Sedimentology and paleogeography of the late Triassic Higham Grit, southeastern Idaho and western Wyoming

by David Ralph Hazen

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences

Montana State University

Abstract:
Stratigraphic and lithofacies analyses of the Late Triassic Higham Grit in the southeastern Idaho and western Wyoming fold and thrust belt show it to be comprised predominantly of coarse to medium-grained pebbly sandstone and pebble conglomerate with lesser amounts of interbedded mudstone. Thickness ranges from 9 to 150 m and increases northwestward. Lithofacies present include massive to crudely horizontally bedded pebbly gravel (Cm), trough crossbedded sand (St), planar tabular crossbedded sand (Sp), horizontally stratified sand (Sh), ripple cross-laminated sand (Sr), and finely laminated sand and mudstone (F1). Deposition occurred in a South Saskatchewan and/or Platte River-type braided stream complex on a broad alluvial plain through the development of longitudinal bars and interbar channel lags (Gm), straight-crested transverse bars (Sp), and sinuous-crested transverse bars and dunes (St). Periodic high-velocity flow resulted in development of upper flow regime plane beds (Sh). Minor episodes of flood plain inundation gave rise to finely laminated sand and mud (F1). These findings differ from previous interpretations of Higham deposition as a coalescing alluvial fan complex.

Pebble size and paleocurrent analysis of medium scale trough and planar-tabular crossbeds denote an overall north to northwest paleoflow direction. Petrographic data indicate erosion of a plutonic/metamorphic source terrain, probably associated with the relict Uncompahgre and/or Front Range components of the Late Paleozoic Ancestral Rocky Mountains uplift. Deposition of Higham detritus thus occurred as a sheet sandstone deposit at a distance (as much as 500 km) from the sediment source which is comparable with the modern South Saskatchewan and Platte Rivers.

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APPROVAL

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David Ralph Hazen

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date December 12, 1985

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ABSTRACT

Stratigraphic and lithofacies analyses of the Late Triassic Higham Grit in the southeastern Idaho and western Wyoming fold and thrust belt show it to be comprised predominantly of coarse to medium-grained pebbly sandstone and pebble conglomerate with lesser amounts of interbedded mudstone. Thickness ranges from 9 to 150 m and increases northwestward. Lithofacies present include massive to crudely horizontally bedded pebbly gravel (Gm), trough crossbedded sand (St), planar tabular crossbedded sand (Sp), horizontally stratified sand (Sh), ripple cross-laminated sand (Sr), and finely laminated sand and mudstone (Fl). Deposition occurred in a South Saskatchewan and/or Platte River-type braided stream complex on a broad alluvial plain through the development of longitudinal bars and interbar channel lags (Gm), straight-crested transverse bars (Sp), and sinuous-crested transverse bars and dunes (St). Periodic high-velocity flow resulted in development of upper flow regime plane beds (Sh). Minor episodes of flood plain inundation gave rise to finely laminated sand and mud (Fl). These findings differ from previous interpretations of Higham deposition as a coalescing alluvial fan complex.

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INTRODUCTION AND PURPOSE OF STUDY

The Late Triassic Higham Grit is a medium to coarse grained gravelly quartz sandstone and gravel conglomerate which crops out in the thrust belt of southeastern Idaho and western Wyoming (Fig. 1). The Higham Grit was deposited as a relatively thin (9-150 m) blanket over a minimum area of 5000 square kilometers in what is now south central Idaho. Mansfield (1916, 1927) and Kummel (1953) give general descriptions and interpretations of the depositional environment of the Higham Grit, but no detailed petrographic of sedimentologic work has been done previous to this study.

Previous investigations of the Higham Grit postulate a source area to the west of the Idaho-Wyoming thrust belt. Westward coarsening and thickening of the Higham Grit has been used to support interpretations of deposition by a series of coalescing alluvial fans originating from an uplift in central Idaho (Mansfield 1927). Oriel (in McKee, 1959) and Rubey (1955) cite lithologic and faunal evidence for a mountain chain separating western Idaho from eastern Idaho during the Late Triassic. Armstrong and Oriel (1965, p. 1853) interpret deposition of the Higham Grit to represent initiation of the breakup of the Cordilleran miogeosyncline. Thus, the Higham Grit could represent detritus shed from incipient uplifts associated with onset of the Sevier orogeny or from some other poorly documented Late Triassic orogenic event. However, Wiltschko

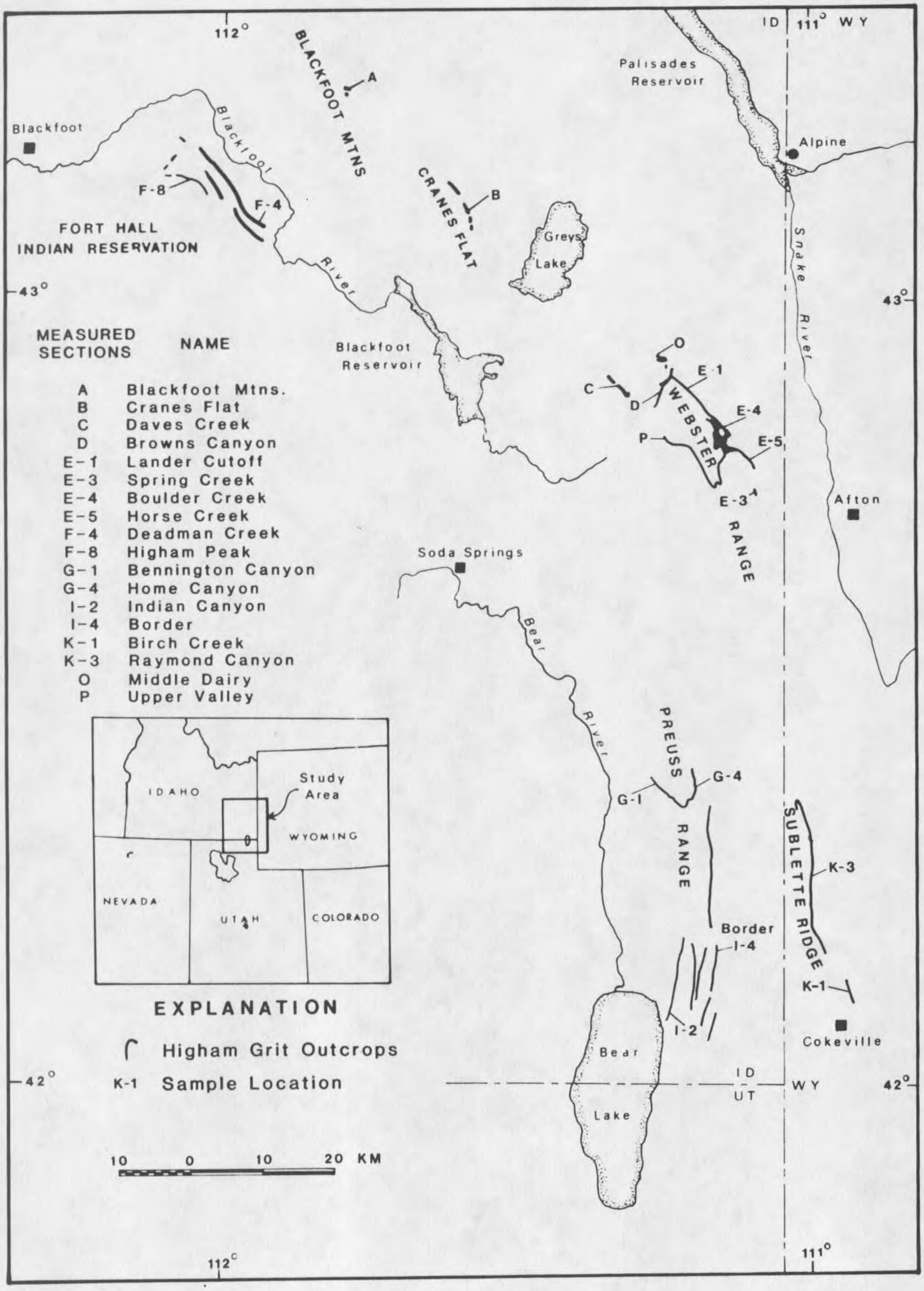

Figure 1. Location of Higham Grit outcrops and measured sections.

and Dorr (1983, p. 1309) note that "neither the specific cause of the uplift nor the exact location of the source area for the Higham Grit is yet well established."

Possible causes of Late Triassic tectonic activity and uplift of the source area for the Higham Grit can be interpretated from recent plate tectonic models of the tectonic evolution of the western Cordillera. Current models postulate the accretion of a microplate (Sonomia) in the early to middle Triassic to the passive western margin of North America (Speed, 1977,1979; Hamilton, 1978; Schweikert and Snyder, 1981). An accretionary wedge of ocean floor strata in front of Sonomia was thrust westward over the continental slope creating the Golconda Allochthon (Speed, 1979). In the latter half of the Triassic, after the Sonoman orogeny, additional packages of rocks containing Mississippian to Upper Triassic chert, argillite, carbonates, greenstone, and Alpine type ultramafic rock were accreted to the western edge on North America (Davis and others, 1978). A volcanic arc then developed on the western edge of North America as a result of eastward subduction of oceanic crust, resulting in Late Triassic arc magmitisim extending into the continent (Burchfiel and Davis, 1975; Davis and others, 1978; Hamilton, 1978; Burchfiel, 1981; Dickinson, 1981). It is possible that uplifts associated with the accretion of these terranes is the provenance of the Higham Grit. Figure 2 shows the general regional tectonic setting, sediment transport directions and sediment thickness of the Late Triassic.

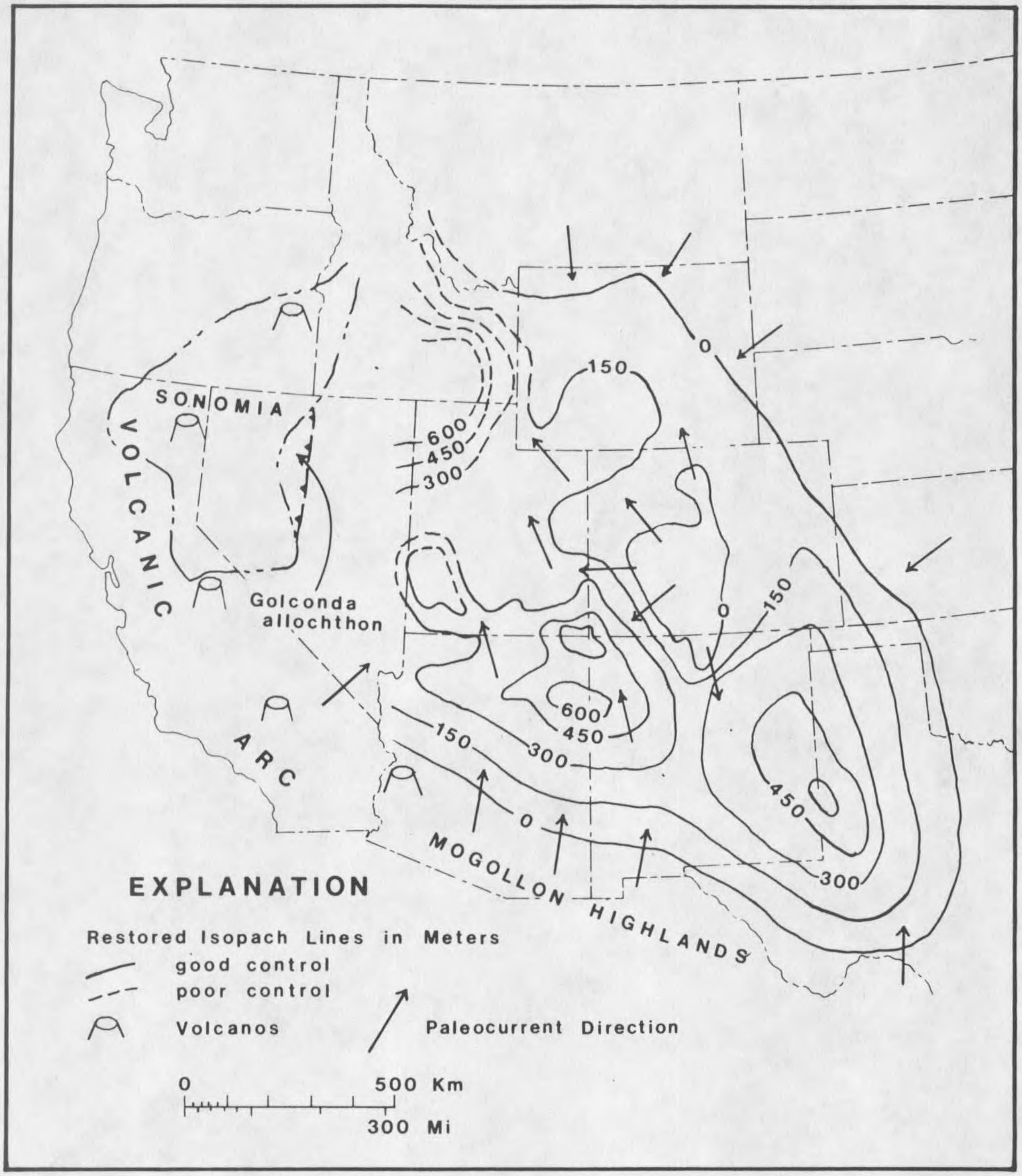

Figure 2. Generalized regional tectonic setting, sediment transport directions, and isopach map of Late Triassic sedimentation, western United States (modified from McKee, 1959; Speed, 1979; and Dickinson, 1981).

The approach taken in this study is to apply modern lithofacies analysis and sedimentary petrographic techniques to the Higham Grit in order to determine its sedimentology and provenance. More specifically, questions to be addressed include: 1) What depositional environments played a roll in Higham accumulation?, 2) What is the composition of Higham detritus?, 3) In which direction(s) was the Higham detritus transported?, and 4) Does the Higham represent an initial synorogenic deposit within the Sevier foreland basin sedimentary sequence, or can it be related to orogenic activity of a different nature elsewhere in the region?

METHODS

FIELD METHODS

Detailed stratigraphic sections within the Higham Grit were measured and described at 18 localities in southeastern Idaho and western Wyoming (Fig. 1). Lithofacies present in each were classified using the terminology of Miall (1977). Approximately 700 crossbed orientations were measured throughout the study area. Both trough and planar crossbeds were utilized. In addition, the size of the largest 20 to 30 gravel-sized clasts was measured at each measured section.

LABORATORY METHODS

Correction for tectonic tilt ranging from 5 to 90 degrees was required for all of the crossbed measurements. Vector orientation and magnitude (consistency factor) were calculated according to Carver (1977) and Curray (1956). When right and left limbs of trough crossbeds were differentiated, plots using the technique described by DeCelles and Langford (1983) were made to determine the average trough axis orientation.

A total of 58 thin sections were prepared from representative lithologic samples for study with the petrographic microscope. All thin sections were stained for potassium feldspar. An average of 320 points were counted per thin section. Modal size (Appendix 1) was visually estimated for most samples from thin section and by examination of the samples with a binocular microscope. Grain size of six samples was determined by measuring 250 points in thin section. Five samples were disaggregated by hand and sieved. No conversion of the modal size estimated from thin section to sieve modal sizes (as determined by Friedman, 1958) was made because of the relatively small difference this would make in the grain size classification of the samples.

PALINSPASTIC RESTORATIONS

All outcrops of the Higham Grit are located in the fold and thrust belt of Wyoming, Idaho, and northeastern Utah (Fig. 3). The most extensive outcrop trends occur in the Crawford and Meade thrust allochthons. Thrusting has transported these strata many kilometers east of their original site of deposition. Also, the northernmost outcrops of Higham may have been rotated in a counterclockwise direction as a result of thrust belt impingement with the ancestral Teton-Gros Ventre foreland uplift, (Grubbs and Van der Voo, 1976). Accurate paleogeographic placement of Higham outcrops relative to other Late Triassic tectonic features requires palinspastic restoration of the thrust sheets. To accomplish this, seven cross sections from Dixon (1982) were restored utilizing his film overlay method. The restored positions of Higham outcrops given by this method are 100 to 150 km west of their present locations (Fig. 3). Thus thrusting has produced shortening on the order of 40 to 65% in the area.

The accuracy of any such restoration is dependent upon the correctness of the original cross sections. The cross sections of the thrust belt used represent the best available at this time.

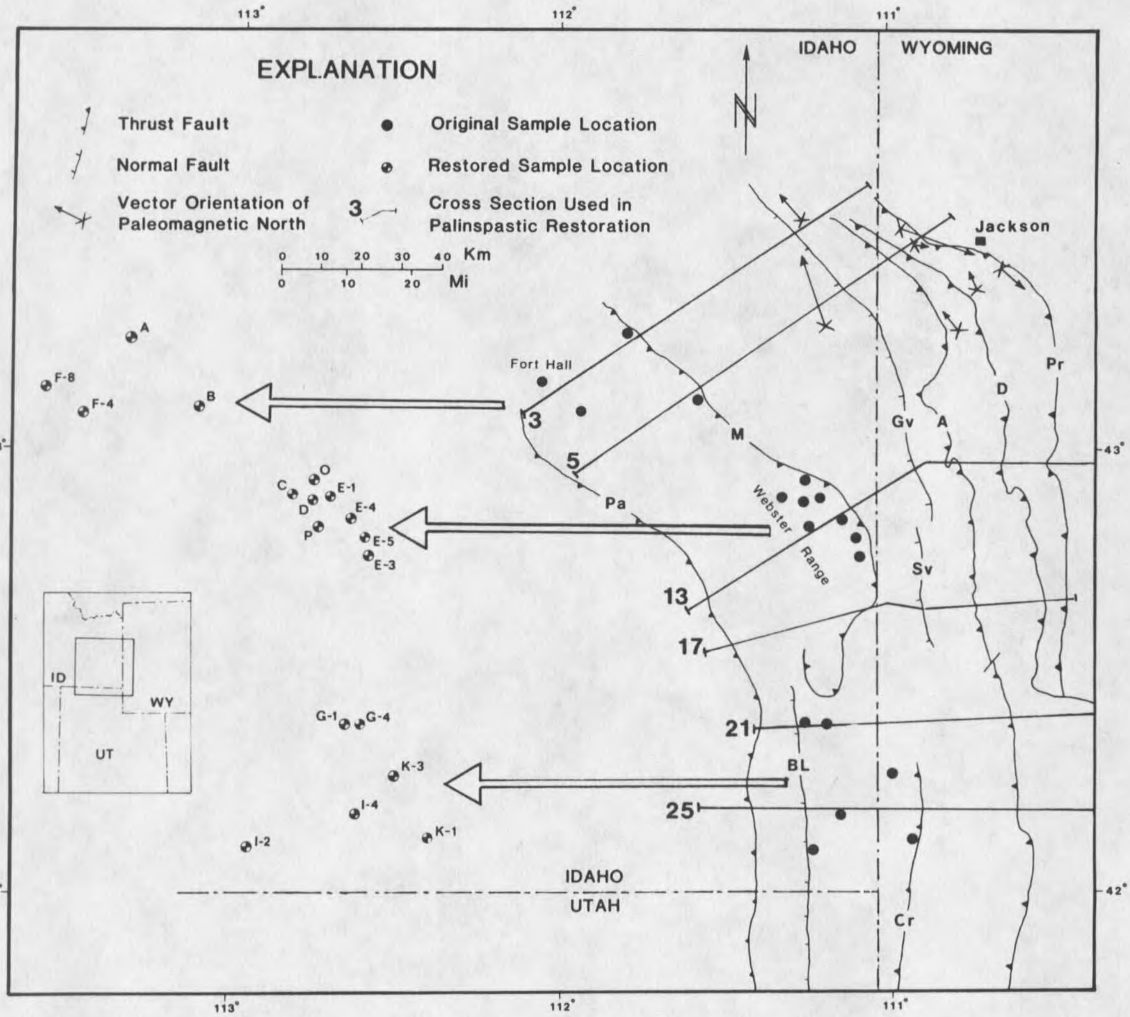

Figure 3. Palinspastic restoration of thrusts in study area. Cross sections used in palinspastic restoration are from Dixon (1982). Vector orientations of paleomagnetic north are from Grubbs and Van Der Voo (1976). Large arrows show general movement of sample locations due to palinspastic restoration. Faults shown are: Pa, Paris thrust; M, Meade thrust; BL, Bear Lake fault; Cr, Crawford thrust; Sv, Star Valley fault; Gv, Grand Valley fault; A, Absaroka thrust; D, Darby thrust; Pr, Prospect thrust;

However, several problems with the palinspastic restoration process require that the restored positions of the outcrops be considered only as approximations. For example, curvature of the northern part of the thrust belt (Fig. 3) causes a basic problem in "pulling" the thrust sheets westward. In order to balance the cross section, it must be drawn perpendicular to the strike of the thrusts. In this case, if the sections in the north end of the thrust belt are restored with their east end fixed, an unrealistic situation results. For example, restored outcrop locations from the Webster Range are superimposed upon restored locations of outcrops in the Fort Hall Indian Reservation. To avoid this superposition of outcrops, it is assumed that the major component of tectonic transport of the thrust sheets was due east. It is also assumed that displacement of rocks in the northern part of the thrust belt was approximately equal to the "east-west" component of the total restoration distance, as determined from the cross-sections. Because these assumptions are only approximations, only an approximate original position of outcrops can be determined. Nonetheless, the restored positions of outcrops are probably much closer to their original position than are their present locations.

Another problem associated with outcrops in the northern part of the area is the possibility that they have been rotated. Paleomagnetic studies by Grubbs and Van der Voo (1976) show that rocks in the hanging wall of the Absaroka, Darby, and Hogsback thrusts were tectonically rotated counterclockwise within a horizontal plane. In these thrust sheets, rotation probably occurred because of impingment of the thrust sheets upon basement involved foreland uplifts of the Teton-Gros Ventre block. Figure 2 shows the present direction of paleomagnetic north in late Triassic red beds as determined by Grubbs and Van der Voo (1976). They indicate that paleomagnetic north in the rocks has been rotated to a position that is approximately parallel to the trace of thrust faults.

Because no paleomagnetic work has been done on formations in thrust sheets further to the west, there exists the possibility that outcrops in the hanging wall of the Crawford thrust were either: 1) rotated to a position similar to those in the later and more eastern Absaroka, Darby, and Hogsback thrusts, 2) not rotated because the Crawford thrust was not directly impinging upon basement uplifts to the east, or 3) were rotated some intermediate amount. Conceivably, resultant paleocurrent vector azimuths in the northern part of the study area could have been rotated a maximum of 45 degrees in a clockwise direction. Either rotated or non-rotated paleocurrent azimuths in this area are possibilities at the present time. Paleocurrent data gathered in this study are presented herein in their non-rotated positions.

STRATIGRAPHY

HISTORY OF INVESTIGATIONS

The first description of the Higham Grit was published by Mansfield (1916, 1920) after geologic investigations on the Fort Hall Indian Reservation, Idaho. He named the formation for Higham Peak on which the Higham Grit is well exposed as a resistant ridge. Mansfield differentiated the Timothy Sandstone, Higham Grit, Deadman Limestone, Wood Shale, and Nugget Sandstone from rocks previously assigned to the Nugget Formation by Gale and Richards (1910). These formations lie above the lower Triassic Thaynes Limestone and below the Jurassic Twin Creek Limestone (Fig 4). All except the Timothy Sandstone were tentatively placed by Mansfield in the Upper Triassic (Mansfield, 1927). However, no fossils were found to support a Late Triassic age for the units. Additional mapping by Mansfield (1927) delineated further outcrops of the Higham Grit in southeastern Idaho and western Wyoming.

Williams (1945) correlated the Higham Grit from Indian, Home, and Montpelier Canyons in the Preuss Range of southeastern Idaho with a lithologically similar sandstone and conglomerate present in the Ankareh Formation of northeastern Utah. This grit, extending eastward into Colorado, was thought to correlate with the Shinarump Conglomerate of the Colorado Plateau (Williams, 1945). Thomas and Krueger (1946) named this sandstone and