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I am submitting herewith a thesis written by Eric Gordon Hogan entitled “Sedimentologic and Stratigraphic Analysis of Units Defining the Basal Sauk Supersequence Across the Craton Margin Hinge Zone, Southeastern California.” I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

Christopher Fedo

Major Professor

We have read this thesis
and recommend its acceptance:

Linda Kah

Micah Jessup

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and
Dean of the
Graduate School

Original signatures are on file with official student records

**SEDIMENTOLOGIC AND STRATIGRAPHIC ANALYSIS OF UNITS DEFINING THE
BASAL SAUK SUPERSEQUENCE ACROSS THE CRATON MARGIN HINGE ZONE,
SOUTHEASTERN CALIFORNIA**

A Thesis Presented for
the Masters of Science
Degree
The University of Tennessee, Knoxville

Eric Gordon Hogan
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DEDICATION

This thesis is dedicated to my mother and father who provided me with the tools to succeed and who never let me forget the Golden Rule.

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ABSTRACT

In the Death Valley and Mojave Desert regions of southeastern California, the contact separating the lower and middle members of the Wood Canyon Formation (WCF) is currently interpreted as a regional scale unconformity coincident with the base of the Sauk Sequence. Regional mapping of this surface, however, reveals a nonconformable contact with underlying crystalline basement in cratonic settings, and a relatively conformable contact atop a northwest thickening wedge of miogeoclinal strata that is capped by the lower member of the WCF. Consistent with an unconformity, the progressive loss of three carbonate units within the lower member of the WCF has been attributed to incision by the base of the middle member WCF. However, fossil evidence and correlation based on carbon isotope compositions of each lower member WCF dolostone units rejects top-down erosion to describe their loss and overall cratonward thinning. Results from multiple detailed, measured, stratigraphic sections of a conglomerate found at the base or low in the middle member WCF also do not support a top-down erosion model because the conglomerate has variable stratigraphic position and absence in some locations. Middle member WCF conglomerate clasts also reveal variation in composition and grain size across the regions. Sequence stratigraphic architecture indicates that filling of available accommodation space and short period normal regression, as opposed to a forced regression, are the causal mechanisms for formation of the basal middle member WCF unconformity, and that the base of the Sauk Sequence rests lower in the stratigraphic section.

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1.0 INTRODUCTION

Modern stratigraphic interpretation of North American cratonic sedimentary sequences is based on the correlation of thick packages of strata bound by interregional unconformities (Sloss, 1988). These unconformities are persistent in contemporaneous basins and represent long periods of time in cratonic regions (Sloss, 1963). Because erosion, slower subsidence rates, and sediment by-pass inherently lead to an incomplete stratigraphic record across the craton interior, thick sequences of rock deposited across the craton margin, which contain the basinward expression of cratonic sequences, may provide more clues as to the origin and nature of these primary stratigraphic divisions.

In the southern Great Basin, Neoproterozoic and Cambrian strata were deposited in response to the break-up of Rodinia (e.g., Prave, 1999), where continent fragmentation allowed extensive siliciclastic sediments to be shed from the craton interior and deposited across the thermally subsiding passive margin (Stewart, 1972; Fedo and Cooper, 2001). Depending on the magnitude, if eustatic sea-level changes were involved in the formation of an interregional-scale unconformity, as has been interpreted for the base of the Sauk Sequence across Laurentia (Sloss, 1963), then evidence of this unconformity should be exposed across cratonic, craton margin, and miogeoclinal settings of the southern Great Basin, California (fig. 1; appendix A).

In the Mojave Desert, cratonic sections begin with the Lower Cambrian middle member of the Wood Canyon Formation (WCF), which rests nonconformably on Mesoproterozoic crystalline basement (Fedo and Cooper, 1990; fig. 2a) and unambiguously marks the base of the Sauk Sequence. Within craton margin and miogeoclinal settings, however, the middle member of the WCF overlies a northwest thickening wedge of Neoproterozoic strata that includes the lower member of the WCF, Stirling Quartzite, Johnny Formation, and Noonday Dolomite

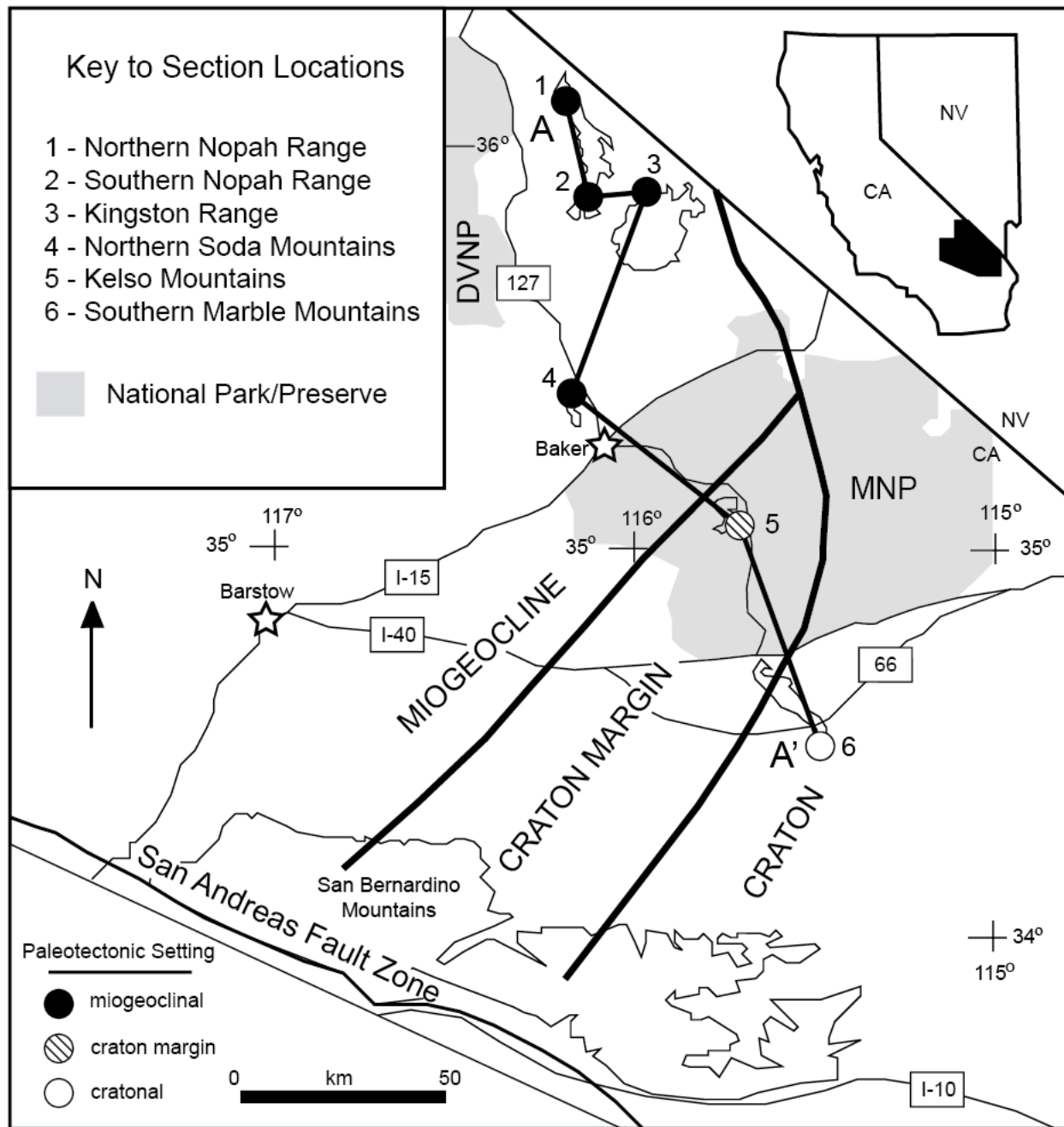


Figure 1: Generalized map of the southern Death Valley and northern Mojave Desert regions. Six study areas are numbered on the map and are connected by the line A-A' for stratigraphic correlation in subsequent figures. Death Valley National Park (DVNP) and the Mojave National Preserve (MNP) are colored in gray on the map. Modified from Fedo and Cooper (2001).

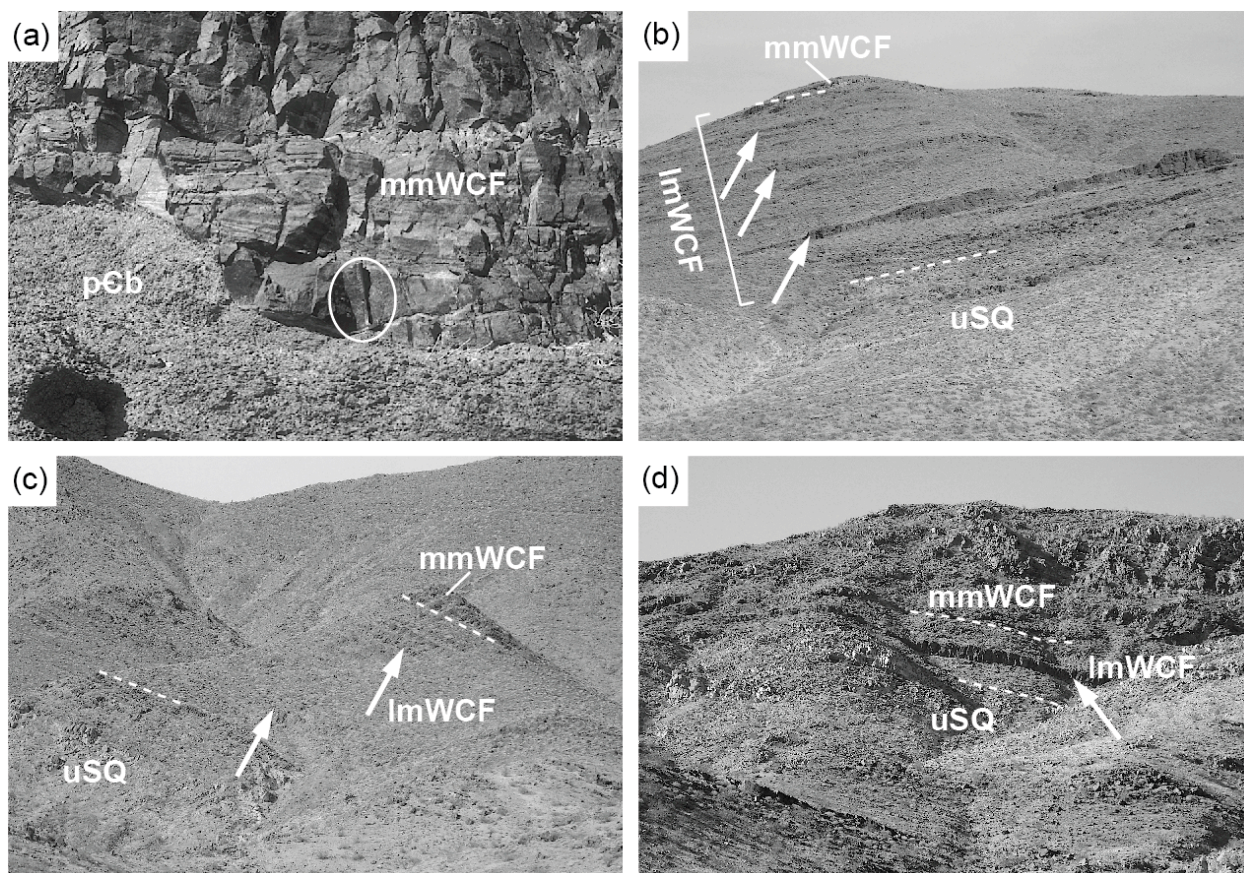


Figure 2: Field photos of the lower and middle members of the Wood Canyon Formation. White dashed lines denote stratigraphic boundaries. Carbonate units, where present are identified with arrows. a, Photo of the middle member of the WCF (mmWCF) nonconformably overlying Proterozoic crystalline basement rock (pCb) in the southern Marble Mountains. A meter deep channel is shown in the photo with a rock hammer for scale (in circle). b, Photo of the lower and middle members of the WCF in the northern Nopah Range at Chicago Pass. The lower member of the WCF (lmWCF) is ~ 150 m thick in this section, rests on the upper member of the Stirling Quartzite (uSQ), and contains three carbonate units, identified by arrows. c, Photo of the lower and middle members of the WCF in the southern Nopah Range at Gunsight Mine. The section is ~ 45 m thick and contains two carbonate units indicated by arrows. d, Photo of the lower and middle members of the WCF in the Soda Mountains. The lmWCF is ~ 35 m thick in this location and contains one carbonate unit indicated by an arrow.

(Link et al., 1993; Fedo and Cooper, 2001; fig. 2b-d). Fedo and Cooper (2001) considered differential subsidence (craton vs. miogeocline) coupled with top-down erosion by the middle member of the WCF as the primary agents of thinning and truncation of these underlying strata in craton and craton margin sections. However, uncertainty about the duration and magnitude of incision, or if incision occurred at all, beneath the middle member of the WCF places the top-down erosion model in need of additional assessment. The purpose of this study is to examine detailed sedimentology and stratigraphy of distinct facies within the lower and middle members of the Wood Canyon Formation, across the presently interpreted base of the Sauk Sequence, to determine the extent to which present sequence stratigraphic interpretations of the basal Sauk Sequence boundary need revision.

2.0 REGIONAL BACKGROUND

2.1 Tectonic Evolution

A record of rifting of the supercontinent Rodinia is captured in Middle to Upper Neoproterozoic strata in the Death Valley and Mojave Desert regions, forming the southwestern margin of Laurentia. Stewart (1972) recognized that during the Late Neoproterozoic, the Cordilleran craton margin of Laurentia underwent a punctuated transformation from an actively deforming rift margin (e.g., Young, 1995; Prave, 1999) to a thermally subsiding passive margin (Bond et al., 1989; Levy and Christie-Blick, 1991). Stratigraphic architecture and the lateral extent of Neoproterozoic and Cambrian rocks in southeastern California record the depositional response to this transformation (Fedo and Cooper, 2001). The wedge-shaped Neoproterozoic package of strata that is defined by the lower member of the WCF at the top and the Noonday Dolomite at the bottom is bound to the southeast by the rifted shoulder of southwestern Laurentia, and is interpreted to be part of the initial immature passive margin phase of

deformation (Bahde et al., 1997; Barth et al., 2009). Sedimentary rocks belonging to the middle member of the WCF and younger Cambrian strata blanket the Neoproterozoic wedge, lap onto the craton and are interpreted to be part of the more mature, passive margin, cratonic sedimentary succession (Fedó and Cooper, 2001) that was first described by Sloss (1963).

Of particular importance to the stratigraphic architecture in the Death Valley and Mojave Desert regions is the position of the craton margin hinge zone (fig. 1), which separates miogeoclinal strata deposited on the more rapidly subsiding continental shelf from strata deposited on the more stable craton (Cooper and Fedó, 1993). Sub-middle member WCF strata are relatively thin and poorly developed in craton margin sections and mark a clear transition between the miogeocline and craton. To the northwest of the craton margin, thicker packages of sub-middle member WCF strata are part of the miogeoclinal wedge (fig. 1), and preserve a more complete sedimentary response of the evolving margin. Slower subsidence rates in cratonic sections would have limited the amount of accommodation space for the accumulation of sediment. A transect from the miogeocline to the craton has the potential to identify deep incision of the craton margin if it were exposed for a significant length of time during the Early Cambrian. Exposures of basal Cambrian sedimentary rocks however, do not lie in their original depositional positions because of tectonic dismemberment.

Subsequent to Paleozoic passive margin conditions, the Cordillera Laurentian margin experienced multiple phases of deformation that shifted in intensity and duration (Christie-Blick and Levy, 1989). Mesozoic compression was compensated by faulting and folding within Neoproterozoic and Cambrian miogeoclinal sediments that rarely extended into crystalline basement (Walker et al., 2002), and by the widespread intrusion of granitic plutons (Miller et al., 2002). The most recent major tectonic event, which began in the mid-Cenozoic and was most

active in the Miocene (e.g., McQuarrie and Wernicke, 2005; Mahan et al., 2009), records extension that has produced north-south trending, rift-related, mountain ranges bounded by high-angle (Dokka, 1989) and low-angle (Wernicke, 1981; Spencer, 1985) normal faults and transform faults (Dokka, 1983). The structures displaced large blocks of Precambrian and Phanerozoic strata (e.g., Fowler and Calzia, 1999; Glazner et al., 2002), and have resulted in the exhumation of numerous metamorphic cores (e.g., Old Woman Mountains and the Death Valley Turtlebacks).

2.2 Stratigraphic Setting

Sequence stratigraphic architecture results from the complex interplay between thermo-tectonic subsidence, eustatic sea-level change, autocyclicity, and sediment yield. An ordered hierarchy is defined based on the duration of time represented by each unconformity bound package of strata and the magnitude of time represented by their respective bounding surfaces. Sloss' (1963) sequences (Sauk, Tippecanoe, Kaskaskia, Absaroka, Zuni, and Tejas) represent 1st order packages of sedimentary rocks and are subdivided into 2nd order supersequences, each being composed of 3rd order depositional sequences (Mitchum et al., 1977; Sloss, 1988). The first of four 2nd order supersequences, defined as Sauk I within the overall Sauk Sequence, begins with the base of the middle member WCF disconformity and is capped by a regional flooding surface and marine shale of the Carrara Formation (Keller et al., 2003). The 1st order unconformity, that marks the base of the Sauk Sequence should reflect a global sea level low-stand and be expressed by erosional downcutting on the craton and a major basinward shift in facies (Sloss, 1988).

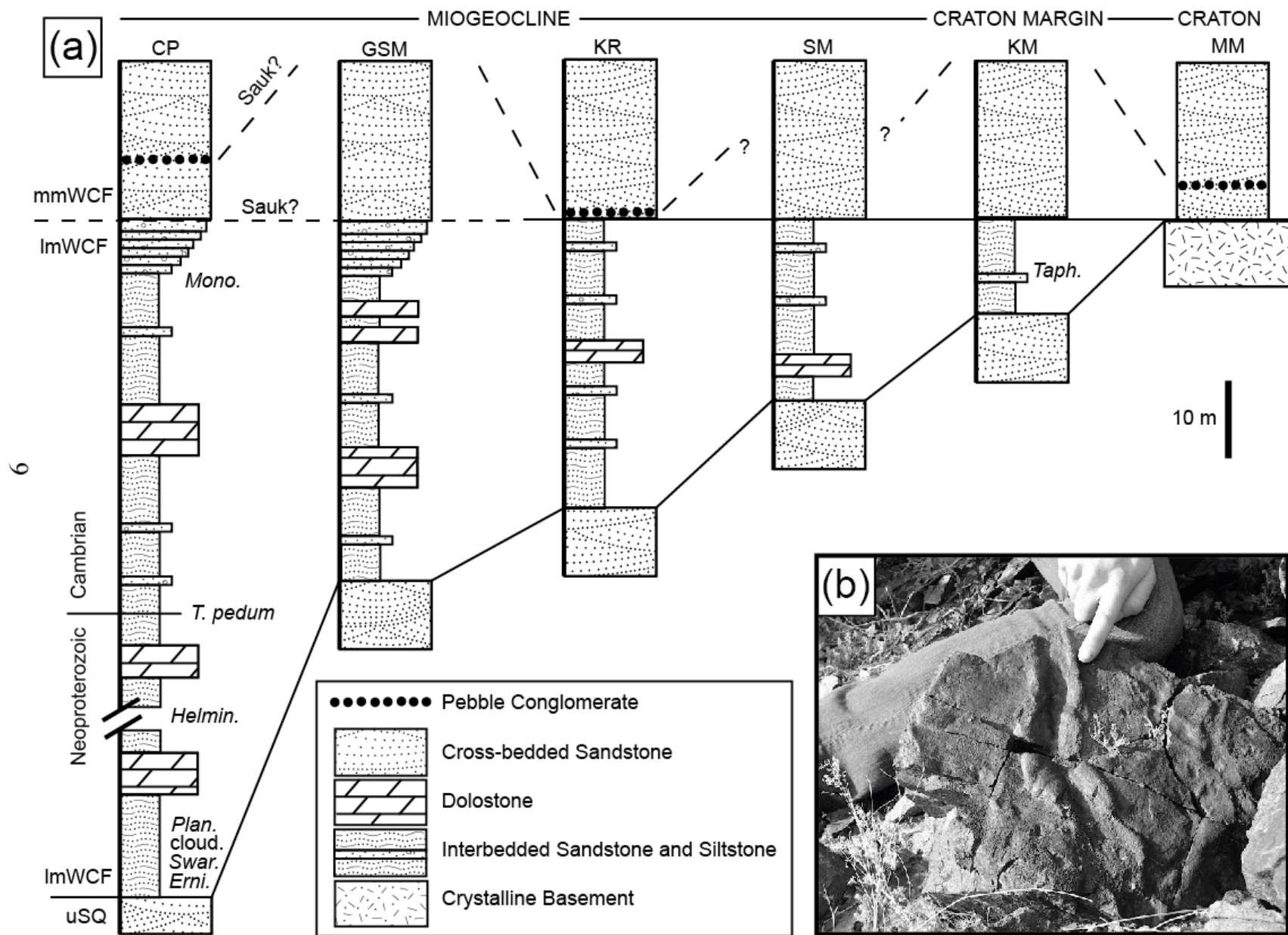
The basal Sauk I unconformity is identified in cratonic settings where coarse-grained siliciclastic sedimentary rocks nonconformably overly Precambrian basement rocks (Runkel et

al., 2007), and is clearly expressed as the base of the middle member of the WCF (lithostratigraphic equivalent: Tapeats Sandstone, Grand Canyon, USA). The middle member is composed dominantly of cross-stratified feldspathic sandstones punctuated with distinct meter-thick pebble conglomerate units, both deposited by braided alluvial systems (Hereford, 1977; Diehl, 1979; Fedo and Cooper, 1990; Fedo and Cooper, 2001). In craton margin and miogeoclinal settings, the Neoproterozoic-Cambrian transition lies within the lower member of the WCF and is marked by the first occurrence of the trace fossils *Treptichnus pedum* and *Taphrhelmenthopsis* (Corsetti and Hagadorn, 2000; Hagadorn et al., 2000; fig. 3a, b). Fedo and Cooper (2001) proposed a stratigraphic reconstruction of the rifted margin, which is used here as a regional guide for developing the present study, which spans the craton margin hinge zone (figs. 1,3) and the Neoproterozoic-Cambrian boundary. In this scenario, the position of the Neoproterozoic-Cambrian transition and its relative position to the craton margin are key stratigraphic and tectonic constraints in the investigation of what mechanism is responsible for thinning of the miogeoclinal wedge.

2.3 Problem Development

Multiple distinct carbonate units and a meter-thick interval of conglomerate are present below and above the inferred basal Sauk Sequence unconformity, respectively, making them useful targets for determining a mechanism for stratigraphic thinning and loss of lower member WCF section across a broad study area. An apparent progressive loss in the number of lower member WCF carbonate units from three in the northern Nopah Range (fig. 2b), to two in the southern Nopah Range (fig. 2c), to one in the Soda Mountains (fig. 2d) and Kingston Range, and none in cratonic sections of the Marble Mountains (fig. 2a, 3a) has been considered to represent top-down erosion by the base of the middle member (Fedo and Cooper, 2001). This architecture

Figure 3: Stratigraphic position of the lower and middle members of the Wood Canyon Formation and identification of the Neoproterozoic-Cambrian boundary. a, Stratigraphic cross section through six study areas showing the lower member of the Wood Canyon Formation (lmWCF) resting on the Stirling Quartzite (SQ) and thinning in the cratonward direction. Measured sections from left to right are taken from the northern Nopah Range at Chicago Pass (CP), southern Nopah Range at Gunsight Mine (GSM), Kingston Range (KR), Soda Mountains (SM), Kelso Mountains (KM), and the southern Marble Mountains (MM). The lmWCF section at Chicago Pass is approximately 150 meters thick. Note the break in section between the first and second dolostone units. The middle member WCF conglomerate is shown with variable stratigraphic position above the unconformity. The Neoproterozoic-Cambrian transition is marked based on the first appearance of the trace fossil *T. Pedum* (Corsetti & Hagadorn, 2000) in the CP location. Other identified fossils (Corsetti & Hagadorn, 2000; Hagadorn et al., 2000) are indicated based on their first appearance and include *Ernietta* (*Erni.*), *Swartpuntia* (*Swar.*), cloudiniid tubes (*cloud.*), *Planolites* (*Plan.*), *Helminthoidichnites* (*Helm.*), *Treptichnus pedum* (*T. pedum*), *Monomorphichnus* (*Mono.*), and *Taphrhelminthopsis* (*Taph.*). b, Cambrian-aged trace fossil *Taphrhelminthopsis* at KM. Hand for scale. The stratigraphic position of the trace fossil on the KM stratigraphic column indicates that this section contains Cambrian-aged strata below the base of the mm WCF in a craton margin location.



is consistent with considerable erosion that would be expected with a regional to interregional disconformity.

A potential stratigraphic connection to thinning and loss of carbonate units is the conglomeratic interval recognized in the lower part of the middle member of the WCF, which has the potential to be the base of an erosive unit cut during sea level lowstand and represent the base of the Sauk Sequence (e.g., Runnegar et al., 1995). Across the Death Valley and Mojave Desert regions, however, the position of the conglomerate within the lower part of the middle member WCF is highly variable and a gradational transition is observed in some sections between the lower and middle members of the WCF, raising questions about the possible significance of this surface representing the base of the Sauk Sequence. Detailed sedimentology and stratigraphy of the lower and middle members of the WCF are used to present three possible scenarios (fig. 4a-c) that may account for the observed stratigraphic thinning and progressive loss of the three distinct carbonate beds within the lower member of the WCF.

The first scenario illustrates an interregional unconformity developed as a result of forced regression (Fedo and Cooper, 2001; fig. 4a) that could have erosionally removed lower member strata from the top down. However, the presence of Cambrian-aged trace fossils, such as *Taphrhelminthopsis* sp. (fig. 3b; Fedo and Cooper, 2001), within marine shales of the lower member WCF in a craton margin location (fig. 3a, Kelso Mountains), means that the loss of carbonate units and overall stratigraphic thinning cannot be simply attributed to top-down erosion. If the mechanism for stratigraphic thinning was top-down erosion, the Cambrian units would have eroded first, leaving Proterozoic shales as the predicted unit that would lie below the middle member of the WCF in craton margin locations. The presence of Cambrian-aged fossils

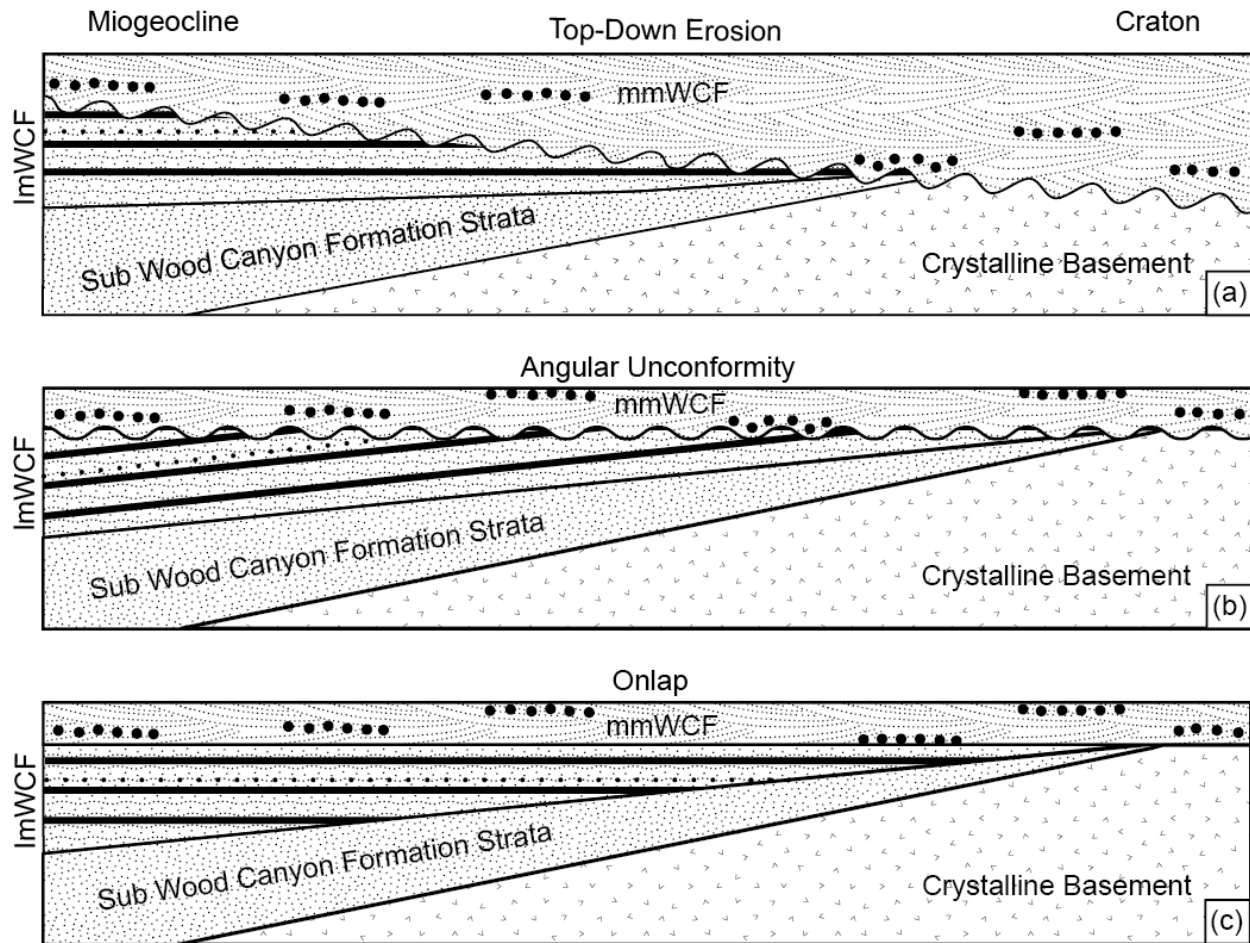


Figure 4: Schematic cross sections of the lower and middle members of the Wood Canyon Formation showing three scenarios that could account for stratigraphic thinning and loss of carbonates within the ImWCF. a, Top-down erosion scenario (Fedo and Cooper, 2001) wherein the mmWCF reflects progressive downcutting into the ImWCF with greater magnitude in the cratonward direction. Each carbonate (thick black lines within the ImWCF) is progressively removed from the top down. b, Angular unconformity scenario (cf., Devlin and Bond, 1988) where the mmWCF has eroded into the ImWCF subsequent to tilting of the ImWCF. Each carbonate is progressively removed from the top down. c, Onlap scenario where the mmWCF has not eroded into the ImWCF. Each carbonate is progressively removed from the bottom up. The dotted line in each model represents the expected position of the Precambrian-Cambrian boundary as denoted by the first appearance of *T. pedum* (Corsetti & Hagadorn, 2000). Diagrams are not to scale.

in this shale essentially eliminates top-down erosion as the sole driver in truncating strata across the craton hinge.

A second scenario shows truncation resulting from rotation of the Neoproterozoic sedimentary wedge producing an angular unconformity (fig. 4b). Such a relationship is tectonically, as opposed to eustatically, derived and is observed for the base of the Sauk Sequence in the Canadian Hamill and Gog Groups (Devlin and Bond, 1988). In the Death Valley and Mojave Desert regions, no direct field evidence in the form of angular stratigraphic relationships has been recorded to support the angular unconformity scenario, so it can also be ruled out.

With neither of these explanations supported by stratigraphic or structural evidence, a third scenario is proposed for consideration. The loss of carbonate units and decreasing thickness within the lower member of the WCF could be explained by a progressive onlap of strata onto the craton (fig. 4c) during marine transgression. This scenario does not require an extended eustatic sea-level low stand to account for sequence boundary formation at the base of the middle member of the WCF and records a normal, as opposed to forced, regression. This study tests the fidelity of the third scenario (fig. 4c) and develops the depositional history based on real data given that the first two explanations (fig. 4a, b) have been ruled out.

3.0 METHODS

3.1 Stratigraphic Measurements

Detailed measured sections (appendix B) of the lower member and part of the middle member of the WCF were made at six study areas (fig. 1), including nine closely spaced locations within the cratonic southern Marble Mountains. There, thicknesses were measured from the nonconformity that separates Proterozoic crystalline basement rock from the middle

member of the WCF, to approximately two meters above the middle member WCF conglomerate interval. In craton-margin and miogeoclinal sections, the entire lower member was measured including the transition into the middle member and upward to the first distinct conglomerate interval. Detailed measurements of carbonate units in the lower member of the WCF were measured at miogeoclinal sections in the Soda Mountains, Kingston Range, southern Nopah Range, and northern Nopah Range (figs. 1-3).

3.2 *Clast Counting*

3.2.1 *Field*

To compare the conglomerate of the middle member WCF in all of the study areas, clast counts were performed using a one-meter square grid. Long- and short-axis measurements and identification of the lithology of individual clasts was made at 5 cm increments throughout the grid. This technique was used to preserve the original clast distribution. Examples of each observed clast type and any unidentifiable clasts were collected at each location for further analysis and identification in the lab.

3.2.2 *Lab*

Clasts were also collected from weathered parts of the conglomerate where pebbles could be plucked from the outcrop or taken from the ground immediately below the bed from which the clasts were derived. A total of 983 clasts of middle member WCF conglomerate were collected from study areas in the northern Nopah Range (214 clasts), the southern Nopah Range (332 clasts), the Kingston Range (165 clasts), the Kelso Mountains (93 clasts), and the southern Marble Mountains (179 clasts). Along with composition determination and rounding, long, intermediate, and short axis lengths were obtained for all of the collected clasts to determine phi

size and sphericity. At least one sample of each identified clast type was analyzed petrographically to confirm interpretation of composition.

3.3 *Isotopic Analysis*

Carbonate samples from the lower member of the WCF were collected from the northern Nopah Range, southern Nopah Range, Kingston Range, and Soda Mountains (fig. 1). Petrographic and cathodoluminescence analysis of carbonate thin sections were used to determine composition, grain size, texture, extent of alteration, and possible fossil occurrences. Carbon isotope composition of each sample was obtained using a Finnigan Delta XL Plus continuous flow mass spectrometer at the University of Tennessee. Approximately 1.5 mg of each powdered carbonate sample was reacted at 120 °C in phosphoric acid to liberate carbon dioxide. The gas was then transferred into the mass spectrometer for analysis. Analytical error for the instrument has been determined to be approximately 0.2 ‰. Two tests were employed to determine if samples were affected by low-grade metamorphism and/or diagenesis, which may have altered carbon isotope compositions. First, powdered bulk rock samples from each carbonate unit were analyzed. Second, polished thick sections of each carbonate sample were observed under cathodoluminescence and areas of each sample interpreted to be the least diagenetically overprinted (Kaufman et. al., 1991) were micro drilled using a 0.5 mm drill bit. Micro drilled powders were then analyzed and compared with bulk rock results. Detailed methods for sample preparation and analysis are described in Bartley et al. (2007). All results are reported in per mil notation relative to Pee Dee Belemnite (PDB).

4.0 UNIT DESCRIPTIONS AND INTERPRETATIONS

The lower member of the WCF is discussed first in order to develop the depositional and stratigraphic history in the order of deposition. This organization permits the lower to middle

member WCF transition to be studied in terms of environmental and stratigraphic change through time as it was developed in nature.

4.1 Lower Member Wood Canyon Formation Carbonates

4.1.1 Carbonate Descriptions

The lower member of the WCF is composed of dark brown mm-thick planar laminated and hummocky cross-stratified sandstone and siltstone interbedded with cm-thick trough cross-stratified sandstone. Soft sediment deformation in the form of load casts and ball and pillow structures are abundant throughout the siliciclastic portion of the lower member (Diehl, 1979). Prominent ledge forming, 1 to 9 m thick dolostone units are reddish-brown and comprised of cm- to m-thick massive, planar laminated, or trough cross-stratified dolomitized grainstone and carbonate mudstone beds and less abundant beds of sandy carbonate conglomerate and breccia (fig. 5a-f).

For the purpose of this study, each of the dolostone units of the lower member were measured and described in detail (fig. 6a-c; appendix C) to determine paleoenvironments and aid in their possible correlation. Physical characteristics, unique to a single or multiple carbonate units, were also used in the stratigraphic correlation process. These characteristics include unit thickness, bed thickness, sedimentary structures, percent of siliciclastic material, and observable petrographic features, such as the extent of diagenetic alteration and fossil occurrences.

Three lower member dolostone units crop out in the northern Nopah Range (fig. 6a). The lowermost dolostone unit in the northern Nopah Range is approximately 9 m thick and forms a sharp contact with sandstone beds above and below the unit. Carbonate beds near the base of the unit are trough cross-stratified (fig. 5a) and are interbedded with carbonate cemented trough cross-stratified sandstone. The middle and upper two thirds of the unit contain planar laminated

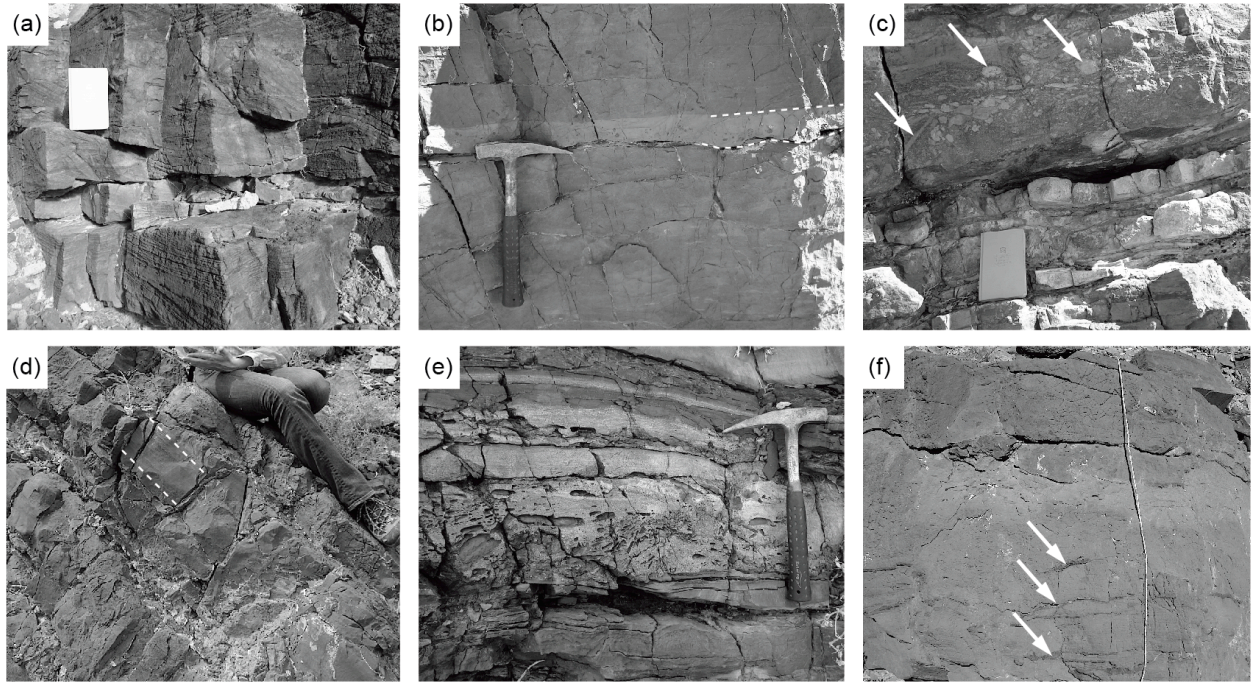


Figure 5: Carbonates from the lower member of the WCF. a, Lowest carbonate unit at Chicago Pass. Trough cross-stratification is visible in multiple beds; field notebook for scale. b, Middle carbonate at Chicago Pass in the northern Nopah Range. This carbonate contains massive beds that are mostly devoid of sedimentary structures and contain very little siliciclastic material. Lighter tan intervals (dashed) define some bedding surfaces. c, Uppermost carbonate at Chicago Pass in the northern Nopah Range. This dolostone contains abundant sand sized siliciclastic material and large dolostone rip up clasts (arrows). d, Lowermost carbonate unit at Gunsight Mine. Parallel laminated beds (dashed) are the only sedimentary structure present in this unit. e, Uppermost carbonate unit at Gunsight Mine in the southern Nopah Range, showing a siliciclastic layer within the carbonate composed of carbonate rip up clasts and sand to granule sized quartz pebbles. f, The single carbonate unit in the lower member of the WCF in the Kingston Range. This carbonate contains sand lenses (arrows) and lacks obvious sedimentary structures. The string in the picture is 1 m long and marked at 10 cm increments.

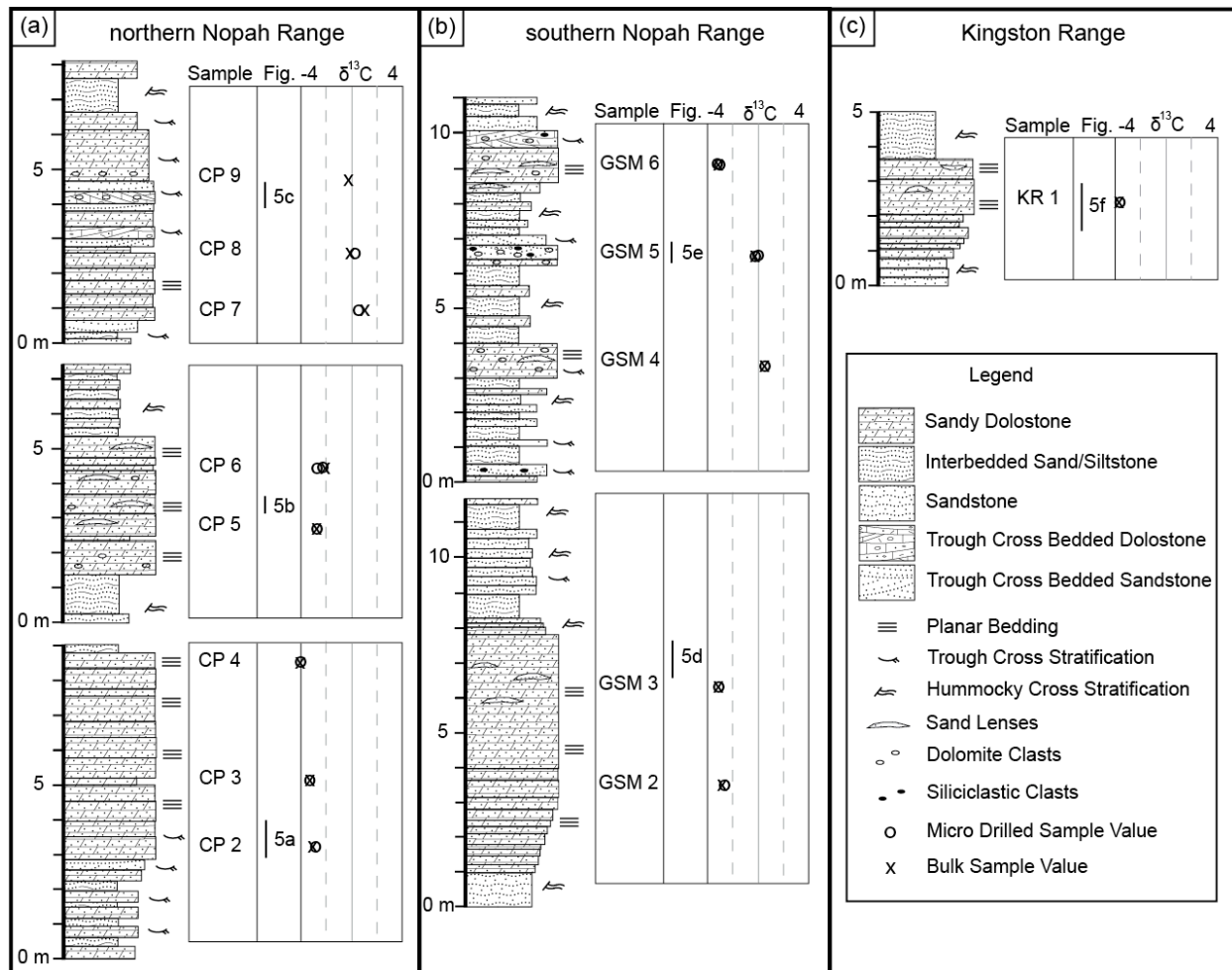


Figure 6: Detailed stratigraphic columns of each carbonate interval from a, the northern Nopah Range at Chicago Pass, b, the southern Nopah Range at Gunsight Mine, and c, the Kingston Range. Sample numbers are noted next to the stratigraphic column at the position where they were collected and lines indicate where in the column each photo was taken from subsequent figure 7. Carbon isotope data is also shown corresponding to its respective sample.

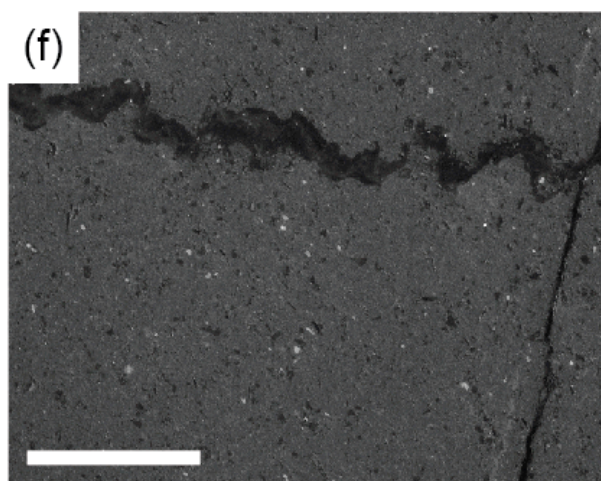
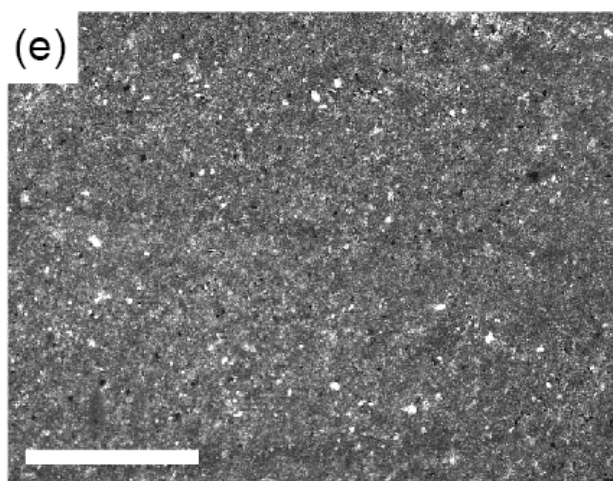
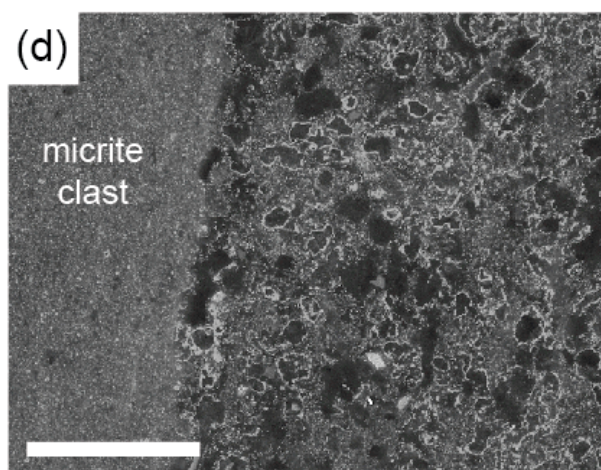
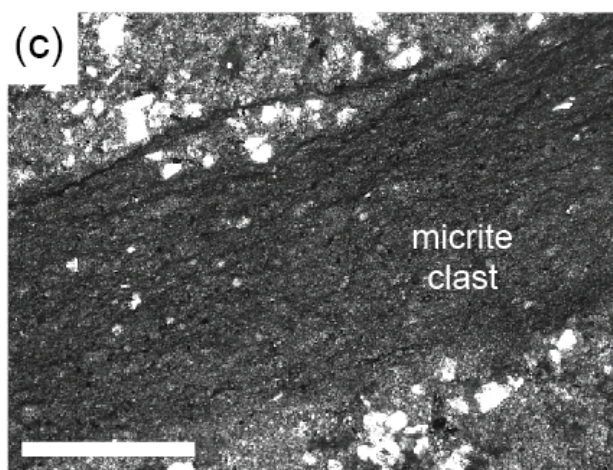
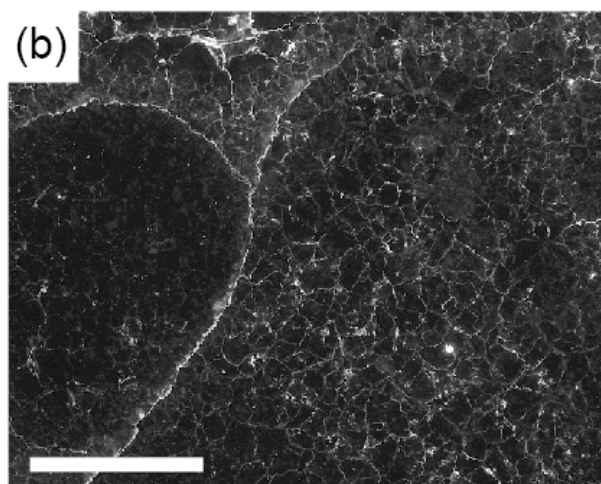
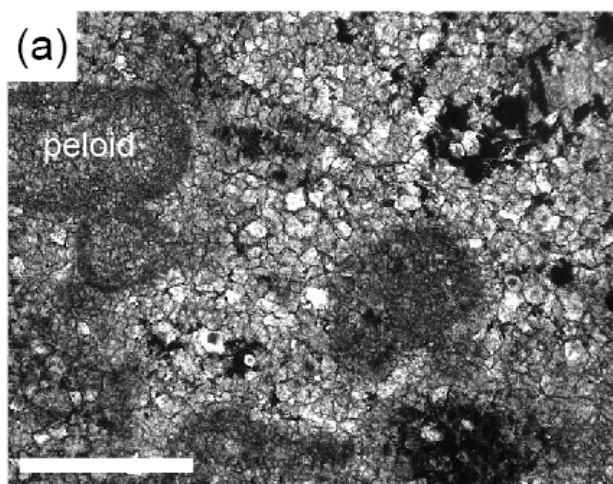
beds and are composed of up to 5 % quartz and feldspar sand. Peloids are visible in thin section (fig. 7a) even though the unit has undergone extensive secondary dolomitization that was mostly fabric destructive (fig. 7b).

The middle dolostone unit from the northern Nopah Range (fig. 6a) is approximately 5 m thick and forms sharp contacts with underlying and overlying siliciclastic beds. This unit contains approximately 0.5 m thick, planar laminated beds and in some places tan intervals define bedding planes (fig. 7b). Up to 5 % of the rock is composed of quartz sand. Dolomite rhombs observed during petrographic and cathodoluminescence inspection overprint the primary micritic fabric and reveal secondary dolomitization that was fabric destructive (Machel, 2004).

The top dolostone unit in the northern Nopah Range (fig. 6a) is 6-7 m thick, forms sharp contacts with sandstone beds above and below, and is characterized by a siliciclastic rich carbonate conglomerate (fig. 5c) in the middle of the unit. Dolostone beds in this unit are either planar laminated or trough cross-stratified and contain 40-50 % quartz, feldspar, and mica. Petrographic and cathodoluminescence observations (fig. 7c, d) reveal that parts of the unit contain micrite clasts that do not appear to have undergone the extent of diagenetic alteration that the rest of the rock has.

In the southern Nopah Range, there are two lower member dolostone units (fig. 6b) that are distinctly different from each other based on physical appearance. The lower of the two units is 6-7 m thick and forms a gradational contact with the sandstone below and a sharp contact with the sandstone above it. Beds are planar laminated (fig. 5d) and contain up to 50 % quartz and feldspar. Petrographic and cathodoluminescence observations reveal dolomite rhombs with internal zoning representing multiple phases of secondary dolomitization (Machel, 2004) that was mostly fabric destructive.

Figure 7: Photomicrographs of carbonate samples under transmitted light and cathodoluminescence (CL). a, Thin section of a sample from the lowest carbonate unit in the northern Nopah Range showing fabric destructive dolomite growth and peloid. b, CL image of the same sample showing complete secondary dolomitization. c, Thin section of a sample from the top carbonate unit in the northern Nopah Range showing a micritic clast preserved in a sandy dolomite. d, CL image of the same sample showing preservation of the micrite clast and fabric destructive dolomite growth around the clast. e, Thin section of a sample from the top carbonate unit in the southern Nopah Range showing minimal fabric destructive secondary dolomitization. f, CL image of the same sample showing preservation of the micritic fabric and a stylolite across the top of the image. The white bars in each image are 0.5 mm in length.



The top dolostone unit in the southern Nopah Range (fig. 6b) is approximately 7 m thick and forms sharp contacts at all bedding plane boundaries. Trough cross-stratified and planar laminated beds are present throughout the unit. A 1-2 m thick conglomeratic sandstone (fig. 5e) is variably present within the unit and contains siliciclastic clasts and carbonate rip-up clasts. The lower part of the unit contains as much as 50 % quartz, feldspar, and mica, whereas the top part contains up to 5 % quartz and feldspar sand. Petrographic and cathodoluminescence observations reveal ooids overprinted by internally zoned dolomite rhombs (e.g., Corsetti et al., 2006) that were partially fabric destructive. Clasts of carbonate from the conglomerate within the unit have experienced minimal secondary dolomitization and are considered to have retained their primary micritic fabric (fig. 7e, f).

In the Kingston Range, a single 3 m thick, planar laminated dolostone is present within the lower member (fig. 6c). Sand lenses are present throughout the dolostone (fig. 5f) and make up approximately 5 % of the rock. Peloids are preserved in the rock but have been mostly obliterated by secondary dolomitization. In the Soda Mountains, a single carbonate is also present within the lower member of the WCF and has been metamorphosed to marble. No primary sedimentary features were observed during petrographic or cathodoluminescence inspection of the Soda Mountains carbonate.

4.1.2 *Isotopic Analysis*

Carbon isotope concentrations for dolomites of the lower member of the WCF contain $\delta^{13}\text{C}$ values between -4.3 ‰ and 1.0 ‰ for both bulk and micro drilled samples (fig. 6a-c; appendix D). Micro drilled powders analyzed in this study matched bulk sample values within error of the instrument, and so are assumed to be consistent with bulk values. Study areas with only one carbonate unit in the lower member of the WCF (Kingston Range and Soda

Mountains) yielded bulk $\delta^{13}\text{C}$ values of -3.9 ‰ and -3.8 ‰, respectively. The Gunsight Mine study area in the southern Nopah Range contains at least two distinct dolomite units (fig. 2b, 6b). The lower of the two dolomites yielded $\delta^{13}\text{C}$ values of -2.5 ‰ and -3.2 ‰. The basal portion of the upper dolomite unit and conglomeratic bed (fig. 5e) within the unit yielded bulk $\delta^{13}\text{C}$ values of 0.4 ‰ and -0.3 ‰ respectively, whereas above the conglomeratic bed the bulk $\delta^{13}\text{C}$ value was recorded at -3.1 ‰. In the northern Nopah Range at Chicago Pass, several samples of each of the dolomite units were collected and analyzed. Bulk $\delta^{13}\text{C}$ values for three samples taken from the lowest dolomite unit (fig. 5a) produced values of -3.1 ‰, -3.4 ‰, and -4.3 ‰, and two samples from the middle dolomite unit (fig. 5b) had $\delta^{13}\text{C}$ values of -2.7 ‰ and -2.2 ‰. The upper most dolomite within the lower member of the WCF at Chicago Pass (fig. 5c) is split in half by a sandy carbonate breccia and yielded three $\delta^{13}\text{C}$ values of 1.0 ‰, -0.2 ‰, and -0.3 ‰.

Of concern is the potential for geochemical alteration as a result of diagenetic processes. Based on interpretations from petrographic and cathodoluminescence observations, each dolostone unit of the lower member of the WCF has experienced moderate to intense recrystallization (Machel, 2004; Corsetti et al., 2006) as a result of the interaction with diagenetic fluids. It has been demonstrated that carbon isotope ratios are not easily changed as a result of interaction with diagenetic fluids (Kaufman et al., 1991) therefore primary carbon isotope ratios are not easily altered. However, complete secondary dolomitization of some samples and the presence of calcite and iron oxide cements do place doubt on whether or not the values represent primary ocean chemistry. Given the consistency of the values obtained between bulk rock and micro drilled samples, the consistency of these values with previously published work (Corsetti and Hagadorn, 2000), and the variation in carbon isotope values from the top to bottom of single

carbonate units, I conclude that these carbon isotope values are reasonable to use for regional correlation purposes.

4.1.3 *Facies Interpretations*

Planar laminated and trough cross-stratified carbonate beds coupled with abundant bimodal paleocurrent directions (Diehl, 1979) and lithologic composition indicates deposition in a high-energy, wave-dominated shoal environment. The presence of peloids in carbonate beds that retained some primary fabrics after undergoing moderate secondary dolomitization, give way to a specific paleoenvironmental interpretation when coupled with observed sedimentary structures. Peloid bearing rocks formed and were deposited in a shallow marine setting frequently disturbed by wave action such as those described by Corsetti et al. (2006) and Dilliard et al. (2010). Sandy dolomite units and carbonate bearing conglomerates are interpreted as being part of the wave dominated, shoaling intertidal carbonate bank disrupted by periodic storm events (e.g., Koerschner and Read, 1989; Corsetti et al., 2007; Tanavsuu-Milkeviciene et al., 2009). More isolated conglomeratic intervals may be interpreted as intertidal mixed siliciclastic and carbonate channel facies, such as those described by Mount and Signor (1991) for time equivalent carbonates of the White-Inyo Range, California. Load casts and ball and pillow structures are characteristic of shallow marine settings with high sedimentation rates (MacNaughton et al., 2008), and attest to the carbonate shelf being inundated with detrital material flushed into the system by basinward migrating storms and/or fluvial discharge. Carbonate units that lack abundant siliciclastic material, are devoid of peloids, and do not contain trough cross-stratified beds were probably deposited in a lower energy intertidal setting that was less affected by storm events (Mount and Signor, 1991).

Shallow marine, hummocky and trough cross-stratified siliciclastic strata and shoaling intertidal dolomite units of the lower member of the WCF represent 4th order depositional cycles (Diehl, 1979; Prave et al., 1991; Corsetti and Hagadorn, 2000). Shallowing-upward siliciclastic intervals with carbonate caps are progradationally stacked. This stacking pattern represents multiple shoaling cycles and attest to progressive subsidence punctuated by a decrease in the rate of creation of accommodation space and infilling of remaining accommodation space within the basin.

4.1.4 *Correlation of Carbonates*

Figure 8 shows the correlation of carbonate units across miogeoclinal sections taking into consideration increasing subsidence rates in the basinward direction. In the Kingston Range and Soda Mountains, where only one lower member carbonate occurs, they are correlated based on carbon isotope composition and their stratigraphic position above the Neoproterozoic-Cambrian boundary. These two carbonates are interpreted to correlate with the top half of the upper carbonate unit in the southern Nopah Range based on their carbon isotope compositions. The uppermost carbonate unit in the northern Nopah Range and the lower part of the upper carbonate unit in the southern Nopah Range are the only units with $\delta^{13}\text{C}$ values above 0.0 ‰, and are thus correlated based on their relatively heavy carbon isotope compositions (e.g., Prave, 1999). The lowest carbonate unit in the southern Nopah Range yielded $\delta^{13}\text{C}$ values of approximately -3.0 ‰, which is what is recorded for the lowermost and middle carbonate units in the northern Nopah Range. Based solely on physical sedimentary structures and petrographic observations, correlation of these units is not straightforward. The middle unit in the northern Nopah Range most likely correlates with the lowest unit in the southern Nopah Range given that there is no

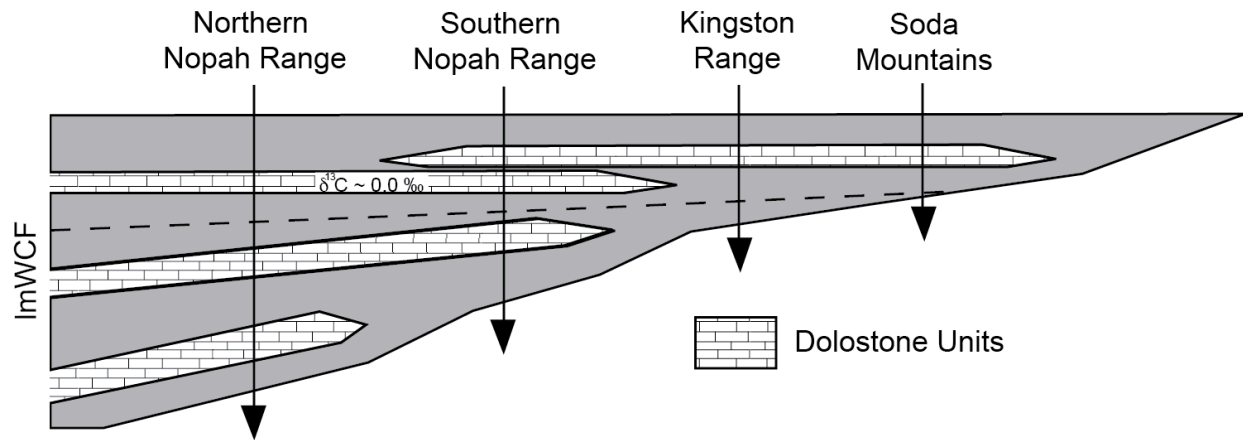


Figure 8: Simplified schematic diagram showing the correlation of lower member WCF carbonate units. Correlation is based on physical and isotopic evidence. Average carbon isotope compositions are between -2.0 ‰ and -4.0 ‰ for each of the carbonate units with the exception of the upper most units in the northern and southern Nopah Range, which yielded values around 0.0 ‰ (noted in figure). Downward pointing vertical arrows, used here to show greater relative subsidence rates in the more basinward sections, indicate the approximate location of each miogeoclinal study area. Dashed line indicates the approximate location of the Neoproterozoic-Cambrian boundary. Diagram not to scale.

direct evidence for the removal of several tens of meters of strata below the Neoproterozoic-Cambrian boundary between the two locations. Stratigraphic evidence is used here to support the disappearance of the lowermost and middle carbonate units of the northern Nopah Range in the cratonward direction, however a downlap relationship is not observed for carbonate units of the lower member. Based on these interpretations, the single lower member carbonate unit preserved in the Kingston Range and Soda Mountains extends northwest into the southern Nopah Range, but is not present in the northern Nopah Range, suggesting that carbonate units may be restricted in their lateral extent. The absence of observed downlap refutes the onlap architecture (fig. 4c).

4.2 Middle Member Wood Canyon Formation Conglomerate

4.2.1 Conglomerate Descriptions

A meter-scale interval of distinct pebble conglomerate defines the base of, or occurs low within, the middle member of the WCF across the Death Valley and Mojave Desert regions. Each interval is composed of one or more conglomerate beds that are amalgamated or separated by poorly-sorted, cross-stratified, coarse-grained sandstone (fig. 9a-d). The conglomeratic interval rests 10 to 50 m above the lower/middle member contact in the northern and southern Nopah Range, respectively, 50 m above the base of the middle member in the Kelso Mountains, and 3 to 7 m above the basal middle member nonconformity in the southern Marble Mountains (fig. 3a, 9a-c, 10a-c). In the northern Marble Mountains and Soda Mountains the middle member does not contain a conglomerate. The Kingston Range is the only location within the study area where the conglomerate is preserved at the base of the middle member, forming a sharp contact with underlying thinly bedded, hummocky cross-stratified, fine-grained sandstone of the lower member WCF.

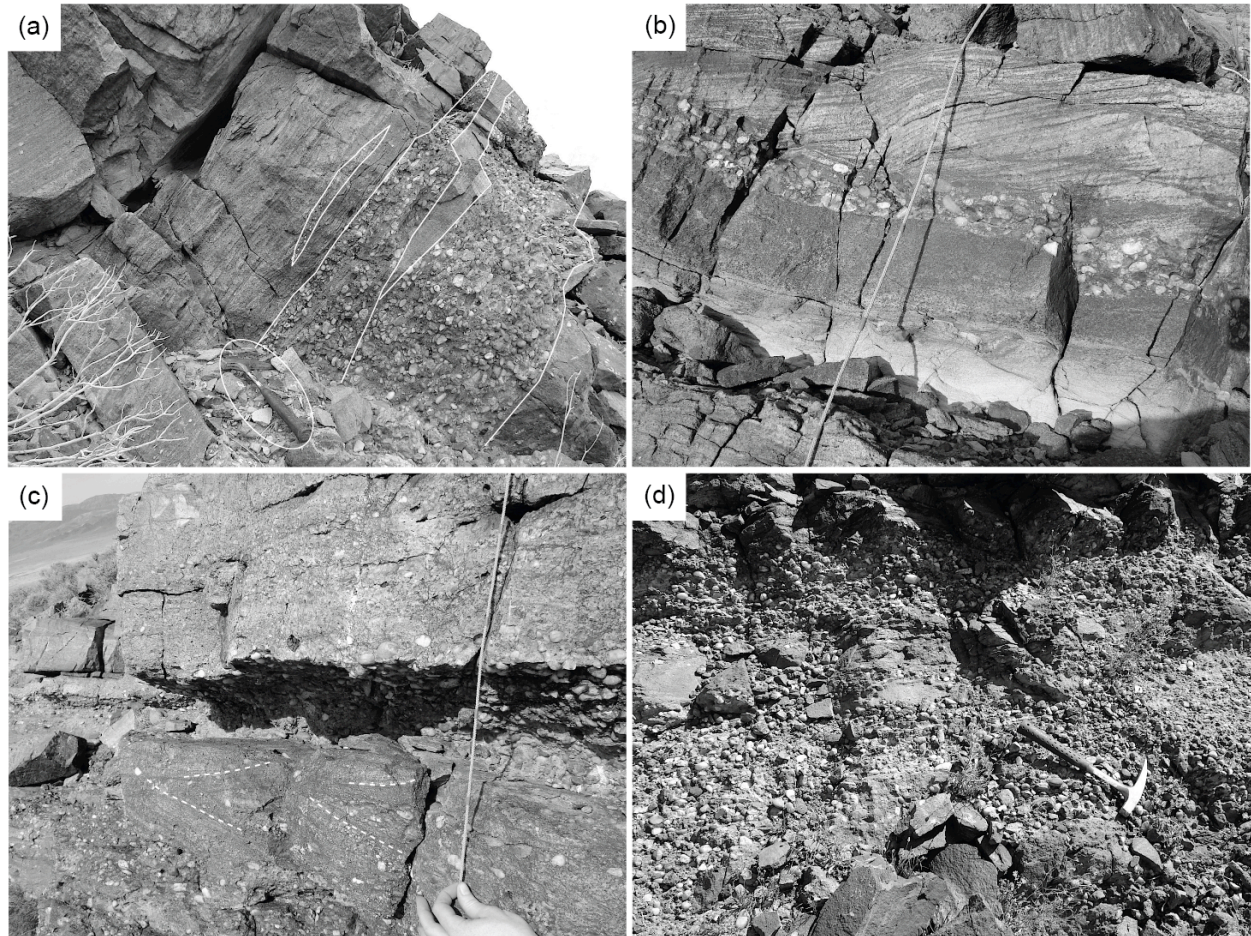


Figure 9: Conglomerate within the middle member of the WCF. a, Lens shaped pebble lags (outlined in white) from the southern Marble Mountains. Rock hammer for scale (circle). b, A single cm-thick conglomerate lens from the southern Marble Mountains. Dark notches on the string are 10 cm apart. c, Trough cross-stratified sandstone (white dashes) and multiple stacked conglomerate beds in the northern Nopah Range. The conglomerate tends to weather more quickly than the surrounding sandstone in this location. Dark notches on the string are 10 cm apart. d, Clasts on the ground below the bed from which they weathered in the southern Marble Mountains. Rock hammer for scale.

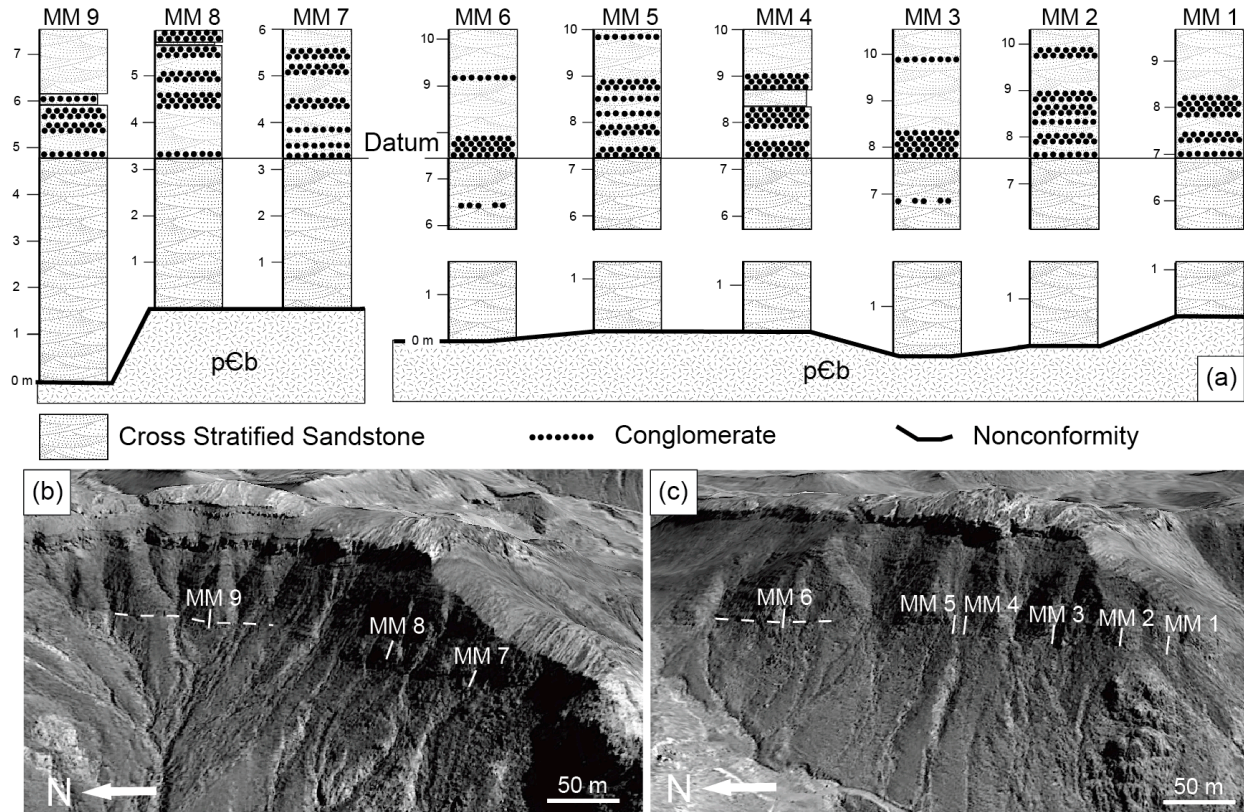


Figure 10: Measured sections and section locations from the southern Marble Mountains. a, Nine stratigraphic columns represent each measured section from the southern Marble Mountains. Note different stratigraphic positions of conglomerate beds. Between 3 and 7 meters of cross-stratified sandstone separate the middle member of the WCF conglomerate from the nonconformity. Note the break in section for columns MM1-MM6. The datum has been placed at the base of the first thick conglomerate bed. b, Stratigraphic columns labeled MM 7 – MM 9 were measured along a single continuous section in the southern Marble Mountains and c, MM 1 – MM 6 were measured along a single continuous section ~1 km southeast of MM 7 – MM 9. For each aerial photograph b and c, the nonconformity is denoted with a dashed line and measured section locations are labeled. Images from Google Earth.

Individual conglomerate beds have sharp, erosive bases and sharp tops (fig. 9b, c), and are between 5 cm (fig. 9b) and 1 m (fig. 9a) thick. Some conglomerate beds form discontinuous lenses and stringers that are several tens of meters wide (fig. 9a, c) and pinch out across an outcrop that is a few hundred meters in length (fig. 10a-c). In places, single conglomerate lenses are only a few clasts thick and approximately one meter wide (fig. 9a, b). Each bed is composed of clast-supported, very poorly sorted, coarse-grained, polymictic conglomerate. Pebble clasts are well rounded, compact to oblate in form, and show long axis preferred orientation perpendicular to paleoflow direction. Mud rip-up chips are also present along some bedding plane surfaces.

4.2.2 *Clast Analysis*

Clast analysis of the middle member WCF conglomerate was used to determine its composition and textural properties at different study locations spanning the craton to miogeocline (appendix E). Two clast counts were performed at the Marble Mountains (fig. 10a-c, MM-5 and MM-9) and northern Nopah Range study locations respectively, and single clast counts were performed at the Kingston Range and southern Nopah Range study areas respectively (appendix F). Six compositional categories were used to group clasts collected from the middle member of the WCF (appendix G). Vein quartz, orthoquartzite (fig. 11a), chert, chalcedony (fig. 11b), jasper, and other less abundant components, including felsic volcanic (fig. 11c), metamorphic (fig. 11d), and granite clasts were identified and grouped for correlation. In the field, compositions of *in situ* clasts were more difficult to determine with only the use of a hand lens, for example the difference between vein quartz and quartzite, thus only four compositional categories were identified. In this case, whole weathered clasts were used to determine the composition and clast shape at each location.

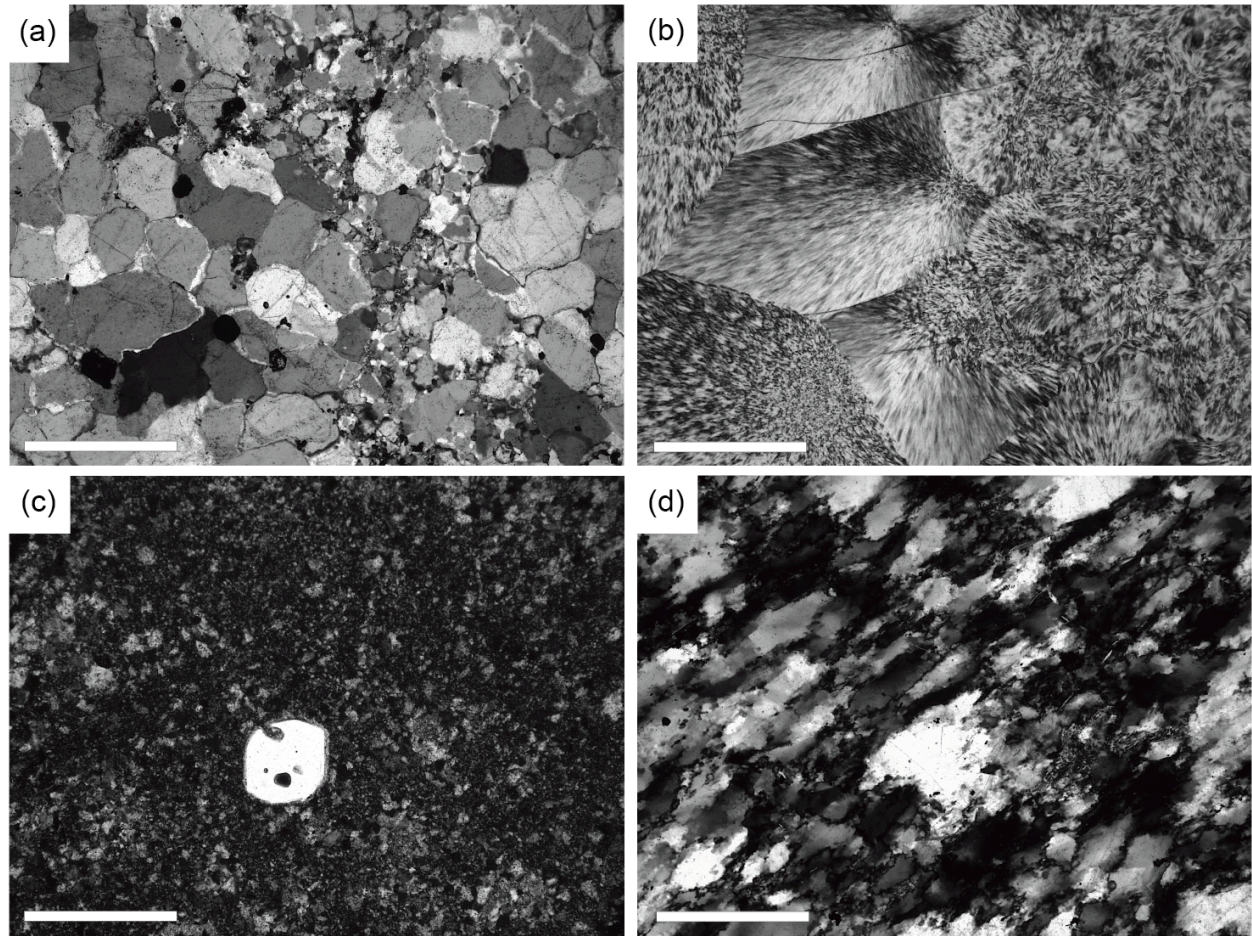


Figure 11: Photomicrographs of middle member WCF clasts. a, Orthoquartzite clast from the northern Nopah Range. b, Chalcedony clast from the southern Marble Mountains. Microcrystalline quartz growth defines concentric bands of each chalcedony clast. c, Felsic volcanic clast from the southern Marble Mountains. An embayed quartz phenocryst confirms this clasts felsic volcanic composition. d, Metaquartzite clast from the northern Nopah Range. Quartz ribbons define a foliation that is oriented from the bottom-left to the top-right of the image. All photomicrographs are in cross-polarized light and scale bars represent 0.5 mm.

The distribution of clast types is variable at each study area (fig. 12). Vein quartz and orthoquartzite clasts were identified at each of the study locations, with the percentage of vein quartz in each clast count ranging from 34 % in the southern Marble Mountains to 90 % in the Kingston Range. Quartzite clasts represent up to 25 % of the clast population in the northern Nopah Range and 33 % in the southern Marble Mountains, whereas other locations contain as little as 4 % quartzite. Chert and chalcedony clasts were not always present in different locations, but where present, do not exceed 11 % of the total clast population. Similarly, jasper and other clast types were not always present and represent between 0 % and 18 % of the total clast population (fig. 12).

Mean grain-size was determined from each *in situ* clast measurement distribution and range from -3.69 to -3.99 ϕ (medium to coarse pebbles) for all locations (appendix F). Mean grain-size determined from laboratory measurements range from -3.83 to -4.71 ϕ (coarse pebbles to fine cobbles) (fig. 13; appendix G). Discrepancies in results between the two methods reflect oblique pebble orientation on an *in situ* surface versus true dimensions measured for collected clasts, and thus collected clasts represent a more accurate range of phi size. The coarsest collected clast size average was recorded in the Kingston Range and the finest collected clast size average was recorded in the southern Nopah Range. Laboratory measurements of collected middle member WCF clasts reveal a difference in grain size of nearly one phi value between adjacent study locations.

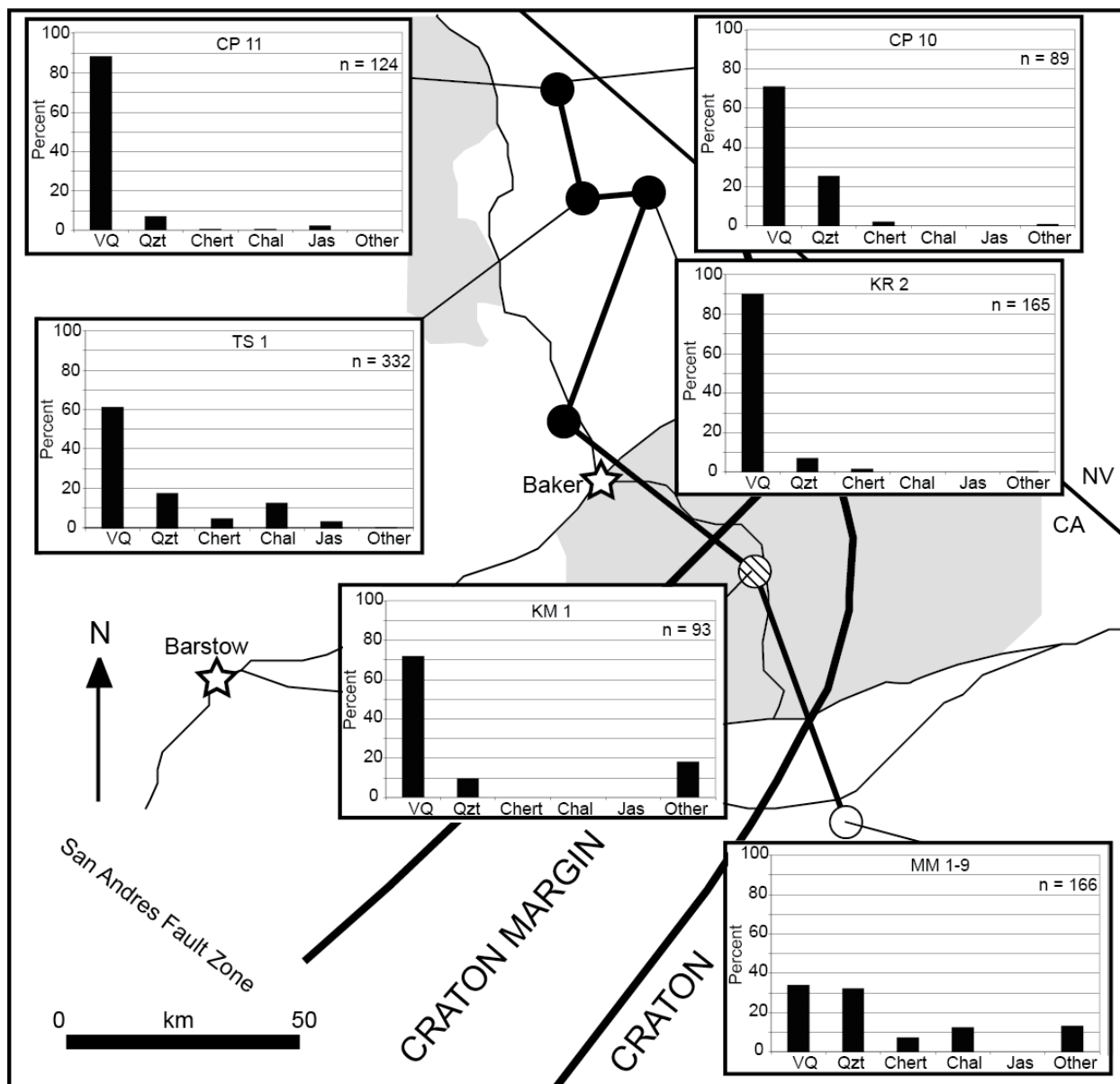


Figure 12: Clast compositions of middle member WCF conglomerate. Histograms from each study location (fig. 1) showing the percent of each clast composition collected from the southern Marble Mountains (MM 1-9), Kelso Mountains (KM 1), Kingston Range (KR 2), southern Nopah Range at Tule Spring (TS 1), and the northern Nopah Range at Chicago Pass (CP 10 and CP 11). Identified clast compositions include vein quartz (VQ), quartzite (Qzt), chert, chalcedony (Chal), jasper (Jas), and metamorphic/felsic volcanic/granite (Other). Note the change in proportion of clast types from cratonic to miogeoclinal locations.

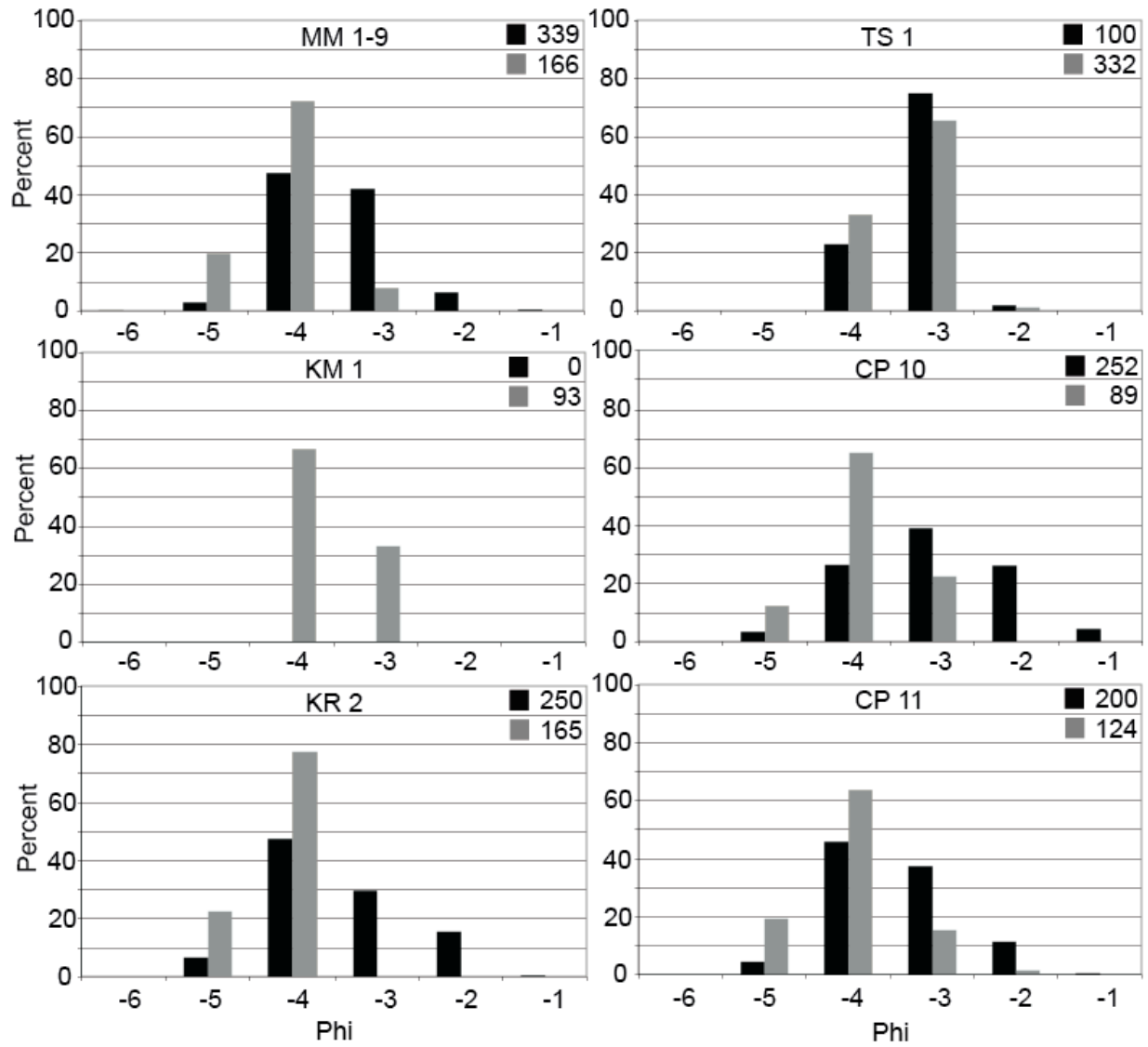


Figure 13: Clast size distributions for middle member WCF clasts. Histograms showing phi size distributions for in situ (black bars) and collected (gray bars) middle member Wood Canyon Formation clasts measured at six different locations from cratonic to miogeoclinal sections in the southern Marble Mountains (MM 1-9), Kelso Mountains (KM 1), Kingston Range (KR 2), southern Nopah Range at Tule Spring (TS 1), and northern Nopah Range at Chicago Pass (CP 10 and CP 11). The number of clasts measured at each section is noted in the top right corner of each graph.

4.2.3 *Facies Interpretation*

Based on dominantly unidirectional, westward dipping paleocurrent directions (Diehl, 1979; Fedo and Cooper, 1990; Stewart, 2001), very poor sorting, and the absence of trace or body fossils, the middle member of the WCF conglomerate is interpreted to have been deposited within a proximal braidplain environment (Diehl, 1979; Fedo and Cooper, 1990, 2001). In this broader context, we interpret laterally discontinuous pebble conglomerate stringers and lenses to be individual sheet and channel fill deposits transported as traction load during the high-energy stages of periodic flood events (cf., Eriksson and Wilde, 2010). Mud chips preserved along bed plain surfaces supports the ephemeral nature of these channel systems, as opposed to meandering systems, in which mud chips record frequent cut bank failure (Pranter et al., 2009). Sand to fine cobble-sized material would have been transported during upper-flow-regime conditions with trough cross-stratified sandstones deposited across the top of each pebble bed during the waning stage or lower energy flood events (Blair and McPherson, 1994). An absence of land plants would have allowed fluvial systems to form braided channel complexes experiencing variable periodicities of high-energy fluid flow (Long, 1978). During flood events, pebbles would have traveled as traction load within unconfined channels and been deposited across a proximal braid plain as a patchwork of discontinuous sheets and channel fill. Similar sheet flood deposits with discontinuous conglomeratic intervals have been interpreted for Proterozoic strata of the Athabasca Basin, Canada (Long, 2006), and for Archaean deposits of the Jack Hills belt, western Australia (Eriksson and Wilde, 2010).

Compositional evidence (fig. 12) indicates that the middle member conglomerate is dominated by a variety of quartz lithologies that were most likely derived from multiple sources. Variable stratigraphic position and differences in clast composition and grain size do not support

the interpretation that the conglomerate was deposited during a single event. Very well rounded clasts combined with zircon age dates taken from the middle member of the WCF indicates that their source is derived from Grenville-aged material (Stewart et al., 2001) that would have traveled great distances. Based on dominantly westward-dipping paleocurrent directions, multiple potential provenances for quartzite, chert, and chalcedony clasts of the middle member of the WCF lie to the east and include the Chuar, Unkar, and Apache Groups of present day Arizona. A likely source for concentrically banded chalcedony clasts are the volcanic deposits of the Apache Group that contain chalcedony and are erosionally overlain by the Neoproterozoic-aged Troy Quartzite (Skotnicki and Knauth, 2007), although no direct evidence for this provenance interpretation has been geochemically or petrographically confirmed.

4.2.4 Correlation of Conglomerates

Because the conglomerate defines the base of the middle member WCF in the Kingston Range, it has the potential to represent the unit resting on a surface of significant erosion as suggested by Runnegar et al. (1995) and Fedo and Cooper (2001). The contact between shallow marine shales of the lower member (Diehl, 1979) and fluvial and braid delta deposits of the middle member (Fedo and Cooper, 1990) represents a basinward shift in facies. However, at small- (fig. 10a) and large-scales (fig. 3a) the conglomerate is laterally discontinuous, and even absent in some sections, making correlation very difficult. Even more striking is the conglomerates variable stratigraphic position between 0 and 50 m from the base of the middle member across the Death Valley and Mojave Desert regions. A lack of lateral continuity across even short distances and variable stratigraphic position from the craton to the miogeocline suggests that multiple episodes of conglomerate deposition occurred during fluvial progradation of the middle member.

A gradational contact between the lower and middle members of the WCF in some settings (e.g. northern and southern Nopah Range) indicates relatively continuous deposition during the transition from marine to fluvial environments. We interpret this facies transition to be the final shoaling cycle that is linked to an increase in sediment supply and/or decrease in the rate of creation of accommodation space resulting in normal regression rather than a major eustatic sea level fall. Pulses of sediment carried in braided stream complexes could have deposited multiple pebble sheets, stacked in different stratigraphic positions, resulting in a patchwork of conglomeratic material that is not linked to substantial (e.g. Sauk scale) erosion of subjacent strata.

5.0 REVISION OF SEQUENCE ARCHITECTURE

5.1 Lower Member – Middle Member Contact

Interregional-scale unconformities form during periods of major eustatic or tectonically driven relative sea-level fall (Sloss, 1988). Either mechanism has the potential to expose large parts of the continental shelf and result in the formation of incised valleys as rivers regraded to meet new base level (Van Wagoner et al., 1990). If the base of the middle member WCF represents a 1st or 2nd order sequence boundary, as would be expected if it represented the base of the Sauk Sequence, there should be consistent evidence of a major eustatic sea level fall. Evidence for such a fall should include incised valleys (Van Wagoner et al., 1990), interfluvial paleosols (McCarthy and Plint, 1998), and considerable erosion of previously deposited units in a cratonward direction.

No study location examined here contained local channel scour greater than 1 m at the base of the middle member of the WCF. This channel depth suggests that braided rivers that deposited the middle member of the WCF might have been on the order of 1 km in width, given

an inferred depth to width ratio of 1:1000 for pre-land plant braided rivers (Long, 1978; Roe and Hermansen, 1993). According to data obtained from the braided confluence of the Jamuna and Ganges rivers, erosive scour should be five times deeper than mean channel depth in order to rule out autocyclic channel scour as the causing mechanism for sequence boundary formation (Best and Ashworth, 1997). Such relief has been noted for other major Neoproterozoic sequence boundaries in the Death Valley region where up to 150 m of local relief is observed (Kaufman et al., 2007). To unambiguously discount autocyclicality from having produced the contact that separates the lower and middle members of the WCF would require erosive scour of greater than 5 m at an inferred water depth of 1 m. Topographic relief on the basement surface at the most proximal study area in the southern Marble Mountains is less than 5 m between all nine measured sections (fig. 10a). This is consistent with autocyclic channel scour as the predominant mechanism for erosion present at the base of the middle member of the WCF.

Narbonne and Aitken (1995) and MacNaughton et al. (2000) identified an unconformity capping a major karst surface within the Windermere Supergroup of the Mackenzie Mountains as the base of the Sauk Sequence. That karst surface represents a period of long-term subaerial exposure. None of the craton margin or miogeoclinal sections investigated in this study contain evidence of deep chemical or physical weathering below the surface that separates the lower and middle members of the WCF, suggesting that these areas were not exposed above base level for an extended period during the Early Cambrian. This evidence, which is consistent with a lack of deep incision, rules out the base of the middle member WCF as a potential 1st or 2nd order sequence boundary in craton margin and more basinward locations.

Models by Leeder and Stewart (1996) indicate that an increase in the rate of sediment supply from craton interiors could result in progradation of facies with minimal incision during

normal regression. In the absence of land plants, a shift to a wet climate or a prolonged release of glacial melt water would cause an increase in the amount of sediment delivered to the craton margin. If availability of accommodation space were limited during times of increased sediment supply, then the record of relative sea-level fall could be a result of normal regression instead of forced regression (cf., Dilliard et al., 2010, Mackenzie Mountains). This would result in a scenario that allowed braid plain deposits of the middle member WCF to shift basinward across underlying shallow marine and intertidal shelf deposits of the lower member WCF with minimal incision (e.g., Blum and Tornqvist, 2000).

5.2 Revised Sea Level History and Sequence Architecture

Interpretations made here are based on detailed stratigraphic measurements, carbon isotope compositions of distinct carbonate units, and facies associations within and between the lower and middle members of the WCF. Results from this study do not permit correlation of lower member WCF carbonate units that reflect a top-down erosion (fig. 4a), angular unconformity (fig. 4b), or purely onlap scenario (fig. 4c) leading us to explain the observed stratigraphic architecture in a different way. A series of block-diagram reconstructions (fig. 14a-c) takes into consideration the correlation of carbonate units in the lower member WCF, the lack of evidence for significant erosion at the base of the middle member WCF, and increased subsidence rates in the basinward direction. Time step 1 (fig. 14a) shows the progressive deposition of the first two lower member shoaling cycles, interpreted here to be time lines. During time step 1, the net availability of accommodation space decreases twice and normal regression takes place during the highstand systems tract. Time step 2 (fig. 14b) illustrates continued relative sea level fall, increased subsidence rates in the basinward direction, and the deposition of at least two more lower member shoaling cycles. Continued infilling of available

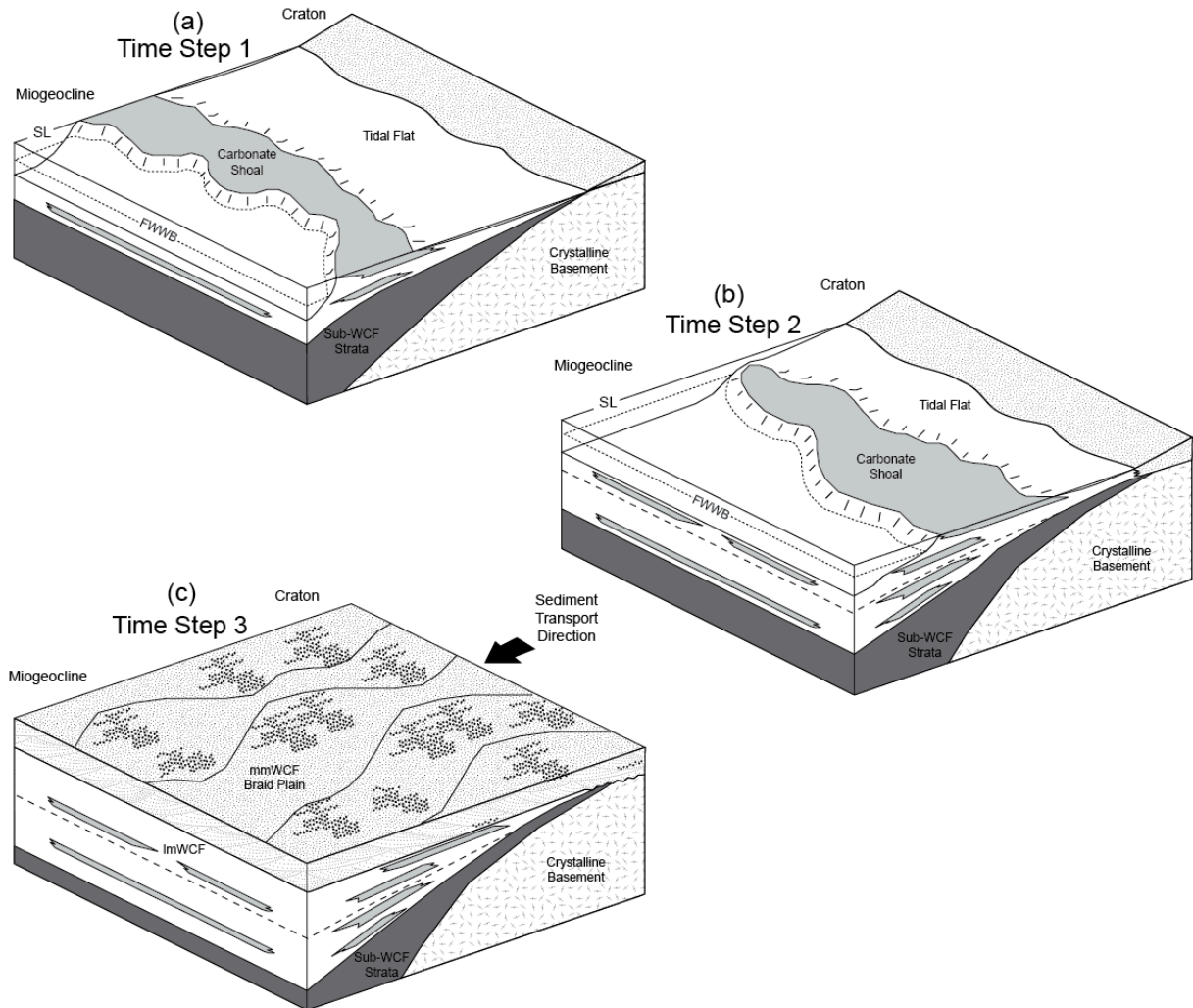


Figure 14: Reconstruction of stratigraphic accumulation to explain stratigraphic thinning and loss of carbonate units in the lower member of the WCF. Sea level (SL) and fair weather wave base (FWWB) are noted where appropriate. a, Deposition of the first two Neoproterozoic-aged shoaling cycles of the ImWCF capped by carbonate units that represent time lines. Note that each shoaling package represents the filling of accommodation space during a single regressive cycle. b, Deposition of Cambrian-aged shoaling cycles. Each shallowing-up package represents the cyclic filling of accommodation space developed during ongoing subsidence. Note increasing stratigraphic thickness in the basinward direction reflecting increased subsidence rates. c, Complete filling of available accommodation space leads to a progradation of facies during a final regressive cycle and deposition of the mmWCF. Conglomerate sheets and channel fill are noted with heavy black dots. Some erosion at the base of the mmWCF takes place in cratonic and proximal miogeoclinal sections due to autocyclic channel scour and a gradational contact is formed in more basinward sections. A dashed line in b and c represents the Neoproterozoic-Cambrian boundary.

accommodation space and the deposition of a final carbonate unit are shown in time step 2 which may represent the transition from the highstand to the falling stage systems tract (fig. 14c). Following time step 2 the influx of sediment from the craton, complete filling of available accommodation space during a fourth regressive cycle, and progradation of terrestrial facies in the basinward direction represents deposition during the falling stage to lowstand systems tracts and results in some autocyclic fluvial incision in cratonic areas (fig. 14c). The resulting architecture illustrates repetitive filling of accommodation space over four 4th order depositional cycles and the thickening of strata in the basinward direction is a result of increased subsidence rates away from the craton.

Fedo and Cooper (2001) mark the base of the Sauk Sequence at the base of the middle member of the WCF as their “disconformity 3,” stating that the base of the middle member is responsible for cutting out the marine shelf facies below. This interpretation was derived from focusing on exposures in the craton margin hinge zone. Incorporation of more distal sections combined with the detailed stratigraphy of the conglomerate and carbonates reveals the gradational contact between the lower and middle members of the WCF and likely negates Fedo and Cooper’s (2001) assessment of their disconformity 3 representing a major erosional surface. Given that the base of the middle member WCF lacks 1st or 2nd order magnitude in craton margin and miogeoclinal settings, the basal Sauk Sequence bounding surface must be lower in the stratigraphic section. Stratigraphic evidence such as fluvial and marine strata separated by larger magnitude disconformities in subjacent strata (e.g., Fedo and Cooper, 2001; Kaufman et al., 2007) indicates that 2nd order Sauk transgression may have been taking place before deposition of the middle member of the WCF, placing less importance on the base of the middle member as a Sloss Sequence boundary in craton margin and miogeoclinal settings. I propose (fig. 15) that

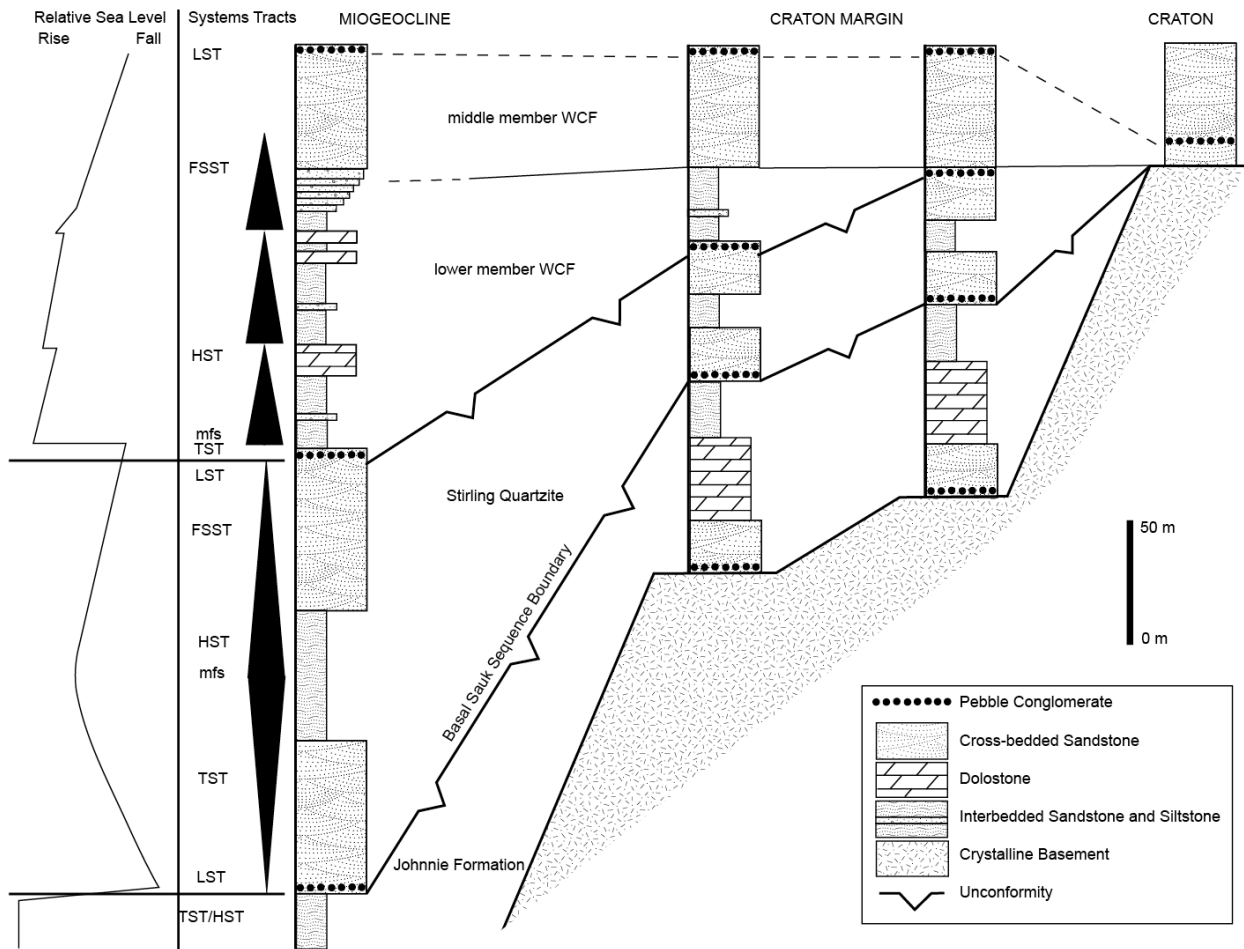


Figure 15: Cross section through the craton margin with major stratigraphic surfaces identified. The base of the Sauk Sequence is proposed to be lower in the section at the unconformity that separates the Stirling Quartzite from the Johnnie Formation. A relative sea level curve and systems tracts are also interpreted for the miogeoclinal succession: LST, lowstand systems tract; FSST, falling stage systems tract; HST highstand systems tract; TST, transgressive systems tract; and mfs, maximum flooding surface. Black triangles are used to indicate regressive, shoaling cycles in the lower and middle members of the WCF and a single transgressive-regressive cycle for the Stirling Quartzite.

the lower member of the WCF is part of a prograding highstand systems tract and not a transgressive systems tract as Fedo and Cooper (2001) have interpreted. Progradational stacking of lower member WCF parasequences attests to this interpretation and the gradational transition from the lower to middle member WCF thus records the falling stage systems tract. The middle member WCF is interpreted to have been deposited as part of the falling stage to lowstand systems tract and is interpreted here to represent the filling of available accommodation space preceding accelerated transgression and deposition of the upper part of the middle member of the WCF at a distinct regional *Skolithos* piperock unit that marks the top of the WCF (Fedo and Cooper, 2001). Thus, the lower/middle member WCF boundary records a short period normal regression that is superimposed on the overall Sauk transgression.

6.0 THE BASAL SAUK SEQUENCE BOUNDARY

The lower member-middle member WCF boundary in the Death Valley and Mojave Desert regions does not have the magnitude of a 1st or 2nd order sequence boundary. The middle member of the WCF and its lithologic equivalents represent the base of the Sauk Sequence in cratonic settings, where they form a nonconformity with underlying Proterozoic basement. These units represent the base of the 1st order Sauk Sequence and the base of the overall set of Sloss sequences. However, the Sloss Sequences do not simply end at the edge of the craton as Sloss (1963) states: "...cratonic sequences...are strictly limited to those portions of the North American craton *and its margins* (emphasis added) in which they exist as natural groupings of strata separated by demonstrable interregional unconformities." Sloss (1963) continues by saying that, "Further work at the craton margins will define the limits beyond which the cratonic sequences lose applicability and significance." This research forms part of that work.

Sedimentary rocks that floor the Sauk Sequence range in age from Latest Neoproterozoic at Laurentia's margins (Sloss, 1963) to Late Cambrian and Early Ordovician across the Laurentian interior (Dixon, 2008), making the basal Sauk Sequence boundary a diachronous surface. In this light, it would not be logical to simply continue tracing an isochronous surface that represents the base of Middle Cambrian-aged strata in the Grand Canyon region (e.g., Tapeats Sandstone) off the craton and call it the base of the Sauk Sequence, because Lower Cambrian lithological equivalents crop out in a more basinward direction. It follows that extending the basal Sauk Sequence boundary basinward as the base of the middle member WCF, in southeastern California, makes just as little sense when it has been demonstrated that the magnitude of this surface in craton margin and miogeoclinal settings is less than that which is expected of a 1st or 2nd order sequence boundary.

Here I suggest that the basal Sauk Sequence boundary may extend into Neoproterozoic-aged strata at the base of the Stirling Quartzite. The unconformity at the base of the Stirling Quartzite separates a major interval of fluvial deposition from open-marine shelf deposits that contain hummocky cross-stratification in the underlying Johnnie Formation (Fedo and Cooper, 2001; Kaufman et al., 2007) suggesting a much greater break in facies than that of the lower/middle WCF boundary. Revising the placement of the basal Sauk Sequence boundary into older strata could have implications for other Laurentian craton margin sections such as the angular unconformity that defines the basal Sauk Sequence boundary in the Canadian Cordillera (Bond and Devlin, 1988). There the boundary is placed at a tectonically derived unconformable surface which may not represent the initial eustatically driven Sauk transgression. Further work in craton margin sections has the potential to reveal a Neoproterozoic-aged surface that represents the base of the Sauk Sequence within strata resting below this angular unconformity.

7.0 CONCLUSIONS

In the Death Valley and Mojave Desert regions, the contact separating the lower and middle members of the WCF is currently interpreted as a regional unconformity coincident with the basal Sauk Sequence boundary. The contact transitions from a nonconformity in cratonic settings to a relatively conformable contact in miogeoclinal settings. Results from the detailed study of rock units that contain this unconformity allows the following conclusions to be made:

1. The lower member of the WCF thins in the cratonward direction and is composed of multiple siliciclastic/carbonate packages that represent shoaling cycles at the parasequence scale. Distinct meter-scale dolostone units interpreted to have been deposited in a shallow-marine, wave-dominated environment caps each cycle. Carbon isotope compositions of each of the carbonate units within the lower member of the WCF do not support a mechanism for stratigraphic thinning and loss of section in a cratonward direction that is related to top-down erosion or cratonward onlap.
2. A distinct meter-scale, coarse-pebble conglomerate is preserved up to 50 m above the lower/middle member WCF contact, and in some places it is absent. The conglomerate is interpreted to have been transported and deposited as bedload material during multiple fluvial flooding events and possesses modest compositional and grain size differences across cratonic, craton margin, and miogeoclinal study areas. The stratigraphic position, composition, and facies associations of the middle member conglomerate do not permit its correlation as a single unit across the Death Valley and Mojave Desert regions.
3. Gradational contacts between the lower and middle members of the WCF, in some locations, suggest that lower member WCF strata were not exposed above base level for an extended period of time. From a sequence stratigraphic perspective, the investigated section was

developed as a result of repeated infillings of accommodation space via normal regression, and basinward progradation of facies. Results from this study point to a lack of significant exposure and erosion expressed by the contact that defines the base of the middle member WCF. The lower and middle members of the WCF represent deposition during a single continuous 3rd order sea level cycle beginning with the highstand systems tract (lower member WCF), followed by the falling stage systems tract (lower to middle member WCF transition), and culminating with the transgressive systems tract (middle and upper portions of the middle member WCF). As a result of short period sea-level fluctuation, no major (1st or 2nd order) sequence boundary was developed at the base of the middle member of the WCF.

4. Based on the present study, the base of the Sauk Sequence in the Death Valley and Mojave Desert regions must lie lower in the stratigraphic section most likely at the base of the fluvial lower member of the Stirling Quartzite, which overlies marine-shelf deposits of the upper Johnnie Formation. This study highlights the necessity for investigating globally recognized unconformities, such as the one that defines the base of the Sauk Sequence, in greater regional detail at the craton margins.

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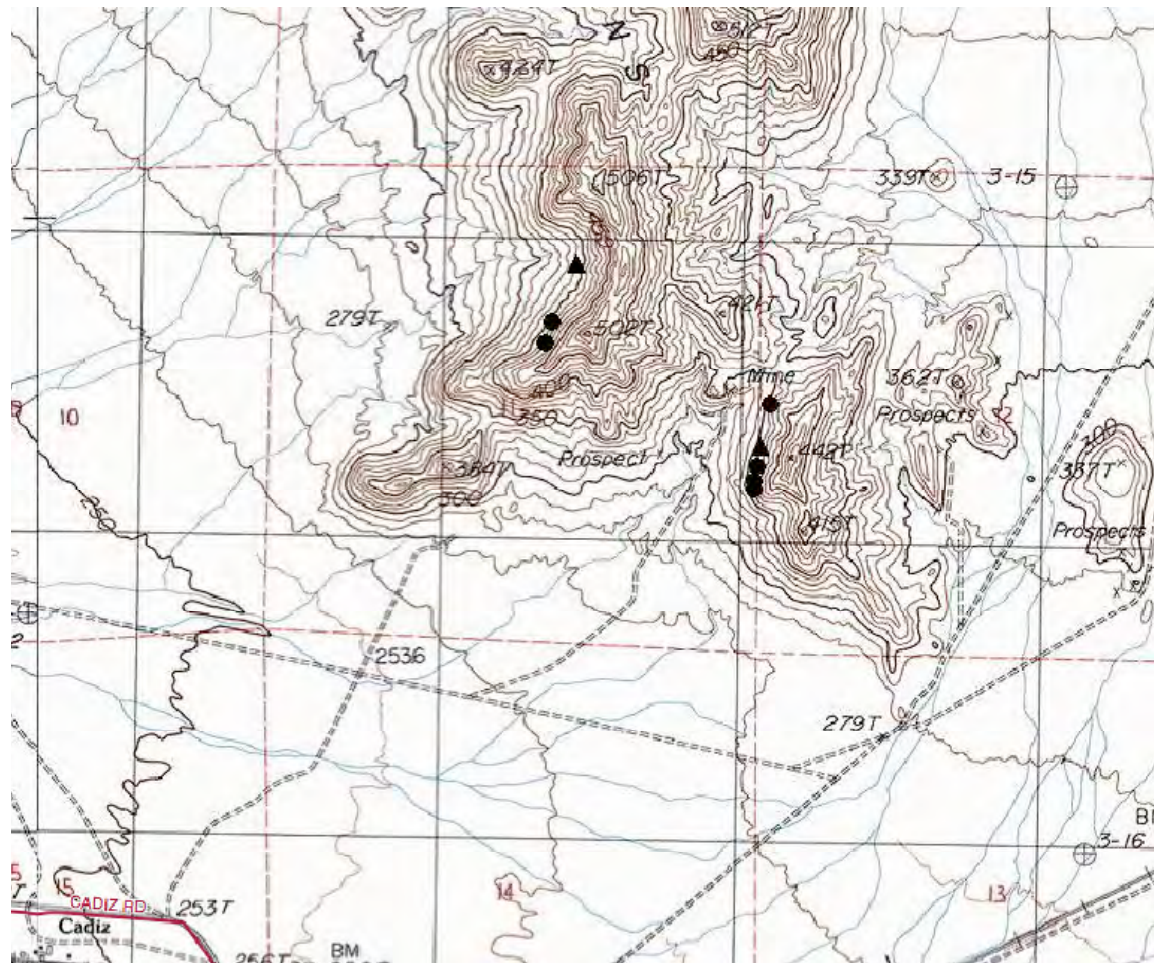
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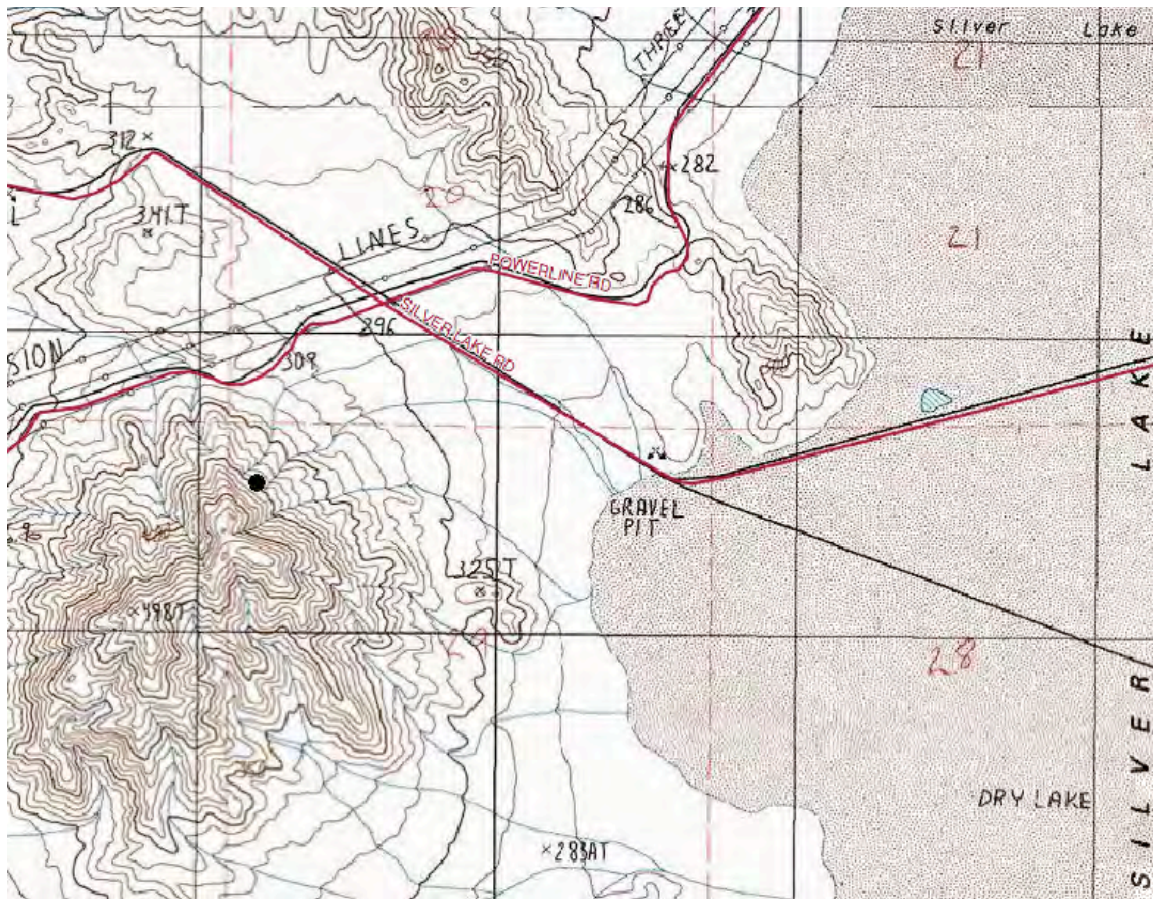
APPENDICES

Appendix A

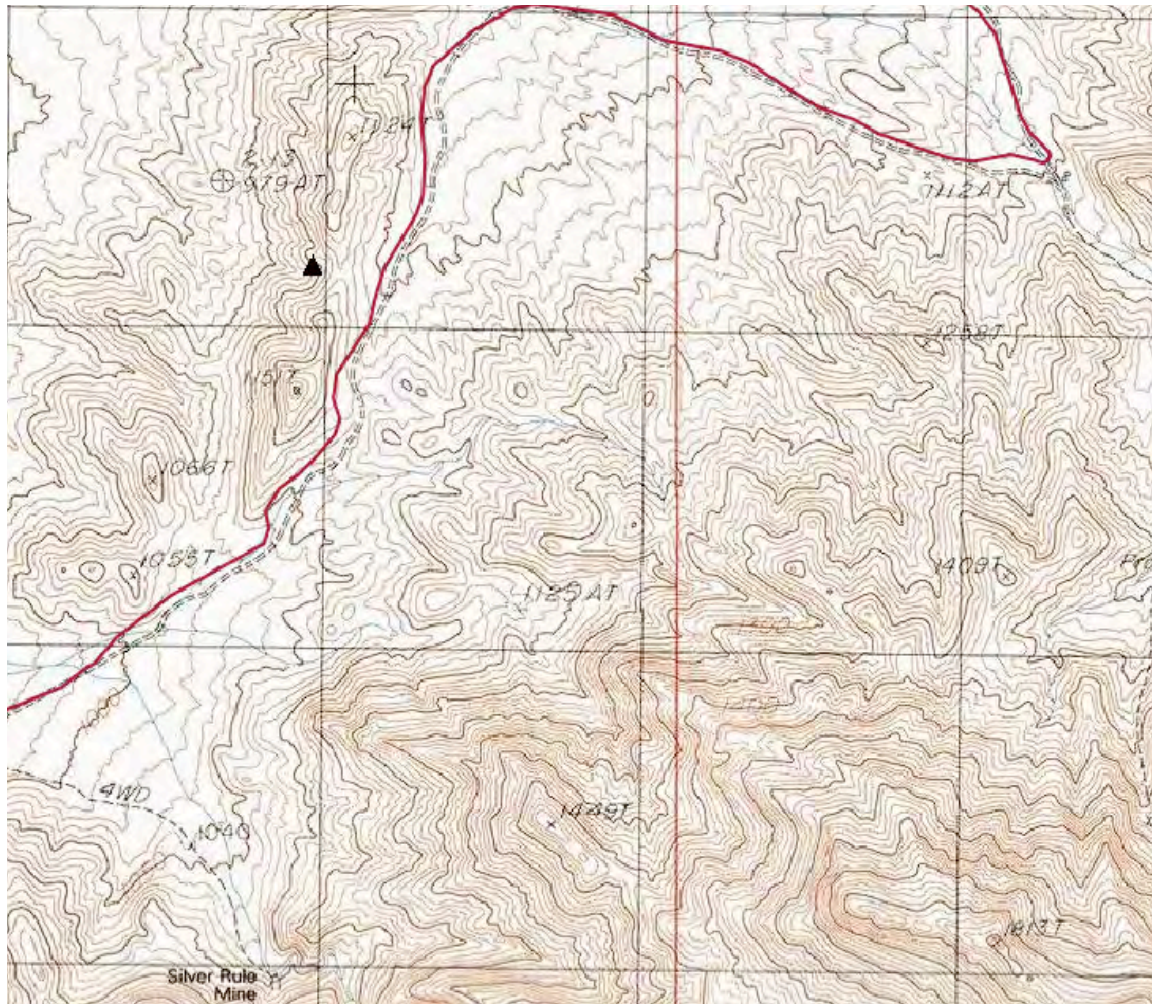
Topographic Maps of Field Locations



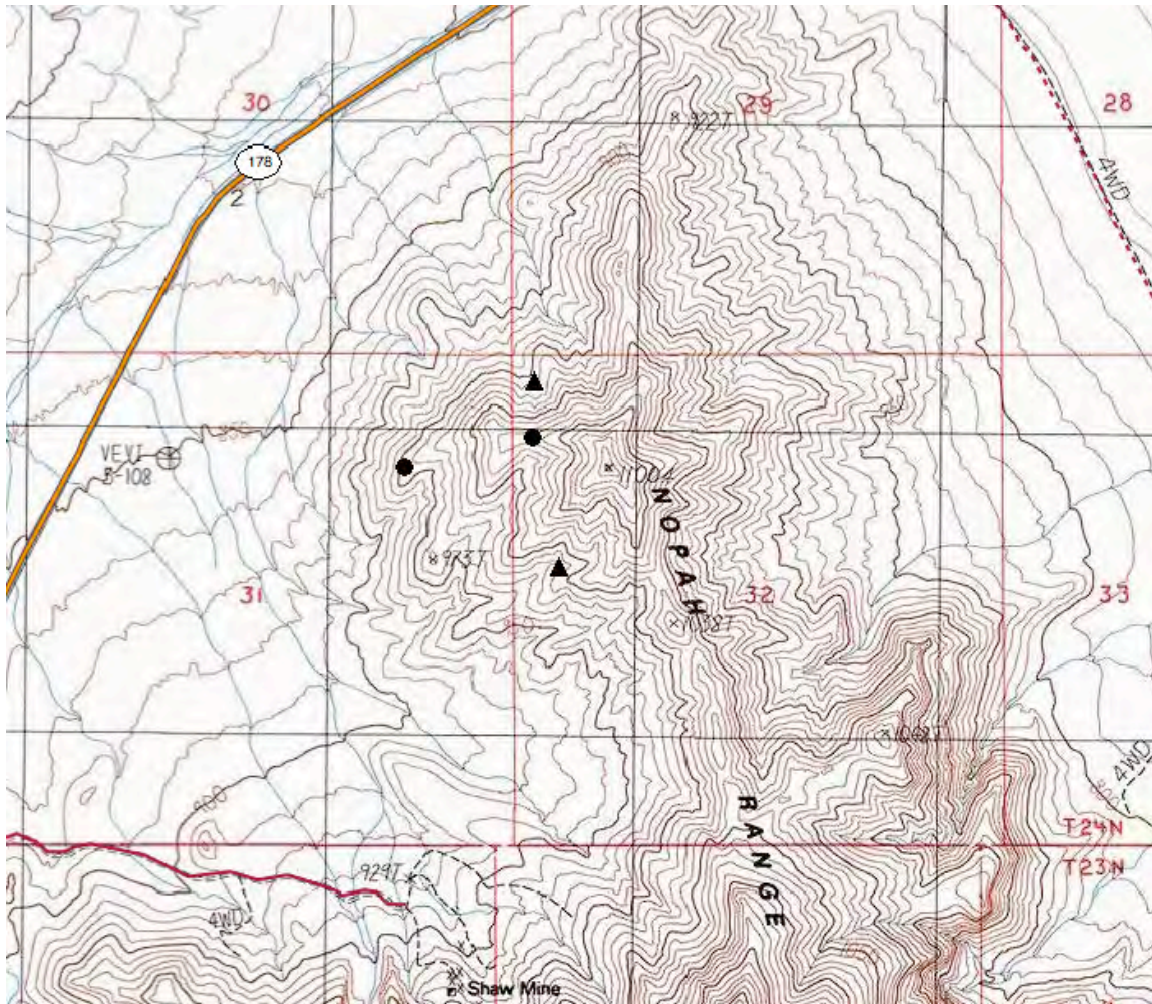
Topographic map of the Southern Marble Mountains study area. Each black circle and black triangle represents a location where section measurements were made. Each measurement location, beginning with the southern most location on the map and moving north, is numbered MM 1 (N 34° 32.007, W 115° 28.492), MM 2 (N 34° 32.022, W 115° 28.492), MM 3 (N 34° 32.050, W 115° 28.484), MM 4 (N 34° 32.085, W 115° 28.477), MM 5 (N 34° 32.085, W 115° 28.477), MM 6 (N 34° 32.162, W 115° 28.456), MM 7 (N 34° 32.273, W 115° 28.942), MM 8 (N 34° 32.310, W 115° 28.931), and MM 9 (N 34° 32.414, W 115° 28.878). Middle member WCF clast samples were collected at location MM 4, MM 5, MM 6, MM 8, and MM 9. Black triangles (MM5 and MM9) represent locations where in situ clast counts were made. Girding lines are spaced at 1 kilometer for scale.



Topographic map of the Soda Mountains Study area. The black circle indicates the location where lower member WCF carbonate samples (SM 4) were collected. Girding lines are spaced at 1 kilometer for scale.



Topographic map of the Kingston Range study area. The black triangle (N 35° 49.690, W 115° 57.634) represents the location where the stratigraphic section was measured, lower member carbonate (KR 1) and middle member conglomerate clast (KR 2) were collected, and an in situ clast count was made. Girding lines are spaced at 1 kilometer for scale.

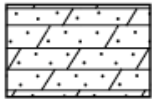


Topographic map of the study area in the Northern Nopah Range at Chicago Pass. A measured section was made between the two black circles from the base of the lower member WCF to the middle member WCF conglomerate, beginning at the western most circle (N 36° 08.535, W 116° 09.201) and ending at the eastern most circle (N 36° 08.590, W 116° 08.925). Black diamonds are the locations where in situ clast counts were made (northern most black diamond: CP 10, N 36° 08.686, W 116° 08.921) (southern most black diamond: CP 11, N 36° 08.357, W 116° 08.864). Girding lines are spaced at 1 kilometer for scale.

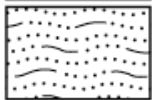
Appendix B

Detailed Stratigraphic Columns

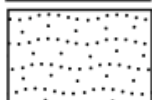
Legend



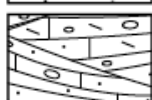
Sandy Dolostone



Interbedded Sand/Siltstone



Sandstone



Trough Cross Bedded Dolostone



Trough Cross Bedded Sandstone



Planar Bedding



Trough Cross Stratification



Hummocky Cross Stratification



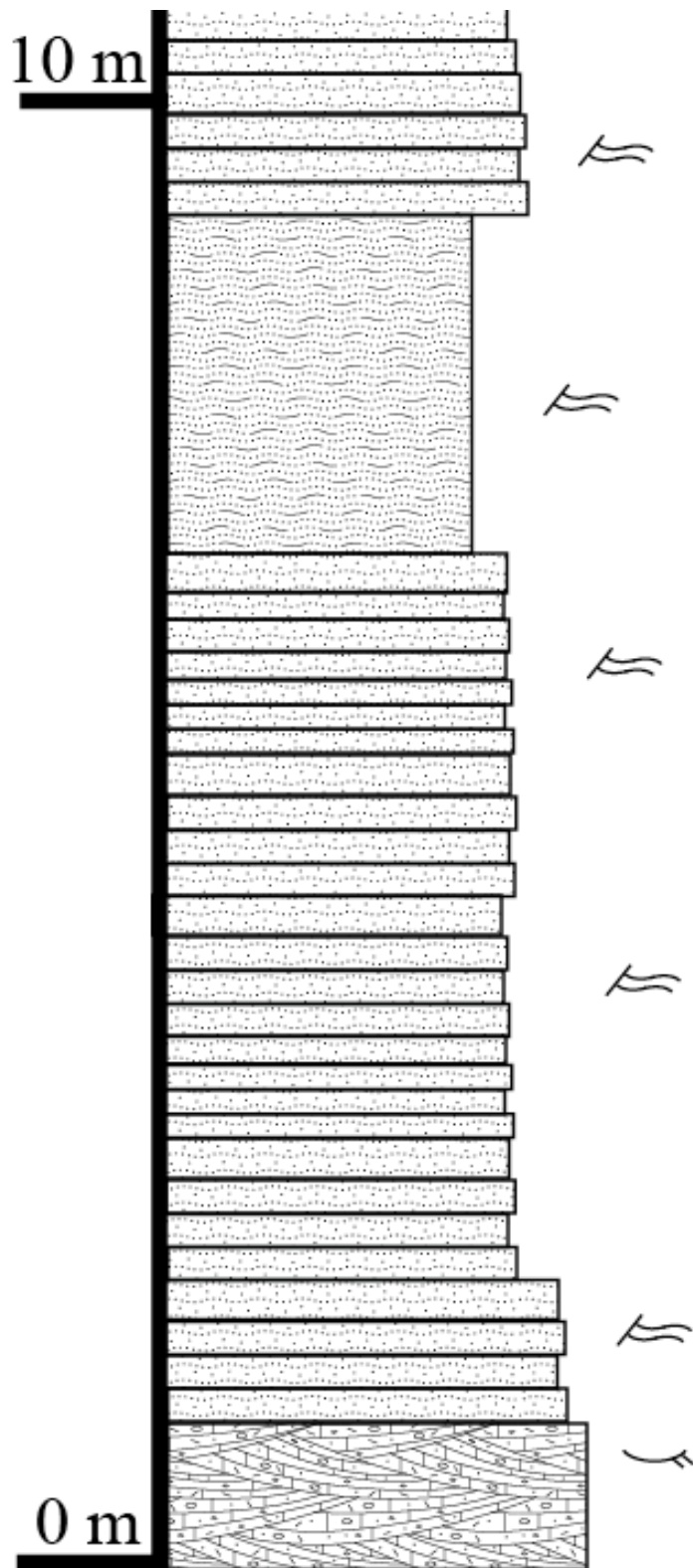
Sand Lens

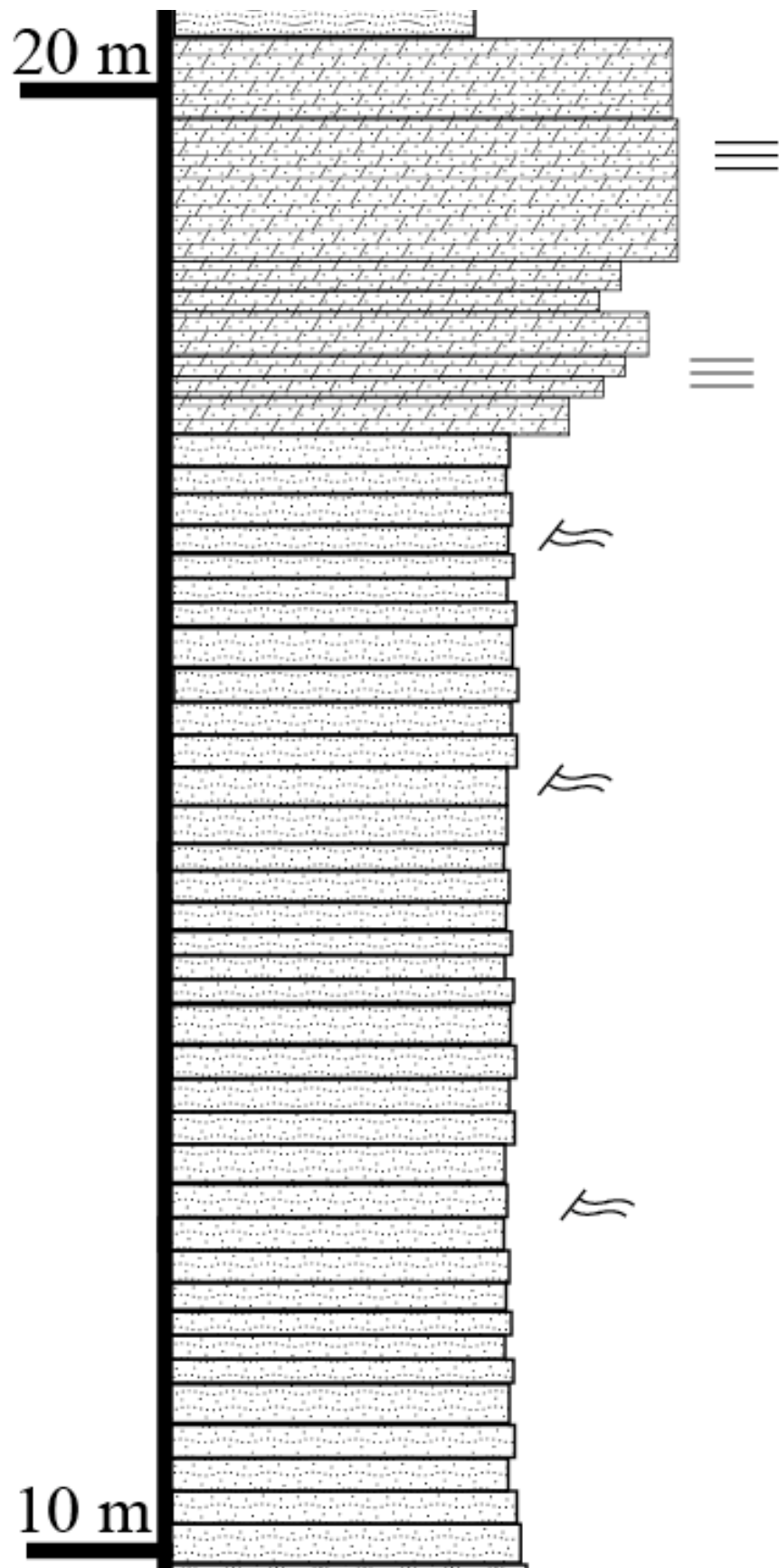


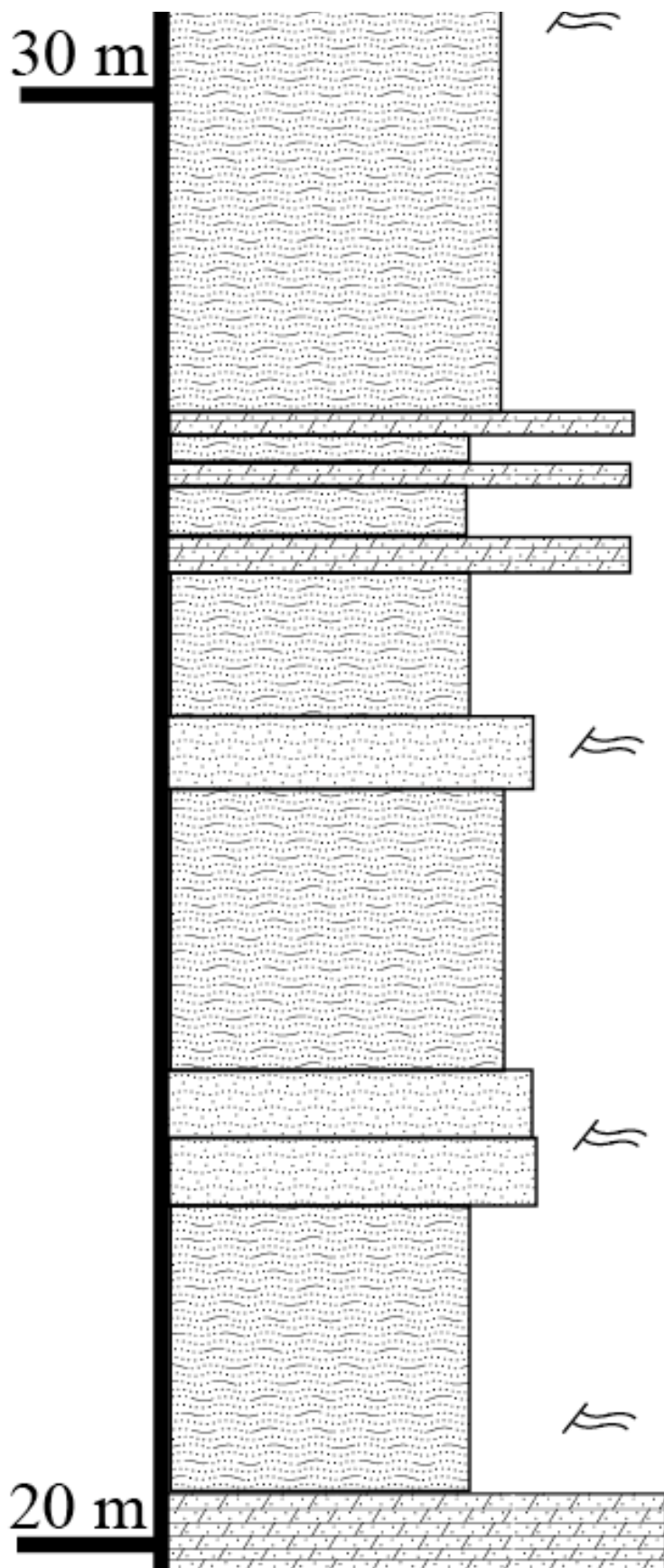
Dolomite Clasts

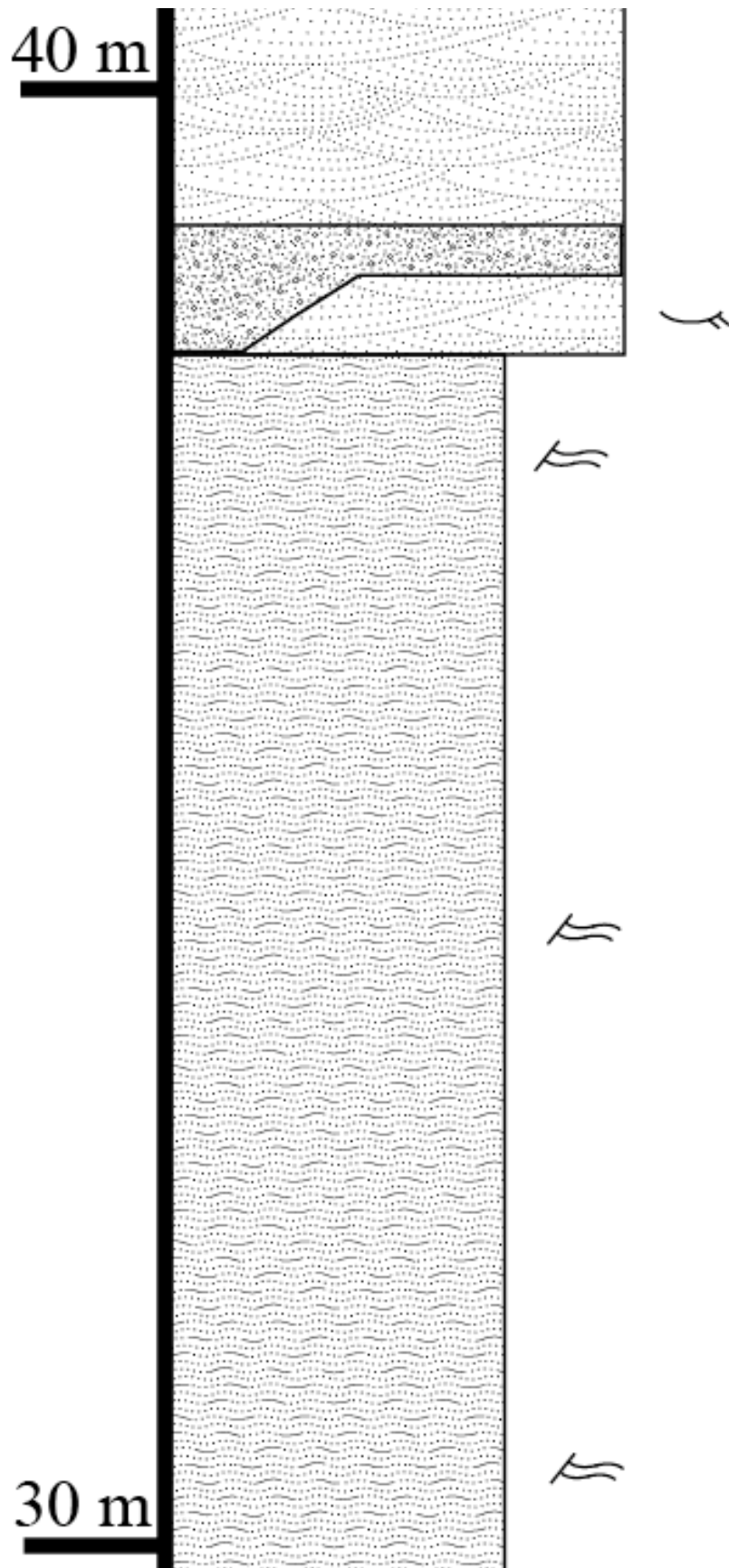


Siliciclastic Clasts

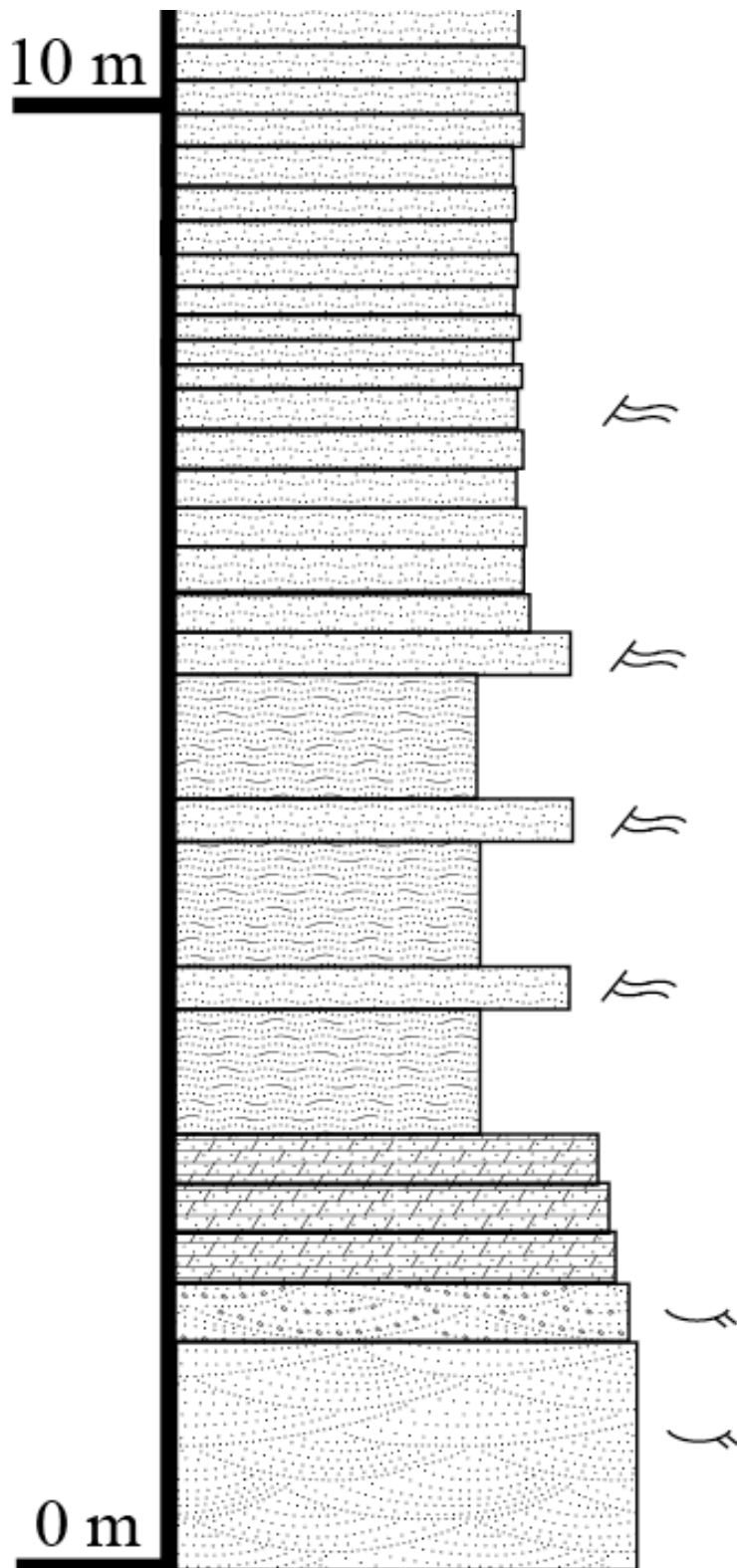
Detailed Stratigraphic Column of the lower member of the Wood Canyon Formation
Kingston Range

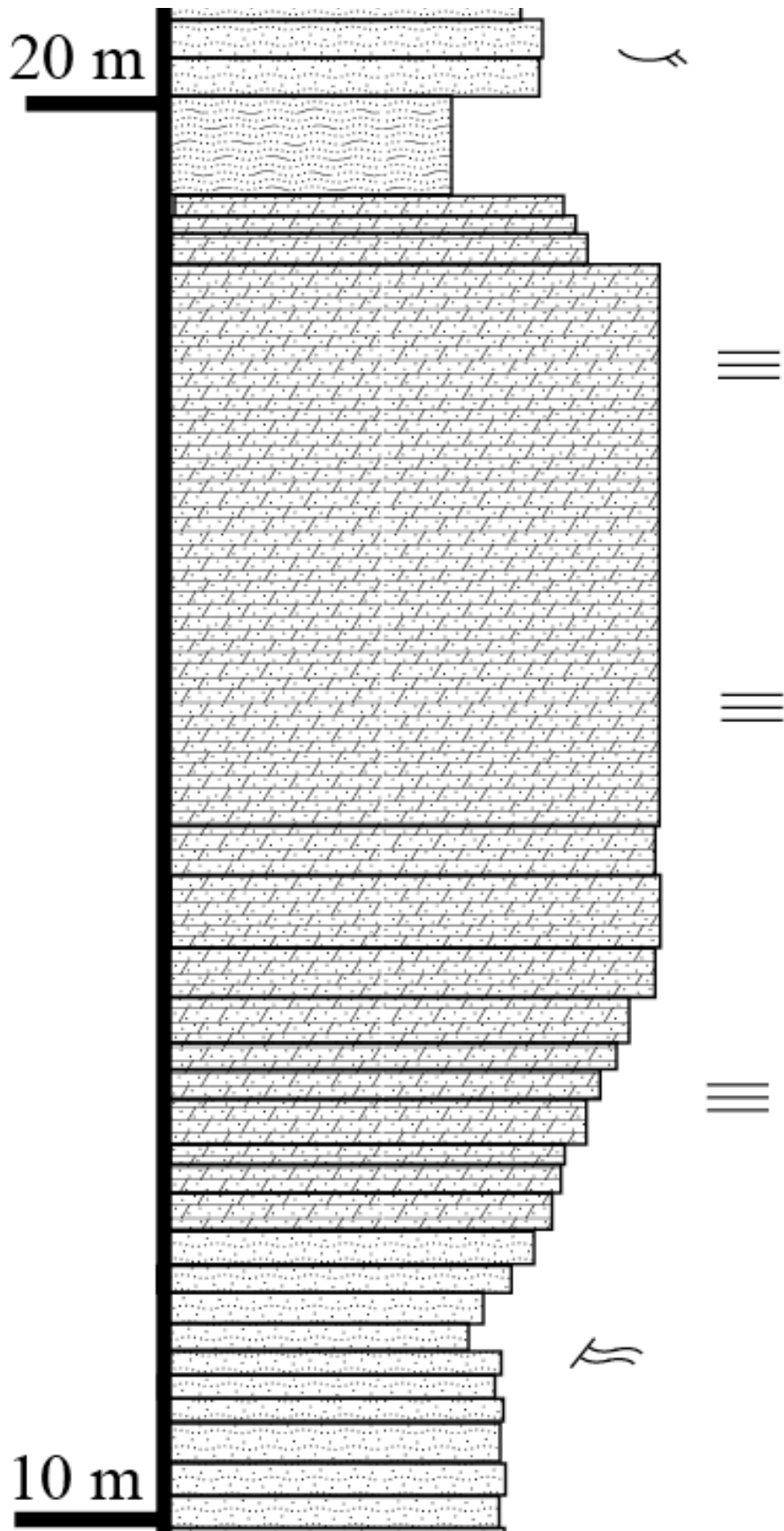


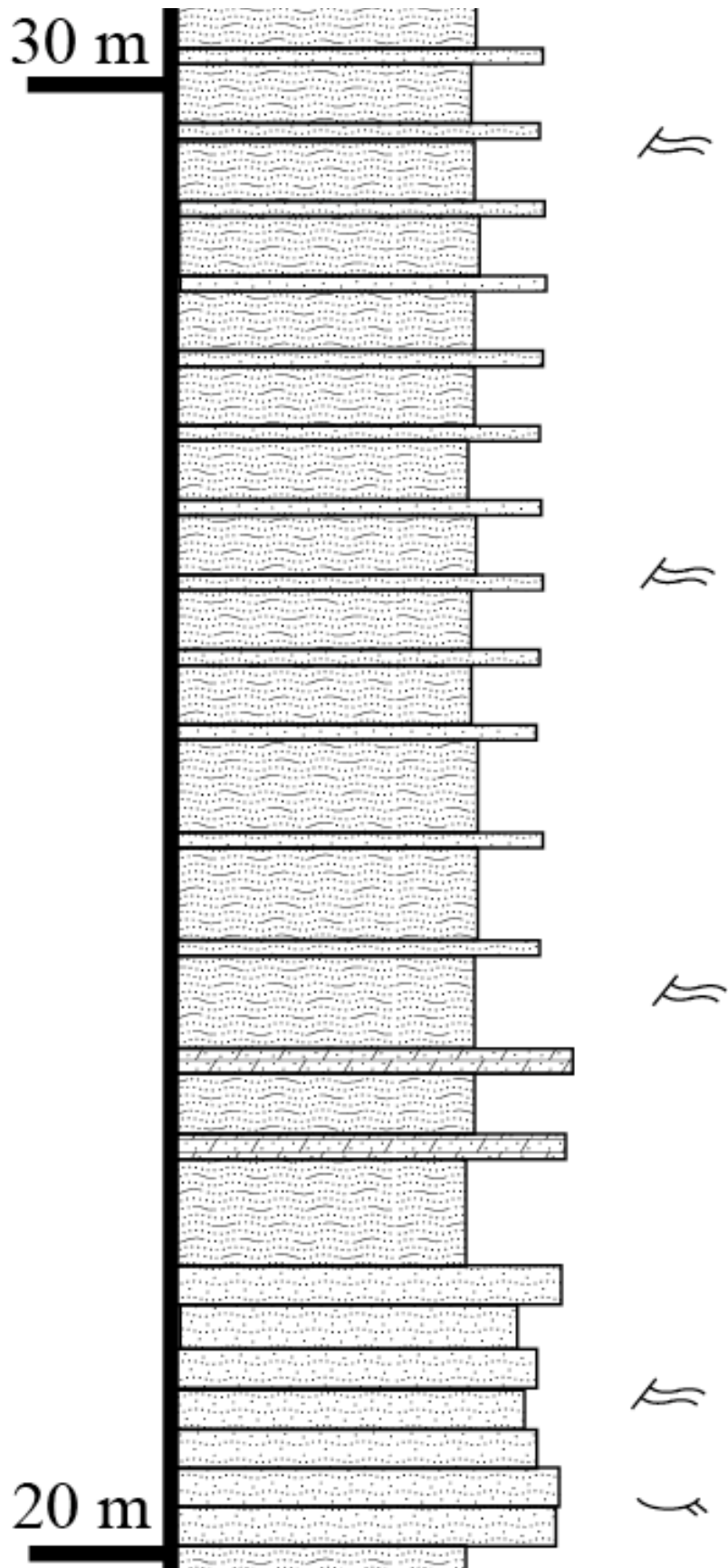


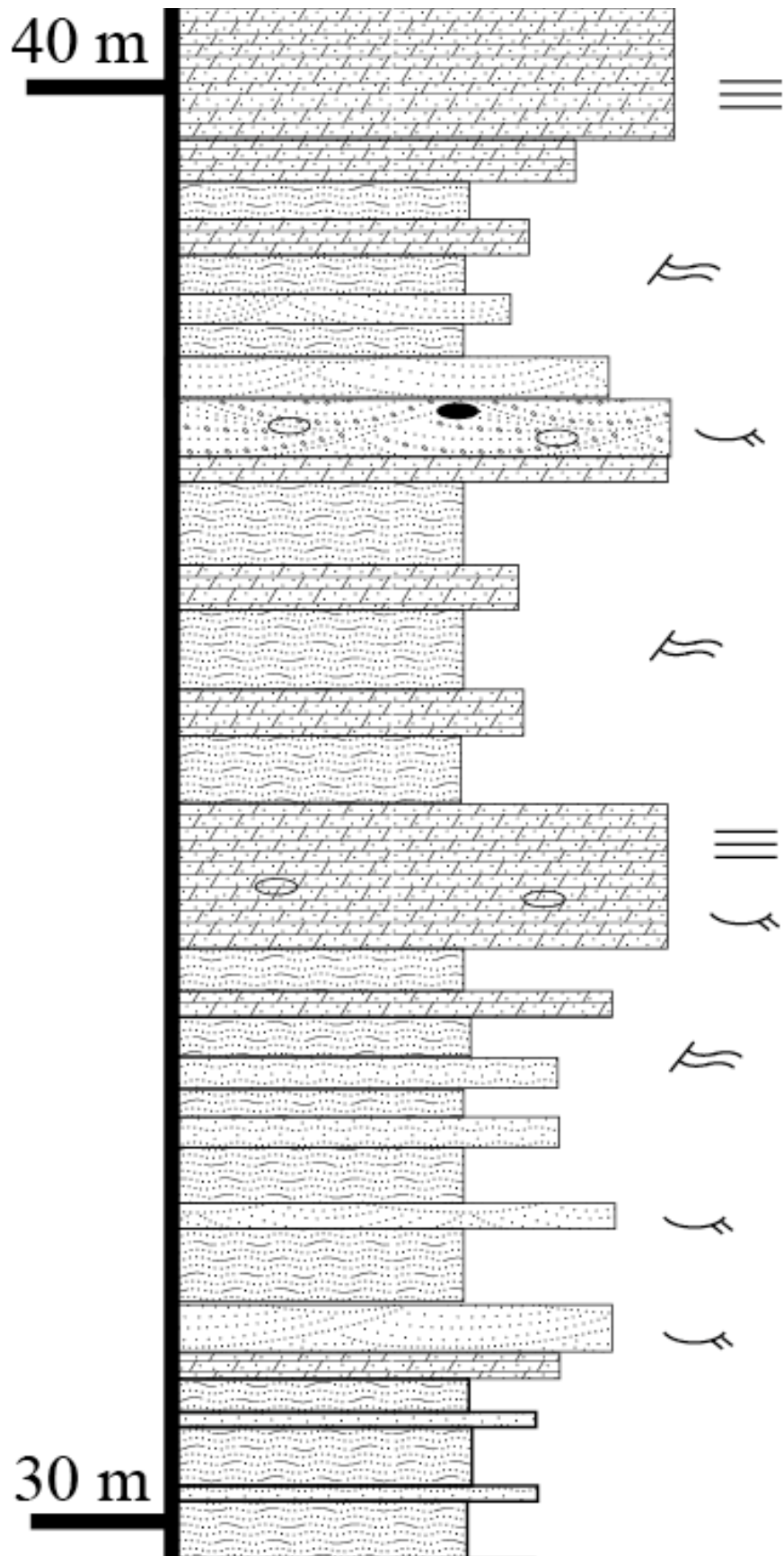


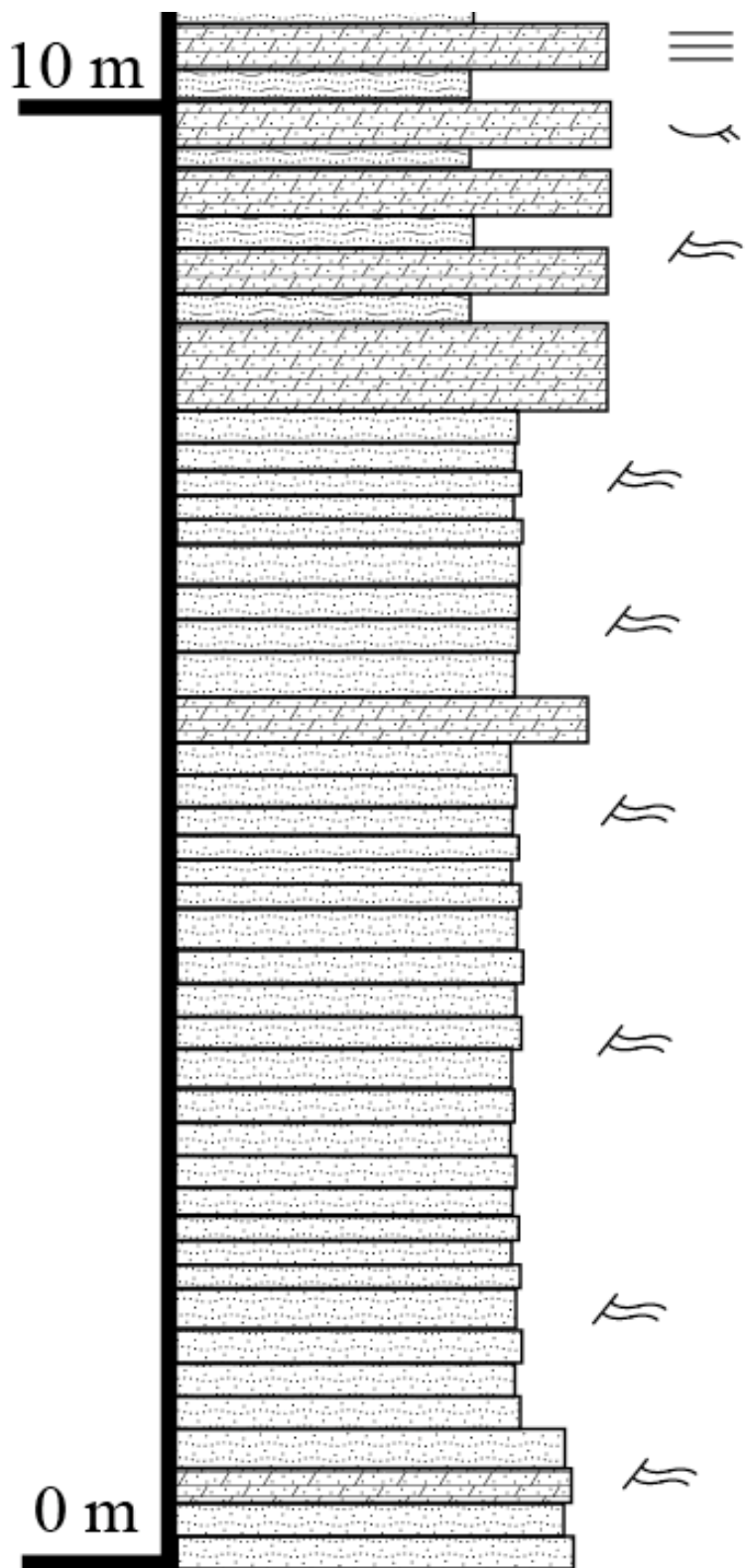
Detailed Stratigraphic Column of the lower member of the Wood Canyon Formation
Southern Nopah Range at Gunsight Mine

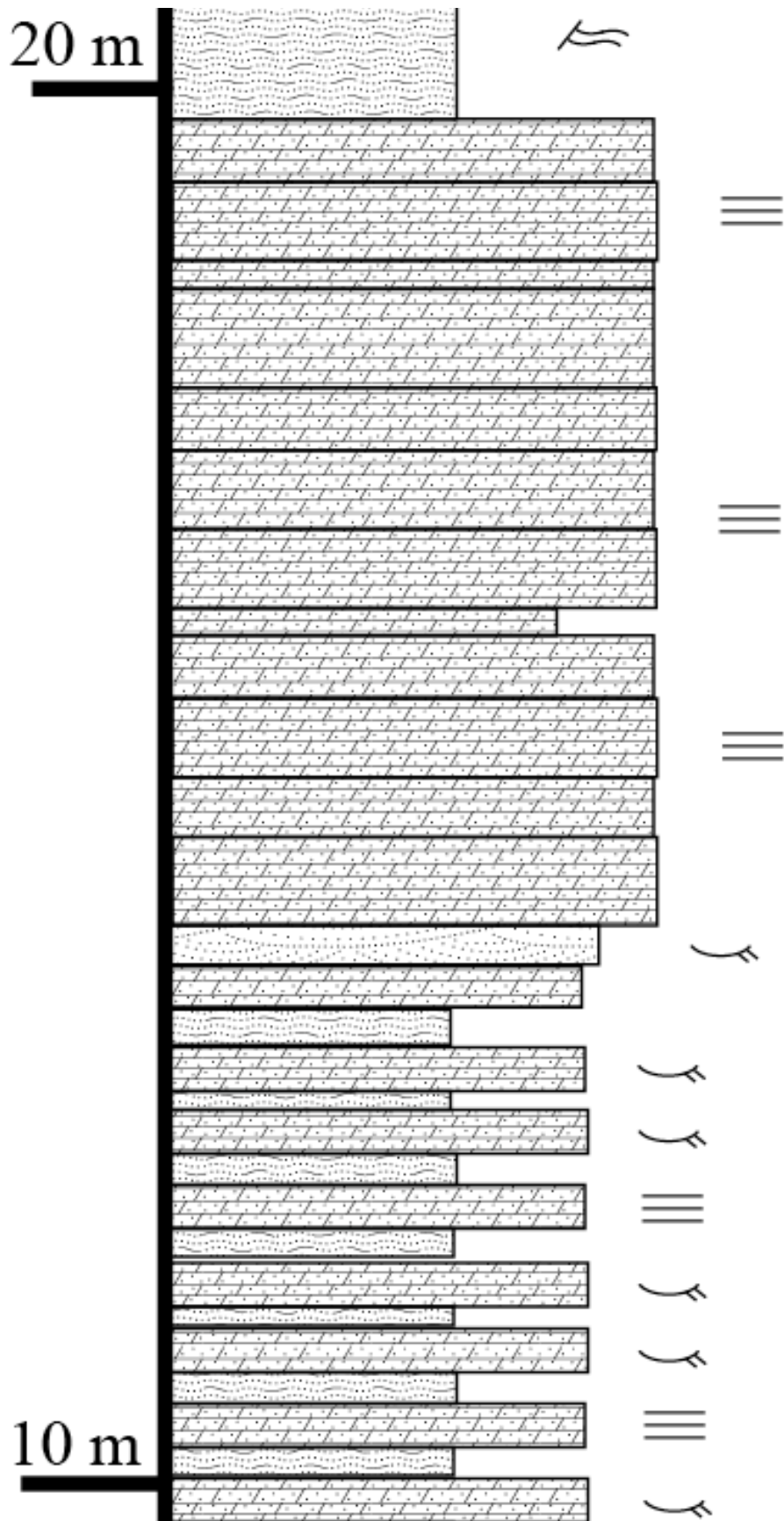


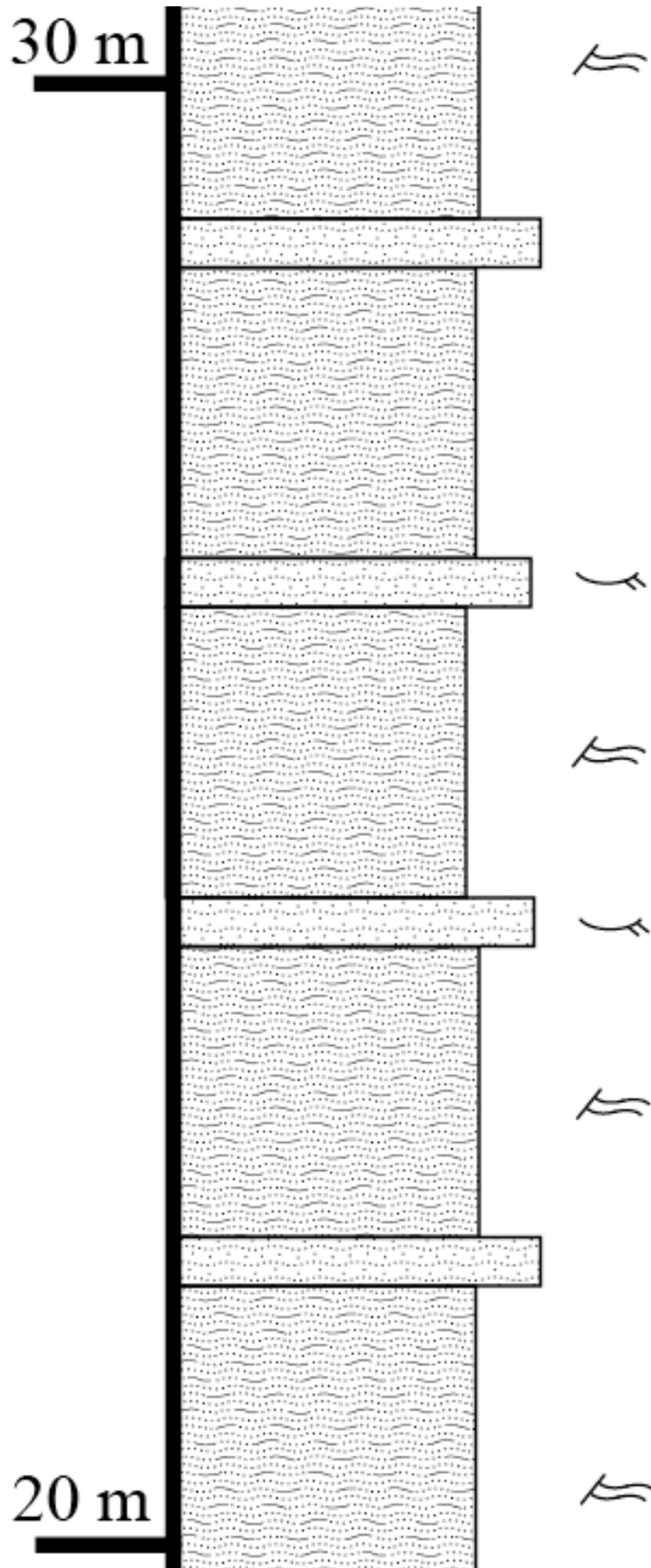


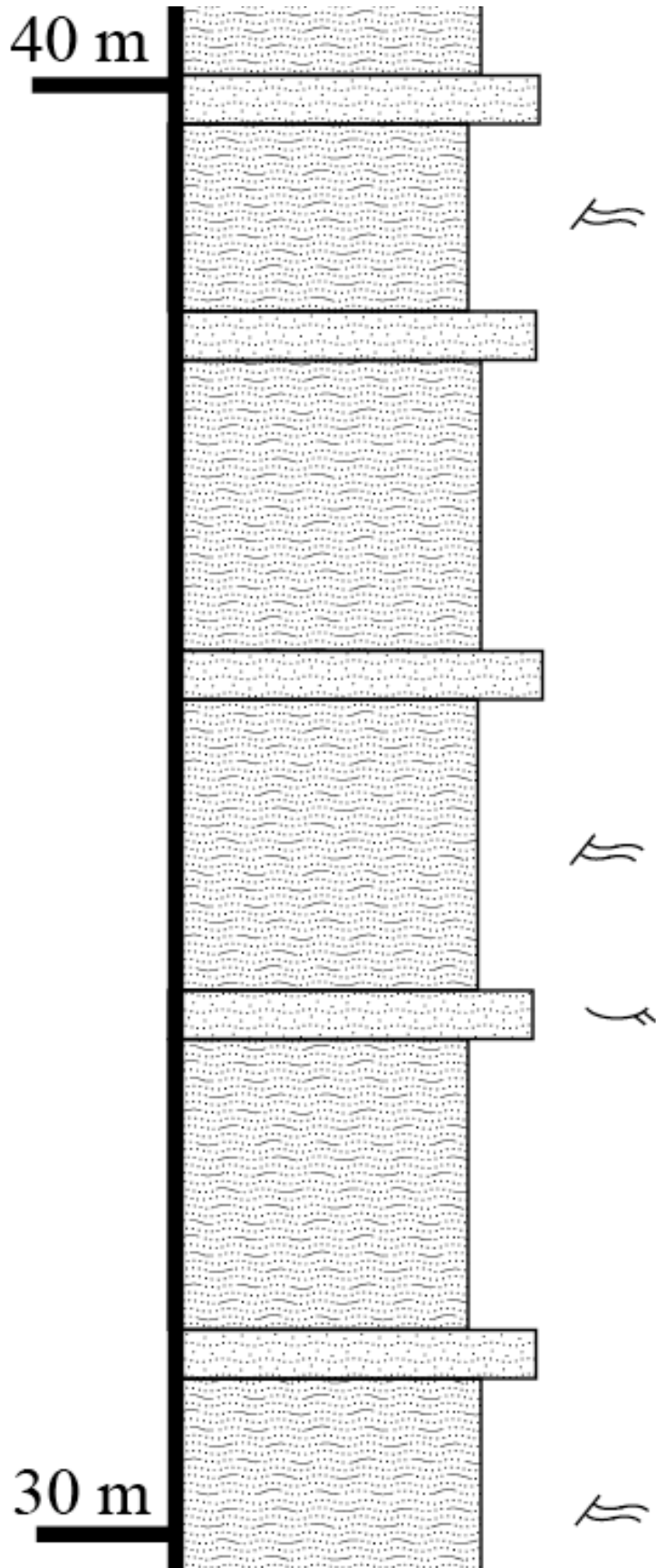


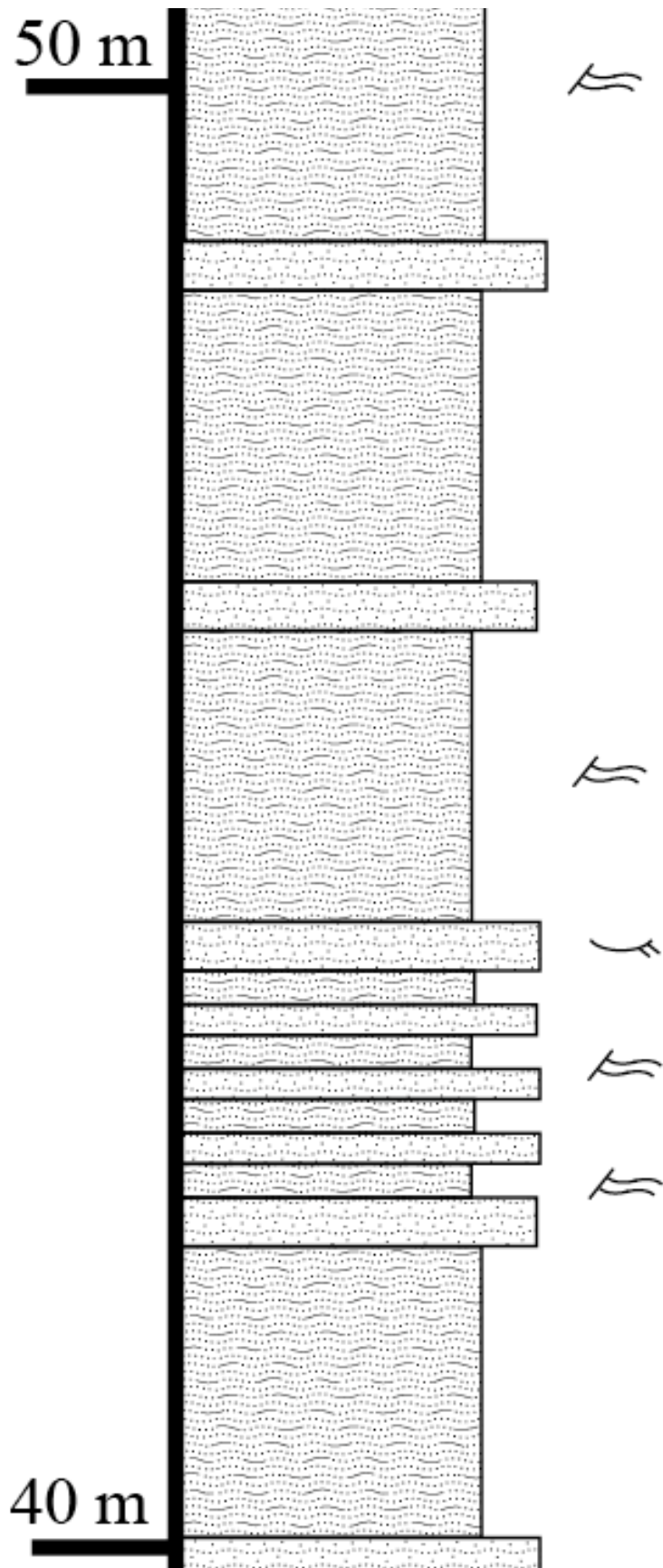


Detailed Stratigraphic Column of the lower member of the Wood Canyon Formation
Northern Nopah Range at Chicago Pass

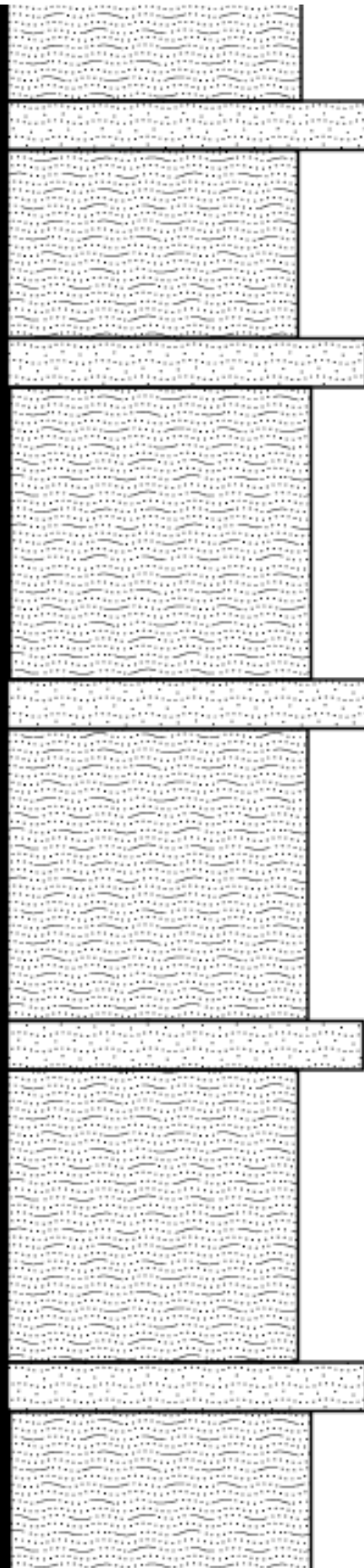








60 m

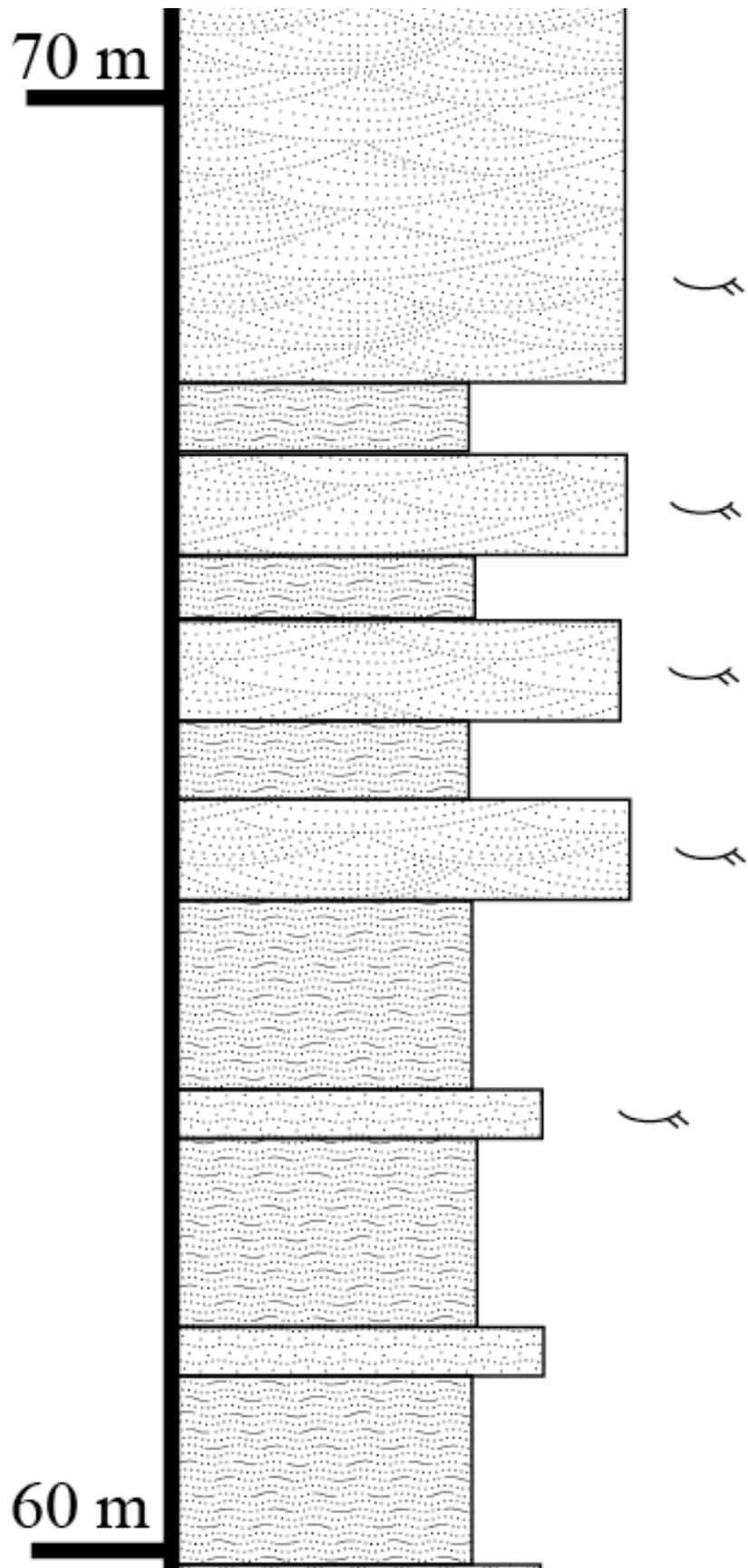


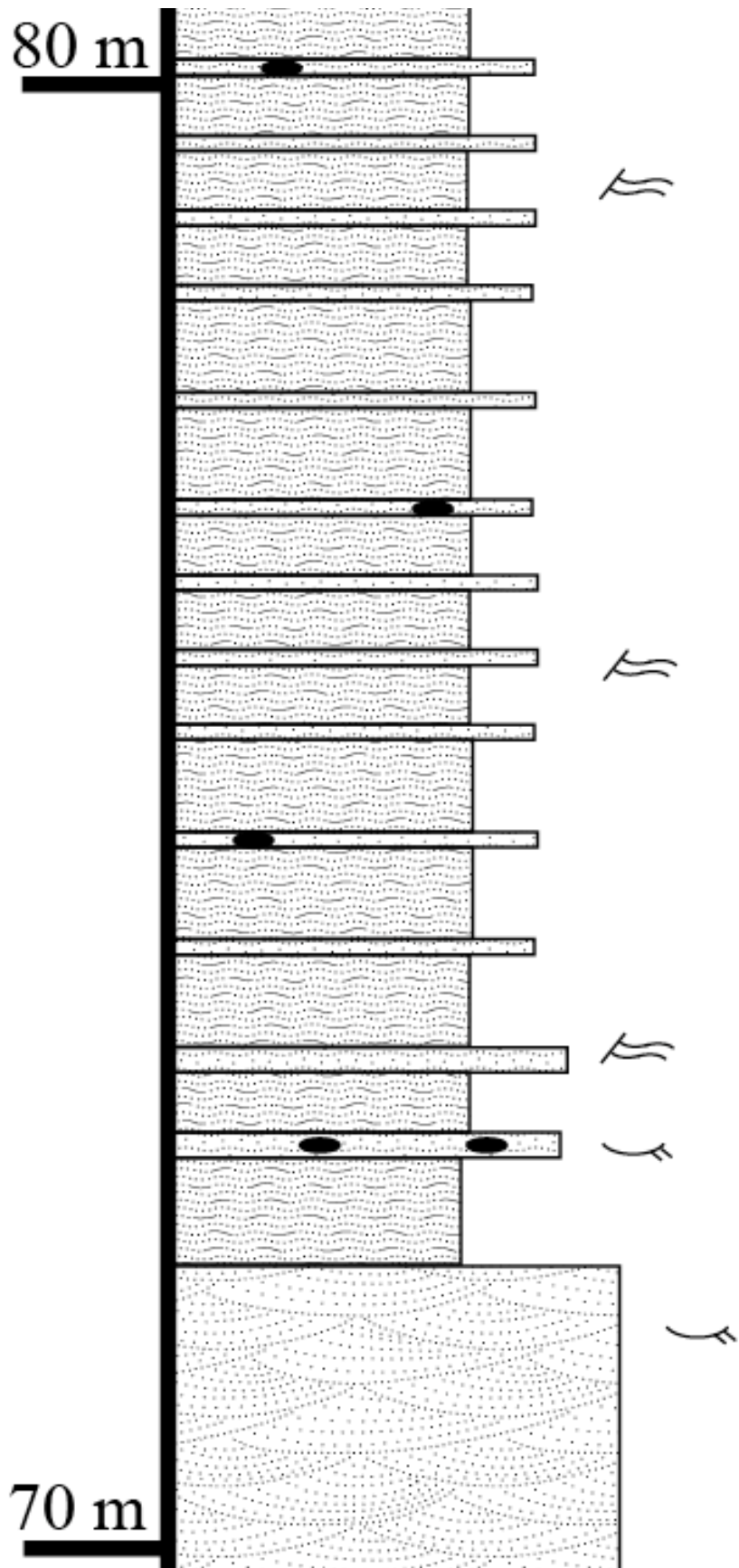
π

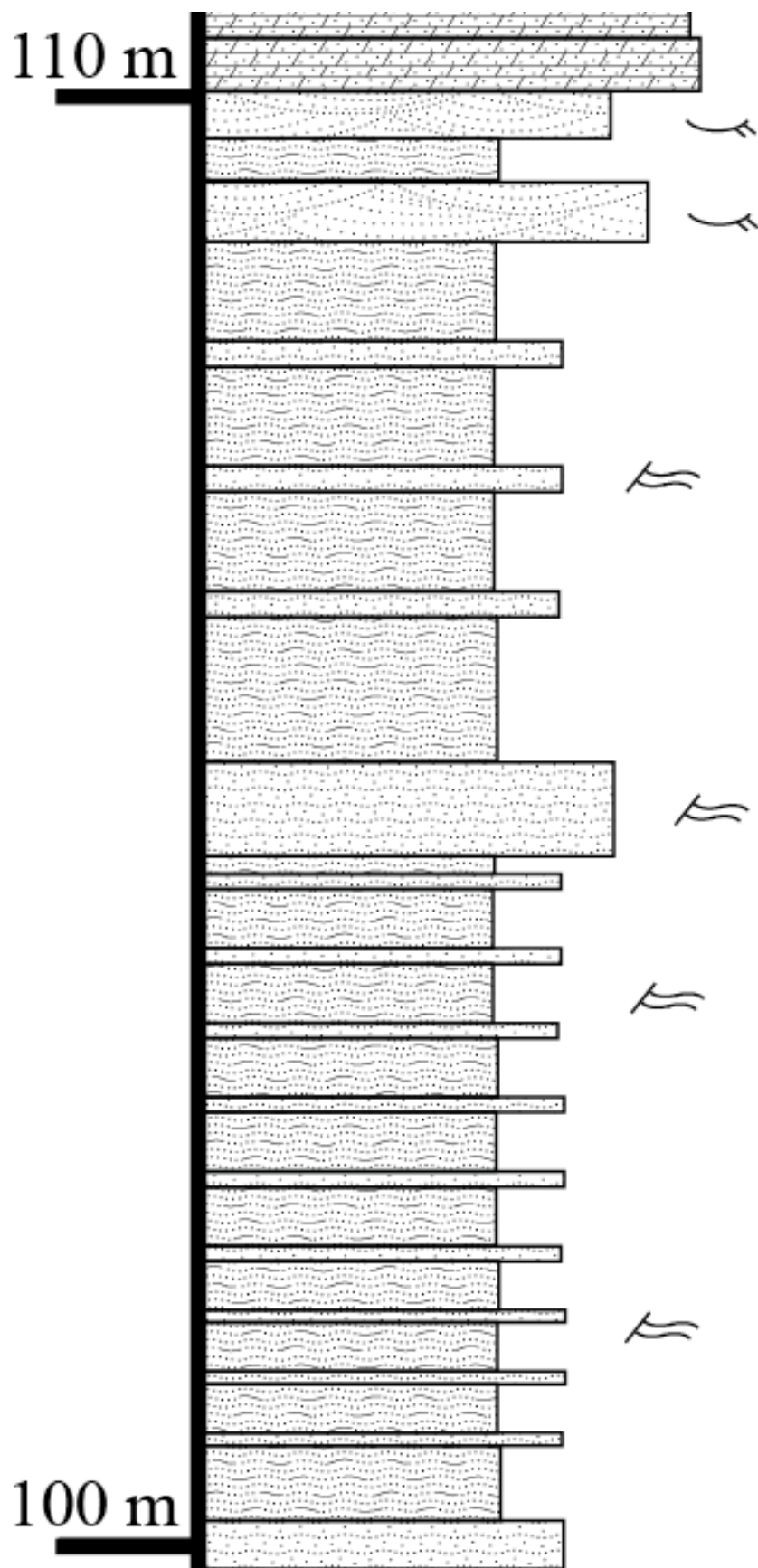
π

50 m

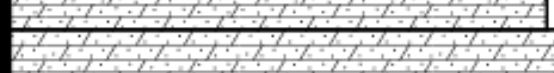
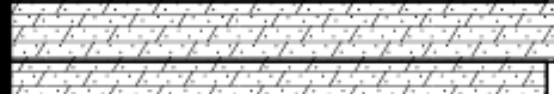
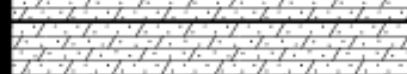
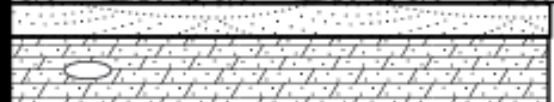
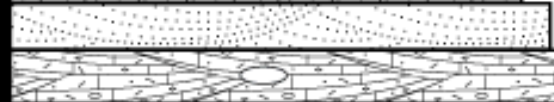
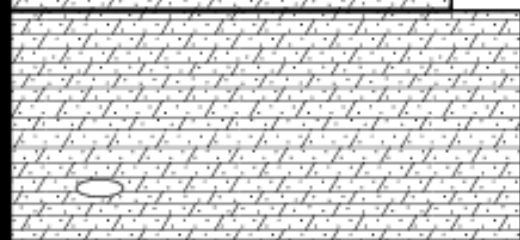
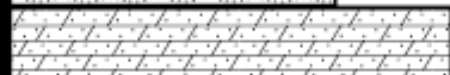
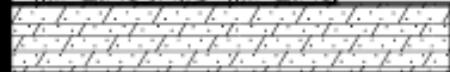
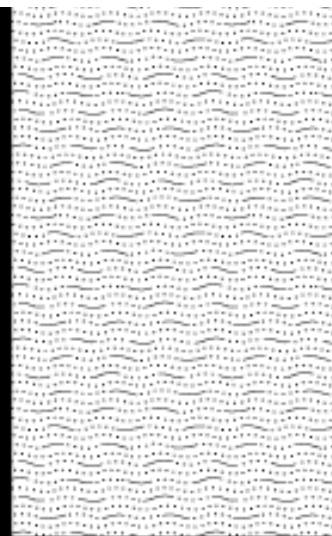
π







120 m



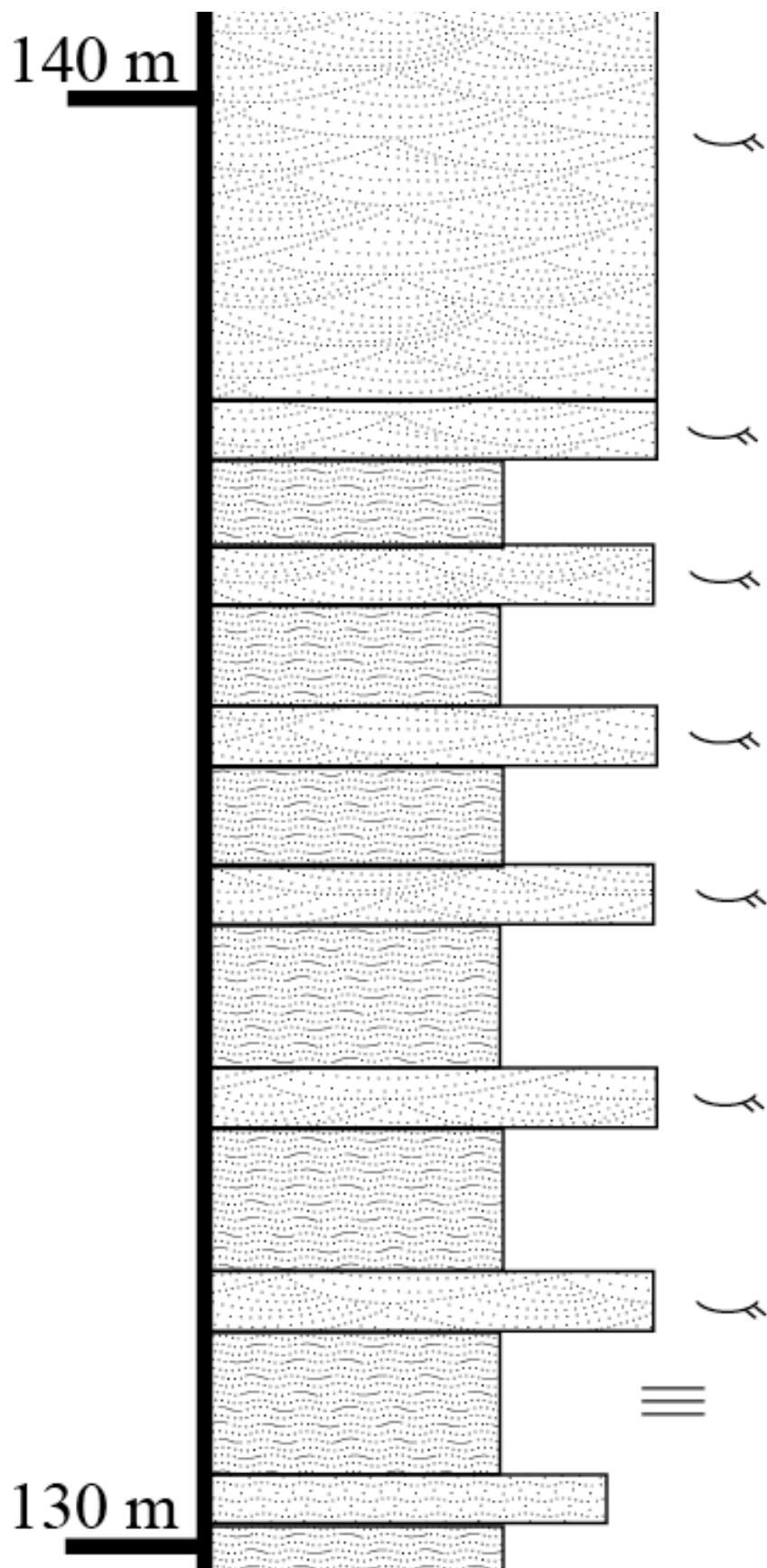
110 m



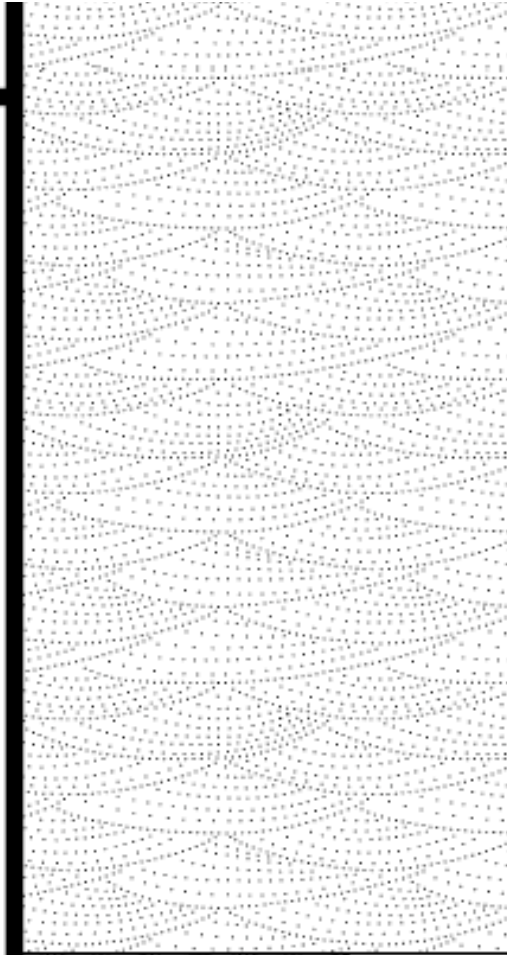
120 m

—

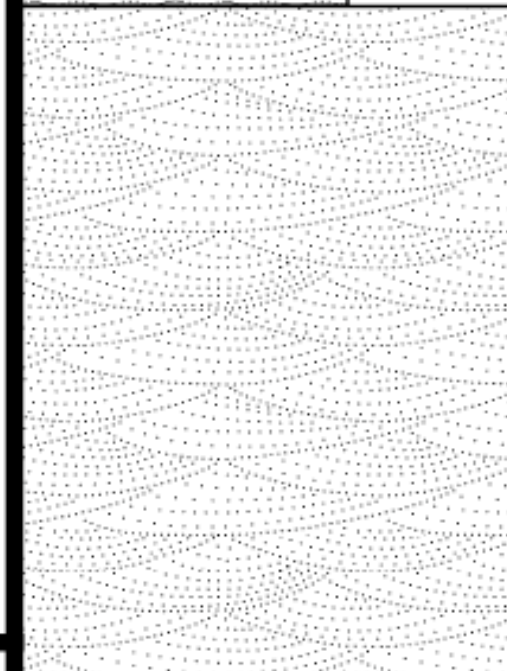
—



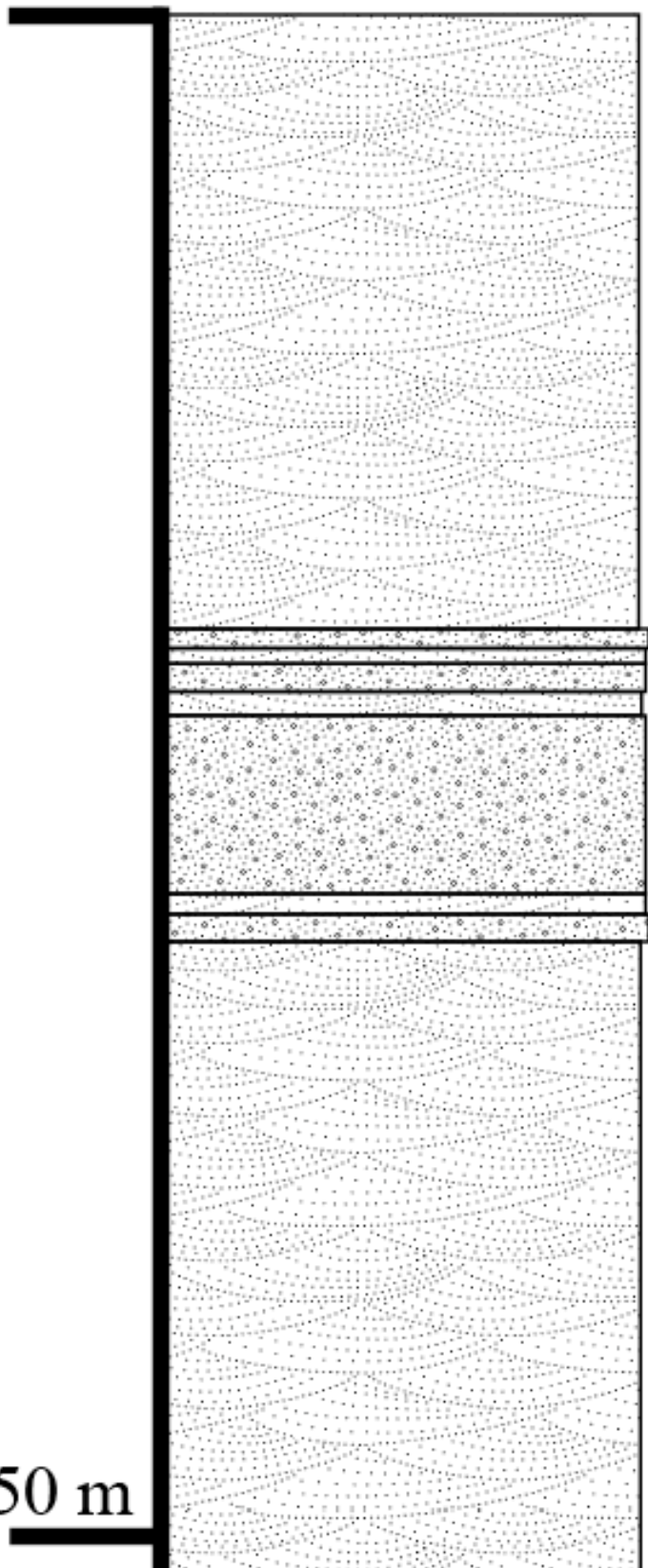
150 m



140 m



160 m



150 m

Appendix C

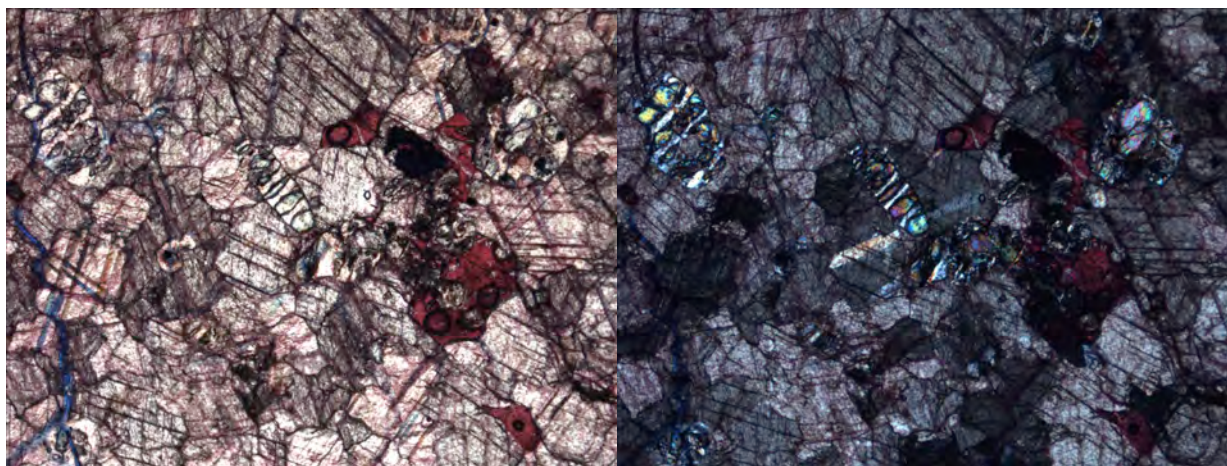
Carbonate Descriptions, Field Photos, and Photomicrographs

Each pair of photomicrographs are approximately 2 mm wide and show the same field of view in plane polarized light (left) and cross polarized light (right).

SM 2: Carbonate from the base of Soda Mountain, lower member Johnnie Formation or middle member Stirling Quartzite

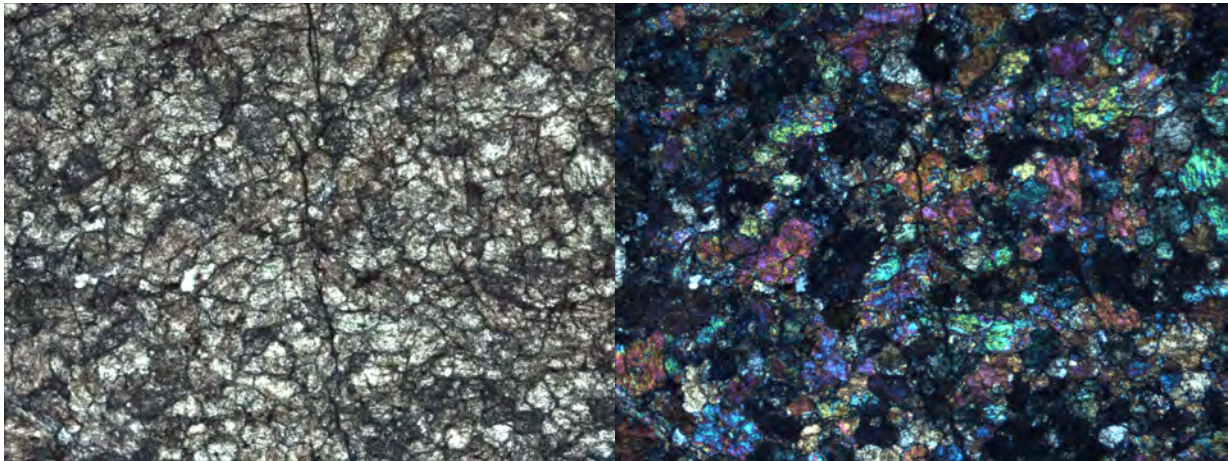
Folk (1959): Intrasparrite (glauconite intraclasts)

The primary fabric of this carbonate has been completely obliterated and replaced with dolomite. Twinned dolomite rhombs, up to 1 mm in size are clearly visible throughout the thin section. Rounded football shaped glauconite is present at 20 % and appears degraded and vuggy. Amphibolite grade metamorphism, due to the nearby emplacement of a diabased dyke, has turned this stone into a calcareous marble. Calcite is present filling pore space and along dolomite rhomb cleavage boundaries. No fossils were observed.



SM 3: Lighter white/pink layer below lower member WCF carbonate in the Soda Mountains

The primary fabric of this carbonate has been completely obliterated and replaced with a metamorphic fabric of interlocking, 0.1 to 1.0 mm diopside crystals that have near 90 ° cleavage intersections and inclined extinction in crossed polarized light. This is interpreted as an alteration phase from dolomite and silica at high temperature. No cement or fossils are visible in the sample.



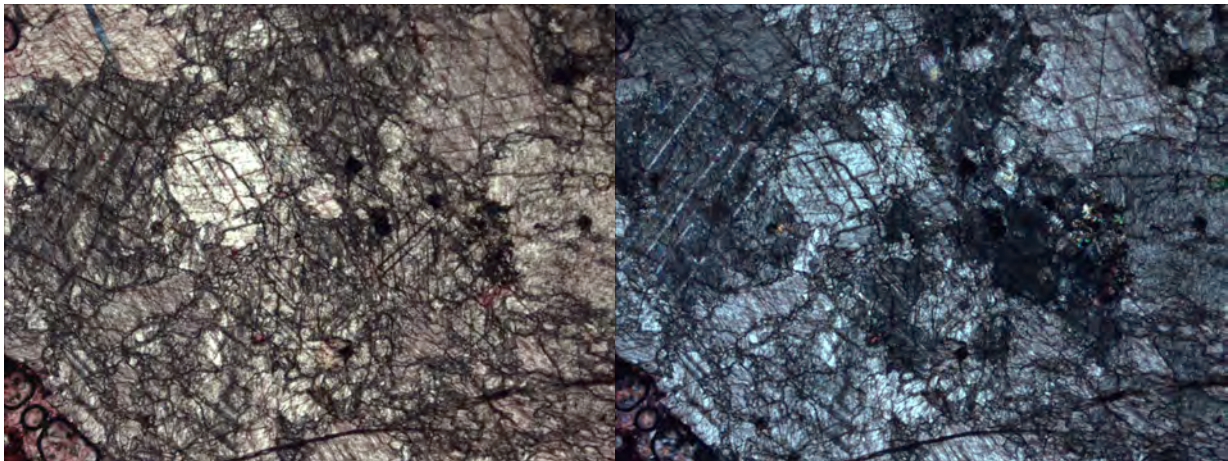
SM 4: Carbonate of the lower member WCF in the Soda Mountains

Folk (1959): Sparite

Dunham (1962): Crystalline

Choquette and Pray (1970): Intercrystalline

The primary fabric of this carbonate has been obliterated and replaced with twinned dolomite rhombs, some exceeding 1.0 mm in size. The rock contains fractures filled with iron oxide and calcite cement. No fossils are present in this sample.



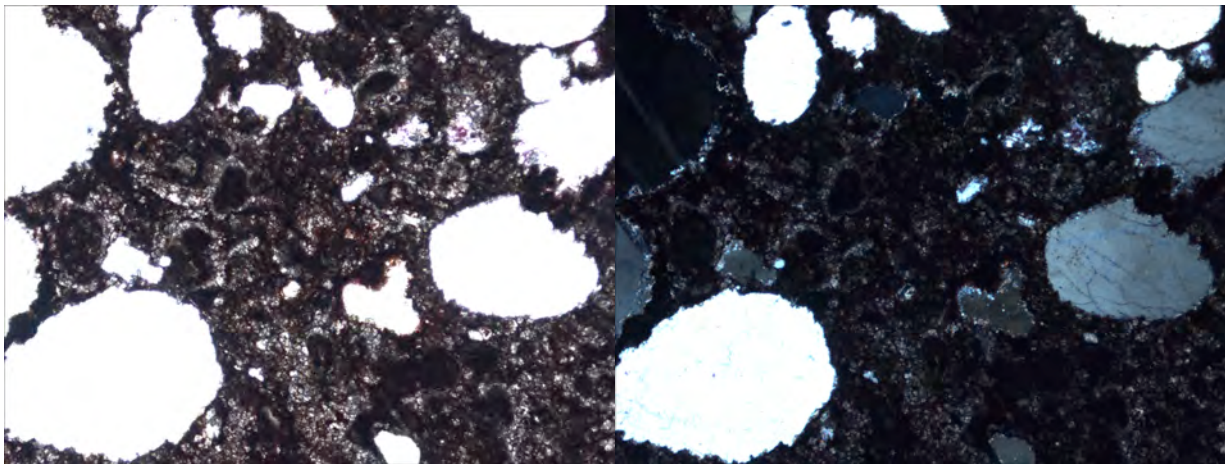
GSM 1: Gray/white layer below carbonate 1 from the southern Nopah Range

This rock is a carbonaceous quartzarenite with 95 % quartz, 3 % microcline and albite feldspar, 1 % muscovite, and 1 % biotite. Grain boundary bulging and undulose extinction are evidence of early stage dynamic recrystallization. Abundant silica, minor calcite cements take up the space between grains and no fossils are visible.



GSM 2: Tan portion of carbonate 1 from the southern Nopah Range

This sample is calcareous sandstone with monocrystalline and polycrystalline quartz grains in a dark reddish brown matrix. Dolomitization has replaced calcite with (0.05 mm) dolomite spar making up approximately 50 % of the rock. Individual quartz grains are fractured and have undergone dynamic re-crystallization in the form of grain size reduction. The edges of most grains appear to be dissolved leaving a rough texture. Calcite cement rims most of the siliciclastic grains that appear to have been etched or dissolved around the edges. Sedimentary structures include planar stratification and trough cross-stratification. No fossils are present.



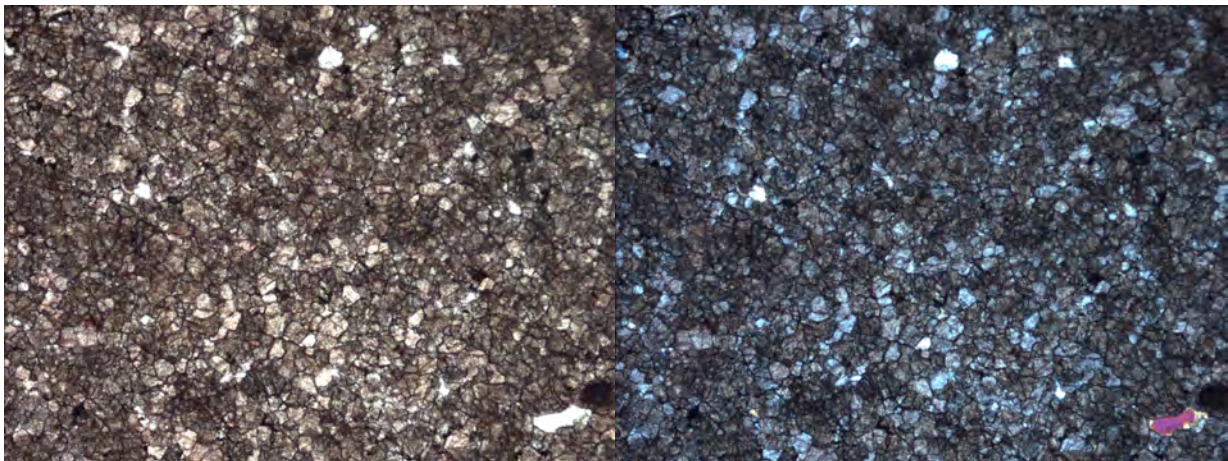
GSM 3: Carboante 1 from the southern Nopah Range

Folk (1959): Sparry dolomite

Dunham (1962): Crystalline

Choquette and Pray (1970): Intercrystalline

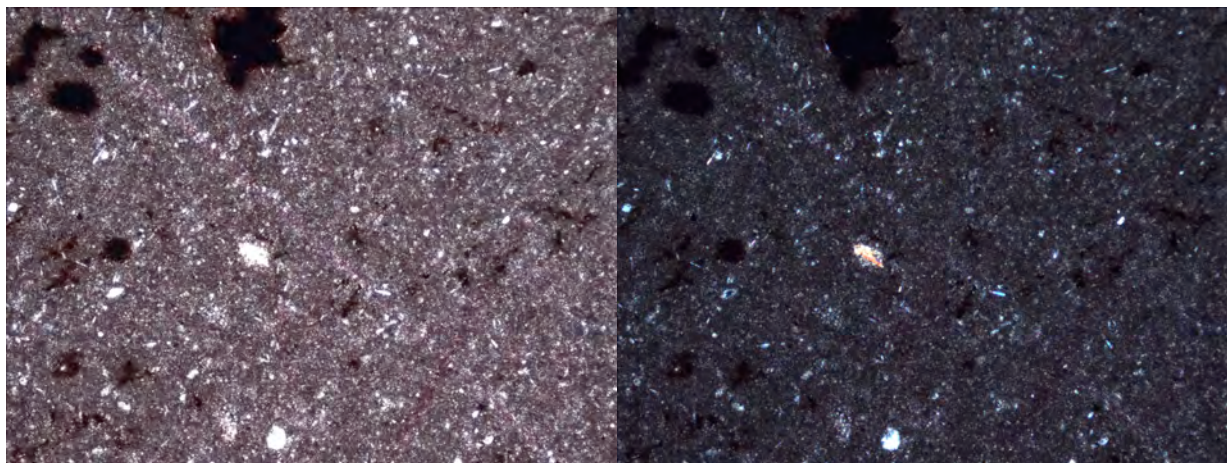
This sample is dolomite with approximately 1 % angular, very fine-grained detrital quartz. Iron oxide cement is present on the dark half of the thin section and calcite and iron oxide cement surrounds quartz grains. Identified sedimentary structures include planar stratification with some trough cross-stratified and laminated intervals. No fossils were identified.



GSM 4: Lower portion of carbonate 2 from the southern Nopah Range

This sample is dolomite containing approximately 50 % detrital quartz, microcline, albite, and muscovite. Detrital material is coarse sand to silt sized. Smaller detrital fragments are angular, whereas larger grains (upper medium to coarse) are well rounded. The lighter portion of sample is coarser than the darker portion. The primary fabric is not present and has been replaced with very fine dolomite spar. Calcite cements nearly all of the detrital material and is present within the dolomite spar as evident by the pink, alizarin red stain in thin section. Sedimentary structures include possible hummocky cross-stratification in sandy intervals with trough cross-stratified intervals. Carbonate and siliciclastic material is chaotically interwoven and contorted. No fossils are observed.

The environment of deposition for this rock was a shallow carbonate shelf with significant siliciclastic input.

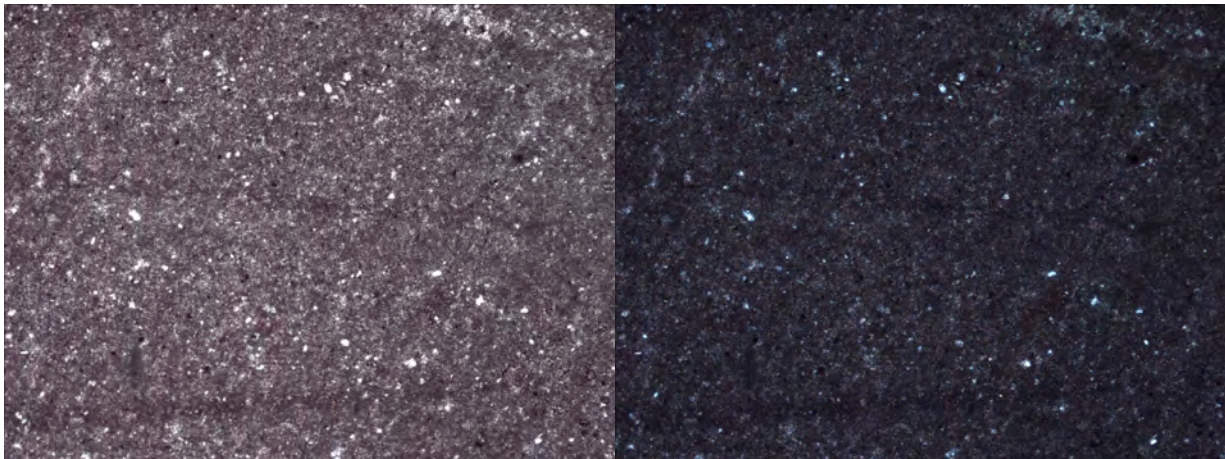


GSM-5: Breccia within carbonate 2 from the southern Nopah Range

Dunham (1962): Grainstone

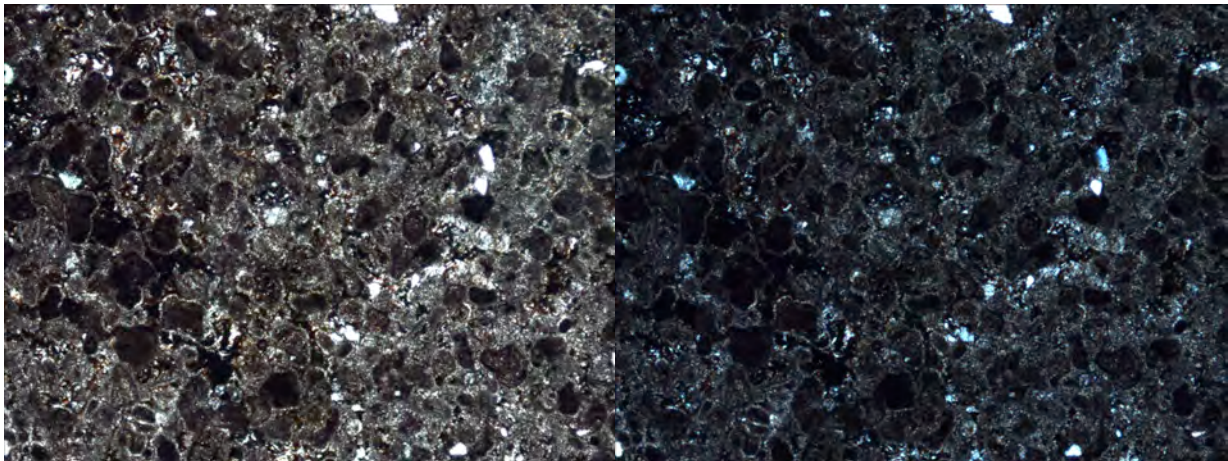
Choquette and Pray (1970): Breccia

The primary fabric of this rock is preserved as pebble sized carbonate clasts in a sandy to micritic dolomite matrix. Some of the clasts contain very fine detrital grains that include quartz, albite and microcline feldspar that have been partially altered to clay. The matrix material is similar in composition to the pebble sized dolomite clasts. Pressure solution within micritic clasts and brittle fracturing is observed throughout the rock. Some fine-grained framework material is composed of polycrystalline quartz. Individual framework grains contain calcite cement that grows in two directions from the grain roughly parallel with the long axis of the thin section. Observed sedimentary structures are planar and massive beds of carbonate rip-up clasts. Carbonate and siliciclastic material is chaotically interwoven and no fossils are present. Calcite cement, if primary or immediately precipitated subsequent to deposition, indicates that this sediment may have been briefly subaerially exposed in an inter-tidal environment.



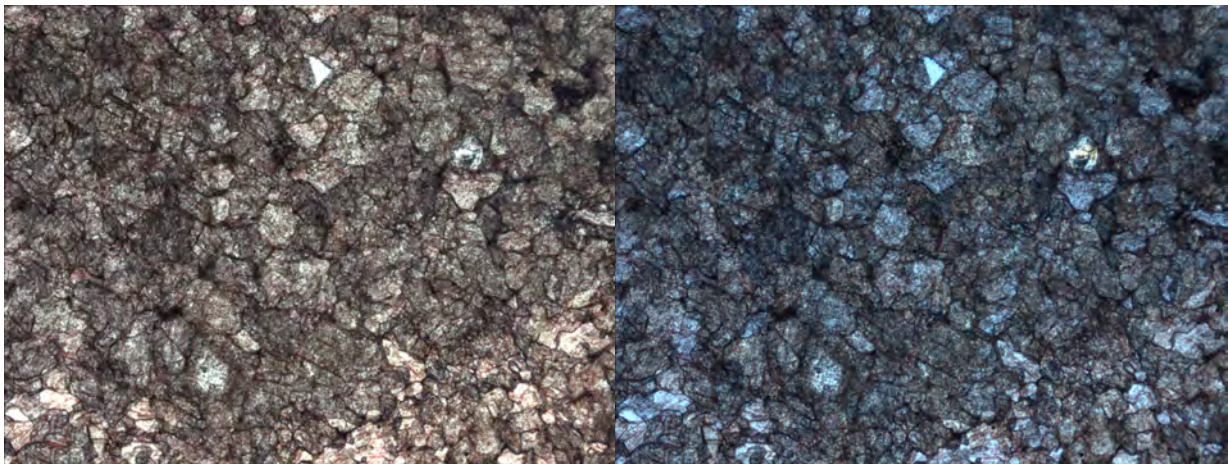
GSM 6: Top carbonate from the southern Nopah Range

This rock is composed of rounded, possibly peloids or ooids, medium grained, micritic calcite with approximately 5 % angular, medium grained, quartz, muscovite, and albite. Dolomite has obliterated the primary fabric, however, leaving only faint round clasts. Primary soft sediment deformation and secondary brittle fractures filled with silica and calcite is abundant in this rock and very fine equant spar calcite surrounds most grains. Sedimentary structures include planar stratification and trough cross-stratification. No fossils are identified.



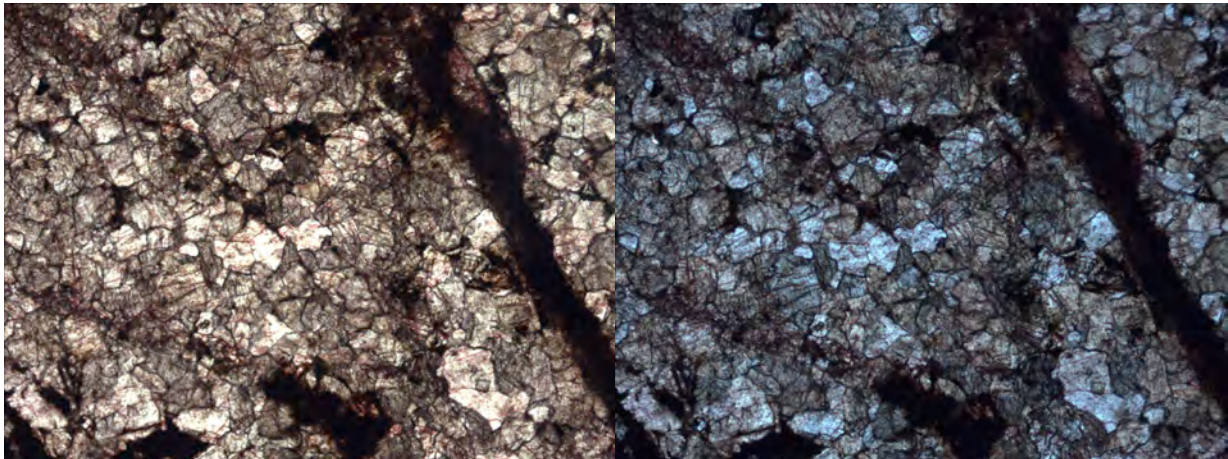
CP 2: Base of carbonate 1 from the northern Nopah Range

This rock is a dolostone with < 5 % quartz, plagioclase, and muscovite. Dolomite rhombs are 0.5-1.0 mm in size. Minor amounts of pressure solution and brittle fracturing are seen in hand sample and in thin section. Calcite fills most of the cracks and surrounds siliciclastic grains. Silica cement is present around some quartz grains. Sedimentary structures include massive beds and planar stratification. No fossils are identified in this rock.



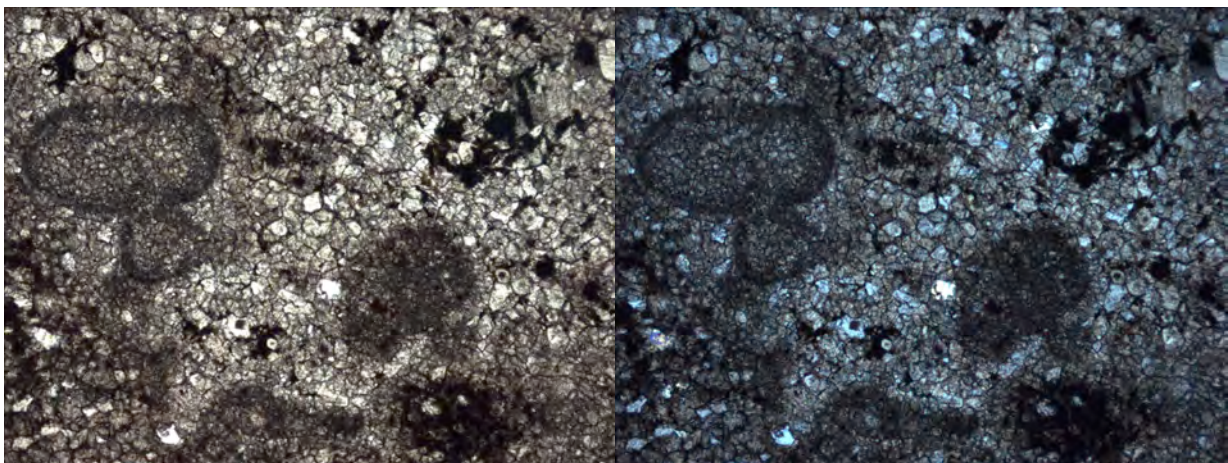
CP 3: Pink layer of carbonate 1 from the northern Nopah Range

This sample is a dolostone with < 1 % detrital quartz and plagioclase feldspar sand. Dolomite rhombs are 0.5-1.0 mm in size. Pressure solution and brittle fracturing are observed with calcite cement filling fractures and surrounding detrital grains. In places dolomite rhombs have been replaced by iron oxide leaving a rhomb halo of calcite around iron oxide. No fossils were observed.



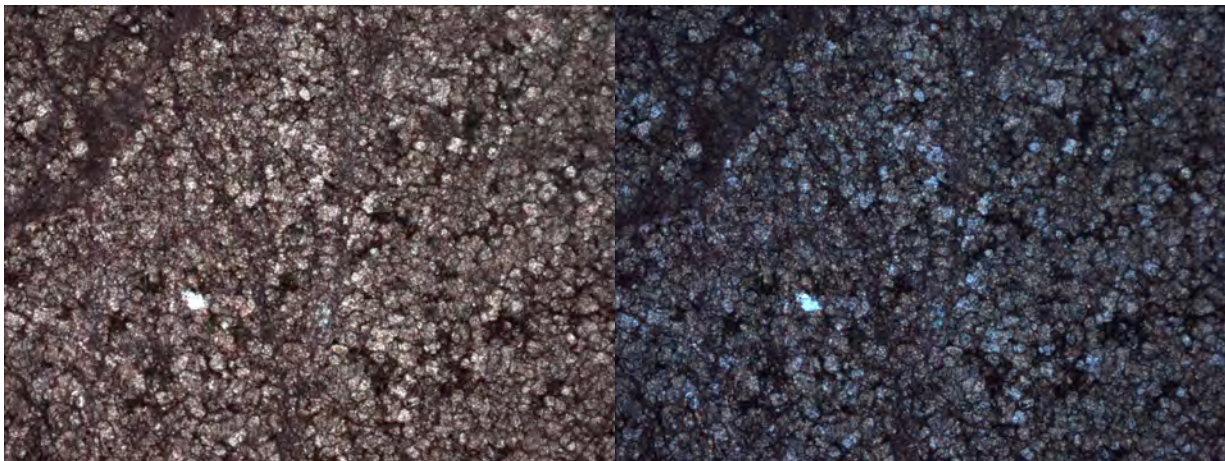
CP 4: Top of carbonate 1 from the northern Nopah Range

This sample is a dolostone with up to 5 % quartz and feldspar. Rounded and deformed objects of various sizes could be ooids with a finer cortex and coarse sparry nucleus or rounded intraclasts with micritized rims. Dolomite rhombs are up to 0.5 mm. Pressure solution and intense brittle fracturing are observed throughout the rock. Calcite and iron oxide cement fills most fractures. Diehl (1979) identified potential syneresis cracks at the top surface of the carbonate unit where this sample was collected.



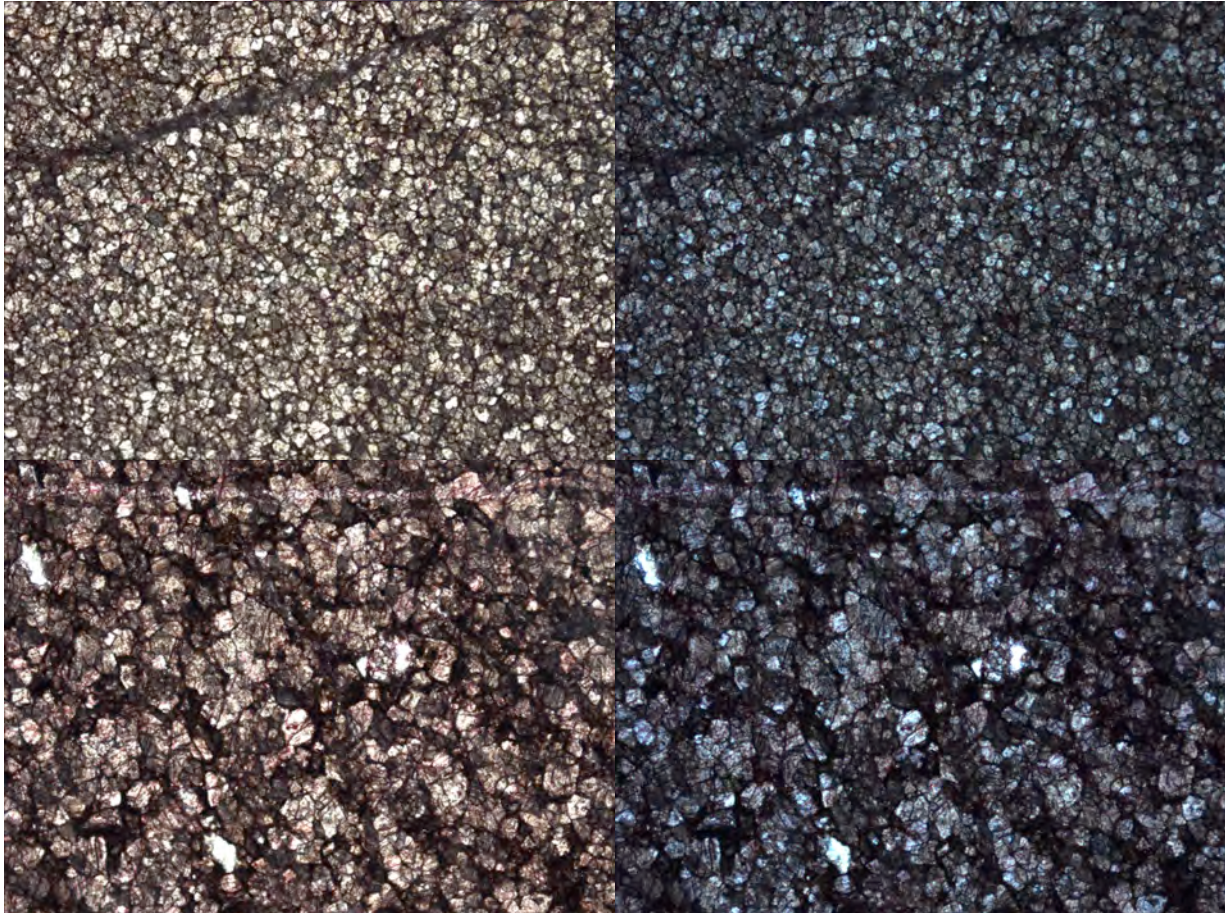
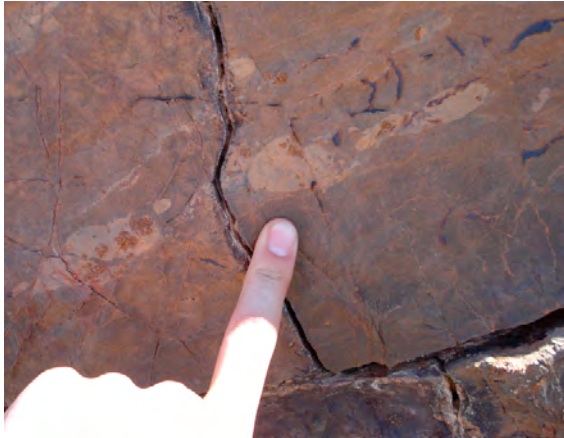
CP 5: Carbonate 2 from the northern Nopah Range

This sample is a dolostone with < 1 % detrital quartz. Dolomite rhombs are < 0.5 mm in size. Intense secondary brittle fracturing is observed throughout the sample and calcite fills these fractures. Sedimentary structures include massive, medium to thick beds lacking internal physical sedimentary structures. No fossils are observed.



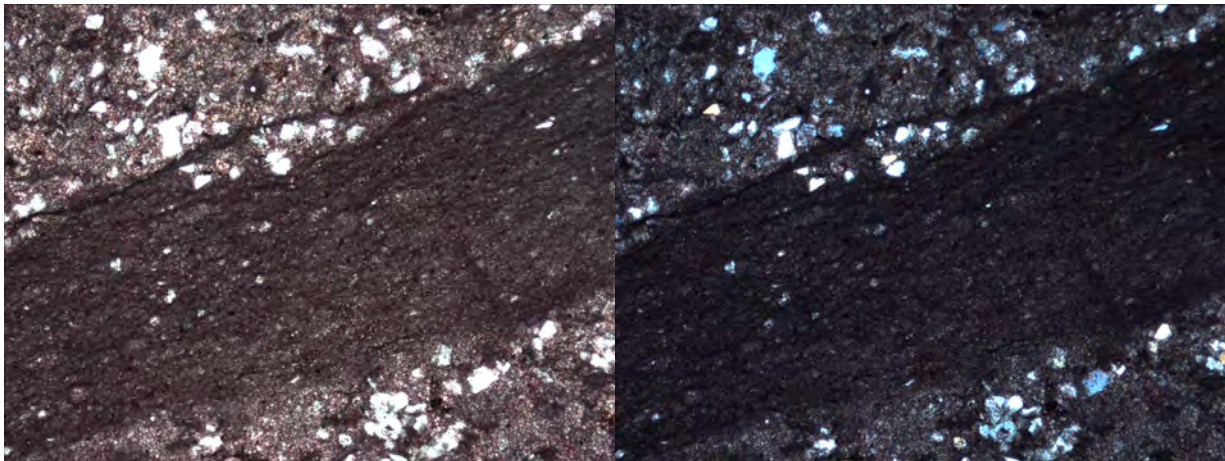
CP 6: Tan clast of carbonate 2 from the northern Nopah Range

The tan clast (top two photomicrographs) is dolomite with $< 1\%$ detrital quartz. Dolomite rhombs are 0.05-0.1 mm in size. Fractures are filled with calcite. No fossils were observed. The brown rock (bottom two photomicrographs) is dolomite in that contains 5% quartz and feldspar. Dolomite rhombs are 0.1-0.5 mm and are coarser than the tan inclusion. Fractures and minor pressure solution are observed throughout. Calcite and silica fills fractures and coats grains. Sedimentary structures include tan carbonate clasts aligned bedding-plane parallel and planar stratification. No fossils were observed.



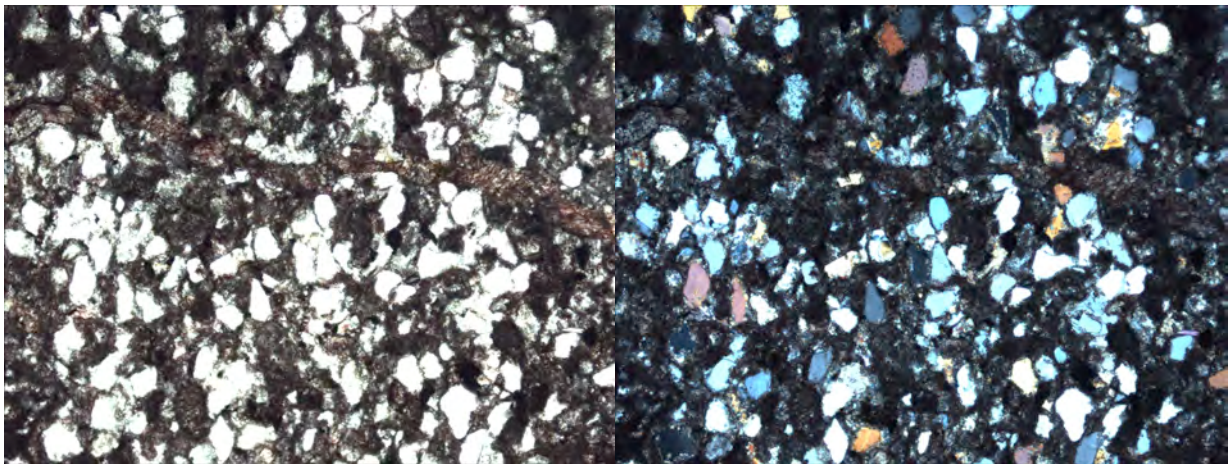
CP 7: Bottom of carbonate 3 from the northern Nopah Range

This rock is a dolostone with 40 % detrital quartz, muscovite, and plagioclase feldspar. Dolomite spar is < .01 mm in size. Elongate clasts, fractures, and pressure solution are visible along some laminations. Calcite and iron oxide cement are visible around detrital grains. Sedimentary structures include planar stratified beds. No fossils are observed.



CP 8: Pink layer in carbonate 3 from the northern Nopah Range

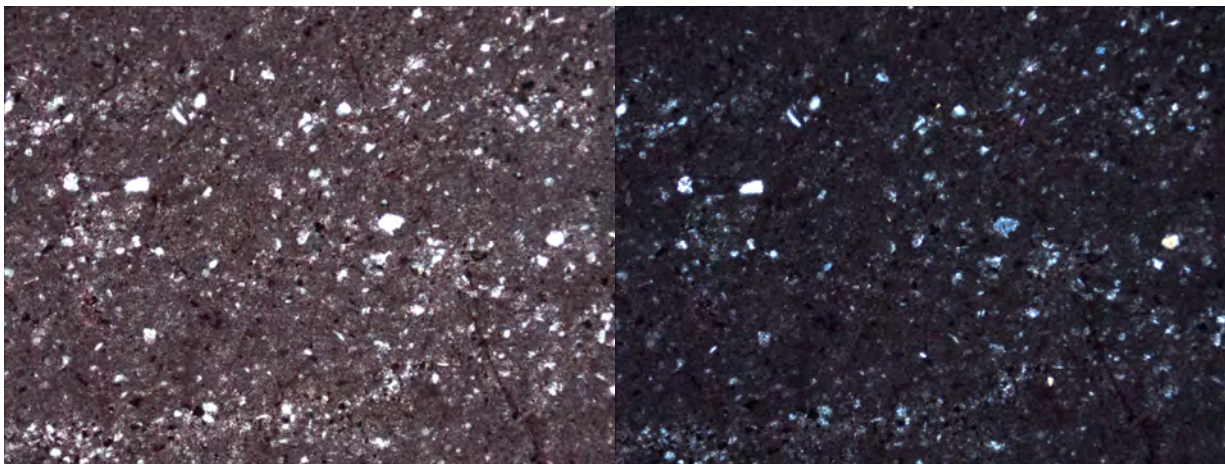
This sample is composed of 1 to 3 mm laminated dolomite with 50 % fine-grained, angular, detrital quartz, plagioclase, microcline, and muscovite. Dolomite spar is < 0.01 mm in size. Fractures and detrital grains are cemented with calcite. Sedimentary structures include thin to medium, planar laminated beds. No fossils are observed.



CP 9: Breccia of carbonate 3 from the northern Nopah Range

A clast of wavy laminated, angular dolomite with 5 % angular, detrital, very fine quartz, feldspar, and muscovite sits in a brown dolomite matrix. The clast is composed of < 0.01 mm dolomite rhombs that have been fractured and filled with calcite cement.

The brown dolomite matrix contains > 50 % well rounded, coarse grained quartz, microcline, muscovite, and rock fragments. The smaller, fine to medium grains are more angular. Dolomite rhombs are 0.01-0.05 mm in size. Fractures are filled with calcite cement and calcite coats etched grains. Sedimentary structures include rip-up clasts of laminated carbonate that form lags. No fossils are observed.



Appendix D

Carbon and Oxygen Isotope Data

Sample	Bulk ‰ ¹³ C	Bulk ‰ ¹⁸ O	Micro Drilled ‰ ¹³ C	Micro Drilled ‰ ¹⁸ O
KR 1	-3.928	-8.514	-3.889	-8.026
SM 4	-3.782	-1.431	-4.068	-11.053
SM 4			-3.601	-9.511
GSM 2	-2.720	-10.353	-2.544	-9.906
GSM 3	-3.224	-8.949	-3.175	-8.702
GSM 4	0.408	-7.881	0.676	-7.639
GSM 5	-0.329	-9.158	-0.340	-7.724
GSM 5			-0.084	-8.084
GSM 6	-3.124	-9.202	-3.262	-10.086
GSM 6			-3.083	-8.282
CP 2	-3.107	-9.519	-2.825	-8.668
CP 3	-3.375	-9.455	-3.190	-8.978
CP 4	-4.256	-9.269	-4.248	-7.930
CP 5	-2.708	-10.383	-2.650	-9.499
CP 6	-2.152	-9.654	-2.217	-8.812
CP 6			-2.823	-10.479
CP 7	1.013	-9.850	0.587	-10.311
CP 8	-0.195	-10.205	0.353	-8.682
CP 9	-0.278	-11.104		

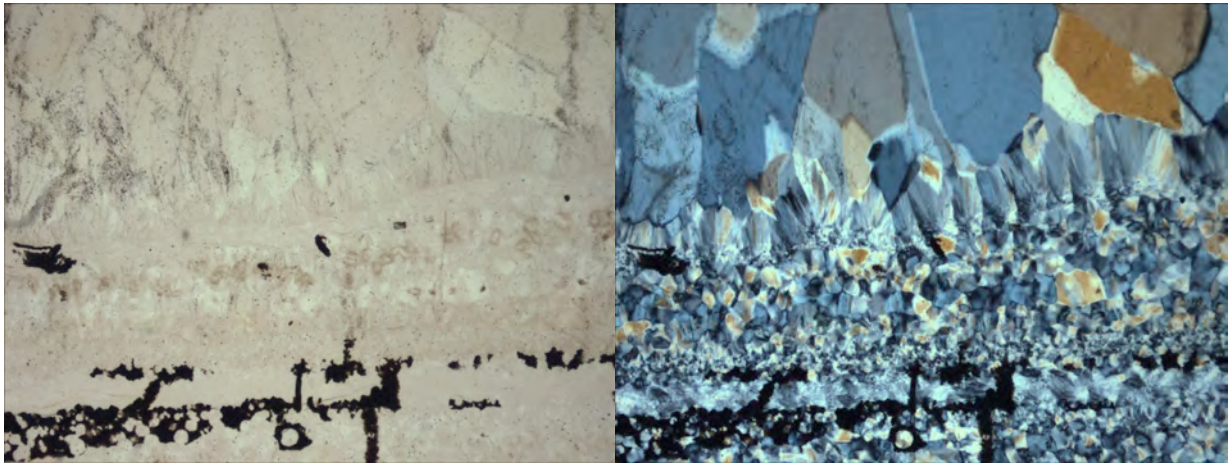
Samples were reacted at 120° C and oxygen values are reported here as 120° C.

Appendix E

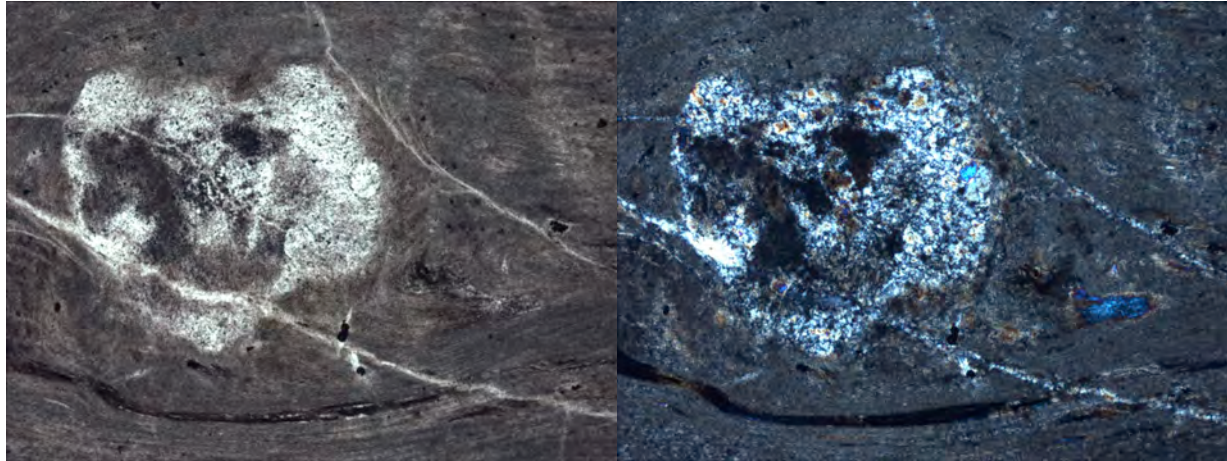
Clast Descriptions and Photomicrographs

Each pair of photomicrographs are approximately 2 mm wide and show the same field of view in plane polarized light (left) and cross polarized light (right).

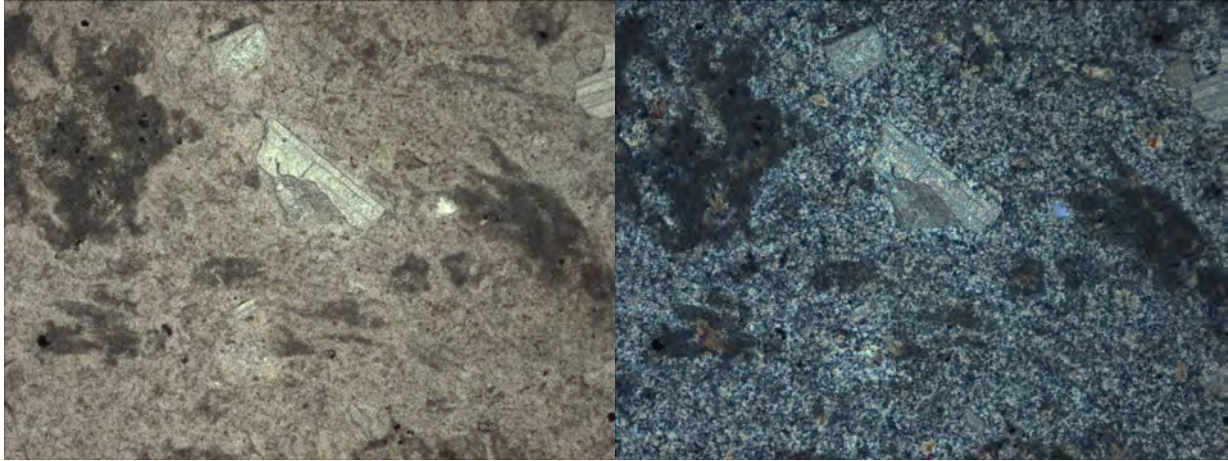
MM 4-9 is a chalcedony clast with bands of silica and iron oxide that define concentric layers. Calcite is present as secondary cement growing into void-space between silica layers. Silica occurs in various branching patterns and the reactivation of crystal growth defines successive bands.



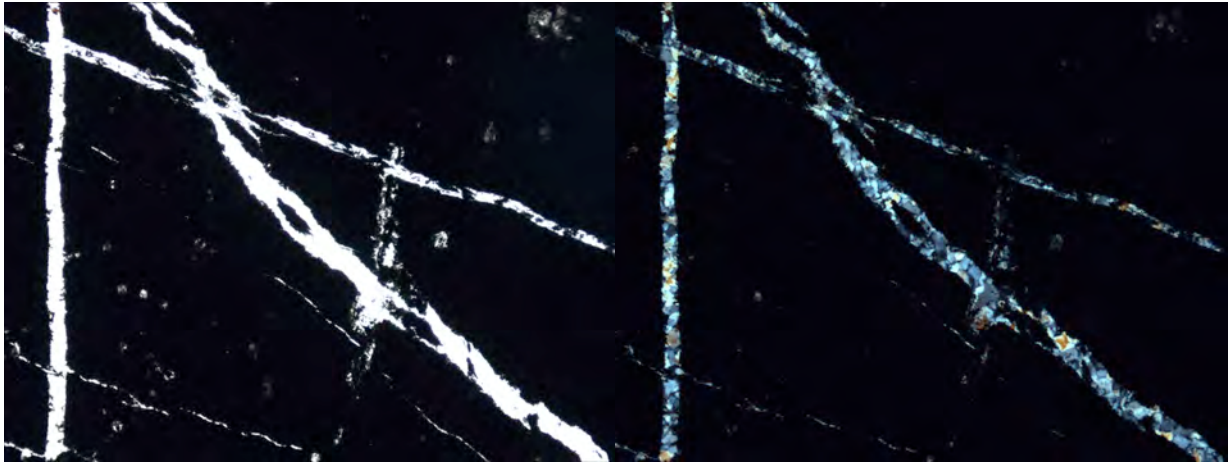
MM 4-14 is a metamorphic clast with an extremely fine-grained matrix composed of muscovite and minor epidote stringers. There is evidence of dynamic recrystallization of two quartz phenocrysts that have fine-grained matrix material deformed and folded around them. In one of two porphoroclasts, there is faint evidence of grain size reduction. A foliation is present at roughly 45° to the main fabric.



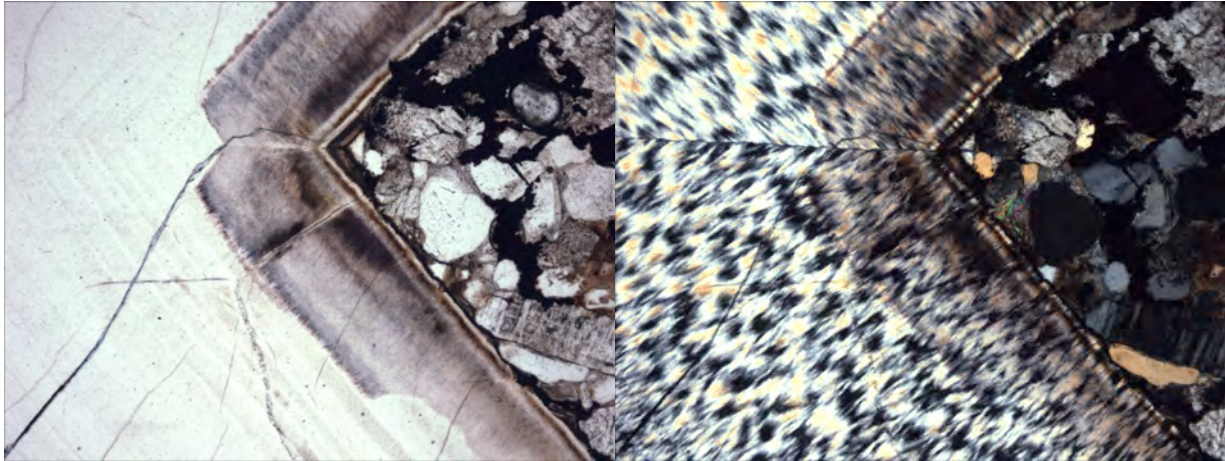
MM 4-16 is a felsic volcanic clast composed of fine-grained devitrified, glassy, groundmass and some remnant euhedral feldspar phenocrysts. The groundmass is dull gray and feldspar has a high degree of alteration to clay minerals.



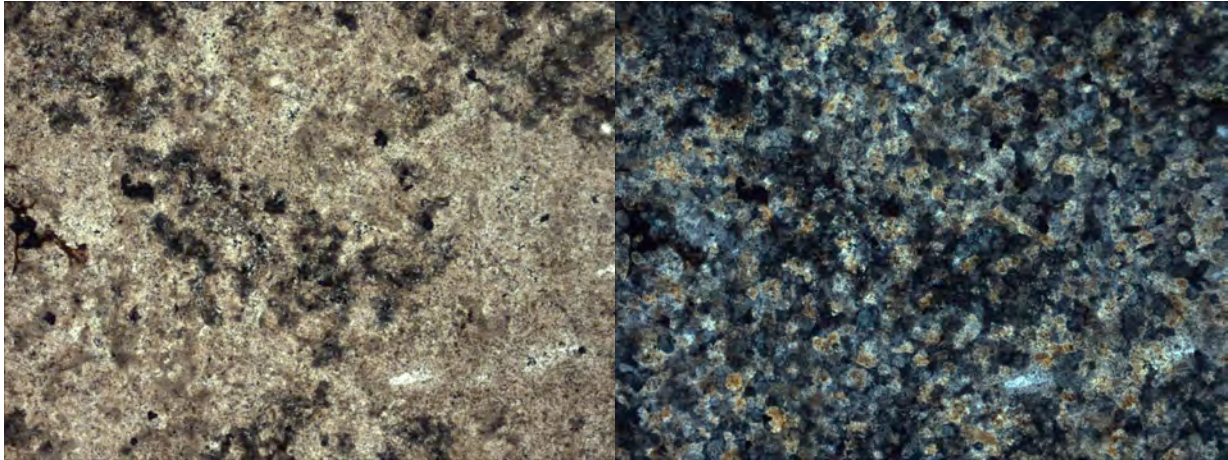
MM 4-20 is a jasper/chert clast composed of highly oxidized red and brown laminated silica that is crosscut with silica filled fractures. Red and brown laminations contain minor amounts of metal oxides.



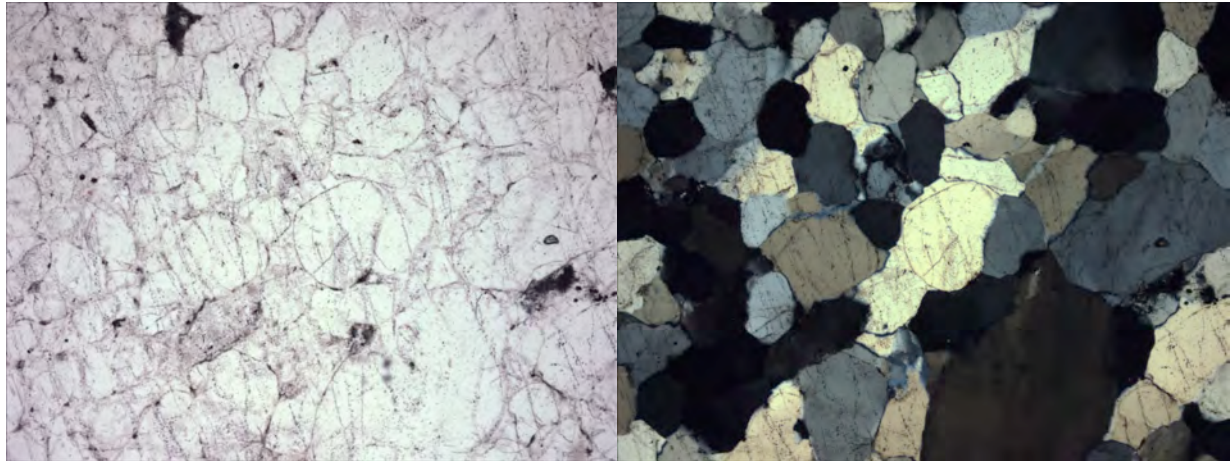
MM 4-22 is a chalcedony clast composed of microcrystalline silica that grows in branching patterns defining concentric bands. The nucleus of this clast was hollowed out, probably during weathering and transport, and filled with medium to very coarse, rounded sand grains. The sand grains are composed of mono- and poly-crystalline quartz, microcline feldspar, muscovite, rock fragments, and zircon. Silica, calcite and iron oxide cements are present between grains.



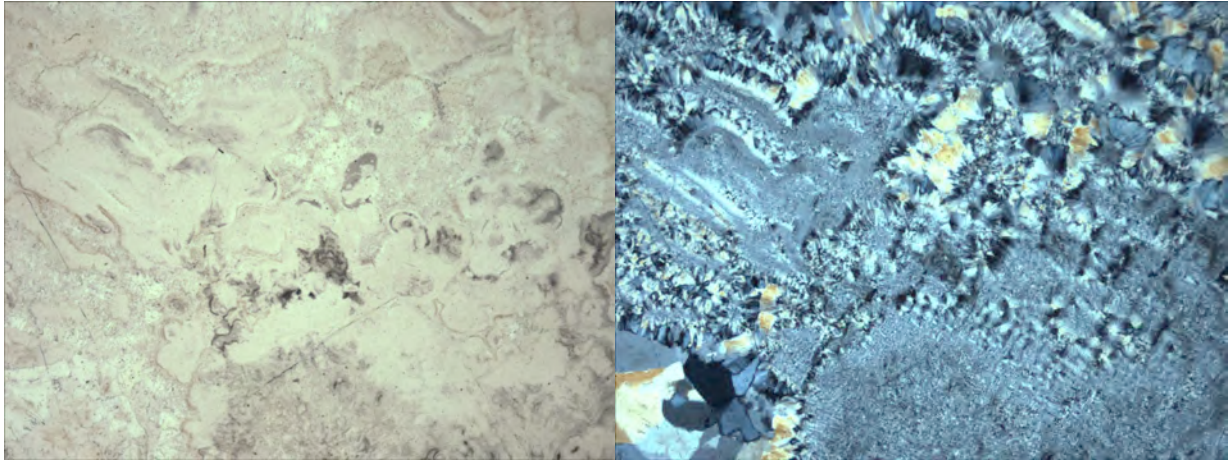
MM 4-23 is a felsic volcanic clast with a devitrified, glassy, groundmass and visible iron staining.



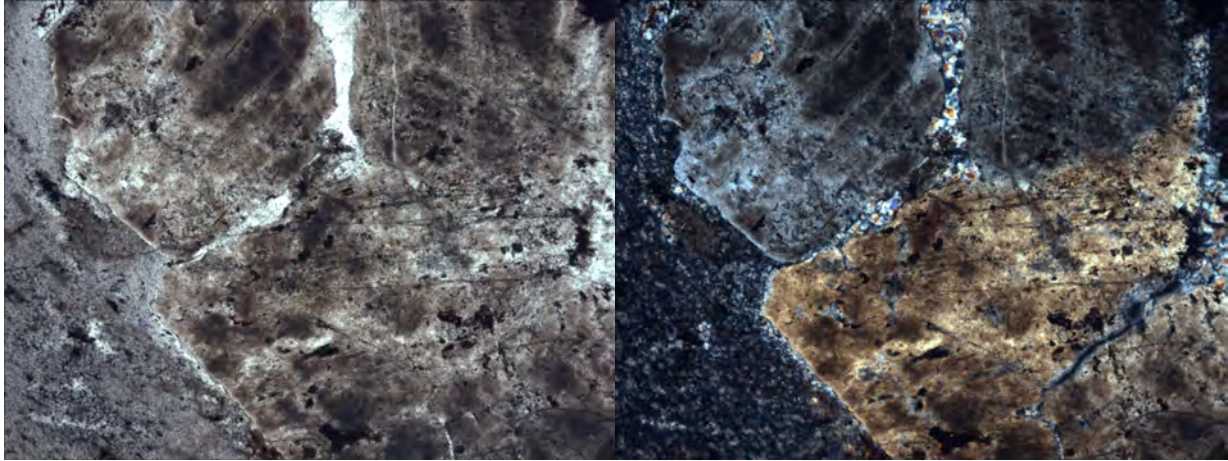
MM 5-28 is an orthoquartzite clast composed entirely of very well rounded, medium grained quartz sand. Individual grains have been annealed, but relict grain boundaries are clearly visible in both plain- and cross-polarized light.



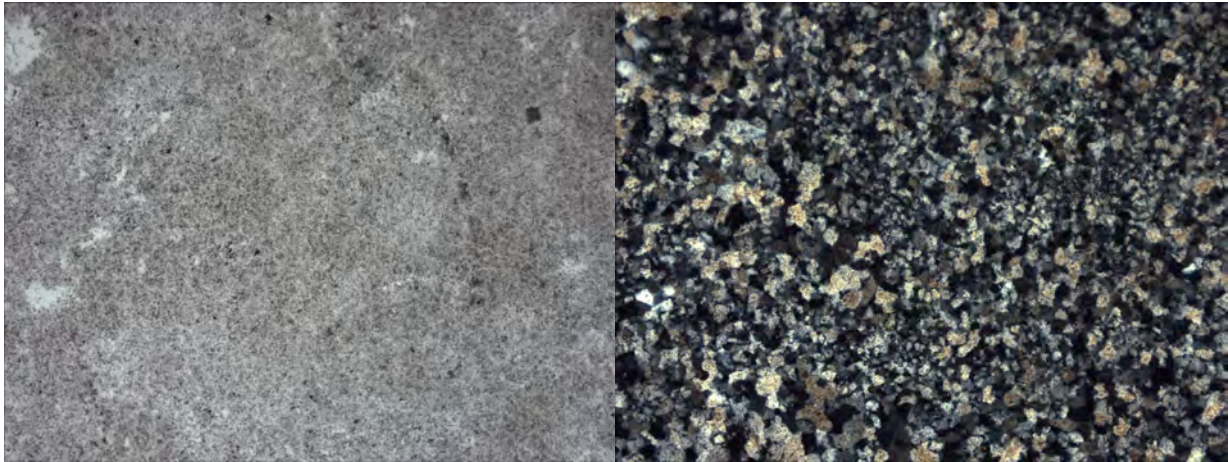
MM 5-46 is a black and white chert clast composed of microcrystalline quartz with areas of competitive silica crystal growth.



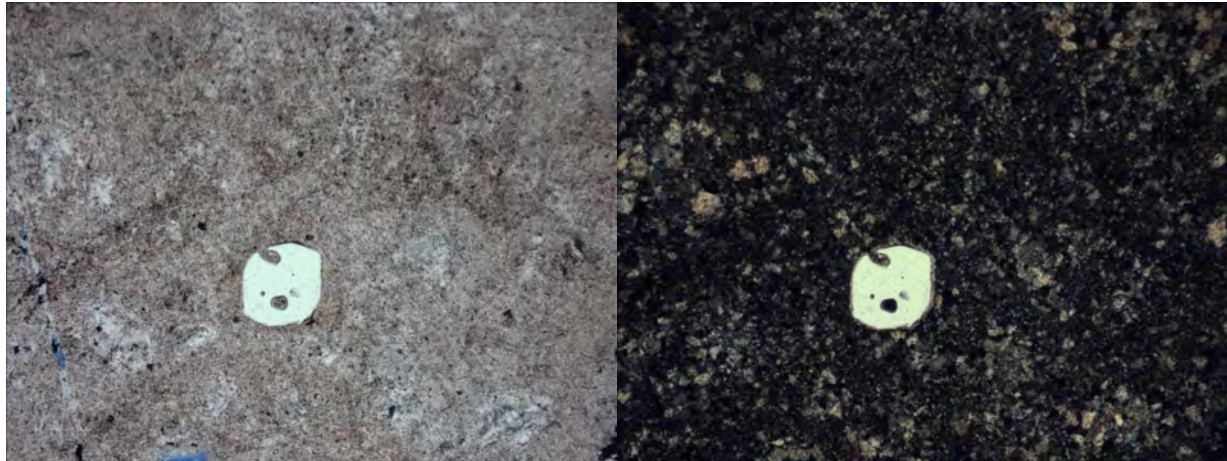
MM 5-52 is a felsic volcanic clast with a fine-grained devitrified, glassy, groundmass and remnant euhedral feldspar phenocrysts. The phenocrysts have a high degree of clay alteration with the exception of a cluster of orthoclase phenocrysts that have not seen the same degree of alteration as other feldspars in the clast.



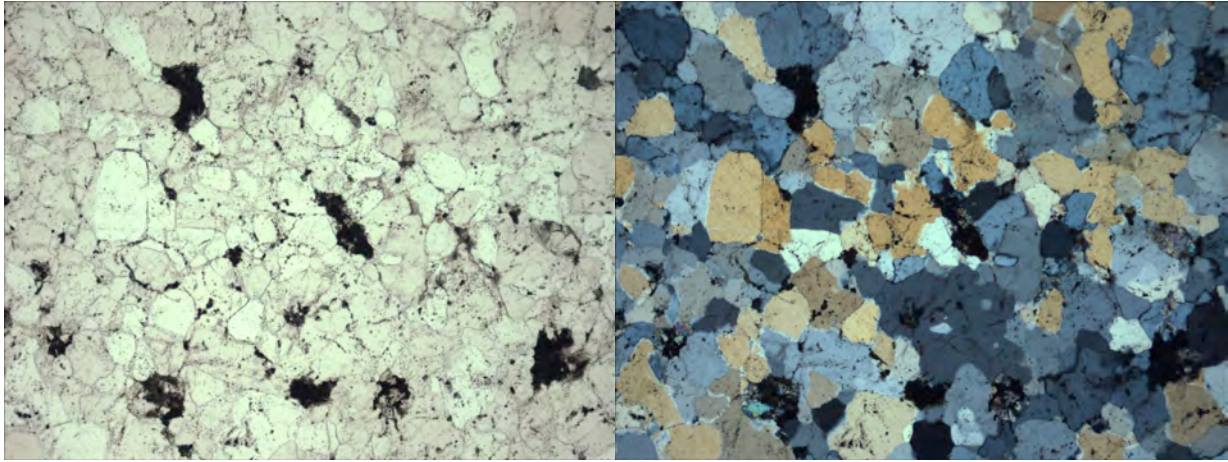
MM 6-2 is a chert clast composed of microcrystalline quartz that has been annealed.



MM 6-23 is a felsic volcanic clast composed of a fine-grained devitrified, quartz, groundmass with phenocrysts of quartz and iron staining. Zircon is present at less than one percent. Euhedral quartz phenocrysts have embayments in them that are characteristic of growth and rapid cooling in a melt.



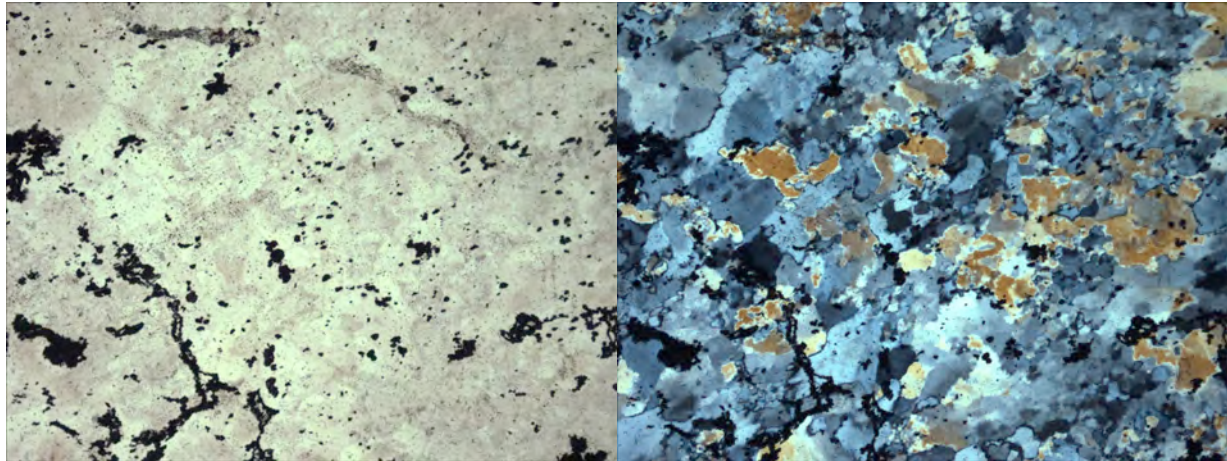
MM 6-48 is an orthoquartzite clast that is composed of 90% quartz, 9% chlorite, and 1% phyllosilicate and zircon. The grains have been annealed.



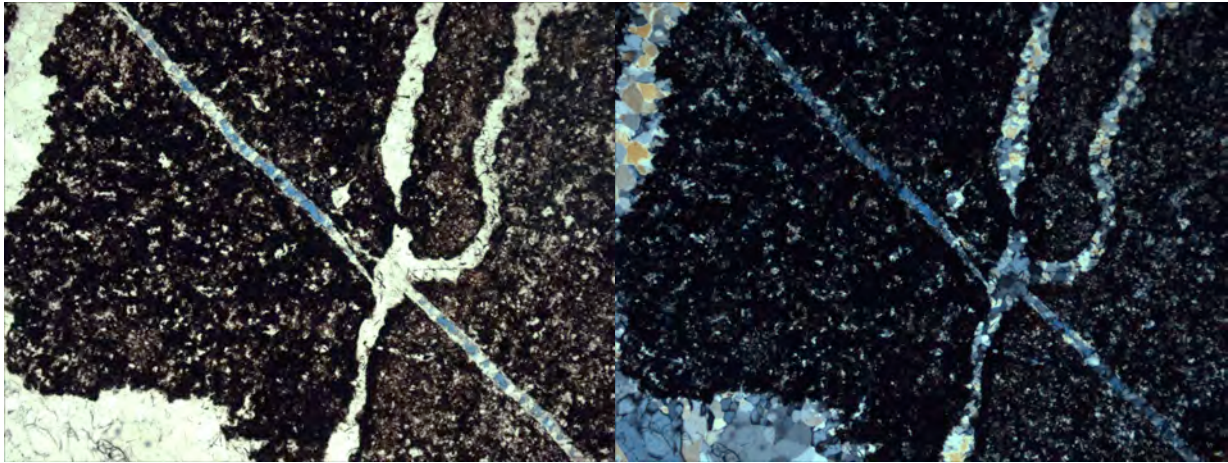
MM 6-55 is a felsic volcanic clast composed of fine-grained devitrified, glassy, groundmass with remnant euhedral feldspar phenocrysts that have been highly altered to clay minerals.



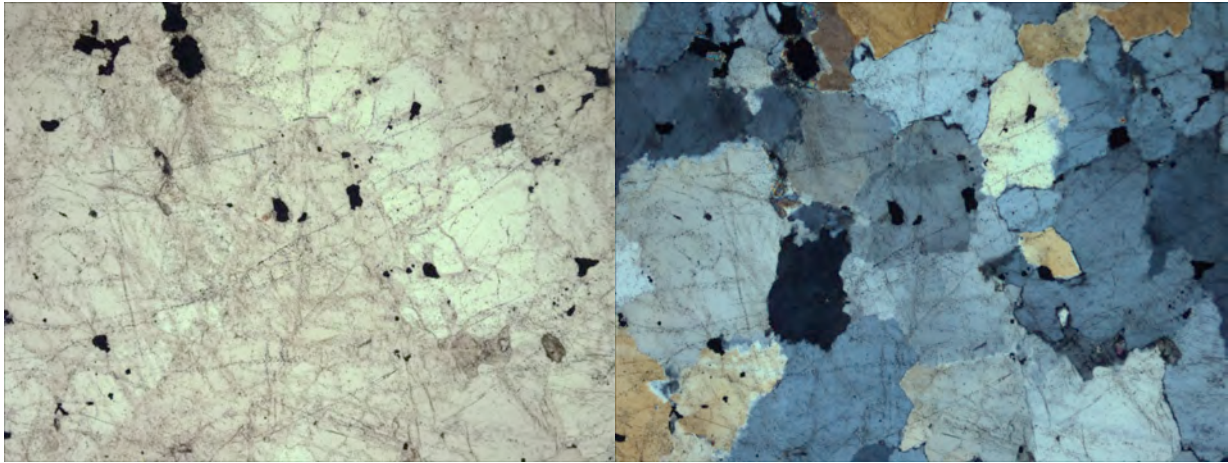
MM 6-59 is a metaquartzite clast composed of very fine-grained quartz with less than 1% of the grains reaching 0.5mm in diameter. Iron oxide cement appears woven into the fabric of the annealed quartz. An undulating extinction throughout the clast indicates that the quartz has undergone some dynamic recrystallization.



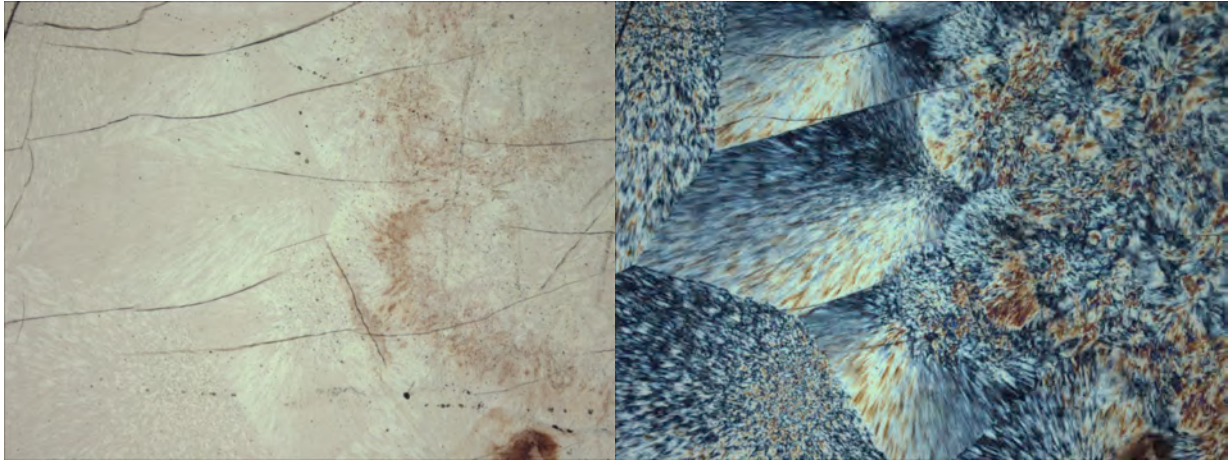
MM 6-63 is a chert clast containing microcrystalline quartz that clearly defines laminations. Individual layers are stained with iron oxide and silica filled fractures are present and look like flame structures.



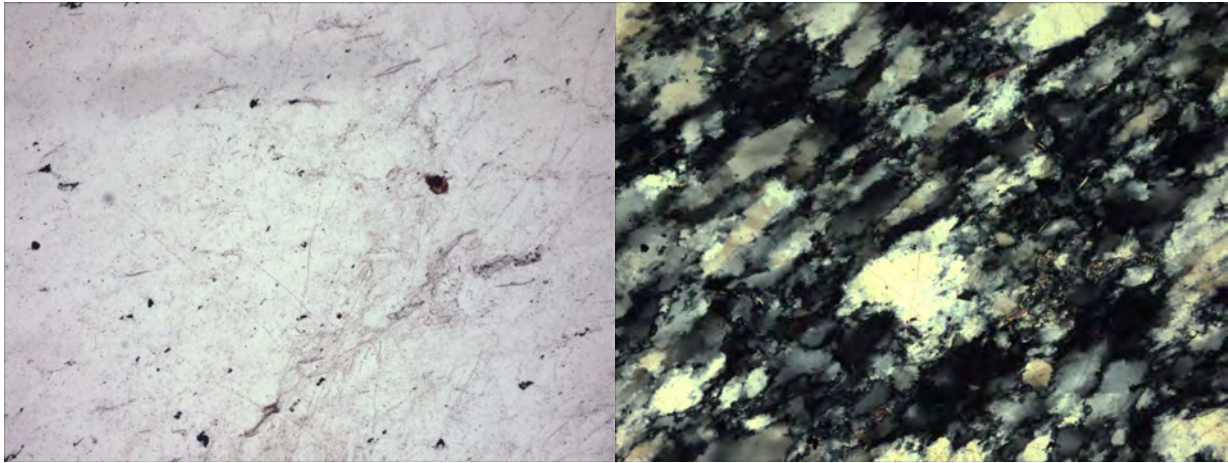
MM 8-7 is a metaquartzite clast composed of 95% quartz and 5% muscovite, chlorite and zircon. The grains within the clast have been annealed and a foliation has developed defined by quartz ribbons.



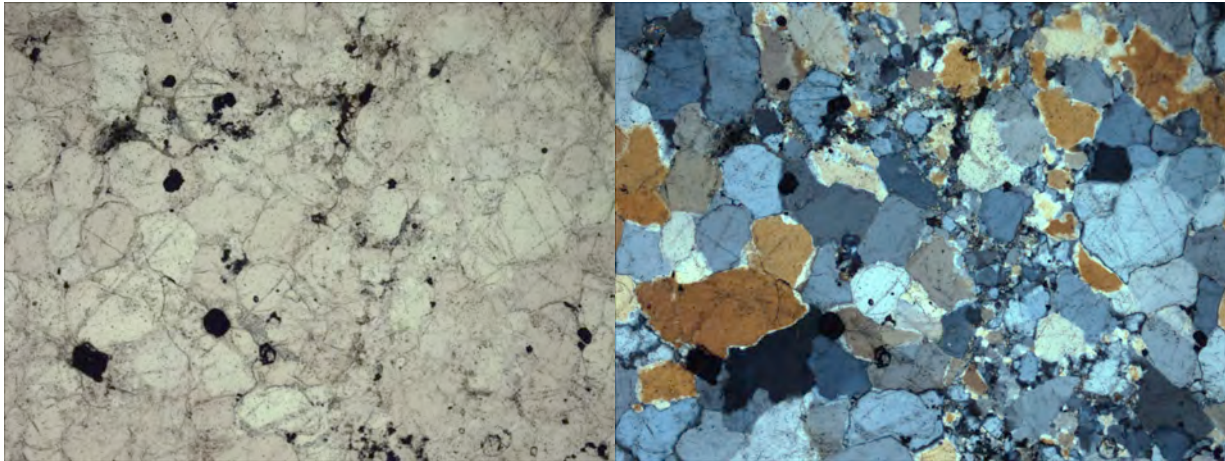
MM 8-24 is a chalcedony clast with bands of branching microcrystalline silica crystal growth defining concentric layers. Iron staining is present in some areas of the clast.



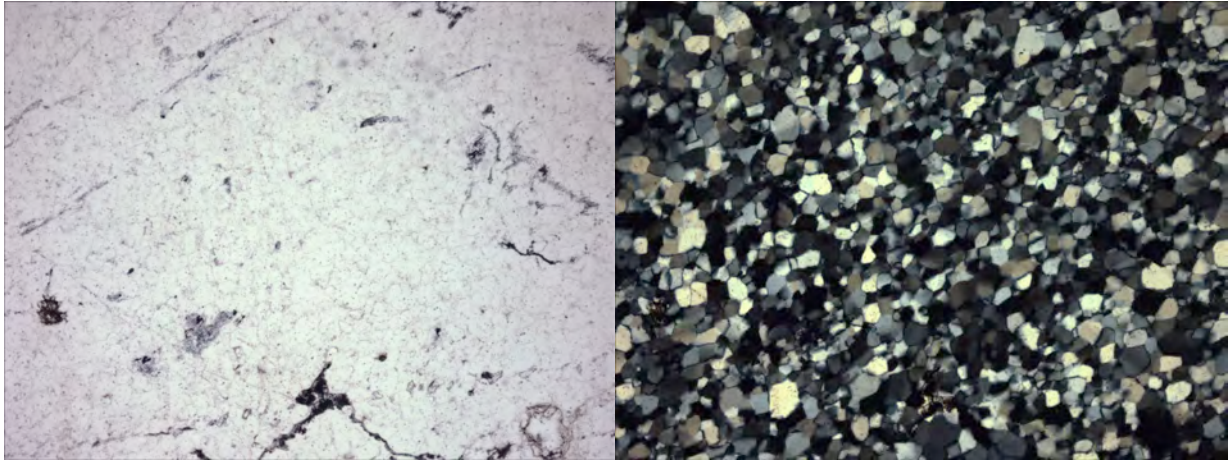
CP 10-42 is a metaquartzite clast that contains a clear fabric defined by quartz ribbons and stringers. The direction of principal strain can be inferred from the orientation of quartz ribbons and muscovite that is present at less than 5%.



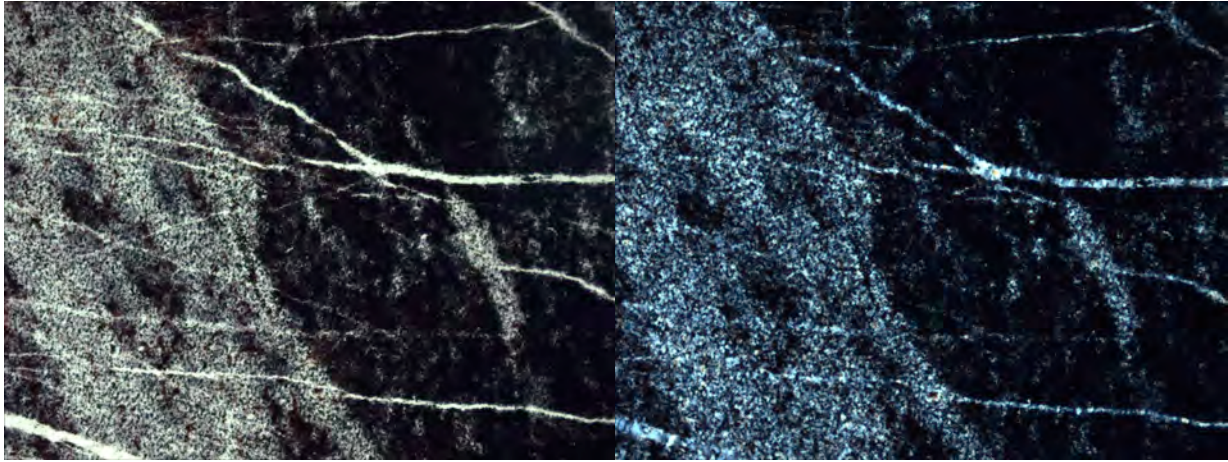
CP 10-80 is an orthoquartzite clast composed of 90% annealed quartz and less than 10% muscovite, microcline feldspar, metal oxides, and zircon. Calcite and iron oxides fill fractures in the clast, whereas silica is present as cement between sand grains.



CP 10-86 is a vein quartz clast composed of polygonal quartz with less than 1% metal oxide. Quartz phenocrysts are homogeneous in size with diameters of $\sim 0.5\text{mm}$.



CP 10-90 is a jasper clast composed of small nuclei of red and brown microcrystalline silica surrounded by more clear silica halos.



Appendix F

In Situ Clast Count Data

In situ clast count data for the middle member of the Wood Canyon Formation in the southern Marble Mountains (MM 5). Identified clast types are vein quartz (vq), chert (c), chalcedony (ca), jasper (j), and unidentifiable clasts (missing).

Clast Type	Long(mm)	Short(mm)	Ratio (l/s)	Phi
c	20	10	2.00	-4.32
ca	20	15	1.33	-4.32
vq	5	5	1.00	-2.32
c	12	5	2.40	-3.58
c	20	10	2.00	-4.32
vq	7	5	1.40	-2.81
vq	25	15	1.67	-4.64
c	10	9	1.11	-3.32
c	22	10	2.20	-4.46
c	6	4	1.50	-2.58
ca	10	6	1.67	-3.32
ca	7	5	1.40	-2.81
vq	14	11	1.27	-3.81
vq	14	13	1.08	-3.81
vq	12	7	1.71	-3.58
vq	17	12	1.42	-4.09
c	9	8	1.13	-3.17
missing	10	8	1.25	-3.32
c	13	12	1.08	-3.70
vq	16	15	1.07	-4.00
vq	11	11	1.00	-3.46
c	11	10	1.10	-3.46
missing	27	19	1.42	-4.75
c	25	10	2.50	-4.64
vq	10	9	1.11	-3.32
c	15	8	1.88	-3.91
vq	25	9	2.78	-4.64
vq	9	5	1.80	-3.17
vq	25	16	1.56	-4.64
vq	10	7	1.43	-3.32
c	23	10	2.30	-4.52
vq	10	9	1.11	-3.32
ca	15	12	1.25	-3.91
c	10	9	1.11	-3.32
ca	16	14	1.14	-4.00
vq	15	12	1.25	-3.91

ca	24	11	2.18	-4.58
vq	19	13	1.46	-4.25
vq	25	20	1.25	-4.64
missing	15	15	1.00	-3.91
vq	10	6	1.67	-3.32
vq	19	12	1.58	-4.25
vq	4	3	1.33	-2.00
ca	16	11	1.45	-4.00
c	16	16	1.00	-4.00
ca	5	3	1.67	-2.32
vq	12	4	3.00	-3.58
vq	19	7	2.71	-4.25
j	14	10	1.40	-3.81
ca	15	10	1.50	-3.91
vq	22	9	2.44	-4.46
vq	15	8	1.88	-3.91
vq	35	22	1.59	-5.13
vq	21	15	1.40	-4.39
vq	20	5	4.00	-4.32
vq	15	15	1.00	-3.91
vq	4	4	1.00	-2.00
vq	17	16	1.06	-4.09
ca	10	5	2.00	-3.32
vq	7	6	1.17	-2.81
missing	19	18	1.06	-4.25
c	19	19	1.00	-4.25
vq	19	10	1.90	-4.25
vq	20	18	1.11	-4.32
ca	10	10	1.00	-3.32
vq	15	4	3.75	-3.91
vq	17	12	1.42	-4.09
c	30	11	2.73	-4.91
c	22	11	2.00	-4.46
vq	28	11	2.55	-4.81
c	15	15	1.00	-3.91
ca	20	4	5.00	-4.32
vq	27	15	1.80	-4.75
vq	25	19	1.32	-4.64
vq	20	9	2.22	-4.32
ca	18	16	1.13	-4.17
vq	16	7	2.29	-4.00
c	9	3	3.00	-3.17
vq	13	9	1.44	-3.70
vq	30	18	1.67	-4.91
c	30	7	4.29	-4.91
missing	15	14	1.07	-3.91

vq	28	7	4.00	-4.81
vq	19	12	1.58	-4.25
c	24	3	8.00	-4.58
ca	25	8	3.13	-4.64
ca	20	19	1.05	-4.32
c	20	18	1.11	-4.32
c	22	17	1.29	-4.46
vq	4	2	2.00	-2.00
ca	23	12	1.92	-4.52
vq	21	18	1.17	-4.39
ca	22	5	4.40	-4.46
vq	19	9	2.11	-4.25
c	28	20	1.40	-4.81
vq	15	10	1.50	-3.91
vq	22	19	1.16	-4.46
vq	10	7	1.43	-3.32
ca	26	17	1.53	-4.70
vq	23	18	1.28	-4.52
vq	20	10	2.00	-4.32
vq	32	25	1.28	-5.00
ca	20	17	1.18	-4.32
vq	15	10	1.50	-3.91
vq	28	21	1.33	-4.81
vq	19	15	1.27	-4.25
vq	33	9	3.67	-5.04
vq	23	15	1.53	-4.52
vq	30	19	1.58	-4.91
c	12	10	1.20	-3.58
c	10	9	1.11	-3.32
c	12	3	4.00	-3.58
vq	10	2	5.00	-3.32
ca	15	12	1.25	-3.91
c	15	10	1.50	-3.91
vq	25	22	1.14	-4.64
vq	77	23	3.35	-6.27
ca	20	15	1.33	-4.32
vq	15	10	1.50	-3.91
vq	5	2	2.50	-2.32
vq	8	5	1.60	-3.00
c	19	10	1.90	-4.25
vq	19	16	1.19	-4.25
ca	25	15	1.67	-4.64
ca	15	5	3.00	-3.91
vq	55	25	2.20	-5.78
vq	13	9	1.44	-3.70
vq	10	6	1.67	-3.32

ca	10	5	2.00	-3.32
ca	28	8	3.50	-4.81
c	10	9	1.11	-3.32
c	22	11	2.00	-4.46
vq	32	7	4.57	-5.00
vq	24	16	1.50	-4.58
missing	10	8	1.25	-3.32
vq	13	7	1.86	-3.70
vq	25	6	4.17	-4.64
vq	11	9	1.22	-3.46
vq	8	3	2.67	-3.00
c	16	10	1.60	-4.00
vq	8	5	1.60	-3.00
ca	15	11	1.36	-3.91
vq	12	11	1.09	-3.58
vq	24	20	1.20	-4.58
vq	22	17	1.29	-4.46
missing	12	10	1.20	-3.58
vq	26	22	1.18	-4.70
c	12	8	1.50	-3.58
vq	15	12	1.25	-3.91
vq	25	9	2.78	-4.64
vq	15	10	1.50	-3.91
vq	45	24	1.88	-5.49
vq	15	13	1.15	-3.91
vq	15	12	1.25	-3.91
vq	30	14	2.14	-4.91
c	22	11	2.00	-4.46
vq	3	2	1.50	-1.58
missing	15	10	1.50	-3.91
ca	5	4	1.25	-2.32
ca	15	14	1.07	-3.91
c	16	10	1.60	-4.00
vq	11	6	1.83	-3.46
c	20	15	1.33	-4.32
vq	18	10	1.80	-4.17
ca	10	7	1.43	-3.32
ca	22	7	3.14	-4.46
c	15	12	1.25	-3.91
vq	39	22	1.77	-5.29
c	15	4	3.75	-3.91
c	8	6	1.33	-3.00
c	15	5	3.00	-3.91
vq	15	15	1.00	-3.91
ca	25	10	2.50	-4.64
vq	25	10	2.50	-4.64

vq	20	20	1.00	-4.32
vq	22	13	1.69	-4.46
ca	10	10	1.00	-3.32
vq	16	9	1.78	-4.00
c	15	10	1.50	-3.91
ca	15	14	1.07	-3.91
vq	11	10	1.10	-3.46
ca	24	6	4.00	-4.58
ca	13	13	1.00	-3.70
ca	15	11	1.36	-3.91
vq	5	4	1.25	-2.32
ca	18	9	2.00	-4.17
vq	25	21	1.19	-4.64
ca	16	14	1.14	-4.00
vq	15	15	1.00	-3.91
vq	8	6	1.33	-3.00
vq	12	8	1.50	-3.58
vq	23	18	1.28	-4.52
ca	25	24	1.04	-4.64

In situ clast count data for the middle member of the Wood Canyon Formation in the Southern Marble Mountains (MM 9). Identified clast types are vein quartz (vq), chert (c), chalcedony (ca), jasper (j), and unidentifiable clasts (missing).

Clast Type	Long(mm)	Short(mm)	Ratio (l/s)	Phi
c	11	9	1.22	-3.46
c	14	9	1.56	-3.81
ca	16	5	3.20	-4.00
vq	12	10	1.20	-3.58
vq	20	5	4.00	-4.32
missing	17	14	1.21	-4.09
ca	18	10	1.80	-4.17
vq	10	7	1.43	-3.32
ca	13	10	1.30	-3.70
ca	17	10	1.70	-4.09
ca	7	4	1.75	-2.81
vq	10	9	1.11	-3.32
ca	14	6	2.33	-3.81
ca	26	10	2.60	-4.70
j	20	13	1.54	-4.32
vq	13	10	1.30	-3.70
vq	20	18	1.11	-4.32
ca	20	5	4.00	-4.32
vq	5	5	1.00	-2.32
c	12	7	1.71	-3.58
vq	25	5	5.00	-4.64
vq	17	9	1.89	-4.09
c	9	6	1.50	-3.17
ca	22	17	1.29	-4.46
c	15	13	1.15	-3.91
ca	21	6	3.50	-4.39
vq	10	8	1.25	-3.32
missing	15	11	1.36	-3.91
c	17	8	2.13	-4.09
c	19	16	1.19	-4.25
vq	7	6	1.17	-2.81
vq	10	9	1.11	-3.32
vq	12	9	1.33	-3.58
ca	11	9	1.22	-3.46
ca	23	12	1.92	-4.52
vq	15	6	2.50	-3.91
ca	21	15	1.40	-4.39
vq	9	6	1.50	-3.17
ca	12	12	1.00	-3.58
vq	15	12	1.25	-3.91

vq	3	2	1.50	-1.58
c	15	8	1.88	-3.91
vq	14	6	2.33	-3.81
ca	25	10	2.50	-4.64
ca	10	10	1.00	-3.32
c	16	9	1.78	-4.00
j	20	7	2.86	-4.32
j	12	11	1.09	-3.58
ca	19	11	1.73	-4.25
c	21	11	1.91	-4.39
ca	20	10	2.00	-4.32
c	15	4	3.75	-3.91
vq	4	2	2.00	-2.00
vq	27	14	1.93	-4.75
vq	18	12	1.50	-4.17
ca	10	6	1.67	-3.32
ca	26	15	1.73	-4.70
vq	14	14	1.00	-3.81
c	10	9	1.11	-3.32
c	25	7	3.57	-4.64
vq	24	15	1.60	-4.58
vq	8	7	1.14	-3.00
ca	6	5	1.20	-2.58
vq	6	4	1.50	-2.58
vq	16	7	2.29	-4.00
c	17	10	1.70	-4.09
c	14	8	1.75	-3.81
c	9	5	1.80	-3.17
vq	8	7	1.14	-3.00
vq	5	5	1.00	-2.32
c	18	4	4.50	-4.17
ca	14	11	1.27	-3.81
ca	14	6	2.33	-3.81
c	18	12	1.50	-4.17
missing	20	15	1.33	-4.32
ca	15	7	2.14	-3.91
vq	24	4	6.00	-4.58
vq	15	12	1.25	-3.91
vq	23	21	1.10	-4.52
ca	21	9	2.33	-4.39
ca	37	9	4.11	-5.21
vq	10	7	1.43	-3.32
ca	16	8	2.00	-4.00
c	15	9	1.67	-3.91
vq	11	11	1.00	-3.46
c	23	10	2.30	-4.52

missing	15	15	1.00	-3.91
vq	21	15	1.40	-4.39
vq	13	11	1.18	-3.70
j	10	8	1.25	-3.32
vq	21	12	1.75	-4.39
ca	27	16	1.69	-4.75
vq	23	15	1.53	-4.52
vq	23	22	1.05	-4.52
vq	20	11	1.82	-4.32
vq	18	9	2.00	-4.17
vq	14	5	2.80	-3.81
ca	8	6	1.33	-3.00
vq	17	12	1.42	-4.09
vq	10	9	1.11	-3.32
ca	17	8	2.13	-4.09
vq	35	15	2.33	-5.13
ca	21	10	2.10	-4.39
ca	14	13	1.08	-3.81
c	26	10	2.60	-4.70
ca	15	10	1.50	-3.91
ca	17	11	1.55	-4.09
c	15	10	1.50	-3.91
vq	8	5	1.60	-3.00
vq	6	2	3.00	-2.58
c	15	9	1.67	-3.91
vq	16	7	2.29	-4.00
vq	21	20	1.05	-4.39
j	18	16	1.13	-4.17
j	30	8	3.75	-4.91
vq	16	10	1.60	-4.00
vq	10	7	1.43	-3.32
vq	11	8	1.38	-3.46
c	9	5	1.80	-3.17
vq	22	14	1.57	-4.46
vq	6	6	1.00	-2.58
ca	15	12	1.25	-3.91
ca	18	10	1.80	-4.17
ca	15	12	1.25	-3.91
vq	17	17	1.00	-4.09
vq	10	7	1.43	-3.32
c	23	14	1.64	-4.52
vq	20	17	1.18	-4.32
ca	19	18	1.06	-4.25
c	19	9	2.11	-4.25
vq	4	4	1.00	-2.00
vq	16	7	2.29	-4.00

ca	12	11	1.09	-3.58
c	15	9	1.67	-3.91
ca	27	9	3.00	-4.75
j	19	17	1.12	-4.25
vq	16	14	1.14	-4.00
j	16	4	4.00	-4.00
c	10	4	2.50	-3.32
vq	10	5	2.00	-3.32
ca	32	9	3.56	-5.00
vq	17	16	1.06	-4.09
vq	10	6	1.67	-3.32
vq	11	9	1.22	-3.46
j	13	6	2.17	-3.70
vq	18	17	1.06	-4.17

In situ clast count data for the middle member of the Wood Canyon Formation in the Kingston Range (KR 2). Identified clast types are vein quartz (vq), quartzite (qz), chert (c), chalcedony (ca), jasper (j), and unidentifiable clasts (missing).

Clast Type	Long(mm)	Short(mm)	Ratio (l/s)	Phi
vq	20	16	1.25	-4.32
vq	9	6	1.50	-3.17
vq	20	8	2.50	-4.32
vq	6	5	1.20	-2.58
vq	11	9	1.22	-3.46
qz	20	12	1.67	-4.32
vq	23	15	1.53	-4.52
vq	4	3	1.33	-2.00
vq	32	14	2.29	-5.00
vq	21	13	1.62	-4.39
vq	19	12	1.58	-4.25
vq	15	8	1.88	-3.91
qz	24	18	1.33	-4.58
qz	20	17	1.18	-4.32
qz	35	20	1.75	-5.13
vq	25	20	1.25	-4.64
qz	36	23	1.57	-5.17
qz	25	17	1.47	-4.64
qz	25	15	1.67	-4.64
vq	18	11	1.64	-4.17
vq	18	10	1.80	-4.17
vq	30	16	1.88	-4.91
vq	6	4	1.50	-2.58
vq	5	4	1.25	-2.32
vq	17	14	1.21	-4.09
qz	10	8	1.25	-3.32
qz	6	5	1.20	-2.58
qz	15	8	1.88	-3.91
vq	18	9	2.00	-4.17
vq	37	15	2.47	-5.21
qz	19	14	1.36	-4.25
qz	19	10	1.90	-4.25
qz	19	15	1.27	-4.25
vq	13	12	1.08	-3.70
vq	16	12	1.33	-4.00
vq	26	19	1.37	-4.70
qz	15	9	1.67	-3.91
qz	16	10	1.60	-4.00
vq	15	12	1.25	-3.91
qz	10	9	1.11	-3.32
vq	19	15	1.27	-4.25

vq	20	15	1.33	-4.32
vq	17	12	1.42	-4.09
qz	34	22	1.55	-5.09
vq	18	12	1.50	-4.17
vq	7	5	1.40	-2.81
vq	10	5	2.00	-3.32
vq	20	11	1.82	-4.32
vq	27	25	1.08	-4.75
vq	13	10	1.30	-3.70
qz	15	9	1.67	-3.91
qz	7	4	1.75	-2.81
qz	5	5	1.00	-2.32
missing	24	10	2.40	-4.58
vq	18	15	1.20	-4.17
vq	10	4	2.50	-3.32
vq	20	14	1.43	-4.32
qz	4	3	1.33	-2.00
qz	6	5	1.20	-2.58
vq	12	5	2.40	-3.58
qz	23	11	2.09	-4.52
qz	44	15	2.93	-5.46
vq	11	8	1.38	-3.46
vq	20	12	1.67	-4.32
qz	7	4	1.75	-2.81
vq	10	6	1.67	-3.32
qz	10	6	1.67	-3.32
qz	9	6	1.50	-3.17
vq	13	9	1.44	-3.70
qz	8	6	1.33	-3.00
qz	10	7	1.43	-3.32
qz	23	19	1.21	-4.52
ca	17	11	1.55	-4.09
qz	4	3	1.33	-2.00
qz	5	4	1.25	-2.32
vq	3	2	1.50	-1.58
vq	8	7	1.14	-3.00
qz	10	5	2.00	-3.32
vq	20	10	2.00	-4.32
vq	10	8	1.25	-3.32
qz	28	17	1.65	-4.81
vq	4	4	1.00	-2.00
qz	20	12	1.67	-4.32
vq	16	12	1.33	-4.00
qz	20	8	2.50	-4.32
qz	17	12	1.42	-4.09
vq	30	15	2.00	-4.91

vq	19	8	2.38	-4.25
vq	6	5	1.20	-2.58
c	17	17	1.00	-4.09
qz	30	15	2.00	-4.91
ca	13	10	1.30	-3.70
qz	23	18	1.28	-4.52
qz	31	17	1.82	-4.95
vq	15	9	1.67	-3.91
vq	22	16	1.38	-4.46
vq	25	18	1.39	-4.64
vq	32	15	2.13	-5.00
vq	20	10	2.00	-4.32
vq	25	15	1.67	-4.64
vq	26	15	1.73	-4.70
qz	5	3	1.67	-2.32
qz	37	20	1.85	-5.21
qz	9	5	1.80	-3.17
vq	10	6	1.67	-3.32
qz	16	11	1.45	-4.00
vq	39	24	1.63	-5.29
vq	22	13	1.69	-4.46
vq	5	4	1.25	-2.32
qz	4	3	1.33	-2.00
vq	18	12	1.50	-4.17
vq	25	15	1.67	-4.64
c	16	14	1.14	-4.00
vq	12	11	1.09	-3.58
qz	10	6	1.67	-3.32
vq	10	7	1.43	-3.32
qz	5	2	2.50	-2.32
vq	16	15	1.07	-4.00
vq	8	6	1.33	-3.00
qz	22	15	1.47	-4.46
vq	8	7	1.14	-3.00
vq	16	12	1.33	-4.00
vq	15	9	1.67	-3.91
vq	4	3	1.33	-2.00
qz	6	5	1.20	-2.58
qz	19	10	1.90	-4.25
vq	16	9	1.78	-4.00
vq	16	7	2.29	-4.00
vq	20	15	1.33	-4.32
qz	6	4	1.50	-2.58
qz	11	9	1.22	-3.46
vq	6	5	1.20	-2.58
vq	13	7	1.86	-3.70

qz	9	4	2.25	-3.17
qz	8	8	1.00	-3.00
vq	4	4	1.00	-2.00
vq	24	13	1.85	-4.58
vq	10	8	1.25	-3.32
vq	12	6	2.00	-3.58
qz	7	3	2.33	-2.81
vq	21	15	1.40	-4.39
vq	13	12	1.08	-3.70
qz	4	2	2.00	-2.00
qz	16	12	1.33	-4.00
vq	16	8	2.00	-4.00
vq	8	7	1.14	-3.00
qz	16	5	3.20	-4.00
qz	10	7	1.43	-3.32
vq	11	6	1.83	-3.46
vq	20	13	1.54	-4.32
vq	27	22	1.23	-4.75
qz	42	22	1.91	-5.39
vq	14	7	2.00	-3.81
qz	5	4	1.25	-2.32
vq	23	18	1.28	-4.52
qz	20	14	1.43	-4.32
c	13	13	1.00	-3.70
qz	17	13	1.31	-4.09
vq	7	5	1.40	-2.81
vq	18	16	1.13	-4.17
vq	25	14	1.79	-4.64
vq	20	10	2.00	-4.32
vq	15	12	1.25	-3.91
vq	5	4	1.25	-2.32
vq	20	16	1.25	-4.32
vq	30	16	1.88	-4.91
vq	16	15	1.07	-4.00
qz	15	9	1.67	-3.91
qz	25	17	1.47	-4.64
qz	15	11	1.36	-3.91
qz	6	5	1.20	-2.58
qz	19	15	1.27	-4.25
qz	39	25	1.56	-5.29
vq	44	36	1.22	-5.46
qz	13	8	1.63	-3.70
vq	31	17	1.82	-4.95
qz	25	16	1.56	-4.64
qz	31	27	1.15	-4.95
vq	31	22	1.41	-4.95

qz	10	6	1.67	-3.32
qz	17	7	2.43	-4.09
vq	12	7	1.71	-3.58
qz	19	19	1.00	-4.25
qz	56	34	1.65	-5.81
qz	24	18	1.33	-4.58
qz	22	19	1.16	-4.46
qz	10	10	1.00	-3.32
qz	15	12	1.25	-3.91
vq	5	4	1.25	-2.32
qz	10	9	1.11	-3.32
vq	15	12	1.25	-3.91
vq	5	4	1.25	-2.32
ca	24	14	1.71	-4.58
qz	27	17	1.59	-4.75
vq	13	9	1.44	-3.70
vq	24	12	2.00	-4.58
missing	42	16	2.63	-5.39
vq	20	15	1.33	-4.32
vq	13	12	1.08	-3.70
qz	15	11	1.36	-3.91
c	29	17	1.71	-4.86
vq	6	5	1.20	-2.58
qz	15	10	1.50	-3.91
qz	19	6	3.17	-4.25
qz	30	20	1.50	-4.91
qz	9	5	1.80	-3.17
vq	35	21	1.67	-5.13
qz	20	13	1.54	-4.32
qz	12	8	1.50	-3.58
vq	6	4	1.50	-2.58
vq	21	14	1.50	-4.39
vq	5	4	1.25	-2.32
qz	10	6	1.67	-3.32
vq	11	9	1.22	-3.46
qz	25	15	1.67	-4.64
qz	20	11	1.82	-4.32
vq	22	15	1.47	-4.46
qz	19	15	1.27	-4.25
qz	25	15	1.67	-4.64
qz	8	4	2.00	-3.00
qz	17	11	1.55	-4.09
qz	20	10	2.00	-4.32
vq	17	12	1.42	-4.09
vq	5	5	1.00	-2.32
vq	25	16	1.56	-4.64

qz	5	4	1.25	-2.32
vq	11	9	1.22	-3.46
qz	15	13	1.15	-3.91
qz	25	22	1.14	-4.64
vq	25	18	1.39	-4.64
vq	13	8	1.63	-3.70
qz	12	5	2.40	-3.58
qz	7	6	1.17	-2.81
qz	23	10	2.30	-4.52
qz	30	22	1.36	-4.91
qz	15	8	1.88	-3.91
vq	22	10	2.20	-4.46
qz	11	7	1.57	-3.46
vq	4	3	1.33	-2.00
qz	16	11	1.45	-4.00
qz	20	11	1.82	-4.32
vq	8	4	2.00	-3.00
qz	13	8	1.63	-3.70
c	35	15	2.33	-5.13
vq	16	12	1.33	-4.00
missing	22	15	1.47	-4.46
vq	26	19	1.37	-4.70
qz	33	18	1.83	-5.04
qz	12	11	1.09	-3.58
j	30	11	2.73	-4.91

In situ clast count data for the middle member of the Wood Canyon Formation in the southern Nopah Range at Tule Spring (TS 1). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), and unidentifiable clasts (missing).

Clast Type	Long(mm)	Short(mm)	Ratio (l/s)	Phi
qtz	12	7	1.71	-3.58
qtz	7	7	1.00	-2.81
qtz	14	9	1.56	-3.81
qtz	15	6	2.50	-3.91
qtz	15	10	1.50	-3.91
c	20	12	1.67	-4.32
qtz	18	13	1.38	-4.17
qtz	11	10	1.10	-3.46
c	8	5	1.60	-3.00
ca	20	15	1.33	-4.32
qtz	12	10	1.20	-3.58
vq	12	9	1.33	-3.58
vq	14	11	1.27	-3.81
qtz	12	6	2.00	-3.58
vq	13	6	2.17	-3.70
qtz	11	9	1.22	-3.46
qtz	16	11	1.45	-4.00
qtz	20	16	1.25	-4.32
qtz	15	9	1.67	-3.91
qtz	16	14	1.14	-4.00
qtz	16	15	1.07	-4.00
qtz	16	9	1.78	-4.00
qtz	19	12	1.58	-4.25
qtz	14	10	1.40	-3.81
qtz	12	9	1.33	-3.58
qtz	11	8	1.38	-3.46
ca	8	5	1.60	-3.00
vq	13	11	1.18	-3.70
qtz	15	10	1.50	-3.91
qtz	13	9	1.44	-3.70
qtz	11	5	2.20	-3.46
qtz	10	7	1.43	-3.32
qtz	20	12	1.67	-4.32
qtz	11	5	2.20	-3.46
qtz	12	9	1.33	-3.58
ca	17	12	1.42	-4.09
qtz	15	10	1.50	-3.91
qtz	9	7	1.29	-3.17
qtz	11	5	2.20	-3.46
qtz	17	11	1.55	-4.09
qtz	13	8	1.63	-3.70

qtz	11	5	2.20	-3.46
qtz	15	10	1.50	-3.91
qtz	20	5	4.00	-4.32
qtz	12	7	1.71	-3.58
ca	12	12	1.00	-3.58
qtz	8	6	1.33	-3.00
vq	12	9	1.33	-3.58
ca	9	6	1.50	-3.17
qtz	8	4	2.00	-3.00
ca	10	5	2.00	-3.32
qtz	14	9	1.56	-3.81
qtz	14	7	2.00	-3.81
qtz	10	7	1.43	-3.32
qtz	11	11	1.00	-3.46
qtz	10	5	2.00	-3.32
qtz	15	13	1.15	-3.91
qtz	12	8	1.50	-3.58
qtz	9	4	2.25	-3.17
c	12	8	1.50	-3.58
c	18	15	1.20	-4.17
ca	13	9	1.44	-3.70
qtz	14	11	1.27	-3.81
qtz	15	10	1.50	-3.91
qtz	11	6	1.83	-3.46
qtz	16	11	1.45	-4.00
qtz	11	7	1.57	-3.46
ca	16	7	2.29	-4.00
qtz	11	5	2.20	-3.46
qtz	10	9	1.11	-3.32
qtz	10	6	1.67	-3.32
qtz	11	5	2.20	-3.46
ca	15	10	1.50	-3.91
qtz	11	6	1.83	-3.46
qtz	15	9	1.67	-3.91
qtz	17	6	2.83	-4.09
vq	14	9	1.56	-3.81
vq	7	6	1.17	-2.81
c	19	9	2.11	-4.25
qtz	17	9	1.89	-4.09
vq	11	8	1.38	-3.46
qtz	10	10	1.00	-3.32
qtz	14	8	1.75	-3.81
qtz	11	8	1.38	-3.46
qtz	10	10	1.00	-3.32
qtz	15	15	1.00	-3.91
ca	12	7	1.71	-3.58

vq	10	5	2.00	-3.32
qtz	16	8	2.00	-4.00
ca	15	11	1.36	-3.91
vq	15	10	1.50	-3.91
qtz	19	10	1.90	-4.25
c	17	10	1.70	-4.09
qtz	15	9	1.67	-3.91
qtz	17	8	2.13	-4.09
vq	10	5	2.00	-3.32
qtz	15	7	2.14	-3.91
ca	12	10	1.20	-3.58
qtz	12	8	1.50	-3.58
qtz	11	9	1.22	-3.46

In situ clast count data for the middle member of the Wood Canyon Formation in the northern Nopah Range at Chicago Pass (CP 10). Identified clast types are vein quartz (vq), chert (c), chalcedony (ca), jasper (j), and unidentifiable clasts (missing).

Clast Type	Long(mm)	Short(mm)	Ratio (l/s)	Phi
vq	10	5	2.00	-3.32
vq	7	4	1.75	-2.81
vq	10	7	1.43	-3.32
c	17	10	1.70	-4.09
vq	9	5	1.80	-3.17
vq	7	4	1.75	-2.81
vq	10	5	2.00	-3.32
vq	9	9	1.00	-3.17
vq	5	3	1.67	-2.32
vq	11	10	1.10	-3.46
vq	5	3	1.67	-2.32
vq	9	5	1.80	-3.17
vq	8	7	1.14	-3.00
vq	2	2	1.00	-1.00
vq	9	4	2.25	-3.17
vq	5	3	1.67	-2.32
vq	5	4	1.25	-2.32
vq	5	3	1.67	-2.32
vq	8	4	2.00	-3.00
ca	12	7	1.71	-3.58
vq	6	5	1.20	-2.58
vq	20	10	2.00	-4.32
vq	7	6	1.17	-2.81
vq	10	6	1.67	-3.32
ca	18	8	2.25	-4.17
vq	9	5	1.80	-3.17
vq	6	4	1.50	-2.58
vq	3	2	1.50	-1.58
vq	4	3	1.33	-2.00
vq	10	8	1.25	-3.32
vq	5	3	1.67	-2.32
vq	4	3	1.33	-2.00
vq	2	2	1.00	-1.00
vq	2	2	1.00	-1.00
vq	4	3	1.33	-2.00
vq	12	9	1.33	-3.58
ca	10	9	1.11	-3.32
j	5	3	1.67	-2.32
vq	10	5	2.00	-3.32
c	8	3	2.67	-3.00

vq	5	3	1.67	-2.32
vq	9	6	1.50	-3.17
vq	7	3	2.33	-2.81
h	7	4	1.75	-2.81
vq	5	5	1.00	-2.32
c	6	4	1.50	-2.58
vq	5	3	1.67	-2.32
vq	3	2	1.50	-1.58
vq	13	7	1.86	-3.70
ca	10	5	2.00	-3.32
vq	10	6	1.67	-3.32
vq	5	4	1.25	-2.32
ca	5	4	1.25	-2.32
vq	17	7	2.43	-4.09
j	5	5	1.00	-2.32
vq	4	3	1.33	-2.00
vq	10	5	2.00	-3.32
vq	15	5	3.00	-3.91
vq	6	6	1.00	-2.58
c	7	6	1.17	-2.81
vq	10	7	1.43	-3.32
vq	10	10	1.00	-3.32
ca	2	2	1.00	-1.00
ca	4	3	1.33	-2.00
vq	7	5	1.40	-2.81
vq	5	4	1.25	-2.32
vq	7	5	1.40	-2.81
vq	10	6	1.67	-3.32
vq	5	4	1.25	-2.32
ca	7	5	1.40	-2.81
vq	5	5	1.00	-2.32
j	5	4	1.25	-2.32
vq	5	3	1.67	-2.32
vq	4	2	2.00	-2.00
vq	3	2	1.50	-1.58
j	8	5	1.60	-3.00
vq	5	4	1.25	-2.32
ca	4	2	2.00	-2.00
vq	11	6	1.83	-3.46
vq	10	6	1.67	-3.32
ca	8	3	2.67	-3.00
c	3	3	1.00	-1.58
vq	8	3	2.67	-3.00
vq	15	4	3.75	-3.91
vq	6	3	2.00	-2.58
j	4	4	1.00	-2.00

ca	5	3	1.67	-2.32
ca	5	4	1.25	-2.32
vq	3	3	1.00	-1.58
ca	6	4	1.50	-2.58
vq	8	3	2.67	-3.00
vq	13	9	1.44	-3.70
j	5	3	1.67	-2.32
vq	30	11	2.73	-4.91
vq	30	20	1.50	-4.91
j	2	2	1.00	-1.00
vq	25	12	2.08	-4.64
vq	20	17	1.18	-4.32
vq	30	12	2.50	-4.91
vq	17	5	3.40	-4.09
vq	5	4	1.25	-2.32
ca	19	11	1.73	-4.25
vq	9	5	1.80	-3.17
vq	18	11	1.64	-4.17
vq	5	3	1.67	-2.32
vq	36	15	2.40	-5.17
vq	20	18	1.11	-4.32
ca	18	11	1.64	-4.17
vq	10	4	2.50	-3.32
vq	15	12	1.25	-3.91
vq	13	10	1.30	-3.70
vq	5	5	1.00	-2.32
vq	19	12	1.58	-4.25
vq	18	10	1.80	-4.17
vq	18	10	1.80	-4.17
vq	24	20	1.20	-4.58
vq	10	4	2.50	-3.32
vq	13	11	1.18	-3.70
vq	24	15	1.60	-4.58
vq	4	4	1.00	-2.00
vq	11	5	2.20	-3.46
ca	9	6	1.50	-3.17
vq	8	4	2.00	-3.00
j	10	4	2.50	-3.32
j	5	5	1.00	-2.32
vq	7	6	1.17	-2.81
vq	17	16	1.06	-4.09
vq	9	7	1.29	-3.17
vq	18	15	1.20	-4.17
vq	8	4	2.00	-3.00
vq	9	3	3.00	-3.17
vq	6	3	2.00	-2.58

vq	9	8	1.13	-3.17
vq	14	12	1.17	-3.81
vq	12	4	3.00	-3.58
vq	13	6	2.17	-3.70
vq	25	10	2.50	-4.64
vq	12	10	1.20	-3.58
vq	20	7	2.86	-4.32
vq	23	14	1.64	-4.52
vq	7	5	1.40	-2.81
vq	25	14	1.79	-4.64
vq	16	8	2.00	-4.00
ca	11	8	1.38	-3.46
vq	14	10	1.40	-3.81
vq	8	5	1.60	-3.00
vq	4	2	2.00	-2.00
ca	13	5	2.60	-3.70
vq	6	3	2.00	-2.58
vq	18	12	1.50	-4.17
vq	7	5	1.40	-2.81
vq	12	7	1.71	-3.58
ca	18	5	3.60	-4.17
vq	11	11	1.00	-3.46
ca	6	5	1.20	-2.58
vq	10	6	1.67	-3.32
vq	13	6	2.17	-3.70
vq	10	7	1.43	-3.32
ca	16	10	1.60	-4.00
vq	19	11	1.73	-4.25
vq	10	4	2.50	-3.32
vq	11	7	1.57	-3.46
vq	9	9	1.00	-3.17
vq	10	6	1.67	-3.32
vq	10	7	1.43	-3.32
vq	9	5	1.80	-3.17
j	28	18	1.56	-4.81
vq	15	10	1.50	-3.91
vq	7	5	1.40	-2.81
c	14	11	1.27	-3.81
vq	17	10	1.70	-4.09
vq	12	11	1.09	-3.58
ca	20	11	1.82	-4.32
c	5	4	1.25	-2.32
vq	15	10	1.50	-3.91
vq	3	3	1.00	-1.58
vq	5	4	1.25	-2.32
ca	15	15	1.00	-3.91

vq	13	13	1.00	-3.70
vq	7	5	1.40	-2.81
vq	40	25	1.60	-5.32
vq	15	10	1.50	-3.91
vq	19	10	1.90	-4.25
vq	18	5	3.60	-4.17
vq	27	11	2.45	-4.75
j	6	5	1.20	-2.58
vq	8	7	1.14	-3.00
vq	8	8	1.00	-3.00
vq	12	10	1.20	-3.58
ca	29	26	1.12	-4.86
vq	20	15	1.33	-4.32
vq	14	8	1.75	-3.81
vq	20	12	1.67	-4.32
c	10	10	1.00	-3.32
ca	35	20	1.75	-5.13
vq	15	11	1.36	-3.91
vq	10	9	1.11	-3.32
vq	25	14	1.79	-4.64
vq	14	11	1.27	-3.81
vq	12	10	1.20	-3.58
vq	11	6	1.83	-3.46
vq	22	22	1.00	-4.46
vq	10	7	1.43	-3.32
vq	11	9	1.22	-3.46
vq	20	14	1.43	-4.32
vq	30	15	2.00	-4.91
vq	20	9	2.22	-4.32
vq	15	9	1.67	-3.91
vq	20	10	2.00	-4.32
vq	12	10	1.20	-3.58
vq	16	12	1.33	-4.00
vq	40	5	8.00	-5.32
vq	11	6	1.83	-3.46
vq	18	5	3.60	-4.17
vq	18	9	2.00	-4.17
c	17	8	2.13	-4.09
j	5	3	1.67	-2.32
ca	15	14	1.07	-3.91
vq	50	20	2.50	-5.64
vq	33	25	1.32	-5.04
ca	19	10	1.90	-4.25
vq	12	10	1.20	-3.58
vq	25	14	1.79	-4.64
vq	40	19	2.11	-5.32

ca	20	15	1.33	-4.32
ca	20	8	2.50	-4.32
vq	17	15	1.13	-4.09
vq	20	6	3.33	-4.32
vq	5	4	1.25	-2.32
vq	16	9	1.78	-4.00
ca	19	10	1.90	-4.25
ca	20	15	1.33	-4.32
vq	11	10	1.10	-3.46
vq	30	16	1.88	-4.91
vq	4	3	1.33	-2.00
vq	6	5	1.20	-2.58
vq	35	20	1.75	-5.13
vq	24	20	1.20	-4.58
vq	22	18	1.22	-4.46
vq	19	10	1.90	-4.25
vq	22	16	1.38	-4.46
vq	15	10	1.50	-3.91
j	14	7	2.00	-3.81
vq	19	7	2.71	-4.25
vq	10	6	1.67	-3.32
ca	15	6	2.50	-3.91
vq	28	20	1.40	-4.81
vq	11	11	1.00	-3.46
vq	25	18	1.39	-4.64
ca	36	15	2.40	-5.17
c	30	14	2.14	-4.91
vq	15	10	1.50	-3.91

In situ clast count data for the middle member of the Wood Canyon Formation in the northern Nopah Range at Chicago Pass (CP 11). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), and unidentifiable clasts (missing).

Clast Type	Long(mm)	Short(mm)	Ratio (l/s)	Phi
vq	23	7	3.29	-4.52
vq	41	26	1.58	-5.36
vq	9	6	1.50	-3.17
qtz	9	9	1.00	-3.17
vq	11	8	1.38	-3.46
qtz	20	13	1.54	-4.32
qtz	4	4	1.00	-2.00
qtz	9	4	2.25	-3.17
qtz	18	14	1.29	-4.17
vq	20	13	1.54	-4.32
vq	10	5	2.00	-3.32
qtz	27	20	1.35	-4.75
qtz	6	4	1.50	-2.58
qtz	9	8	1.13	-3.17
qtz	15	9	1.67	-3.91
qtz	22	18	1.22	-4.46
qtz	21	15	1.40	-4.39
c	6	4	1.50	-2.58
qtz	10	6	1.67	-3.32
qtz	9	5	1.80	-3.17
vq	22	16	1.38	-4.46
qtz	40	30	1.33	-5.32
qtz	12	8	1.50	-3.58
qtz	33	11	3.00	-5.04
qtz	28	28	1.00	-4.81
vq	10	9	1.11	-3.32
qtz	6	4	1.50	-2.58
vq	4	4	1.00	-2.00
qtz	10	7	1.43	-3.32
qtz	14	12	1.17	-3.81
qtz	30	14	2.14	-4.91
qtz	27	14	1.93	-4.75
qtz	9	5	1.80	-3.17
qtz	18	17	1.06	-4.17
vq	24	15	1.60	-4.58
qtz	5	5	1.00	-2.32
qtz	19	14	1.36	-4.25
qtz	12	6	2.00	-3.58
qtz	29	13	2.23	-4.86
qtz	19	10	1.90	-4.25
qtz	15	13	1.15	-3.91

ca	21	12	1.75	-4.39
qtz	12	10	1.20	-3.58
qtz	20	10	2.00	-4.32
ca	21	9	2.33	-4.39
qtz	20	16	1.25	-4.32
qtz	22	16	1.38	-4.46
qtz	15	8	1.88	-3.91
vq	22	13	1.69	-4.46
qtz	19	18	1.06	-4.25
qtz	19	11	1.73	-4.25
vq	19	16	1.19	-4.25
ca	9	4	2.25	-3.17
qtz	15	12	1.25	-3.91
vq	15	14	1.07	-3.91
qtz	12	12	1.00	-3.58
qtz	15	8	1.88	-3.91
qtz	5	4	1.25	-2.32
qtz	10	3	3.33	-3.32
qtz	23	10	2.30	-4.52
qtz	16	7	2.29	-4.00
ca	25	12	2.08	-4.64
vq	6	5	1.20	-2.58
vq	13	10	1.30	-3.70
qtz	26	18	1.44	-4.70
qtz	9	5	1.80	-3.17
qtz	4	3	1.33	-2.00
qtz	9	7	1.29	-3.17
qtz	13	10	1.30	-3.70
vq	21	19	1.11	-4.39
qtz	20	15	1.33	-4.32
qtz	25	14	1.79	-4.64
qtz	9	8	1.13	-3.17
qtz	30	10	3.00	-4.91
qtz	40	13	3.08	-5.32
qtz	17	12	1.42	-4.09
vq	12	7	1.71	-3.58
vq	17	10	1.70	-4.09
qtz	21	22	0.95	-4.39
qtz	9	6	1.50	-3.17
qtz	10	8	1.25	-3.32
qtz	26	10	2.60	-4.70
qtz	9	5	1.80	-3.17
qtz	13	8	1.63	-3.70
qtz	15	9	1.67	-3.91
qtz	20	13	1.54	-4.32
vq	21	13	1.62	-4.39

qtz	17	11	1.55	-4.09
qtz	13	9	1.44	-3.70
qtz	25	17	1.47	-4.64
vq	13	9	1.44	-3.70
ca	30	15	2.00	-4.91
vq	17	14	1.21	-4.09
qtz	16	15	1.07	-4.00
qtz	16	10	1.60	-4.00
qtz	20	14	1.43	-4.32
qtz	17	10	1.70	-4.09
qtz	5	4	1.25	-2.32
qtz	15	6	2.50	-3.91
qtz	30	11	2.73	-4.91
qtz	32	25	1.28	-5.00
qtz	13	6	2.17	-3.70
vq	9	7	1.29	-3.17
qtz	30	15	2.00	-4.91
qtz	16	16	1.00	-4.00
qtz	21	12	1.75	-4.39
vq	15	8	1.88	-3.91
qtz	6	5	1.20	-2.58
vq	19	8	2.38	-4.25
qtz	14	10	1.40	-3.81
qtz	14	4	3.50	-3.81
vq	6	4	1.50	-2.58
qtz	9	6	1.50	-3.17
vq	24	13	1.85	-4.58
qtz	20	11	1.82	-4.32
vq	18	7	2.57	-4.17
qtz	23	12	1.92	-4.52
qtz	12	5	2.40	-3.58
qtz	20	12	1.67	-4.32
vq	4	3	1.33	-2.00
qtz	10	7	1.43	-3.32
qtz	12	7	1.71	-3.58
qtz	20	11	1.82	-4.32
qtz	22	17	1.29	-4.46
qtz	28	13	2.15	-4.81
qtz	15	9	1.67	-3.91
qtz	20	10	2.00	-4.32
qtz	12	11	1.09	-3.58
qtz	16	15	1.07	-4.00
vq	11	10	1.10	-3.46
qtz	6	5	1.20	-2.58
qtz	9	6	1.50	-3.17
qtz	34	20	1.70	-5.09

vq	20	12	1.67	-4.32
qtz	7	7	1.00	-2.81
qtz	30	25	1.20	-4.91
qtz	21	14	1.50	-4.39
ca	29	21	1.38	-4.86
ca	30	18	1.67	-4.91
qtz	35	25	1.40	-5.13
qtz	9	5	1.80	-3.17
qtz	6	4	1.50	-2.58
qtz	17	10	1.70	-4.09
vq	13	8	1.63	-3.70
j	8	3	2.67	-3.00
qtz	13	9	1.44	-3.70
qtz	5	4	1.25	-2.32
vq	5	4	1.25	-2.32
qtz	7	5	1.40	-2.81
qtz	22	14	1.57	-4.46
vq	15	8	1.88	-3.91
qtz	15	15	1.00	-3.91
qtz	23	12	1.92	-4.52
qtz	16	10	1.60	-4.00
qtz	14	9	1.56	-3.81
qtz	10	7	1.43	-3.32
qtz	15	12	1.25	-3.91
qtz	10	5	2.00	-3.32
qtz	7	7	1.00	-2.81
vq	8	6	1.33	-3.00
qtz	20	12	1.67	-4.32
qtz	20	15	1.33	-4.32
vq	13	11	1.18	-3.70
qtz	32	22	1.45	-5.00
qtz	25	12	2.08	-4.64
qtz	14	10	1.40	-3.81
qtz	15	9	1.67	-3.91
vq	25	19	1.32	-4.64
qtz	26	11	2.36	-4.70
qtz	20	14	1.43	-4.32
vq	26	15	1.73	-4.70
qtz	10	6	1.67	-3.32
qtz	18	11	1.64	-4.17
vq	15	10	1.50	-3.91
vq	21	11	1.91	-4.39
qtz	20	13	1.54	-4.32
qtz	15	12	1.25	-3.91
qtz	5	4	1.25	-2.32
qtz	15	12	1.25	-3.91

qtz	20	12	1.67	-4.32
qtz	22	10	2.20	-4.46
qtz	8	5	1.60	-3.00
qtz	20	16	1.25	-4.32
vq	7	4	1.75	-2.81
qtz	36	17	2.12	-5.17
vq	17	10	1.70	-4.09
qtz	3	2	1.50	-1.58
qtz	20	15	1.33	-4.32
qtz	20	13	1.54	-4.32
vq	19	16	1.19	-4.25
qtz	12	7	1.71	-3.58
qtz	12	11	1.09	-3.58
vq	16	10	1.60	-4.00
ca	20	12	1.67	-4.32
qtz	20	10	2.00	-4.32
qtz	30	18	1.67	-4.91
qtz	10	5	2.00	-3.32
qtz	5	4	1.25	-2.32
qtz	11	8	1.38	-3.46
qtz	12	5	2.40	-3.58

Appendix G

Collected Clast Count Data

Three dimensional clast measurement data for collected clasts of the middle member of the Wood Canyon Formation in the southern Marble Mountains (MM 4). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	26.81	17.20	12.05	-4.74	0.68	0.45
2	vq	31.15	29.20	20.14	-4.96	0.76	0.65
3	vq	23.70	23.03	15.55	-4.57	0.76	0.66
4	vq	23.73	19.06	15.48	-4.57	0.81	0.65
5	vq	33.21	21.80	17.01	-5.05	0.74	0.51
6	vq	22.76	15.65	10.37	-4.51	0.67	0.46
7	vq	18.74	15.49	11.12	-4.23	0.75	0.59
8	vq	18.32	15.78	9.38	-4.20	0.67	0.51
9	ca	44.70	33.59	18.10	-5.48	0.60	0.40
10	ca	22.27	18.53	13.10	-4.48	0.75	0.59
11	ca	21.93	21.86	14.76	-4.45	0.77	0.67
12	ca	16.74	15.13	10.69	-4.07	0.77	0.64
13	c	27.98	16.26	11.72	-4.81	0.67	0.42
14	meta	38.28	16.45	13.00	-5.26	0.65	0.34
15	qtz	26.43	16.22	12.04	-4.72	0.70	0.46
16	volcanic	20.28	17.32	13.22	-4.34	0.79	0.65
17	volcanic	16.03	14.78	8.42	-4.00	0.67	0.53
18	ca	26.42	25.81	17.33	-4.72	0.76	0.66
19	ca	29.24	18.70	12.71	-4.87	0.67	0.43
20	c	33.28	22.44	16.72	-5.06	0.72	0.50
21	qtz	26.17	15.41	14.19	-4.71	0.79	0.54

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the southern Marble Mountains (MM 5). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	28.25	18.61	13.04	-4.82	0.69	0.46
2	vq	21.55	19.12	15.50	-4.43	0.84	0.72
3	vq	28.15	20.31	13.49	-4.82	0.68	0.48
4	vq	25.34	16.60	11.23	-4.66	0.67	0.44
5	vq	22.12	18.33	10.98	-4.47	0.67	0.50
6	vq	25.01	21.48	14.60	-4.64	0.73	0.58
7	vq	11.51	7.58	6.97	-3.52	0.82	0.61
8	vq	17.44	12.66	8.57	-4.12	0.69	0.49
9	vq	16.52	14.16	9.17	-4.05	0.71	0.56
10	vq	15.11	11.95	9.91	-3.92	0.82	0.66
11	vq	14.74	14.39	10.27	-3.88	0.79	0.70
12	vq	19.93	14.60	10.23	-4.32	0.71	0.51
13	vq	23.96	20.94	14.64	-4.58	0.75	0.61
14	vq	30.09	14.92	14.55	-4.91	0.78	0.48
15	vq	16.47	12.85	11.01	-4.04	0.83	0.67
16	vq	21.20	15.51	12.96	-4.41	0.80	0.61
17	vq	27.42	20.27	12.81	-4.78	0.67	0.47
18	vq	20.24	18.68	15.07	-4.34	0.84	0.74
19	vq	30.52	22.40	14.74	-4.93	0.68	0.48
20	qtz	25.26	22.62	14.10	-4.66	0.70	0.56
21	vq	23.42	15.13	11.67	-4.55	0.73	0.50
22	qtz	24.84	18.44	8.60	-4.63	0.54	0.35
23	c	27.25	26.01	16.55	-4.77	0.73	0.61
24	qtz	23.26	17.10	10.50	-4.54	0.65	0.45
25	qtz	27.80	23.85	15.66	-4.80	0.72	0.56
26	qtz	28.80	18.24	13.53	-4.85	0.70	0.47
27	qtz	24.90	20.41	15.46	-4.64	0.78	0.62
28	qtz	45.18	24.41	18.37	-5.50	0.67	0.41
29	volcanic	23.28	21.82	10.54	-4.54	0.60	0.45
30	qtz	27.19	16.52	8.70	-4.77	0.55	0.32
31	qtz	16.39	14.03	11.65	-4.03	0.84	0.71
32	qtz	12.49	9.94	6.63	-3.64	0.71	0.53
33	qtz	15.49	13.25	7.51	-3.95	0.65	0.48
34	qtz	15.88	13.48	10.48	-3.99	0.80	0.66
35	qtz	18.92	17.39	11.52	-4.24	0.74	0.61
36	qtz	19.36	12.73	10.15	-4.28	0.75	0.52
37	qtz	12.99	10.78	5.94	-3.70	0.63	0.46
38	qtz	21.49	14.15	10.53	-4.43	0.71	0.49
39	qtz	15.79	13.61	13.18	-3.98	0.93	0.83

40	qtz	17.63	15.62	9.55	-4.14	0.69	0.54
41	qtz	14.13	10.45	6.12	-3.82	0.63	0.43
42	qtz	10.10	8.19	6.80	-3.34	0.82	0.67
43	ca	25.87	19.05	14.75	-4.69	0.76	0.57
44	ca	21.87	19.29	9.37	-4.45	0.59	0.43
45	ca	23.42	18.97	15.10	-4.55	0.80	0.64
46	ca	22.19	16.12	13.40	-4.47	0.79	0.60
47	ca	30.12	26.49	15.44	-4.91	0.67	0.51
48	ca	30.32	18.88	15.00	-4.92	0.73	0.49
49	volcanic	29.25	22.66	15.24	-4.87	0.71	0.52
50	volcanic	18.99	13.40	11.21	-4.25	0.79	0.59
51	volcanic	13.70	10.16	8.82	-3.78	0.82	0.64
52	volcanic	23.99	21.94	14.55	-4.58	0.74	0.61
53	volcanic	44.85	28.00	22.18	-5.49	0.73	0.49
54	c	30.37	20.53	16.66	-4.92	0.76	0.55

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the Marble Mountains (MM 6). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	58.85	26.21	24.96	-5.88	0.74	0.42
2	c	41.05	39.64	28.86	-5.36	0.80	0.70
3	vq	15.50	14.25	11.60	-3.95	0.85	0.75
4	vq	18.88	15.58	15.40	-4.24	0.93	0.82
5	vq	15.98	11.18	10.46	-4.00	0.85	0.65
6	vq	17.50	15.62	11.51	-4.13	0.79	0.66
7	qtz	26.83	19.83	17.79	-4.75	0.84	0.66
8	vq	28.37	18.60	17.61	-4.83	0.84	0.62
9	vq	38.18	27.26	20.42	-5.25	0.74	0.53
10	volcanic	21.59	15.03	13.40	-4.43	0.82	0.62
11	vq	24.06	24.00	13.51	-4.59	0.68	0.56
12	vq	29.26	20.12	16.23	-4.87	0.76	0.55
13	vq	27.36	18.36	14.20	-4.77	0.74	0.52
14	vq	17.06	12.17	11.11	-4.09	0.84	0.65
15	vq	35.35	17.67	7.92	-5.14	0.46	0.22
16	qtz	37.42	23.88	15.24	-5.23	0.64	0.41
17	vq	26.09	23.48	15.19	-4.71	0.72	0.58
18	vq	17.43	14.99	9.37	-4.12	0.70	0.54
19	vq	25.26	14.48	11.03	-4.66	0.69	0.44
20	vq	26.33	21.22	15.39	-4.72	0.75	0.58
21	vq	19.98	11.80	7.70	-4.32	0.63	0.39
22	vq	22.91	15.22	13.13	-4.52	0.79	0.57
23	volcanic	42.95	32.55	28.62	-5.42	0.84	0.67
24	vq	32.66	22.81	15.66	-5.03	0.69	0.48
25	vq	36.37	19.48	16.36	-5.18	0.72	0.45
26	vq	26.32	23.08	13.37	-4.72	0.67	0.51
27	qtz	23.20	14.04	10.04	-4.54	0.68	0.43
28	vq	22.44	22.14	12.13	-4.49	0.67	0.54
29	volcanic	26.42	24.76	19.50	-4.72	0.83	0.74
30	volcanic	44.55	25.73	12.48	-5.48	0.51	0.28
31	volcanic	29.85	23.80	16.28	-4.90	0.72	0.55
32	qtz	32.97	14.75	13.58	-5.04	0.72	0.41
33	qtz	20.65	14.70	9.38	-4.37	0.66	0.45
34	qtz	26.18	17.15	9.71	-4.71	0.59	0.37
35	qtz	17.26	14.16	9.86	-4.11	0.74	0.57
36	volcanic	31.75	23.43	18.55	-4.99	0.77	0.58
37	qtz	29.15	21.66	15.68	-4.87	0.73	0.54
38	qtz	21.59	14.75	11.54	-4.43	0.75	0.53
39	qtz	25.79	16.29	13.55	-4.69	0.76	0.53
40	qtz	30.31	27.52	20.80	-4.92	0.80	0.69
41	qtz	37.57	23.37	17.66	-5.23	0.71	0.47

42	qtz	25.40	22.58	15.80	-4.67	0.76	0.62
43	qtz	22.10	16.63	8.46	-4.47	0.58	0.38
44	qtz	36.67	29.70	16.93	-5.20	0.64	0.46
45	qtz	29.70	26.64	20.19	-4.89	0.80	0.68
46	qtz	19.94	13.66	9.36	-4.32	0.69	0.47
47	qtz	23.95	20.41	11.82	-4.58	0.66	0.49
48	qtz	26.57	18.81	15.51	-4.73	0.78	0.58
49	qtz	42.27	25.27	21.78	-5.40	0.76	0.52
50	qtz	25.85	21.11	7.81	-4.69	0.48	0.30
51	qtz	38.06	24.96	14.22	-5.25	0.60	0.37
52	c	33.51	25.31	17.57	-5.07	0.71	0.52
53a	qtz	33.38	20.66	14.06	-5.06	0.66	0.42
53b	ca	34.71	32.21	19.74	-5.12	0.70	0.57
54	ca	22.09	14.15	11.88	-4.47	0.77	0.54
55	volcanic	34.97	23.18	15.58	-5.13	0.67	0.45
56	c	21.09	17.29	9.69	-4.40	0.64	0.46
57	c	16.83	13.86	8.30	-4.07	0.67	0.49
58	volcanic	23.75	18.45	12.49	-4.57	0.71	0.53
59	qtz	32.98	25.09	19.25	-5.04	0.77	0.58
60	qtz	19.08	17.21	11.47	-4.25	0.74	0.60
61	c	37.51	24.00	18.22	-5.23	0.72	0.49
62	c	19.03	15.25	10.27	-4.25	0.71	0.54

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the Marble Mountains (MM 8). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	qtz	30.94	24.73	15.30	-4.95	0.67	0.49
2	qtz	32.06	24.35	17.78	-5.00	0.74	0.55
3	qtz	45.58	24.76	20.29	-5.51	0.71	0.45
4	vq	22.07	19.50	10.25	-4.46	0.62	0.46
5	qtz	39.54	25.45	17.61	-5.31	0.68	0.45
6	qtz	39.69	22.69	19.36	-5.31	0.75	0.49
7	qtz	26.24	24.91	15.27	-4.71	0.71	0.58
8	vq	19.01	11.94	11.21	-4.25	0.82	0.59
9	vq	22.67	17.98	11.57	-4.50	0.69	0.51
10	vq	24.45	13.07	10.80	-4.61	0.71	0.44
11	vq	19.75	16.12	10.01	-4.30	0.68	0.51
12	vq	26.93	16.30	13.78	-4.75	0.76	0.51
13	volcanic	40.11	18.37	14.99	-5.33	0.67	0.37
14	ca	48.17	32.52	27.72	-5.59	0.79	0.58
15	ca	26.86	20.44	18.10	-4.75	0.84	0.67
16	ca	40.53	30.20	28.92	-5.34	0.88	0.71
17	vq	17.66	14.87	8.75	-4.14	0.66	0.50
18	ca	19.55	13.43	10.65	-4.29	0.76	0.54
19	volcanic	26.57	21.07	17.42	-4.73	0.82	0.66
20	volcanic	25.68	18.25	15.34	-4.68	0.79	0.60
21	volcanic	25.82	21.91	14.09	-4.69	0.71	0.55
22	c	20.20	15.63	6.19	-4.34	0.50	0.31

Table : Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the Marble Mountains (MM 9). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	28.16	22.30	13.24	-4.82	0.65	0.47
2	qtz	18.97	14.98	9.23	-4.25	0.67	0.49
3	vq	19.28	14.63	11.41	-4.27	0.77	0.59
4	ca	22.57	20.18	15.09	-4.50	0.79	0.67
5	volcanic	25.97	16.98	16.27	-4.70	0.84	0.63
6	qtz	24.28	20.86	13.80	-4.60	0.72	0.57

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the Kingston Range (KR 2). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	41.53	36.40	32.51	-5.38	0.89	0.78
2	qtz	36.97	26.98	24.28	-5.21	0.84	0.66
3	qtz	40.98	27.40	10.62	-5.36	0.46	0.26
4	vq	38.66	25.18	20.14	-5.27	0.75	0.52
5	vq	39.55	27.86	22.61	-5.31	0.77	0.57
6	vq	36.09	26.51	21.04	-5.17	0.77	0.58
7	vq	34.74	26.34	20.86	-5.12	0.78	0.60
8	qtz	36.47	21.95	18.83	-5.19	0.76	0.52
9	vq	26.40	25.72	18.43	-4.72	0.79	0.70
10	vq	36.30	20.17	17.40	-5.18	0.75	0.48
11	vq	36.13	23.18	15.03	-5.18	0.65	0.42
12	vq	29.19	23.61	17.98	-4.87	0.78	0.62
13	vq	28.06	24.62	10.27	-4.81	0.53	0.37
14	vq	27.43	20.73	14.36	-4.78	0.71	0.52
15	vq	26.74	26.50	18.16	-4.74	0.77	0.68
16	volcanic	24.36	22.91	12.37	-4.61	0.65	0.51
17	vq	33.14	30.62	23.01	-5.05	0.81	0.69
18	qtz	26.30	23.90	14.35	-4.72	0.69	0.55
19	vq	28.01	21.49	15.79	-4.81	0.75	0.56
20	vq	34.64	21.55	12.91	-5.11	0.61	0.37
21	qtz	25.48	20.65	11.80	-4.67	0.64	0.46
22	qtz	30.87	24.89	21.66	-4.95	0.85	0.70
23	vq	27.27	18.30	15.51	-4.77	0.78	0.57
24	vq	36.15	21.29	16.06	-5.18	0.69	0.44
25	vq	25.84	18.57	12.48	-4.69	0.69	0.48
26	vq	36.11	21.29	17.19	-5.17	0.73	0.48
27	c	28.89	24.05	13.20	-4.85	0.63	0.46
28	vq	27.28	21.64	11.19	-4.77	0.60	0.41
29	vq	22.79	20.40	14.34	-4.51	0.76	0.63
30	vq	29.72	16.49	16.28	-4.89	0.81	0.55
31	qtz	24.81	21.08	16.29	-4.63	0.80	0.66
32	vq	28.62	21.59	14.47	-4.84	0.70	0.51
33	vq	30.71	20.10	12.70	-4.94	0.64	0.41
34	qtz	22.47	19.08	13.81	-4.49	0.76	0.61
35	vq	25.79	22.57	16.00	-4.69	0.76	0.62
36	vq	22.20	18.03	14.33	-4.47	0.80	0.65
37	vq	25.71	18.89	13.61	-4.68	0.73	0.53
38	vq	27.22	17.50	15.96	-4.77	0.81	0.59
39	vq	23.57	19.53	12.59	-4.56	0.70	0.53
40	vq	23.20	19.45	12.34	-4.54	0.70	0.53
41	vq	24.32	21.03	16.44	-4.60	0.81	0.68

42	vq	25.88	21.77	14.42	-4.69	0.72	0.56
43	vq	23.78	19.54	13.26	-4.57	0.72	0.56
44	qzt	28.60	21.70	16.16	-4.84	0.75	0.57
45	vq	30.24	22.11	12.39	-4.92	0.61	0.41
46	vq	26.78	23.70	20.05	-4.74	0.86	0.75
47	vq	26.06	18.46	10.79	-4.70	0.62	0.41
48	vq	24.22	19.29	14.26	-4.60	0.76	0.59
49	vq	24.41	21.14	19.05	-4.61	0.89	0.78
50	vq	20.00	19.21	16.12	-4.32	0.88	0.81
51	vq	16.26	12.61	9.62	-4.02	0.77	0.59
52	vq	28.55	17.39	17.17	-4.84	0.84	0.60
53	vq	22.00	16.67	14.01	-4.46	0.81	0.64
54	vq	27.65	25.02	15.78	-4.79	0.71	0.57
55	vq	19.52	16.67	11.30	-4.29	0.73	0.58
56	vq	21.05	15.80	10.75	-4.40	0.70	0.51
57	vq	21.63	16.94	13.56	-4.43	0.79	0.63
58	vq	23.52	19.72	13.00	-4.56	0.71	0.55
59	vq	25.44	16.75	15.35	-4.67	0.82	0.60
60	vq	22.09	15.85	12.46	-4.47	0.76	0.56
61	vq	21.41	16.99	14.01	-4.42	0.81	0.65
62	vq	26.35	17.61	7.58	-4.72	0.50	0.29
63	vq	20.02	14.46	13.87	-4.32	0.87	0.69
64	vq	20.58	15.90	10.26	-4.36	0.69	0.50
65	vq	21.65	18.34	12.60	-4.44	0.74	0.58
66	vq	16.48	12.81	10.09	-4.04	0.78	0.61
67	vq	31.30	18.06	12.05	-4.97	0.64	0.38
68	vq	19.51	16.93	12.78	-4.29	0.79	0.66
69	vq	21.99	14.53	9.90	-4.46	0.67	0.45
70	vq	24.23	14.55	11.23	-4.60	0.71	0.46
71	vq	18.47	16.22	12.57	-4.21	0.81	0.68
72	vq	25.00	17.94	11.89	-4.64	0.68	0.48
73	vq	24.50	19.40	15.50	-4.61	0.80	0.63
74	vq	21.41	14.36	12.05	-4.42	0.78	0.56
75	vq	17.11	12.93	11.48	-4.10	0.84	0.67
76	vq	20.33	17.23	12.16	-4.35	0.75	0.60
77	vq	18.58	12.82	8.58	-4.22	0.68	0.46
78	vq	20.94	15.20	9.20	-4.39	0.64	0.44
79	vq	17.68	16.39	9.77	-4.14	0.69	0.55
80	vq	19.44	17.83	13.68	-4.28	0.81	0.70
81	vq	20.31	14.93	11.12	-4.34	0.74	0.55
82	vq	16.34	11.52	8.69	-4.03	0.74	0.53
83	vq	21.06	14.76	11.78	-4.40	0.76	0.56
84	vq	20.06	15.36	11.11	-4.33	0.74	0.55
85	vq	16.80	11.90	9.48	-4.07	0.77	0.56
86	vq	19.41	14.60	10.89	-4.28	0.75	0.56
87	vq	19.25	16.68	10.56	-4.27	0.70	0.55

88	vq	18.61	15.85	11.72	-4.22	0.78	0.63
89	vq	17.64	14.89	12.72	-4.14	0.85	0.72
90	vq	22.40	18.81	11.42	-4.49	0.68	0.51
91	vq	18.11	17.70	12.71	-4.18	0.80	0.70
92	vq	22.55	16.33	13.38	-4.50	0.79	0.59
93	vq	25.74	15.45	11.27	-4.69	0.68	0.44
94	vq	18.13	16.60	8.36	-4.18	0.61	0.46
95	vq	18.59	17.36	14.65	-4.22	0.87	0.79
96	vq	16.86	15.76	5.94	-4.08	0.51	0.35
97	vq	17.17	13.04	10.34	-4.10	0.78	0.60
98	vq	21.38	15.31	11.49	-4.42	0.74	0.54
99	vq	18.99	14.40	10.62	-4.25	0.74	0.56
100	vq	16.10	14.48	9.38	-4.01	0.72	0.58
101	qzt	46.49	35.32	35.26	-5.54	0.91	0.76
102	vq	37.56	27.38	24.35	-5.23	0.83	0.65
103	vq	37.76	31.38	23.04	-5.24	0.77	0.61
104	vq	25.60	19.91	15.36	-4.68	0.77	0.60
105	vq	51.77	36.38	22.34	-5.69	0.64	0.43
106	vq	47.48	31.12	30.64	-5.57	0.86	0.65
107	vq	26.24	24.39	15.83	-4.71	0.73	0.60
108	vq	32.09	23.77	17.26	-5.00	0.73	0.54
109	vq	32.58	23.35	19.12	-5.03	0.78	0.59
110	vq	31.83	23.53	17.86	-4.99	0.75	0.56
111	vq	26.49	23.40	16.47	-4.73	0.76	0.62
112	c	30.95	22.63	16.71	-4.95	0.74	0.54
113	vq	37.93	24.95	22.34	-5.25	0.81	0.59
114	vq	32.77	31.32	25.00	-5.03	0.85	0.76
115	qzt	39.24	23.46	19.93	-5.29	0.76	0.51
116	vq	29.29	20.37	17.82	-4.87	0.81	0.61
117	vq	39.13	25.22	20.65	-5.29	0.76	0.53
118	vq	31.13	21.41	13.85	-4.96	0.66	0.44
119	vq	47.20	33.33	25.88	-5.56	0.75	0.55
120	vq	36.32	23.68	19.26	-5.18	0.76	0.53
121	vq	38.85	26.66	17.00	-5.28	0.65	0.44
122	vq	38.42	26.26	20.03	-5.26	0.74	0.52
123	vq	25.74	19.90	18.18	-4.69	0.86	0.71
124	vq	37.52	28.65	26.49	-5.23	0.87	0.71
125	vq	39.12	16.72	13.44	-5.29	0.65	0.34
126	qzt	24.09	19.49	18.82	-4.59	0.91	0.78
127	vq	21.79	20.61	10.47	-4.45	0.62	0.48
128	vq	32.85	25.15	17.97	-5.04	0.73	0.55
129	c	36.33	31.86	23.74	-5.18	0.79	0.65
130	vq	22.65	19.98	16.85	-4.50	0.86	0.74
131	vq	32.32	22.78	19.80	-5.01	0.81	0.61
132	vq	30.64	24.99	12.74	-4.94	0.60	0.42
133	vq	21.50	20.28	13.76	-4.43	0.76	0.64

134	vq	33.01	27.07	12.33	-5.04	0.55	0.37
135	vq	25.99	18.18	10.19	-4.70	0.60	0.39
136	vq	24.04	20.00	15.14	-4.59	0.78	0.63
137	vq	33.32	18.85	11.24	-5.06	0.59	0.34
138	vq	23.31	21.97	19.98	-4.54	0.92	0.86
139	vq	28.66	24.87	13.45	-4.84	0.63	0.47
140	vq	28.77	17.62	14.10	-4.85	0.73	0.49
141	vq	23.97	22.70	20.23	-4.58	0.91	0.84
142	vq	21.69	16.01	11.37	-4.44	0.72	0.52
143	vq	27.12	23.18	17.44	-4.76	0.79	0.64
144	vq	27.04	21.05	12.62	-4.76	0.65	0.47
145	vq	24.12	24.16	14.57	-4.59	0.71	0.60
146	vq	25.21	19.12	11.80	-4.66	0.66	0.47
147	vq	26.54	18.64	13.28	-4.73	0.71	0.50
148	vq	29.92	28.12	14.27	-4.90	0.62	0.48
149	vq	29.30	23.79	19.40	-4.87	0.81	0.66
150	vq	30.15	27.78	13.81	-4.91	0.61	0.46
151	vq	35.08	21.37	18.82	-5.13	0.78	0.54
152	vq	24.42	19.06	14.94	-4.61	0.78	0.61
153	vq	27.74	21.56	11.95	-4.79	0.62	0.43
154	vq	23.67	19.58	12.93	-4.56	0.71	0.55
155	vq	23.12	18.29	12.75	-4.53	0.73	0.55
156	vq	24.18	18.81	15.26	-4.60	0.80	0.63
157	vq	24.54	19.31	18.54	-4.62	0.90	0.76
158	vq	25.24	17.71	15.50	-4.66	0.81	0.61
159	vq	25.56	23.52	11.40	-4.68	0.60	0.45
160	vq	28.28	20.29	14.63	-4.82	0.72	0.52
161	vq	26.82	21.96	16.44	-4.75	0.77	0.61
162	vq	21.09	18.29	16.25	-4.40	0.88	0.77
163	vq	28.09	21.72	20.57	-4.81	0.89	0.73
164	vq	23.99	18.87	12.72	-4.58	0.71	0.53
165	vq	24.21	20.11	11.14	-4.60	0.63	0.46

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the Kelso Mountains (KM 1). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	23.88	20.10	14.14	-4.58	0.75	0.59
2	vq	29.42	22.36	19.94	-4.88	0.85	0.68
3	qtz	27.35	18.97	12.64	-4.77	0.68	0.46
4	vq	20.48	15.93	10.45	-4.36	0.69	0.51
5	vq	18.95	14.63	9.70	-4.24	0.70	0.51
6	vq	23.01	20.17	15.17	-4.52	0.79	0.66
7	qtz	29.30	16.80	15.19	-4.87	0.78	0.52
8	qtz	27.45	19.50	12.73	-4.78	0.67	0.46
9	volcanic	25.22	17.93	17.44	-4.66	0.88	0.69
10	vq	20.04	12.65	11.43	-4.32	0.80	0.57
11	vq	24.15	17.70	14.58	-4.59	0.79	0.60
12	vq	20.22	16.59	12.79	-4.34	0.79	0.63
13	qtz	23.95	18.43	11.92	-4.58	0.69	0.50
14	volcanic	20.08	17.41	12.88	-4.33	0.78	0.64
15	vq	18.37	15.42	10.89	-4.20	0.75	0.59
16	vq	24.11	17.24	12.81	-4.59	0.73	0.53
17	vq	21.10	13.72	12.62	-4.40	0.82	0.60
18	volcanic	24.36	16.60	13.88	-4.61	0.78	0.57
19	vq	23.45	16.21	14.10	-4.55	0.81	0.60
20	vq	21.25	15.31	12.48	-4.41	0.78	0.59
21	vq	28.82	20.33	16.46	-4.85	0.77	0.57
22	vq	24.53	19.25	12.05	-4.62	0.67	0.49
23	qtz	28.36	21.87	15.73	-4.83	0.74	0.55
24	volcanic	22.78	16.13	13.23	-4.51	0.78	0.58
25	vq	20.58	19.19	14.98	-4.36	0.83	0.73
26	qtz	20.08	14.60	9.75	-4.33	0.69	0.49
27	vq	15.67	12.08	10.22	-3.97	0.82	0.65
28	vq	19.83	17.22	11.97	-4.31	0.75	0.60
29	vq	16.88	13.96	9.87	-4.08	0.74	0.58
30	volcanic	20.35	16.27	11.94	-4.35	0.76	0.59
31	vq	24.27	19.13	8.16	-4.60	0.52	0.34
32	vq	16.62	16.61	10.65	-4.05	0.74	0.64
33	vq	24.73	13.87	13.46	-4.63	0.81	0.54
34	vq	18.34	10.58	9.11	-4.20	0.75	0.50
35	vq	13.73	11.91	9.49	-3.78	0.82	0.69
36	volcanic	19.44	16.21	11.85	-4.28	0.76	0.61
37	vq	21.34	15.02	11.66	-4.42	0.75	0.55
38	vq	19.76	16.10	11.20	-4.30	0.73	0.57
39	vq	24.89	14.66	11.62	-4.64	0.72	0.47
40	vq	21.63	16.00	14.19	-4.43	0.83	0.66
41	vq	20.87	14.60	11.24	-4.38	0.75	0.54

42	vq	10.49	9.85	6.52	-3.39	0.74	0.62
43	vq	16.48	12.87	9.60	-4.04	0.76	0.58
44	vq	19.91	16.68	10.37	-4.32	0.69	0.52
45	volcanic	21.88	15.43	11.57	-4.45	0.73	0.53
46	vq	19.57	15.73	11.54	-4.29	0.76	0.59
47	vq	16.75	12.74	8.90	-4.07	0.72	0.53
48	vq	23.95	15.55	10.58	-4.58	0.67	0.44
49	vq	13.61	14.16	9.45	-3.77	0.77	0.69
50	vq	16.15	15.54	14.20	-4.01	0.93	0.88
51	volcanic	17.63	13.26	10.88	-4.14	0.80	0.62
52	vq	21.57	15.03	8.16	-4.43	0.59	0.38
53	volcanic	17.50	14.55	11.49	-4.13	0.80	0.66
54	volcanic	19.79	10.91	8.50	-4.31	0.69	0.43
55	vq	16.85	14.07	9.82	-4.07	0.74	0.58
56	qzt	19.73	15.13	10.80	-4.30	0.73	0.55
57	vq	17.18	14.39	10.19	-4.10	0.75	0.59
58	vq	18.72	14.12	11.71	-4.23	0.80	0.63
59	vq	13.74	11.32	9.96	-3.78	0.86	0.72
60	volcanic	15.66	13.50	10.31	-3.97	0.80	0.66
61	vq	17.32	12.17	8.69	-4.11	0.71	0.50
62	vq	12.09	10.07	8.02	-3.60	0.81	0.66
63	vq	16.33	12.51	9.41	-4.03	0.76	0.58
64	vq	15.62	12.31	9.78	-3.97	0.79	0.63
65	vq	20.32	16.94	13.97	-4.34	0.83	0.69
66	vq	14.42	12.20	9.66	-3.85	0.81	0.67
67	vq	14.48	10.84	7.70	-3.86	0.72	0.53
68	vq	16.32	11.96	9.15	-4.03	0.75	0.56
69	vq	20.52	20.78	10.28	-4.36	0.63	0.50
70	vq	14.53	9.95	9.11	-3.86	0.83	0.63
71	vq	13.44	11.02	9.36	-3.75	0.84	0.70
72	volcanic	17.20	15.53	8.49	-4.10	0.65	0.49
73	vq	14.92	11.43	7.85	-3.90	0.71	0.53
74	vq	14.58	10.58	7.48	-3.87	0.71	0.51
75	volcanic	10.71	10.47	8.57	-3.42	0.87	0.80
76	qzt	20.22	13.45	12.16	-4.34	0.82	0.60
77	volcanic	15.86	14.21	10.98	-3.99	0.81	0.69
78	volcanic	16.54	12.23	9.41	-4.05	0.76	0.57
79	vq	11.69	10.44	5.13	-3.55	0.60	0.44
80	qzt	14.19	12.59	8.73	-3.83	0.75	0.62
81	vq	10.44	8.80	4.97	-3.38	0.65	0.48
82	vq	13.32	9.27	7.95	-3.74	0.80	0.60
83	vq	14.08	11.85	8.80	-3.82	0.77	0.63
84	vq	14.83	11.05	8.63	-3.89	0.77	0.58
85	vq	9.67	8.21	6.08	-3.27	0.78	0.63
86	vq	13.52	11.91	8.91	-3.76	0.79	0.66
87	vq	13.39	9.32	7.86	-3.74	0.79	0.59

88	vq	11.11	8.99	6.50	-3.47	0.75	0.59
89	vq	11.32	10.61	7.04	-3.50	0.74	0.62
90	vq	13.21	12.61	11.03	-3.72	0.90	0.83
91	volcanic	11.28	8.80	6.51	-3.50	0.75	0.58
92	volcanic	12.13	11.03	8.59	-3.60	0.82	0.71
93	vq	9.06	8.25	7.40	-3.18	0.90	0.82

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the southern Nopah Range at Tule Spring (TS 1). Identified clast types are vein quartz (vq), quartzite (qzt), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	qzt	22.97	14.73	13.71	-4.52	0.82	0.60
2	qzt	22.54	17.97	7.39	-4.49	0.51	0.33
3	vq	23.71	14.76	11.92	-4.57	0.74	0.50
4	qzt	24.56	15.01	13.22	-4.62	0.78	0.54
5	c	20.19	13.68	13.15	-4.34	0.86	0.65
6	vq	25.90	18.69	15.58	-4.69	0.79	0.60
7	vq	16.42	13.78	11.92	-4.04	0.86	0.73
8	qzt	23.09	12.07	9.38	-4.53	0.68	0.41
9	qzt	27.93	15.37	11.23	-4.80	0.66	0.40
10	vq	26.51	13.44	11.67	-4.73	0.73	0.44
11	vq	22.51	22.31	11.65	-4.49	0.65	0.52
12	vq	18.50	12.11	10.29	-4.21	0.78	0.56
13	vq	21.47	17.55	14.73	-4.42	0.83	0.69
14	j	21.02	15.80	10.80	-4.39	0.71	0.51
15	vq	17.63	12.70	10.59	-4.14	0.79	0.60
16	vq	17.32	13.07	10.62	-4.11	0.79	0.61
17	vq	17.02	11.80	9.79	-4.09	0.78	0.58
18	vq	20.22	11.62	9.56	-4.34	0.73	0.47
19	ca	17.97	17.08	14.51	-4.17	0.88	0.81
20	ca	17.38	14.97	10.47	-4.12	0.75	0.60
21	vq	13.33	11.95	9.68	-3.74	0.84	0.73
22	qzt	17.16	11.79	9.25	-4.10	0.75	0.54
23	c	17.98	15.12	10.02	-4.17	0.72	0.56
24	ca	16.15	9.77	8.12	-4.01	0.75	0.50
25	vq	11.48	9.19	7.51	-3.52	0.81	0.65
26	vq	15.13	11.10	10.71	-3.92	0.88	0.71
27	vq	13.04	8.33	7.87	-3.70	0.83	0.60
28	vq	12.50	9.05	7.99	-3.64	0.83	0.64
29	vq	12.24	9.87	5.88	-3.61	0.66	0.48
30	vq	15.51	9.60	7.68	-3.96	0.73	0.50
31	c	19.69	12.92	9.44	-4.30	0.70	0.48
32	vq	18.39	11.64	9.74	-4.20	0.76	0.53
33	qzt	12.78	11.49	8.75	-3.68	0.80	0.68
34	vq	16.58	10.28	9.68	-4.05	0.82	0.58
35	qzt	18.88	12.57	9.83	-4.24	0.74	0.52
36	vq	16.15	12.11	6.97	-4.01	0.63	0.43
37	vq	14.26	10.95	8.92	-3.83	0.80	0.63
38	qzt	14.81	12.37	11.63	-3.89	0.90	0.79
39	vq	11.00	10.40	6.57	-3.46	0.72	0.60
40	vq	13.65	9.52	8.33	-3.77	0.81	0.61

41	j	18.49	15.78	13.85	-4.21	0.87	0.75
42	vq	21.28	13.85	13.39	-4.41	0.85	0.63
43	vq	15.05	11.44	9.66	-3.91	0.82	0.64
44	qzt	13.24	11.70	8.62	-3.73	0.78	0.65
45	vq	12.38	11.23	8.30	-3.63	0.79	0.67
46	ca	13.10	10.83	8.33	-3.71	0.79	0.64
47	vq	19.04	13.66	11.55	-4.25	0.80	0.61
48	vq	14.27	12.78	10.27	-3.83	0.83	0.72
49	qzt	17.15	10.72	10.16	-4.10	0.82	0.59
50	vq	17.39	12.96	12.27	-4.12	0.87	0.71
51	vq	17.02	9.99	9.30	-4.09	0.80	0.55
52	vq	14.48	11.90	7.08	-3.86	0.66	0.49
53	qzt	15.60	11.81	9.79	-3.96	0.80	0.63
54	vq	11.77	10.77	9.97	-3.56	0.92	0.85
55	vq	15.03	10.40	7.02	-3.91	0.68	0.47
56	vq	15.11	10.51	8.45	-3.92	0.77	0.56
57	vq	15.65	13.51	8.57	-3.97	0.70	0.55
58	vq	13.35	10.50	8.37	-3.74	0.79	0.63
59	qzt	13.47	9.68	8.45	-3.75	0.82	0.63
60	vq	13.86	13.34	9.82	-3.79	0.80	0.71
61	qzt	23.09	12.10	9.96	-4.53	0.71	0.43
62	qzt	20.45	11.36	10.84	-4.35	0.80	0.53
63	vq	18.01	13.46	10.39	-4.17	0.76	0.58
64	vq	14.53	10.78	9.96	-3.86	0.86	0.69
65	vq	12.89	12.18	8.73	-3.69	0.79	0.68
66	vq	17.13	11.97	11.44	-4.10	0.86	0.67
67	vq	16.31	10.30	9.64	-4.03	0.82	0.59
68	vq	18.31	12.91	10.00	-4.19	0.75	0.55
69	vq	17.98	13.32	10.77	-4.17	0.79	0.60
70	c	13.75	12.32	8.62	-3.78	0.76	0.63
71	vq	15.86	13.27	9.79	-3.99	0.77	0.62
72	vq	18.52	10.60	10.17	-4.21	0.81	0.55
73	c	15.89	12.30	8.21	-3.99	0.70	0.52
74	j	16.38	10.02	8.46	-4.03	0.76	0.52
75	qzt	13.79	8.68	7.51	-3.79	0.78	0.54
76	qzt	18.56	14.13	10.27	-4.21	0.74	0.55
77	vq	13.40	11.72	7.11	-3.74	0.69	0.53
78	vq	21.69	11.20	10.65	-4.44	0.78	0.49
79	qzt	21.63	12.68	12.23	-4.43	0.82	0.57
80	qzt	18.29	12.19	9.43	-4.19	0.74	0.52
81	qzt	21.17	14.44	10.25	-4.40	0.70	0.48
82	qzt	24.87	13.93	13.22	-4.64	0.80	0.53
83	ca	20.49	16.44	14.18	-4.36	0.84	0.69
84	vq	14.35	11.03	9.06	-3.84	0.80	0.63
85	vq	14.93	11.25	8.19	-3.90	0.74	0.55
86	qzt	19.67	10.78	9.63	-4.30	0.76	0.49

87	qzt	17.05	10.26	4.97	-4.09	0.52	0.29
88	vq	13.22	12.07	7.94	-3.72	0.73	0.60
89	vq	13.72	11.14	8.05	-3.78	0.75	0.59
90	j	17.95	13.61	10.04	-4.17	0.74	0.56
91	vq	20.11	15.92	11.90	-4.33	0.76	0.59
92	vq	15.03	11.38	7.72	-3.91	0.70	0.51
93	ca	15.31	11.97	9.90	-3.94	0.81	0.65
94	j	15.44	11.73	9.70	-3.95	0.80	0.63
95	granite	14.76	11.78	10.49	-3.88	0.86	0.71
96	ca	16.65	12.34	9.52	-4.06	0.76	0.57
97	qzt	16.09	13.75	10.64	-4.01	0.80	0.66
98	vq	16.63	11.97	8.35	-4.06	0.70	0.50
99	vq	17.09	11.40	10.79	-4.10	0.84	0.63
100	vq	22.57	15.17	9.23	-4.50	0.63	0.41
101	vq	15.05	13.46	9.29	-3.91	0.75	0.62
102	vq	16.64	10.78	9.50	-4.06	0.80	0.57
103	vq	13.72	11.35	9.75	-3.78	0.85	0.71
104	vq	13.12	10.55	9.35	-3.71	0.86	0.71
105	vq	13.54	11.99	8.54	-3.76	0.77	0.63
106	vq	5.17	12.13	8.54	-2.37	1.05	1.65
107	vq	11.47	10.99	9.97	-3.52	0.92	0.87
108	vq	12.65	11.13	7.85	-3.66	0.76	0.62
109	qzt	17.74	12.12	10.72	-4.15	0.81	0.60
110	qzt	13.85	10.82	8.47	-3.79	0.78	0.61
111	vq	11.04	9.17	6.85	-3.46	0.77	0.62
112	vq	16.67	11.44	8.24	-4.06	0.71	0.49
113	vq	11.30	10.31	6.75	-3.50	0.73	0.60
114	vq	14.55	11.78	11.18	-3.86	0.90	0.77
115	vq	14.97	9.80	9.69	-3.90	0.86	0.65
116	vq	13.24	10.91	6.64	-3.73	0.67	0.50
117	vq	16.27	11.80	7.51	-4.02	0.66	0.46
118	vq	13.33	10.97	8.28	-3.74	0.78	0.62
119	c	17.56	16.36	8.76	-4.13	0.64	0.50
120	vq	17.20	12.88	12.02	-4.10	0.87	0.70
121	vq	15.47	10.58	9.07	-3.95	0.80	0.59
122	vq	12.65	6.81	6.54	-3.66	0.79	0.52
123	qzt	16.99	12.07	6.80	-4.09	0.61	0.40
124	ca	18.55	13.06	10.46	-4.21	0.77	0.56
125	vq	12.73	12.32	8.33	-3.67	0.76	0.65
126	ca	13.66	11.56	8.40	-3.77	0.76	0.61
127	vq	12.63	10.02	8.30	-3.66	0.82	0.66
128	qzt	15.41	11.48	9.21	-3.95	0.78	0.60
129	vq	14.84	8.75	9.18	-3.89	0.87	0.62
130	vq	13.35	13.25	7.62	-3.74	0.69	0.57
131	vq	19.65	12.87	9.96	-4.30	0.73	0.51
132	qzt	16.33	10.37	9.50	-4.03	0.81	0.58

133	vq	11.93	9.89	7.87	-3.58	0.81	0.66
134	qzt	16.37	9.14	7.84	-4.03	0.74	0.48
135	qzt	15.66	11.37	8.25	-3.97	0.73	0.53
136	vq	18.16	10.27	9.35	-4.18	0.78	0.51
137	vq	21.41	12.50	11.89	-4.42	0.81	0.56
138	vq	15.43	10.69	8.82	-3.95	0.78	0.57
139	j	20.00	11.76	7.40	-4.32	0.62	0.37
140	vq	13.55	12.28	8.38	-3.76	0.75	0.62
141	vq	20.97	10.81	9.10	-4.39	0.71	0.43
142	vq	19.46	12.92	12.07	-4.28	0.83	0.62
143	vq	21.43	13.37	9.70	-4.42	0.69	0.45
144	vq	15.29	11.32	9.00	-3.93	0.78	0.59
145	vq	14.61	10.66	6.20	-3.87	0.63	0.42
146	vq	12.67	12.41	6.44	-3.66	0.64	0.51
147	qzt	17.02	14.65	11.34	-4.09	0.80	0.67
148	vq	13.92	11.77	9.39	-3.80	0.81	0.67
149	vq	10.27	9.12	5.66	-3.36	0.70	0.55
150	vq	13.35	10.78	7.34	-3.74	0.72	0.55
151	vq	20.05	11.70	8.88	-4.33	0.70	0.44
152	qzt	16.43	11.13	7.32	-4.04	0.66	0.45
153	vq	17.40	15.68	10.18	-4.12	0.72	0.59
154	qzt	13.34	10.06	9.06	-3.74	0.85	0.68
155	vq	16.30	11.18	9.49	-4.03	0.79	0.58
156	c	15.23	11.38	10.63	-3.93	0.87	0.70
157	vq	12.97	9.63	6.72	-3.70	0.71	0.52
158	qzt	14.99	9.70	7.79	-3.91	0.75	0.52
159	vq	14.13	11.28	9.70	-3.82	0.84	0.69
160	vq	17.56	9.77	7.73	-4.13	0.70	0.44
161	qzt	14.18	12.38	8.23	-3.83	0.73	0.58
162	ca	13.49	11.12	10.80	-3.75	0.92	0.80
163	qzt	11.67	8.97	7.04	-3.54	0.78	0.60
164	vq	14.19	11.38	7.43	-3.83	0.70	0.52
165	c	16.11	10.54	9.96	-4.01	0.84	0.62
166	vq	12.98	12.83	7.60	-3.70	0.70	0.59
167	vq	13.15	10.65	7.61	-3.72	0.75	0.58
168	qzt	16.97	12.13	7.90	-4.08	0.67	0.47
169	vq	11.84	8.40	7.76	-3.57	0.85	0.66
170	vq	9.69	7.46	7.10	-3.28	0.89	0.73
171	vq	17.06	9.57	9.20	-4.09	0.80	0.54
172	vq	11.81	9.55	7.36	-3.56	0.78	0.62
173	vq	14.46	11.53	10.54	-3.85	0.87	0.73
174	vq	14.19	10.92	7.05	-3.83	0.68	0.50
175	c	13.21	10.44	6.36	-3.72	0.66	0.48
176	vq	12.52	9.84	5.84	-3.65	0.65	0.47
177	vq	19.22	10.94	9.49	-4.26	0.75	0.49
178	vq	13.82	9.86	6.03	-3.79	0.64	0.44

179	vq	11.77	9.48	7.47	-3.56	0.79	0.63
180	vq	11.64	7.30	6.88	-3.54	0.82	0.59
181	vq	12.05	8.35	8.05	-3.59	0.86	0.67
182	vq	12.55	9.69	7.59	-3.65	0.78	0.60
183	vq	18.94	12.64	10.19	-4.24	0.76	0.54
184	vq	14.76	11.37	10.31	-3.88	0.86	0.70
185	vq	13.69	12.21	9.82	-3.78	0.83	0.72
186	qzt	16.20	12.01	8.71	-4.02	0.73	0.54
187	vq	13.35	10.88	7.28	-3.74	0.71	0.55
188	c	15.50	8.13	8.06	-3.95	0.80	0.52
189	qzt	16.79	12.85	7.43	-4.07	0.63	0.44
190	vq	14.52	11.85	10.38	-3.86	0.86	0.71
191	ca	18.78	13.11	8.60	-4.23	0.67	0.46
192	vq	13.49	11.02	9.56	-3.75	0.85	0.71
193	vq	14.73	9.81	7.54	-3.88	0.73	0.51
194	vq	15.69	9.46	5.93	-3.97	0.62	0.38
195	vq	16.58	11.06	7.87	-4.05	0.70	0.47
196	ca	12.64	11.29	7.24	-3.66	0.72	0.57
197	qzt	16.52	9.53	7.36	-4.05	0.70	0.45
198	qzt	15.43	10.66	7.58	-3.95	0.70	0.49
199	qzt	17.01	13.11	11.11	-4.09	0.82	0.65
200	vq	14.73	12.80	11.27	-3.88	0.88	0.77
201	qzt	12.97	10.55	8.76	-3.70	0.82	0.68
202	qzt	12.15	8.93	5.55	-3.60	0.66	0.46
203	vq	11.72	9.17	8.43	-3.55	0.87	0.72
204	vq	13.38	10.72	8.18	-3.74	0.78	0.61
205	vq	11.20	9.35	7.96	-3.49	0.85	0.71
206	vq	13.45	10.05	6.48	-3.75	0.68	0.48
207	vq	11.11	10.02	6.66	-3.47	0.74	0.60
208	qzt	14.48	9.99	8.11	-3.86	0.77	0.56
209	vq	13.14	9.58	5.80	-3.72	0.64	0.44
210	vq	11.49	9.52	5.52	-3.52	0.65	0.48
211	vq	13.31	10.50	7.73	-3.73	0.75	0.58
212	qzt	10.52	9.18	7.39	-3.40	0.83	0.70
213	vq	11.42	9.33	7.12	-3.51	0.78	0.62
214	vq	11.32	8.72	7.54	-3.50	0.83	0.67
215	vq	9.78	8.42	7.14	-3.29	0.85	0.73
216	vq	11.46	8.84	8.12	-3.52	0.87	0.71
217	vq	9.46	8.78	8.20	-3.24	0.93	0.87
218	vq	11.26	8.09	7.90	-3.49	0.88	0.70
219	ca	11.02	8.53	6.46	-3.46	0.76	0.59
220	vq	8.48	7.27	5.61	-3.08	0.80	0.66
221	qzt	14.25	9.78	8.71	-3.83	0.82	0.61
222	ca	10.59	8.40	8.21	-3.40	0.91	0.78
223	vq	18.34	11.75	7.00	-4.20	0.61	0.38
224	vq	13.94	10.98	10.47	-3.80	0.89	0.75

225	qzt	13.08	9.93	6.78	-3.71	0.71	0.52
226	ca	12.56	9.49	8.28	-3.65	0.83	0.66
227	vq	11.31	9.24	7.63	-3.50	0.82	0.67
228	vq	13.46	12.82	8.73	-3.75	0.76	0.65
229	ca	13.61	10.59	9.85	-3.77	0.88	0.72
230	vq	13.27	9.83	9.13	-3.73	0.86	0.69
231	vq	11.87	9.42	7.32	-3.57	0.78	0.62
232	c	11.89	8.93	6.80	-3.57	0.76	0.57
233	vq	10.00	7.60	7.15	-3.32	0.88	0.72
234	vq	9.76	9.43	8.47	-3.29	0.92	0.87
235	vq	13.37	10.38	7.45	-3.74	0.74	0.56
236	vq	9.68	9.61	8.09	-3.28	0.89	0.84
237	j	12.50	8.90	8.80	-3.64	0.89	0.70
238	c	14.36	8.63	5.81	-3.84	0.65	0.40
239	vq	11.65	8.68	7.65	-3.54	0.83	0.66
240	ca	11.94	9.97	8.40	-3.58	0.84	0.70
241	qzt	10.11	8.20	4.04	-3.34	0.58	0.40
242	j	6.90	6.65	5.16	-2.79	0.83	0.75
243	vq	15.03	10.10	6.67	-3.91	0.66	0.44
244	vq	14.32	12.17	8.03	-3.84	0.72	0.56
245	vq	14.67	9.52	8.69	-3.87	0.81	0.59
246	vq	10.18	9.40	6.12	-3.35	0.73	0.60
247	vq	12.83	12.80	7.36	-3.68	0.69	0.57
248	ca	12.93	11.30	7.32	-3.69	0.72	0.57
249	vq	13.75	9.47	6.05	-3.78	0.66	0.44
250	vq	11.18	9.25	8.32	-3.48	0.87	0.74
251	vq	12.57	9.44	6.93	-3.65	0.74	0.55
252	vq	10.41	8.85	5.53	-3.38	0.69	0.53
253	vq	13.76	12.40	8.07	-3.78	0.73	0.59
254	vq	13.39	9.41	7.07	-3.74	0.73	0.53
255	vq	12.95	10.84	7.58	-3.69	0.74	0.59
256	vq	14.85	10.13	9.48	-3.89	0.84	0.64
257	vq	16.32	10.05	7.39	-4.03	0.69	0.45
258	vq	11.15	9.95	8.42	-3.48	0.86	0.76
259	vq	12.38	8.22	7.22	-3.63	0.80	0.58
260	j	11.98	8.45	7.95	-3.58	0.85	0.66
261	qzt	13.25	10.41	8.45	-3.73	0.80	0.64
262	vq	13.00	9.33	8.03	-3.70	0.81	0.62
263	vq	15.26	10.43	6.68	-3.93	0.65	0.44
264	vq	12.75	9.40	5.49	-3.67	0.63	0.43
265	j	13.05	9.12	6.93	-3.71	0.74	0.53
266	ca	11.11	9.55	8.98	-3.47	0.91	0.81
267	qzt	12.02	9.04	5.81	-3.59	0.68	0.48
268	vq	11.06	7.99	5.93	-3.47	0.74	0.54
269	vq	12.83	8.50	6.62	-3.68	0.74	0.52
270	qzt	11.91	9.15	7.17	-3.57	0.78	0.60

271	c	11.29	11.00	6.93	-3.50	0.73	0.61
272	qzt	12.64	8.54	6.48	-3.66	0.73	0.51
273	qzt	11.71	9.08	7.02	-3.55	0.77	0.60
274	vq	8.95	8.45	6.91	-3.16	0.86	0.77
275	j	12.66	11.11	8.30	-3.66	0.79	0.66
276	qzt	12.10	8.33	7.18	-3.60	0.80	0.59
277	vq	10.91	10.13	6.94	-3.45	0.76	0.64
278	vq	12.65	9.33	5.95	-3.66	0.67	0.47
279	qzt	9.59	8.02	7.42	-3.26	0.89	0.77
280	vq	8.41	7.93	6.29	-3.07	0.84	0.75
281	vq	11.07	9.58	9.22	-3.47	0.93	0.83
282	vq	10.69	8.41	7.01	-3.42	0.82	0.66
283	vq	9.99	7.44	7.26	-3.32	0.89	0.73
284	vq	11.25	8.81	4.78	-3.49	0.61	0.42
285	qzt	11.56	9.49	7.22	-3.53	0.78	0.62
286	vq	9.61	9.60	6.57	-3.26	0.78	0.68
287	vq	10.97	10.40	6.26	-3.46	0.70	0.57
288	vq	12.84	8.94	7.47	-3.68	0.79	0.58
289	c	12.19	9.15	6.53	-3.61	0.73	0.54
290	vq	8.66	7.70	6.78	-3.11	0.88	0.78
291	vq	9.68	7.01	4.14	-3.28	0.63	0.43
292	vq	9.41	8.04	4.59	-3.23	0.65	0.49
293	vq	10.00	6.44	5.81	-3.32	0.81	0.58
294	vq	9.23	8.04	5.99	-3.21	0.78	0.65
295	c	10.65	9.52	5.89	-3.41	0.70	0.55
296	vq	12.37	9.20	6.28	-3.63	0.70	0.51
297	vq	11.45	8.30	5.89	-3.52	0.71	0.51
298	vq	11.33	9.10	6.50	-3.50	0.74	0.57
299	vq	11.74	8.50	6.58	-3.55	0.76	0.56
300	vq	8.50	5.90	5.66	-3.09	0.86	0.67
301	vq	12.79	11.18	5.40	-3.68	0.59	0.42
302	vq	6.98	5.99	4.86	-2.80	0.83	0.70
303	vq	8.17	7.39	4.97	-3.03	0.74	0.61
304	vq	9.30	6.73	6.12	-3.22	0.84	0.66
305	vq	9.03	7.92	5.20	-3.17	0.72	0.58
306	vq	8.63	6.16	5.15	-3.11	0.79	0.60
307	vq	8.73	8.51	6.71	-3.13	0.85	0.77
308	vq	5.64	4.90	4.78	-2.50	0.94	0.85
309	ca	20.43	15.23	12.04	-4.35	0.78	0.59
310	ca	17.43	12.63	11.62	-4.12	0.85	0.67
311	ca	17.74	13.95	12.09	-4.15	0.84	0.68
312	ca	18.09	14.80	8.27	-4.18	0.63	0.46
313	ca	19.57	16.88	13.71	-4.29	0.83	0.70
314	ca	22.59	15.66	13.05	-4.50	0.78	0.58
315	ca	18.08	9.23	7.93	-4.18	0.72	0.44
316	ca	20.33	13.34	9.73	-4.35	0.70	0.48

317	ca	15.18	12.75	8.21	-3.92	0.70	0.54
318	ca	15.17	11.55	7.62	-3.92	0.69	0.50
319	ca	16.18	9.92	9.91	-4.02	0.85	0.61
320	ca	14.47	12.54	11.53	-3.85	0.90	0.80
321	ca	18.50	17.11	11.50	-4.21	0.75	0.62
322	ca	13.05	10.11	9.57	-3.71	0.89	0.73
323	ca	12.93	9.95	8.75	-3.69	0.84	0.68
324	ca	18.19	14.92	12.27	-4.19	0.82	0.67
325	ca	15.42	7.71	6.67	-3.95	0.72	0.43
326	ca	14.75	11.18	9.81	-3.88	0.84	0.67
327	ca	19.11	11.16	10.81	-4.26	0.82	0.57
328	c	20.49	9.55	6.61	-4.36	0.61	0.32
329	ca	17.27	15.22	9.75	-4.11	0.71	0.56
330	ca	15.39	15.28	12.50	-3.94	0.87	0.81
331	ca	19.65	12.01	9.60	-4.30	0.73	0.49
332	ca	12.22	10.62	9.36	-3.61	0.88	0.77

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the northern Nopah Range at Chicago Pass (CP 10). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	52.59	35.70	30.72	-5.72	0.80	0.58
2	vq	26.86	16.64	13.53	-4.75	0.74	0.50
3	vq	17.90	16.25	11.49	-4.16	0.77	0.64
4	vq	9.24	8.46	6.25	-3.21	0.79	0.68
5	vq	23.14	15.12	12.26	-4.53	0.75	0.53
6	vq	17.55	17.15	10.20	-4.13	0.70	0.58
7	vq	12.98	12.32	6.88	-3.70	0.67	0.53
8	vq	13.60	9.99	6.16	-3.77	0.65	0.45
9	vq	15.45	11.59	9.11	-3.95	0.77	0.59
10	vq	20.19	15.38	11.49	-4.34	0.75	0.57
11	vq	36.43	23.11	17.18	-5.19	0.71	0.47
12	vq	18.44	14.35	12.65	-4.20	0.85	0.69
13	vq	47.29	29.67	24.32	-5.56	0.75	0.51
14	vq	34.99	24.50	14.59	-5.13	0.63	0.42
15	vq	30.50	25.09	18.22	-4.93	0.76	0.60
16	vq	21.07	16.82	11.45	-4.40	0.72	0.54
17	vq	13.52	10.26	8.22	-3.76	0.79	0.61
18	qtz	29.24	18.11	12.05	-4.87	0.65	0.41
19	vq	20.47	15.41	13.10	-4.36	0.82	0.64
20	vq	20.98	18.55	12.28	-4.39	0.73	0.59
21	qtz	26.95	16.19	15.69	-4.75	0.83	0.58
22	vq	22.04	14.99	10.50	-4.46	0.69	0.48
23	vq	35.66	28.91	19.77	-5.16	0.72	0.55
24	qtz	31.21	27.27	21.31	-4.96	0.81	0.68
25	c	30.27	22.33	17.22	-4.92	0.76	0.57
26	vq	36.45	27.84	20.29	-5.19	0.74	0.56
27	vq	42.09	37.72	26.19	-5.40	0.76	0.62
28	vq	29.80	22.32	14.99	-4.90	0.70	0.50
29	vq	27.44	24.72	15.70	-4.78	0.71	0.57
30	vq	20.58	12.69	6.50	-4.36	0.54	0.32
31	vq	26.47	20.62	15.29	-4.73	0.75	0.58
32	vq	27.36	13.33	10.82	-4.77	0.68	0.40
33	vq	24.46	20.23	18.37	-4.61	0.88	0.75
34	vq	32.68	19.51	14.18	-5.03	0.68	0.43
35	vq	27.53	22.96	13.74	-4.78	0.67	0.50
36	vq	26.08	21.41	11.26	-4.70	0.61	0.43
37	vq	28.26	19.89	13.50	-4.82	0.69	0.48
38	vq	27.92	20.69	15.30	-4.80	0.74	0.55
39	vq	22.72	20.63	14.21	-4.51	0.76	0.63
40	vq	20.98	17.31	11.32	-4.39	0.71	0.54

41	qtz	27.92	24.57	18.88	-4.80	0.80	0.68
42	qtz	57.96	25.95	20.95	-5.86	0.66	0.36
43	vq	22.55	16.34	13.40	-4.50	0.79	0.59
44	vq	26.77	22.32	19.97	-4.74	0.87	0.75
45	qtz	28.49	21.50	17.85	-4.83	0.80	0.63
46	vq	20.74	15.14	9.30	-4.37	0.65	0.45
47	vq	18.83	12.58	6.01	-4.23	0.53	0.32
48	qtz	18.96	15.24	10.50	-4.24	0.73	0.55
49	vq	23.80	14.88	8.01	-4.57	0.57	0.34
50	vq	18.85	14.41	8.68	-4.24	0.65	0.46
51	qtz	19.52	15.50	10.86	-4.29	0.73	0.56
52	vq	12.11	10.09	7.64	-3.60	0.78	0.63
53	vq	13.27	10.73	7.48	-3.73	0.73	0.56
54	vq	12.35	10.16	8.27	-3.63	0.82	0.67
55	vq	18.89	13.49	8.29	-4.24	0.65	0.44
56	qtz	16.47	14.10	12.06	-4.04	0.86	0.73
57	vq	14.55	10.43	8.30	-3.86	0.77	0.57
58	vq	20.81	13.52	9.40	-4.38	0.68	0.45
59	vq	18.29	14.74	11.51	-4.19	0.79	0.63
60	vq	11.52	7.81	6.89	-3.53	0.81	0.60
61	vq	16.33	15.63	6.34	-4.03	0.54	0.39
62	qtz	16.84	12.71	6.77	-4.07	0.60	0.40
63	vq	17.14	16.65	10.95	-4.10	0.75	0.64
64	vq	14.91	11.95	8.95	-3.90	0.77	0.60
65	qtz	18.58	16.02	9.64	-4.22	0.68	0.52
66	qtz	15.73	12.88	9.58	-3.98	0.77	0.61
67	vq	16.20	11.82	9.80	-4.02	0.79	0.60
68	vq	20.36	12.90	11.89	-4.35	0.81	0.58
69	qtz	17.50	12.42	6.63	-4.13	0.59	0.38
70	vq	12.33	11.62	5.78	-3.62	0.62	0.47
71	vq	14.28	13.33	9.29	-3.84	0.77	0.65
72	vq	15.99	11.02	10.91	-4.00	0.88	0.68
73	vq	11.11	10.12	8.10	-3.47	0.84	0.73
74	vq	12.27	9.46	8.66	-3.62	0.86	0.71
75	vq	14.26	11.33	7.36	-3.83	0.69	0.52
76	vq	9.42	9.35	5.90	-3.24	0.73	0.63
77	qtz	13.05	8.37	8.31	-3.71	0.86	0.64
78	qtz	24.37	20.77	10.94	-4.61	0.62	0.45
79	c	27.98	18.74	10.66	-4.81	0.60	0.38
80	qtz	38.50	24.84	24.06	-5.27	0.85	0.62
81	qtz	27.83	19.56	13.21	-4.80	0.68	0.47
82	qtz	23.54	16.46	10.70	-4.56	0.67	0.45
83	vq	16.77	13.33	9.32	-4.07	0.73	0.56
84	qtz	40.00	25.54	22.70	-5.32	0.80	0.57
85	qtz	19.33	17.20	10.87	-4.27	0.71	0.56
86	vq	29.97	26.12	14.41	-4.91	0.64	0.48

87	qtz	29.05	21.22	16.26	-4.86	0.75	0.56
88	qtz	16.75	14.28	9.86	-4.07	0.74	0.59
89	qtz	29.11	17.83	17.18	-4.86	0.83	0.59

Three dimensional clast measurement data for the middle member of the Wood Canyon Formation in the northern Nopah Range at Chicago Pass (CP 11). Identified clast types are vein quartz (vq), quartzite (qtz), chert (c), chalcedony (ca), jasper (j), felsic volcanic (volcanic), and metamorphic (meta).

Sample #	Clast Type	Long	Medium	Short	Phi	Sphericity	S/L
1	vq	38.63	24.36	23.74	-5.27	0.84	0.61
2	vq	52.37	20.50	17.94	-5.71	0.67	0.34
3	vq	37.56	26.23	18.11	-5.23	0.69	0.48
4	vq	35.77	21.17	15.22	-5.16	0.67	0.43
5	vq	30.07	27.31	17.58	-4.91	0.72	0.58
6	vq	27.44	25.59	21.90	-4.78	0.88	0.80
7	vq	20.22	17.26	13.81	-4.34	0.82	0.68
8	vq	33.39	25.15	15.42	-5.06	0.66	0.46
9	vq	34.11	21.71	13.19	-5.09	0.62	0.39
10	vq	25.89	22.11	18.29	-4.69	0.84	0.71
11	vq	23.55	21.58	14.78	-4.56	0.75	0.63
12	vq	36.78	25.63	15.19	-5.20	0.63	0.41
13	vq	35.01	23.19	19.22	-5.13	0.77	0.55
14	vq	42.44	18.41	16.31	-5.41	0.70	0.38
15	vq	31.42	20.93	15.83	-4.97	0.72	0.50
16	vq	28.62	22.70	20.75	-4.84	0.87	0.73
17	qzt	48.72	29.11	12.61	-5.61	0.48	0.26
18	vq	24.14	16.04	14.03	-4.59	0.80	0.58
19	qzt	25.61	19.03	17.40	-4.68	0.85	0.68
20	vq	27.03	21.88	21.09	-4.76	0.91	0.78
21	vq	32.91	21.13	19.86	-5.04	0.83	0.60
22	vq	25.29	22.25	14.36	-4.66	0.72	0.57
23	vq	20.28	14.97	14.36	-4.34	0.88	0.71
24	vq	28.17	14.61	11.53	-4.82	0.69	0.41
25	vq	27.93	19.15	18.08	-4.80	0.85	0.65
26	vq	24.10	16.42	14.69	-4.59	0.82	0.61
27	vq	18.49	13.76	10.76	-4.21	0.77	0.58
28	vq	20.93	18.95	14.77	-4.39	0.82	0.71
29	vq	33.66	22.63	10.88	-5.07	0.54	0.32
30	vq	26.12	16.97	12.49	-4.71	0.71	0.48
31	vq	33.46	21.18	17.79	-5.06	0.76	0.53
32	vq	30.69	18.64	17.87	-4.94	0.82	0.58
33	qzt	28.71	23.97	16.11	-4.84	0.72	0.56
34	vq	26.56	23.97	17.28	-4.73	0.78	0.65
35	vq	29.49	18.42	14.58	-4.88	0.73	0.49
36	qzt	24.02	18.17	14.77	-4.59	0.79	0.61
37	vq	36.23	20.38	14.37	-5.18	0.65	0.40
38	qzt	28.84	20.28	19.91	-4.85	0.88	0.69
39	qzt	41.36	30.83	18.18	-5.37	0.64	0.44
40	vq	46.24	22.88	21.86	-5.53	0.77	0.47

41	vq	36.60	24.48	17.21	-5.19	0.69	0.47
42	vq	26.50	18.38	15.35	-4.73	0.79	0.58
43	j	32.63	23.99	20.12	-5.03	0.80	0.62
44	j	55.90	37.41	22.03	-5.80	0.61	0.39
45	vq	24.55	18.37	11.69	-4.62	0.67	0.48
46	vq	24.60	16.05	7.52	-4.62	0.52	0.31
47	vq	21.66	19.65	15.84	-4.44	0.84	0.73
48	vq	20.10	19.39	15.46	-4.33	0.85	0.77
49	vq	40.90	17.66	12.19	-5.35	0.59	0.30
50	vq	31.35	22.65	18.78	-4.97	0.79	0.60
51	vq	28.83	21.30	15.82	-4.85	0.74	0.55
52	vq	28.86	26.64	16.99	-4.85	0.72	0.59
53	vq	33.62	19.49	18.33	-5.07	0.80	0.55
54	vq	15.75	14.92	8.59	-3.98	0.68	0.55
55	vq	23.38	19.74	10.10	-4.55	0.60	0.43
56	vq	24.67	21.13	10.07	-4.62	0.58	0.41
57	vq	23.38	18.27	14.78	-4.55	0.80	0.63
58	vq	27.94	23.17	13.85	-4.80	0.67	0.50
59	vq	27.57	17.61	13.87	-4.79	0.73	0.50
60	vq	22.70	23.05	14.95	-4.50	0.75	0.66
61	vq	30.45	19.89	14.68	-4.93	0.71	0.48
62	vq	28.93	20.54	16.13	-4.85	0.76	0.56
63	vq	19.09	14.11	11.21	-4.25	0.78	0.59
64	vq	35.15	28.61	15.52	-5.14	0.62	0.44
65	j	39.00	17.89	15.13	-5.29	0.69	0.39
66	vq	27.99	14.33	12.61	-4.81	0.73	0.45
67	vq	22.83	18.52	11.89	-4.51	0.69	0.52
68	vq	28.91	20.95	20.40	-4.85	0.88	0.71
69	vq	20.94	13.98	11.71	-4.39	0.78	0.56
70	vq	22.22	16.47	13.64	-4.47	0.80	0.61
71	vq	29.39	18.34	14.03	-4.88	0.71	0.48
72	vq	22.17	20.84	17.87	-4.47	0.88	0.81
73	vq	26.60	21.56	18.73	-4.73	0.85	0.70
74	vq	22.02	16.46	15.00	-4.46	0.85	0.68
75	vq	20.70	15.63	10.02	-4.37	0.68	0.48
76	vq	21.53	17.78	11.42	-4.43	0.70	0.53
77	vq	22.79	16.94	13.55	-4.51	0.78	0.59
78	vq	17.73	15.11	8.75	-4.15	0.66	0.49
79	vq	19.95	16.40	14.93	-4.32	0.88	0.75
80	vq	22.41	20.00	11.84	-4.49	0.68	0.53
81	qzt	21.60	16.00	13.09	-4.43	0.79	0.61
82	vq	25.53	17.63	11.87	-4.67	0.68	0.46
83	vq	16.14	14.96	12.14	-4.01	0.85	0.75
84	vq	19.57	18.59	13.39	-4.29	0.79	0.68
85	vq	15.78	15.61	11.14	-3.98	0.80	0.71
86	vq	24.10	18.08	11.57	-4.59	0.67	0.48

87	vq	16.90	12.67	10.80	-4.08	0.82	0.64
88	vq	22.55	17.37	11.91	-4.50	0.71	0.53
89	vq	18.66	15.77	10.77	-4.22	0.73	0.58
90	vq	22.21	17.11	10.32	-4.47	0.65	0.46
91	vq	20.41	12.60	9.95	-4.35	0.73	0.49
92	vq	19.58	16.54	12.16	-4.29	0.77	0.62
93	vq	19.62	11.11	7.89	-4.29	0.66	0.40
94	vq	20.81	13.25	9.95	-4.38	0.71	0.48
95	vq	15.28	12.76	6.36	-3.93	0.59	0.42
96	vq	16.50	14.75	8.70	-4.04	0.68	0.53
97	vq	15.18	12.78	9.60	-3.92	0.78	0.63
98	vq	16.41	11.18	8.77	-4.04	0.75	0.53
99	vq	12.44	12.07	9.10	-3.64	0.82	0.73
100	vq	15.01	9.96	7.61	-3.91	0.73	0.51
101	vq	17.71	17.67	14.72	-4.15	0.88	0.83
102	ca	17.35	14.86	11.66	-4.12	0.81	0.67
103	vq	17.87	15.03	13.91	-4.16	0.90	0.78
104	qzt	17.91	15.71	10.23	-4.16	0.72	0.57
105	c	18.83	15.05	11.96	-4.23	0.80	0.64
106	vq	13.21	11.61	7.80	-3.72	0.73	0.59
107	vq	16.33	13.44	11.20	-4.03	0.83	0.69
108	qzt	16.08	13.40	8.19	-4.01	0.68	0.51
109	vq	12.92	10.43	9.94	-3.69	0.90	0.77
110	vq	12.40	10.95	8.45	-3.63	0.81	0.68
111	vq	11.80	8.31	4.22	-3.56	0.57	0.36
112	vq	17.11	10.73	9.26	-4.10	0.78	0.54
113	vq	13.18	11.92	9.31	-3.72	0.82	0.71
114	vq	11.36	8.16	7.71	-3.51	0.86	0.68
115	vq	14.68	10.80	9.18	-3.88	0.81	0.63
116	vq	11.92	8.99	6.80	-3.58	0.76	0.57
117	vq	12.41	10.46	7.85	-3.63	0.78	0.63
118	vq	52.30	21.95	19.09	-5.71	0.68	0.37
119	vq	9.77	8.74	5.45	-3.29	0.70	0.56
120	vq	9.29	7.55	6.62	-3.22	0.85	0.71
121	vq	8.03	6.95	3.46	-3.01	0.60	0.43
122	vq	9.73	7.12	4.69	-3.28	0.68	0.48
123	vq	6.57	5.24	3.79	-2.72	0.75	0.58
124	vq	7.56	6.21	5.02	-2.92	0.81	0.66

VITA

Eric Hogan was born in East Point, GA on April 24, 1986 and grew up in Sharpsburg, GA. He graduated from Northgate High School in 2004 and received his B.S. in geology from the University of Georgia in Athens, GA. Eric is currently perusing his M.S. in geology from the University of Tennessee in Knoxville, TN and will soon be starting a career with ExxonMobil as a petroleum geoscientist.