The Middle Jurassic Elko Orogeny - A Major Tectonic Event in Nevada-Utah

By
Charles H. Thorman[1] and Fred Peterson[2]

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[1]U.S. Geological Survey, Emeritus, Denver, Colorado 80225 and CTGS Intl., Inc., 12464 W. 2nd Drive, Lakewood, CO 80228 (cthorman@comcast.net)
[2]U.S. Geological Survey, Emeritus, Denver, Colorado 80225

Introduction

The Middle Jurassic Elko orogeny extended from central Nevada to central Utah (Figures 1 and 2). Its age and nature are based on direct and indirect evidence. The youngest unit involved is lower Middle Jurassic sandstone near Currie, Nevada. Late- to post-tectonic upper Middle Jurassic plutons (155 to 165 Ma) cut structural and regional metamorphic features throughout the region. Central Nevada to central Utah has undergone a continuum of eastward-progressive deformational pulses from the Middle Paleozoic to Early Tertiary. Each successive orogenic event resulted in the superposition of structures. This has made it difficult to determine the age of many structures because of their similarity in style where crosscutting relationships do not exist. These events commenced with the Antler orogeny (Late Devonian-Middle Mississippian) and continued with the Humboldt (Late Pennsylvanian), Sonoma (Late Permian-Early Triassic), Elko, and Sevier (middle Early Cretaceous-Early Tertiary) orogenies.

A Middle Jurassic foredeep in western Utah along the leading edge of the Elko orogenic belt is inferred from Middle Jurassic strata in central Utah, which thicken westward towards the Colorado Plateau-Basin and Range border. Equivalent strata are not preserved in the Basin and Range of western Utah. Therefore, the depocenter of the westward expanding sedimentary sequence was in western Utah, and possibly easternmost Nevada, but was uplifted and eroded during the Sevier orogeny. The existence of a Middle Jurassic foredeep subsequently uplifted and eroded during the Sevier orogeny is compatible with an orogenic belt to the west and provides a plausible explanation for the missing westward thickening wedge.

The Elko orogeny includes extensional structures, making it somewhat different from the Cretaceous Sevier orogeny in the Paleozoic miogeocline of eastern Nevada-western Utah. Sevier structures typically are contractional with eastward vergence and included large-scale crustal shortening. In contrast, comparable large-scale crustal shortening of Middle Jurassic age has yet to be demonstrated, though many Elko structures indicate crustal shortening occurred. Low-angle and high-angle extensional faulting has been documented in numerous ranges as being Middle Jurassic in age. Both orogenies involved younger-over-older low-angle and bedding-parallel faulting, and older-over-younger thrusting.

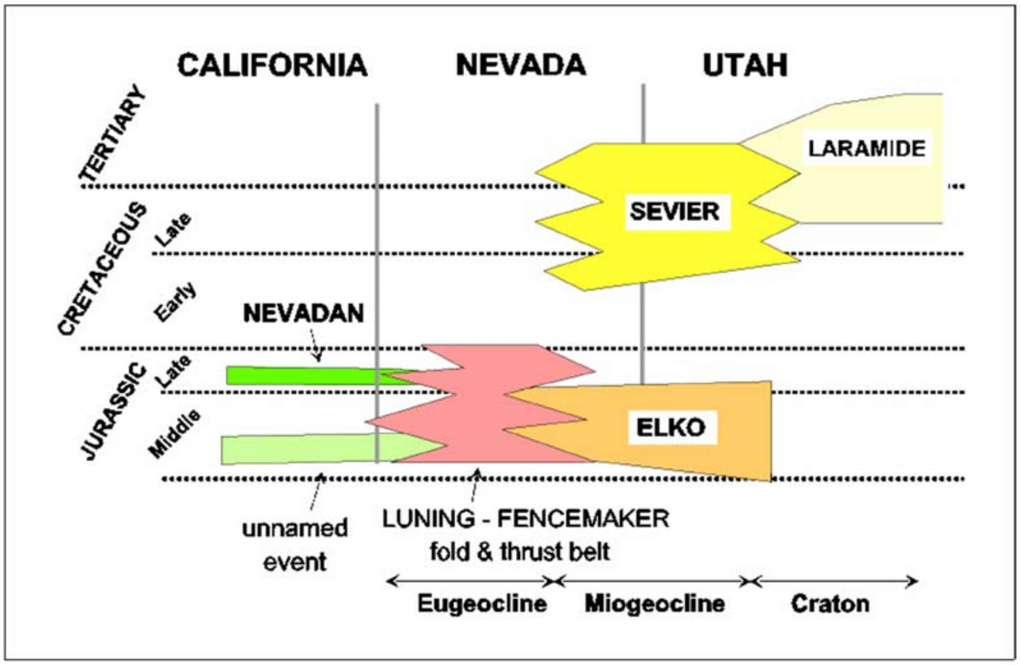

Figure 1. Diagram showing temporal and spatial relationships between the Elko orogeny and other Jurassic to Tertiary deformational events in the region.

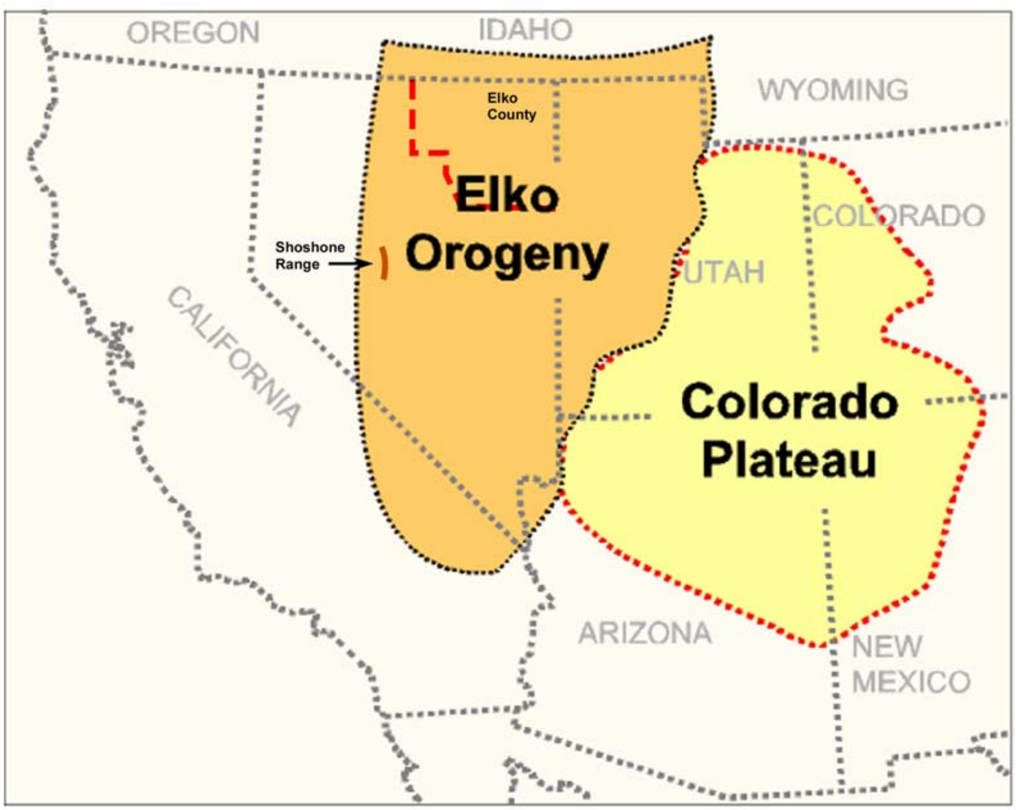

Figure 2. Map showing general area of Elko orogeny in eastern Nevada and western Utah.

Why Name A New Orogeny?

Why name a new orogeny when it is clear that deformation along the western margin of North America has been continuous and we could include Jurassic deformation in the younger Sevier orogeny? The same question may be asked in stratigraphic nomenclature. Why name a new formation when one could just as easily expand the definition of an existing formation? The answer to both questions is the same. When one can better, more accurately describe an event or rock unit and put it in its proper position relative to other events or units, then it is appropriate to do so by assigning a new name. In the case of the Elko orogeny, it is presented with two main objectives.

- First, this is a major event in the Middle Jurassic that can be closely dated and defines deformation over a large area.
- Second, it maintains the significance of the Sevier orogeny as a major Cretaceous-Early Tertiary event that is well dated. Only by recognizing these as separate events in an overall continuum of deformation along the western margin of North America can we better describe the evolution of the region.

The Elko Orogeny

Middle to Late Mesozoic deformation has long been recognized from central Nevada to western Utah, but until the mid-1980s it was difficult to determine how many orogenic events might have occurred during the time from Jurassic to Early Tertiary. Further, if more than one orogenic event occurred, what were the areal extent and tectonic signatures of those events? Dating of deformed rock units and crosscutting plutonic rocks is essential to determine the number of events and their ages in a deformed region. As noted, several orogenies are recognized in the region, and the ages of most of these are based on the extent of areal unconformities. Whereas the ages of deformed Paleozoic and Mesozoic sedimentary and volcanic units have been well established since the 1950s or earlier, the more recent dating of a multitude of plutons made it apparent that at least two orogenic events have occurred between Middle Jurassic and early Tertiary time. It can now be clearly demonstrated that the Middle Jurassic Elko orogeny is temporally and physically distinct from the Cretaceous Sevier orogeny though it occurred in the same general region. The Elko orogeny (Thorman et al., 1990, 1992) is so named because much of the evidence for the age of deformation is in Elko County.

Gilluly and Gates (1965) named a deformational event in the northern Shoshone Range the Lewis orogeny. They considered the Lewis orogeny to be of probable Mesozoic age, suggesting that it may be Jurassic in age, but pointed out that relationships did not allow such a restricted determination. Lower Triassic rocks are the youngest involved in thrusting in the range and are overlain by Miocene units. Apparently, due to the broad age span suggested for the Lewis orogeny, it has not been incorporated into the tectonic nomenclature of the region.

In 1968, Armstrong defined the Sevier orogeny as a late Early Cretaceous to earliest Tertiary contractional event that involved large-scale eastward-directed thrusting of

Upper Precambrian to Cretaceous units. The frontal overthrust belt of the Sevier extends from southwestern Wyoming southward through western Utah to southern Nevada. Central to eastern Nevada was the hinterland of the Sevier. A foredeep formed in west-central Utah in front of the fold and thrust belt and was the depocenter for thousands of feet of clastic debris. The Sevier orogeny is a major contractional event whose structures dominate eastern Nevada and western Utah.

However, as the dating of plutons in central and eastern Nevada and western Utah progressed, it became clear that a suite of late Middle Jurassic (~165-155 Ma) plutons extends from California across northern Nevada and into northwestern Utah and that many of these plutons crosscut deformed rocks ranging in age from Cambrian through Early Jurassic. Thus, a Mesozoic event that predates the Sevier orogeny occurred in essentially the same region as the Sevier. Where structures are not cut by plutons, the structures cannot be dated more closely than being younger than the rocks involved and older than unconformably overlying units. Prior to this time, it was generally accepted practice to consider all deformation of Paleozoic-Mesozoic rocks in eastern Nevada and western Utah as being of Sevier age.

Elko Orogeny Structures

The Elko orogeny includes structural features and styles like those of orogenies along the western margin of North America from Middle Paleozoic to Early Cenozoic. Eastward-directed contractional deformation in the form of older-over-younger and younger-over-older faulting is a major style. In some instances, younger-over-older faults that could be interpreted as having cut out large amounts of strata may in fact be small-displacement structures that are disrupted unconformities. Genetically related to the contractional faulting are abundant high-angle east- to east-southeast-trending tear/strike-slip faults in the allochthonous rocks. The magnitude of slip along tear faults is probably small in most instances, though it is difficult, to impossible, to determine because juxtaposed units are commonly of the same or similar age and facies; however, in a few instances, displacements probably are large. Several of these tear faults are interpreted to be controlled by the upward propagation of major basement flaws/structures of Paleozoic and(or) Precambrian age (Thorman and Ketner, 1979; Thorman et al., 1991). Many of the tear faults were reactivated as tear faults during Sevier thrusting and as normal faults during Cenozoic Basin-and-Range deformation.

Regionally metamorphosed eastern/carbonate facies of Paleozoic strata, some of which are folded on a scale of 100s of meters, are intruded by post-metamorphic upper Middle Jurassic plutons in several ranges. Large-scale folding of Elko age appears to be uncommon. Outcrop- and smaller-scale folding has been observed in the regionally metamorphosed rocks. Extensional tectonic features have been documented in several ranges. In contrast to the Sevier orogeny, no large-scale thrusting and deep tectonic burial have been documented as being of Elko age.

Age of the Elko Orogeny

The upper and lower age limits of the Elko orogeny are well bracketed. Its upper age is limited by the upper Middle Jurassic (165-155 Ma) crosscutting, typically post-tectonic, plutons. These plutons commonly have an east-west elongation and many were emplaced along pre-existing high-angle tear faults noted above. Lower Middle Jurassic sedimentary units are the youngest based on the involvement of Nugget/Aztec-equivalent age strata at Currie, northeast Nevada.

Elko Orogenic Foredeep

We propose that an Elko foredeep developed along the leading edge of the deformed belt in western Utah. For many years, the abrupt westward termination of rapidly thickening Middle Jurassic units at the western edge of the Gunnison/Colorado Plateau did not have an adequate explanation. The foredeep, which was uplifted and eroded during the Cretaceous Sevier orogeny, is inferred from stratigraphy along the western margin of the Plateau and formed along the leading eastern edge of the orogenic belt in western Utah.

The Elko foredeep interpretation presents a logical explanation for the westward-expanding Middle Jurassic sequence that terminates at the Gunnison/Colorado Plateau-Basin and Range boundary. The Middle Jurassic San Rafael Group thickens rapidly to the west onto the Gunnison Plateau, and rocks of comparable age have not been found farther west. Foredeep accommodation decreased from early to late Middle Jurassic time, as indicated by reduced depositional rates upward from the Temple Cap to the Carmel-Arapien-Twin Creek to the Curtis-Summerville formations of the San Rafael Group (Figure 3). The [upper Middle] Upper Jurassic Morrison Formation (155-148 Ma) marks the end of the Elko orogeny, and it is succeeded by the Cedar Mountain Group. A +/- 20-Ma hiatus separates the Morrison and Cedar Mountain. Clasts in the Morrison Formation on the Colorado Plateau were derived from miogeoclinal facies of Pennsylvanian and Permian rocks in eastern Nevada and/or western Utah. Red and green chert pebbles in the Morrison probably came from eugeoclinal Ordovician rocks farther west in central Nevada. Over a large area in western Utah-eastern Nevada, Lower to Middle Paleozoic strata are the youngest preserved units and are interpreted as the source for these clasts.

Hydrocarbon and Mineral Deposits

The role of the Elko orogeny in the formation and accumulation of hydrocarbons in eastern Nevada and western Utah is not well understood at the present time. Burial depths, and subsequent maturation, of Paleozoic and Lower Mesozoic strata prior to and during the Elko for the majority of the region undoubtedly differed little, if any, from that calculated for Sevier time. No major mineral deposits of Elko age are documented in eastern Nevada-western Utah. Mineralization related to the plutons formed predominantly small to moderate polymetallic base-metal deposits with subordinate gold. It is of major importance, however, to note that Elko-age mineralization was strongly controlled by the E- to ESE-trending faults and related structures. This being the case, migration of hydrocarbons at the Elko was most certainly influenced by these same structures. Thus, Mesozoic migration of hydrocarbons controlled by structures most likely began, at a minimum, in Middle Jurassic time. The superposition of Sevier deformation ~30-50 Ma later probably disrupted traps, resulting in the loss of the trapped hydrocarbons or their migration to other sites. Cenozoic Basin-and-Range deformation, both high-angle range-bounding and low-angle extensional faults further disrupted traps, though in several instances the low-angle faults formed the traps that presently produce most of Nevada's oil.

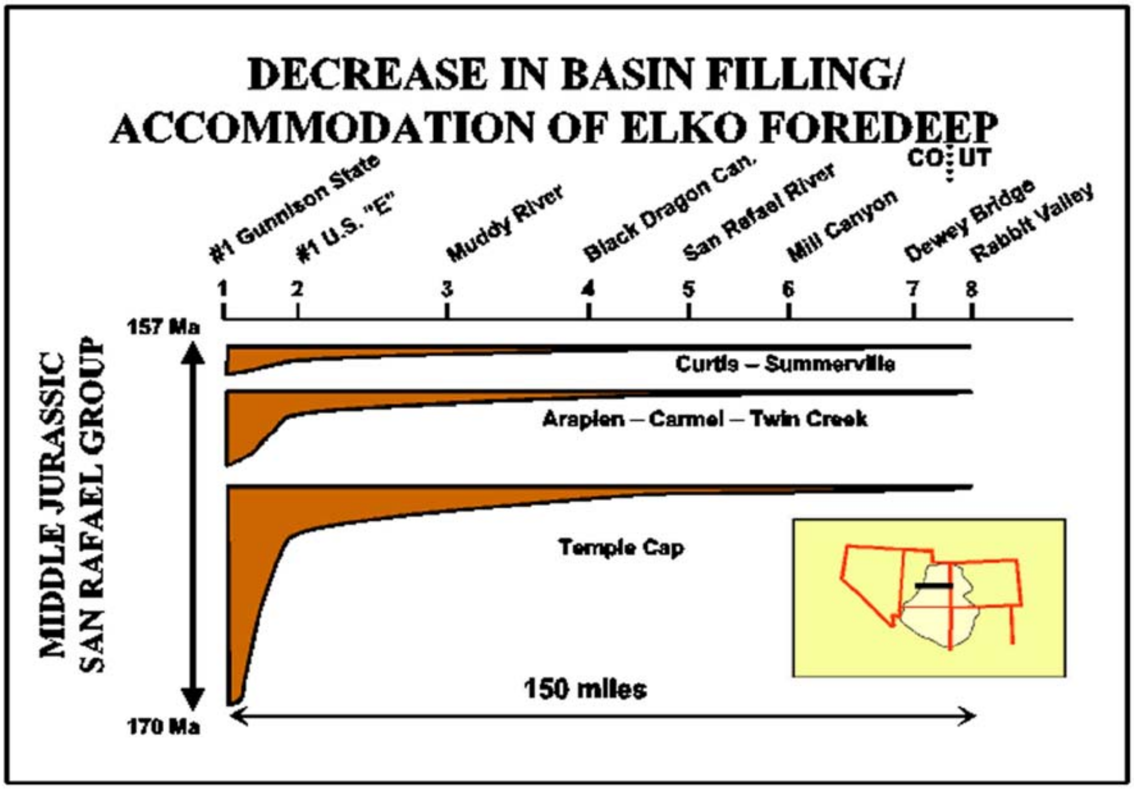

Figure 3. Diagrammatic east-west section from Colorado-Utah state line westward to the edge of the Gunnison Plateau showing the rapid increase in thickness and its abrupt termination within the Middle Jurassic San Rafael Group.

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