CRUSTAL STRUCTURE AND ITS RELATION TO GOLD BELTS IN NORTH-CENTRAL NEVADA: OVERVIEW AND PROGRESS REPORT

By V. J. S. Grauch

ABSTRACT

A schematic cross-sectional view of the crustal structure across north-central Nevada was derived from results presented in papers in this section. The main elements of this preliminary view are that deeply penetrating fault zones generally coincide with the Carlin and Battle Mountain-Eureka mineral trends and separate large blocks of dominantly carbonate upper crust. The faults may be the underlying controls on the alignment of mineral deposits. Many questions remain about the tectonic evolution of the crustal structure and the relation between crustal structure and mineralization processes.

INTRODUCTION

Much attention has been given to alignments of mineral deposits in Nevada since Roberts (1966) first named some mineral belts and described their association with the alignment of structural windows in the Roberts Mountains allochthon. Exploration for new discoveries along these alignments has been fairly successful for sediment-hosted disseminated ("Carlin-type") gold deposits along the Carlin and Battle Mountain-Eureka mineral trends in north-central Nevada (fig. 1). These mineral alignments are commonly attributed to pre-Tertiary structural features that regionally controlled the spatial distribution of structural windows and mineralization (for example Shawe, 1991). However, geologic evidence for deep-seated regional structures is indirect.

This section includes three papers describing geophysical and geochemical-isotopic methods applied to understanding different aspects of subsurface crustal structure in north-central Nevada. The resultant view of the subsurface crustal structure (presented below) helps us understand the tectonic evolution of deep-seated regional structures or crustal provinces and their role in controlling the spatial distribution of mineral deposits at the surface. The paper by Grauch and others (this volume) applies gravity, magnetic, seismic-reflection, and magneto-telluric methods to develop a preliminary cross-sectional model of crustal structure across the Battle Mountain-Eureka trend. The paper by Rodriguez (this volume) presents a preliminary magnetotelluric profile model across both the Battle Mountain-Eureka and Carlin trends. Wooden and others (this volume) use Pb and Sr isotopes collected from igneous rocks across north-central Nevada to map crustal provinces and infer their origin.

VIEWING THE SUBSURFACE

Geophysical and geochemical-isotopic methods can provide evidence of major subsurface structures and changes in crustal composition insofar as they are expressed by changes

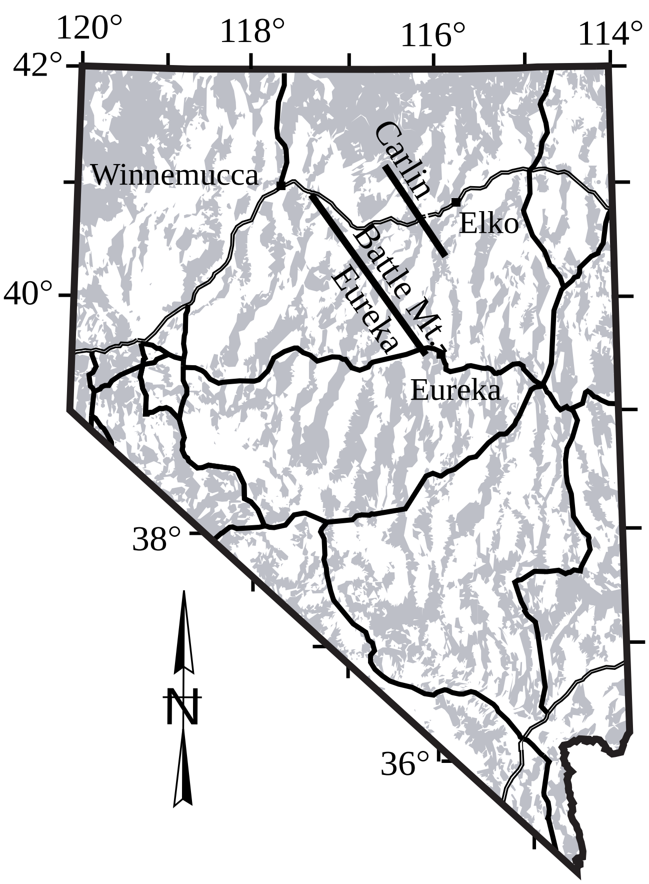


Figure 1. Location of Battle Mountain-Eureka mineral belt and the Carlin trend in Nevada. Outline of modern ranges (shaded) and major roads are also shown.

in rock properties or can be understood from chemical analyses of rocks at the surface. Geochemical-isotopic methods also provide information on crustal structure at different times. However, each method only provides information about certain aspects of the overall crustal structure, which necessitates an integrated approach combining several different geophysical methods, geochemical-isotopic studies, and constraints from geologic knowledge.

Figure 2 demonstrates the range of data available from geophysical and geochemical-isotopic studies for integration into a preliminary picture of crustal structure. These data are described in more detail in the previous papers contained in this section. The figure also exemplifies how information from the data sets can be complimentary. Shown are the basement gravity map (Grauch and others) and Pb and Sr isotopic province boundaries (Wooden and others). The basement gravity data show changes in density in the upper crust that are related to lithologic changes and/or regional structures. In particular, an abrupt change in density coincides with the Battle Mountain-Eureka mineral belt (Grauch and others, 1995). The isotopic provinces provide information about chemical compositions in the middle and lower crust in the past. As shown on figure 2, the Carlin trend coincides with a boundary between two Pb isotopic provinces and the northern part of the Battle Mountain-Eureka trend coincides with a deflection in the another province boundary (Wooden and others, this volume). The basement-gravity and Pb-Sr isotopic province boundaries together provide evidence that deep-seated regional structures and changes in crustal composition are related to the mineral trends.

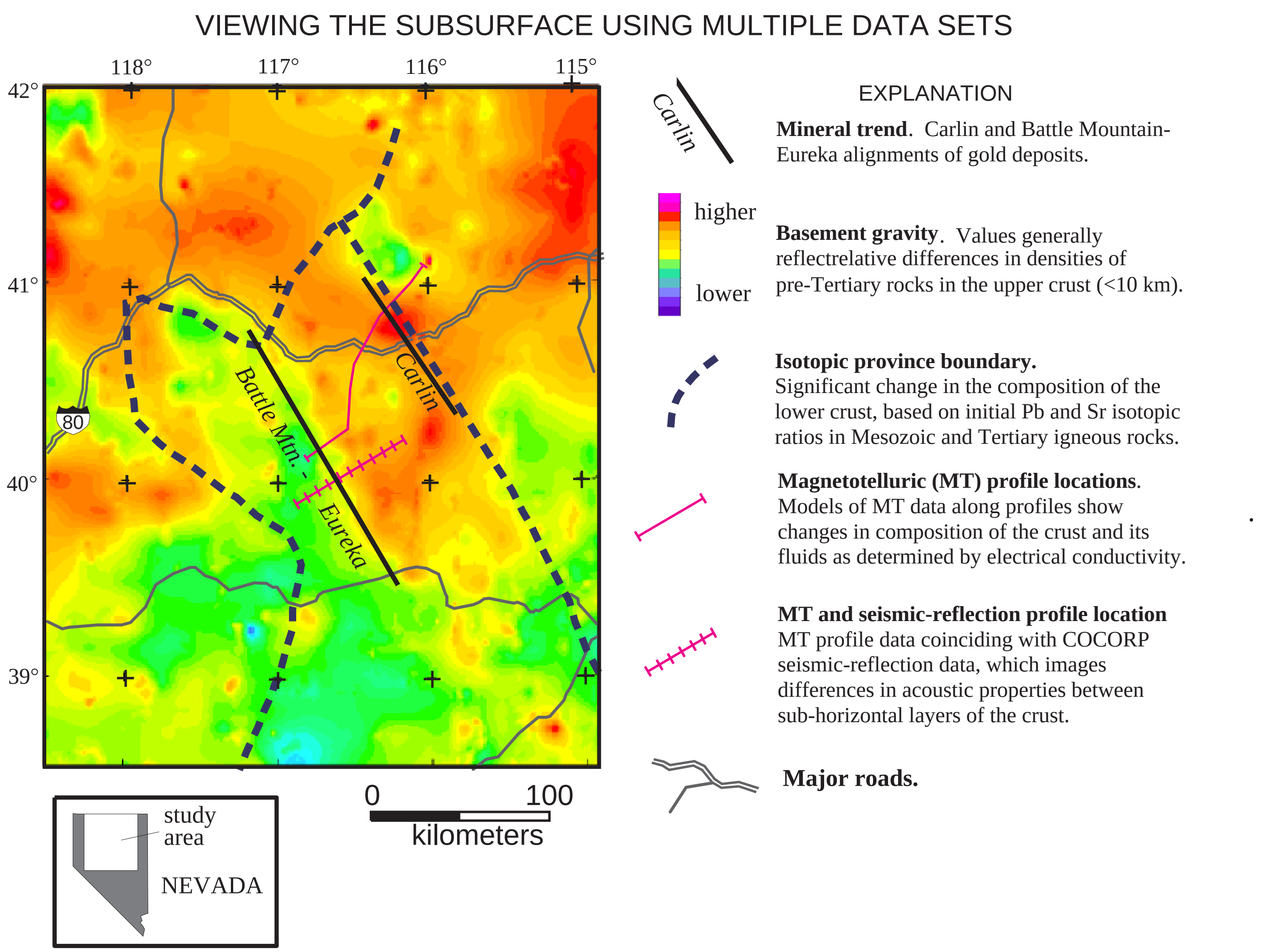
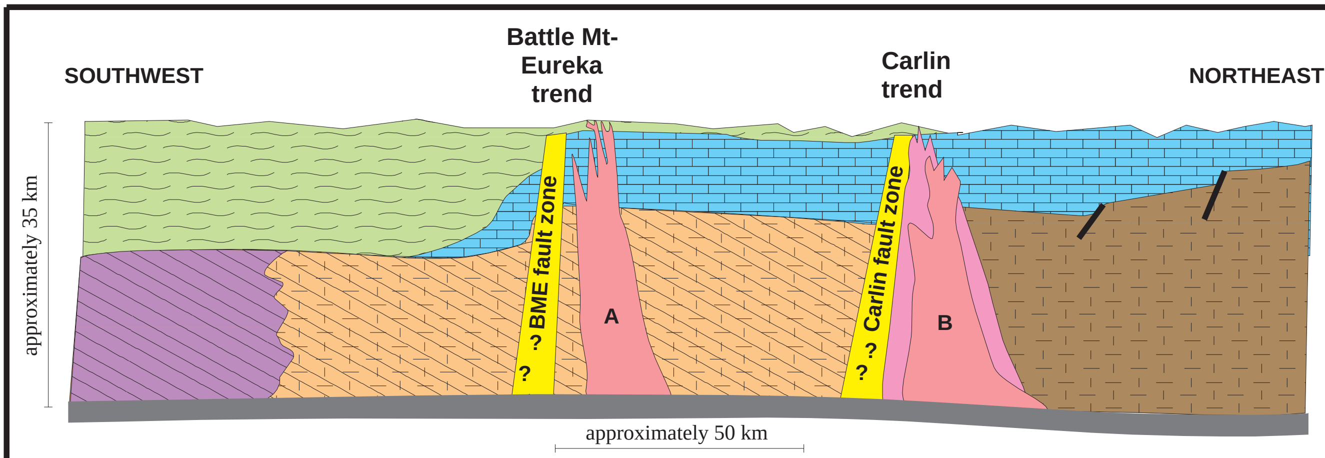


Figure 2. Map of basement gravity values overlain by isotopic province boundaries and locations of magnetotelluric and seismic-reflection profiles. Magnetic data cover the same map area but are not shown



KEY	INTERPRETED ELEMENT	EVIDENCED IN WHICH DATA SET(S)
	Fault zone that probably served as a conduit for mineralizing fluids. First formed during development of a passive margin in Late Precambrian and reactivated during subsequent tectonic events.	BME fault zone: MT, basement gravity Carlin fault zone: MT, isotopic data
	Intrusions. A: Extensive, linear, rift and magmatic system formed after Carlin-type mineralization. B: Multiple intrusions localized near southern end of Carlin trend, emplaced before and during Carlin-type mineralization.	MT, magnetic data, geology
	Dominantly carbonate rocks, thrusted and extended.	Basement gravity, MT, geology
	Dominantly clastic and volcanic rocks, thrusted and extended.	Basement gravity, MT, geology
	Continental crust.	Isotopic data
	Dominantly oceanic crust.	Isotopic data
	Transitional crust.	Isotopic data
	Moho (base of the crust)	Seismic-reflection data

Figure 3. Schematic southwest-northeast cross-section across the Battle Mountain-Eureka and Carlin trends showing a preliminary hypothesis of the crustal structure. The table explains each interpreted element and which data set(s) provide(s) the evidence.

PRELIMINARY HYPOTHESIS

Integration of the results given by the papers in this section provides a schematic cross-sectional view of the crustal structure across the Battle Mountain-Eureka and Carlin trends along a southwest-northeast line (fig. 3). The major elements of the cross-section are as follows:

Fault zones: Deep crustal penetrating fault zones generally coinciding with the Battle Mountain-Eureka and Carlin trends are evident from electrically conductive zones in magnetotelluric data (Grauch and others, this volume; Rodriguez, this volume). Additional evidence for a fault coinciding with the Battle Mountain-Eureka trend is provided by the abrupt, linear change in gravity values in the basement gravity map (fig. 2). The geochemical-isotopic studies (Wooden and others, this volume) suggest the faults separate large crustal blocks of differing lithology or chemistry. These blocks probably originated during Late Proterozoic continental rifting, and remained fairly intact during reactivation of the faults in subsequent tectonic events (Tosdal and Wooden, 1997; Wooden and others, this volume).

Intrusions: Large intrusions are shown near the mineral trends on figure 3, but they are not consistently located next to the fault zones in map view. The intrusion near the Battle Mountain-Eureka trend (A, fig. 3) is associated with the mid-Miocene northern Nevada rift of Zoback and others (1994). The rift diverges from the mineral belt toward the north and northeast. It was formed after most of the mineral deposits along the trend (Maher and others, 1993; Seedorff, 1991). The intrusion shown near the Carlin trend (B, fig. 3) does not extend to the northwest and southeast beyond the middle of the trend. It consists of intrusions of Jurassic, Cretaceous, and Eocene age (Teal and Jackson, 1997).

East-west change in upper crust composition: The Battle Mountain-Eureka trend coincides with a change from lower-density, lower-resistivity upper crust on the southwest to high-density, high-resistivity upper crust on the northeast, as evidenced in basement gravity and magnetotelluric data (Grauch and others, this volume; Rodriguez, this volume). The western upper crust is interpreted as dominantly clastic and volcanic (eugeoclinal) rocks and the eastern upper crust as dominantly carbonate (miogeoclinal) rocks. Both the western and eastern upper crusts consist of numerous thrust sheets and extensional blocks, as evidenced at the surface. However, these structures lack much expression at deeper levels of the crust, as inferred from the geophysical data (fig 2; Grauch and others, this volume; Rodriguez, this volume).

West to east progression from oceanic to continental crust: Isotopic provinces indicate a progression from dominantly oceanic crust on the west to relatively unmodified continental crust on the east (Wooden and others, this volume). The change from transitional crust to continental crust occurs abruptly at the Carlin trend.

The general coincidence of the fault zones and the mineral belts suggest that the deeply penetrating faults focused magmatism and hydrothermal circulation. However, many questions remain. For example, what was the source of hydrothermal fluids? What was the source of gold? What was the interaction between the fluids, the gold, and the crustal structure? What is the relation of the faults to other tectonic features such as the northern Nevada rift? These questions may be answered with additional geologic, geochemical, and geophysical study.

REFERENCES CITED

Grauch, V. J. S., Jachens, R. C., and Blakely, R. J., 1995, Evidence for a basement feature related to the Cortez disseminated gold trend and implications for regional exploration in Nevada: Economic Geology, v. 90, p. 203-207.

Grauch, V.J.S., Klein, D.P., and Rodriguez, B.D., (this volume), Progress on understanding the crustal structure near the Battle Mountain-Eureka mineral trend from geophysical constraints, *in* Tosdal, R.M., ed., Contributions to the Au metallogeny of northern Nevada: U.S. Geological Survey Open-File Report.

Maher, B. J., Browne, Q. J., and McKee, E. H., 1993, Constraints on the age of gold mineralization and metallogenesis in the Battle Mountain-Eureka mineral belt, Nevada: Economic Geology, v. 88, p. 469-478.

Roberts, R. J., 1966, Metallogenic provinces and mineral belts in Nevada: Nevada Bureau of Mines Report 13, p. 47-72.

Rodriguez, B.D., (this volume), Regional crustal structure beneath the Carlin Trend, Nevada based on deep electrical geophysical measurements, *in* Tosdal, R.M., ed., Contributions to the Au metallogeny of northern Nevada: U.S. Geological Survey Open-File Report.

Seedorff, Eric, 1991, Magmatism, extension, and ore deposits of Eocene to Holocene age in the Great Basin—mutual effects and preliminary proposed genetic relationships, *in* Raines, G. L., Lisle, R. E., Schafer, R. W., and Wilkinson, W. H., eds., Geology and ore deposits of the Great Basin: Geological Society of Nevada, Reno, Nevada, p. 133-178.

Shawe, D. R., 1991, Structurally controlled gold trends imply large gold resources in Nevada, *in* Raines, G. L., Lisle, R. E., Schafer, R. W., and Wilkinson, W. H., eds., Geology and ore deposits of the Great Basin: Geological Society of Nevada, Reno, Nevada, p. 199-212.

Teal, L., and Jackson, M., 1997, Geologic overview of the Carlin Trend gold deposits and descriptions of recent deep discoveries: Society of Economic Geologists Newsletter, no. 31, p. 1 and 13-25.

Tosdal, R. M., and Wooden, J. L., 1997, Granites, Pb isotopes, and the Carlin and Battle Mt.-Eureka trends, Nevada: Geological Society of America Abstracts with Programs, v. 29, no. 6, p. A-61.

Wooden, J. L., Tosdal, R. M., and Kistler, R. W., 1997, Pb and Sr isotopic mapping of crustal structure in the northern Great Basin: Society of Economic Geologists Guidebook Series, v. 28, p. 47-51.

Wooden, J.L., Tosdal., R.M., and Kistler, R.W., (this volume), Pb isotopic mapping of crustal structure in the northern Great Basin and relationships to Au deposit trends, *in* Tosdal, R.M., ed., Contributions to the Au metallogeny of northern Nevada: U.S. Geological Survey Open-File Report.

Zoback, M. L., McKee, E. H., Blakely, R. J., and Thompson, G. A., 1994, The northern Nevada rift: Regional tectono-magmatic relations and Miocene stress direction: Geological Society of America Bulletin, v. 106, p. 371-382.