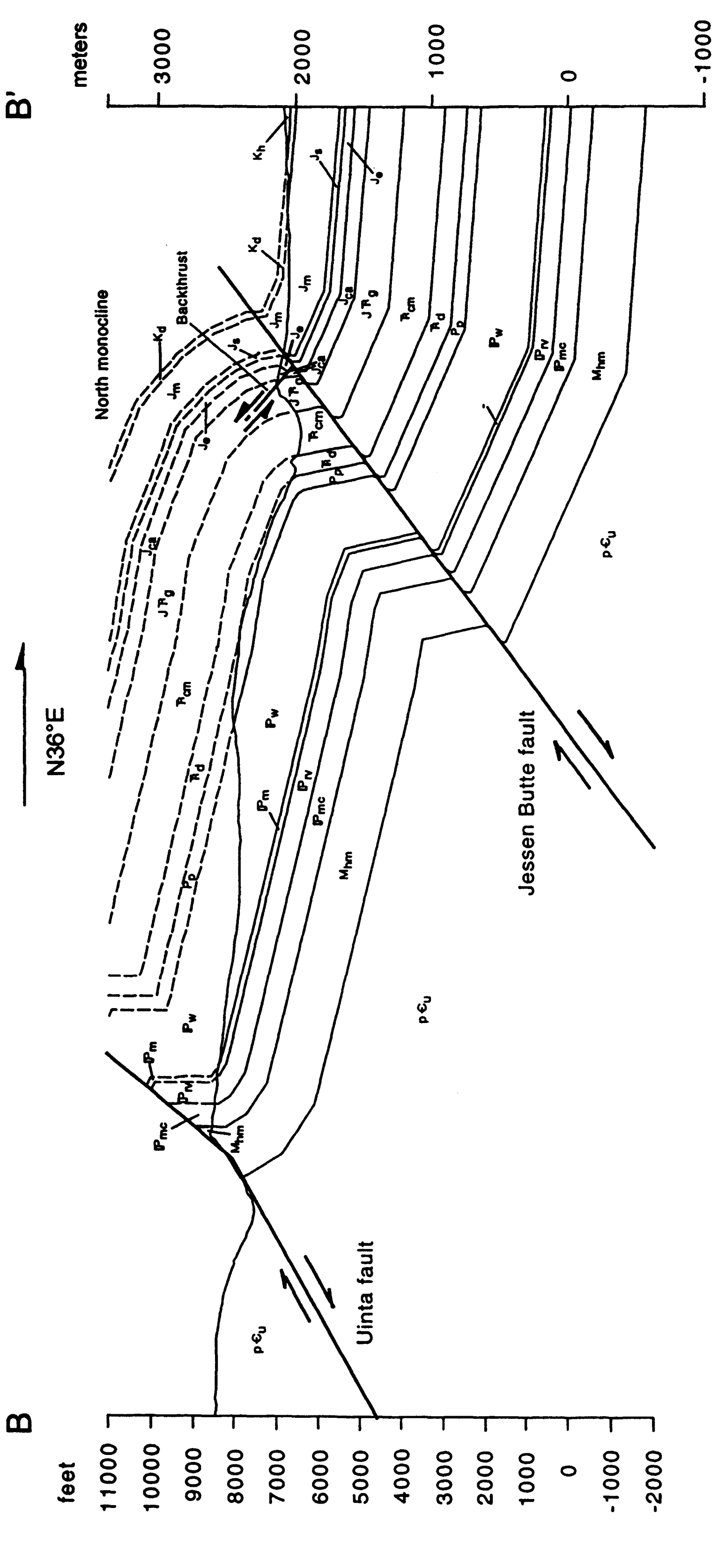


Fig. 3C

FIG. 3. Geologic cross sections showing major structures in the study area. See Figure 2 for locations of the profiles (continues on following pages).



B
B'
feet
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
meters
3000
2000
1000
0
-1000
N36°E
North monocline
Backthrust
Uinta fault
Jessen Butte fault

Fig. 3B

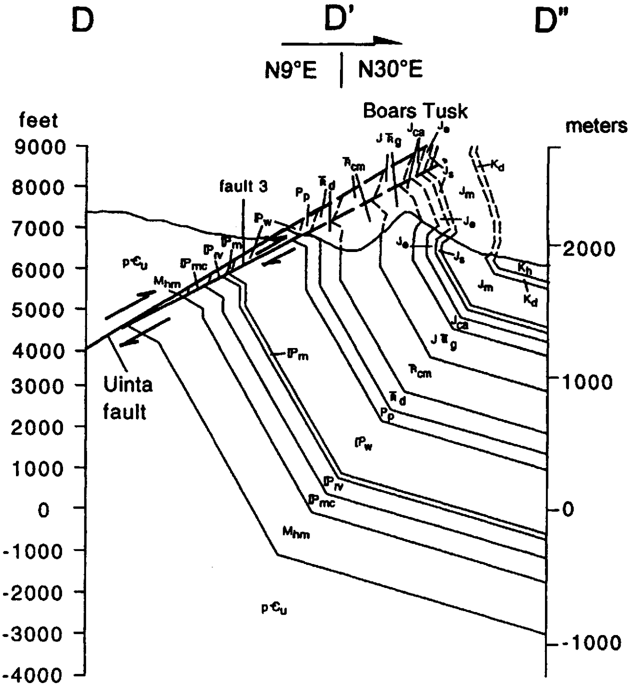


Fig. 3D

E-striking segment of the Uinta fault is consistent with the map relationship that the footwall syncline trends northwest and is aligned obliquely with respect to this segment of the Uinta fault (Fig. 2). Although individual faults have variable trends, their overall transport directions are rather consistent (Fig. 4); all are in the N50–70°E direction. This implies that the local compressional direction across the fault was ENE-WSW.

Displacement across the Uinta fault decreases westward and completely vanishes at the eastern end of the South monocline (Figure 2). This relationship suggests that the Uinta fault becomes a blind fault beneath the South monocline (see cross section AA' in Figure 3). The South monocline has two hinge zones. Its upper hinge zone is defined by a change in bedding dip from about 20–45°N in the south to >80°N in the north (Fig. 2). Its lower hinge zone is located north of the upper hinge zone, and is defined by a change in bedding dip from ~35–55°N in the south to ~20°N in the north. The North monocline lies directly above the hanging wall of the Jessen Butte fault (Fig. 2; also see cross sections AA' and BB' in Figure 3).

Strata in the Uinta Mountain Group steepen toward the Uinta fault (Figs. 5 and 6), exhibiting extensive inter-bedding flexural slip expressed by striations that typically trend N50–70°E. The footwall rocks directly below the fault experienced extensive cataclastic deformation with striations on minor fault surfaces adjacent to the main fault surface. Footwall strata are tightly folded into an E-verging overturned syncline, the axis of which parallels the NW-trending segment of the Uinta fault (Fig. 2). Flexural slip and bed attenuation also are observed in the footwall strata.

The kinematics of the SW-dipping Jessen Butte fault is not well known, owing to poor exposure. However, a minor N-dipping backthrust is observed directly above the eastern segment of the Jessen Butte fault in its hanging wall. Striations in the backthrust indicate generally dip-slip motion (Fig. 7). Motion on the backthrust and the Jessen Butte fault resulted in a small pop-up structure within which bedding is upright to overturned. If the minor backthrust is kinematically linked with the main Jessen Butte fault, the latter should also be a reverse fault with its hanging wall thrust toward the north-

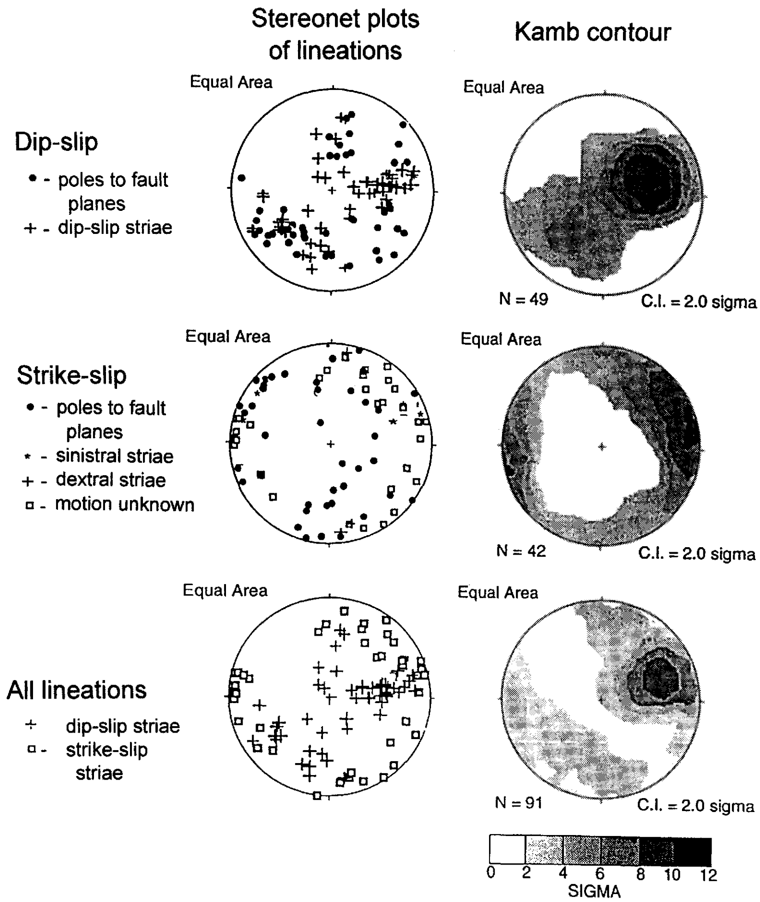


FIG. 4. Stereographic projections of fault striations taken from the Uinta fault zone in the western field area. Data from dip-slip and strike-slip faults were plotted separately in the upper and middle plots. The lower plot shows all the fault striations data from both strike-slip and dip-slip faults.

east. This interpretation is consistent with the presence of a tight, NE-verging footwall syncline that parallels the WNW-striking Jessen Butte fault (Fig. 2). The total displacement along the Jessen Butte fault is ~50 m (see cross section AA' in Figure 3).

Minor E-striking high-angle faults are common in the western field area. They are left-slip with displacement typically less than 2 m. Small high-angle right-slip faults also are observed, and typically strike NNE and have similar slip magnitudes to the left-slip faults. These two sets of faults are locally exposed together and show mutual cross-cutting relations, indicating their development was coeval as a conjugate set. The conjugate geometry of the strike-slip faults indicates that the maximum compressive stress was in the NE-SW direction. Because this direction is perpendicular to the fold axes in the area, we interpret the strike-slip faults to have developed during the Laramide orogeny during the NE-SW compression.

Central area. The structural pattern of this area in map view is S-shaped, with bedding striking northwest in the northeast, then changing to northeast in the central area, and finally switching to northwest in the south (Fig. 2). Both the South and North monoclines diminish in magnitude of shortening eastward as they enter the central area. Map-scale faults include: (1) the NW-trending South Valley fault, previously interpreted as a dip-slip fault by Hansen (1965), demonstrated by us to be left-slip; (2) a SW-dipping oblique left-reverse fault (fault 1 in Fig. 2); and (3) a SW-dipping reverse fault (fault 2 in Fig. 2). Both faults 1 and 2 have stratigraphic separation of < 20 m.

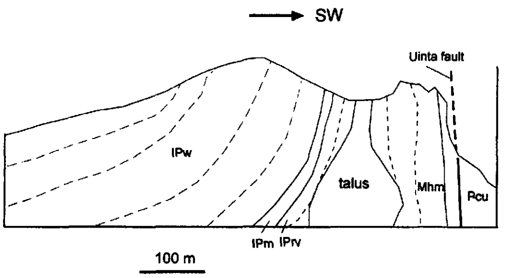


FIG. 5. Sketch of the Uinta fault and its relationship to nearby bedding attitude. Vertical to overturned strata near the Uinta fault, view to the southeast. The footwall strata are progressively less deformed and become gently dipping at ~15–20°N away from the fault. See Figure 2 for the location and the age and names of stratigraphic units.

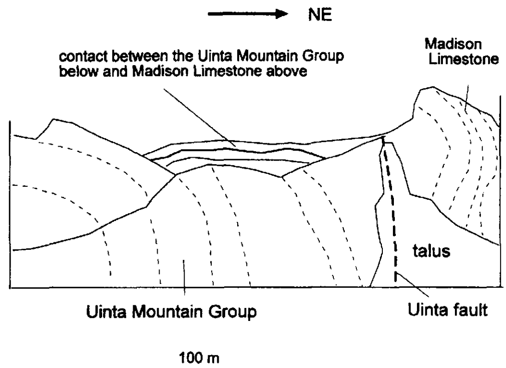


FIG. 6. The main trace of the Uinta fault in the western field area near its termination, where shortening across the Uinta fault is transferred to the South monocline. The Precambrian Uinta Mountain Group defines a monocline with bedding dipping toward the Uinta fault. Footwall rocks of the Mississippian Madison Limestone are vertical to overturned to the northeast. The Madison Limestone unconformably overlies the Uinta Mountain Group in the upper middle portion of the photo. View to the northwest. See Figure 2 for location.

Fault 1 south of the South Valley fault is a S-dipping high-angle structure (Figure 2). Striations on fault 1 have nearly equal vertical and horizontal components. Kinematic indicators such as tension cracks, tool marks, and offset beds suggest left-slip motion with its southwest side up (Fig. 8). Striations on fault 2 and kinematic indicators in the fault zone suggest that this fault is a thrust.

The trace of the Jessen Butte fault is obscured by Quaternary deposits where it enters the central field area. It terminates south of the South Valley fault in Jurassic and Triassic strata. Minor strike-slip faults are abundant in the South Valley fault zone. Offset beds and nearly subhorizontal striations indicate that this is a left-slip fault (Fig. 9). The maximum left-slip offset across this fault is about 300–400 m (Fig. 2).

Eastern area. The major structure in the area is the S-dipping Uinta fault, which placed the Uinta Mountain Group in the south over Mississippian–Jurassic strata in the north. Bedding in this area strikes northwest, oblique to the E-striking Uinta fault. Within the generally NE-dipping stratigraphic sequence are numerous folds that also trend in a northwest direction. Bedding is locally overturned on the northern limbs of those folds (Fig. 2). We interpret the minor folds and the tilting of strata in the footwall of the Uinta fault to have occurred synchronously with movement along the Uinta fault. This interpretation implies that the E-trending Uinta fault accommodated left-slip.

The Uinta fault zone is complexly deformed. Bedding near the fault zone is from nearly vertical to overturned. A minor fault with reverse sense of separation (fault 3 in Fig. 2) is present directly below the main fault. Together the two faults bound a small block within which bedding is overturned. Numerous unmappable minor faults with a variety of sense of motions are present between the Uinta fault and fault 3. Fault striations taken from the main surface of the Uinta fault, fault 3, and various minor faults within the Uinta fault zone are shown in Figure 10. The dominant dip-slip directions are southwest and northeast, whereas the dominant strike-slip components are nearly east and west. When integrated together, the average transport direction for faults in the Uinta fault zone is ENE-WSW. The kinematic data in conjunction with reverse separation across the Uinta fault suggest that the Uinta fault is a reverse left-slip fault, with its dominant transport direction to ENE. This transport direction is consistent with the western segment of the Uinta fault zone (Figure 4).

Structural Evolution of the Uinta Mountain Uplifts

Our kinematic data indicate that the Uinta and the Jessen Butte faults along the north-central Uinta uplift all have an ENE transport direction, suggesting that the generally E-striking and S-dipping Uinta fault system in the area is a reverse left-slip structure. The left-slip South Valley fault is aligned

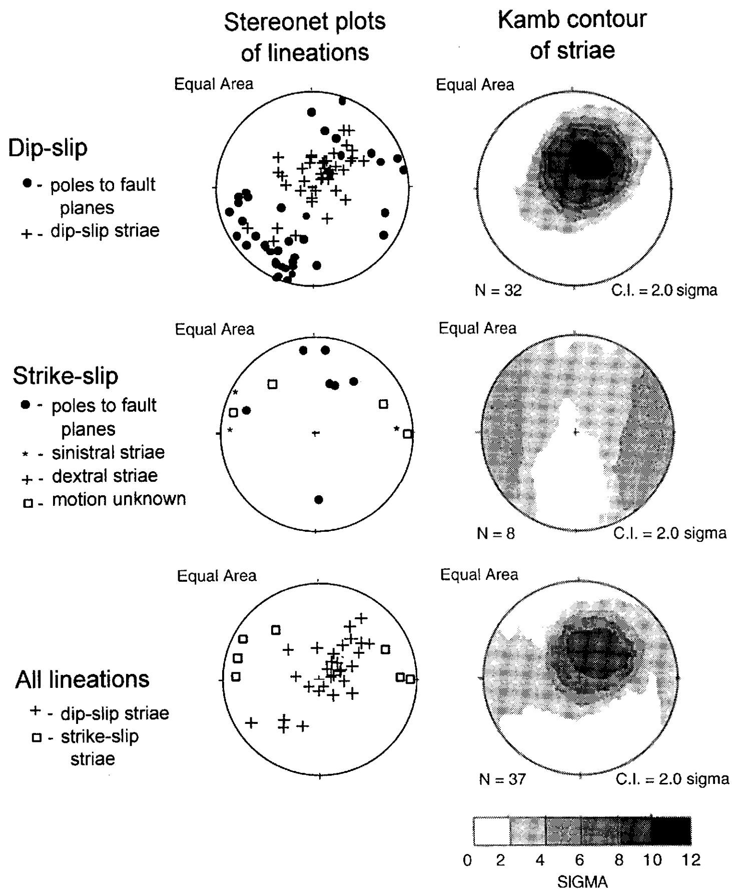


FIG. 7. Stereographic projections of fault striations taken from a small backthrust directly above the central portion of the Jessen Butte fault.

parallel to the Jessen Butte fault. Either it functioned as a slip-partitioning structure absorbing left-slip motion along the Jessen Butte fault, or it was a P-shear in the overall left-slip simple shear zone of the E-trending Uinta fault system. In either case, its kinematics are consistent with the interpretation that the northern Uinta fault system in the north central Uinta Mountains is a left-slip transpressional structure.

The structural evolution of the Uinta fault, the Jessen Butte fault, and the related North and South monoclines is shown in Figure 11. Figure 11A is a schematic reconstruction of cross section BB' in Figure 3. We interpret both the North and South monoclines to be fault propagation folds that developed during the upward propagation of the Uinta and Jessen Butte faults. This interpretation is supported by the map relationship that both faults terminate into tight folds at their ends. As a result of increase in the magnitude of slip along the Uinta fault eastward, the monoclines in the western area (see cross sections AA' and BB' in Figure 3) become tight folds in the footwall of the Uinta fault in the eastern area (see cross section DD" in Fig. 3). Such a development is shown in Figure 11B, which is the reconstruction of cross section DD" of Figure 3.

The conclusion that the northern Uinta Mountains experienced ENE-WSW compression during the Laramide orogeny is drastically different from the hypothesis that the Uinta uplift is bounded by purely dip-slip, E-trending thrusts on both its north and south sides (e.g., Gries, 1983b). We are uncertain whether the Uinta uplift is bounded by two left-slip transpressional structures (Fig. 12A) or by one

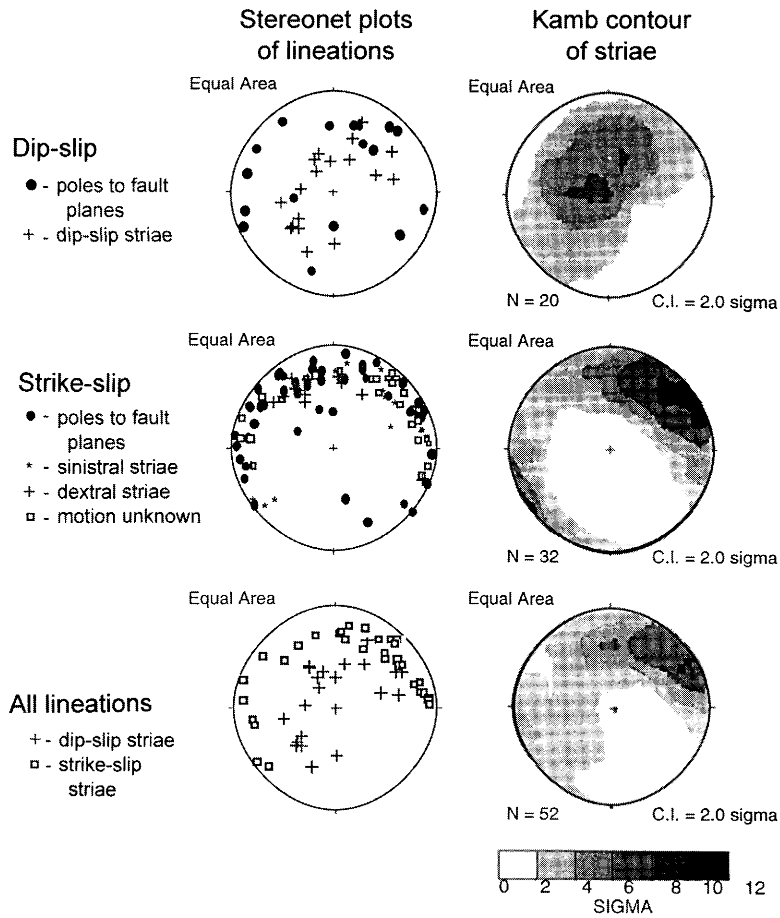


FIG. 8. Stereographic projections of fault striations from faults 1 and 2 in the central field area.

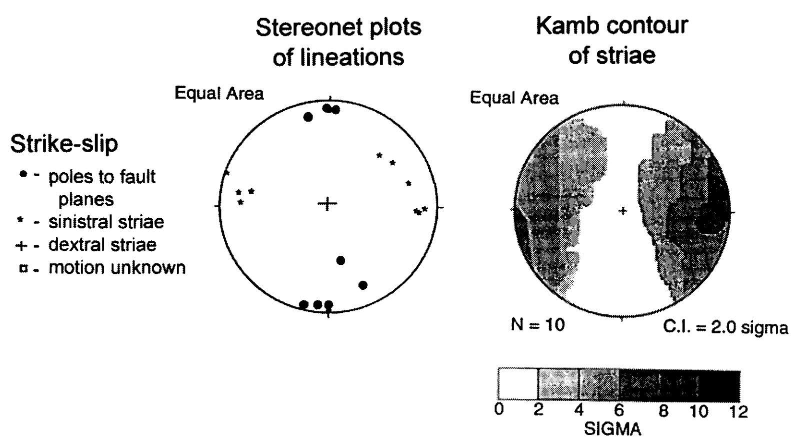


FIG. 9. Stereographic projections of fault striations from the South Valley fault.

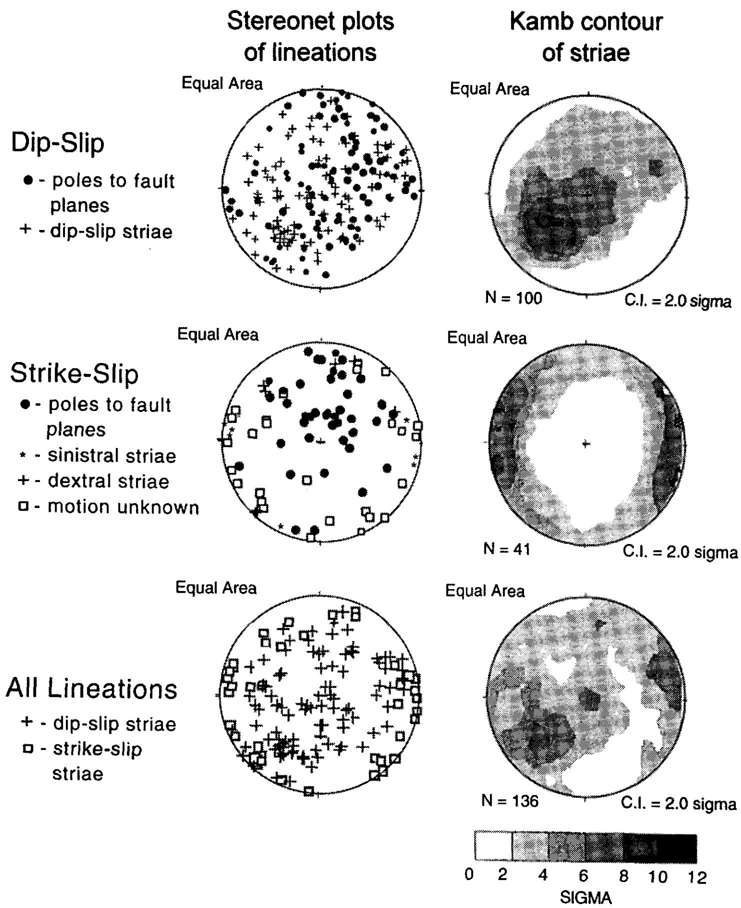


FIG. 10. Stereographic projections of fault striations from the Uinta fault zone and fault 3 in the eastern field area.

reserve left-slip fault in the north and one thrust in the south (Fig. 12B). The first option implies that left-slip simple shear was broadly distributed across the entire Uinta uplift during the Laramide orogeny, whereas the second indicates that the transpressional tectonics was partitioned by two fault systems, with its northern bounding fault responsible for most of the left-slip motion while the southern bounding fault absorbed N-S shortening. Gregson and Erslev (1997) obtained maximum compressive stress directions in the N-S and NE-SW directions in the southern part of the eastern Uinta Mountains. They suggest that this observation could either be attributed to complex local slip transfer or to spreading of the Uinta uplift outward to the east, north, and south during the Laramide orogeny. The latter situation would produce transpressional left-slip faulting at its northern boundary and right-slip faulting at its southern boundary. Because the axial traces of major faults are highly curved on map view in the southern part of the eastern Uinta Mountains, we suggest that they define oroclinal bends due to large-scale left-slip shear. This interpretation would favor the second hypothesis (Fig. 13B) and would explain the two prominent anticlines in the core of the Uinta Mountains that are aligned in an en echelon fashion (Fig. 1). We also note that the extent of the anticlines inside the Uinta Mountains is closely related to the extent of the range-bounding faults. For example, the eastern anticline within the Uinta uplift ends exactly where the Uinta fault terminates in our study area (Figs. 1 and 2), suggesting that the Uinta fault is a blind thrust underneath the eastern Uinta uplift.

If the Uinta uplift was created by left-slip transpressional tectonics, the natural question is

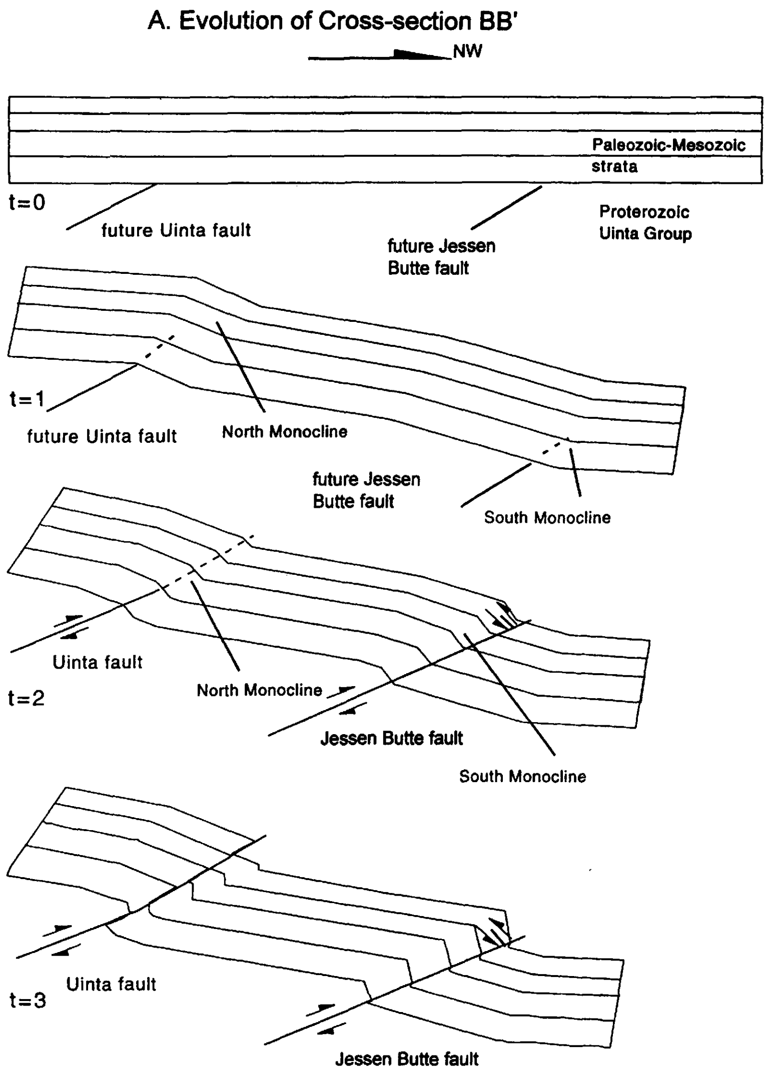


FIG. 11. A. Schematic reconstruction of cross-section BB' shown in Figure 2 (continues on following page).

where the strike-slip motion along its bounding faults was transferred from the west to the east. We suggest that the left-slip simple shear deformation across the Uinta uplift accommodated differential ENE-WSW shortening between the Wyoming Laramide province in the north and the relatively rigid Colorado Plateau in the south. In a sense, the Laramide faults bounding the Uinta uplift are similar to the Garlock fault that bounds the highly extended Basin and Range in the north and the less extended Mojave block in the south (Davis and Burchfiel, 1973), acting as a transfer structure as suggested by Brown (1988). Based on this interpretation, we propose a model for the overall evolution of the Uinta Mountains uplift during the Laramide orogeny. In the first stage, the Laramide deformation reactivates the Proterozoic faults that bound the Uinta Mountain Group strata. As the magnitude of shortening is greater in Wyoming north of the Uinta faults than that in the Colorado Plateau south of the Uinta

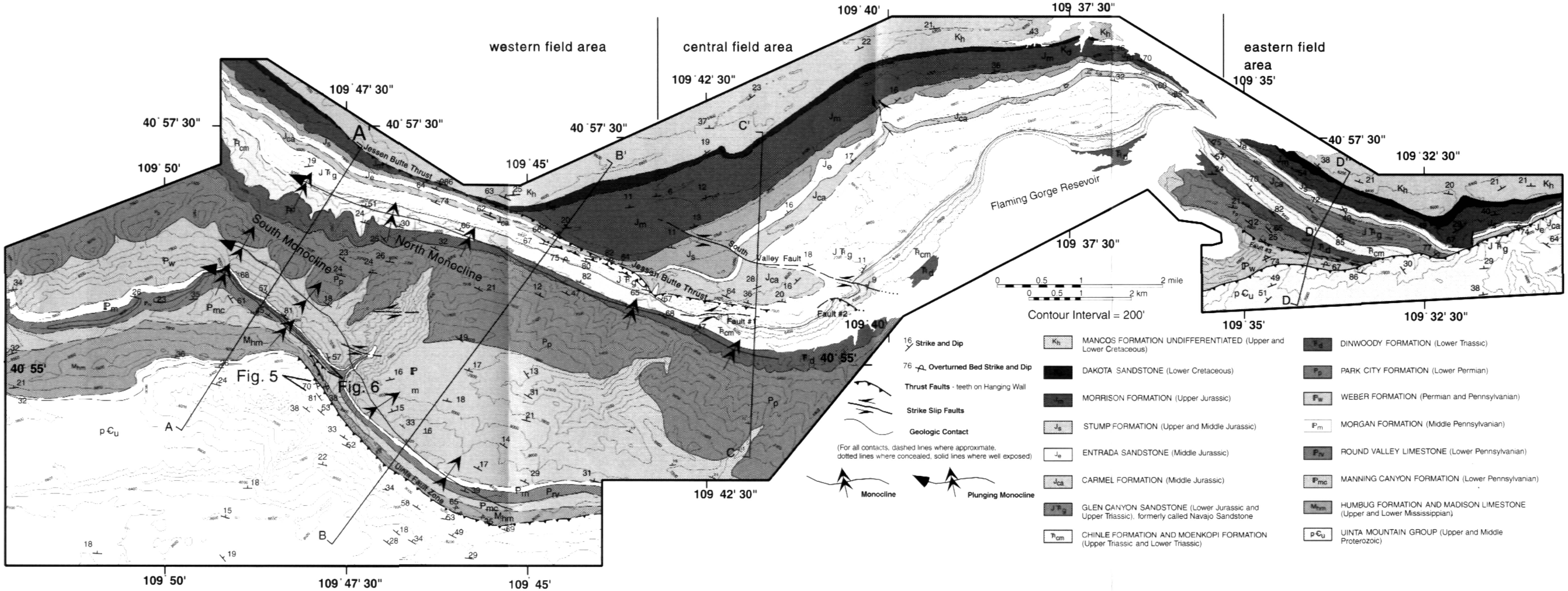


FIG. 2. Geologic map of the study area in the north-central Uinta Mountains. The study area is divided into the eastern, central, and western field areas as described in detail in the text. See Figure 1 for location.

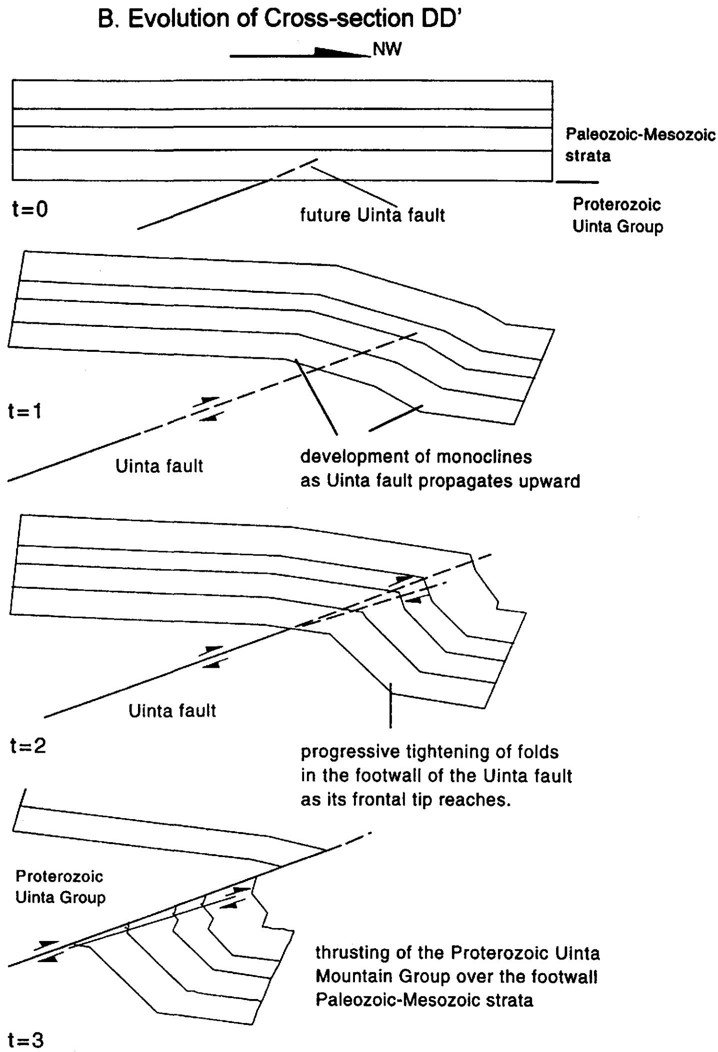


FIG. 11. B. Schematic reconstruction of cross-section DD' shown in Figure 2.

faults, left-slip motion was required (Fig. 13A). As a result of left-slip simple shear deformation, two large-scale en echelon anticlines were developed within the Uinta uplift (Fig. 13B). The left-slip motion south of the uplift was transferred to the east and was absorbed by development of nearly N-S–trending folds and thrusts along the eastern edge of the Colorado Plateau (Fig. 1).

Conclusions

The Uinta uplift formed in the latest Cretaceous to Early Tertiary was created by left-slip transpressional tectonics. It is expressed by reverse left-slip motion along its northern bounding fault, the Uinta fault, and by the development of NW-trending en echelon folds in the core of the uplift. The transpressional tectonics developed as a result of contraction in an ENE-WSW direction. This direction is similar to the regional shortening direction over the entire Laramide orogenic belt, as inferred from plate interactions, numerical simulations, and field observations. This result suggests that the Laramide stress field was rather simple throughout the western United States, although both structural trends and

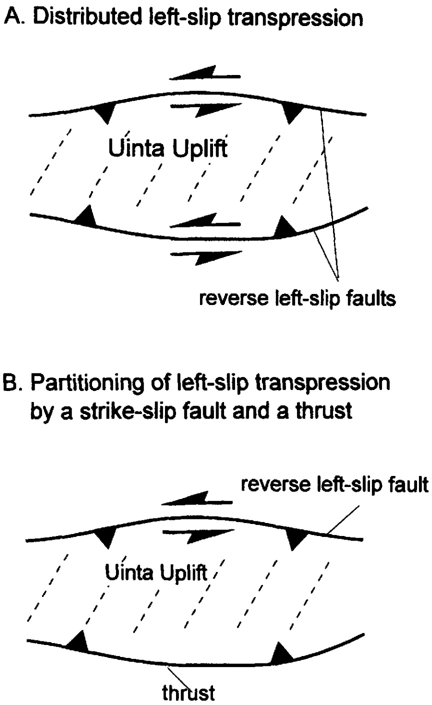


FIG. 12. Two possible models for the distribution of left-slip transpressional deformation across the Uinta uplift during the Laramide orogeny. A. The northern bounding fault is a left-slip transpressional structure whereas the southern bounding fault is a pure thrust. B. Both the northern and southern bounding faults are left-slip transpressional structures.

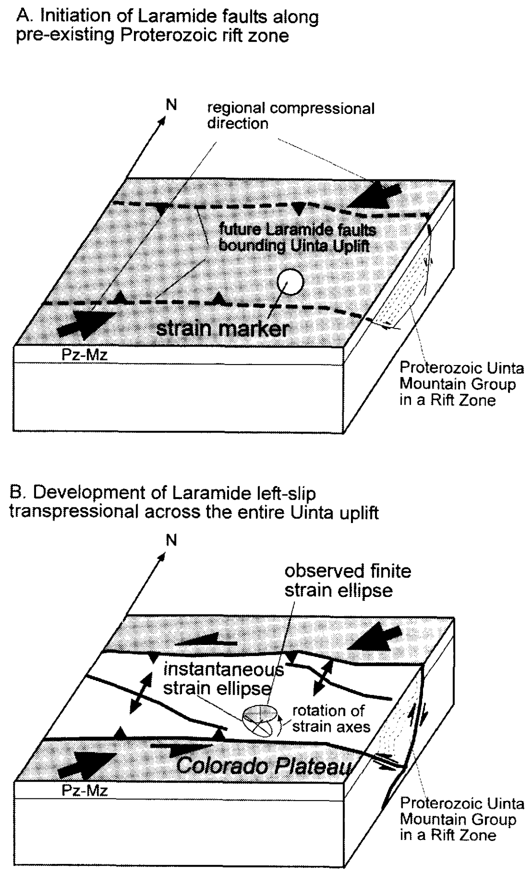


FIG. 13. Tectonic model for the evolution of the Uinta uplift during the Laramide orogeny. A. The Laramide deformation reactivates the Proterozoic faults that bound the Uinta Mountain Group strata under the regional ENE-WSW compression. B. Because E-W shortening is greater in the Laramide Wyoming province directly north of the Uinta faults than that in the Colorado Plateau directly south of the Uinta faults, left-slip transpressional deformation resulted. This led to the development of en echelon anticlines in the core of the Uinta uplift.

fault kinematics produced by the Laramide deformation are highly variable.

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